ICANN 2025
ABSTRACT BOOK

9th International Conference on Advanced Nanomaterials and Nanotechnology

12 - 14
December
2025

Organised by
Centre for Nanotechnology
IIT Guwahati

9th International Conference on Advanced Nanomaterials and Nanotechnology

ICANN 2025

December 12 - 14, 2025

Organized by
Centre for Nanotechnology
Indian Institute of Technology Guwahati
Guwahati-781039, Assam, India

Message from Prof. Devendra Jalihal, Director, IIT Guwahati

भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

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प्रो. देवेन्द्र जालिहाल
Prof. Devendra Jalihal
निदेशक
Director

December 5, 2025

Message from the Director

I am pleased to welcome all invited speakers, participants, and guests to the **9th International Conference on Advanced Nanomaterials and Nanotechnology (ICANN 2025)**, hosted by the Centre for Nanotechnology, IIT Guwahati, from **12–14 December 2025**. ICANN has grown into one of India's most respected forums for advancing knowledge, nurturing collaborations, and connecting global leaders in nanoscience and nanotechnology.

This edition comes at a particularly important time. Guwahati is emerging as a key node in India's semiconductor ecosystem, supported by national initiatives and a rapidly expanding innovation landscape in the Northeast. In this context, ICANN 2025 provides an essential platform for bridging fundamental research with real-world technological needs. The conference brings together scientists, engineers, clinicians, industry experts, innovators, entrepreneurs, and policymakers—reflecting the increasingly interdisciplinary and application-oriented nature of the field.

The inclusion of a Doctor's Conclave, dedicated industry sessions, and plenary discussions involving both academia and industry underscores our commitment to translational research and technology development. These interactions are crucial for enabling new pathways in areas such as healthcare, sustainable energy, advanced materials, semiconductors, quantum technologies, micro/nanofluidics, sensors, and device engineering.

IIT Guwahati, located on the serene banks of the Brahmaputra, offers a vibrant academic setting conducive to meaningful dialogue and collaboration. The cultural richness and natural beauty of Assam add to the overall experience, making ICANN 2025 both intellectually stimulating and personally memorable.

I congratulate the Centre for Nanotechnology and the organizing team for their dedicated efforts. I also extend my sincere appreciation to all invited speakers, contributors, and participants for enhancing this conference with your insights and engagement.

I wish ICANN 2025 great success. May the discussions here inspire impactful ideas, strengthen global partnerships, and contribute to shaping the future of nanotechnology and its applications.

Devendra Jalihal
(Devendra Jalihal)

Message from Prof. Akshai Kumar A. S, Head, Centre for Nanotechnology, IIT Guwahati

Dr. Akshai Kumar A. S
Head, Center for Nanotechnology

भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
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Center for Nanotechnology

It gives me immense pleasure to welcome you all to the 9th International Conference on Advanced Nanomaterials and Nanotechnology (ICANN 2025), being organized by the Centre for Nanotechnology, IIT Guwahati, from 12–14 December, 2025. Since its inception in 2009, the ICANN conference series has grown into one of India’s most prominent biennial international events in the domain of nanoscience and nanotechnology. Over the years, ICANN has consistently brought together leading thinkers, innovators, entrepreneurs, technologists, and young researchers from across the globe to engage in meaningful discussions and foster collaborations across disciplines.

IIT Guwahati, with its lush green 700-acre campus on the banks of the majestic Brahmaputra River, offers a serene and inspiring environment for scientific deliberation. The region is enriched with the cultural and ecological heritage of Assam, including the renowned Kamakhya and Umananda temples as well as several UNESCO World Heritage Sites such as Kaziranga National Park, Manas Wildlife Sanctuary, and Majuli Island. We hope that this unique setting adds to your experience during the conference.

ICANN 2025 aims to showcase emerging breakthroughs across a wide range of verticals—nano-materials, nano- catalysis, MEMS & NEMS devices, semiconductors, advanced solar cells, healthcare technologies, sensors, photonics, micro/nanofluidics, computation, quantum technologies, translational research, and start-up & entrepreneurship ecosystems. The conference program includes plenary sessions, invited talks, oral and poster presentations, and interactive discussions that promise to create opportunities for knowledge sharing, innovation, and meaningful networking.

Organizing a conference of this scale is a collective effort. I would like to acknowledge the dedication and hard work of the organizing committee, faculty members, administrative staff, project staff and the team of student volunteers who have worked tirelessly to make ICANN 2025 a truly memorable event. I also extend my sincere gratitude to all participants, whose contributions and enthusiasm form the heart of this conference series.

I warmly welcome each one of you to IIT Guwahati and hope that ICANN 2025 inspires new ideas, fosters collaborations, and contributes to the advancement of nanoscience and nanotechnology. I wish you all an enriching and productive conference experience.

Sincerely,

Dr. Akshai Kumar Alape Seetharam
Head, Centre for Nanotechnology

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ICANN 2025

The 9th International Conference

On

Advanced Nanomaterials and Nanotechnology

PROGRAM SCHEDULE

12-14 December 2025
IIT Guwahati

Day 1, 12th December 2025, FN Sessions

Time	Schedule	
7:30-9:00 PM	Breakfast (Venue – Conference Hall)	
7:30-10:00 AM	Registration	
9:30-10:30 AM	**Inaugural Session** (Venue – Mini Auditorium)	
10:30-10:35 AM	Group Photo	
10:35-10:45 AM	Refreshments	
10:45-11:30 AM	**Healthcare Frontiers** (Venue – Bhupen Hazarika Auditorium Lobby)	**Doctor's Conclave: "*Possibilities in Nano-Medicine Diagnostics and Surgical Interventions*"** **Panelists:** Dr Sajal Sen, AAHII **(Session Moderator),** Prof. (Col.) Ashok K Puranik, Executive Director, AIIMS Guwahati, Dr Sridhar Sivasubbu, Chief Diagnostics & Research Officer, Karkinos, Dr Venkata Sasidhar Manda, Chief Scientific Officer, Apollo Hospitals Research Foundation (AHERF), Dr Satyaki Saikia, Apollo Excelcare, Dr. Subash Chandra Gupta, AIIMS Guwahati. (Venue – Mini Auditorium)
11:30-12:15 AM	**Healthcare Frontiers** (Venue – Bhupen Hazarika Auditorium Lobby)	**Doctor's Conclave: "*Emerging Drug Delivery Systems in Cancer Care.*"** **Panelists**: Prof. (Col.) Ashok K Puranik, AIIMS Guwahati **(Session Moderator)**, Dr Arindam Baruah, Robotic Oncosurgeon, Swagat Hospital, Guwahati, Dr Jyoutishman Saikia, Assistant Professor, AIIMS, Delhi, Shri Nandish Pethani, Co-founder and Director, Policy Resilience Foundation (PRF), Dr Sajal Sen, AAHII, Dr. Satyajit Mohapatra, AIIMS Guwahati. (Venue – Mini Auditorium)

Day 1, 12th December 2025, FN Sessions

Time	Schedule
12:15-12:45 PM	**Panel Discussion – "*Deep Tech Innovation Leading to High Impact Publication.*"** **Panelists**: Prof. Pratik Shah (Roskilde University, **Session Moderator**), Dr Rohini Dattatraya Kitture (Wiley), Dr Sweta Raghavan (The Royal Society of Chemistry), Prof. Gilles Alcaraz (CNRS), Prof. Alan Goldman (Rutgers University), Prof. Louise Torp Dalgaard (Roskilde University). (Venue – Hall 2)
12:45-1:15 PM	**Panel Discussion – "*A Session on Patents, Start-ups and Entrepreneurship*"** **Panelists:** Dr Swapnil Sinha (BioNEST, **Session Moderator**), Dr Sandeep Patil (ESpin Nanotech Pvt. Ltd.), Mr Ankit Chowdhury (Primary HealthTech Pvt. Ltd.), Mr Amit Mishra (Yotta Data Services). (Venue – Hall 3)
1:15-2:00 PM	Lunch

Day 1, 12th December 2025, AN Sessions

Time	Schedule		
2:00-3:00 PM	2:00-3:00 PM	**Poster Presentation Sponsored by The Royal Society of Chemistry (RSC)** **(Conference Hall Lobby)**	
	Oral Presentation Sponsored by Wiley		
		Hall 2 **(Session Chair:** Prof. Mitradip Bhattacharjee, Prof. Ayan Roy Chaudhuri**)**	**Hall 3** **(Session Chair:** Prof. Abir Ghosh, Prof. Joydip Chaudhuri**)**
	2:00-2:12 PM	Ramkrishna Das Adhikari	Srishti Verma
	2:12-2:24 PM	Mitul Kalita	Akash M
	2:24-2:36 PM	Shipra Aswal	Surbhi Chauhan
	2:36-2:48 PM	Mukul Biswas	Priyam Ghosh
	2:48-3:00 PM	Suchandra Biswas	Mohammad Abubakar Sadique
3:00-3:40 PM	**Plenary talk - Prof. Amitava Patra** (Venue: Hall 2) **Session Chair:** Prof. Bhisma Kumar Patel		
		Theme: Nanoelectronics **Session Chair:** Prof. Dr Andreas Terfort	**Theme: Healthcare** **Session Chair:** Prof. Louise Torp Dalgaard
3:40-4:10 PM		Prof. Nonappa Nonappa	Prof. Ramu Adela
4:10-4:40 PM		Prof. Ayan Roy Chaudhuri	Prof. Mitradip Bhattacharjee
4:40-4:50 PM	Tea Break		
4:50-5:20 PM		Prof. Bulumoni Kalita	Prof. Pratik Shah
5:20-5:50 PM		Prof. Uday Narayan Maiti	Prof. Sneha Singh
5:50-6:15 PM	Shouvik Kumar Bagchi, HHV Advance Technologies Pvt. Ltd. (Venue: Hall 2)		
7:30 PM Onwards	Dinner		

Day 2, 13th December 2025, FN Sessions		
Time	**Schedule**	
7:30-9:00 AM	Breakfast (Venue – Conference Hall)	
9:30-10:10 AM	**Plenary Talk - Prof. Louise Torp Dalgaard** (Venue: Hall 2) **Session Chair:** Prof. Mohd. Qureshi	
	Hall 2	**Hall 3**
	Theme: Nanoelectronics **Session Chair:** Prof. Ankush Bag	**Theme: Healthcare (Karkinos Sponsored)** **Session Chair:** Prof. Nonappa Nonappa
10:10-10:40 AM	Prof. Agile Mathew	Prof. Saumya Ray Chaudhuri
10:40-11:10 AM	Prof. Shilpa Sharma	Dr Sweta Raghavan
11:10-11:40 AM	Prof. Shirsendu Mitra	Prof. Rajiv Kar
11:40-11:50 AM	Tea Break	
11:50-12:20 AM	Prof. Manoj A.G. Nambboothiry	Prof. Erwin Fuhrer
12:20-12:50 PM	Prof. Suraj Soman	Prof. Joydip Chaudhuri
12:50-01:20 PM	Prof. Ujjwal Pal	Prof. Rupa Mukhopadhyay
01:20-02:00 PM	Lunch	

Day 2, 13th December 2025, AN Sessions			
Time	**Schedule**		
2:00-3:00 PM	2:00-3:00 PM	**Poster Presentation Sponsored by The American Chemical Society (ACS)** **(Conference Hall Lobby)**	
	Oral Presentation Sponsored by Wiley		
		Hall 2 **(Session Chair:** Prof Aditya Narayan Panda, Prof. Swati Sharma**)**	**Hall 3** **(Session Chair:** Prof. Tamanna Bhuyan, Prof. Sangeeta Roy Chaudhuri**)**
	2:00-2:12 PM	Swayamprakash Biswal	Ushmita Dey
	2:12-2:24 PM	Ujjala Dey	Aakanksha Ayodhya Pathak
	2:24-2:36 PM	Antara Ghosh	Hrishikesh Sarma
	2:36-2:48 PM	Krishnendu M R	Rohan Rohilla
	2:48-3:00 PM	Sayanika Saikia	Sawna Roy
3:00-3:40 PM	**Plenary Talk - Prof. Jen-Inn Chyi** (Venue: Hall 2) **Session Chair:** Prof. Dr Karl-Heinz Ernst		
		Theme: Nanomaterials and Nano catalysis (RSC Sponsored) **Session Chair:** Prof. Chinmoy Ranjan	**Theme: Nanomaterials and Nano-catalysis in Healthcare (Karkinos Sponsored)** **Session Chair:** Prof. Saran Kumar
3:40-4:10 PM		Prof. Ekambaram Balaraman	Prof. Bidyut Bikash Sarma
4:10-4:40 PM		Prof. Praveen Kumar	Prof. Saptarshi Ghosh
4:40-4:50 PM	Tea Break		
4:50-5:20 PM		Prof. Swati Sharma	Prof. Aparna Mukhopadhyay
5:20-5:50 PM		Prof. Tharamani C.N.	Prof. Sangeeta Roy Chaudhuri
6:30 PM Onwards	Gala Dinner		

Day 3, 14th December 2025, FN Sessions		
Time	**Schedule**	
7:30-9:00 AM	Breakfast (Venue – Conference Hall)	
9:30-10:10 AM	**Plenary Talk - Prof. Alan Goldman** (Venue: Hall 2) **Session Chair:** Prof. Gilles Alcaraz	
	Hall 2	**Hall 3**
	Theme: Nanomaterials and Nano catalysis **Session Chair:** Prof. Ekambaram Balaraman	**Theme: Nanomaterials and Nano catalysis for Healthcare** **Session Chair:** Prof. Pratik Shah
10:10-10:40 AM	Prof. Abir Ghosh	Prof. Pankaj Barah
10:40-11:10 AM	Prof. Chinmoy Ranjan	Prof. Dilip Kumar Singh
11:10-11:40 AM	Dr Rohini Dattatraya Kitture	Prof. Saran Kumar
11:40-11:50 AM	Tea Break	
11:50-12:20 AM	Prof. Kusum K. Bania	Prof. Ishita Matai
12:20-12:50 PM	Prof. Shaikh M. Mobin	Prof. Aviru Kumar Basu
12:50-01:20 PM	Prof. Gilles Alcaraz	Prof. Krishna Kanti Dey
1:20-2:00 PM	Lunch	

Day 3, 14th December 2025, AN Sessions		
Time	**Schedule**	
2:00-2:40 PM	**Plenary Talk – Prof. Dr Karl-Heinz Ernst** (Venue: Hall 2) **Session Chair:** Prof. Alan Goldman	
	Hall 2	**Hall 3**
	Theme: Nanoelectronics and Nanomaterials **Session Chair:** Prof. Kusum K. Bania	**Theme: Nanomaterials and Nanoelectronics in Healthcare** **Session Chair:** Prof. Pankaj Barah
2:40-3:10 PM	Prof. Abhijit Hazarika	Prof. Amit Kumar Singh
3:10-3:40 PM	Prof. Seena V	Prof. Kalishankar Bhattacharyya
3:40- 3:50 PM	Tea Break	
3:50-4:20 PM	Prof. Himangshu Jyoti Gogoi	Prof. Shyam Pandey
4:20-4:50 PM	Prof. Vipul Singh	Prof. Abhay Sachdev
4:50-5:20 PM	Prof. Dr Andreas Terfort	Prof. Tamanna Bhuyan
5:30-6:00 PM	Valedictory Session (Venue: Hall 2)	
6:30 PM Onwards	Dinner	

Bio-sketches and Abstracts of:

- Plenary Speakers
- Distinguished Speakers
- Invited Speakers

Prof. Amitava Patra

Professor, School of Materials Sciences, IACS, Kolkata, India

Prof. Amitava Patra is a Senior Professor at the School of Materials Sciences, Indian Association for the Cultivation of Science (IACS), Kolkata, and currently serves as the Director of the Institute of Nano Science and Technology (INST), Mohali (2020–2025). Prof. Patra earned his Ph.D. from Jadavpur University (CGCRI) in 1993 and pursued postdoctoral research at the University of Tokyo (1993–1994) and RIKEN, Japan (1994–1995). He later served as a Visiting Scientist at the Hebrew University of Jerusalem and Research Associate at the University at Buffalo, USA.

Prof. Patra's research focuses on ultrafast excited-state dynamics, energy and electron transfer in nanostructured systems, including quantum dots, gold nanoclusters, carbon dots, semiconducting polymers, graphene, and luminescent hybrid materials. His work advances understanding of photonic and optoelectronic materials, with applications in light harvesting, sensing, and energy conversion.

He has authored over 290 research papers, 5 book chapters, and 2 patents, with more than 15,000 citations and an h-index of 65, reflecting his global impact in the fields of photophysics and nanomaterials.

Ultrafast Carrier Dynamics of Light-Harvesting Nanomaterials

Amitava Patra
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Nanomaterials-based light-harvesting systems have been the research subject because they can generate exciton after photoexcitation. A deep understanding of hot carrier (HC) dynamics is crucial to improving the performance of optoelectronic devices by reducing thermalization losses. Here, we investigate the carrier dynamics, energy transfer, and charge carrier dynamics of 2D CdSe nanoplatelets and perovskite nanocrystals.[1-8] Ultrafast spectroscopic investigations provide direct insight into the impacts of electron and hole transfer at the interface of hybrid materials for optoelectronic applications. The fundamental knowledge of these photophysical processes is crucial for developing efficient light-harvesting systems.

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Prof. Louise Torp Dalgaard

Professor, Department of Science and Environment, Roskilde University, Denmark

Prof. Louise Torp Dalgaard is a Professor of Molecular and Medical Biology at the Department of Science and Environment, Roskilde University, Denmark. She earned her PhD in Biomedicine from the University of Copenhagen, and her research career focuses on regulation of metabolism, endocrine health and disease, with a special emphasis on the roles of non-coding RNAs (microRNAs) in diabetes, obesity, and β-cell biology. Her research group investigates how microRNAs influence pancreatic β-cell function, survival, and insulin secretion, and how dysregulation of these RNAs contributes to metabolic disease, β-cell failure, and complications such as diabetic wound healing, obesity, non-alcoholic fatty liver disease, and reproductive metabolic disorders. The group also explores the potential of circulating microRNAs as biomarkers to detect metabolic risk, disease onset, or complications. In addition to research, Prof. Dalgaard has substantial teaching and academic-leadership experience: she has served as Head of Studies for the Medical Biology program (2018–2020), taught courses ranging from cell biology, genetics, immunology, genomics, immunometabolism and cell physiology, and supervised master's students, PhD students, and project-groups. Through her combined efforts in research, teaching, and mentorship, Prof. Dalgaard has significantly advanced the understanding of microRNA-mediated metabolic regulation and contributed to translational approaches toward metabolic disease diagnostics and therapy.

Micro RNA Inhibitors for Treatment of Chronic Diabetic Wounds

Louise T. Dalgaard
Professor of Molecular Metabolism, Department of Science and Environment, Roskilde University, Denmark

MicroRNAs (miRNAs) are small, non-coding RNAs that regulate gene expression by binding to target mRNAs, leading to degradation or translation inhibition. Since their discovery, miRNAs have been identified as key regulators in processes like differentiation, proliferation, metabolism, and apoptosis. Dysregulation of miRNAs is linked to diseases such as cancer, cardiovascular disorders, and metabolic conditions like diabetes. Therapeutic strategies targeting miRNAs, including mimics and inhibitors, hold potential for addressing these diseases. Diabetes, a chronic metabolic disorder characterized by hyperglycemia, affects millions globally and leads to complications such as cardiovascular disease, nephropathy, and impaired wound healing. MiRNAs regulate key pathways in insulin signaling and inflammation, making them crucial therapeutic targets. Wound healing, impaired in diabetes, involves processes like inflammation, angiogenesis, and remodeling, all regulated by miRNAs. Dysregulated miRNAs, such as miR-146a-5p, miR-29a-3p and miR-155-5p are key targets for improving chronic diabetic wounds.

It has previously been observed that microRNAs (miR)-146a-5p and miR-29-3p were upregulated in chronic non-healing wounds in diabetes. We assessed the molecular and cellular effects of their single and dual inhibition using human keratinocytes (HaCaT) and in vivo using a mouse model of type 1 diabetes.

In HaCaT keratinocytes, we screened for proteome changes by LC-MS/MS after transfection with miR-146a-5p and miR-29a-3p inhibitors individually or in combination and following stimulation with TNFα. The multiple low-dose streptozotocin type 1 diabetes model was used, having a 6-week diabetes duration, in which we performed full-thickness wounds, which were topically treated with scramble controls, miR-146a-5p or miR-29a-3p inhibitors and investigated at days 0, 3- and 10 post wounding.

We identified a panel of extracellular matrix proteins, in particular laminins, whose levels were altered following the transfection with miR-146a-5p and miR-29a-3p inhibitors, opposite to the effect of TNFα. Moreover, the dual inhibition of miR-146a-5p and miR-29a in vivo improved wound closure, increased angiogenesis on day 3 and day 10, while also decreasing the ROS formation 3 days post wounding. The actions of the dual miRNA inhibitors were additive to single inhibitor treatment.

These findings demonstrate that simultaneous inhibition of miR-146a-5p and miR-29a-3p in diabetic wounds improves healing, superior to the actions of single miRNA inhibition, and suggest that topical miRNA inhibition could be a therapeutic strategy for diabetic wound healing; however, studies in human subjects are warranted.

Prof. Jen-Inn Chyi

Professor, Department of Electrical Engineering, Executive Vice President for NCU
Director for Center for Advanced Science and Technology National Central University,
Taoyuan City, Taiwan

Prof. Jen-Inn Chyi is a distinguished electrical engineering researcher and academic leader at National Central University (NCU), Taiwan, where he serves as Executive Vice President and Chair Professor in the Department of Electrical Engineering. He earned his B.S. (1982) and M.S. (1984) in Electrical Engineering from National Tsing Hua University, Taiwan, and his Ph.D. in Electrical Engineering from the University of Illinois at Urbana-Champaign in 1990. Immediately after his doctorate, he joined NCU in 1991 and has since established strong research labs in molecular beam epitaxy (MBE), metal-organic vapor phase epitaxy (MOVPE), and optoelectronic/high-speed device fabrication and characterization. His research spans III-V semiconductor heterostructures, InP-based heterojunction bipolar transistors, GaN-based emitters (ultraviolet to green), quantum-dot photonic devices, and high-power, high-temperature devices. Prof. Chyi has published hundreds of journal articles, holds numerous patents, and has been recognized with prestigious awards such as the Distinguished Research Awards from Taiwan’s National Science Council, the Industrial Contribution Award from the Ministry of Economic Affairs, and the Distinguished Professor Award from the Chinese Institute of Electrical Engineering. Beyond research, he has held key leadership positions: Director of the Optical Sciences Center, Dean of the College of Electrical Engineering & Computer Science, Vice Chancellor of the University System of Taiwan.

h-BN Mediated Epitaxy of III-Nitrides on Foreign Substrates

Jen-Inn Chyi, Muzafar Ahmad Rather, Dipak Dutta, and K.-Y. Lai
National Central University, Taoyuan 32001, Taiwan R.O.C.
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III-nitride semiconductors, especially GaN-based materials, have played a pivotal role in flat panel displays, power electronics, and wireless communications due to their unique optical and electronic properties. The quest for advancements in epitaxial growth technology continues as more applications of GaN-based devices are proposed. Currently, epitaxial growth of GaN is mainly conducted on sapphire, Si, and SiC substrates, which are not compatible with GaN in lattice constant or thermal expansion coefficient, and impose restrictions on the exploitation of the potential of III-nitrides. In this work, we demonstrate epitaxy of III-nitrides can be achieved on poly-AlN, (100) Si as well as oxidized Si substrates by using a two-dimensional boron nitride (BN) intermediary layer (IL).

The hexagonal boron nitride (h-BN) was grown on a sapphire substrate and transferred onto the host substrates of interest, serving as a buffer and seed layer for the heteroepitaxial growth of III-nitrides. The heteroepitaxy of III-nitrides was carried out using metal-organic chemical vapor deposition. As evidenced by X-ray diffraction, the epitaxial growth on the two-dimensional h-BN layer proceeded in the van der Waals epitaxy mode and followed the same crystalline orientation as h-BN, i.e. the (0001) plan. As a proof-of-concept, a multiple-quantum-well (MQW) heterostructure was also grown on poly-AlN substrate and showed narrow blue light at 423 nm under optical pumping. These results confirm the feasibility of growing nitride epilayers on non-crystalline substrates for specific purposes by using an h-BN layer.

Prof. Alan Goldman

Professor, Chemistry, Rutgers University, USA

Prof. Alan Goldman received his B.A from Columbia University in New York in 1980 and his Ph.D. from Columbia in 1985, studying the mechanisms of photoinduced organometallic reactions in the laboratory of Prof. David R. Tyler. He then took an IBM Post-doctoral Fellowship in the lab of Prof. Jack Halpern at the University of Chicago. Goldman began his independent career as an assistant professor at Rutgers University in 1987 where he is currently Distinguished Professor of Chemistry. His research focuses on the development and mechanistic study of transition-metal-catalyzed transformations of small molecules and relevant fundamental chemistry. Honors received by Goldman include an Alfred P. Sloan Fellowship, a Dreyfus Teacher-Scholar Fellowship, the inaugural ACS Catalysis Lectureship Award for the Advancement of Catalytic Science, the 2019 ACS Award in Organometallic Chemistry, the 2020 Royal Society of Chemistry Sir Geoffrey Wilkinson Award, and election to Fellowship in the American Association for the Advancement of Science in 2021. He is an Honorary Professor in the Centre for Nanotechnology, Indian Institute of Technology, Guwahati.

Reduction of N_2 to Ammonia Catalyzed by Transition Metal Complexes. Design of a New Paradigm Based on Fundamental Considerations

Alan S. Goldman
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The synthesis of ammonia from N_2 affords the fixed nitrogen for all synthetic fertilizer and thereby supports approximately half the world's food production. The current dominant process, based on fossil fuel reforming, is responsible for nearly 2% of the world's fossil fuel consumption and CO_2 emissions. There is thus great interest in the development of electrochemical N_2 reduction, using a sustainable source of energy, with water as the source of protons and electrons. Such a process may also be applicable on a scale much larger even than fertilizer and chemicals, including the use of ammonia for storage and transportation of renewable energy. Historically, metal-catalyzed N_2 fixation has been envisioned to occur via sequential additions of electrons and protons (net H-atom additions) to a metal-bound N_2 molecule. We and other groups have recently adopted a very different approach – based on the cleavage of one N_2 molecule by two metal centers to give two metal nitrides. Although cleavage of the strong N_2 triple bond is typically considered to be the "difficult" step in N_2 fixation, we find that bimetallic N_2 cleavage is often very facile. The resulting metal nitrides, however, are typically very stable and the driving force for their subsequent reduction/protonation (i.e. their N-H BDE) is quite low. Based on a novel N_2 reduction catalyst that we have recently developed, a new paradigm for N_2 reduction based on bimetallic cleavage is proposed. This approach involves N_2 cleavage that is thermodynamically less favorable than with conventional systems, yet kinetically facile. The resulting nitrides have a significantly stronger driving force to form an N-H bond, i.e. the corresponding N-H BDE is much greater than in the more well precedented systems.

Prof. Dr. Karl-Heinz Ernst

Empa Distinguished Senior Scientist, EMPA, Switzerland

Prof Karl-Heinz Ernst, originally trained as a Chemical-Technical Assistant, studied Chemical Engineering at the University of Applied Sciences Berlin (TFH, now Beuth) and Chemistry at the Freie Universität Berlin, where he also earned his PhD in Physical Chemistry. After a post-doctorate study at the University of Washington, Seattle, he joined Empa (Swiss Federal Laboratories for Materials Science and Technology) in 1992, where he established the Molecular Surface Science Group. He completed his Habilitation at the University of Zurich in 2007, became a Titular Professor in 2010, and was promoted to Empa Distinguished Senior Scientist in 2014. Prof. Ernst has received numerous honors, including the Humboldt Research Award and the Surfaces and Interfaces Award of the Royal Society of Chemistry. He has authored 184 publications (146 peer-reviewed) with an h-index of 46 and ≈8000 citations. The research group of Prof. Ernst performs state-of-the-art research on molecular surface systems with the scope of providing more insight into molecular self-assembly, crystallization phenomena and molecular surface dynamics.

Chiral phenomena of novel surface systems

Karl-Heinz Ernst[1,2,3]
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1. Introduction

From the inception of molecular theory, the interplay between chirality and magnetism has been a source of fascination for scientists. The question of whether enantiospecific adsorption of chiral molecules takes place on magnetic surfaces still lingers. Enantiomer discrimination was initially postulated to result from the absolute handedness of molecules and their exchange interaction with the substrate's magnetization. Nevertheless, a comprehensive understanding of such phenomenon remains elusive.

2. Magneto-chiral adsorption

We present findings regarding the enantiospecific adsorption of heptahelicene (C30H18, [7]H), a chiral helical polyaromatic molecule, on ferromagnetic singlecrystal cobalt surfaces in ultrahigh vacuum using spinpolarized scanning tunneling microscopy (SP-STM). A contrast in differential conductance (dI/dV) emerges due to the varying spin-polarized tunneling probabilities between the oppositely magnetized Co nanoislands and the magnetic STM tip. Since the absolute magnetization direction of the STM tip remains unknown, it is possible to assign only a relative distinction of a higher or lower dI/dV signal in relation to the direction of the island's magnetization. Immobilization of molecules in the chemisorbed state suggest that enantiospecificity is a consequence of spin-dependent van der Waals (vdW) interactions in a physisorbed precursor state. Notably, lateral enantioselection occurs on domains with opposite out-ofplane magnetization initially in a transient physisorbed precursor state before progressing to chemisorption. Our statistical analysis, conducted within the framework of a trinomial distribution, reveals that for the combined datasets, the magneto-enantiospecific ratio is strongly deviating from unity. In other words, this signifies that the adsorption of [7]H enantiomers on a ferromagnetic Co(111) island is notably influenced by both the molecular handedness and the substrate magnetization.

3. Spin-selective electron tunneling

Simultaneous measurements of the tunneling current through both enantiomers on a given Co nanoisland yields a magneto-chiral specific conductance of up to 50% for single helicene molecules, thus refuting previously proposed ensemble effects as origin of the socalled chirality-induced spin selectivity (CISS). Our results open the opportunity towards new single-molecule spin-valve devices and shine light into the origin of CISS.

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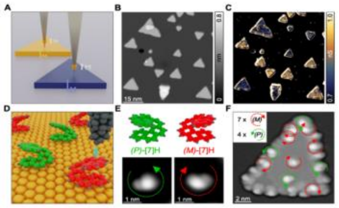

Figure 1. Principles of spin-polarized and enantioresolved STM. (A) Sketch of two oppositely out-ofplane magnetized Co nanoislands probed with a magnetic Co-functionalized STM tip. (B) Constantcurrent topographic STM image of Co nanoislands on Cu(111). (C) dI/dV map measured with amagnetic Co-functionalized STM tip. (D) Sketch of STM imaging of single molecules. (E) Ball-and-stick model of [7]H enantiomers and assignment of their absolute handedness from STM contrast. (F) Example for 'chirality counting' of [7]H molecules on a single Co nanoisland. Indicated by circular arrows, 4 (P)- and 7 (M)-enantiomers are identified.

Prof. Nonappa Nonappa

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Dr. Nonappa Nonappa is an Associate Professor in Nanochemistry at the Faculty of Engineering and Natural Sciences, Tampere University, Finland, since 2020. He earned his Ph.D. in Organic Chemistry from the Indian Institute of Science, Bangalore, in 2008. Following his doctorate, he conducted postdoctoral research at the University of Jyväskylä, Finland, and later at Aalto University's Department of Applied Physics, where he also served as a Research Fellow and Docent until 2020. He holds the title of Docent in Soft Matter Microscopy from Aalto University (2017) and obtained the Abilitazione Scientifica Nationale (ASN) in Chemical Technology from MIUR, Italy (2018). Additionally, he earned an Executive MBA from Quantic School of Business and Technology in 2020. Dr. Nonappa's research focuses on efficiently controlling the structure and properties with the highest possible precision, developing lab-on-a-chip sustainable in vitro preclinical models for personalized and precision breast cancer disease and diagnostic platforms, and fabricating bio-based short-distance optical fibers and microlasers in the optics and photonics areas.

3D Electron Microscopy of Nanoscale Assemblies and Dynamics

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Transmission electron microscopy (TEM) imaging has revolutionized modern materials science, nanotechnology, and structural biology. Its ability to provide information about materials' structure, composition, and properties at atomic-level resolution has enabled groundbreaking discoveries and the development of innovative materials with precision and accuracy. Importantly, TEM imaging enables the real-time visualization of the structural transformation of individual nanoparticles or the interaction between two nanoparticles under various environmental conditions, including temperature, electron beam irradiation, gases, and liquids. TEM tomography, utilizing a series of two-dimensional (2D) projections, has become an essential method for gaining three-dimensional (3D) structural details of nanomaterials.[1] I will discuss how TEM tomography offers unprecedented morphological features of 3D objects, internal structures, packing patterns, growth mechanisms, and self-assembly pathways of self-assembled colloidal systems.[2-4] Furthermore, I will discuss how *in situ* TEM imaging allows real-time monitoring of nanoscale dynamics and precise manipulation of the structure, mechanical performance, and optoelectronic properties of metal nanoparticles.[5]

Figure 1. An overview of TEM tomography-assisted 3D reconstructed colloidal superstructures.

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Dr. Ayan Roy Chaudhuri

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Dr. Ayan Roy Chaudhuri is an Associate Professor at the Materials Science Centre, Indian Institute of Technology Kharagpur. He earned his Ph.D. degree (Integrated Ph.D., Chemical Sciences) from the Indian Institute of Science Bangalore in 2009, where he was affiliated with the Materials Research Centre. Dr. Roy Chaudhuri received the prestigious Alexander von Humboldt Fellowship for postdoctoral research to work on nanoengineering of functional oxide thin films at the Max Planck Institute of Microstructure Physics in Halle (Saale). He then worked as a Senior Research Scientist at the Institute of Electronic Materials and Devices, Leibniz University Hannover, Germany, where he contributed extensively to the MBE growth of epitaxial lanthanide oxides on Si for high-k dielectric applications. Since January 2016, Dr. Roy Chaudhuri has been serving as a faculty member at IIT Kharagpur. In 2017, he received the Faculty Excellence Award of IIT Kharagpur for his contributions to teaching, research, and institute administrative works.

Resistive Switching in Amorphous WO_{3-x} Thin Films for High-Density Memory and Synaptic Device Applications

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Resistive switching (RS) in metal oxides holds significant potential for future electronic memory and neuromorphic computing devices. The realization of self-compliance and multiple resistance states in various metal oxide thin films is particularly promising for designing selector-less, high-density resistive random-access memory (RRAM) devices. Oxygen vacancies (V_Os) are known to play a crucial role in the RS mechanism of metal oxides. An in-depth investigation of V_Os-engineered amorphous WO_{3-x} thin films reveals a transition from forming-free to forming-required RS in W/WO_{3-x}/Pt stacks depending on the V_Os concentration in the switching layer. A nearly stoichiometric WO_{3-x} layer shows no RS characteristics even under large applied DC bias, emphasizing the deterministic role of V_Os in enabling switching. By optimizing the V_Os concentration in non-stoichiometric WO_{3-x} thin films, we demonstrate self-compliance and multilevel RS without the need for high-voltage forming. Additionally, a high concentration of V_Os enables clear synaptic functionalities-such as potentiation, depression, and improved conduction-modulation linearity-indicating suitability for neuromorphic computing applications. This study establishes that an optimal V_Os concentration leads to forming-free filamentary switching in WO_{3-x}. Reversible formation and annihilation of oxygen-rich regions in the filament near the WO_{3-x}/electrode interface appear responsible for self-compliance during set processes and voltage-controlled multilevel reset states. These findings suggest that non-stoichiometric WO_{3-x} - combined with an active metal/oxide interface capable of reversible oxygen migration - can enable the development of high-density, reliable RRAM devices for memory and neuromorphic applications.

Keywords: Electronic devices; oxide thin films; resistive switching; reactive sputtering.

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Dr. Ramu Adela is an associate professor in the Department of Pharmacy Practice at the National Institute of Pharmaceutical Education and Research in Guwahati. He completed his PhD at JNTU Hyderabad and later pursued a postdoctoral fellowship at AIIMS New Delhi. Dr. Adela focuses on identifying biomarkers that can predict the progression of cardiovascular complications in individuals with diabetes through basic, pre-clinical, and clinical research. His work investigates the interactions between platelets, immune cells, and inflammation in both macrovascular and microvascular complications associated with diabetes. More specifically, his research aims to employ interdisciplinary approaches to address critical questions regarding how metabolic changes, proteomic alterations, and inflammation contribute to the development of cardiovascular disorders. To address these biological questions, he utilises high throughput technologies, including proteomics, transcriptomics, and metabolomics. These techniques facilitate the identification of biomarkers, understanding the mechanisms of disease onset, and inform the development of new therapeutic strategies.

Translational Biomarkers for Improved Healthcare: Bench-to-Bedside Innovation

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The global healthcare landscape is shifting toward precision medicine, emphasizing early detection and targeted intervention to reduce disease burden and enhance patient outcomes. Biomarker-led strategies form the cornerstone of this transformation, enabling the translation of molecular discoveries into clinically actionable tools. Within this framework, our research focuses on cardiometabolic diseases where predictive diagnostics remain a critical unmet need.

We identified circulating Bone Morphogenetic Protein-8B (BMP8B) as a robust, non-invasive biomarker for non-alcoholic steatohepatitis (NASH). Quantitative analyses across healthy, NAFLD, and NASH cohorts revealed a progressive increase in BMP8B levels paralleling disease severity and correlating strongly with hepatic injury indices (ALT, AST). Its high diagnostic precision supports potential use in clinical stratification. Complementary investigations in coronary artery disease (CAD) recognized soluble TLT-1 (sTLT-1) as a platelet-derived marker of vascular inflammation. Elevated sTLT-1 reflected enhanced platelet activation and immune interactions, showing strong predictive performance for CAD identified through ROC analysis.

Collectively, biomarkers represent a pivotal link between molecular discovery and clinical impact, driving the evolution of healthcare toward predictive, preventive, and personalized paradigms. The development and validation of robust biomarkers will remain central to advancing global health equity and shaping the next generation of evidence-based clinical practice.

Prof. Pratik Shah

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Pratik Shah is an Associate Professor of Bio nanotechnology at the Department of Science and Environment at Roskilde University. Educated at Mumbai University (India) and Nottingham Trent University (UK) in Biotechnology, Dr. Shah completed a PhD in Synthetic Biology at the University of Copenhagen, focusing on DNA-based nanomaterials to investigate the microRNA biogenesis in plant development. As a postdoctoral fellow at the University of California, Irvine (USA), he investigated the orthogonal replication systems in yeast. Dr. Shah was awarded the prestigious Korea Research Fellowship to establish a multidisciplinary research program in bioinorganic chemistry, DNA nanoscience, and molecular cell biology at Yonsei University (South Korea). Dr. Shah returned to Denmark in 2022 at Roskilde University. His research uncovers how DNA not only templates but actively programs the structure and photophysics of nanomaterial, silver nanoclusters. These insights drive his group’s development of DNA-nanomaterial tools for intracellular sensing, dynamic pH and redox mapping, and next-generation molecular diagnostics. In addition to high-impact publications, Dr. Shah has also contributed to patents and collaborative industry projects, translating DNA-based nanotechnologies into diagnostic platforms.

Dynamic DNA-Silver Nanocluster Interactions for Responsive Biosensing And Imaging

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Biosensing technologies capable of detecting molecular signals inside living cells are essential for advancing both diagnostics and basic cell biology. DNA has emerged as a versatile scaffold in this space due to its programmable structure, biocompatibility, and ease of functionalization. Yet, in most DNA–nanomaterial systems, the DNA serves as a passive template. In contrast, our work with DNA-stabilized silver nanoclusters (DNA/AgNCs) reveals a unique, reciprocal interaction—where the DNA structure dynamically tunes the optical properties of the AgNCs, and the AgNCs, in turn, reshape the DNA into novel non-canonical conformations. This mutual feedback mechanism acts like a "molecular handshake," where both the DNA and nanocluster adjust to one another, unlocking unique modes of sensing. We exploit this dynamic to rationally design Hoogsteen triplex DNA motifs that modulate AgNCs fluorescence in response to pH changes. Through detailed structural and biochemical analysis, we show how AgNCs organize within triplex scaffolds and reversibly alter their emission properties. Building on this, we've developed responsive biosensors for microRNA and reactive oxygen species (ROS), enabling potential applications in live-cell imaging. Our results establish a new design approach in DNA nanotechnology, where structural and functional integration between scaffold and signal element enables the development of dynamic nanosensors. These advances open up opportunities for intracellular biosensing, imaging, and the design of programmable nanodevices.

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Dr. Aviru Kumar Basu

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Dr. Aviru Kumar Basu is a Scientist and faculty member in the Department of Quantum Materials and Devices at the Institute of Nano Science and Technology, DST, Govt. of India, in Mohali and Adjunct Faculty of IISER Mohali. His research focuses on 2D materials, Invasive/Non-Invasive Diagnostics, Water Treatment, Biosensors, lab-on-chip, MEMS-based devices, 3D Printing, AI/ML, photocatalysis, and gas sensing. Recently, his research on AI based water Treatment has been highlighted by the Department of Science and Technology, Govt of India, Press IB, Govt. of India and also featured in top leading 6 national newspapers all over India (ABP news, The Tribune, The Indian Express, Ajkaal Patrika, The Hindu and Amar Ujala). He has also received the Young Scientist Award from RSC, UK, 2024 for his contribution in nanotechnology. During his PhD studies under Professor Shantanu Bhattacharya at the Indian Institute of Technology, Kanpur, he contributed to the development of 2D MATERIAL Functionalized MEMS-based nano-cantilever sensors for rapid detection of trace analytes. Following his PhD, he conducted postdoctoral research at the Singapore University of Technology and Design and the National University of Singapore, with a focus on 3D printing and 2D material-based devices. Dr Basu's expertise spans various aspects of advanced materials and sensor technology. He has written several journals, conference proceedings, book chapters and two books as editor with AIP Publishing, USA.

Advancements in Nanoscale-Based Diagnostics/ Biosensing and Iot-Integrated Flexible Sensors for Water Treatment and HER/OER Applications

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INST Mohali, Department of Science and Technology, Govt. of India

The rapid advancements in 2-D materials and Microelectromechanical Systems (MEMS) and Nanoelectromechanical Systems (NEMS) have enabled the development of highly sensitive and miniaturized invasive/non-invasive biosensors for various environmental and biomedical applications. This talk will focus on the integration of nanoscale-based biosensing platforms with machine learning (ML) and the Internet of Things (IoT) to achieve real-time monitoring and detection of volatile organic compounds (VOCs) and other critical contaminants. The discussion will highlight the role of flexible sensors in environmental monitoring, particularly in water treatment applications, where precision sensing is crucial for ensuring water quality.

Additionally, the talk will explore the application of these advanced sensor technologies in the water treatment and enhancement of Hydrogen Evolution Reaction (HER) and Oxygen Evolution Reaction (OER) processes. The use of flexible, IoT-enabled sensor platforms allows for seamless integration with existing water treatment infrastructure, providing continuous monitoring and optimization of catalytic activities for sustainable energy applications. By leveraging machine learning algorithms, sensor data can be analyzed efficiently, enabling predictive maintenance and improved decision-making in industrial and environmental settings.

Overall, the convergence of MEMS/NEMS biosensing, ML, IoT, and flexible sensor technology holds immense potential for revolutionizing water treatment processes and advancing green hydrogen production. This talk will present recent advancements, challenges, and future perspectives in this rapidly evolving field, paving the way for innovative solutions in environmental sustainability and energy generation.

Dr. Sneha Singh

Assistant Professor, Birla Institute of Technology, Mesra, India

Dr. Sneha Singh is an Assistant Professor in the Department of Bioengineering at Birla Institute of Technology, Mesra, Ranchi, India. She received her Ph.D. in Nanobiotechnology from BIT Mesra in 2015, with a specialization in bio-nanofabrication. Her research focuses on nanotechnological innovations for biomedical applications, particularly the development of smart biomaterials—such as stimuli-responsive polymers, composites, and ceramics— functionalized with phytobioactives and nanomaterials for bone regeneration and wound healing.

In recognition of her outstanding scientific acumen and exceptional research contributions, Dr. Sneha Singh was honoured with the Royal Society of Chemistry (RSC)- **Young Scientist Award** at Indo-Taiwan International Conference BioHeal-2025. She has been recognized with the **Distinguished Research Contribution Award** (2023) by BIT Mesra and was selected for the **Japan-Asia Youth Exchange Program in Science** (2017). She serves on the Editorial Board of Scientific Reports and contributes as an expert reviewer for research grants at RIIMS, Ranchi. Dr. Singh maintains active collaborations with leading national and international research institutions with several research publications, books and patents to her credit.

Next-generation Smart Bioactive Bone Substitutes to Augment Bone Formation in Critical-Sized Bone Defect

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Bone is a dynamic connective tissue capable of self-repair, yet critical-sized defects arising from trauma, surgical resection, metabolic disorders, and infections exceed its intrinsic regenerative capacity. Current clinical gold-standard bone grafts face limitations of availability and donor-site morbidity, while many existing bone substitutes and metallic implants lack osteoinductivity, are bio-inactive, and are often non-resorbable. These limitations highlight the need for next-generation bone substitutes that are osteogenic, bioresorbable, osteopromotive, and economically feasible, particularly in countries such as India, where musculoskeletal disorders are prevalent and dependence on costly imported implants is high. This work focuses on developing bio-inspired, multifunctional bone substitutes through interdisciplinary tissue-engineering approaches and the integration of phytobioactives as osteoinductive cues. Plant-based compounds, long used in traditional medical systems and valued for their low toxicity and accessibility, offer a promising alternative to synthetic drugs, which often suffer from adverse effects, poor solubility, and limited bioavailability. Cissus quadrangularis (CQ), a plant commonly known as Hadjod or bone setter, and Resveratrol, one of the potent constituents of CQ, were selected as the osteoinductive cue and loaded into the nanocomposite delivery system to enhance its osteoinductivity with efficient neo-bone formation. An attempt has been made to stabilize the two isomeric forms of resveratrol (cis- and trans-) on the surface of GNPs to explore their osteoinductive potential further. Nanotechnological interventions provided new insights into rendering stability to the cis-isoform of resveratrol (cRes), which so far was considered unstable, and allowed us to explore its osteogenic potential for the first time. The study first stabilized the typically unstable cis-resveratrol (cRes) by biologically synthesizing cRes-capped gold nanoparticles (cRGNPs). These small, stable nanoparticles (25.6 ± 0.4 nm) maintained structural integrity in physiological environments and demonstrated hemocompatibility, high antioxidant capacity, and strong proliferative and pro-migratory effects in pre-osteoblasts. cRGNPs enhanced alkaline phosphatase (ALP) activity and significantly upregulated osteogenic markers including RUNX2, OPN, OCN, BMP, OPG, and Col1A, establishing cis-Resveratrol's osteoinductive potential for the first time. A parallel effort stabilized trans-resveratrol (tRes) on gold nanoparticles (tRGNPs; 22.1 ± 0.6 nm). These nanoparticles were cytocompatible and hemocompatible, enhancing ALP activity at low doses, increasing mineral deposition, and exhibiting robust anti-inflammatory and antioxidant activity. tRGNPs mitigated oxidative and hyperglycemic stress, increasing cell survival by 1.8-fold and improving migration and proliferation. The tRGNPs were incorporated into a porous polymer-nHAP composite scaffold to create a hybrid nano-scaffold with improved surface roughness, protein adsorption, mechanical properties, and cell–material interactions. In a 4-mm critical-sized tibial defect in Wistar rats, the nano-scaffold significantly enhanced mineralization and improved neo-bone formation, as confirmed by Micro-CT and histological analyses, without compromising pore architecture. A complementary study developed nano-cement ceramic bone substitutes loaded with CQ phytobioactives. These formulations enhanced osteogenesis (4-fold calcium deposition), increased cell migration, and improved mineral density and fractional bone volume in vivo. Overall, the work demonstrates that phyto-nanomaterials-functionalized bone substitutes offer superior biomimicry, multi-functionality, and regenerative potential compared to nonfunctionalized materials. The successful healing of critical-sized defects in rodent models establishes these multifunctional scaffolds as promising candidates for future clinical translation in orthopedic applications.

Prof. Tharamani C.N.

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Dr. Tharamani C. Nagaiah is an Associate Professor and Head of the Department of Chemistry at the Indian Institute of Technology (IIT) Ropar, India. She earned her Ph.D. from Bangalore University and completed postdoctoral fellowships at the University of Saskatchewan, Canada, and Ruhr University Bochum, Germany, with an Alexander von Humboldt Fellowship.

Dr. Nagaiah has received numerous awards, including the CRSI Bronze Medal (2023), the Silver Medal from the Society Chirantan Rasayan Sanstha (2023), the Electrochemical Society of India's Metrohm National Award (2023), and the A.V. Rama Rao Prize for Women Scientists (2024). She is a Fellow of the Royal Society of Chemistry (Leaders in the Field scheme) and the Indian Chemical Society. Dr. Nagaiah serves on the editorial boards of Sustainable Energy & Fuels (Royal Society of Chemistry), Electrocatalysis (Springer Nature), and Zeitschrift für anorganische und allgemeine Chemie (Wiley).

Her research focuses on the design and development of novel nanostructured materials for energy conversion and storage, including electrocatalysts for fuel cells and batteries, and electrochemical biosensors for environmental and biological applications. Her group employs advanced electrochemical, spectroscopic, and microscopic techniques to decipher catalyst properties and improve their performance.

Designing Greener Energy Conversion System for a Sustainable Future

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Global energy requirements are touching new meridians with the gradual advancement in the living standards and the day-by-day growing world population. This necessitates the exploration to seek for greener and sustainable energy reservoir systems which ought to be environmentally agreeable for such an intriguing purpose. Electrochemical energy conversion and storage devices offer some most alluring aptitudes for providing clean energy. To name a few of these include fuel cells, rechargeable metal

air/peroxide batteries and HCl/ H_2S electrolysis and likewise.[1,2] Oxygen being central to the processes in these devices, a lot of attention has been focused upon the study of oxygen chemistry in terms of oxygen reduction reaction (ORR) and also Hydrogen evolution reaction (HER) and thence to the melioration of the associated electrocatalysts. In the past decade research has depicted tremendous improvement towards the betterment of fuel cells/Zn based batteries/hydrogen production in its legions of shortcomings or corrigible features.[3,4] But still an infinite pursuit towards the exploration of effective, sturdy and energy efficient catalysts continues. The talk addresses,

• Several strategies pursued to replace noble-metal free electrocatalysts for ORR/HER. • Zn based batteries

• Visualization of local electrocatalytic activity by SECM.

Keywords: ORR, HER, electrocatalyst, Zn based batteries, SECM

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Dr. Bidyut Bikash Sarma

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Dr. Bidyut Bikash Sarma is an Assistant Professor (Catalysis & Fine Chemistry) at the Laboratoire de Chimie de Coordination (LCC-CNRS), Toulouse, France. He obtained his Ph.D. in Chemistry from the Weizmann Institute of Science, Israel in 2016. Afterward, he worked as an Alexander von Humboldt fellow at the department of heterogeneous catalysis at the Max-Planck-Institut für Kohlenforschung, Germany in the area of single atom catalyst. He then moved to Karlsruhe Institute of Technology (KIT), Germany, in 2020 as a senior research associate to work in the field of in-situ/operando spectroscopy. In 2023, he worked as Marie Skłodowska-Curie postdoctoral fellow at the University of Cambridge, UK, on the topic of photo-electro catalysis. His current research at CNRS advances in-situ/operando spectroscopic investigations of catalytic mechanisms, single-atom catalysis, and CO/CO_2 activation toward sustainable transformations.

Tracking the Dynamic Behavior of Molecular and Solid Catalysts with In-situ/Operando Spectroscopy

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Catalysts are highly dynamic in nature and tend to restructure under the reaction conditions.[1] As molecular catalysts undergo ligand association and dissociation in solution, solid catalysts tend to show severe restructuring when exposed to the reaction mixture both in solution as well as in the gas phase. Therefore, it is challenging to know whether the active site is the as-synthesized form of the catalyst or it turns to a very different species. In order to understand such dynamic behavior, in-situ/operando spectroscopy [1-2] is the key, which refers to spectroscopic investigations that are as close as possible to the experiments conducted in the laboratory.

In-situ/operando X-ray absorption/emission spectroscopy (XAS/XES) [2] and diffuse reflectance Fourier transform infrared spectroscopy (DRIFTS) [3],[4] are some of the convenient tools to track the dynamic behavior of catalyst. XAS/XES is a bulk technique that provides average information (oxidation state, symmetry, coordination of metals) of bulk and surface sites whereas DRIFT is surface sensitive and complementary to XAS. These aspects will be discussed by taking two examples; (a) electron transfer oxygen transfer reaction in homogeneous medium, and (b) CO/CO_2 hydrogenation over supported catalysts.

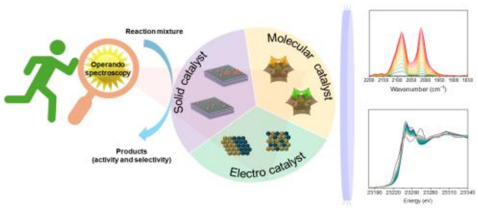

Figure 1. Schematics of in-situ/operando spectroscopy to understand the dynamic behavior of catalyst. On the right-hand side, examples of temperature dependent DRIFT and XAS spectra are shown.

This kind of investigation has been beneficial for both fundamental and industrial application and getting increasing demands in the recent years.

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Prof. Shaikh M. Mobin

**Professor, Center for Electric Vehicle and Intelligent Transport Systems (CEVITS),
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Dr. Shaikh accomplished his Bachelor's and Master's from Wilson College, University of Mumbai with major in Chemistry and PhD from Mumbai University in Chemistry. In 2012, he joined IIT Indore and presently working as a Professor in Department of Chemistry. He had developed his research group working in wide area of research including Optical and Electrochemical sensing, Solid-state structural reactivity, MOFs based Supercapacitors for energy storage, catalysis, sensing and bio -medical applications. Metal oxide nano-materials derived by employing metal complexes / MOFs as single source molecular precursors are used for catalyst in organic transformation and electrocatalyst for water splitting. Design and synthesis of greener c-dots and their wide range of bioimaging and biosensing applications and Lead-Free solar cells are major area of focus by the group. Moreover, the research group designs and synthesizes small molecules as cellular organelles target and cell imaging. He has also initiated a Startup "Bio-TAG" for Smart Bandages for Wound Healing.

Recently, he has taken over as Professor-In-Charge, Centre for Entrepreneurship Education and Development (CEED) and CEO (Part Time), Advanced Centre for Entrepreneurship (ACE) Foundation at IIT Indore.

Achievements

- Fellow of Royal Society of Chemistry (FRSC). 2021 and recipient of Material Research Society of India (MRSI) Medal 2021.
- Fellow of Maharashtra Academy of Sciences (FMASc). 2020 and Indian Chemical Society (FICS) 2021.
- Elected as member of Dalton Community Council, Royal Society of Chemistry UK, 2023.
- Dr Shaikh has been named as Golden Author by Dalton Transaction, Royal Society of Chemistry on occasion of 50th Volumes of Dalton Trans.
- Recognized among top 10 researchers in Chemistry in India by Careers 360 (Most Outstanding Researcher Award, 2018) with a h-index of 70, more than 550 publications with over 20,000 citations to date.
- Dr. Shaikh has been recognized as the Outstanding Reviewers for Dalton Transactions in 2018 (Dalton Trans., 2019, 48, 4758-4758).
- Dr. Shaikh has been listed amongst highly prolific authors by Current Science, (CURRENT SCIENCE, VOL. 109, NO. 5, 10 SEPTEMBER 2015) rivalling researchers from prestigious institutions such as CSIR-IICT, CSIR-NCL and IIT Kharagpur.

Multifunctional Carbon Dots-Based Photothermally Active Membranes for Solar-driven Interfacial Water Evaporation

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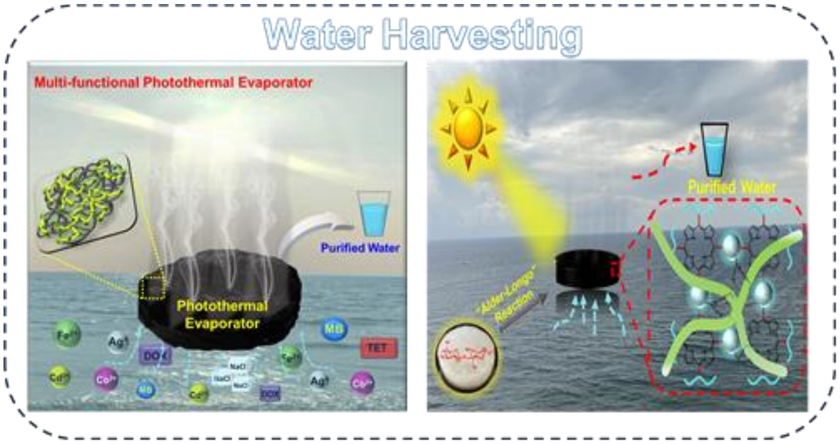
Solar-driven interfacial evaporation has emerged as a promising green technology for addressing global freshwater scarcity. Both lignin-derived and conjugated-framework carbon dots (CDs), when integrated into bacterial cellulose (BC), offer sustainable and high-performance photothermal platforms for clean water generation. In this combined work, two advanced CD-upgraded BC membranes were developed using distinct crosslinking approaches, i.e., (i) nitrogen-doped lignin-derived CDs covalently anchored onto BC (c-BC@N-LCD),[1] and (ii) a porphyrin-linked CDs organic network incorporated into BC via the Alder-Longo reaction (F-CD-p@BC).[2] The BC scaffold in both systems provides a highly porous, hydrophilic, and thermally insulating matrix that ensures rapid water transport and reduced heat loss, while the CD imparts broad-spectrum solar absorption, high photothermal conversion, and pollutant remediation ability. Both evaporators demonstrated excellent water evaporation rates under 1 sun irradiation (2.2-2.3 kg m^{-2} h^{-1}), alongside efficient desalination and pollutant removal. Long-term stability, salt resistance, and adaptability across diverse water sources highlight their durability for real-world applications. Collectively, these multifunctional CD-BC hybrid evaporators represent eco-friendly, scalable, and cost-effective platforms for sustainable solar desalination and wastewater purification, paving the way for advanced photothermal water treatment technologies.



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Prof. Gilles Alcaraz

Director of Research, CNRS, France

Prof. Gilles Alcaraz is currently a Research Director (Directeur de Recherche) at CNRS, France, working within the "Organometallics: Materials and Catalysis" team at the University of Rennes. He obtained his Ph.D. in 1995 from the University of Toulouse under the supervision of Dr. Guy Bertrand. He then pursued postdoctoral research at ETH Zürich (1995–1997) with Prof. Hansjörg Grützmacher, focusing on phosphiranes chemistry. In 1997, he joined as a CNRS fellow in Dr. Michel Vaultier's group at the University of Rennes 1. In 2006, he moved to the Laboratoire de Chimie de Coordination (Toulouse) to work in a new team called "Organometallic Architecture and Catalysis." He was promoted to Research Director at CNRS in 2011 and went back to Rennes in 2016. Dr. Alcaraz's research activity is mainly orientated towards organic and organometallic boron and main group chemistry (Si, P,...) aiming at developing new synthetic methodologies and to design molecular architectures displaying customized properties by taking advantage of the intrinsic properties of the incorporated heteroleum.

Monosubstituted Boranes Reactivity: from Molecules to Polymers

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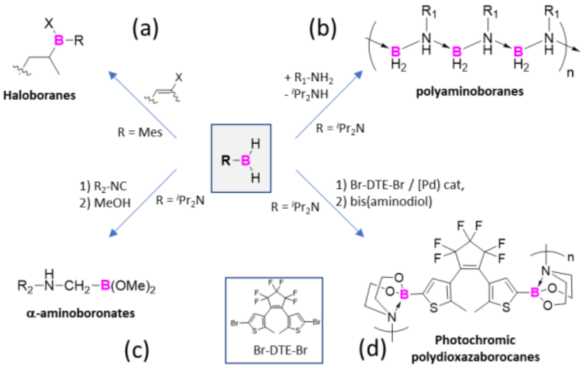
Monosubstituted boranes have received relatively little attention, despite the many advantages they offer as synthetic tools and building blocks for the development of new materials. We are constantly working to understand the mechanisms involved in the use of this family of compounds in order to optimize their use and the properties of the molecules and materials obtained. Through a few examples of reactivity and by adjusting their intrinsic Lewis acidity, we will illustrate the importance of this property in synthesis, for the production of molecules of perfectly defined size (**a**[1] & c), for the production of small photochromic oligomers based on dithienylethene units incorporating dioxazaborocane-type connectors (**d**),[2] and for the production of high-mass polymers (**b**).[3]



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Prof. Dr. Andreas Terfort

Professor, Faculty of Biochemistry, Chemistry, Pharmacy, Goethe University Frankfurt, Germany

Prof. Dr. Andreas Terfort currently serves as the Vice-Director at the Institute of Inorganic and Analytical Chemistry at Goethe University Frankfurt, where he also holds the Chair for Surface Chemistry. He studied Chemistry at the University of Göttingen and obtained his PhD from the University of Regensburg in 1994. Following his doctoral studies, he conducted postdoctoral research at Harvard University in the renowned group of Prof. George Whitesides. In 1996, he established his own research group at the University of Hamburg, where he later completed his Habilitation in 2003. He subsequently served as interim professor at the Universities of Bochum, Frankfurt, and Marburg. Since 2008, Andreas Terfort is full professor at the Institute of Inorganic and Analytical Chemistry at the Goethe University Frankfurt. Prof. Terfort's research focuses on surface chemistry, porous materials, electrochemistry, biochemistry, and molecular electronics, with particular emphasis on the synthesis, mechanisms, and applications of self-assembled monolayers. He has published over 130 peer-reviewed papers and has an h-index of 34, reflecting his significant contributions to the understanding and advancement of molecular and surface science.

Fully Biodegradable, Non-Toxic Corrosion Inhibitors from Green Starting Material

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Corrosion is one of the major cost factors during the operation of all kinds of machinery, what in 2013 caused a worldwide loss of US$ 2.5 trillion, equivalent to 3.4% of the global gross domestic product. Different strategies are used to limit corrosion, with many of them being based on coating the metal surfaces. Although the respective coating products help reducing the damages caused by corrosion, they often are toxic and damage the environment causing secondary costs and in the worst-case loss of lifes. Typical examples are benzotriazol, chromium(VI) and phosphate esters, which are cheap but highly toxic to all kind of organisms, including humans.

Based on our experiences with self-assembled monolayers (SAMs), we set out to develop new materials, which can cover and protect metal surfaces, but are biodegradable and non-toxic when emitted into the environment. The materials should be as versatile as possible, so that they can be used with different kinds of metals, which is a challenge as typically each metal has different affinities to different binding groups. We addressed this by using a multi-functional terminus, which can bind to several surface chemistries. In the talk, we will demonstrate that this approach also permits the use of water as deposition solvent, thus avoiding toxic or flammable solvents, which in turn results in a new and highly efficient deposition mechanism.

Prof. Shyam S. Pandey

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Kyushu Institute of Technology, Japan

Dr. Shyam S. Pandey is a Professor in the Graduate School of Life Science and Systems Engineering Department of Biological Functions Engineering, Kyushu Institute of Technology, Japan. He earned his Ph.D. in 1997 from the National Physical Laboratory, New Delhi, India. Dr. Pandey began his research career in Japan as a Fukuoka IST postdoctoral fellow (1998–2001) at the Kyushu Institute of Technology, working on photo-functional materials and devices. He later held prestigious JSPS and Knowledge Cluster research fellowships (2001–2007), focusing on soft actuators, artificial muscles, and protein biochips. His contributions to glucose biosensor technology earned him the National Technology Award (2005) from the National Research & Development Corporation, Government of India. Joining Kyushu Institute of Technology as an Assistant Professor in 2009, he established the Organic Photofunctional Materials and Devices Group in 2012. His research spans dye-sensitized and organic solar cells, organic electronics, biosensors, and quantum chemical modeling. Dr. Pandey has published more than 230 papers and holds about 30 patents across India, Japan, Europe, and the USA.

Photofunctional Near-Infrared Sensitive Materials for Biosensing and Bioimaging

Shyam S. Pandey

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The development of novel near-infrared (NIR) dyes has come a long way due to their remarkable photophysical properties, making them highly viable for a broad array of applications. Spectral and colour changes of NIR dyes resulting from their interaction with external stimuli are highly suitable for sensing applications. At the same time, the detection of these changes in the NIR region not only allows enhanced sensitivity for detection but also avoids the prior sample processing, which is highly desired for the development of point-of-care testing devices. Fluorescence-activated probes working on the principle of the fluorescence resonance energy transfer (FRET) bearing NIR-sensitive dyes have a great potential in the sensing and bio-imaging owing to their minimal autofluorescence in the diagnostic window wavelength region of 650 nm-900 nm. This requires very good fluorescent and quenching moieties with good spectral sensitivity in the NIR wavelength region. Recently, we have demonstrated a tremendous fluorescence (140 times) enhancement in the Amine-terminated symmetrical squaraine dyes, offering a great potential in designing FRET-based sensing probes. Utilizing NIR-dye-spacer-Peptide-spacer-NIR-dye based FRET systems, we have designed highly specific and enzyme-selective probes for various enzymes such as Trypsin, Chymotrypsin and Elastage in the detection range as low as 10 nM-50 nM. Specificity for a particular enzyme was imparted by judicious selection of amino acid sequences (typically tri-tetrapeptides) and spacer length in such a manner that the distance between the two terminal NIR dyes should remain within the Forster radius (typically 2 nm-5 nm). At the same time, we have demonstrated the suitability of our newly designed NIR probes not only for biosensing but also for bio-imaging. Our newly designed FRET-activable Elastage probe has demonstrated very good potential for bio-imaging. In the Mouse model, they have been demonstrated to be non-toxic and have very good results for in-vivo and in vitro samples containing Elastage hyperactivity. At the same time, we have also demonstrated a newly designed non-FRET-based and NIR-Sensitive Elastage probe, which efficiently and covalently binds with Neutrophil-Extracellular Traps developed in tissues after the inflammation. This probe is highly suitable for all of the bio-diagnostic tools, such as in-vivo, in-vitro, pathophysiological samples and flow cytometry. This probe has been demonstrated to be very efficient for the imaging of inflammatory diseases with the astonishing pixel quality of 90 nm/pixel, which is 50-100 times better in resolution compared to the commercially available Elastage probes, owing to its very low molecular weight, leading to deep tissue penetration.

Dr. Bulumoni Kalita

Assistant Professor, Department of Physics, Dibrugarh University, Assam, India

Dr. Bulumoni Kalita is an Assistant Professor in the Department of Physics at Dibrugarh University, Assam, India. She received her Ph.D. in Physics from *Tezpur University*, focusing on the structural and electronic properties of bare and supported palladium nanoclusters using density functional theory (DFT). She has completed M.Sc. in Physics from Gauhati University and B.Sc. in Physics from *Cotton College*. She has pursued the DST Nanoscience Postdoctoral Fellowship at the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore, where she conducted advanced DFT studies on nanomaterials. Dr. Kalita's research interests include computational and theoretical condensed matter physics**,** with emphasis on nanomaterials, metal and alloy clusters, hydrogen storage, gas sensing, and optoelectronic materials**.** She has been recognized with several fellowships and awards, including the Summer Research Fellowship from the Indian National Science Academy (2016) for hydrogen adsorption studies, UGC-BSR Research Start-Up Grant (2014), DST Postdoctoral Fellowship in Nanoscience & Technology (2011), CSIR Senior Research Fellowship (2009), and she represented India as a Chinese Language Expert in the Indian Youth Delegation to China (2009). She has published multiple research articles and actively supervises students in computational nanoscience and materials modelling.

Tuneable Electronic Properties of Magnesium Mono-Chalcogenide Monolayers

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Two-dimensional graphene-like materials have become a major area of research interest, particularly due to their tunable electronic, optical, and mechanical properties achieved through band-gap engineering [1,2]. In this work, we employ DFT-based methods to investigate the electronic properties of hexagonal MgX (111) (X = O, S, Se) monolayers (MLs) in both pristine and defective forms.

Our results indicate that the presence of an oxygen vacancy in MgO ML significantly reduces the band gap, making it a promising material for optoelectronic applications [3]. Both pristine and defective MgO MLs exhibit distinct gas-sensing characteristics. MgS and MgSe monolayers are found to be dynamically stable only under applied strain, maintaining stability across a wide range of strain conditions. The strain-induced modulation of the band gap results in considerable variations in the optoelectronic responses of these monolayers. Furthermore, all the magnesium chalcogenide monolayers demonstrate efficient thermoelectric behavior.

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Dr. Shirsendu Mitra

Assistant Professor, Department of Chemical, School of Energy Technology, PDEU, Gujarat, India

Dr. Shirsendu Mitra is working as an Assistant Professor in the Department of Chemical Engineering at PDEU. He completed his PhD at IIT Guwahati and carried out postdoctoral research at IIT Gandhinagar and the University of Birmingham. His research interests cover micro/-nano motors, soft matter, biosensors, plasmonics, and computational modelling. He has worked extensively on modelling micro/nanomotor dynamics under different force fields and has contributed to the development of biosensors and portable diagnostic devices. He is also working on machine learning based spectroscopic data analysis, medical image analysis, for sensing application.

He has published more than 35 articles in international peer reviewed journals, and have 3 granted patents in his name. He is an early career researcher, working on **plasmonic sensors for down syndrome detection and chromosomal abnormality detection**. He is also working on simulation of diverse plasmonic nanostructure targeting biomedical applications.

Numerical Study of Dispersion-Engineered Plasmonic Modes in Asymmetric Nanodimer Arrays

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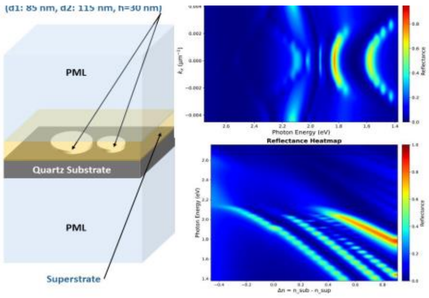

Electric field enhancement and guided tuning electric field distribution in plasmonic nanostructure are important for diverse applications that include biosensing, photo-voltaic, photocatalysis, nano-lasing, plasmonic filters, meta-materials, and more. Herein, we consider a system (refer to the Figure) comprises of array of asymmetric silver nano dimer periodically arranged onto a quartz substrate and the structures are covered with a thin polymer film. A multiscale numerical study has been carried out taking silver nanodimer arrays to explore the interplay of localized surface plasmon resonances (LSPRs), surface lattice resonances (SLRs), quasi–bound states in the continuum (qBICs), and guided resonances (GRs). By systematically varying the refractive index contrast between the substrate and superstrate from –0.46 to 0.94, we show that different resonance modes emerge depending on the optical environment. Our results reveal that low index contrast suppresses SLR formation, while higher contrast promotes the coexistence of LSPR, SLR, qBIC, and GR. Furthermore, angle-resolved reflectance spectra against photon energy demonstrate that tuning the incidence angle leads to the appearance and evolution of these resonances, including accidental GRs and symmetry - breaking induced qBICs. This study provides insight into tailoring plasmonic nanodimer lattices for controlled light–matter interactions and highlights their potential in biosensing and photonic device applications.

Keywords: Localised Surface Plasmon Resonance (LSPR), Surface Lattice Resonance (SLR), Guided Resonance (GR).

Dr. Abhijit Hazarika

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Dr. Abhijit Hazarika is a Senior Scientist in the Polymers and Functional Materials Department at CSIR-Indian Institute of Chemical Technology (CSIR-IICT), Hyderabad. His primary expertise lies in the synthesis, surface chemistry, and photophysics of colloidal inorganic semiconducting nanomaterials, with current research focused on renewable energy applications, including metal halide perovskite solar cells and colloidal quantum materials for optoelectronic applications.

Dr. Hazarika earned his Ph.D. from the Solid State and Structural Chemistry Unit, Indian Institute of Science, Bangalore under the supervision of Prof. D D Sarma. His doctoral research was focused on the synthesis and photophysical properties of manganese-doped colloidal semiconducting nanocrystals.

Following his Ph.D., Dr. Hazarika spent a couple of years as post-doctoral scholar at the University of Chicago in the group of Prof. Dmitri V Talapin, where he pioneered methods for the atomic precision synthesis of complex heterostructures in colloidal semiconducting nanomaterials. Then, he moved to the National Renewable Energy Laboratory (NREL), Golden, Colorado, to work as a post-doctoral researcher in the group of Dr. Joseph M. Luther, where he focused on metal halide perovskite quantum dot materials and solar cell devices. After spending nearly two years at NREL, Dr. Hazarika has joined CSIR-IICT in 2019 as a Scientist.

Hot Carrier Harvesting in Narrow Bandgap Metal Halide Perovskite Quantum Dots

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Effective extraction of hot carriers (HCs) in semiconductor absorbers is crucial to surpass the Shockley-Queisser (S-Q) limit of energy conversion efficiency in photovoltaic devices, as it enables the utilization of excess energy before thermalization. These HCs, generated by photons with energy higher than the bandgap of the absorber materials, interact with the lattices, and transfer the excess energy to phonons through carrier-phonon scattering on a timescale of a few hundred femtoseconds. For an optimal bandgap of 1.34 eV, the detailed balance limit of power conversion efficiency (PCE) of a photovoltaic device is ~33%.[1, 2] Theoretical studies indicate that if HCs are extracted before relaxing to the band edges, this efficiency could be increased to as high as ~66% under standard one sun illumination conditions.[3] Thus, the efficient extraction of HCs is critically important for advancing next-generation optoelectronic devices like Hot Carrier Solar Cells (HCSCs) to overcome the S-Q limit. However, there are several practical challenges, and various ways have been proposed to extract the HCs, such as choosing energy selective contacts for electron and hole extraction, selecting absorber materials with discrete energy levels (such as QDs) and with inherently long hot carrier lifetime, etc. Metal halide perovskites (MHPs) have intrinsically slow HC cooling as compared to other semiconductors due to their unique electronic structures.[4, 5] This advantageous property of MHPs can be leveraged by tethering suitable extractor materials to extract photoexcited hot charge carriers. By introducing quantization effects that induce energy discretization, such as in perovskite quantum dots (PQDs), HCs cooling process can further be slowed down. We demonstrate efficient room-temperature hot-hole extraction from CsPbI3 (CPI) PQDs, a narrow bandgap MHP composition, and which has been shown as good candidate for quantum dot solar cells,[6, 7] to energetically favorable 5,10,15,20-tetra(4-pyridyl) porphyrin (TPyP) molecules. Steady-state and time-resolved photoluminescence (PL) studies reveal dynamic PL quenching which is attributed to strong binding affinity of the TPyP molecules towards the CPI PQDs surface. Employing femtosecond time-resolved transient absorption spectroscopy, we show that there is significant lowering of hot-hole cooling time of CPI colloidal QDs from ~900 fs to ~700 fs in presence of TPyP. Further, we demonstrate that hot hole extraction is feasible in case of electronically coupled CPI QD solid films.

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Prof. Seena V.

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Dr. Seena V. received Ph.D. in Microelectronics, Department of Electrical Engineering with an "*Award for Excellence in Ph.D Thesis*" from IIT Bombay. She served as a faculty member at IIT Jodhpur and as R& D Consultant for NanoSniff Technologies Pvt. Ltd., SINE, IIT Bombay. She is currently a Professor in the Dept. of Avionics Institute of Space Science and Technology (IIST).

She has more than 15 years of research expertise in the field of Semiconductors-Microelectronics, Micro Electro Mechanical Sensor Systems (MEMS). She is a recipient of awards such as: NASI-Young Scientist Platinum Jubilee Award', The National Academy of Sciences, India (2012), 'SERB Women Excellence Award' from DST) (2015-2018), Kerala State Young Scientist Award, Govt. of Kerala (2017), 'IEI Young Engineer Award', (2014-2015), Gandhian Young Technological Innovation Award-2012 for "Ultra-sensitive, low cost Hand held Explosive Detector System" , and TCS fellowship for doctoral studies at IIT Bombay (2006-2011).

MEMS Nanomechanical Beam-Membrane Sensors for Gas Sensing

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MEMS sensors and devices have numerous applications spanning across consumer gadgets, automotive electronics, biomedical, space, industrial medical, defence etc. Silicon and derived materials have been the primary materials in nanoelectronics and hence in Microsystems (Micro Electro Mechanical Systems- MEMS) too. However, over the last decade, many classes of microsystems have been demonstrated using alternative materials like polymers and ceramics for reducing the cost of fabrication with inherent benefit of improved sensor performance. Among these MEMS devices, nanomechanical cantilevers (NMC) could find applications in the realization of many physical, chemical, and biological sensors. Introduction of structural modification to NMC sensor combined with agile transduction schemes provide ultra-sensitive nanomechanical sensors. Most of the commercially available MEMS sensors are based on passive transduction mechanisms such as capacitive or piezoresistive with inherent performance limitations. FET based active transduction schemes have the potential to overcome these limitations with ease in CMOS-MEMS integration as an additional merit. This talk would give a brief overview of our attempts towards indigenous development of MEMS Gas sensors using silicon and Polymer MEMS technologies.

Dr. Uday Narayan Maiti

Associate Professor, Department of Physics, IIT Guwahati

Dr. Uday Narayan Maiti completed his Ph.D. from Jadavpur University, Kolkata in 2010. He did his postdoctoral research (2011-to 2014) at the Korea Advanced Institute of Science and Technology (KAIST), South Korea. In 2014, he joined as an Assistant Professor in the Department of Physics, Indian Institute of Technology Guwahati, and now he is serving as an Associate Professor in the same department. He is the recipient of several prestigious awards like 'IBS Outstanding Researcher Award' awarded by the Institute of Basic Science, Republic of Korea, 'Young Scientist Award', awarded by the Materials Research Society of India (MRSI). He has over 80 publications in reputed international journals, including Nature Communications, Advanced Materials, Advanced Functional Materials, and Small, with citations of more than 5000, and six patents. His research interests include energy storage and conversion, strain sensors, and piezoresistive sensors based on electronically tuned 2D nanomaterials.

Electronic Synergy Between Support and Supported Nanoclusters to Get Hydrogen from Water

Uday Narayan Maiti,
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Precise manipulation of the size and shape of nanocrystals is known to display interesting electronic properties that can be used for a wide range of functional applications, including green hydrogen generation through electrolytic water splitting. The ultra-small metallic clusters need support to stabilize them against aggregation due to their high surface energy. Despite significant research in this area in recent times, two major questions still need to be answered, namely i) how to precisely control the size of the clusters and stabilize them, and ii) the nature of the electronic synergist between the support and the supported nano-clusters. In this talk, I shall discuss some of our recent results to address the aforementioned issues. First, I shall discuss the density functional theory approach to understand the catalytic process from a metal surface and how the electronic interaction between support and supported catalysts can play a significant role in electrolytic hydrogen generation. Next, I shall introduce some of our recent results on the development of precisely tuned nanoclusters of ruthenium, iridium, palladium, etc., supported on carbon nanomaterials. It will be elaborated on how the simple control of the graphitic order of the support can play a crucial role in the precise tunability of the nanoclusters. The role of the tuned electronic structure of the clusters and their interaction with the substrate in overcoming the energy uphill in the water splitting process will be discussed.

Prof. Manoj A G Namboothiry

Professor, Physics, IISER TVM, Kerala, India

Prof. Manoj A. G. Namboothiry is currently a professor at School of Physics, Indian Institute of Science Education and Research (IISER TVM), Thiruvananthapuram, Kerala. He did his PhD from JNCASR, Bangalore. He has long been associated with research in the area of photovoltaic devices involving organic, organic-inorganic hybrid materials and nanocomposites. His research work is focused on making devices such as solar cells, light emitting diodes, memory devices, field effect and phototransistors. Incorporation of plasmonic nanostructures, photocurrent spectroscopy, conducting polymer/biomolecular interface for biosensor applications are major areas of focus of his group. His current interests are in studying the photophysical and electrical properties of photovoltaic devices to understand how to improve the efficiency of the devices further.

Metal Nanoclusters for Interface Engineering and Enhanced Photovoltaic Performance in Organic Solar Cells

Prof Manoj A G Namboothiry
Professor, Physics, IISER TVM, Kerala, India

Novel and diverse strategies are constantly under development to boost the efficiency and stability of organic solar cells (OSCs). Interface engineering involving various functional materials is currently a research focus because of its promising potential to enhance the device performance of OSCs. Atomically precise metal nanoclusters, with tunable properties and notable dipole moments resulting from surface ligand interactions that provide stability to the nanoclusters, can be a promising candidate as an interfacial modifier. Copper nanoclusters (Cu NCs), synthesized by a one-pot synthesis method, are shown to exhibit dipole moment and can cause work function modification on a surface. The novel approach of introducing Cu NCs as an interfacial modifier between the electron transporting layer and the active layer has yielded improved photovoltaic performance in both fullerene and non-fullerene based OSCs (PTB7-Th:PC71BM and PM6:Y6 based OSCs). On insertion of Cu NCs, the best power conversion efficiency (PCE) obtained for the non-fullerene based system is 15.83% compared to that of 14.22% for the control device while the PCE enhanced from 7.79% to 8.62% for the fullerene based system. The interface modification has resulted in reduced recombination losses and charge accumulation at the interfaces. Impedance and transient measurements have also revealed efficient extraction of photogenerated charge carriers in Cu NC incorporated devices. The improved performance in Cu NC interfaced devices is attributed to work function modification, enabling reduced energy barrier and enhanced charge collection. Moreover, The Cu incorporated devices exhibit better operational stability under MPP tracking than the control device. This work demonstrates the potential of a new class of materials for interface modification and enhancing the performance of OSCs.

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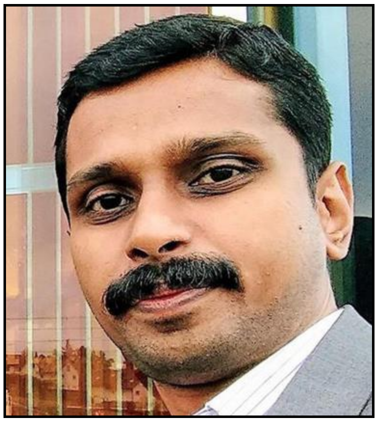
Dr. Suraj Soman

Senior Scientist, CSIR NIIST, Kerala, India



Dr. Suraj received his Ph.D. from Dublin City University, Ireland, and pursued postdoctoral research at Caltech and Michigan State University, USA. He joined CSIR-NIIST in 2014 and currently serves as a Senior Scientist at the Centre for Sustainable Energy Technologies (C-SET). His research focuses on the indigenous development of indoor solar cells using third-generation molecular light-harvesting technologies such as dye-sensitized and perovskite solar cells, aiming to replace one-time use primary batteries realizing self-powered gadgets. He established a state-of-the-art indigenous dye solar module manufacturing facility at CSIR-NIIST and has authored over 50 publications as corresponding author in this area. He has also developed innovative self-powered products integrating the indoor solar cells made indigenously at NIIST, which are undergoing field trials at various locations. Dr. Suraj is a recipient of several prestigious awards, including the Solar Challenge Award (2023), CSIR Young Scientist Award (2020), INSA Medal for Young Scientist (2020), Kerala State Young Scientist Award (2018) and BRICS Young Scientist Award (2017).

Pioneering Lab to Land Journey of Versatile Indoor Solar Cells

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In the realm of third-generation molecular light-harvesting technologies, our focus is on efficiently capturing and recycling diverse light sources, including indoor, artificial, ambient and diffused sunlight using custom engineered dye-sensitized solar cells (DSCs). DSCs stand out for their high efficiency, exceeding 40%, and their suitability for indoor use due to their lower cost, stability and ease of production.[1-2] Recent innovations, such as co-sensitization approach, introduction of dual-species copper based electrolytes replacing traditional iodide systems, use of bilayer $TiO2$-ZnO nanostructured electrodes, have addressed recombination issues, enhancing performance of these innovative nano photovoltaic devices under indoor and ambient lighting conditions.[1-4] These advancements not only improve efficiency but also promote environmentally friendly practices, positioning DSCs as a viable option to replace conventional one-time-use primary batteries for powering electronic devices, facilitating self-powered applications thereby reducing the carbon footprint.

My presentation will highlight CSIR-NIIST's pursuit of self-reliance in indoor light-harvesting technologies underscored by advancements in the domain of DSCs and the fascinating lab to land transition being realized developing indigenous scale-up production equipment's, innovative self-powered products over the past decade in my research lab at CSIR-NIIST. At NIIST, our endeavors extend to the custom design and optimization of these indoor light harvesters, utilizing tailor-made molecules, materials, and device architectures realizing efficiencies of 40% and above. By nurturing capabilities, CSIR-NIIST strives to establish a formidable position in the global indoor photovoltaic landscape, and propelling India towards self-sufficiency in emerging photovoltaic sectors.

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Prof. Ujjwal Pal

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Dr. Ujjwal Pal is a Senior Principal Scientist at CSIR-Indian Institute of Chemical Technology (CSIR-IICT) & Professor (AcSIR) India. He is affiliated with the Department of Energy and Environmental Engineering. He received his Bachelors (1997) at Burdwan University and Master's (2000) from the Jadavpur University, Kolkata, and Ph.D. degree from CSIR-IICT (2008). In the same year, he joined as a Postdoctoral Fellow in Mexico State University, USA, and Moffitt Cancer Centre Research Institute, USA. He started his independent research career in Artificial Photosynthesis and renewable energy research at CSIR-Central Mechanical Engineering Research Institute, India, in 2010 and later he moved to CSIR-IICT. Dr. Pal has authored 108 research publications including 80 articles on hydrogen energy research and one book chapter, four review articles with a major focus on photocatalytic hydrogen evolution reaction. Currently, he is the principal Investigator in the project entitled "2D Transition Metal layered Double Hydroxides: A cost -Effective Catalyst for Hydrogen Production by (Photo) Electrochemical water spitting" in "Hydrogen and fuel cell". His current research interest include design of Heterogenous semiconductor nanostructures, metal nanoparticles and sensitizing dyes for harvesting light energy and direct splitting of water into hydrogen and oxygen gas, photocatalytic CO_2 reduction and artificial photosynthesis molecular materials. His research integrates multidisciplinary research program in MOFs, semiconductor photocatalysis and energy conversion processes.

Single-Atom Catalysts for Solar-to-Fuel Conversion: Designing the Future Energy Landscape

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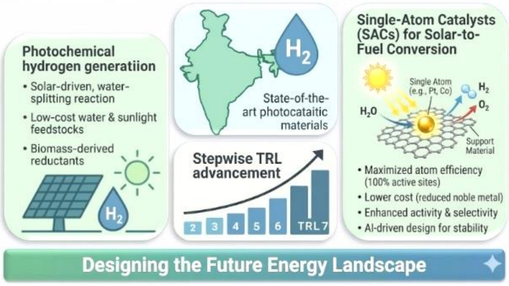
Single-atom catalysts (SACs) represent a new frontier in solar-to-fuel conversion, offering atomic-level precision to enhance light harvesting, accelerate charge transfer, and maximize catalytic efficiency. However, stabilizing uniformly dispersed active sites under operational conditions remains a persistent challenge. In this talk, we will discuss the rational design of advanced SAC systems that overcome these bottlenecks to deliver high-performance photocatalytic hydrogen and solar fuel production. Atomically dispersed Cu and Ni dual-metal sites anchored on graphitic carbon nitride (CuNi–g-C_3N_4) achieve a remarkable hydrogen evolution rate of 1275 μmol g^{-1} h^{-1} under visible light irradiation. DFT reveals that synergistic modulation of the electronic structure enhances proton adsorption and suppresses charge recombination. XAS, PL, and EIS confirm the atomic dispersion, accelerated charge separation, and interfacial charge transfer. The catalyst retains its activity over repeated cycles, ensuring practical stability. Furthermore, we report a facile strategy to anchor isolated Ru atoms into CNF(ZnO) nanocages, yielding 5.8 mmol g^{-1} h^{-1} H_2 production and 249 μmol g^{-1} CH_3OH from CO_2 reduction with high quantum efficiencies. These results underscore the promise of tailored single-atom and dual-atom catalysts as scalable solutions for solar-driven hydrogen and value-added fuel generation. This work advances atomic-level catalyst engineering toward a sustainable future energy landscape.

Keywords: Single-Atom Catalysts; Solar-to-Fuel Conversion; Photocatalytic H_2 Evolution; Charge Carrier Dynamics; CO_2 Reduction



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Dr. Saumya Ray Chaudhuri

Chief Scientist, CSIR - Institute of Microbial Technology, Chandigarh, India

Dr. Saumya Ray Chaudhuri is a Chief Scientist at the CSIR Institute of Microbial Technology (IMTech), Chandigarh, where he leads research on microbial genetics, physiology, and communication. He completed his first postdoctoral research in ribosomology, focusing on pseudouridine synthases of E. coli, at the University of Miami, and his second postdoctoral research in ocular gene therapy at the Texas Medical Center, Baylor College of Medicine, USA. He also served as a visiting fellow in 2008, at SMI, Karolinska Institute, Sweden. Before joining IMTech, and his research now focuses on understanding how microbes coordinate collective behavior and adapt to environmental challenges. His studies explore how metabolic states and gene regulation influence microbial communities and pathogenicity, contributing to broader insights in microbiome research and infection control. Dr. Chaudhuri has published widely on topics such as quorum-sensing regulation, cross-feeding among bacterial species, and natural genetic variants affecting transcriptional networks.

Probiotic-Mediated Control of Diarrheal Diseases: An Area Requiring Support From The "Nanoworld"

Dr. Saumya Ray Chaudhuri
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Diarrheal disease is a deadly condition and the third leading cause of death among children. Clinically, there are three types of diarrhoea: acute, persistent, and chronic. Among diarrheal diseases, cholera is one of the most lethal, caused by Vibrio cholerae, a bacterium in the gamma proteobacteria family. Decades of research have uncovered many interesting facts about the organism's biology and the overall pathophysiology of the disease. Despite traditional treatment methods, cholera remains a major problem and is responsible for 21,000 to 143,000 deaths worldwide each year, according to the WHO. Therefore, the current situation demands alternative strategies to combat the pathogen. One emerging area to control bacterial growth and pathogenesis by gut commensals. In this connection, our group has demonstrated that a combination of glucose and probiotic Escherichia coli strains can tackle bacterial growth and pathogenesis. Other than cholera, we have also demonstrated the effectiveness of probiotic E. coli-mediated control of adherent invasive E. coli (AIEC), a bacterium linked with IBD and chronic diarrhoea in a zebra fish infection model. The next level of investigation will focus on the development of nanocarrier mediated effective delivery of a pre-probiotic formulation. Our research further suggests that cell free supernatants of E. coli enriched with acidic metabolites restrict the growth of Vibrio cholerae. Therefore, CFS-nanoparticle delivery of acidic metabolites to control diarrheal infection should also be explored as an alternative approach to control cholera. Finally, the efficacy and safety of nano formulations should be examined in the context of the gut microbiota and microbial community.

Dr. Sweta Raghavan

Head of Innovation, Strategy & Gov Affairs (India & South Asia)
Royal Society of Chemistry

Dr. Sweta Raghavan is the Head of Innovation, Strategy and Government Affairs (India & South Asia) at the Royal Society of Chemistry. She specialises in intervention design & implementation sciences, and has worked with several governments, life sciences companies, startups, and academic institutions for nearly 10 years. Prior to her current role, Sweta served as a Senior Advisor on Science & Innovation with the Science & Innovation Network at the UK's Government's Foreign & Commonwealth Office. She is credited with effectuating evidence-based policy-decisions and innovations for societal challenges such as healthcare, climate change and sustainable development, as well as in promoting STEM education. Consequently, she has been appointed to serve as Advisor to the Ministry of Health & Family Welfare in Karnataka and as Professor of Practice at St. Joseph's University.

Dr. Sweta received her PhD from King's College London in Cell Biology. Through Scientists & Co., a social initiative she founded in 2016, Sweta promotes STEM education among disadvantaged students and health literacy campaigns for underprivileged families. Over 12,000 disadvantaged students have benefitted from their educational programmes. Some of the organisations popular campaigns include Pandemic Preparedness delivered to 1080 families dwelling in slums, Menstrual Health to 6000+ girls from vulnerable and marginalised & Health Management in Conflict Settings to internally displaced people in violence-torn Manipur.

Sweta is the recipient of numerous international awards, has been published in leading news outlets and invited as an expert speaker at prestigious forums.

Nano-Solutions for a Warming Planet: A Policymaker's Call to Rethink Health Technologies

Dr. Sweta Raghavan
Headvive of Innovation, Strategy & Gov Affairs (India & South Asia)
Royal Society of Chemistry

Climate change is accelerating antimicrobial resistance (AMR) in ways our health systems are not prepared to manage. As a policymaker working in AMR and climate-linked health threats, I increasingly see a gap between the tools we urgently need and the technologies currently reaching the field. Rising temperatures, extreme rainfall, and stressed agricultural systems are creating new reservoirs of resistant pathogens, yet our diagnostics, surveillance networks, and environmental monitoring remain slow, centralized, and inaccessible to the regions most vulnerable to climate shocks.

This talk is an invitation to the nano-science community to engage directly with these frontline challenges. I will outline where nanotechnology such as rapid point-of-care sensors, nano-enabled environmental surveillance, catalytic materials for antibiotic residue removal, and rugged diagnostic platforms, can transform our preparedness. But more importantly, I will describe the design constraints that matter to policymakers: ultra-low cost, robustness in harsh climates, minimal instrumentation, and scalability within public health systems.

To address climate-driven AMR, we need innovations built with deployment in mind, not only scientific novelty. My goal is to bridge the science–policy divide and highlight how nano-enabled solutions can become indispensable public health tools in the climate era.

Dr. Rajiv K. Kar

Assistant Professor, Centre for Nanotechnology
Jyoti and Bhupat Mehta School of Health Sciences and Technology

Dr. Rajiv K. Kar, has worked on application-oriented biomolecular systems using computational and experimental spectroscopy. During his Ph.D., he designed anti-freeze peptides, which now have proven utility in medical cryopreservation. Other areas of his work include antimicrobial, anti-amyloid peptides, hybrid quantum materials, graphene and molecularly imprinted polymers-based applications in sensors. During his post-doctoral training, he specifically focused on advanced simulations, quantum mechanics, electronic structures, and data science methods. His current objective is to understand the fundamental basis for designing optogenetics tools and translate them into suitable medical devices. His expertise in ab initio calculations and their quantitative correlation with experimental measurements are reflective with more than 60 publications in journals of high repute.

The Biomedical Utility of Riboflavin

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Riboflavin (vitamin B2), features an isoalloxazine ring core, whose electronic structure enables a π-π* transitions. This yields a unique fluorescence property and redox activity, critical for metabolic functions in biosystem. In the field of optogenetics, the photo-excitable state of flavin-based proteins like Light-Oxygen-Voltage domains, allows precise control over cellular processes in synthetic biology [1]. Furthermore, in context of biomedical applications, riboflavin functions as an effective cross-linking agent and drive nanomaterial-enhanced biosensors for diagnostics. This talk will highlight key findings that shed light on electronic structure of riboflavin within biomacromolecular system. Inspired from these properties, the role of riboflavin in tuning dispersion properties and inducing surface interactions of graphene-based materials will also be discussed [2]. The incorporation of riboflavin into these carbonaceous materials like graphene oxide not only improves colloidal stability but also improved their physico-mechanical properties and bioimaging suitability. We validated these findings through antimicrobial assays and cell-line (HeLa and HEK) based assays for improved cellular uptake and cytocompatibility [3]. Further, these processes are helpful in preparing nanocomposites made from chitosan and riboflavin-supplemented carbonaceous materials, presenting newer possibilities for wound healing applications [4]. Overall, the talk will discuss the journey of riboflavin's utility from electronic structure theory to its role in colloidal dispersion and wound healing process.

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Dr. Erwin Fuhrer

Assistant Professor
Jyoti and Bhupat Mehta School of Health Sciences and Technology, IIT Guwahati, Assam, India

Dr. Erwin Fuhrer received his PhD in 2019 from the Karlsruhe Institute of Technology, Germany, and is currently an Assistant Professor at the Jyoti and Bhupat Mehta School of Health Sciences and Technology, IIT Guwahati. His research focuses on the development of low-field MRI devices, including magnet design, gradient and RF hardware, and adaptive signal acquisition.

He also investigates nanomaterial-based contrast agents for improving relaxation efficiency at very low magnetic fields. The work is conducted in collaboration with his research group and colleagues at IIT Guwahati

Nanotechnology in Low-Field MRI

Dr. Erwin Fuhrer
Assistant Professor
Jyoti and Bhupat Mehta School of Health Sciences and Technology, IIT Guwahati

MRI at very low magnetic fields, which means below 0.1 T, is an emerging medical diagnostic modality and is a promising possible route towards lighter and far more affordable scanners that could be used directly at the point of care. However, the main limitation at such weak fields is that the image contrast becomes weak because polarization is low and relaxation changes unfavorably. Nanotechnology offers a solution to tackle this problem by introducing new contrast agents that are tailored to work efficiently under these conditions. Superparamagnetic iron oxide nanoparticles (SPIONs) are of particular interest, as their relaxivities can be tuned directly by changing the particle size, surface coating, and aggregation. These factors determine the local magnetic field distortion and how they affect T_1 relaxation. This presentation will give a small overview of the MRI technology and the integration of nanotechnology to prepare suitable CAs. We discuss the present direction of low-field MRI development and show early results from our SPIONs made for sub-0.1 T operation.

Dr. Krishna Kanti Dey

Associate Professor, Department of Physics, IIT Gandhinagar, Gujarat, India

Dr. Krishna Kanti Dey is currently serving as Associate Professor and Associate Dean (Postgraduate Studies) in the Department of Physics at the Indian Institute of Technology Gandhinagar, India. He earned his B.Sc. in Physics from Gauhati University in 2002, followed by an M.Sc. (2004) and PhD (2011) in Physics and Nanotechnology from the Indian Institute of Technology Guwahati. He completed his postdoctoral research at The Pennsylvania State University, USA (2012–2016), where he worked extensively on enzyme-powered micromotors and active colloidal systems.

At IIT Gandhinagar, Dr. Dey leads the Laboratory of Soft and Living Matter, focusing on active matter physics, colloidal dynamics, enzyme-driven micromotors, and microfluidic systems for biological and technological applications. His research explores collective motion, non-equilibrium dynamics, and transport mechanisms in synthetic and biological active systems. Among his honors and Fellowships are: Visiting Professor, Centre for Soft and Living Matter, Institute of Basic Research, Ulsan, Republic of Korea (2018–Present) and Excellence-in-Research Fellowship, Indian Institute of Technology Gandhinagar (2016–2019). He has published over 80 research papers with more than 2,500 citations and an h-index of 26.

Enzyme-Regulated Non-Thermal Fluctuations Enhance Ligand Diffusion And Receptor-Mediated Endocytosis

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Active enzymes, while catalyzing chemical reactions, generate significant mechanical fluctuations that can influence the dynamics of their surroundings. [1-3] This phenomenon opens new avenues for controlling mass transport in complex, dynamically inhomogeneous environments through localized chemical activity. We present experimental results demonstrating how such non-thermal fluctuations modulate the uptake of transferrin molecules in retinal pigment epithelial cells via clathrin-mediated endocytosis. In the presence of enzyme catalysis within the extracellular environment, we observed significant enhancement in the intracellular transport of fluorophore-tagged transferrin. [4] Fluorescence correlation spectroscopy and total internal reflection fluorescence microscopy measurements revealed a substantial increase in transferrin diffusivity in the presence of active fluctuations. These observations suggest that enzyme-substrate reactions in the extracellular environment can induce long-range mechanical effects, facilitating more efficient intracellular delivery of materials compared to passive diffusion alone. These findings have important implications for developing improved therapeutic strategies by overcoming the limitations of slow molecular transport in complex biological systems.

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Prof. Rupa Mukhopadhyay

Senior Professor, School of Biological Sciences, IACS, Kolkata, West Bengal, India

Prof. Rupa Mukhopadhyay is a Senior Professor in the School of Biological Sciences at the Indian Association for the Cultivation of Science (IACS), Kolkata. Prof. Mukhopadhyay received B.Sc. from Presidency College (Calcutta University) and M.Sc. from IIT Kanpur. She has received the Doctoral degree under the supervision of Professor H. Allen O. Hill, FRS, at the University of Oxford, United Kingdom. After a brief sojourn at IIT Guwahati and IIT Kanpur, she moved to the Interdisciplinary Nanoscience Centre (iNANO) in Denmark and worked under the mentorship of Professor Flemming Besenbacher. She joined IACS as an Assistant Professor in 2007, and at present, she is serving as a Senior Professor. Her research interest is the combined use of bio- and nano-systems to engineer surfaces for nanoscale biosensing (for PCR-independent, fluorescent label-free sensing), bioelectronics (for sustainable development) and single molecule level structural biology. This involves explorations with alternative nucleic acids as sensing probes, protein modification and assembly, and force-based microscopy/spectroscopy at single molecule level. Inducted as Fellow of the West Bengal Academy of Science & Technology (WAST) in the Biochemistry and Biophysics section in 2023. Prof. Mukhopadhyay has been recognized as an Exceptional Collaborator of American Chemical Society (ACS) and for her ongoing contributions to world class chemistry via ACS journals in 2015. In 2013, she was inducted as a Fellow of the Indian Chemical Society and received the Indira Gandhi Priyadarshini Award from the All-India National Unity Conference the same year. Her work on ‘LNA-based DNA detection’ was covered by Indo-Asian News Service (IANS) in Zee News and Times of India in December 2012, and in 'India Reviews' by the Indian Embassy at Washington DC in January 2013. She is also honoured with the Felix Scholarship Award of the year 1996 for overall performances in all the public examinations from the School Final to the M.Sc. level, which enables one to pursue for D.Phil. degree from the University of Oxford, England. Professor Prafulla Chandra Ray Centenary Award of the year 1994 for outstanding performance in all College Examinations in West Bengal. Other awards include: Cunninghum Memorial Award of the year 1994 for outstanding performance in B. Sc examination in Calcutta University, Professor P. C. Rakshit Memorial award of the year 1994 for outstanding performance in B. Sc., Professor Prafulla Chandra Ray award of 1993 for outstanding performance in B. Sc., Sudip Shome Memorial award of the year 1993 for outstanding performance in B. Sc., Presidency College (Calcutta) Alumni Association award of the year 1992 for showing strong desire in pursuing career in chemical science., Dr. Ashok Sarkar Memorial Award of the year 1989 for outstanding performance in secondary examination in West Bengal, Dr. Bidhan Chandra Roy Memorial Award of the year 1989 for outstanding performance in secondary examination in West Bengal and National Scholarship Awards of the years 1989 and 1991 for outstanding performances in secondary and higher secondary examinations.

Nanomechanical Sensing of Disease-Linked Gene Mutations: A Molecularly Resolved Detection Approach Using LNA Capture Film

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Development of robust, reliable, precise and sensitive strategies for nucleic acid analysis is of consistent research efforts worldwide, since analysis of nucleic acid interactions play a pivotal role in genomics based medical diagnostics. Different types of nucleic acid analysis platforms are in practice, most of which depend on fluorescence or other types of labeling though, and are time-consuming. Where direct readout is possible, so that the labeling steps can be eliminated from the protocol, the total analysis time can be reduced. One such possibility can be pursued using atomic force microscopy (AFM) cantilever based nanomechanical sensing approach. Though the DNA-based nucleic acid detection has found wide applicability in microscale and nanoscale detection of nucleic acid sequences, the development of improved sensing assay for producing fast, accurate, reproducible and valid data is still sought for. Especially, reduced bioactivity due to potential DNA-surface interactions through relatively exposed nucleobases, and chances of DNA nuclease-induced degradation of the DNA probes, point to the requirement of more robust and reliable alternatives. Here, it will be exemplified how the synthetic xeno nucleic acid (XNA) capture probes like locked nucleic acid (LNA) [1-6] having different sugar backbone can be integrated in the nanomechanical sensing platform in form of a well-organized nanoscale film (Fig. 1) with effectively oriented capture probes for improved molecularly resolved nucleic acid recognition, at the level of single base mismatch discrimination [1-6]. We have tested this generic assay in detection of gene mutations of the multiple drug-resistant Mycobacterium Tuberculosis [6] and have achieved some success in detection of the EGFR gene mutations that are linked to non-small cell lung cancer.

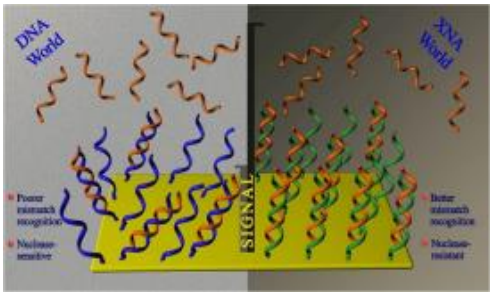

Figure 1. Improved nucleic acid sensing performance of the LNA capture film over DNA film.

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Dr. Ekambaram Balaraman is an Associate Professor in the Department of Chemistry at the Indian Institute of Science Education and Research (IISER) Tirupati. He earned his B.Sc. (1997-2000) and M.Sc. (2000-2002) from the University of Madras, and his Ph.D. from the University of Hyderabad (2002-2008). After post-doctoral work at the Weizmann Institute of Science, he served as Assistant Professor at SRM University, Senior Scientist at CSIR-NCL, Pune, before joining IISER Tirupati in December 2018. His research focuses on organometallics and sustainable catalysis, particularly the design of catalytic materials for hydrogen generation, acceptorless dehydrogenative coupling, conversion of CO_2 to value-added chemicals, Ziegler-Natta catalysis, and sustainable chemical synthesis. He has over 139 publications, more than 9000 citations, and an h-index of ~51. His selected recent works include “Sustainable and Affordable Synthesis of (Deuterated) N-Methyl/Ethyl Amines from Nitroarenes” (Organic Letters, 2022) and “Tandem Acceptorless Dehydrogenative Coupling–Decyanation under Nickel Catalysis” (J. Org. Chem., 2021). His honours include the SwarnaJayanti Fellowship (2020), CRSI Bronze Medal (2020), Thieme Journal Award (2020), APA Young Scientist (2019), AV Rama Rao Young Scientist Award (2018), and Fellowship of the Royal Society of Chemistry.

Transition Metal-Supported N-Doped Carbons: Catalytic Advances Beyond Electrochemical Applications

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Nanocatalysis serves as a vital bridge between efficient homogeneous and reusable heterogeneous catalytic systems, delivering significant advancements across catalytic science. Transition-metal-anchored N-doped carbon materials, in particular, hold tremendous potential to transform the nanocatalyst industry by enabling sustainable applications and long-term growth. Reusable nanocatalysts based on transition-metal-anchored carbon supports are of growing interest due to their broad utility in photo-, electro-, and thermocatalysis. These materials exhibit enhanced catalytic activity for diverse chemical transformations owing to their unique structural attributes. Their high surface area and porous architecture enable superior metal dispersion, resulting in a greater number of accessible active sites. In addition, carbon-based supports offer excellent thermal stability under inert atmospheres, resistance to acidic and basic environments, facile recoverability, and significantly lower cost compared to traditional metal oxide supports such as silica or alumina. Metal species anchored on carbon surfaces can also be readily reduced, generating the catalytically active phase required for various molecular transformations. In this talk, the focus will be on N-graphitized graphene–supported transition-metal nanoparticles for dehydrogenation and related transformations.

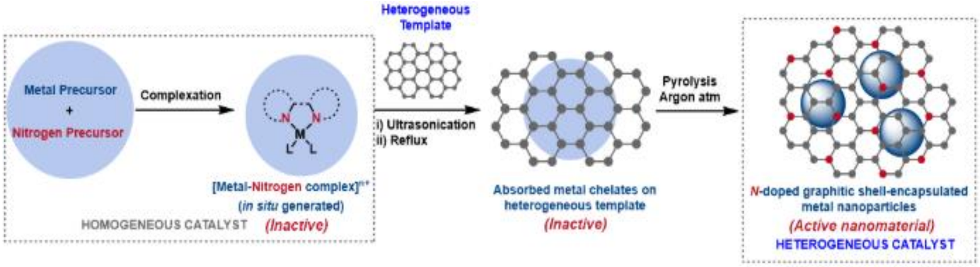

Figure 1. Synthesis of N-Doped Metal-nanocatalysts.

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Dr. Praveen Kumar

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Dr Praveen Kumar is working as an Associate Professor at Plaksha. Prior to joining Plaksha, he worked as an Associate Professor at Indian Association for the Cultivation of Science, Kolkata. Dr Kumar also holds collaborative positions with multiple prestigious institutions globally. His research portfolio centers on advanced materials, encompassing III-V semiconductors, oxides, two-dimensional (2D) materials, and MXenes, with a primary focus on their applications in energy harvesting and conversion technologies. Dr Kumar pursued postdoctoral research as a Marie Curie Fellow at the Universidad Politécnica de Madrid, Spain, and as a postdoctoral fellow at Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru, India. He holds a PhD in Physics from the Indian Institute of Technology, Delhi, and an MSc in Physics from the University of Rajasthan, where he received a Gold Medal for academic excellence. Dr Kumar's distinguished career includes prestigious recognitions: New Generation Ideation Award 2024 (HPCL), Fulbright-Nehru Professional Excellence Fellowship 2023, Materials Research Society of India Medal 2021, Marie Curie Alumni Association Societal Impact Award 2019, Department of Atomic Energy Young Achiever Award 2019, BRICS Young Scientist Award 2017, INSPIRE Faculty Award 2014, and Marie Curie Fellowship 2012. Dr Kumar is leading pioneering efforts in the National Quantum Mission, concentrating on the development of hexagonal boron nitride (h-BN) and transition metal dichalcogenides (TMDCs) using molecular beam epitaxy (MBE). His research focuses on advancing single photon emitters (SPE) and single photon avalanche detectors (SPAD) for operation in the visible spectrum at room temperature. Dr Kumar has made significant contributions to the scientific community, evidenced by his authorship of 102 peer-reviewed publications, four patents, and contributions to 11 books or book chapters. His global impact is further demonstrated through delivering over 85 invited talks worldwide. He holds memberships in the Global Young Academy (GYA), the National Academy of Sciences India (NASI), and the Indian National Young Academy of Sciences (INYAS). Additionally, he serves on the editorial boards of Materials Letters (Elsevier), Materials Letters X (Elsevier), and Nanotechnology (IOP Publishing), while led the Career Development Working Group and the Indian Chapter of the Marie Curie Alumni Association.

Harnessing Spin-Dependent Catalysis and Self-Powered Photodetection in 2D Materials

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In this talk, I will present my research on advancing spin-dependent catalysis through engineered two-dimensional (2D) materials, with a focus on fundamental mechanisms and their potential for transformative applications. I will first discuss the role of spin-orbit coupling in Janus MoSSe, where an external magnetic field modulates its catalytic activity, enabling spin-dependent electrocatalysis. By integrating delaminated Mo_2C-Tx MXene with MoSSe/SiNW photocathodes, we achieve a 52% enhancement in photocurrent under a 0.4 T field at zero bias, demonstrating a novel route for efficient photoelectrochemical (PEC) water splitting. Additionally, I will highlight magnetically induced hydrogen evolution in quasi-2D $MnSe_2$, showcasing the potential of asymmetric 2D materials for next-generation catalytic systems.

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Dr. Swati Sharma

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Indian Institute of Technology, Mandi, India

Dr. Swati Sharma is an Assistant Professor at the Indian Institute of Technology (IIT) Mandi in the School of Mechanical and Materials Engineering. Before joining IIT Mandi in 2019, she worked as a Scientist at the Karlsruhe Institute of Technology and the University of Freiburg in Germany for over five years. She obtained her M.S./ Ph.D. from the University of California Irvine, USA in 2013. Prior to this, she spent one year at UNIST, South Korea as a Researcher. She completed her B.E. (Hons.) in Chemical Engineering from BITS, Pilani, India in 2004 and worked as a Research Scientist for over 4 years at Ranbaxy Research Laboratories, Gurgaon. Her current research is focused on carbon materials and manufacturing for energy and sensing applications. She is best known for proposing a new microstructural model for non-graphitizing carbons, confirming the presence of fullerenes in this class of carbon materials. Her research contributions have been published in several reputed journals, patents and books. She is the sole author of a textbook titled "Carbon for Micro and Nano Devices" published by DeGruyter, Germany. She has also designed and taught a NPTEL course "Carbon Materials and Manufacturing" which has been offered four times and is currently running. She is a council member of the Indian Carbon Society and an active advisory board member for various events related to carbon in India and Europe.

Advances in Chemical Vapor Deposition of Carbon: From Nanomaterials to Hybrid Nano-Functional Bio-Carbon

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Since its inception in the 1960s, Chemical Vapor Deposition (CVD) has played a central role in the synthesis of carbon materials [1]. The fundamental principle of CVD involves the pyrolysis of a hydrocarbon precursor, such as methane, leading to the deposition of carbon from the vapor phase. One of the earliest carbon materials produced by this technique was Highly Oriented Pyrolytic Graphite (HOPG), which entailed hot-pressing of carbon sheets [2]. The process was later adapted as Chemical Vapor Infiltration (CVI), a related approach still used today for densifying various carbon-based composites. Over the past two decades, CVD has become a key method for producing graphene, carbon nanotubes (CNTs), and other carbon filaments, with each material requiring distinct catalysts and process parameters. Although CVD enables large-scale synthesis of these nanostructures, a trade-off exists between quantity and quality; increased production rates often introduce structural defects that limit their application in high-precision electronics or other advanced technologies [3]. Despite its wide adoption and the proliferation of commercial CVD systems in both academia and industry, the economic sustainability of conventional carbon nanomaterial production remains a challenge due to high operating costs and limited market value. A promising new direction is to apply CVD to the development of novel carbon materials with unconventional applications. One such area involves the fabrication of carbon scaffolds for biological and environmental systems, particularly for large-scale cell and microbial culture in soil-related studies. Unlike porous biochars, which may contain harmful impurities, ultrapure carbon from CVD offers a chemically clean alternative for soil quality enhancement and microbial growth support. To reduce production costs and improve scalability, carbon-on-carbon deposition can be achieved by using biomass-derived carbon substrates under inert conditions during the one-step CVD process itself. In our research group, we have recently developed a hybrid nano-functional bio-carbon, produced by combining pine-needle-derived carbon with CVD-grown nanostructures. These next-generation materials exhibit multifunctional properties, making them promising not only for environmental remediation and soil improvement, but also for energy storage applications, such as battery anodes. This presentation will provide an overview of carbon-CVD process, highlight emerging research directions, and showcase recent results from our group on CVD-assisted hybrid bio-carbons as sustainable and versatile materials for future technologies.

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Dr. Mitradip Bhattacharjee

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Indian Institute of Science Education and Research (IISER) Bhopal, India

Mitradip Bhattacharjee (Senior Member, IEEE) is an Assistant Professor with the Electrical Engineering and Computer Science Department, Indian Institute of Science Education and Research (IISER) Bhopal, India, where he is leading the i-Lab Research Group. His research interests include electronic sensors and systems, biomedical engineering, bioelectronics, flexible/printed and wearable electronics, soft robotics, intelligent systems, IoT, micro/nanoelectronics, and reconfigurable sensing antennas. He has authored more than 100 research articles in reputed journals/conferences and filed more than 27 national/international patents. He has also authored several books/book chapters to date. He is the recipient of several awards and honours, such as the INAE Young Engineer Award in 2025, INAE Young Associate 2025, Young Professional Award in 2025 by the IEEE Sensors Council USA, the Visvesvaraya YFR Fellowship by MeitY, Govt. of India in 2025, the Marie-Curie Seal of Excellence Award by the European Commission in 2019, among others. He served as the chair of the IEEE Sensors Council Young Professionals in 2022. He is serving as a guest editor and associate editor in various journals and magazines such as IEEE IoT Journal, npj Flexible Electronics, IEEE Sensors Letters, IEEE Sensors Alert, IEEE JFLEX, among others. He is also serving as the web Editor-in-Chief of the IEEE Sensors Council. Mitradip has been elected as the Member-at-Large of the IEEE Sensors Council in 2025.

Electronics That Live, Work, and Disappear: Shaping a Sustainable and Connected Future through Wearable and Disposable Systems

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The emerging field of wearable and disposable electronics is redefining how we design, deploy, and interact with electronic systems across robotics and biomedicine. By integrating soft, flexible, and biodegradable materials with advanced sensing, communication, and energy-harvesting technologies, we can now create devices that seamlessly conform to dynamic surfaces—whether human skin, robotic structures, healthcare devices, or biological tissues—and perform complex tasks before safely degrading or recycling. This talk will explore the design principles, materials innovations, and fabrication strategies of various disposable and wearable sensors for biosensing, healthcare, and robotic automation. A selection of our group's recent research efforts in this direction will be discussed, illustrating how interdisciplinary advances in materials science, device engineering, and system integration are driving the development of next-generation wearable and disposable electronics. Finally, the talk will discuss key challenges and outline future directions toward a truly circular and adaptive electronics ecosystem.

Dr. Saptarshi Ghosh

Senior Post-Doctoral Researcher, Hebrew University of Jerusalem, Israel

Saptarshi Ghosh did his B. Tech & M. Tech in Instrumentation and Electronics Engineering and then received his PhD from the Department of Instrumentation and Electronics Engineering at the Jadavpur University in 2017, in development of an Electronic Nose for quality monitoring of agro-products. Afterward, he pursued post-doctoral research in the Holon Institute of Technology and in the Weizmann Institute of Science, Israel in the field of 1D inorganic nanotubes and fullerenes. In 2022 he joined the Hebrew University of Jerusalem, Israel as a senior post-doctoral researcher where his area of research was quantum optics and photonics involving 2D materials and quantum dots. Thus far he has authored 22 publications and is a coinventor of 2 patents. He would be joining as a senior scientist in an Indian lab-grown diamond company involved in creation of defects for quantum metrology. His talk for today will be on “Thickness Mapping Together with Layer Number Identification and Charge Transport Properties of Individual Exfoliated 2D Flakes via Spectroscopic Micro-Ellipsometry”.

Thickness Mapping Together with Layer Number Identification and Charge Transport Properties of Individual Exfoliated 2D Flakes via Spectroscopic Micro-Ellipsometry

Ralfy Kenaz[1], **Saptarshi Ghosh**[1], Pradheesh Ramachandran[1], Mailis Lounasvuori[2], Takashi Taniguchi[3], Kenji Watanabe[3], Hadar Steinberg[1], Tristan Petit[2], Andreas Furchner[2], Ronen Rapaport[1]
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In the ever-growing field of 2D heterostructure devices, the physics involved is governed by the nanoscale thicknesses and homogeneity of their constituent mono- to few-layer flakes. Thus, accurate mapping of these properties with high lateral resolution becomes imperative. Spectroscopic ellipsometry provides a non-invasive, angstrom-level precise measurement for such atomically-thin film characterization. While such state-of-the-art ellipsometers are regularly deployed in semiconductor metrology, thin film deposition and in bioadsorption studies, they are limited in characterizing exfoliated 2D flakes due to their tens-of-microns lateral resolution or slow data acquisition. In this work, we demonstrate a Fourier imaging spectroscopic micro-ellipsometry (SME) method with sub-5 μm lateral resolution together with simultaneous recording of information at multiple angles. The SME exploits back-focal-plane imaging in a reflection microscopy geometry to simultaneously capture the spectral and incidence-angle-dependent optical response of individual flakes with up to diffraction-limited lateral resolution. The system provides angstrom-level accurate and consistent thickness mapping on exfoliated mono-, bi- and trilayers of graphene, hexagonal boron nitride (hBN) and transition metal dichalcogenide (MoS_2, WS_2, $MoSe_2$, WSe_2) flakes. Among these, a monolayer hBN offers minimal contrast under optical microscope, thus presenting a challenging proposition for other characterization tools. The SME could also account for lateral inhomogeneities in 2D flakes, mapping its minute thickness variations. Matching the results with widely accepted characterization tools for layer number identification and thickness measurement like atomic force microscopy (AFM) and Raman spectroscopy further corroborated the effectiveness of the SME. The capabilities of the SME were further extended towards another class of 2D materials, namely micrometer-sized $Ti_3C_2T_x$ MXene flakes, which were quantitatively characterized for their intrinsic optical, structural, and transport properties. Although delaminated stack of MXene flakes have been studied extensively, the ellipsometer could extract meaningful information from individual flakes. A comprehensive study from mono- to 32-layer flakes revealed the thickness-dependent variations in the complex refractive index and charge transport properties, where resistivity increases as the number of $Ti_3C_2T_x$ layers (NoLs) decreases. As with the other 2D flakes, the findings of the SME for the MXene flakes were also matched for their thickness, NoL and non-uniformities with AFM and scanning transmission electron microscopy (STEM). Additionally, charge transport properties extracted from SME agree with four-probe measurements performed on single-flake devices. The prospect of adding standard optical elements to augment generic optical imaging and spectroscopy setups with accurate in situ ellipsometric mapping capability presents potential opportunities for investigation of exfoliated 2D materials.

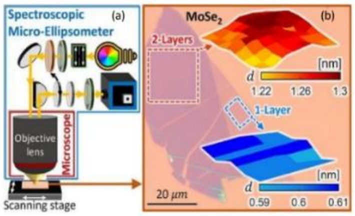

Figure 1. (a) Schematic of the spectroscopic micro-ellipsometer. (b) Thickness mapping of bilayer and monolayer areas of an exfoliated MoSe2 flake.

Dr. Aparna Mukhopadhyay

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Dr. Aparna Mukhopadhyay is an Assistant Professor in the Department of Life Sciences at Presidency University, Kolkata. She earned her Ph.D. in Biomedical Sciences from the Albert Einstein College of Medicine, Bronx, New York, in 2007. Prior to her current position, she served as an Adjunct Assistant Professor at Medgar Evers College, The City University of New York, teaching general biology laboratory courses. Dr. Mukhopadhyay holds an M.Sc. in Biomedical Sciences (2004) and an M.Sc. in Biotechnology (2000) from Albert Einstein College of Medicine and Banasthali Vidyapith, Rajasthan, India, respectively. She completed her B.Sc. in Physiology (Hons.) from Presidency College, Calcutta University, India, in 1998. Her research focuses on cell biology, virology, and molecular physiology, with a particular interest in membrane trafficking, endocytosis, and viral pathogenesis. Dr. Mukhopadhyay has published several peer-reviewed research articles in journals such as the Journal of Virology, Journal of Cell Science, and Radiation Research. She was awarded the Presidential Poster of Distinction at the 62nd Annual Meeting of the American Association for the Study of Liver Diseases in 2011and the Mrs. Thangam Vasudevan Award at the 37th annual IABMS conference, Shobhit University, Meerut, UP, for the best research paper in any aspect of biomedical sciences, for scientists below 45 years.

Vertical Transmission Of SARS CoV-2- An Unexplored Territory for Nanomaterials

Aparna Mukhopadhyay
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SARS CoV-2 infection is well known to cause primarily respiratory problems, although other organs such as the heart, GI tract, liver, kidneys and neural tissue have also been reported to be affected primarily due to high expression of the entry receptor ACE-2. Mother-child or vertical transmission however still remains an enigma, with numerous reports of affected placental histology but scarce reports of affected newborns. In this work, we dealt with the effect of SARS CoV-2 exposure on the placenta.

Literature screening and in silico interactome analysis revealed three interactors of Spike protein namely - CD147, LDLR and EGFR. Their binding was validated by docking and stable interaction was studied through MD simulation. Simultaneously patient survey was done through questionnaire and based on the survey they were classified as control patients and COVID exposed patients. From this survey relationship between exposure score and pregnancy duration and child health was drawn. This was followed by analysis of the mRNA expression of these aforementioned interactors at the transcriptional level by real-time PCR from placental samples. The placental samples were classified as per the trimester of pregnancy the women were exposed to COVID infection and compared with the control group.

From the hospital-based survey of pregnant women (n=60), it was found that exposure was associated with more complications during delivery ($r=0.27$, $p<0.05$). mRNA expression of both EGFR and LDLR was high with odds ratio 2.2 and 6.6 respectively with exposure later in pregnancy. For CD147, upon exposure later in the trimester, mRNA expression increased (odds ratio 2.2). At the transcriptional level CD147 expression was high, if exposure was at second or third trimester. We also found high level of mRNA of both EGFR and LDLR in placenta with COVID exposure when compared to control. More complication during delivery was observed in COVID exposed patients compared to the control group. Further wet lab experiments are needed to confirm the interactions of these receptors with Spike.

Future work would involve generation of SARS CoV-2 pseudoparticles which are noninfectious membranous vesicles expressing Spike protein on the surface. These particles can be used to test the importance of the above-mentioned receptors in viral entry and also provide the scope for testing of nanomaterials to prevent viral entry and thereby placental transmission.

Dr. Sangeeta Roy Chaudhuri

SACT-I, Raja Narendralal Khan Women's College, West Bengal, India

Dr. Sangeeta Roy Chaudhuri is an SACT-I faculty member at Raja Narendralal Khan Women's College, where she teaches inorganic chemistry with a focus on solid-state chemistry, organometallics, coordination compounds, and acid–base chemistry. She earned her Ph.D. in Inorganic and Physical Chemistry from the Indian Institute of Science, Bangalore (2004–2010), completing her doctoral research on the "Ancillary Ligands Effect on the Anticancer Activity of Ruthenium(II) Piano Stool Complexes." She holds an M.Sc. in Chemistry with an inorganic specialization (2002–2004) and a B.Sc. (Hons.) in Chemistry (1999–2002), both from Jadavpur University. Dr. Roy Chaudhuri has extensive postdoctoral experience in Germany. At Martin Luther University, Halle (2010–2011), she worked on the synthesis and reactivity of platinum carbonato complexes, followed by research at the Biozentrum in Halle (2011) studying cellular mechanisms of platinum amino acid complexes. She later served as a Postdoctoral Research Fellow at the Institute of Organic Chemistry, Leibniz University of Hannover (2012–2021), where she focused on flow chemistry, developing new reaction methodologies in microreactors and exploring inductive heating technologies. Her research interests span organometallic chemistry, coordination compounds, bioinorganic systems, nanoparticles, and drug-delivery applications.

All Inorganic Halide Perovskite $KCuCl_3$ Memristors: A lead-free material for Neuromorphic Computing

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Neuromorphic computing, inspired by the functionality of human brain, has emerged as a promising alternative to traditional Von Neumann computing, offering transformative potential for next-generation artificial intelligence (AI). Memristors, owing to their resistive switching (RS) properties, are considered promising candidates for developing neuromorphic chips. At the heart of the new technology development lies the development of materials that exhibit stable and reliable electrical properties suitable for device applications. Among various material systems, halide perovskites have attracted considerable attention for synaptic applications owing to their high ionic conductivity, structural flexibility, and defect tolerance. However, conventional lead-based and hybrid perovskites face significant challenges, including toxicity and thermal instability, limiting their practical use. As an alternative to lead-based halide perovskites, in this work, we report potassium trichloridocuprate(II) (KCuCl3), a lead-free all-inorganic halide perovskite (LFAIHP), as a RS material for memristive and neuromorphic applications. Solution-processed W/KCuCl3/FTO memristors exhibit stable analogue bipolar switching behavior with a low operating voltage of ~1.1 V, excellent endurance over 3100 cycles, and retention exceeding 104s. The RS mechanism is governed by chloride ion vacancy-mediated filament formation and dissolution. Furthermore, the devices emulate essential synaptic functionalities such as potentiation/depression, amplitude- and duration-dependent plasticity, paired-pulse facilitation, and associative learning. Neural network simulations using experimentally extracted synaptic weights yield high recognition accuracies ~98% for MNIST, ~90% for Fashion-MNIST, and ~80% for CIFAR-10, demonstrating the device's efficacy for neuromorphic computing. These results highlight KCuCl3 as a sustainable, high-performance halide perovskite platform that integrates linear synaptic modulation, complex plasticity, and robust device characteristics. This work paves the way for scalable, low-power, brain-inspired electronic systems.

Dr. Chinmoy Ranjan

Associate Professor
Department of Inorganic and Physical Chemistry, Indian Institute of Science, Bangalore

Dr. Chinmoy Ranjan is an Associate Professor in the Department of Inorganic and Physical Chemistry at the Indian Institute of Science (IISc), Bangalore. He completed his undergraduate degree at IIT Kanpur and earned his PhD in Chemistry from Cornell University in 2007 and has since been actively engaged in research on materials chemistry and renewable energy technologies. After working in semiconductor R&D for 3 years, he joined the Fritz Haber Institute as a project leader and subsequently served as a group leader at the Max Planck Institute of Chemical Energy Conversion. His work primarily focuses on electrochemical energy conversion and storage, with special emphasis on the design and characterization of catalysts for key reactions such as the oxygen evolution reaction (OER), oxygen reduction reaction (ORR), and CO_2 reduction. He also employs advanced in-situ spectroscopic techniques to probe active sites and unravel reaction mechanisms at the molecular level. Dr. Ranjan has published 29 research papers**,** which have collectively garnered over 740 citations, reflecting the significant impact of his contributions in the field of electrochemical catalysis and sustainable energy materials.

Electrochemical Studies on Oxide Electrodes: Mechanistic Insights

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CO_2 electro-reduction using solid oxide electrodes is a highly promising approach for converting CO_2 into fuels (Power to X). This remains one of the most energy efficient pathways of CO_2 reductions with reported faradaic efficiencies at 100% (to CO) and energy efficiencies exceeding 90%.

Our studies on conventional cathodes such as Ni-YSZ have demonstrated high activity for pure CO_2 electrolysis and overturned previously believed catalyst deactivation mechanisms. Our operando studies that include Raman spectroscopy and mass spectroscopy show that the catalyst deactivation correlates with total NiOx reduction at the cathode and dopants such as Cu can prevent easy reduction of NiOx, ultimately keeping the electrodes active.

Dr. Rohini Dattatraya Kitture

Deputy Editor-Small AND Nanocluster Journals

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Dr. Rohini Dattatraya Kitture is the Deputy Editor for Small and the Small-series nanoscience journals at Wiley, where she oversees editorial strategy, high-quality content curation, and global author engagement for some of the field's leading materials and nanoscience publications. With more than fifteen years of experience across scientific research and academic publishing, she has previously served as Associate Editor for Advanced Materials and Advanced Functional Materials, and contributed extensively to editorial operations, reviewer selection, SOP development, and peer-review process optimization. Before transitioning to publishing, Dr. Kitture worked as a Postdoctoral Research Associate at the Defence Institute of Advanced Technology, focusing on nanomaterials for drug delivery, sensors, EMI shielding, antimicrobial coatings, and diagnostics, and she also held a Visiting Scientist position at Karlsruhe Institute of Technology, Germany. She holds a Ph.D. in Physics from Savitribai Phule Pune University, where her work centered on nanomaterials synthesis for photocatalysis and cancer theranostics, and an M.Sc. in Physics from Shivaji University. Dr. Kitture is the author of seven international books and a recipient of the STAR Award at Springer Nature, reflecting her significant contributions to scientific communication, process innovation, and research publishing excellence.

Mastering Research Publishing: Insights from the Editor’s Desk

Dr. Rohini Kitture
Deputy Editor, Wiley

Publishing research is crucial in academia as it facilitates knowledge sharing and progress in various fields. However, the intricacies of the publishing process often pose challenges for researchers. This talk aims to provide valuable insights from an experienced editor to enhance the effectiveness of research publications. The session will begin with an overview of Wiley's journals, offering the attendees an idea of the range of potential venues for their research submissions. It will then delve into the detailed editorial review process, covering initial assessments and peer review, and clarifying reasons for desk rejections. By gaining a clearer understanding of these processes, attendees will be better equipped to avoid common pitfalls, thereby increasing the likelihood of their submissions being successful. Drawing on practical tips from editors, this talk aims to empower budding researchers to improve their publication outcomes and maximize the impact of their work.

Prof. Kusum K. Bania

Professor, Department of Chemical Sciences
Tezpur University, Assam, India

Dr. Kusum K. Bania is currently working as a Professor in the Department of Chemical Sciences, Tezpur University and has more than 20 years of teaching experience. He studied chemistry and obtained M.Sc. in Chemistry from Gauhati University in 2005. He worked as Junior Research Fellow at IIT, Guwahati and obtained the Ph.D. degree from Tezpur University. Dr. Bania did his postdoctoral research from RMIT University, Melbourne Australia and summer research fellowship work at University College London, UK. He is a recipient of Indo-Australia Early Mid-Career Research Fellowship by INSA, Govt. of India. Six (06) Ph.D. scholars were awarded with PhD degree under his supervision and currently twelve (12) PhD scholars are working under his guidance. He has supervised more than 44 M.Sc. project dissertations. His research interests are: heterogeneous catalysis, zeolites, fine chemical synthesis, and fuel cells. He has so far completed five (05) projects from various funding agencies like CSIR, UGC, DST-SERB. Prof. Bania has been awarded Excellent Grade by DST-SERB for DST-SERB-EMEQ- project entitled "Design of Reusable Chiral Heterogeneous Catalyst for Asymmetric Synthesis'. At present four (04) projects funded by DST are ongoing under his supervision. He was conferred with the prestigious Dr. J.N. Baruah Memorial Award by CSIR, NEIST for his contribution to chemistry and chemical research in Sept 02, 2022. He is a member of American Chemical Society, Life member of Chemical Research Society of India (CRSI) and Materials research Society of India (MRSI). He is currently the Associate Editor of Chemical Reaction Engineering, Frontiers in Chemical Engineering as well as the Associate Editor of Multidisciplinary Research Journal. Prof. Bania got outstanding Reviewer Certificate by prestigious journals like Journal of Colloid and Interface Science, Applied Organo Metallic Chemistry. He has published more than 80 research articles in highly reputed international journals.

Nanocatalysts for Utilization of C1 and C2 Alcohols in Clean Energy Production and Fine Chemical Synthesis

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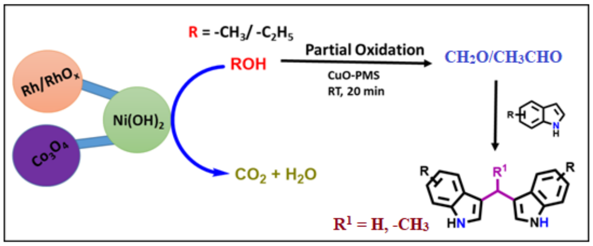
In the current apprehension about environmental pollution and climate change, methanol and ethanol appeared to be important sources of fuel in the development of alcohol fuel cell (AFC). In concern with these, few nonmaterial's are designed that can find application as anode materials in AFC. The $Ni(OH)_2$ nano tubules decorated in Co_3O_4 represented a high current density of ~4.2 Amg-1 at an onset potential of ~1.4 V vs. RHE in MOR [1]. At the same time, Rh-Ni hybrid catalyst in zeolite-carbon matrix exhibited significant activity in both methanol and ethanol oxidation reactions (MOR/EOR) [2]. Apart from the applicability of these C1 and C2 in AFC, nanocatalysts are synthesized that can promote the partial decomposition of these alcohols and facilitates the replacement of volatile formaldehyde (HCHO) and acetaldehyde (CH_3CHO) in different organic synthesis reactions. In this context, bulk CuO nanocatalyst was found to do the in-situ oxidation of methanol and ethanol by activating peroxy-monosulfate which further underwent the condensation with indole to yield 3,3′-bis(indolyl)methanes [3].



Keywords: Copper oxide, Ethanol, Methanol, Nickel hydroxide

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Dr. Abir Ghosh

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Department of Chemical Engineering and Technology at the Indian Institute of Technology (BHU), Varanasi, India

Dr. Abir Ghosh is an Assistant Professor in the Department of Chemical Engineering and Technology at the Indian Institute of Technology (BHU), Varanasi, where he leads the *Fluids and Interfaces for Next-Gen Devices (FIND) Lab*. He obtained his Ph.D. from IIT Kanpur in 2018, M.Tech. from IIT Guwahati in 2012, and B.Tech. from Heritage Institute of Technology, Kolkata, in 2010. Before joining IIT (BHU) in 2020, he served as a Postdoctoral Research Associate at Imperial College London (2019–2020) and as a Senior Research Fellow at IIT Guwahati (2018–2019). His research spans thin films, soft interfaces, electrokinetics, complex fluid flows, and electrochemical energy storage systems, including lithium-ion and next-generation batteries. He has published around 16 research papers in reputed international journals such as *ACS Energy Letters* and *Journal of the Electrochemical Society*, with over 750 citations and an h-index of 8. Dr. Ghosh has received several recognitions, including the SERB International Travel Grant (2017) and the Best Poster Award at the 3rd Indo-German Workshop on Advances in Materials, Reactions, and Separation Processes (2016).

Self-Organization of Nematics: A Reconciliation of Continuum and Molecular Observations

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Self-organization in ultra-thin (< 100 nm) films composed of anisotropic fluids, such as nematic liquid crystals (NLCs), has been a subject of interest for decades, particularly in the context of advancing nano/microfabrication technologies.[1] However, achieving self-organization in pure thin NLC films at room temperatures is challenging due to the intrinsic elasticity arising from the anisotropic molecular orientation at the interfaces.[2] In this regard, a comprehensive understanding regarding the tuning of fundamental thermodynamic, and orientational anisotropy driven kinetic parameters – governed by inter-molecular interactions is essential, which eventually dictates the feasibility of self-organization in such systems at desired length scales observed in continuum-scale theoretical, and experimental settings.[3] In this study, with the help of continuum scale-based non-linear simulations (NLS) and molecular dynamics (MD) simulations, we (i) investigate the diverse morphological characteristics of an NLC thin film undergoing self-organisation either in the presence of an external electric field (Figure 1a) or due to solvent evaporation (Figure 1b). Additionally, (ii) we explore the essential thermodynamic conditions that modify the intrinsic rheological behaviour of NLCs, thereby facilitating self-organization that is otherwise unachievable in pure thin NLC films at room temperature. NLC films tend to develop multiscale structures – consisting of a co-existence of columnar and secondary, droplet, filament, and coalesced structures (Figure 1) when exposed to different external force fields. Furthermore, the NLC molecules align along the direction of the resultant field within these morphologies, suggesting potential applications as a photomask or sensors.1 Additionally, we found that the pattern formation is governed by the extent of simultaneous discontinuities in both thermodynamic and kinetic properties originating from intermolecular interactions. Further, the aforementioned molecular information is found to influence the length and time scale of instability-driven pattern formations, with a qualitative consistency with continuum scale-based predictions.

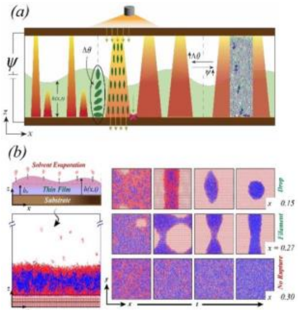

Figure 1. Morphological transitions of NLC in (a) pure thin NLC film due to electric field and (b) due to solvent evaporation from a thin NLC solution film at different NLC concentrations.

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Dr. Dilip K. Singh is currently working as Assistant Professor of Physics, at Birla Institute of Technology Mesra, Ranchi. He obtained B.Sc Physics Honours from St. Xavier's college Ranchi and M.Sc Physics from P. G. Department of Physics Ranchi University. In year 2011, he earned Ph.D in Nanotechnology from IIT Guwahati. During 2011-2014 he served at Department of Physics and Astronomy, Seoul National University, South Korea as Brain-Korea 21 post-doctoral Fellow. In 2014, he was awarded DST Inspire faculty award by Department of Science and Technology, Govt. of India. During 2014-2017 he served at CSIR-National Physical Laboratory New Delhi. His major research interests includes Nanoscale semiconductor devices, Raman spectroscopy, Diffraction through sub-wavelength structures and Light-matter interactions. He has got 03 patents, has authored 55 research articles in journal of international repute with about 1600 citations, has guided 03 Ph.D scholars and 14 M.Sc thesis. Currently another 03 are persuing research for Ph.D under his guidance. His students are currently working at Universities of repute like University college London UK, Hanyang University South Korea, Ariel University Israel and Oxford University UK. He is reviewer of many international journals of Physics, physical chemistry, material science & engineering and nanotechnology. He is life member of scientific socities like Material Research Society of India (MRSI), Electron Microscope Society of India, Ion-beam society of India (IBS), Indian Carbon Society etc. He has been principal investigator of number of projects funded by government agencies and has mobilized grant of 75 lakhs as Principal Investigator and 1.5 Crore as Co-Principal Investigator for research. He has delivered more than 20 invited presentations at international and national scientific conferences. He is a passionate teacher and has demonstrated successfully technological solutions for societal needs like food adulterant sensors, machine learning based noise tolerant surveillance systems to avoid road accidents etc.

Engineering Nanostructured Efficient Photodetectors and Bio-Sensors

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Advancements towards industry 4.0 goals particularly development of cyber physical systems (CPS), internet of things (IoT), cognitive computing and artificial intelligence requires compact, energy efficient and ultra-high sensitive devices. For number of applications, additionally these devices should be flexible and wearable. This requires use of engineered nanostructured materials particularly semiconductor nanowires and 2D-materials as active layers for charge transport and sensing, replacing the existing silicon technology. Through experiments, we have explored the potential of Zinc oxide nanowires (ZnO NWs), graphitic carbon nitride (g-C_3N_4) and monolayer semiconductors like MoS_2 and WS_2 to realize efficient and flexible devices. The growth of monolayered MoS_2 and WS_2 with crystallite size ~ 80 m and coverage area > 92 % was achieved by optimizing the growth parameters using single zone Chemical vapor deposition (CVD) system [1-2].

Using as grown ZnO NWs, g-C_3N_4, monolayered MoS_2 and WS_2 photodetectors (PD) were fabricated using shadow masking techniques with similar dimension. Among these, WS_2 based PDs showed best photo-response (record high responsivity of 290 AW^{-1} and detectivity 52 × 1014 Jones) followed by MoS_2 based PDs (responsivity 101 A/W and detectivity of 6 × 1012 Jones) and g-C_3N_4/ Si heterostructure (responsivity 32 A/W, detectivity of 28×1013 Jones) at incident low power density of 0.06 mW/cm^2 and excitation wavelength of 405 nm [3-5]. Although 2D Semiconductors based PDs shows excellent responsivity, they lack in terms of switching speed (~ 2 sec) as compared to g-C_3N_4/ Si heterostructured devices (~ 0.04 sec). Further, we explored the possibility of realizing flexible photodetectors [6], piezoresistive/ piezoelectric pressure sensors and nano-generators based on ZnO NWs [7] and Pancreatic Lipase sensors using g-C_3N_4 [8] on Indium tin oxide (ITO)-coated polyethylene terephthalate (PET) substrate. The methodology of device fabrication reported here requires less time and enables efficient flexible devices towards wearable technology.

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Dr. Saran Kumar earned his Ph.D. in Biological Sciences from National University of Singapore. He completed his post-doctoral training in vascular biology at Hebrew University of Jerusalem, Israel, before joining IIT Delhi in 2021. He leads the Vascular Biology and Cancer Laboratory at IIT Delhi, where his research addresses fundamental and translational questions on how blood vessels influence disease. His lab combines cellular and molecular biology, in vitro 3-D cancer organoids, in vivo mouse models, and bioinformatics to study: tumor angiogenesis, cancer stem cells, tumor hypoxia, spatial heterogeneity within tumors, cancer metabolism, and vascular aging.

Dr. Kumar's aim is to unravel the genetic, epigenetic, and metabolic mechanisms underlying tumor plasticity, therapeutic resistance, and vascular contributions to cancer and other diseases — thereby identifying novel therapeutic targets.

Charting Perfusion-Driven Spatial Methylome Heterogeneity in Glioblastoma

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Glioblastoma (GBM) exhibits profound intratumoral heterogeneity (ITH) driven by its dynamic tumor microenvironment (TME), posing significant therapeutic challenges. While metabolic niches and transcriptomic programs defined by perfusion are recognized, the epigenetic drivers underlying this spatial ITH remain poorly understood. To address this, we developed PFDLC-Methylome Sequencing (PFDLC-MeS), a novel technique enabling spatial epigenetic profiling of cancer cells based on perfusion gradients. Our study provides the first spatial methylome atlas for any cancer, revealing that differential perfusion profoundly shapes the GBM methylome, leading to distinct Differentially Methylated Regions (DMRs) in perivascular, intermediate, and hypoxic niches.Integrating spatial methylome and transcriptomic data, we identified 125 hypomethylated/upregulated and 42 hypermethylated/downregulated genes in the hypoxic fraction. Notably, GBE1 and CXCL14 emerged as key genes exhibiting hypoxia-induced promoter hypomethylation and subsequent transcriptional upregulation. These findings were robustly validated across in vitro, in vivo xenograft models, bulk GBM patient samples, and further confirmed by single-cell RNA sequencing and spatial transcriptomics datasets. GBE1 and CXCL14 expression correlated with aggressive GBM subtypes (mesenchymal, IDH-wildtype, Non-G-CIMP), pseudopalisading cells (a hallmark of hypoxia), and critically, with poor patient survival. Single-cell analysis further demonstrated distinct pathway associations for GBE1 (strong hypoxia, H1 subcluster) and CXCL14 (milder hypoxia, H3 subcluster). This study unveils differential methylation as a pivotal hierarchical driver of GBM's spatial ITH and provides a novel framework to identify therapeutic targets for overcoming treatment resistance.

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Dr. Ishita Matai is an Assistant Professor at the School of Biological Sciences, Amity University Punjab, and a former DST INSPIRE Faculty in Engineering Sciences at CSIR-CSIO, Chandigarh, India. Her research focuses on nanotechnology-enabled biomaterials, particularly stimuli-responsive hydrogels, multifunctional nanocomposites, and antimicrobial interfaces for translational biomedical applications such as drug delivery, biofilm inhibition, implantable therapeutics, and biosensing.

She earned her M.Tech. and Ph.D. in Nanotechnology from the Indian Institute of Technology Roorkee, where she developed poly(amidoamine) dendrimer-based nanomaterials for cancer theranostics. She subsequently pursued postdoctoral research at the University of Connecticut Health Center, USA, under Prof. Cato T. Laurencin, with a focus on 3D regenerative engineering.

Dr. Matai has authored over 40 peer-reviewed international journal articles, 8 book chapters, 2 books, and 4 Indian patents, with 3,485 citations and an h-index of 25. She has been recognized among the Top 2% Most Cited Scientists globally (Stanford University, 2023–2025) and is a recipient of the prestigious Scientific High Level Visiting Fellowship (SSHN-2025) awarded by the French Embassy in India for collaborative research with the Institut Européen des Membranes, Université de Montpellier, France.

She has successfully guided three Ph.D. scholars and six master’s students to completion and currently mentors four ongoing scholars in the area of advanced functional biomaterial systems. Her group’s work emphasizes the design of antifouling, photothermal, and stimuli-adaptive hydrogel biomaterials for translational biomedical applications.

Functional Hydrogels for Antifouling and Photothermal Therapeutics

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Hydrogels have emerged as versatile biomaterials capable of mimicking the extracellular matrix while enabling dynamic therapeutic functionalities. The strategic design and development of multifunctional hydrogels integrated with nanomaterials have led to advanced biomaterial systems exhibiting antifouling and photothermal therapeutic responses. By engineering the hydrogel network with anti-infective nanomaterials, these systems can effectively inhibit biofilm formation, prevent bacterial colonization, and minimize inflammation at tissue–implant interfaces.

Tailoring the hydrogel composition, crosslinking density, and nanoscale architecture further enhances their ability to resist microbial adhesion while maintaining biocompatibility and structural stability. Notably, stimuli-responsive injectable hydrogels embedded with photothermal nanomaterials such as 1D gold nanorods, 2D MXenes, or graphene can enable localized, "on-demand" drug release upon light irradiation. This controlled activation not only facilitates precise therapeutic delivery but also reduces systemic side effects.

Emphasis is placed on understanding structure–function relationships, material tunability, and the translational potential of these hybrid systems in infection management, tissue repair, and site-specific drug delivery. Overall, this approach bridges materials innovation with biomedical relevance, demonstrating how multifunctional hydrogels can redefine next-generation therapeutic and implantable interfaces.

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Dr. Tamanna Bhuyan received Ph.D. (Nanotechnology) from Indian Institute of Technology Guwahati in 2020 in the area of Micro/Nanorobots for Therapeutics. She received the Best PhD Thesis Award for the year 2021 and bagged a Gold Medal in her Masters in Biotechnology. She is currently working as an Assistant Professor and a researcher at the Dept. of Applied Biology, University of Science and Technology Meghalaya. She has been awarded projects sponsored by DST-ANRF, Ministry of Electronics and Information Technology (Govt. of India), and New Generation Innovation and Entrepreneurship Development Centre project funded by NSTEDB-DST (Govt. of India). She has been a DST INSPIRE Fellow and has published more than 20 research papers in reputed journals such as ACS, RSC, Springer Nature, and Elsevier. She has edited books, authored 7 book chapters, and holds 3 patents granted by Government of India. She bagged SITARE- GYTI (Gandhian Young Technological Innovation) Appreciation 2021 and National Level Women Scientist Award 2023 by the Microbiologists Society India (MBSI) in recognition of her contribution to academics. Her current research interests include fabrication of micro/nanobots, nanoparticle synthesis, microfluidics, drug delivery studies, antimicrobial studies, anticancer therapeutics, and environmental remediation.

Therapeutic Millet Microcapsules from *Saraca Asoca* (Roxb.) W.J. De Wilde of Meghalaya for Dysmenorrhea Management

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Dysmenorrhea, characterized by painful menstrual cramps, remains one of the most prevalent gynecological disorders among women of reproductive age. Conventional therapeutic approaches, including nonsteroidal anti-inflammatory drugs, oral contraceptives, hormones, and surgical interventions, provide only symptomatic relief and are often associated with undesirable side effects. Recent interest in medicinal plants has highlighted their potential as safer, natural alternatives; however, reports on the development of value-added therapeutic formulations specifically targeting dysmenorrhea remain scarce. Furthermore, pH-responsive nanotherapeutic systems for addressing dysmenorrhea and associated uterine disorders, such as infections and endometriosis, have not yet been explored. The research aimed to address this critical gap by developing a novel millet-based functional microcapsule enriched with bioactive extracts of Saraca asoca (Roxb.) W.J.de Wilde, a women-friendly medicinal plant native to Northeast India. The innovation lies in nanoencapsulating bioactive nanostructures onto the surface of millet microcapsules, thereby enabling pH-responsive, sustained release of therapeutic molecules. Such an approach not only ensures cramp suppression through targeted action on uterine contraction but also provides combinatorial benefits against uterine infections. Importantly, these biocompatible polymeric microcapsules represent the first value-added pharmaceutical designed exclusively for severe dysmenorrhea. In line with WHO's concerns about women's health disparities, the innovation empowers women to maintain productivity and quality of life during their menstrual cycles.

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Dr. Joydip Chaudhuri is an Assistant Professor in the Department of Chemical Engineering at the Indian Institute of Technology Kharagpur. He obtained his Ph.D. and M.Tech. in Chemical Engineering from the Indian Institute of Technology Guwahati, following his B.E. in Chemical Engineering from Jadavpur University. Before joining IIT Kharagpur, he pursued postdoctoral research at the Max Planck Institute for Polymer Research, Mainz, Germany.

At IIT Kharagpur, Dr. Chaudhuri leads the PhySICS Lab (Physics of Soft and Interfacial Complex Systems), which explores the fundamental physics of fluid flow in complex environments—from static droplets to dynamic biological systems. His research integrates theoretical modeling, computational simulations, and experimental studies to understand fluid behavior in passive and active matter systems.

His interdisciplinary work bridges chemical engineering, soft matter physics, and biological fluid mechanics, addressing challenges relevant to microfluidics, healthcare, soft materials, and energy applications. Through this approach, his group aims to uncover the physical principles governing complex fluids and to translate this understanding into real-world innovations.

Physics Sculpts Life: Living Nanopatterns in Cells

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Actin waves and spatiotemporal patterns at the cell cortex are hallmarks of dynamic cellular behavior, driving polarity, migration, and morphogenesis. While biochemical feedback has long been considered the primary origin of such nanopatterns, recent evidence highlights the crucial role of active mechanics. In this work, we develop a minimal hydrodynamic framework that treats the actin cortex as a thin active fluid film, where hydrodynamics couple to actin density and contractile stresses.

Linear stability analysis and nonlinear simulations reveal a striking asymmetry: contractile systems destabilize, generating sustained cortical waviness and propagating actin waves, whereas extensile systems suppress perturbations and restore a non-wavy, stable cellular cortex. We further incorporate actin polymerization, polarity, and hydrodynamic flows, showing that contractile instability alone can dictate the localization of polymerization and depolymerization hotspots along cortical waves.

This physics-driven mechanism naturally explains the emergence of patterns such as spots, spirals, and waves, providing a unifying picture of how mechanical instabilities seed biochemical activity. Our results suggest that cortical hydrodynamics may dominate over pure biochemical kinetics in shaping actin architectures—emphasizing that physics initiates the instability and biology follows through.

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Dr. Agile Mathew

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Dr. Agile Mathew is an Assistant Professor in the Department of Electronics & Communication Engineering at Central Institute of Technology (CIT), Kokrajhar, Assam. He also serves as the Training & Placement Officer. Dr. Mathew earned his PhD in Nanotechnology from IIT Guwahati. Before that he completed M.Tech in Optoelectronics & Laser Technology from CUSAT, and a B.Tech in Electronics Engineering, also from CUSAT. His teaching and research interests include nanoelectronics, quantum computing, devices, VLSI, and related fields. Since joining CIT Kokrajhar in 2015, Dr. Mathew has been involved in mentoring students, guiding projects, and contributing to institutional activities beyond academics, including his role in Training & Placement. He has published several research papers in journals and conference proceedings, particularly in the areas of nanoelectronics and device technology.

Edge Engineering in Armchair Graphene Nanoribbons: Bandgap Tuning and Enhanced Resonant Tunneling via Localized Edge States

Dr. Agile Mathew
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As device miniaturization approaches atomic-scale limits, quasi-1D materials such as graphene nanoribbons (GNRs) emerge as highly promising candidates for overcoming the constraints of conventional semiconductor scaling. In this talk, I will present our recent non-equilibrium Green's function (NEGF)–based numerical investigations on armchair GNR (AGNR)–based quasi-1D structures, highlighting four key advances:

1. **Bandgap tuning through tailored edge patterning**

Systematic modification of edge geometries and structural parameters enables precise control of the electronic bandgap and semiconducting behavior.

2. **A novel resonant tunneling diode (RTD) using edge-engineered AGNR heterostructures**

We propose an RTD structure [see Fig. below] incorporating a double-barrier quantum well (DBQW) that hosts a well-defined quasi-bound state, whose presence and spatial distribution are confirmed through local density of states (LDOS) analysis.

3. **Identification of a distinct edge-state-mediated tunneling mechanism**

Beyond conventional resonant tunneling through the DBQW quasi-bound state, we uncover an additional transport channel driven by localized edge states in the electrode regions, active even when the source conduction band bottom is misaligned with the central quasi-bound state.

4. **Significantly enhanced device performance**

This edge-state-assisted transport mechanism produces sharper resonance features and substantially higher peak-to-valley current ratios compared to traditional DBQW-based RTDs. These results underscore the remarkable potential of edge engineering in graphene nanoribbons for realizing ultra-scaled, high-performance quantum transport devices for next-generation nanoelectronics.

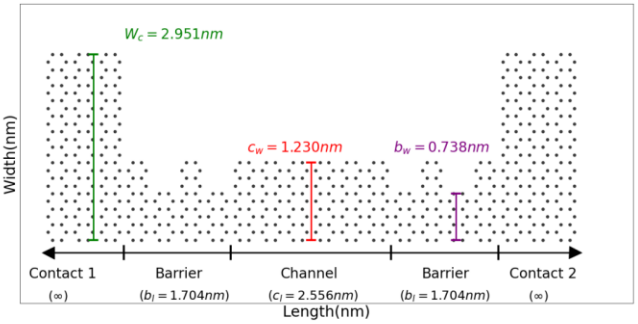

Figure 1: Proposed RTD structure

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Dr. Shilpa Sharma is a Nanobiotechnology researcher with a PhD in Nanotechnology from IIT Guwahati (2013), and a B.Tech in Biotechnology from Guru Gobind Singh Indraprastha University, Delhi. Her prior roles include Scientist 'B' at the Institute of Nano Science and Technology, Mohali, and Research Associate in the Department of Pathology, All India Institute of Medical Sciences (AIIMS), New Delhi. Since August 2014, Dr. Sharma has been part of NSUT as Assistant Professor in the Dept. of Biological Sciences & Engineering. Her teaching portfolio covers a broad range of courses, including Microbiology, Immunology, Molecular Biology, Bioelectronics & Biosensors, Nanobiotechnology, Cell & Tissue Engineering, and related subjects. Her research interests encompass:

- Development of nanoformulations of therapeutic metabolites;
- Thermostable cellulases and biofuels;
- Use of nanocomposites for wastewater treatment;

Dr. Sharma has been recognized with several awards, such as the Shri Vinayak M. Deshpande Young Scientist Award (Indian Chitin & Chitosan Society, 2019), the Premier Research Award from NSUT (2023), and multiple commendation awards from NSUT.

Cellulose Nanofibers and Their Nanocomposites for Efficient Wastewater Remediation

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Environmental contamination from synthetic dyes and industrial effluents has become a primary global concern, demanding sustainable, efficient, and cost-effective remediation strategies[1]. Nanocellulose has emerged as a promising green material due to its abundance, biodegradability, renewability, and facile surface functionalization. Herein, cellulose nanofibers (CNFs) were synthesized from sugarcane bagasse through enzymatic hydrolysis using novel thermostable cellulases, namely cellobiohydrolase (CBH)[2] and β-glucosidase (BGL)[3] from the thermophilic mold Myceliophthora thermophila, thereby providing an ecofriendly and sustainable production route. The obtained CNFs had an average size of ~20.77±1.11 nm, high crystallinity (85.70%), excellent thermal stability, and strong mechanical properties, making them ideal candidate for environmental applications [1].

Further, CNFs were functionalized to develop two novel nanocomposites: (i) magnetic cellulose nanofiber/graphene oxide (MCNFs/GO) and (ii) magnetic carbon dot derived from CNFs (MCD) nanocatalyst to enhance photocatalytic and adsorption performance. Both nanocatalysts demonstrated rapid and visible light photodegradation of dyes with high recyclability and stability. Moreover, liquid chromatography–mass spectrometry analysis confirmed enhanced dye mineralization, indicating complete breakdown of dye molecules into non-toxic intermediates, which validates the effectiveness of photocatalytic process. The synthesized CNFs and their nanocomposites effectively removed dyes from both synthetic and real wastewater samples, demonstrating their practical applicability in environmental remediation. This "waste-to-wealth" approach transforms agricultural residues into high value, multifunctional nanomaterials for sustainable wastewater treatment, showcasing the promise of enzyme-derived nanocellulose-based nanocomposites in advancing green nanotechnology and circular bioeconomy initiatives.

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Dr. Himangshu Jyoti Gogoi

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Dr. Himangshu Jyoti Gogoi has done his B.Tech in Electronics and Communication Engineering and his M.Tech. in Microelectronics and VLSI from the NIT SIlchar. He completed his PhD on Fabrication and Modelling of Perovskite based Memristor from the Indian Institute of Technology Guwahati in 2022. Post PhD, he worked as a Project Engineer at Centre for Nanotechnology, IIT Guwahati and was engaged in the research of design and fabrication of crossbar arrays of Perovskite ReRAMs. Currently, he is working as an Assistant Professor in the Dept. of Electronics at the Assam Skill University Mangaldoi, where he is involved in designing course curriculum and Industry Collaboration for different short term and long term skill courses in the field of electronics and semiconductors.

Multifunctional Resistive Switching in Hybrid Perovskite Memristors and Ionic Defect Analysis using Deep Level Transient Spectroscopy

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Resistive Random-Access Memories (ReRAMs) fall into the Beyond-CMOS paradigm of the IEEE International Roadmap for Devices and Systems (IRDS) and find their applications in the fields of high-density data storage, reconfigurable logic circuits, physically unclonable functions, in-memory computing, neuromorphic computing, etc. Many of the commercial ReRAMs are based on inorganic oxide and chalcogenide materials. In this talk, the discussion will be on the fabrication and characterization of flexible ReRAMs using methyl ammonium lead iodide (MAPbI3) based hybrid perovskite memristors, the existence of multifunctional resistive switching in these memristors, and their significance to mitigate the sneak path effect. The MAPbI3 memristor exhibits two distinct types of bipolar resistive switching, which can be achieved by applying electric fields of opposite polarities. With proper selection and control of the polarity of the operating field and compliance current, I–V characteristics similar to those expected from complementary resistive switching behavior can be obtained, which could be useful to reduce the problem of sneak current in ReRAM crossbar arrays. Besides, temperature-dependent deep-level transient spectroscopy (DLTS) measurement is useful to study the ion dynamics and to understand the origin of ion migration in these HOIP memristors. The DLTS study indicates the presence of methyl ammonium vacancies in the MAPbI3 memristor.

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Prof. Vipul Singh

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Dr. Vipul Singh is an Associate Professor in the Discipline of Electrical Engineering at IIT Indore. He obtained his B.E. in Electronics and Communication Engineering from Delhi College of Engineering in 2003, followed by his M.E. and Ph.D. from the Kyushu Institute of Technology, Japan. His early research focused on conducting polymer–based organic optoelectronic devices, including OFETs, OSCs, OLEDs, and charge transport phenomena. He later worked as a scientific researcher at Shizuoka University, Japan, studying MOSFET-based single-electron devices and low-frequency noise in bulk and SOI technologies. Since joining IIT Indore in 2010, Dr. Singh has expanded his work to nanostructured oxide semiconductors, nanoparticle synthesis, pulsed laser ablation, LSPR, hybrid photodetectors, photoconductive devices, piezoelectric generators, energy harvesting systems, and biosensor applications.

Recent Developments in Fabrication of High-Performance OFETs for Optoelectronic Applications

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OFETs consisting of conjugated polymers (CP) have become increasingly significant in optoelectronic applications, primarily due to their advantages such as mechanical flexibility, lightweight, and tunable bandgap [1, 2]. Fabricating organic thin films with highly aligned chains exhibiting notable optical and electrical anisotropy is desirable for efficient planar devices to improve organic field-effect transistors (OFET) performance. This study demonstrates significant enhancements in the device parameters of OFETs utilizing the oriented thin films of poly 2, 7-(9, 9-dioctylfluorene)- alt- 4,7-bis (thiophen-2-yl) benzo-2,1,3- thiadiazole (PFO-DBT)/ [6,6]-phenyl-C61-butyric acid methyl ester (PCBM) blend processed via ribbon-FTM. OTFTs were fabricated with a bottom-gate and top-contact device architecture on Si/SiO_2 substrates, with an ultrathin layer of CYTOP modifying the surface to enhance the device performance. The blended polymer thin film OFET displayed a superior charge carrier mobility (μ) of 9.4 × 10-3 cm^2/V-sec and an Ion/Ioff of 3 × 10^3, significantly outperforming its pristine counterpart, which exhibited a μ of 5 × 10^{-3} cm^2/V-sec and an Ion/Ioff of 2 × 10^3. These outcomes emphasize the potential of ribbon-FTM in the development of high-performance OFETs, specifically intended for white light sensors expanding their potential in various optoelectronic applications. Among the various CPs, poly[2,5-bis(3-tetradecylthiophen-2-yl)thieno[3,2-b]thiophene] (PBTTT C-14) stands out for its exceptionally high charge carrier mobility and excellent stability, solution processability and its sensitivity towards visible light [3]. To achieve significant advancements in mobility within PBTTT-C14, we improved the polymer chain alignment within the film by utilizing the R-FTM fabrication technique and CYTOP surface passivation [4]. In this talk a detailed review of ribbon-FTM technique will be given and its application towards development of high sensitivity OPTs will be presented. Furthermore, application of this technique in the development of photosensitive OFETs will be discussed in detail, which will pave way for future developments in the filed of OPTs.

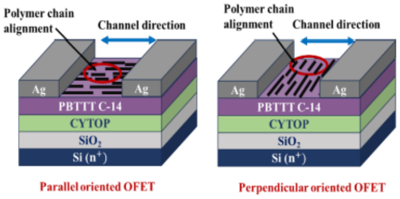

Figure 1. shows the device schematic.

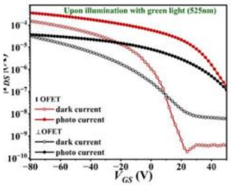

Figure 2. shows the transfer characteristics of the OFETs fabricated.

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Dr. Amit Kumar Singh

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Dr. Amit Kumar Singh is an Assistant Professor of Biotechnology at the School of Sciences, Woxsen University, Hyderabad, India. He is a Member of the Royal Society of Chemistry (MRSC) and serves on the Editorial Board of *Discover Biotechnology* (Springer Nature). Dr. Singh holds a Ph.D. in Nanotechnology from the Indian Institute of Technology (IIT) Guwahati, where his research focused on designing self-propelling magnetic micro/nanobots for biomedical, environmental, and energy applications. He completed his postdoctoral research at George Mason University, USA, in the Department of Mechanical Engineering, where he developed micro(nano)bot-based therapeutic systems for pulmonary infections.

Dr. Singh's research interests lie at the intersection of nanobiotechnology, and microrobotics, with a focus on healthcare and water treatment. He has received several prestigious recognitions, including the Fulbright-Nehru Postdoctoral Fellowship (2022–23), the Marie Skłodowska-Curie Actions Seal of Excellence (2022–23), the Gandhian Young Technological Innovation (SRISTI-GYTI) Award (2019), and the DST-SERB International Travel Grant (2016). His work bridges innovative research, interdisciplinary collaboration, and translational science for societal impact.

Pulmonary Matrix-Derived Hydrogels from Patients with Idiopathic Pulmonary Fibrosis Induce a Proinflammatory State in Lung Fibroblasts

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Idiopathic Pulmonary Fibrosis (IPF) is a chronic and fatal lung disease with limited treatment options, underscoring the need to better understand its underlying pathobiology. Traditional two-dimensional (2D) culture systems are inadequate because they significantly alter fibroblast behavior and fail to replicate disease-associated phenotypes observed in vivo. To overcome this limitation, we developed a three-dimensional (3D) in vitro model using hydrogels derived from decellularized extracellular matrix (ECM) obtained from lungs of IPF patients.

We analyzed the behavior of normal human lung fibroblasts (NHLF) and IPF-derived fibroblasts (IPFF) cultured in these ECM hydrogels. Fibroblasts embedded in IPF ECM showed reduced expression of the canonical myofibroblast marker α-smooth muscle actin (α-SMA) while retaining contractile function. Importantly, the IPF ECM hydrogels induced a pronounced proinflammatory state in fibroblasts—restoring inflammatory cytokine expression that is typically lost when cells are transferred to standard 2D plastic culture.

This proinflammatory phenotype was validated through conditioned media studies: media derived from fibroblasts cultured in 3D IPF hydrogels promoted monocyte proliferation and activation, an effect absent in 2D culture media. These findings highlight the critical influence of the fibrotic microenvironment on fibroblast phenotype and suggest that fibroblasts can serve as immune-signaling hubs.

Overall, this 3D ECM-based model provides a powerful platform for studying fibroblast–immune cell crosstalk and may aid in discovering new therapeutic targets for IPF treatment.

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Dr. Kalishankar Bhattacharyya is an Assistant Professor in the Department of Chemistry, Indian Institute of Technology Guwahati, India. He obtained his Ph.D. in Chemistry from the Indian Association for the Cultivation of Science (IACS), Kolkata (2019). Following his doctorate, he worked as a Max Planck Postdoctoral Fellow and subsequently as an Alexander von Humboldt Research Fellow at the Max-Planck-Institut für Kohlenforschung (Mülheim an der Ruhr, Germany) and later as a Postdoctoral Fellow at the Max-Planck-Institut für Polymer Research (Mainz, Germany) before joining IIT Guwahati in 2023. Dr. Bhattacharyya's research integrates quantum chemical modeling, molecular dynamics, and data-driven machine learning to design functional materials for sustainable energy conversion and storage. His current focus includes electrocatalytic water oxidation, CO_2 and N_2 reduction, photochemical energy transfer (singlet fission, TADF), and excited-state dynamics of organic and inorganic materials. He also leads efforts in machine-learning-accelerated discovery of catalytic materials and quantum-mechanical modeling of reaction kinetics. He has authored over 50 peer-reviewed publications in leading journals such as J. Am. Chem. Soc., Angew. Chemie, Nano Letters, Chem. Sci., Langmuir, and J. Phys. Chem. with an H-index of 20 and > 1100 citations. At IIT Guwahati, Dr. Bhattacharyya heads the Computational Materials Chemistry Laboratory (CMCLab), where he mentors a multidisciplinary team exploring AI-assisted quantum materials design and constant-potential electrochemical modelling. His research vision aims to bridge quantum mechanics and machine learning for predictive understanding of catalytic phenomena relevant to next-generation energy technologies.

Atomistic Insights into Electrochemical Heterogeneous Catalysis

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In this invited talk, I will discuss the critical roles of constant potential and spin states in layered hydroxide-based electrocatalysis for the oxygen evolution reaction (OER). We present a comprehensive computational study on single-atom iron-doped graphene catalysts under constant potential conditions. A new simulation protocol is developed, based on grand canonical quantum mechanics and on-the-fly potential control, to accurately capture electron transfer dynamics throughout the reaction pathway. This methodology enables the prediction of structural evolution as a function of applied potential and pH.[1] Our results demonstrate that axial ligand coordination on single-atom catalysts significantly modulates the spin state, directly impacting catalytic activity. Spin-polarized DFT and ab initio molecular dynamics (AIMD) calculations reveal that single atom Fe exhibits the lowest overpotential, governed by the *OOH formation step as the potential - determining step (PDS), while larger clusters are limited by *O formation. Crystal orbital Hamilton population analysis and adsorption energy scaling relationships provide mechanistic insights and guide strategies for optimizing multi-Fe site catalysts through *OH binding energy modulation.[2]

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Dr. Abhay Sachdev

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Dr. Abhay Sachdev is currently serving as a Principal Scientist at CSIR–Central Scientific Instruments Organisation (CSIO), Chandigarh, India. Dr. Sachdev earned his M.Tech and Ph.D. degrees in Nanotechnology from the Indian Institute of Technology Roorkee. His research interests are Nanomaterials synthesis, Hydrogels, Biomaterials, Biosensors, Microfluidics and Antimicrobials. With a strong research background, he has successfully led and contributed to 10 nationally funded research projects sponsored by CSIR, SERB, DBT, and the Ministry of Jal Shakti. He is a recipient of several honors such as the SERB-NPDF (2017), SERB-Early Career Research Award (2019), IIT Roorkee Nanotechnology Alumni Award (2023), and the French Embassy SSHN Visiting Fellowship (2024). Dr. Sachdev has an impressive publication record with over 48 SCI-indexed journal articles, 6 book chapters, and 2 books, collectively accruing over 2900 citations (Google Scholar). Furthermore, has taken the lead in filing patents and holds 5 patents to his credit. He has guided several Ph.D. scholars, with five successfully completed, and continues to mentor postgraduate research dissertations.

Hybrid: Hydrogel-Nanocomposite Platforms for Electrochemical Bioanalytical and Wound Healing Applications

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The integration of advanced nanomaterials and hydrogels has opened new possibilities in both bioanalytical sensing and wound healing applications. Hydrogel–nanocomposite systems represent a versatile class of materials with broad applicability in bioanalytical sensing and biomedical engineering. Graphene-based hydrogel nanocomposites have been engineered into electrochemical microfluidic platforms capable of detecting diverse biologically relevant targets. These include lipopolysaccharides (LPS) as bacterial endotoxin markers, nitrite ions as indicators of oxidative stress, and illicit drugs such as clonazepam and flunitrazepam for forensic applications. The integration of microfluidic architecture enables precise fluid handling, reduced sample volumes, and rapid analyte transport, thereby improving analytical throughput and reproducibility. Meanwhile, the incorporation of conductive graphene nanostructures within the hydrated hydrogel matrix enhances electron transfer efficiency, analyte diffusion, and overall sensing performance, achieving high sensitivity and selectivity in real-time electrochemical measurements. In parallel, the therapeutic application of hydrogels was investigated through the development of cold microplasma-assisted wound healing devices. A compact device was developed for on-site wound care using cold microplasma-assisted hydrogel delivery. It integrates a hydrogel injection module, a microplasma generator, and a cooling unit that maintains a non-thermal temperature range of 35–45 °C. During operation, the hydrogel precursor is extruded and simultaneously treated with cold microplasma, inducing rapid cross-linking and in situ hydrogel formation. The resulting hydrogel provides uniform, contact-free coverage, while plasma-generated reactive species enable surface disinfection, infection control, and enhanced tissue regeneration. This integrated approach offers a sterile and efficient platform for advanced wound management.

Dr. Pankaj Barah

Assistant Professor and Ramalingaswami Fellow in Department of Molecular Biology and Biotechnology, Tezpur University, Tezpur, Assam, India

Dr. Pankaj Barah completed his M.Sc. in Bioinformatics from the University of Madras and trained at premier research institutions in India, including NCBS Bengaluru, IISc Bengaluru, CCMB Hyderabad, and the University of Pune. He earned his Ph.D. in Computational Systems Biology from the Norwegian University of Science and Technology (NTNU), Norway, in collaboration with the Technical University of Denmark. He later worked as a Bioinformatics Scientist at the German Cancer Research Center (DKFZ), Heidelberg. During his doctoral and postdoctoral research, Dr. Barah gained extensive experience at leading institutes across Europe, including the Wellcome Sanger Institute and the John Innes Centre (UK), as well as research centers in Norway, Denmark, Belgium, Italy, the Netherlands, and Germany.

Currently, he serves as an Assistant Professor at Tezpur University and is a recipient of the prestigious DBT-Ramalingaswami Re-entry Fellowship. His research focuses on cancer genomics, plant stress adaptation, and big data analytics in biology and medicine. He was also a member of the national core committee of the Indian National Young Academy of Sciences (INSA-INYAS). Dr. Barah has been recognized with ten national and eleven international awards for his significant contributions to science.

Physicochemical Properties of Gallstone and Serum Metabolomic Profiles Distinguish Gallbladder Cancer Sybtypes in Assam, India

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Gallbladder cancer (GBC) is among the most aggressive hepatobiliary malignancies, with an alarmingly high incidence in Assam, India. The disease frequently co-occurs with gallstones (GBCGS), yet the molecular and physicochemical connections between gallstone formation and carcinogenesis remain unclear. In this study, we adopted an integrative approach combining serum metabolomics and physicochemical characterization of gallstones to decipher the mechanisms linking gallstone disease (GSD) and GBC progression.

Untargeted metabolomic profiling revealed distinct and overlapping metabolic signatures in GBC and GBCGS patients, highlighting dysregulation in bile acid metabolism, amino acid turnover, and lipid reprogramming associated with metastasis. Complementary structural and elemental analyses of gallstones uncovered crystalline cholesterol phases and carcinogenic trace elements that may contribute to chronic inflammation and mutagenic stress.

These findings demonstrate that gallstone physicochemical properties significantly influence the tumor microenvironment in GBC. Moreover, several novel serum metabolites were identified as potential minimally invasive biomarkers for early detection and patient stratification. This integrative framework offers new insights for translational diagnostics and provides a foundation for nanomaterial-based biosensing applications in gallbladder cancer management.

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Shouvik Kumar Bagchi

HHV Advanced Technologies Pvt. Ltd.

Shouvik Kumar Bagchi has an over 19 years of experience in sales, marketing, and business development, he currently serves as Sales Manager at HHV Advanced Technologies Pvt. Ltd, leading operations across the Eastern and Western regions of India and Bangladesh. Specializing in high-vacuum and thin-film technology solutions, he supports research institutions, government laboratories, and academic organizations by driving business growth and expanding market presence. His expertise spans strategic planning, client relationship management, marketing strategy, and team leadership. An MBA in Marketing, he is dedicated to fostering long-term partnerships, enabling successful project execution through technical discussions, proposal development, and negotiations. He remains committed to advancing innovative technologies and addressing the evolving needs of the research and industrial sectors.

HHV Advanced Thin-Film Deposition & Vacuum Coating Systems: Meeting Global Standards

Shouvik Kumar Bagchi
HHV Advanced Technologies Pvt. Ltd.

The presentation will provide an overview of HHV's advanced high-vacuum and thin-film coating systems, highlighting their role in enabling precision research and industrial applications. It covers the core technologies behind vacuum deposition, thin-film coating processes, and system capabilities ranging from laboratory-scale units to large industrial platforms. The session outlines how HHV solutions support sectors such as optics, materials science, nanotechnology, aerospace, defence, and semiconductor research.

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Grain Boundary Assisted Infiltration and Surface Reconstruction Enables Durable Perovskite Solar Cells

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Trap-assisted non-radiative recombination in grain boundaries and interfaces of perovskite layers severely limits the efficiency and stability of inverted perovskite solar cells (PSCs). Here, we present a graded infiltrated low-dimensional heterojunction (GILDH) strategy, where quasi-2D perovskite infiltrates from the top surface to the bottom interface via grain boundaries. This infiltration heals structural voids, relieves lattice stress, and reorients the internal electric field, enabling efficient charge extraction while suppressing type-II band alignment. Coupled with a dipolar interfacial layer, GILDH-based devices achieve 24.24% efficiency, 1.176 V open-circuit voltage, and an 84.6% fill factor. The devices also exhibit superior humidity and operational stability, highlighting infiltration as a promising route to durable, high-performance PSCs.

Keywords: Perovskite solar cells; Low-dimensional heterojunction; Stability; High PCE

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N-Acetyl-L-Cysteine Capped CdS core and CdS/ZnS core/shell Quantum Dots for Hg^{2+} ion Sensing and phosphor converted Light Emitting Diode Applications

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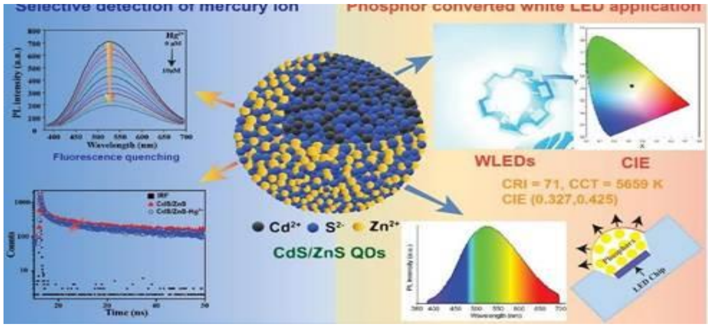
The development of phosphor-converted materials for light-emitting diode (LED) and sensor applications have become important due to the rise in demands for superior optical properties. Herein, we have synthesized a quick and sensitive fluorescence-based nanoprobe for the detection of mercury ion by using CdS core and CdS/ZnS core/shell quantum dots (QDs) capped with N-Acetyl-L-Cysteine (NAC) via a simple aqueous synthesis method. The as synthesized core-shell QDs showed a long photoluminescence lifespan decay, good stability in aqueous conditions, and an average particle size of about ~ 4.34±0.07 nm. Interestingly, the synthesized QDs show a linear detection range of 0-10 µM and a detection limit of 0.81 µM and 0.32 µM for core and core/shell QDs respectively, indicating good selectivity and sensitivity towards the mercury ions. With a recovery percentage of ~97–108%, the effective application of synthesised quantum dots for mercury ion detection has been established in real sample analysis. Furthermore, the synthesized QDs can also be used as a phosphor converted white LED application due to its better chromaticities of (0.31, 0.41) and (0.32, 0.42), color rendering indices (CRI) of 71 and correlated color temperatures (CCT) of ~5974 K and 5659 K for CdS core and CdS/ZnS core/shell QDs respectively (**scheme 1**) which may be employed as a advanced material for future low-cost LED-based devices.



Scheme 1. CdS/ZnS core/shell QDs for sensing and LED applications.

Directly Grown $ReSe_2$/SOI Heterojunction Photodetectors with High Responsivity, Fast Optical Switching, and Broadband Detection

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Two-dimensional rhenium Diselenide ($ReSe_2$), with its distorted 1T structure and intrinsic in-plane anisotropy, enables direction-dependent optoelectronic response. To explore its integration with silicon-based platforms, we directly synthesized directly $ReSe_2$ on silicon-on-insulator (SOI) substrates using a chemical vapor deposition approach. This in-situ growth strategy ensures intimate $ReSe_2$–Si contact, minimizes interfacial contamination, and yields a high-quality heterojunction. Symmetric Cr/Au electrodes were patterned via a hard-mask method to preserve the active region and maintain low contact resistance. The resulting $ReSe_2$/SOI photodetector exhibits broadband photoresponse (365–808 nm) with peak performance at 532 nm, achieving a photo-to-dark current ratio of $\sim 10^4$, responsivity up to ~18 A/W, and detectivity of $\sim 4.1\times10^{12}$ Jones at low illumination power (0.006 mW cm^{-2}). The device maintains a low dark current ($\sim 3\times10^{-8}$ A) and demonstrates a linear dynamic range (LDR) of 71.7 dB, confirming high sensitivity and scalability. Time-resolved measurements reveal a rise time of ~10 μs and decay time of ~140 μs, signifying fast optical switching. The enhanced performance arises from the type-II band alignment at the $ReSe_2$/Si interface, which promotes efficient photocarrier generation, separation, and collection. This work highlights a CMOS-compatible, scalable route to hybrid $ReSe_2$/SOI photodetectors, combining the anisotropic and broadband characteristics of 2D $ReSe_2$ with the maturity of silicon technology for next-generation optoelectronic and sensing applications.

Keywords: Rhenium Diselenide; High Responsivity; $ReSe_2$/2DSi Heterostructure; CVD growth, Broadband Photodetection.

Surface Modified MoS_2-based Vertical Triboelectric Nanogenerator (V-TENG) for Advanced Wireless Information Processing

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Triboelectric nanogenerators (TENGs) hold immense promise for sustainable energy harvesting, converting ambient mechanical energy into usable electrical energy. However, a significant challenge in 2D material-based TENGs lies in their inherent charge retention, leading to substantial leakage and reduced efficiency. This work addresses the issues through a dual-pronged approach: dielectric engineering and surface functionalization. Specifically, the study integrated a Polyethylene Terephthalate (PET) transition layer with Kapton to enhance charge storage capabilities. Furthermore, the surface of molybdenum sulfide (MoS_2) was modified with aromatic carboxylic acids, notably 4,4′- Oxybis (Benzoic acid), to optimize vertical TENG performance. The carboxyl (-COOH) anchoring group of this acid effectively tuned the MoS_2 work function and surface charge density, dramatically improving output performance. Consequently, the "PET-Kapton@4,4′-MoS_2" TENG exhibited a fivefold increase in open-circuit voltage (V_{OC}), rising from 6 V to 30 V, and a more than three-fold increase in short-circuit current (I_{SC}), from 65 nA to 202 nA. This synergistic combination of dielectric engineering and surface modification yielded a maximum power density of 399 mW m^{-2}. The fabricated TENG successfully powered six LEDs and a calculator to demonstrate its practical viability. Moreover, the sensing capabilities were showcased through a microcontroller-based system that accurately deciphered Morse code and wirelessly transmitted it to a smartphone via Wi-Fi, highlighting the device's potential for advanced sensing applications.

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Unveiling Strong Carrier–Phonon Coupling and Phonon-Activated Resonance in $LaFe_{12}O_{19}$: Toward Advanced THz Photonics and 6G Communication

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Materials with high refractive index, low dielectric loss, and resonance frequencies extending beyond the terahertz (THz) operational range are essential for future communication technologies. In this work, we systematically investigate the temperature-dependent THz time-domain spectroscopy (THz-TDS) response of phase-pure lanthanum M-type hexaferrite ($LaFe_{12}O_{19}$, LaM) from 296 to 683 K. A decrease in transmission amplitude accompanied by increased time delay at elevated temperatures highlights the strongly dispersive nature of LaM in the THz regime. The reduced transmission and enhanced absorption arise from intensified phonon–carrier interactions and thermally activated lattice vibrations. At 1.4 THz, LaM exhibits a high refractive index ($n \approx 3.71$), large dielectric constant ($\varepsilon' \approx 14$), and low dielectric loss ($\tan \delta \approx 0.08$), primarily driven by ionic polarization. The nonlinear temperature dependence of refractive index and permittivity indicates enhanced ionic polarizability induced by phonon activity. Lorentz oscillator model fitting of the dielectric function and optical conductivity confirms phonon-assisted resonance, along with temperature-dependent variations in resonance frequency, oscillator strength, and damping coefficient. These results reveal the pivotal role of carrier–phonon coupling in governing the THz response of LaM and underscore its promise for next-generation THz photonic and 6G communication devices.

Enzyme-Regulated Non-Thermal Fluctuations Enhance Ligand Diffusion and Receptor-Mediated Endocytosis

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Herein, the electrochemical sensing efficacy of the carboxylic acid functionalized multi-walled carbon nanotubes (C-MWCNT) interlaced with coexisting phases of Gadolinium monosulphide (GdS) and Gadolinium oxide (Gd_2O_3) nanosheets have been explored for the first time. The nanocomposite has shown splendid specificity towards non-enzymatic electrochemical detection of Uric acid (UA). The nanocomposite was synthesized using the co-precipitation method and thoroughly characterized. The presence of functional groups and disorderness in the as-synthesized nanocomposites are confirmed using Fourier Transform-Infrared Spectrometer and Raman spectra. Furthermore, Field Emission Scanning Electron Microscopy, High-Resolution Transmission Electron Microscope, X-ray powder diffraction, and X-ray Photoelectron Spectroscopy provide a clear understanding of the morphology, coexisting phases, and elemental composition of the as-synthesized nanocomposites. The differential pulse voltammetry technique has been utilized for electrochemical sensing of UA using GdS-Gd_2O_3/C-MWCNT modified glassy carbon electrode (GCE), The sensor shows the enhanced current response by more than two-fold compared to bare GCE. Also, the sensor's performance has been further improved by dispersing the nanocomposites in ionic liquid with the exceptional reproducibility (SD = 0.0025, n = 3). The fabricated UA sensor GdS-Gd_2O_3/C-MWCNT/IL/GCE has a wide linear range of detection covering 0.5 – 30 µM and 30 – 2000 µM that successfully satisfies the entire physiological range of UA in biological fluids with a limit of detection (LOD) of 0.380 µM (+3SD of blank), and a sensitivity of 356.125 µA mM^{-1} cm^{-2}. Moreover, the electrodes' storage stability has been observed for two weeks with decrease in zero-day current by only 4.5%. The sensor has been validated by quantifying UA in un-processed 12 clinical human urine and serum and its comparison with the gold standard test were astounding ($P > 0.05$). Hence, the proposed non-enzymatic electrochemical UA sensor is selective, sensitive, reproducible, and stable, making it reliable for point-of-care diagnostics.

Achieving Synergistic Cancer Therapy with Magnetic Hyperthermia and Luminescent Photothermal Agent: A Study of Eu-Doped Fe_3O_4 Mesocrystals

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In the pursuit of multifunctional and safer cancer treatments, nanoparticle-mediated hyperthermia is a highly promising approach. While Fe_3O_4 are effective magnetic hyperthermia (MHT) agents, their use is limited in patients with magnetic-field-sensitive implants. To address this, we have developed a bimodal therapeutic agent by doping Fe_3O_4 mesocrystals with Europium (Eu^{3+}), enabling bio-imaging, MHT and near-infrared (NIR) photothermal therapy (PTT). Structural analysis via XRD shows no distinct changes in the inverse spinal ferrite structure of mesocrystals upon Eu-doping. However, Raman spectroscopy reveals a distinct surface phase transformation from magnetite to maghemite. Furthermore, the XPS analysis shows the increase in the oxygen vacancies with increase in dopant concentration. This suggests that Eu^{3+} substitution creates local oxygen vacancies (V_O) through charge compensation mechanism ($Eu^{3+}+Fe^{2+}\rightarrow Eu^{3+}+Fe^{3+}+V_O$) which further validates the structural transformation occurred in the samples. The TEM images show that increasing Eu^{3+} concentration inhibits the self-assembly of primary nanoparticles, reducing the size from well-defined 202 nm mesocrystals in the undoped sample to discrete ~9 nm nanoparticles at 5% doping. Importantly, samples doped up to 3% retain excellent magnetization (73 emu/g) and exhibit NIR absorption, high extinction coefficient and distinct photoluminescent emission at 614 nm, compared to other samples. MHT studies confirm that the pristine, 1% and 3% Eu-doped samples, reaches therapeutic temperatures (~ 42 °C) at concentrations of 5 and 10 mg/mL. This was further validated by COMSOL heat-transfer simulation under different conditions. In addition to this Eu 3% sample reach therapeutic temperature in a shorter time under the illumination of 808 nm laser shows its PTT capabilities. Furthermore, a PTT-integrated *in vitro* study on the Eu 3% doped sample shows great potential against a colon cancer cell line. In brief, these Eu-doped iron oxide mesocrystals are robust bimodal agents, possessing magnetic, photothermal, and luminescent functionalities for synergistic hyperthermia and image-guided cancer therapy.

Smart Dual-Polymer Gated Mesoporous Silica Nanoparticles for Colon Cancer Therapy

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Colon cancer continues to be a major global health issue, requiring the investigation of novel therapeutic approaches. Although oral medication is non-invasive and convenient, its disadvantages include non-targeted distribution and pH sensitivity, requiring elevated dosages to compensate for the loss. We aimed to develop colonic bacterial enzyme-responsive dual-polymer-capped drug-loaded mesoporous silica nanoparticles (MSN). Polymeric coating not only protects the drug cargo during gastrointestinal transit but also enables colon-specific release in the presence of colonic bacterial enzymes. The silica nanoparticles were covered with polymeric solutions using chemical and ionic crosslinking. The shape and dimensions of the nanoparticles were validated via TEM and DLS. The coating was validated via Zeta and FTIR measurements. The release of the drug was examined at various physiological pH levels and in the presence of simulated colonic bacterial enzymes (Gavlighi et al. 2013; Lončarević, Ivanković, and Rogina 2017). The anticancer efficacy of the method was validated through cell culture tests against HT-29 human colorectal adenocarcinoma cells. The physicochemical analysis validated the polymeric coating and drug incorporation of MSN. Drug release investigations demonstrated that the dual polymeric coating exhibited limited or negligible release at various pH levels (1.5, 6.8, and 7.4) throughout the digestive system until activated by colonic bacterial enzymes. Cell cytotoxicity and imaging investigations indicated cellular toxicity, reactive oxygen species (ROS) production, and cell cycle arrest in HT29 cells exposed to the drug produced by colonic bacterial enzymes (Bhardwaj and Mishra 2024; Yadav et al. 2023). This study's findings offer significant new insights into the potential of polymer-coated nanoparticles as a viable strategy for oral medicine administration in colon cancer treatment. The colonic-bacterial enzyme-responsive system presents significant potential for future in vivo and clinical applications, providing a focused strategy for colon cancer treatment.

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NIR-emissive mitochondria-targeted AIEgen for mitigation of amyloid-mediated toxicity in Alzheimer's disease

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Alzheimer's disease (AD), the leading cause of age-related dementia, is a complex neurodegenerative disorder involving multiple pathological cascades, including cholinergic dysfunction, oxidative stress, metal ion dyshomeostasis, and amyloid-β (Aβ) aggregation. Among these, the aberrant aggregation of Aβ peptides into toxic fibrillar assemblies is a key driver of synaptic dysfunction and neuronal death. Addressing this multifactorial pathology requires the development of next-generation multifunctional probes that can simultaneously diagnose and intervene in disease progression. This work focuses on developing two triphenylamine (TPA)-based near-infrared (NIR) small-molecule theranostic agents designed to selectively target Aβ aggregates while enabling therapeutic intervention. The lead compound, TPA-RPA, exhibits a remarkable ~5-fold fluorescence turn-on response upon binding to Aβ40 fibrils, enabling high-contrast detection of pathological aggregates at low concentrations. Beyond diagnostic capability, both TPA-RPA and TPA-ER efficiently inhibit Aβ fibrillogenesis and disassemble preformed fibrils, demonstrating robust anti-amyloidogenic activity. Notably, the probes preferentially localize within mitochondria, where they mitigate Aβ-induced mitochondrial dysfunction, an underexplored but critical aspect of AD pathophysiology. Furthermore, selective binding to disease-relevant metal ions (Cu^{2+} and Fe^{3+}) highlights its potential to modulate metal-mediated Aβ aggregation. Both molecules can mitigate Aβ-mediated ROS generation and successfully attenuate the apoptosis pathway. Together, these results establish TPA-RPA and TPA-ER as analogues of promising mitochondria-targeted Aβ-responsive theranostic probes with integrated diagnostic, therapeutic, and imaging capabilities for AD.

Point-of-Care Graphene Oxide–Silver Nanohybrid Electrochemical Biosensors for Early Detection of Dengue Biomarkers

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Emerging and re-emerging dengue outbreaks necessitate rapid, sensitive, and field-deployable diagnostics to facilitate early intervention and control of epidemics.[1] We report an electrochemical immunosensor based on a graphene oxide–silver nanoparticle (GO-AgNP) nanohybrid interface tailored for the sensitive detection of dengue biomarkers (e.g., NS1 antigen). The GO platform offers a high surface area and abundant oxygenated functional groups, facilitating stable bioconjugation. Moreover, AgNPs enhance electron transfer and act as electrocatalytic signal amplifiers, resulting in a synergistic combination that improves analytical sensitivity and lowers the limit of detection.[2] Electrochemical characterization (CV, DPV, EIS) demonstrates significant signal enhancement after GO-AgNP modification, and the immunosensor shows a wide linear range, low nanogram-level limits of detection, and good selectivity against common serum interferents.[3] We discuss the future possibilities of real-sample validation, stability considerations, and the prospects for integrating the nanohybrid into portable, smartphone-readout point-of-care platforms. These results align with recent advances highlighting nanomaterial-driven electrochemical biosensors as practical routes to clinically relevant viral diagnostics.[4]

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Ferromagnetic Synergy in Ruthenium Single Atom Catalyst for Magnetically Enhanced Water Splitting Reaction

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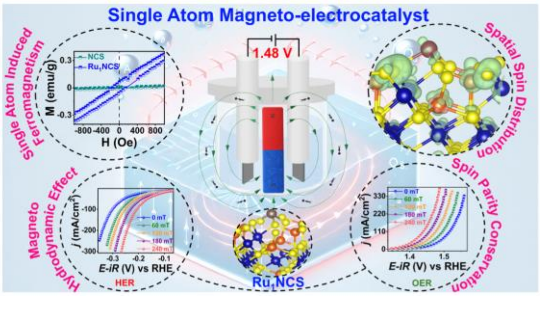
Atomic modulation in single-atom catalysts (SACs) induces ferromagnetism by redistributing localized electrons, thereby enhancing electronic interactions and improving catalytic activity in electrocatalytic water splitting. The emergence of ferromagnetic behavior, along with electronic structure modifications, facilitates magnetohydrodynamic effects and spin-polarized charge transport, leading to more efficient hydrogen and oxygen evolution reactions. To leverage this effect, the SAC Ru_1NCS was synthesized by anchoring ruthenium (Ru) onto paramagnetic $NiCo_2S_4$ (NCS), resulting in improved electronic conductivity and magnetic properties, as confirmed by experimental analyses and spin-polarized density functional theory (DFT) simulations. Under an applied magnetic field of 240 mT, these enhancements led to low overpotentials of 49 mV for the hydrogen evolution reaction (HER) and 173 mV for the oxygen evolution reaction (OER). Ru_1NCS demonstrated superior catalytic performance, surpassing conventional Pt/C and RuO_2 catalysts in mass activity and turnover frequency (TOF). The application of a magnetic field further improved water-splitting efficiency, reducing the overall cell voltage from 1.53 V to 1.48 V. The role of ferromagnetic behavior was further validated through stable catalytic activity in time-dependent magneto-electrocatalysis and chronoamperometry. This study highlights the significance of atomic-level modulation in enhancing magneto-responsive properties, providing a promising approach to overcoming kinetic limitations in overall water splitting.

Keywords: Single atom catalysis, Magneto-electrochemistry, Overall water splitting, Transition metal dichalcogenides



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Synthesis of 2D Molecular Moiré Superlattices for Enhanced Sensing and Electronic Applications

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Engineered molecular assemblies have significantly facilitated the advancement of molecular electronics, spintronics, and quantum technologies. Consequently, numerous novel molecule-based materials are being explored, and their properties are being investigated for optimal utilization in these areas. One important material would be the 2D molecular moiré materials where interactions at the twisted interfaces give rise to unique properties that are not present in the original 2D nanocrystals. Moiré superlattices are formed after twisted stacking of 2D nanosheets where lattice mismatch occurs, and as a result higher periodicity patterns are observed where the periodicity depends on the angle of rotation. Herein, we have utilized simple organic molecules such as amino acids as building blocks to chemically synthesize molecular moiré superlattices in aqueous medium. The small molecules at first self-assembled to form a two-dimensional nanocrystalline sheet. Further interaction resulted in the twisted stacking of these nanosheets, thus forming moiré superlattices and resulted in new photoluminescence and conductive properties. Further, the application potential of these molecular moiré superlattices were investigated as quantum materials for photochemical CO_2 sensing and enhanced charge transport by pH tuning. This presents significant opportunities for developing different multifunctional molecular systems by offering new approaches and would be an important step towards advancing the field of molecular electronics technology.

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A Multifunctional NIR Responsive Upconversion Porphyrin Nanoprobe for Fenton/FRET Induced ROS Amplification and Targeted Drug Delivery

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The tumor microenvironment (TME) is marked by hyperactivated signaling molecules, acidic pH, elevated GSH levels, immune evasion, and hypoxia causing therapeutic resistance. Monotherapy is restricted by various constraints in the intracellular system which calls for combinational technologies to enhance individual effects. In the present work, we have constructed a core-shell upconversion porphyrin metal organic framework (UCNP@Cu-TCPP MOF) nano drug delivery system with an in-built combinational, photodynamic (PDT) and chemodynamic therapy (CDT) under 980 nm light irradiation. A rapid microwave method was applied for synthesis of $NaYF_4$: Yb,Er upconversion nanoparticles (UCNPs), and the shelling of porphyrin MOF was achieved through a single step in-situ method. Cu^{2+} is reduced to Cu^{+} by GSH in the TME which is reacted upon by H_2O_2 via Fenton reaction to produce reactive oxygen species (ROS) mainly (•OH) leading to GSH depletion and oxygen elevation in the cells. Further, NIR (near IR) light conversion through FRET mechanism between UCNP and Cu-TCPP MOF amplified the production of ($^1O_2$), confirmed with EPR and UV–visible spectroscopy. The porous structure of MOF allows ample loading of anticancer drug, Doxorubicin (~20 %) and folic acid, facilitating targeted delivery. The pH-responsive activity of UCNP@Cu-TCPP@FA@DOX with excellent water dispersibility, stability, and biocompatibility, shows cancer cell apoptosis up to 80 %. The synthesized nano drug delivery system harnesses the photosensitizing properties of porphyrin, along with copper ions induced chemodynamic effect and targeted chemotherapy, promising a multifunctional approach towards cancer treatment.

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Dextran-coated CeO_2 and Mn_3O_4 nanozymes for scavenging multiple reactive oxygen species and mitigating oxidative stress in biological systems

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Reactive oxygen and nitrogen species such as hydroxyl radicals (•OH), singlet oxygen ($^1O_2$), and peroxynitrite ($ONOO^-$) disrupt redox homeostasis and cause extensive oxidative and nitrosative stress in biological systems. Synthetic antioxidant molecules often exhibit limited scavenging efficiency and require stringent conditions, whereas recently discovered nanozyme-based antioxidants offer tunable catalytic activity and structural stability. Herein, we have synthesized dextran-coated cerium oxide (Dex-CeO_2 NPs) and manganese oxide (Dex-Mn_3O_4 NPs) nanozymes exhibiting ROS scavenging similar to biological enzymes. TEM imaging revealed quasi-spherical particles of 2–3 nm, and XRD confirmed the fluorite CeO_2 and tetragonal hausmannite Mn_3O_4 crystal phases. XPS data confirmed the coexistence of Ce^{3+}/Ce^{4+} valence states (0.65/0.35) in Dex-CeO_2 NPs, indicating abundant oxygen vacancies and facile surface redox cycling that enables efficient ROS neutralization. Similarly, Dex- Mn_3O_4 NPs exhibited mixed Mn^{2+}/Mn^{3+} oxidation states with two spin–orbit pairs of $2p_{3/2}/2p_{1/2}$ at 640.1/651.9 and 642.9/654.6 eV, supporting an intrinsic redox cycling mechanism for the catalytic antioxidant activity. Both nanozymes efficiently scavenged •OH radicals, with IC50 values in the order Dex-Mn_3O_4 NPs (2.3 µM) < Dex-CeO_2 NPs (5.4 µM) < NAC (28.4 µM). For $^1O_2$ scavenging, Dex-Mn_3O_4 NPs (IC_{50} = 4.75 µM) outperformed sodium azide (60.5 µM) and Dex-CeO_2 NPs (857.27 µM). Both nanozymes effectively neutralized $ONOO^-$, with the IC_{50} values in the order of, GSH (24.14 µM) <Dex-Mn_3O_4 NPs (42.58 µM) <Dex-CeO_2 NPs (317.74 µM). Dex-Mn_3O_4 NPs exhibited protection to IEC-6 and SKOV3 cells, by mitigating the nitrosative stress induced by SIN-1. Dex-Mn_3O_4 NPs exposure restored ~65.7% cell viability, maintained mitochondrial membrane potential by reducing intracellular $ONOO^-$ levels, compared to cells with nitrosative stress. Dex-Mn_3O_4 NPs pre-treatment also preserved the typical morphology of IEC-6 cells as evidenced by TEM imaging. In conclusion, Dex-Mn_3O_4 NPs demonstrated the multi-ROS [•OH, $^1O_2$, and $ONOO^-$] scavenging and also offer cytoprotection to mammalian cells thus establish a potent nanozyme platform for oxidative stress management.

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Chromium(VI) Reduction and Methyl Violet Degradation using Light Harvesting Silver Nanoparticle Decorated at Polyoxovanadate-Reduced Graphene Oxide

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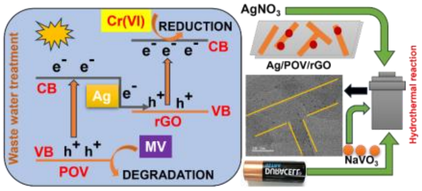
A novel ternary nanocomposite consisting of silver nanoparticles (Ag NPs), polyoxovanadate (POV) nanorods, and reduced graphene oxide (rGO) was successfully synthesized via a hydrothermal method. The synergistic structure of the composite material enhances the efficiency by combining the special qualities of 0D Ag NPs, 1D POV nanorods, and 2D rGO sheets. The composite was investigated for its effectiveness in reducing hexavalent chromium [Cr(VI)] and degradation of methyl violet (MV) dye under UV- light irradiation. The Ag/POV/rGO nanocomposite exhibited remarkable activity, achieving 99.07% reduction of Cr(VI) and 96.34% degradation of MV. This enhancement is attributed to efficient charge carrier separation, broader light absorption, and increased surface area. Morphological analysis revealed a distinctive "Christian Cross" structure formed by POV nanorods anchored on rGO sheets. The integration of Ag NPs and POV onto the rGO nanosheet significantly improved the transfer and separation of photogenerated electron–hole pairs. Density functional theory (DFT) calculations were conducted on Ag NPs, pristine POV, and Ag-decorated POV clusters to further understand their electronic structures. Additionally, electromagnetic field simulations were performed using COMSOL Multiphysics software. To elucidate the photocatalytic mechanism behind Cr(VI) reduction and MV dye degradation, Mott–Schottky analysis and active species trapping experiments were carried out. The results indicated effective generation and utilization of reactive species during the photocatalytic processes. Furthermore, the heterojunction nanocomposite demonstrated good stability and reusability, maintaining its activity up to the fifth cycle.

Keywords: 0D/1D/2D nanocomposite, Silver nanoparticles, Polyoxovanadate, Reduced Graphene Oxide.



A 0D/1D/2D Ternary Nanohybrid of Silver nanoparticles, polyoxovanadate (POV) nanorods and reduced graphene oxide (rGO) nanosheet for reduction of Chromium(VI) and Degradation of Methyl Violet under UV- light.

Convergent Assembly of UCNP and Cu-TCPP on TMC Nanosheets for NIR-Responsive ASGPR-Targeted Triple-Modal Liver Cancer Therapy

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The hostile tumour microenvironment, exhibiting oxygen deprivation, limited reactive oxygen species (ROS) precursors, and metabolic imbalances, remains a major obstacle to achieving effective therapeutic outcomes. Integrating several oncological strategies into one nanoplatform offers a potential path to overcome the limitations of traditional monotherapies while hindering collateral damage to healthy tissues. 2D transition metal carbides (TMC) have been explored as promising nanoplatforms for oncological therapeutics due to their high surface area, good water dispersibility, tunable electronic properties, and efficient photothermal conversion. In this work, we introduce an approach to enhance the therapeutic performance of photodynamic therapy (PDT), chemodynamic treatment (CDT), and photothermal therapy (PTT) by covalently conjugating two-dimensional TMC nanosheets with UCNPs, Cu-TCPP, and lactobionic acid (TMC@UCNP@Cu-TCPP@LA). These nanohybrids enable PTT and PDT that are triggered by a single 808 nm Laser irradiation, where the singlet oxygen ($^1O_2$) is generated by the FRET-based NIR light conversion between UCNP and Photosensitizer (Cu-TCPP). Integration of TMC nanosheets not only improves the photothermal conversion efficiency (~28%) and water dispersibility but also promotes efficient charge transfer, leading to suppressed exciton recombination, thereby markedly increasing ROS ($^1O_2$, •OH) generation compared to UCNP@Cu-TCPP@LA. LA enables hepatocellular carcinoma targeted synergistic treatment. GSH-mediated reduction of Cu^{2+} to Cu^+ in the tumour microenvironment encourages Fenton-type reactions with H_2O_2, yielding •OH radicals, eliminates GSH, and increases intracellular oxygen. The potential of TMC-based nanocomposites for clinical translation in multimodal oncology is shown by the integration of therapeutic mechanisms, which produce strong tumour elimination with minimal off-target damage.

Dual-Signal Paper Based Nanosensor for Heparin Monitoring with Smartphone Integration

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Heparin, a widely used anticoagulant in various clinical practice, requires precise monitoring to ensure patient safety and avoid complications such as thrombocytopenia **(1)**. However, the complexity of its chemical structure and low abundance make precise monitoring challenging in clinical settings. Conventional laboratory assays face limitations in sensitivity and specificity, highlighting the need for innovative approaches **(2)**. In this study, we developed a dual-mode nanosensor based on chitosan functionalized gold nanoclusters (Ch-AuNCs) for sensitive and selective nanosensor heparin detection. AuNCs with their discrete electronic states, size-dependent fluorescence, enzyme-like properties, and biocompatibility, interact favorably with glycosaminoglycans (GAGs) through electrostatic and supramolecular interactions, thus facilitates the formation of colloidal networks with high-water content **(3)**. These properties make AuNCs a promising material for molecular sensing applications, particularly in the detection of heparin.

The developed nanosensor exhibited both fluorometric quenching and colorimetric enhancement, demonstrating analytical performance with a fluorometric linear range of 0.25–15 U/mL (LOD = 0.016 U/mL) and a colorimetric linear range of 0–30 U/mL for UFH (LOD = 0.023 U/mL) for heparin. High selectivity was achieved against common serum interferents, and recovery studies in spiked serum samples yielded 93–112% with RSDs <5%. Furthermore, the system was adapted into a paper-based platform with smartphone-assisted readout via ImageJ analysis, highlighting its suitability for point-of-care therapeutic monitoring and overdose detection. Thus, this dual mode nanosensor provides a simple, portable, and clinically relevant strategy for heparin monitoring.

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Highly Water-Rich Robust Coating for Separating Immiscible Liquids Mixtures of Wide Range of Surface Tension Differences

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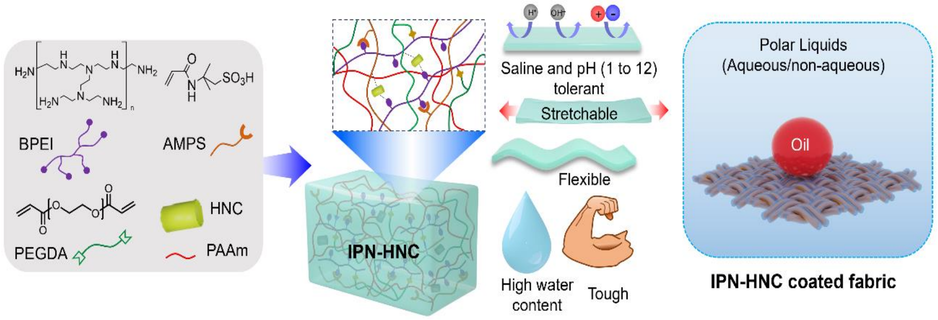
Creating coatings that are both mechanically strong and chemically resilient while retaining a high-water content is still a significant challenge. In this study, the introduction of a hollow nano-clay into a dual crosslinked and interpenetrating polymer network has led to the development of a coating with high water content (approximately 95 wt%) that dramatically enhances the toughness of a flexible fibrous substrate, increasing it from 0.5 ± 0.03 MJ/m^3 to 9.9 ± 0.6 MJ/m^3. The combination of covalent and physical crosslinking provides the material with the necessary resistance to various harsh chemical environments, including extreme pH levels, seawater, river water, and organic solvents. The high-water content in this hydrogel network imparts exceptional bio-inspired underwater non-adhesive superoleophobic properties, with an oil contact angle of 160.7 ± 0.2° and a very low oil-droplet adhesion force of 8.7 ± 0.3 μN. This innovative approach also creates a liquid-selective filtration membrane that offers ultra-high efficiency in separating crude oil from water, achieving a separation efficiency of 99.7%. The membrane also exhibits excellent performance under high intrusion pressure (3.5 ± 0.4 kPa) and maintains a high separation flux of 11,162 $L/m^2/h$, even when the surface tension of the aqueous phase is reduced to levels close to that of the oily phase. Furthermore, the material successfully separates mixtures of immiscible, non-aqueous liquids with surface tension differences of less than 2.5 mN/m.



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A Machine Learning Approach for Selective VOCs Detection Using CNT-Metal Oxide Composite Sensor Array

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This study presents the design, fabrication, and validation of an artificial intelligence-integrated chemiresistive sensor array for selective, real-time detection of volatile organic compounds (VOCs) at room temperature. The sensor backbone is a freestanding, macroscopic Carbon Nanotube (CNT) film, synthesized via a one-step floating catalyst chemical vapor deposition (FC-CVD) process at 1200°C to form a highly conductive, interconnected network [1,2]. A six-element sensor array was fabricated to generate a multi-dimensional response dataset. This array comprises one pristine CNT film and five composite films created by functionalizing the CNT network with graphitic carbon nitride (g-C_3N_4) via dip-coating and with various metal oxides (CuO, TiO_2, WO_3, V_2O_5) via magnetron sputtering. The core sensing mechanism relies on the engineered p-n heterojunctions at the CNT-metal oxide interface, which modulate charge transport upon gas adsorption, thereby amplifying the chemiresistive response and tuning selectivity for specific analytes (Ethanol, Methanol, Acetone, Benzene, Hexane, Toluene). To decode the sensor array's output, a Multi-Layer Perceptron (MLP) neural network was developed using the TensorFlow library with the Keras API. Bayesian optimization was employed to determine the optimal model architecture: a single hidden layer with 10 neurons and a 0.4 dropout rate. The model utilized a ReLU activation function and was trained with an Adam optimizer to minimize the Categorical Cross Entropy loss function. The training dataset consisted of 2394 data points, derived from the response magnitude, response time, and recovery time of the sensors. The trained MLP demonstrated perfect classification efficacy on a reserved test dataset (30% of total data), achieving scores of 1.0000 for Accuracy, Precision, Recall, and F1-Score. This flawless performance was validated by a confusion matrix, which showed zero misclassifications across all six VOC classes. Beyond classification, the model also provided precise concentration predictions, achieving R-squared values consistently exceeding 0.99. The physical sensor platform exhibits superior temporal performance, with a minimum response time of 2 seconds and an outstanding limit of detection (LoD) of 10 ppb. In conclusion, the synergistic integration of heterojunction-engineered CNT composites with a validated machine learning framework provides a robust and highly accurate methodology for developing next-generation electronic noses. This platform is validated for high-sensitivity applications in environmental monitoring, industrial safety, and public health.

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Magneto-luminescent Bacterial Biohybrid Bots against Cervical Cancer and Biofilms

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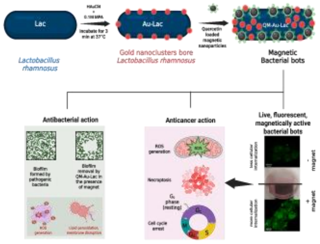
Biohybrid bots have immense biomedical applications in targeted drug delivery and bio-imaging. Traditional methods for drug delivery have certain limitations, such as drug resistance, low specificity, and treatment failure. Cancer is one such complex disease that involves uncontrolled growth and spread of cells, leading to detachment from their original site and invasion of other organs. Also, cancer patients, due to frequent hospital visits, along with previous antibiotic exposure, surgeries, urinary catheter use, and comorbidities, are at high risk of developing antibiotic resistance. The goal of the ongoing work is to develop a bacterium-based micro-bot that can target cervical cancer cells and deliver the drug more effectively while lowering the secondary infection of pathogenic bacteria. The bacterial biohybrid bots are prepared by attaching drug-loaded magnetic nanoparticles to the surface of human-friendly Lactobacillus bacteria. The fabricated magnetic bacterial bots are live, fluorescent, and magnetically active so that their motion can be controlled precisely, along with tracking. The bot shows significant cytotoxic potential against HeLa-cervical cancer cells by generating reactive oxygen species, altered cell cycle, and necroptosis. Also, it was observed that the magnetic bacterial bots show significant antibiofilm activity against pathogenic bacteria like P. aeruginosa that tend to form biofilms. Due to their magnetically active nature, the magnetic bacterial bots offer disruption, killing, and cleaning of the biofilms. Therefore, this approach offers a dual targeting approach for an effective way to treat both cervical cancer and bacterial infections.

Keywords: Bacterial bot, cancer, magnetic nanoparticles, cancer theranostics, antibiofilm, bacterial infection.



All-dielectric Metasurface-based Ultra-narrow Notch Filter at Telecom Wavelength

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All-dielectric metasurfaces serve as a powerful platform for realizing ultra-thin and low-loss optical devices such as modulators, filters, and optical switches. Here, we demonstrate an all-dielectric metasurface–based ultra-narrow optical notch filter operating in the telecom band regime. The proposed optical device enables line rejection for laser-noise suppression and channel isolation in wavelength-division multiplexing (WDM) systems, while avoiding the absorption losses and fabrication challenges associated with metal-based or multi-cavity designs.

The metasurface consists of a periodic array of four identical amorphous silicon (a-Si) nanoblocks placed on a quartz substrate, resulting in a polarization-insensitive response due to the C_{4v} symmetry of the meta-atom. The meta-atom geometry (lateral dimensions and lattice period) is optimized to excite a high-Q resonance that enforces destructive transmission and near-unity reflection at the telecom wavelength.

Full-wave electromagnetic simulations reveal an efficient ultra-narrow band rejection at 1552.4 nm, with minimum transmittance ($T \approx 0.0013$) and more than 96% transmission across off-resonant wavelengths. Additionally, the resonant characteristics can be tuned by varying the periodicity, nanoblock thickness, and inter-block gap. The single-layer, all-dielectric, CMOS-compatible platform offers a compact footprint and straightforward fabrication (E-beam lithography on a-Si/SiO_2), while ensuring low off-resonant losses.

Overall, these results underscore the potential of dielectric metasurfaces for ultra-selective, low-loss line rejection in integrated photonics, fiber-optic communication systems, and narrow-band spectroscopy.

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Microdroplet Tribogenerator Stimulated by Coupled Phononic and Photonic Excitations

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The present study reports the development of a microfluidic energy harvester (µEH) that integrates mechanical, acoustic, and optical energy conversion mechanisms. The µEH converts oil–water two-phase flow into a multiphase triboelectric nanogenerator system, where oil serves as the continuous phase and water as the dispersed phase, effectively minimizing electrolysis. Uniquely, the µEH functions as a microdroplet-operated transistor, employing fluidic droplets as floating gates to regulate charge transport. Systematic optimization of two-phase flow parameters, tuned according to the viscosity of the continuous medium, demonstrates a pronounced influence on triboelectric performance, achieving a power density of 10 kW m^{-3} under concurrent mechanical, acoustic, and photonic excitations. This integration of droplet-gated transistor functionality with multimodal energy harvesting establishes a foundation for scalable and high-efficiency energy systems in future applications.

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Bulk Doping–Driven In-Situ Modulation of Buried Interface Energetics Enables Improved Charge Transport Dynamics for Perovskite Solar Cells

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Perovskite materials have garnered tremendous attention owing to their exceptional optoelectronic properties and rapidly improving photovoltaic performance. However, the presence of bulk and interfacial defects remains a major bottleneck, impeding further enhancement in device efficiency and operational stability. Conventional interfacial engineering approaches, although effective for defect passivation, often lead to uncontrolled and non-uniform interlayer growth, adversely affecting charge transport and energy-level alignment. Herein, we introduce a multifunctional small molecule, 3MPAH, incorporated into the perovskite precursor to achieve in-situ modulation of both bulk and buried interface energetics. Theoretical calculations and experimental analyses reveal that 3MPAH undergoes ionic dissociation during film formation, wherein the cationic component governs the controlled crystallization and defect suppression within the perovskite bulk, while the anionic moiety migrates toward and accumulates at the buried interface. This dual functionality enables simultaneous passivation of non-radiative recombination centre, improve buried interface morphology and favourable energy-level alignment, thereby enhancing charge transport dynamics across the perovskite layer. As a result, the optimized 3MPAH-modified devices deliver an impressive power conversion efficiency (PCE) of 25.7%, with a high open-circuit voltage (Voc) of 1.195 V and a fill factor (FF) of 84%, outperforming the control devices (PCE: 22.4%, Voc: 1.115 V, FF: 80.4%). Moreover, the unencapsulated devices exhibit excellent operational stability under continuous illumination and when stored under controlled humidity and oxygen environments. This work demonstrates an effective in-situ strategy to concurrently tailor the bulk and buried interface energetics, paving the way toward highly efficient and durable perovskite solar cells.

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Strong Light-Matter Interaction through Phonon-Polaritons Coupling in Formamidinium-based Perovskite film Hybridized with Terahertz Toroidal Metamaterial

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Strong coupling between photons and phonons in polar materials leads to the formation of phonon-polaritons, which carry rich physical properties, e.g., strong subwavelength field confinement, low group velocity, and long lifetimes, enabling efficient light-matter interaction and low-loss THz propagation. Herein, we demonstrate a strong light-matter interaction by the formation of phonon-polaritons in the THz frequency range, generated within a crystallized lead halide FA0.90Cs0.10PbI3 perovskite (Pe) film deposited on a toroidal metamaterial (TMM). When the resonance of the TMM aligned with the phonon resonance of the crystallized Pe film, Rabi splitting was observed as a result of the strong coupling between the resonances. The observed Rabi splitting energy was ~1.4 meV (332 GHz), exceeding the linewidths of both the toroidal and phonon resonances, which is notably higher than those reported earlier with other meta-structures. Additionally, the estimated interaction potential (0.693 meV) confirms the strong coupling regime. By tuning the metamaterial resonance, we modulate the polaritonic branches and clearly observe an anti-crossing behavior in the resulting dispersion curve. Furthermore, in-situ THz spectroscopy was employed during the annealing process to monitor the evolution of Rabi splitting with crystallization of the perovskite. By examining the Avrami exponent, we observed a dimensionality shift from 1D to 3D as the temperature increased from 70°C to 140 °C. These results offer significant insight into the coupling between metallic toroidal modes and Perovskite phonons and enable efficient light–matter interaction, low-loss THz propagation, and offer great potential for ultrafast THz sources, detectors, and active control of THz light.

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Energy Efficient Optoelectronic Synapse using Halide Perovskite/Organic Semiconductor Heterostructure for Neuromorphic Computing, Optical Logic and Wireless Communication

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With the advancement of artificial intelligence, the emulation of biological neural processes through neuromorphic computing has gained significant attention. Artificial optoelectronic synapses have emerged as promising components for neuromorphic computing due to their simple structure, low energy consumption, and ability to overcome the von Neumann bottleneck. Here, we design a multifunctional, energy-efficient optoelectronic synapse based on a formamidinium cesium lead iodide (FAxCs1-xPbI3)/P3HT heterojunction in a two-terminal vertical structure. The synaptic device exhibits key synaptic characteristics, such as excitatory post-synaptic current, paired-pulse facilitation, and achieves a transition from short-term to long-term memory with an exceptionally low energy consumption of 0.55 fJ per synaptic event. Long-term potentiation enables efficient visual object recognition with 90.3% accuracy on the Modified National Institute of Standards and Technology dataset using an artificial neural network. In addition, light logic functions ("AND", "OR") and associative learning (Pavlov's dog experiment) are demonstrated using 405 and 532 nm pulses. More significantly, optical wireless communication is experimentally performed using Morse code for words such as IITG, 2025, HELP, and SOS. The device achieves 86.76% pixel-wise accuracy in the semantic segmentation of urban street scenes using a U-Net model. Finally, the working mechanism of the device, attributed to the specific band alignment and accumulation of photogenerated electrons at the perovskite side, without the direct role of defects, offers deep insights into the optoelectronic plasticity. These findings show the path towards the development of a highly integrated, photonic neuromorphic device for future intelligent systems.

Keywords: Optoelectronic Synapse; Neuromorphic Computing; Halide Perovskite; Optical Wireless Communication.

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Defect-Engineered 2D Bi_2Te_3 Based Broadband Optoelectronic Synapse for Neuromorphic and Optical Information Processing

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The development of optoelectronic synapses (OES) has traditionally relied on intricate architectures involving complex transistors, sophisticated fabrication methods, and multilayer heterojunction stacks—factors that significantly limit practical implementation. In this work, we introduce a simple two-terminal OES device based on 2D semiconducting Bi_2Te_3, a material whose potential for OES applications has remained largely unexplored. This single-device platform is multifunctional and applicable across neuromorphic computing, biometric recognition, and artificial visual perception. The operating mechanism is governed by persistent photoconductivity induced by Te vacancies, introduced during thin-film preparation, which act as efficient charge trapping and de-trapping centers. By precisely tuning the annealing temperature of thermally evaporated Bi_2Te_3 films, we achieve controlled defect engineering and establish a clear correlation between vacancy states and the resulting device performance. The critical role of Te vacancies is validated using first-principles calculations and comprehensive material characterization. The device exhibits excellent optoelectronic synaptic characteristics, including a high paired-pulse facilitation (PPF) of 191.7% and an ultra-low energy consumption of 37.2 fJ per spike. The OES also demonstrates classical associative learning (Pavlovian response) through its wavelength-dependent behavior. A 6×6 array, functioning as an artificial retina, shows strong image retention and a memory performance of 57.4%. In computational tasks, the device achieves high accuracy in facial recognition (93.3%) and urban traffic scene segmentation (86.7%) within only 100 training epochs. Furthermore, the fabricated devices support optical logic gate operations and Morse code decoding, highlighting their potential for optical signal recognition and wireless communication applications.

Semi-metallic Bi_2Se_3 Contact-Based Interface Engineering on Monolayer MoS_2 for High-Performance Field-Effect Transistor and Flexible Photodetector

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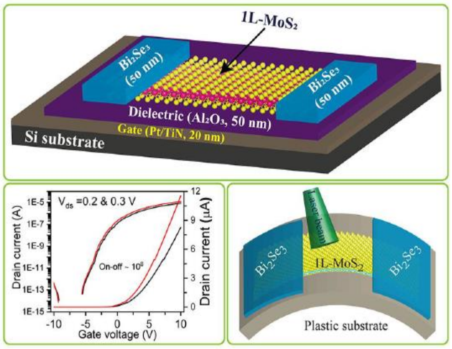
The metal–semiconductor junction interface plays a crucial role in determining the performance of semiconductor optoelectronic devices. Conventional metal contacts with high evaporation temperatures often induce defects at the metal/semiconductor interface of ultrathin 2D materials, leading to degraded device performance. This work introduces a low-temperature deposited semi-metallic topological insulator, Bi_2Se_3, as contacts for monolayer MoS_2 (1L-MoS_2) to realize high-performance electronic and optoelectronic devices. Bi_2Se_3 contacts on 1L-MoS_2 significantly reduce interface defect density and lower the potential barrier, resulting in enhanced field-effect transistor performance with improved subthreshold swing, mobility, and threshold voltage. The on–off ratio increases by two orders of magnitude, reaching 10^8 due to reduced off-state current. A flexible 1L-MoS_2 photodetector (PD) fabricated on a PET substrate using Bi_2Se_3 contacts demonstrates an impressive on–off ratio (~10^3), more than twice that achieved with conventional Cr/Au contacts, and shows sensitivity to bending strain. Key photodetector performance parameters—including responsivity, detectivity, and external quantum efficiency—exhibit substantial improvement owing to optimized contact engineering. These results underscore the importance of a nearly defect-free interface and reduced potential barrier in advancing 2D material-based electronic and optoelectronic devices. Ultrathin Bi_2Se_3 thus presents strong potential for cost-effective and flexible electronics on low-cost substrates.



Tunable CVD Growth Of 2D Bi_2O_2Se and Bi_2O_3 Flakes and Their Wavelength-Dependent Ambipolar Photoresponse

Sourav Dey[1*]; Abdul Kaium Mia[1], Subhankar Debnath[2], Md Tarik Hossain[2]; P. K. Giri[1,2]

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With the increasing demand for faster information processing and data transmission, the development of high-performance devices for efficient computing and communication has become essential. Optoelectronic logic devices are considered strong candidates for next-generation in-sensor computing systems. In this work, we develop a controlled chemical vapor deposition (CVD) approach to synthesize Bi_2O_2Se flakes from a Bi_2Se_3 precursor by systematically adjusting oxygen flow, growth temperature, and reaction time. While intrinsic Bi_2O_2Se exhibits negligible photoresponse, increasing oxygen flow and extending growth duration promote the formation of β-Bi_2O_3 flakes. Structural and elemental characterizations confirm this phase conversion. Photodetector devices fabricated via photolithography reveal that β-Bi_2O_3 demonstrates strong photoresponse in the UV and visible regions. Remarkably, after a short-duration plasma treatment, β-Bi_2O_3 exhibits a distinct negative photoresponse at longer wavelengths. Using both positive and negative photoresponses within a single device under different laser excitations, we demonstrate the implementation of all seven fundamental logic gates solely by tuning the illumination wavelength. These findings present a promising route toward wavelength-dependent optoelectronic logic operations in oxide-based devices.

Keywords: CVD growth; 2D Bi_2O_2Se; β-Bi_2O_3; Ambipolar photoresponse; Logic gates.

Sensitivity Enhanced Surface Plasmon Resonance (SPR) Sensor Based On $BaTiO_3$, Bluep-WS_2 Heterostructure And BlackP

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A Kretschmann angular configured six-layer Surface Plasmon Resonance (SPR) sensor with enhanced sensitivity is presented in this work. The proposed sensor incorporates Barium Titanate ($BaTiO_3$) as an oxide layer over a silver (Ag) coated BK7 prism along with a combination of Blue Phosphorus-Tungsten Disulphide (BlueP-WS_2) heterostructure and Black Phosphorous (BlackP). The sensing performance of the sensor is evaluated by three parameters; Sensitivity, Full Width at Half Maximum (FWHM) and Quality Factor (QF) at an operating wavelength of 633 nm for the Refractive Index range of 1.33-1.335 of the sensing medium. The thicknesses of various layers such as Ag, $BaTiO_3$, BlueP-WS_2 hetero-structure and BlackP layers are optimized to obtain the highest sensitivity of 280˚/RIU. The sensor having 56 nm Ag, 1.6 nm $BaTiO_3$, trilayer of BlueP-WS_2(2.25 nm) and seven layers of BlackP (3.71 nm) demonstrates significant improvement in sensitivity over the conventional SPR sensor. The proposed sensor also exhibits enhanced sensitivity compared to several recently reported SPR sensors and is well suited to monitor changes in RI within the range of 1.330-1.335.

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Influence of Low Entropy Design on the Ferroelectric Response of Bi_3TiNbO_9-Based Oxide

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Ferroelectric materials are widely studied for dielectric energy storage applications. However, conventional ferroelectrics generally exhibit broad and lossy P–E loops, which limit their recoverable energy density. In this work, a low-entropy design strategy is implemented to modify the Bi_3TiNbO_9 (BTO9) ferroelectric oxide with the goal of achieving a slimmer P–E loop and enhancing energy storage performance. The composite was synthesized via a conventional solid-state reaction route. Structural characterization was carried out using X-ray diffraction, Raman spectroscopy, and field-emission scanning electron microscopy, along with ferroelectric measurements. The low-entropy composition shows reduced hysteresis and lower energy loss. This study demonstrates the potential of entropy engineering in tuning ferroelectric behavior and developing high-performance dielectric materials.

Keywords: High entropy, Ferroelectric

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Probing the Ferroelectric and Magnetic Properties of $BaTiO_3$ Composite

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Multiferroic composites exhibiting both ferroelectric and magnetic order are of great interest for applications in sensors, memory devices, and energy-harvesting technologies. Understanding the coupling between their electric and magnetic phases is essential for designing high-performance multifunctional systems. In this study, we examine how incorporating the magnetic phase $BaFe_{12}O_{19}$ into ferroelectric $BaTiO_3$ influences its ferroelectric and magnetic behaviour. The addition of $BaFe_{12}O_{19}$ leads to a deterioration of the ferroelectric response, primarily due to enhanced electronic conductivity arising from electron hopping across mixed-valence cations. This increased leakage current suppresses polarization saturation. The results offer insight into the interplay between electrical and magnetic interactions in multiferroic composites.

Keywords: Ferroelectric, Ferromagnetic, Multiferroics

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Study and Development of Chirality Selective Spintronic Thin Films and Active Devices for Biochemical-Electronic Interface Applications

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Chiral enantiomers are fundamental to biology, governing processes such as smell, taste, DNA replication, and pharmaceutical activity. Human sensory systems can distinguish enantiomers with extraordinary sensitivity for instance; the human nose can detect over one trillion odours and differentiate enantiomers of many molecules. However, despite rapid progress in nanoelectronics, conventional devices based on charge transport lack the ability to electronically discriminate chirality. Current optical techniques such as circular dichroism (CD) are slow, require bulky instrumentation, and are often ineffective for weakly chiral molecules. A new, integrable, and sensitive electronic approach is needed. Recent advances highlight Chirality-Induced Spin Selectivity (CISS), where electron spin interacts selectively with chiral molecules. CISS was first observed by Ray et al. in electron transmission through chiral molecular films and later confirmed in DNA monolayers and other chiral systems. Remarkably, spin polarization up to 94% has been demonstrated in chiral perovskites, surpassing typical ferromagnets despite consisting of light elements. Moreover, adsorption of chiral molecules on ferromagnets has been shown to directly manipulate magnetization, offering a route to low-power spin control compared to conventional spin-transfer-torque approaches. Yet, no practical device architecture has been established to actively harness CISS for biochemical-electronic integration.

Micromagnetic Simulation of Spin Hall Nano-Oscillators for Tunable High-Frequency Operation

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Spin Hall Nano-Oscillators (SHNOs) have attracted growing interest for their potential applications in microwave generation, signal processing, and neuromorphic computing [1][2]. In this work, we present a micromagnetic simulation study of a nano-constriction-based SHNO, focusing on its frequency tunability under varying driving current and external magnetic field. The simulations were performed using GPU-accelerated **MuMax3**, with current density and magnetic field distributions obtained from **COMSOL Multiphysics**, and subsequent data analysis conducted in **Python**.

A fine-tuning behaviour was observed with increasing current density, from 1.7 mA to 3.0 mA; the oscillation frequency gradually decreased from 10 GHz to 9.6 GHz. In contrast, a coarse-tuning response was obtained with external field variation, where the frequency increased linearly from 10 GHz to 16 GHz for fields ranging from 0 T to 0.2 T. The oscillation mode profiles confirm stable and coherent magnetization precession within the constriction region.

The framework developed in this study will be extended to include synthetic antiferromagnet (SAF) coupled free layers to explore the influence of interlayer exchange coupling on frequency stability and tunability [3]. These results and ongoing efforts contribute toward understanding and optimizing SHNOs as compact, reconfigurable microwave sources for next-generation spintronic and neuromorphic systems.

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Fabrication of Tungsten Disulfide Based Gas Sensor using Material Printing System

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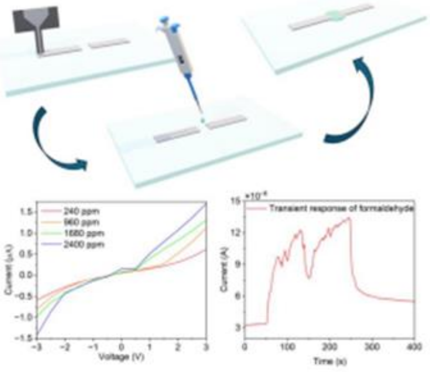
The need for detection of hazardous gaseous chemicals in our environment necessitates the development of reliable and efficient gas sensors. Some volatile organic compounds (VOCs) can be harmful to human health. One such VOCs is formaldehyde, a colorless, flammable and toxic gas with a pungent odor used in various applications. Formaldehyde (HCHO) can be hazardous due to its toxicity, especially with inhalation. Exposure should be minimized and therefore the need to detect its presence. Tungsten disulphide (WS_2) exhibits excellent sensitivity and selectivity to formaldehyde. Researchers have found that the defect WS_2 is particularly sensitive to formaldehyde. Although, development of reliable and cost-effective formaldehyde gas sensors using WS_2 has not been reported. In our work, the active sensing material nanosheet is prepared by liquid phase exfoliation (LPE). The devices are fabricated using micro-cantilever printing (MCP), a simple, fast and cost-efficient method. The device is then tested in a controlled environmental chamber (CEC) for its performance. To verify sensitivity and selectivity, the device is checked with different gases. The results showed that our fabricated device is most sensitive towards HCHO. In conclusion, we have developed an efficient and cost-effective formaldehyde sensor.



Strain-Driven Defect States and Magneto transport Anomalies in Epitaxial $Ba_{0.5}La_{0.5}Fe_{12}O_{19}$ M-type Hexaferrite Films

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In this study, we demonstrate the optimized heteroepitaxial growth of M-type hexaferrite $Ba_{0.5}La_{0.5}Fe_{12}O_{19}$ (BLM) thin films on $SrTiO_3$ (001) single-crystal substrates, despite the significant lattice mismatch. High-quality c-axis-oriented epitaxial films were successfully obtained at a substrate temperature of 800°C under an oxygen partial pressure of 20 mTorr for 30 minutes, followed by post-annealing at 1000°C for 15 minutes. Any deviation from these optimized conditions resulted in the formation of polycrystalline films. Magnetic characterization indicates strong perpendicular magnetic anisotropy along the c-axis—the easy axis of magnetization—with an anisotropy constant (Ku) of 5.6×10^6 erg/cm³, showing a notable temperature-dependent variation between in-plane and out-of-plane magnetization. Electrical transport measurements reveal an unusual insulating-to-metallic transition around 65 K, contrasting sharply with the highly resistive, insulating nature of bulk BLM. At low temperatures, conduction follows Mott's variable-range hopping mechanism, while at higher temperatures, the metallic regime is governed by weak localization and scattering due to electron–electron, phonon, and magnon interactions. The observed reduction in resistivity under a perpendicular magnetic field ($H = 9$ T) is attributed to enhanced carrier delocalization resulting from the suppression of weak localization, alignment of local magnetic moments that increase the localization length in the hopping regime, and reduced spin-flip and domain-wall scattering. To uncover the microscopic origin of these anomalous transport features, first-principles slab models with [001] orientation and varying supercell sizes— [1×1×1], [1×1×2], and [1×1×3]—were constructed. The calculations suggest that epitaxial strain induces distortions in the Fe 2a, 12k, and $4f_1$ sites, altering the O 2p electronic states near the Fermi level. These strain-driven distortions give rise to defect states that play a critical role in governing the low-temperature transport behavior of epitaxial BLM thin films.

Interface-Engineered Porphyrin–Carbon Nitride Hybrid for Broad-Spectrum Solar Hydrogen Generation

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The quest for efficient photocatalysts for solar-driven hydrogen evolution remains hindered by weak charge transfer and limited visible-light absorption in carbon nitride–based systems. Despite various modification strategies, conventional hybrids relying on noncovalent interactions or metal nanoparticles often suffer from poor electronic coupling and restricted light utilization.[1]In this work, a novel porphyrin–carbon nitride hybrid material was designed with a structurally integrated interface that enables robust electronic communication and extended visible-light absorption. The incorporation of porphyrin units introduces strong optical coupling within the carbon nitride framework, enabling effective utilization of the solar spectrum while providing uniformly distributed and electronically accessible metal centers.[2]

Spectroscopic and electrochemical analyses confirm improved charge transfer dynamics, enhanced photoresponse, and increased catalytic accessibility. As a result, the material exhibits substantially higher photocatalytic hydrogen evolution activity and stability compared to pristine carbon nitride. This study presents a molecular-level design strategy that overcomes the intrinsic limitations of conventional semiconductors, offering a versatile platform for developing next-generation photocatalysts for sustainable energy conversion.

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Self-propelling µ-Catbots Targeting On-the-fly Energy Harvesting

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Self-propelling catalytic micro/nano bots µ-Catbots producing pure hydrogen (H_2) and oxygen (O_2) can be directly fed to the fuel cells for on-the-fly energy harvesting. For this purpose, 500 nm polystyrene (PS) beads are coated with iron oxide (Fe_3O_4) nanoparticles – FeONPs and iron (Fe) nanoparticles–FeNPs, which are found to catalytically decompose hydrogen peroxide (H_2O_2) into oxygen (O_2) and formic acid (HCOOH) into hydrogen (H_2). The presence of the FeONPs and FeNPs on the surface of the PS beads infuses a remote magnetic control on the motions of the µ-Catbots. While the pure H_2 and O_2 thus produced help in a facile and on-demand powering of a toy fuel cell in real-time, the magnetic handle helps in generating self-propulsion and demixing of bubbles inside the liquid medium alongside an easy separation of the µ-Catbots. Importantly, the bubble ejection of the gases on the µ-Catbots helps in establishing an unprecedented image analysis-based approach to evaluate the rate kinetics of hydrogen peroxide (H_2O_2) and formic acid (HCOOH) decompositions. Interestingly, a proof-of-concept has also been demonstrated wherein the rapid catalytic decomposition of the peroxide fuel with the help of a collection of µ-Catbots can help in developing a portable oxygen concentrator. The images of the rate of ejections of the O_2 and H_2 bubbles from the surface of the µ-Catbots have been correlated to the Langmuir-Hinshelwood (L-H) kinetics of such decompositions composed of the steps – diffusion of the reactants, adsorption on the active site, surface reaction, desorption, and diffusion of the product to bulk. The rate constant from the image (IM) analysis and standard gas chromatography (GC) are found to have a close matching, highlighting the potential of the method proposed in this work.

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Erbium-doped cerium oxide (CeO2) nanoparticles for catalysis and solid oxide fuel cells

Priyanshu Soni

Erbium (Er)-doped cerium oxide (CeO_2) nanoparticles were synthesized using a solid-state reaction method to explore the influence of rare-earth doping on CeO_2's structural, optical, and catalytic properties. Stoichiometric amounts of CeO_2 and Er_2O_3 powders were thoroughly ground and calcined at elevated temperatures to ensure uniform Er^{3+} incorporation. X-ray diffraction (XRD) confirmed the retention of the cubic fluorite structure, with minor lattice contraction due to the smaller ionic radius of Er^{3+}. Scanning and transmission electron microscopy (SEM/TEM) revealed well-dispersed nanoparticles with average sizes of 15–25 nm. UV–Vis spectroscopy indicated a slight redshift in the absorption edge, suggesting band gap narrowing and enhanced oxygen vacancy formation. Photoluminescence (PL) studies showed increased emission intensity, reflecting defect-mediated recombination induced by Er doping. Catalytic evaluation demonstrated improved redox activity and oxygen storage capacity compared to pure CeO_2. These findings indicate that Er-doped CeO_2 prepared via solid-state reaction exhibits promising properties for applications in catalysis, solid oxide fuel cells, and luminescent materials.

Harnessing FA-Based Perovskite Memristors for Next-Generation Resistive Memory and Neuromorphic Applications

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Perovskite memristors present significant promise for next-generation memory and neuromorphic computing due to their ultralow switching voltage, simple solution-processing, and scalable device architecture. In this work, we demonstrate an ITO/$Cs_{0.1}FA_{0.9}PbI_3$/Ag memristor exhibiting stable low-voltage resistive switching with well-defined high- and low-resistance states. Systematic electrical measurements confirm filamentary conduction as the dominant switching mechanism, while pulsed measurements reveal the stochastic nature of filament formation and rupture. This intrinsic randomness enables true random number generation, extending the device's utility beyond memory applications. Overall, the CsFA-based perovskite memristor showcases strong potential for brain-inspired computing and emerging intelligent electronic systems.

Keywords: memristor, switching device, neuromorphic

Reductant-Driven Strong Coupling of NiOx and Self-Assembled Molecules Enables High-Stability Inverted Perovskite Solar Cells

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Self-assembled monolayers (SAMs) on nickel oxide (NiOx) play a crucial role in achieving high-performance inverted perovskite solar cells (PSCs). However, during perovskite film formation, these SAMs may partially dissolve and redeposit, creating leaky interfaces that reduce stability and accelerate device degradation. To address this challenge, we introduce a reductive-interface engineering strategy using cyanoacrylic acid–based molecules (CZ-BT-CA and CZ-BT-MN) to create a strongly coupled NiOx–SAM hole transport layer (HTL). CZ-BT-CA effectively reduces NiOx, forming C=O···Ni coordination and O–H···O–Ni hydrogen bonds, while its –COOH groups coordinate with unbound Pb^{2+} ions in the perovskite layer. These interactions lead to a denser SAM layer, enhanced hole extraction, and suppressed interfacial non-radiative recombination. Simulation results further confirm higher adsorption energy and improved interface stability. Devices employing this integrated HTL deliver a power conversion efficiency of 24.54%, retaining 91.5% of their initial performance after 1200 hours of continuous illumination and 85.5% after thermal aging at 85 °C under nitrogen. This strategy provides a promising pathway for developing compact, stable NiOx-based HTLs for durable, high-efficiency PSCs.

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Ferromagnetism in Mist-CVD–Grown Mn-Doped β-Ga_2O_3 Thin Films for Spintronic Applications

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Ferromagnetism in semiconductors is a key enabler for bridging conventional semiconductor technology with emerging spintronics, driving the exploration of oxide systems that exhibit robust room-temperature magnetic ordering. In this work, Mn-doped gallium oxide (β-Ga_2O_3) thin films were synthesized using an in-house, cost-effective Mist Chemical Vapor Deposition (Mist-CVD) technique to realize an oxide-based ferromagnetic semiconductor (FMS). The synthesis parameters were optimized to stabilize the monoclinic β-phase of Ga_2O_3, followed by controlled Mn doping (0–25 at.% in 5% increments). Structural (XRD), vibrational (Raman), and optical (UV–Vis) analyses confirmed successful substitution of Ga^{3+} by Mn^{3+}/Mn^{4+} ions within the β-Ga_2O_3 lattice up to 15% doping while preserving the host crystal symmetry. Beyond this solubility limit, the emergence of secondary MnO_x phases indicated dopant oversaturation and phase segregation. Magnetic measurements using Vibrating Sample Magnetometry (VSM) revealed clear room-temperature ferromagnetic hysteresis, confirming intrinsic ferromagnetism in Mn-doped β-Ga_2O_3. The observed magnetic ordering is attributed to Bound Magnetic Polarons (BMPs), formed through exchange interactions between localized Mn ions and defect-mediated charge carriers. The ability to incorporate Mn into the β-Ga_2O_3 lattice without significant structural distortion enhances BMP density and promotes long-range ferromagnetic coupling, establishing this material as a promising FMS platform. These results offer valuable insights into dopant incorporation, defect-driven exchange mechanisms, and ferromagnetic ordering pathways—key factors for advancing semiconductor spintronics, magnetic sensors, and spin-enabled optoelectronic devices.

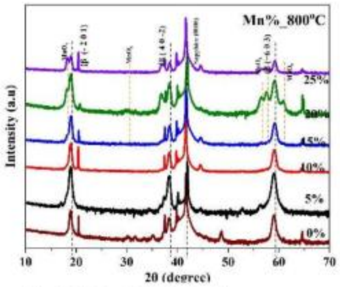

Fig. 1: XRD of Mn:Ga_2O_3 films grown at 800 °C with varying Mn%

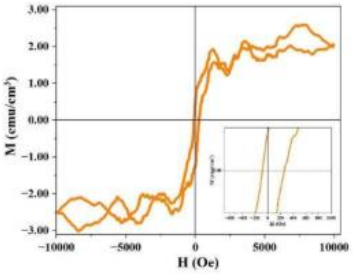

Fig. 2: M–H curve of 15% Mn:Ga_2O_3 thin film measured at room temperature

Controlled Growth of LiGa5O8 Thin Films *via* Mist-CVD: Role of Deposition Temperature

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LiGa5O8 has emerged as a *p*-type, ultra-wide bandgap semiconductor material with promising optoelectronic properties. As Ga_2O faces significant limitations due to its lack of viable *p*-type conductivity, other *p*-type wide bandgap semiconductors such as p-type NiO, CuO, and SiC have been employed to fabricate *p-n* heterojunction devices with Ga_2O_3. However, the performance of these heterojunction devices remains limited by lattice mismatch, interface defects, and band alignment issues, resulting in reliability issues for long-term operations. Due to these challenges, there is a need to explore alternative *p*-type UWBG materials or improved doping strategies to enable effective bipolar device fabrication based on β-Ga_2O_3. Recently, $LiGa_5O_8$ has been discovered as a *p*-type UWBG material. however, the growth of LiGa5O8 depends on several parameters, including processing temperature, carrier gas flow rate, and deposition techniques. In this work, we have fabricated $LiGa_5O_8$ thin films using the cost-effective Mist Chemical Vapor Deposition (Mist-CVD) technique at different processing temperatures ranging from 400 °C to 900 °C. Further, the deposited thin films were characterized using various techniques such as X-ray diffraction (XRD), UV-Vis spectrophotometer, and field emission scanning electron microscope (FESEM) to investigate their structural and optical properties, and surface morphologies. The XRD confirms the growth of $LiGa_5O_8$ thin films. At a lower temperature below 600 °C, mixed phases of $LiGa_5O_8$ along with LiGaO2 and κ-Ga_2O_3 form, which diminish at higher processing temperatures. The optical band gap of the deposited films was calculated to be between 4.9 to 5.3 eV. The surface morphology of the LiGa5O8 film deposited at 800 °C exhibits a granular structure. The current findings of our work highlight the role of processing temperature on the growth of $LiGa_5O_8$ thin films.

Thin-Film Instability and Dewetting Dynamics in Spin-On Coatings for Semiconductor Devices

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The fabrication of semiconductor devices relies heavily on the precise deposition of thin, defect free films—particularly during the photoresist coating and dielectric layer formation stages of photolithography. Spin coating remains the industry's preferred technique for achieving nanoscale uniformity and smoothness in such films. [1] However, the occurrence of dewetting and rupture during the coating [2] or baking stages continues to pose a major challenge, leading to non-uniform coverage, pinholes, and pattern distortion. These defects compromise critical dimension control and device performance, underscoring the need for a deeper physical understanding of film instability mechanisms at the nanoscale.

In this study, we investigate the fundamental hydrodynamics governing the stability of thin polymeric and dielectric films typically used in semiconductor processes. The analysis captures the coupled effects of viscous, capillary, inertial, and intermolecular (van der Waals) forces that compete during the spin-coating and drying stages. By formulating and analyzing a nonlinear thin film equation incorporating disjoining pressure and surface tension, we identify the force balance responsible for either stabilizing the film or triggering rupture. A general linear stability analysis (GLSA) is then employed to determine the growth rate of surface perturbations and to map the stability regimes as a function of film thickness, viscosity, surface energy, and substrate interaction parameters.

The resulting plots reveal critical combinations of process parameters that minimize instability growth, thereby promoting uniform coatings. These theoretical predictions are further correlated with experimentally observed dewetting patterns and defect morphologies in photoresist and spin on dielectric films.

By elucidating the physical origins of thin-film instability during spin coating, this work offers a scientific basis for process optimization in semiconductor manufacturing, enabling improved coating reliability, reduced material wastage, and enhanced lithographic precision. The insights extend to next-generation spin-on materials for advanced nodes, MEMS fabrication, and nanoscale photonic devices, where film integrity and defect control remain paramount.

PVDF–BCZT Nanocomposite Films via Doctor Blade Method for Efficient, Scalable, and Cost-Effective Hybrid Energy Harvesting

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Triboelectric nanogenerators (TENGs) have emerged as efficient and versatile system for harvesting ambient mechanical energy from daily activities like walking, machine vibrations etc. Ferroelectric materials with spontaneous and switchable polarization can significantly enhance the triboelectric performance of these energy harvesters. This additional polarization in system can modify surface potential, improve charge transfer efficiency and charge retention. In this work, $Ba_{0.85}Ca_{0.15}Zr_{0.1}Ti_{0.9}O_3$ (BCZT) incorporated into a polyvinylidene fluoride (PVDF) matrix to form PVDF–BCZT nanocomposite films to enhance triboelectric performance of pure PVDF film. BCZT piezoceramic nanoparticles were synthesized via the sol–gel method and XRD and SEM analyses confirmed phase-pure BCZT nanoparticles (<70 nm). The films were fabricated using the doctor blade technique, yielding uniform and scalable ferroelectric films. TENG performance was evaluated in contact– separation mode, showed a significant increase in triboelectric output for PVDF–BCZT composites compared to pure PVDF films, with V_{OC} enhanced 1.5 times compared to pure PVDF. The device was tested after one month and for multiple operational cycles, showing no degradation in performance. The fabricated device successfully powered small electronic gadgets, demonstrating its application potential. These results indicate great promise for the large-scale production of composite films with remarkable flexibility, durability for ambient energy harvesting and self-powered wearables.

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Spectroscopic study of CVD-grown MoO_2@MoS_2 core–shell nanorods: role of structural geometry

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The chemical vapor deposition (CVD) growth of high-aspect-ratio MoO_2@MoS_2 core–shell nanorods with a crystalline MoO_2 core and multilayer MoS_2 shell is demonstrated on sapphire and silica substrates. Optical and vibrational studies using photoluminescence (PL) and Raman spectroscopy reveal distinct resonance-enhanced features arising from strong coupling between the MoO_2 core and the MoS_2 shell. A detailed Raman analysis highlights selective resonant mode enhancement and complex peak overlap due to simultaneous resonance of both components. Furthermore, a pronounced blue shift (≈ 40–70 meV) in the A-exciton PL peak is observed, attributed to interfacial strain and dielectric modulation at the core-shell boundary. These findings underscore the crucial role of structural geometry and interfacial interactions in tailoring the optoelectronic response of MoO_2@MoS_2 core-shell nanorods.

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Diagonally related and electronically identical 3d-4d redox pairs for competing double exchange/super exchange interactions in pseudocapacitive energy storage

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Leveraging the similarities in redox potentials and ionic radii of Mn and Ru species by virtue of their exclusive diagonal relationship in the periodic table, Ru doped $K_{1.39}Mn_3O_6$ (**$KMnO_2$:Ru**) was proposed as an electrode material, yielding rich synergistic redox chemistry for high-performance supercapacitor applications. The competing interplay between double exchange (**Mn^{3+}/Mn^{4+}**) and super exchange (**Mn^{3+}/Ru^{4+}**) interactions among Mn and Ru species led to a notable electrochemical performance, exhibiting a specific capacitance of 475 F/g at 2 A/g within a potential window of 0 V to 1.1 V (vs Hg/HgO) in a pH neutral aqueous electrolyte. Distribution of Relaxation Times (DRT) tool was used for the analysis of timescales corresponding to the processes governing the ohmic, charge-transfer, and diffusion resistances at the electrode/electrolyte interface. A two-electrode system consisting of $KMnO_2$:Ru as a cathode and activated carbon as anode was fabricated, delivering a high energy density of 160 W h/kg at a power density of 2.1 kW/kg over a potential window of 2.1 V. Density functional theory (DFT) was used to estimate the trends in quantum capacitance (C_Q) and surface charge density (Q), within the potential between $-1.2\ V < \Phi < 1.2\ V$, revealing that Ru doping alters the electronic structure by increasing the population density at Fermi-level, enhancing C_Q and Q as a consequence of improved electronic conductivity and redox activity. This study demonstrates that Ru doping effectively enhances the charge storage properties of $KMnO_2$, highlighting its potential as an efficient material for advanced energy storage applications.

Designing Donor–Acceptor Interfaces with Built-In Electric Potential Using Hierarchically Grown NiTe–CeO_2 Heterostructure for Efficient Water Oxidation

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Hydrogen is regarded as a promising energy carrier for future demands, and water electrolysis stands out as a highly effective and practical approach for its production. However, the overall efficiency of water electrolysis is hindered by the sluggish kinetics of the oxygen evolution reaction (OER), a complex four-electron transfer process that significantly limits the reaction rate. Therefore, developing highly efficient electrocatalysts with low overpotentials is crucial to accelerate the reaction rate, thereby enhancing the overall process. Noble metal oxides such as IrO_2 and RuO_2 have been recognized as benchmark electrocatalysts for the OER in both acidic and alkaline environments. However, their limited availability and high cost significantly hinder large-scale application. Hence, the development of cost-effective and readily available catalysts is essential to address this challenge and enable large-scale hydrogen production. Catalysts based on transition metal tellurides have gained global scientific interest due to the lower electronegativity and stronger metallic character of tellurium (Te) than other chalcogens like selenium (Se), sulphur (S), and oxygen (O), imparting covalent character to the metal-chalcogen bond leading to a favourable electronic band structure align for water oxidation and reduction. The activity of the OER is determined by the adsorption behaviour of intermediates, which is influenced by the electronic structure of the catalyst. However, earlier studies revealed that transition metal tellurides struggle to overcome the high-energy barrier for converting the O* intermediate into the crucial OOH* intermediate, thereby restricting their catalytic efficiency. As heterojunction engineering is considered an effective approach for modifying the surface charge states of catalysts, therefore CeO_2 is combined with telluride owing to its variable oxidation states, oxygen vacancies, and high surface area.

In this work, we developed a NiTe/CeO_2 heterojunction[5] utilizing a donor–acceptor strategy, where CeO_2 serves as the electron donor and NiTe acts as the electron acceptor. Kelvin probe force microscopy (KPFM) measurements indicated that the work functions of NiTe and CeO_2 promote charge transfer during their interfacial coupling. This interfacial interaction generates a built-in electric field within the heterojunction, which strongly tunes the surface electronic structure of NiTe through its coupling with CeO_2, delivering an overpotential of 263 mV at 10 mA $cm^{-2}$and a Tafel slope of 81 mV $dec^{-1}$for the OER. The heterojunction formation enhanced the electrochemically active surface area (C_{dl} of 10.5 µF cm^{-2}) and lowered the charge-transfer resistance (1 Ω), leading to a higher turnover frequency (3 s^{-1}) compared to the pristine material.

Origin and Impact of Electron-Phonon Interaction on Reversible Thermochromism in Cs2NaFeCl6 Halide Double Perovskite

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Halide double perovskites (HDPs) have emerged as structurally robust and environmentally friendly alternatives to organic-inorganic hybrid perovskites, making them highly attractive for photovoltaic and optoelectronic applications. Owing to their excellent stability and tunable electronic properties, HDPs have been successfully explored in solar cells, light emitting diodes, photodetectors, lasers, and photocatalysis. Among their intriguing characteristics is thermochromism, a phenomenon in which the material undergoes a color change with temperature. Such a property has potential applications in smart windows, temperature sensors, virtual thermometers, displaying devices, and many more areas. In HDP semiconductors, charge carriers are typically confined near the band edges, where electron-phonon interactions are dominated by long-wavelength lattice vibrations. Factors such as crystallographic defects, compositional disorder, doping, and external stimuli like temperature or pressure may introduce potential fluctuations into the semiconductor's electronic structure, enhancing electron-lattice scattering. As a basic control parameter, temperature primarily introduces lattice thermal expansion and alters the carrier-phonon interactions, which subsequently impact the optoelectronic properties of the material. Here, we offer both qualitative and quantitative analyses of the fundamental causes of electron-phonon interactions and their impact on the electronic structure of the novel halide double perovskite $Cs_2NaFeCl_6$ through comprehensive Raman spectroscopy, X-ray diffraction (XRD), and X-ray absorption fine structure (XAFS) studies. Although no structural phase transition was observed in this material, local octahedral distortion due to charge localization and strong electron-phonon coupling was noted. This distortion alters the electronic landscape of the lattice, which is responsible for the material's remarkable thermochromic behaviour and is reversible in nature. Understanding the structure-property correlation and the potential dynamic mechanism in this lead-free halide double perovskite will reinforce the designing of emerging optoelectronic devices.

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Reversible $CsPbBr_3$ ↔ $CsPb_2Br_5$ Transformation via Reverse Micellar Aqueous Solution

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Lead-halide perovskites suffer from water and moisture instability due to the highly ionic nature of the crystal structures, though a few groups took advantage of it for the chemical transformation via water-assisted strategy. However, direct exposure of perovskite to bulk water leads to uncontrolled chemical transformation. Here, we report a controlled chemical transformation of $CsPbBr_3$ to $CsPb_2Br_5$ triggered by nanoconfined water, by placing $CsPbBr_3$ in the non-polar phase within a reverse micelle. The chemical transformation reaction is probed by using steady-state and time resolved optical spectroscopy. We observe absorption and photoluminescence in the UV region stemming clearly from the $CsPb_2Br_5$ phase upon interaction with the reverse micellar aqueous solution. Transmission electron microscopy and X-ray diffraction measurements further provide the structure and morphology. Our results direct the formation of $CsPbBr_3$-$CsPb_2Br_5$ nanocomposite under dry conditions while the chemically transformed $CsPb_2Br_5$ phase exists only in the moist condition, which we explain via the CsBr-stripping mechanism.

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Copper Nanoclusters Exhibiting Aggregation-Induced Delayed Fluorescence for the Fluorescent Detection of Hg^{2+} and ClO^- Ions

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Aggregation-induced fluorescence exhibits huge potential in modifying the luminescent properties of metal nanoclusters, as aggregation enhances both prompt and delayed fluorescence (DF). The aggregation-induced delayed fluorescence (AIDF) widens the chemical sensing abilities due to extended luminescence lifetimes. Here, we demonstrate an unprecedented aggregation effect on the photoluminescence mode of copper nanoclusters (CuNCs) from prompt to delayed fluorescence upon addition of metal salts. The aggregation behavior and the corresponding AIDF depend on the nature of metal ions and the corresponding counter anions (SO_4^{2-}, CH_3COO^-, and NO_3^-). Zn^{2+} ions effectively promoted the AIDF compared to other metal ions. Surprisingly, the Zn^{2+}-induced AIDF was augmented only in the presence of the acetate (CH_3COO^-) anion, which resulted in a narrow size distribution due to its strong ability to stabilize the primary nanoclusters. On the other hand, NO_3^- could not stabilize the nanoclusters, which resulted in a broad distribution, forming less organized self-assembly. Moreover, AIDF harnessed from Zn-CuNCs was successfully employed to detect hypochlorite (ClO^-) and mercuric (Hg^{2+}) ions in aqueous medium, which was further compared with normal fluorescence sensing. The limits of detection (LODs) of ClO^- and Hg^{2+} for DF were 1.05 and 6.63 nM, whereas the LODs obtained by fluorescence sensing were 4.14 and 8.16 nM, respectively. Thus, AIDF improves the sensing property of Zn-CuNCs compared to normal fluorescence.

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Influence of Sn and Yb substitution on the NIR reflectance of Fe2O3 based red pigments

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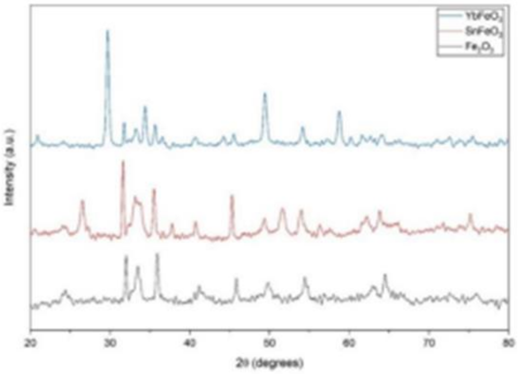

Iron (III) oxide is a widely used red and related pigment with notable NIR reflectance and other optical properties [1]. However, its optical and reflectance properties are often influenced by various factors including crystallinity, particle size and other structural modifications. In the present investigations, Fe_2O_3 was synthesized from $FeCl_3$ and was calcined at varying temperatures [2]. The varying temperature optimizes the phase stability and morphology. To study the effect of cation substitution, the Fe_2O_3 was further combined with compounds such as SnO_2 and Yb_2O_3 in proper stoichiometric ratios using Solid-State reaction method, followed by high temperature calcination to form $SnFeO_3$ and $YbFeO_3$ pigments [3]. The synthesized composites were characterized by X-ray diffraction for structural analysis and FESEM for morphological evaluation. The UV-Vis-NIR was taken in order to find the optical behavior and NIR Reflectance efficiency of the composites. The reflectance results shows that the incorporation of Sn and Yb increase the NIR reflectance of the title compound.

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Flexible PVDF Films Reinforced with Mildly Delaminated $Ti_3C_2T_x$ for Enhanced Piezoelectric Energy Harvesting

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Two-dimensional MXenes, such as titanium carbide ($Ti_3C_2T_x$), exhibit excellent electrical conductivity, large surface area, and tunable surface chemistry, making them ideal candidates for flexible piezoelectric nanocomposites. In this study, $Ti_3C_2T_x$ nanosheets were prepared via a mild delamination process and subsequently incorporated into a poly(vinylidene fluoride) (PVDF) matrix with different weight percentages using a drop-casting technique to fabricate flexible thin films. Structural and phase analyses using X-ray diffraction (XRD) confirmed the crystallinity of the $Ti_3C_2T_x$ and its successful integration into PVDF, while Fourier-transform infrared spectroscopy (FTIR) revealed a significant enhancement of the electroactive β-phase in PVDF induced by the MXene filler. Morphological characterization by scanning electron microscopy (SEM) demonstrated uniform dispersion of $Ti_3C_2T_x$ within the polymer matrix and strong interfacial interactions. The conductive MXene network facilitated efficient charge transport, enhancing the generation of piezo-induced charges. Preliminary performance evaluation under mechanical excitation indicated improved output compared to pristine PVDF, highlighting the potential of $Ti_3C_2T_x$/PVDF composites as flexible, self-powered materials for energy-harvesting applications.

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Large-sized reduced graphene oxide thin film for improved heat dissipation

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In modern electronics, continuous miniaturisation of devices causes an exponential increase in power density. Efficient thermal management has become a critical challenge for maintaining device performance, reliability, and lifespan. Graphene oxide and its derivative thin films emerged as a promising material for thermal management applications because of their tunable thermal and structural properties. The properties of reduced graphene oxide thin films strongly depend on their lateral size. In this work, we explore the lateral size-driven surface free energy and thermal conductivity, as well as the heat dissipation ability of the reduced graphene oxide (rGO) thin films. Reduced graphene oxide thin films having large lateral size (rLGO) exhibit significantly more hydrophobic behaviour compared to conventional reduced graphene oxide films (rGO), resulting in a lowest surface energy of 38.268 mJ/m2. Surface free energy analysis confirms the differences in oxygen functional group density with respect to its lateral sizes. The thermal measurements indicate that the rLGO film exhibits higher thermal conductivity than the rGO films. The distinct effect of lateral size is also visible in heat dissipation performance. rLGO thin films have higher heat dissipation ability than rGO. The improved heat-spreading performance of rLGO thin films highlights its capability as thermal interface materials (TIMs) in next-generation electronics on a large scale.

Keywords: Reduced graphene oxide thin film; Thermal interface material; Surface free energy; Heat dissipation

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PVDF/MoSSe-based Piezoelectric Nanogenerator for Self-Sustained Gas Sensing Platform

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Development of self-operated gas sensors is highly valuable in the field of ambient energy harvesting technologies. Among other methodologies, piezoelectric nanogenerators (PENGs) are more attractive because of their stable and repetitive output generation. In this work, a self-sustained gas sensor based on a PVDF/MoSSe piezoelectric nanogenerator (PMPNG) was developed for gas sensing applications. Janus MoSSe nanosheets were prepared using a hydrothermal technique, and their addition as filler materials in optimised proportions significantly improved the conductivity of the composite film. The active layer of the PENG comprised the PVDF/MoSSe nanocomposite film, which provided a peak output voltage of 20 V and current output of 1.6 µA, exceeding the output response of the structure made without the filler. The harvested electrical energy was also verified by the charging of various commercially procured capacitors. A portable gas sensor was prepared on a Kapton substrate having an interdigitated electrode structure that was defined through a sputtering technique. Upon packaging with the PMPNG, the sensor showed high selectivity as well as significant sensitivity to the target gas. In conclusion, this research reveals an affordable strategy for the fabrication of self-operated gas sensors, hence paving the way forward for the advancement of smart sensing platforms as part of Industry 4.0 as well as Internet of Things (IoT) applications.

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Tunable Energy Dispersion in Double Quantum Wires via Rashba Spin–Orbit Interaction and External Fields

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This theoretical study examines the energy dispersion properties of tunnel-coupled double quantum wires (DQWRs) subjected to a double-well confinement potential under the influence of external magnetic and electric fields, as well as Rashba spin– orbit interaction (SOI). A uniform magnetic field is applied perpendicular to the wire plane. Within the effective mass approximation and assuming a parabolic band structure, the time-independent Schrödinger equation is solved numerically using matrix diagonalization to obtain the system's energy levels and corresponding wavefunctions [1]. The results reveal that external perturbations—namely, magnetic and electric fields together with Rashba SOI—significantly modify the energy spectrum, leading to both lateral and vertical shifts as well as upward and downward displacements. These findings demonstrate the tunability of DQWR systems and underscore their potential for future applications in quantum wire-based electronic and spintronic devices.

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Enhancing Triboelectric Nanogenerators Performance with MXenes -Silicone Nanocomposites: A Leap Forward in Energy Harvesting and Touch-Sensitive Technologies

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Two-dimensional transition metal carbides and nitrides (MXenes) have multifunctional applications in energy storage, electromagnetic interference (EMI) shielding, sensors, and flexible electronics. However, utilization of MXenes for energy harvesting applications is limited and started recently with triboelectric nanogenerators (TENGs). This work introduces a simple and cost-effective approach for advancing the performance of TENGs by utilizing MXene-Silicone nanocomposite film and aluminium as a triboelectric pair. MXene is combined with Silicone, a flexible polymer matrix, to form a nanocomposite layer for TENG applications. The electron-accepting nature of Silicone film was enhanced by adding triboelectric negative MXenes. To reduce TENG's device fabrication steps, nanocomposite films were prepared directly on the aluminium foil by the film casting technique. The fabricated MXene-Silicone nanocomposite based TENG exhibited an impressive power density of 14.9 W/m^2, which is 3-fold higher than a pristine Silicone-based TENG. Under consistent mechanical stimulation, the TENG was capable of producing sufficient power to illuminate two LED lamps and continuously operate a digital calculator. The stability and robustness of the TENG were evaluated through a series of tests spanning 10,000 cycles over a period of six months, demonstrating consistent performance. Finally, using Arduino boards and the Blink app, self-powered touch-sensing technology was developed for security applications. The developed technology can send wireless alerts or notifications to mobile devices in the event of unauthorized access. These results illustrate MXene's potential as a preferred material for applications such as energy harvesting, wearable electronics, self-sustaining systems, and touch-sensitive technologies.

V_2C MXene based Self Powered Supercapacitor for Energy Harvesting and Storage Applications.

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The evolution of flexible and sustainable energy harvesting systems will be essential to get bigger demand for self-powered technology. Triboelectric nanogenerators (TENGs) have gained importance due to their ability to conversion low-frequency mechanical energy into electrical power. This study introduces a V_2C MXene/polyvinylidene fluoride (PVDF) composite-based TENG that is connected with a supercapacitor for efficient energy storage.

Adding V_2C MXene into PVDF enhances its dielectric constant, charge trapping ability, and interfacial polarisation, therefore which leads to higher triboelectric output. The device generates constant voltage and current under mechanical stimulation and successfully charges the integrated super capacitor, which has exceptional charge-discharge properties and high energy retention. Using V_2C MXene and PVDF boosts the TENG's energy harvesting efficiency and provides a reliable source of power for wearable electronics, sensors, and portable devices. This study presents a viable approach to combined nanogenerator-super capacitor systems for sustainable energy solutions.

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Er^{3+} tailored structural, dielectric and optical tuning in $BaBi_4Ti_4O_{15}$:Bi_2O_3 Ceramics for advanced device applications

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In the present work, $BaBi_4Ti_4O_{15}$ (BBT) and Er-doped $BaBi_{3.92}Er_{0.08}Ti_4O_{15}$ (BBTE8) ceramics were prepared using the conventional solid-state reaction route to examine the role of erbium incorporation on the structural, dielectric, and optical characteristics of BBT ceramics. To counter the volatilization of Bi_2O_3, 2 wt% excess bismuth oxide was introduced. The synthesized powders were first calcined at 950 °C, followed by sintering at 1050 °C. X-ray diffraction confirmed the formation of a pure tetragonal Aurivillius phase in all samples, whereas scanning electron microscopy indicated smaller grain sizes and higher structural disorder in the BBTE8 composition. Dielectric measurements revealed a diffuse phase transition with frequency-dependent permittivity peaks, a hallmark of relaxor-type ferroelectrics. A noticeable shift in Curie temperature and a higher diffuseness parameter (γ) were observed, with BBTE8 displaying the most prominent relaxor behaviour. Polarization–electric field (P–E) loop analysis showed enhanced remnant polarization ($2P_r$), attaining a value of 15.38 $\mu C/cm^2$ for BBTE8, which is associated with lower oxygen vacancy density and reduced domain wall pinning. Photoluminescence spectra were employed to probe the optical response. Taken together, the BBTE8 composition demonstrates significant potential as a lead-free material for dielectric and energy storage applications owing to its superior relaxor behaviour and improved electrical as well as optical properties.

Keywords: BLSF Ceramics; Dielectric Properties; Photoluminescence; Er doped $BaBi_4Ti_4O_{15}$.

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Impact of surface energy of SAM blends on photophysical properties of perovskite thin films

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Metal halide perovskite solar cells have achieved impressive power conversion efficiencies, reaching ~26% for single-junction and over 34% for perovskite-silicon tandem devices. However, challenges related to efficiency losses and long-term stability still hinder their widespread adoption. A significant factor contributing to these losses is the suboptimal performance of conventional charge transport layers. Recently, self-assembled monolayers (SAMs), particularly carbazole-based ones like 2PACz, have shown promise as superior hole transport layers (HTLs), offering improved energy alignment, reduced parasitic absorption, and enhanced device stability. Specifically, their tunable dipole moments and ability to modify the work function of transparent electrodes enable precise control of interface energetics and surface properties. Recently, it has also been understood that forming SAMs from blends of 2PACz derivatives with different functionalization has enabled precise tuning of the valence band energy level alignment at the HTL interface, which led to improved photostability of wide bandgap PSCs [1]. Therefore, functionalization of SAMs not only optimizes electronic alignment but also influences perovskite film morphology by altering substrate surface energy, which in turn affects the perovskite film's photophysical properties and the solar cell device performance.

In this study, we precisely blended SAM molecules containing polar and non-polar functional groups to simultaneously modulate the surface energy and electronic energy levels of the resulting SAM/ITO substrates. This approach produced substrates with water contact angles ranging from 56° to 74° and photoemission onsets between 5.0 eV and 5.4 eV. Utilising these substrates, we systematically examined how variations in surface energy influence perovskite film coverage, morphology, and photophysical behaviour. As the hydrophobicity of the SAM blends increased, we observed reduced film coverage and smaller grain sizes, which correlated with decreased photoluminescence quantum yield, photoconductivity, and carrier mobility, as determined by time-resolved THz spectroscopy. Transient reflectance (TR) and gated-CCD-based time-resolved photoluminescence (TRPL) measurements further revealed how SAM hydrophobicity affects excited-state dynamics and recombination from shallow trap states. Finally, we explore how the simultaneous tuning of surface energy and interfacial energetics in SAM blends influences overall device performance.

Gallium-Incorporated Copper Oxide Semiconductor for p-Channel Thin Film Transistors

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Metal oxide semiconductor (MOS) is widely studied in various emerging electronic applications such as thin film transistor (TFTs), active-matrix flat panel display (AMFPD), and neuromorphic computing due to their high transparency, wide band gap and excellent electrical properties. There are many TFTs for n-type metal oxide semiconductors (NMOS), such as zinc oxide (ZnO), indium oxide (InO), indium zinc oxide (IZO), indium gallium oxide (IGO), indium zinc tin oxide (IZTO), and indium gallium zinc oxide (IGZO), but very limited p-type metal oxide semiconductors (PMOS) for TFT manufacturing. Therefore, the development of PMOS for high-performance next-generation electronics is essential. Among many PMOS materials, copper oxide (CuO) offers a promising candidate, but has low mobility that limits the TFT performance. In this study, we investigate gallium incorporated CuO thin films prepared at a low process temperature. Gallium doping in CuO leads to a smoother surface morphology and significant suppression of trap states. Hall effect measurement confirms the p-type conduction in CuGaO film. Fabricated p-channel CuGaO TFTs exhibit excellent electrical properties such as low subthreshold swing (SS), higher field-effect mobility, as compared to pristine CuO TFT. Hence, p-channel CuGaO is a promising candidate for next-generation TFTs and logic circuits.

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High-Performance of Solution-Processed AlZrO$_x$ Memristor

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Metal oxides (MOs) high-k dielectric materials have emerged as promising candidates for next-generation electronics. Due to their high dielectric constant, and compatibility with low-temperature fabrication process makes cost effective. In this work, we demonstrate the synthesis and characterization of aluminium zirconium oxide (AlZrO$_x$) thin films prepared via solution-based methods, targeting their application in thin film transistors (TFTs) and memristive devices. The optimized AlZrO$_x$ film exhibited high bandgap and excellent transparency enables transparent electronics. The electrical properties of AlZrO$_x$ memristor exhibits stable switching characteristics. Furthermore, controlled UV/ozone (UV/O$_3$) treatment was employed to modulate oxygen vacancies, leading to enhanced device performance and improved reliability. The observed switching at low operating voltage of 0.5 V, coupled with high retention and endurance up to ~ 10^4. Thus, this study provides insights into the processing structure property relationship of high-k dielectrics in miniaturization of device and their integration into emerging devices in next-generation low power consumption electronics.

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Exploring two site occupation for ultra-broadband near infrared phosphor- Columbite $MgNb_2O_6$: Cr^{3+}

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With a considerable increase in the study of next-generation near infrared (NIR) spectroscopy across numerous industries, such as agriculture, food security and medical treantment, novel highly efficient NIR photonic materials exceeding 850 nm have limited success. In this work, a series of Cr^{3+} doped $MgNb_2O_6$ phosphor were successfully developed. X-ray diffraction (XRD) and Raman spectroscopy have confirmed material structure and phase purity of the $MgNb_2O_6$ phosphor. Under excitation with 515nm, phosphor generates a NIR emission peak at 930nm coving range of 750-1250 nm. The emission peak located at 930 nm have fullwidth at half maximum of 170 nm. This ultrabroadband NIR emission originates from the $^4T_2 \rightarrow ^4A_2$ transition of Cr^{3+} and simultaneous occupation of [MgO_6] and [NbO6] octahedrons by Cr3+ ion. Such occupancy of Cr^{3+} is confirmed by excitation wavelength dependent emission spectra, Time-resolved photoluminescence spectra (TRPL), and Electron Paramagnetic Resonance spectra (EPR).

Keywords: Phosphor, Near infrared, Broadband.

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Impact of Thermal Annealing on Microstructural Evolution and Electrical Performance Enhancement of DC Sputtered Cr_2O_3 Thin Films for Schottky Diode Applications

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Cr_2O_3 thin films were synthesized by DC magnetron sputtering under varying oxygen flow rates to systematically investigate the influence of oxygen content and thermal annealing on their structural, optical, and electronic characteristics. XRD and Raman spectroscopy confirmed the formation of pure phase Cr_2O_3 with enhanced crystallinity and reduced lattice strain after annealing, while SEM/EDS analysis demonstrated uniform and compact film morphology across all samples. XPS investigations indicated predominant Cr^{3+} oxidation states with oxygen deficiency that substantially decreased upon thermal treatment, confirming improved chemical stability and complete transformation from amorphous to polycrystalline phase at temperatures above 400°C. Optical characterization revealed a direct band gap ranging from 2.7 to 3.1 eV with notably reduced Urbach energy following annealing, indicating decreased structural disorder, while Hall effect measurements confirmed p-type conductivity with carrier concentrations in the range of 10^{16}-10^{18} cm^{-3} and reduced resistivity after thermal treatment. Schottky diode I-V characterization demonstrated using thermionic emission, Cheung, and Norde extraction methods revealed significant improvements in device parameters following annealing including ideality factor decrease from ~4.87 to 2.95, series resistance drops from ~995 kΩ to 115 kΩ, and barrier height stabilization at approximately 0.78 eV, indicating reduced defect mediated conduction mechanisms and enhanced carrier transport pathways. These results demonstrate that controlled thermal annealing significantly enhances the structural integrity, optical properties, and electronic performance of Cr_2O_3 thin films deposited by DC magnetron sputtering, with optimized films showing good potential for integration into diode structures and optoelectronic devices.

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Scalable Ultrasonic Spray Pyrolysis of MnO_xS_y Thin Films for Next-Gen Supercapacitors

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Manganese oxy-chalcogenide (MnO_xS_y) thin films were fabricated using ultrasonic spray pyrolysis as electrode materials for supercapacitor applications. The systematic variation of thiourea concentration (0.1-0.6 M) and substrate temperature (200–300 °C) enabled controlled sulfur doping and optimization of film properties. X-ray photoelectron spectroscopy analysis revealed the formation of mixed-valence manganese oxysulfide phases with coexisting Mn^{2+}/Mn^{3+} oxidation states and the presence of both sulfide and oxidized sulfur species, confirming successful chalcogen incorporation. XPS quantification established the stoichiometric formula as approximately $Mn_3O_{3.7}S_{0.4}$, indicating a mixed oxide-sulfide composition with an oxide-to-sulfide ratio of 9.18:1. Energy-dispersive X-ray spectroscopy confirmed sulfur content ranging from 3.8% to 16.9% depending on synthesis conditions. Films synthesized at 220 °C with a 1:4 ratio of manganese acetate to thiourea exhibited optimal electrochemical performance. They showed a specific capacitance of 28.9 Fg^{-1}, a charge transfer resistance of 8.63 kΩ, and a solution resistance of 7.20 Ω. Additionally, these films demonstrated superior wettability, with a contact angle of 46.4°. The corresponding areal capacitance was measured at 0.66 mF/cm^2. Thermogravimetric studies confirmed that the selected temperature window facilitates complete precursor decomposition while maintaining effective sulfur integration. This work establishes ultrasonic spray pyrolysis as a viable synthesis route for producing compositionally tunable manganese oxy-chalcogenide thin films with controllable surface chemistry and electrochemical characteristics suitable for flexible energy storage devices.

Engineering of Cathode and Electrolyte Additives Enables Highly Reversible Zn-ion Battery

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Demand for high-efficiency energy storage and conversion devices is continuously increasing due to the ever-increasing human population and modernisation of society. Renewable energy technologies, such as fuel cells and batteries, have garnered significant attention for mitigating carbon emissions. Aqueous zinc-ion batteries are considered viable alternatives to lithium-ion batteries due to their built-in safety, adaptable structural options, and eco-friendly the primary categories of cathode materials found in zinc-ion batteries are manganese-based compounds, vanadium-based substances, Prussian blue analogues, organic compounds, transition metal sulfides and oxides, metal–organic frameworks (MOFs), covalent organic frameworks (COFs), and MXene-based layered materials. They encounter challenges related to zinc ion diffusion resistance and vanadium solubility. Transition metal sulfides and oxides also have high theoretical specific capacities, but their electrical conductivity and structural stability require improvement. The structures of metal-organic frameworks (MOFs) and covalent organic frameworks (COFs) can be designed to offer large specific surface areas; however, they suffer from low electrical conductivity and involve complicated synthesis methods. Enhancing the efficiency of zinc-organic batteries can be achieved by creating new organic molecules and polymer-based cathodes. Organic triazine-based framework shows commendable chemical stability and redox capability as a cathode material; however, they possess low electronic conductivity. To improve the conductivity, herein we proposed an in-situ method of electronic conductive N-doped reduced graphene oxide (NrGO) to activate Poly (Imides-Triazine) based framework for a superior cathode material for a stable aqueous Zn-ion Battery. Another challenge in Zn-based batteries is the non-uniform deposition of Zn during plating, which results in dendrite growth. Due to the irreversible nature of the Zn anode, the lifetime of the battery is reduced. By engineering the electrolyte, the desolvation of Zn can be directed for the uniform deposition of Zn, and the local environment of the Zn anode can be modulated for the dendrite suppression. This approach enables the enhancement of zinc reversibility without compromising energy density or other additional processes. Herein, a dual electrolyte strategy has been employed by using two polar aprotic cosolvents, Dimethyl ethylene glycol dimethyl ether (DME) and Hexamethylphosphoramide (HMPA), in a 2M ZnSO4 electrolyte to regulate the solvation structure of Zn. Due to the presence of two cosolvents, the parasitic HER and Zn corrosion are suppressed. The abundant coordination sites of both electrolytes interact with the Zn ion, facilitating the reduction of the number of water molecules in the Zn solvation structure. The HMPA facilitated the deposition of zinc on the (002) plane, which has low surface energy and facilitates uniform growth. Simultaneously, DME will suppress the parasitic hydrogen evolution reaction (HER) to enhance the stability and reversibility of the Zn anode.

DG-DM-DDP-SiGe-TFET: A Promising Platform for Low-Power, High-Sensitivity Biosensors

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A dual-metal double-gate heterostructure tunnel field-effect transistor with a drain dielectric pocket (DM-DG-DDP-SiGe-TFET) was simulated to evaluate its electrical performance. The device incorporates a high-permittivity hafnium dioxide (HfO_2) layer as the gate dielectric and silicon-germanium ($Si_{0.6}Ge_{0.4}$) as the source, which provides a low-bandgap injection region. Silicon with varying concentrations serves as both the channel and drain, creating a high-bandgap pathway for carrier transport and collection. The dual metal electrodes have a work-function of 4.08 and 5.1 electron volts (eV), respectively, along with a high-k (HfO_2) dielectric pocket, which is positioned near the HfO_2/drain contact to improve ambipolarity. This heterostructure material configuration increases the drain current, leads to negligible OFF-state leakage current (I_{OFF}), improves gate electrostatics, and reduces short-channel effects. The combined use of engineered materials and device geometry—including a moderate to high work-function for the gate electrodes and a high-permittivity dielectric—improves switching, reduces off-state leakage, and achieves a steep subthreshold swing. These design elements support low-power operation and biosensor applications. The performance of the proposed DM-DG-DDP-SiGe-TFET, such as I_{ON}/I_{Amb} ratio and subthreshold swing, is quantitatively compared to conventional Si-TFET and heterostructure TFET devices under identical simulation conditions. The effects of DDP length (Lp), thickness (tp), and alloy fraction (x) of the Si1-xGex source on device performance are analyzed. The DM-DG-DDP-SiGe-TFET achieves a much higher I_{ON}/I_{Amb} ratio and a lower subthreshold swing (SS) for optimized values of Lp = 40 nm and tp = 3 nm. Device simulations used the Silvaco Technology Computer-Aided Design (TCAD) Atlas simulator.

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High-Performance Biomass-Derived Red- and Green-Emissive Carbon Dots with Narrow Emission for White-Light-Emitting Diodes Comprising a 97 Colour Rendering Index

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Carbon dots (CDs) derived from natural resources have been particularly promising nanomaterials in recent years for white-light-emitting diodes (WLEDs) due to their high stability, low cost, and ecofriendliness. Deep-red-emissive CDs with narrow full-width at half-maxima (FWHM) are essential for application in WLEDs industries. Here, we synthesised deep-red (>660 nm)-emissive CDs with a narrow FWHM of 22 nm by a readily available biomass source. The solvent alteration approaches produce green-emissive CDs using the same precursors. Experimental investigations suggest that CDs' deep-red emission originates from the synergetic effect of CDs' core and edge states. Red- and green-emissive polymer composite films are prepared by dispersing the corresponding CDs into polyurethane and poly (vinyl alcohol). The composite films are laid out on top of a UV chip to create a white light. The fabricated WLEDs obtained Commission Internationale de l'Eclairage coordinates were (0.32, 0.34), which is almost exactly white, with a high colour rendering index (CRI) of 97 and a colour-correlated temperature (CCT) of 5987 K, which is suitable for implementation in display technology. This research offers newly developed deep-red-emitting CDs with narrow FWHM and also provides a biomass-derived fluorophore for fabricating exceptionally high CRI in WLEDs. Furthermore, biomass-derived CDs, with low cytotoxicity and medicinal significance, also serve as a promising biocompatible alternative for bioimaging.

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Flash Joule Heating of Plastic Waste into Graphene Nanomaterials for High-Performance Supercapacitors

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This study employs flash joule heating (FJH) to efficiently synthesize turbostratic graphene from high-density polyethylene (HDPE) plastic waste, advancing sustainable nanomaterial production. In a lab-scale FJH setup, HDPE is transformed into graphene via rapid capacitive voltage discharge, heating precursors above 3000°C in milliseconds. The resulting graphene's quality is evaluated using Raman spectroscopy, scanning electron microscopy, and transmission electron microscopy. Raman analysis reveals a high I2D/IG ratio (1.22) and a low ID/IG ratio (0.05), confirming minimal defects and high-quality nanostructure formation. A mechanically flexible, binder-free electrode was fabricated using functionalized carbon nanotubes (FCNT) as the current collector and flash graphene (FG) as the active material, and tested in a three-electrode supercapacitor configuration. It achieves a specific specific capacitance of ~246 F/g at a current density of 0.3 A/g, alongside an energy density of ~1.17 Wh/kg and a power density of ~4.2 kW/kg. These results highlight FG's exceptional charge storage capacity and rapid energy delivery, making it highly suitable for advanced supercapacitor applications, such as in electric vehicles and portable electronics. By upcycling HDPE waste, this method addresses plastic pollution while producing valuable nanomaterials. By eliminating use of hazardous chemicals during synthesis and post synthesis treatment distinguishes it from conventional graphene synthesis methods like CVD or chemical oxidation, which are energy-intensive and less eco-friendly.

Keywords: Ultrafast Synthesis; Flash Joule Heating; Graphene; Raman Spectroscopy

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MoTe₂ Synaptic Memristor for Brain Inspired Neuromorphic Architectures: Toward Associative Learning and Image Recognition

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Memristor devices fabricated through solution processing demonstrate strong potential for synaptic applications, delivering scalable, economical, and energy-efficient platforms for future neuromorphic computing.[1] Memristors can emulate biological synapses by using their electrically programmable resistance to precisely control various functions over space and time which makes them a critical component for creating sophisticated neuromorphic systems.[1]In this study, a two-terminal memristor device was fabricated using highly crystalline 2H-MoTe2 embedded in a PVA matrix to investigate how the formation of a percolative network drives the device's resistive switching behavior. The device with a $MoTe_2$: PVA ratio (3:1) exhibits stable bipolar resistive switching with a lower operating voltage (~0.3V). The device can also mimic crucial synaptic functions, such as paired-pulse facilitation (PPF), spike-timing dependent plasticity (STDP), spike number dependent plasticity (SNDP), and voltage dependent plasticity (VDP). Their neuromorphic potential is further demonstrated through associative learning, morse code detection, image recognition and benchmarked through simulations employing multilayer perceptron (MLP) and convolutional neural network (CNN) architectures for off-chip digit classification on the CIFAR-10 dataset. Overall, the experimental findings establish $MoTe_2$ memristors as promising enablers for next generation in-memory computing, neuromorphic systems, and AI-driven technologies.

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Gamma Radiation-Induced Defect Dynamics and Sensing Potential of TeO_2/n-Si Thin Films

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This study reports on the structural, electrical, and chemical characterization of TeO_2/n-Si thin film diodes, fabricated by depositing TeO_2 onto Si substrates through the thermal vapor deposition technique. The deposited samples were subsequently exposed to varying doses of gamma irradiation up to 200 Gy. Comprehensive analyses were performed to evaluate the impact of gamma irradiation to assess the potential the material for gamma radiation sensing. Morphological characterization using scanning electron microscopy (SEM) revealed no significant changes at the microscale level. X-ray photoelectron spectroscopy (XPS) depth profiling was employed to investigate the chemical states of the samples and their variation with depth. Optical measurements through Ellipsometry indicated a widening of the band gap from 2.58 eV to 3.07 eV with increasing irradiation dose. This is attributed to enhanced amorphization of the films. Electron paramagnetic resonance (EPR) spectroscopy was utilized to study the formation and evolution of irradiation-induced defects, with particular focus on the feasibility of retrospective EPR dosimetry(1). The EPR spectra, analyzed using EasySpin software, revealed three distinct paramagnetic defect centers, which are associated with Te ions and oxygen-related defects(2,3). Notably, the double-integral area under the EPR derivative signal decreased linearly with irradiation dose, demonstrating the suitability of TeO_2/n-Si thin film diodes for gamma radiation sensing applications.

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Microalgae biomass-based carbon dots as fluorescent turn-off probes for sensitive detection of hexavalent chromium ion (VI)

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The alarming rise in environmental pollutants raises significant concerns for human health. Heavy metal pollution is a global concern. One of the heavy metals, chromium, is widely used in various industries, including electroplating, leather and steel manufacturing. Humans may get exposed to it through contaminated air, drinking water or food as it is released into the environment in different forms. The presence of excess chromium, particularly as hexavalent chromium (VI), is highly toxic and can lead to severe health problems, including dermal, cancer and respiratory issues. To address this issue, carbon dots (CDs) have emerged as a promising platform for heavy metal detection due to their unique optical, thermal and physicochemical properties. In this study, we have synthesized water-soluble, environment-friendly and low-cost CDs derived from microalgae biomass. The green hydrothermal method was utilized for carbonization reactions. The as-synthesized CDs showed blue colour upon irradiation under UV light, confirming its excitation in UV range while in the photoluminescence (PL) study, it showed emissions in visible range. We then harnessed its optical property for the detection of hexavalent chromium ions by utilizing the principle of fluorescence quenching. Upon exposure to chromium ions, a significant quenching has been observed, and the PL reduction efficiency was found to be in the range of 47-96 %. The calculated quantum yield was 3.3 %. The calculated limit of detection (LOD) was approximately 1.803 ppm or 6.129 µM for hexavalent chromium ions measured across a broad concentration range of 0-150 µM. The synthesized CDs exhibited higher selectivity and sensitivity for chromium ions which makes them a promising biomass-based carbon dots detection system. These CDs offer a biodegradable, biocompatible, non-toxic and sustainable approach for real-world sensing applications. Thus, it proposes a potential blueprint for heavy metal detection in aqueous systems.

Pore-Engineered Vertically Aligned CoFe-LDH on Carbon for Enhanced Oxygen Evolution Reaction

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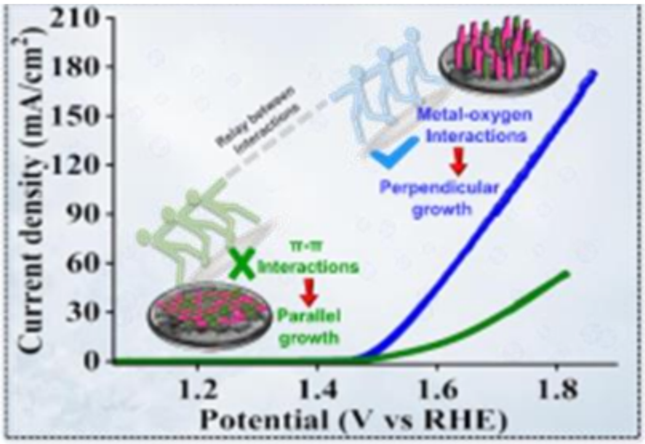
Porous carbon-supported CoFe-LDH catalysts were produced and utilized as exceptional catalysts for the oxygen evolution reaction in an alkaline medium. High-resolution transmission electron microscopy images and N_2-sorption measurements demonstrated the vertical growth of LDH on carbon support and the narrow mesoporous features of the materials, respectively. We proposed that the surface oxygen functional groups of carbon materials function as nucleation sites for the crystallization of the LDH on the carbon substrate via short-range electrostatic interactions, leading to the vertical development of LDH with a narrow mesoporous architecture. Among the synthesized materials, CoFe LDH/MMC shown an outstanding mass activity of 559.2 A g^{-1}, a turn-over frequency of 4.22 s^{-1}, and a significant roughness factor of 269. This exceptional reactivity is attributed to: (a) the vertically aligned narrow mesoporous structure of the material, which enhances electrolyte accessibility and thereby improves catalytic active sites, (b) the material's high electrical conductivity, and (c) the increased electron contribution to the 3d orbital of cobalt from carbon, which weakens the Co-oxygen bond and further facilitates O–O bond formation and O_2 desorption during water oxidation.



Modification Of Carbon Cloth Anode Using MnO_2 and Fe_2O_3 Nanoparticles in a Miniaturized Microbial Fuel Cell for Improved Power Generation

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In microbial fuel cells (MFC), one of many issues that hampers power production is linked to electrode efficiency thus, many research endeavors are made in the field of electrode modifications, particularly anode to accelerate microbial attachment and electron transport (Agrahari el at. 2021). This study involves anode modifications using metal oxide nano-particles like MnO and FeO on carbon cloth anode with varying ratios of both particles with carbon black. The synthesized nanoparticles were subjected to structural, morphological and size characteristics through FTIR, UV-Visible, PSA, XRD and FE-SEM analysis. Miniaturized single cell MFCs were operated using unmodified and modified anodes and analyzed for electrochemical characteristics. Electrochemical analysis of plain and modified carbon cloth (CC) reveals the peak current density of the MnO-modified anode was significantly higher than the unmodified anode. The modified anodes were operated on six different SC-MFC setups i.e., MFC 1 (bare CC anode and cathode), MFC 2 (FeO anode, bare cathode), MFC 3 (MnO anode, bare cathode), MFC 4 (bare CC anode and platinised cathode), MFC 5 (FeO anode, platinized cathode) and MFC 6 (MnO anode, platinized cathode). Of all six SC-MFCs the MFC 5, with CC anode modified using MnO nanoparticles (80%), showed the highest voltage of 354 mV with the maximum power density of 101.12 mW/m^2 followed by MFC 6, modified using 60% FeO nanoparticles. The FeO nanoparticles modified anode MFC 6 generated maximum power density of 88.21 mW/m^2 while the unmodified MFC provides a power density of 30.53 mW/m^2. Hence, the resulting modification enhances the power density 3.3x times for modified MnO2 and 2.8x times for modified FeO as compared to unmodified electrode MFC. Anode modification with economic and relatively less toxic nano-materials like MnO and FeO is an eco-friendly and cost-effective approach to upscale MFC technologies for field applications (Nosek et al. 2023)

Activated Carbon-Polyoxometalate Composite for High-Performance Supercapacitor Application

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Supercapacitors (SCs), also known as electrochemical capacitors, are gaining recognition for their long cycle life, high specific power, and fast charge-discharge rates. In this study, we fabricated a nanohybrid material by incorporating a faradaic-type POM into layers of activated carbon (AC). AC supported POM, a novel polyanion, silicotungstate n-hydrate ($K_5[SiVW_{11}O_{40}]$. nH2O) (abbreviated as $SiVW_{11}$), serves as a high-performance electrode material for SC. The combination of faradaic materials with capacitive materials has been validated using various analytical techniques. The AC-$SiVW_{11}$ hybrid material demonstrates a specific capacitance of 273.6 F/g at a current density of 0.5 A/g. It also shows enhanced energy and power densities of 38 Wh/kg and 1000 W/kg, respectively, when tested in a 0.5M H_2SO_4 electrolyte within a two-electrode symmetric configuration. Figure 1 depicts (a) BET analysis, (b) GCD, and (c) XRD plots of the AC-POM nanohybrid. Additionally, the hybrid material shows remarkable cycle stability, retaining 77% of its initial capacitance after 4000 sweeping cycles.

Keywords: Supercapacitor, Polyoxometalates, Activated Carbon (AC), Symmetric Cell

Tetrahedral kesterite Cu_2ZnSnS_4 nanomaterial for energy storage application

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Global energy demand has increased due to population explosion and climate change resulting from their enhanced lifestyle. While fossil fuels are expected to decline rapidly, renewable energy sources are gaining more popularity as they are kinder to the environment and may provide energy security. Energy storage devices are crucial for an uninterrupted supply of energy because the intermittent nature of these devices can alter their output. Batteries and supercapacitors are two sorts of electrochemical energy storage system that are vital for the economy to thrive. Supercapacitors have gained a great deal of interest and play a crucial role in future electric device, especially because of their significantly elevated power density, lengthy cycle life, and higher value of specific capacitance. Tetrahedral kesterite structure of Cu2ZnSnS4 commonly termed as CZTS have been extensively studied for solar cell applications due to its favourable optoelectronic characteristics and environmental friendliness. The most thermodynamically stable kesterite structure of CZTS is also being investigated for energy storage application from past few years due to its high surface area and other electronic properties. Our work contains a comprehensive investigation of CZTS as an electrode material for supercapacitors, highlighting a shift toward adaptive, viable, and renewable energy storage options.

Keywords: Kesterite, CZTS, energy storage, electrode material.

Harvesting Electricity from Living Beings Through Clay-Based Ionic Thermoelectric Devices

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Direct conversion of body heat to electricity through thermoelectric (TE) devices is emerging as an attractive option to power wearable electronics. As semiconducting TE devices suffer from the trade-off between electronic and thermal conductivity and high operating temperature, ionic thermoelectric devices relying on atmospheric humidity perfectly fit this low-temperature operating condition. Here, atomically thin 2D channels of reconstructed clay membranes were applied to demonstrate the possibility of harvesting electricity from body heat through ionic thermoelectric (i-TE) effect. Nanofluidic membranes prepared by reconstructing layers of montmorillonite clay (MMT) displayed outstanding ionic-TE characteristics. Thermal transport of intercalating cations through interconnected network of 2D channels yielded Seebeck coefficient (S_i) up to 13.63 ± 1.13 mV K^{-1}. As hydration of molecularly thin 2D channels are relied on atmospheric water molecules, ionic conductivity and S_i of MMT increases with the increasing humidity levels in the atmosphere. In contrast to polymer-based i-TE devices, clay membranes sustain exposure to high temperatures (~ 200 °C, 5 min) and self-repair physical damages with the help water droplets. The MMT membrane deposited on PET film generated voltages up to 63 mV (ΔT=1.8) at 85 % RH upon being pasted on human skin.

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Synergetic Combination of Bio-Electrolytes and Bio-Fluidic Channels as a Novel Resource of Sustainable Energy

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Exploration for sustainable energy resources is essential to minimize our dependence on fossil fuels and to improve environmental parameters. Here, we examined the possibility of utilizing bio-waste-derived electrolytes as an electrical energy resource by placing them across semipermeable membranes prepared through parallel stacking of coir fibres. The nanofluidic membrane (d-CF-V) prepared by modifying the inner walls of the bio-fluidic channels with atomically thin layers of vanadium pentoxide (VO) showed excellent perm-selectivity (t_+ = 0.87, with 1000-fold concentration difference) and electricity conversion efficiency (~ 28.2 %). With simulated sea and river water, the d-CF-V yielded output energy up to 2.4 W/m^2, similarly with mineral acid bases (0.5 M HCl and 0.01 M NaOH), the d-CF-V showed an energy output of 11.8 W/m^2. The sun-dried Garcinia morella (Kuji thekera), and charred peels of Musa balbisiana (banana) were used as sustainable sources of bio electrolytes, which in combination with permselective d-CF-V yielded a power density of about 1.4 W/m^2. By replacing standard Ag/AgCl electrodes with nanomaterials exhibiting contrasting charge transfer activities, i.e. oxidized carbon nanotube membrane (o-CNT) and polyaniline (PANI) membrane the voltage was improved from - 127.1 mV to - 568.9 mV, and current was improved from 10.2 µA to 51.5 µA.

Keywords: Bio-Fluidic Channels and Bio-Electrolytes; Nanofluidic Channels; Concentration Driven Energy; Membrane; Renewable resources.

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Synergistic Integration of RuO_2 Nanoparticles and PAni Nanofibers within rGO Framework for Flexible Energy Storage Devices

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The escalating demand for wearable electronic devices has catalysed extensive research into the development of flexible and compact energy storage materials that can deliver high energy density while maintaining superior power density, excellent cyclic stability, and long-term durability [1]. In this context, we have strategically engineered a ternary nanocomposite (NC) by embedding ruthenium oxide nanoparticles (RuO_2 NPs) and polyaniline nanofibers (PAni NFs) within the interlayer spaces of reduced graphene oxide (rGO) to serve as a high-performance supercapacitor electrode material. This structural design effectively mitigates the restacking tendency of rGO sheets, thereby maximizing its electric double-layer capacitance. Simultaneously, the incorporation of RuO_2 and PAni introduces additional pseudocapacitance, while the PAni NFs serve as conductive bridges between RuO_2 and rGO, facilitating efficient charge-transfer dynamics across the composite network.

The optimized ternary NC exhibits an impressive areal capacitance of 1.66 F cm^{-2} at a current density of 2 mA cm^{-2}. When configured into a flexible symmetric solid-state device (FSSSD), the electrode achieves a specific capacitance of 677 mF cm^{-2} with a coulombic efficiency of 87% at 2 mA cm^{-2}, along with a low charge-transfer resistance ($R_{ct} = 5.5\ \Omega$), indicative of rapid charge transport. The device delivers a maximum energy density of 60.18 µWh cm^{-2} at a power density of 0.8023 mW cm^{-2}. Remarkably, its practical applicability is demonstrated by powering a red LED for up to 180 seconds using three FSSSD units connected in series.

Bromelain-Stabilized Fluorescent Copper Nanoclusters: Synthesis and Antibacterial Activity against *Escherichia coli* and *Staphylococcus aureus*

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Bromelain, a bioactive proteolytic enzyme comprising cysteine proteases derived from pineapple (*Ananas comosus*), and copper (Cu), in both bulk and nanoscale forms, are known for their intrinsic antibacterial activities. In this study, bromelain-capped copper nanoclusters (Bro-CuNCs) were synthesized for the first time via a green chemistry route to harness their synergistic antimicrobial potential. The resulting Bro-CuNCs displayed strong orange fluorescence with a quantum yield (QY) of 4.47% in aqueous medium. Comprehensive characterization using UV–Vis, fluorescence, FT-IR, and HR-TEM analyses confirmed the successful formation of ultrasmall, well-dispersed nanoclusters. The Bro-CuNCs exhibited pronounced antibacterial activity, showing stronger interaction with Gram-negative Escherichia *coli* compared to Gram-positive *Staphylococcus aureus*. Interestingly, fluorescence enhancement was observed upon interaction with *E. coli*, whereas quenching occurred in the presence of *S. aureus*. Moreover, Bro-CuNCs effectively inhibited the growth of *Pseudomonas aeruginosa*, a multidrug-resistant bacterium. These findings highlight the potential of Bro-CuNCs as eco-friendly, multifunctional nanomaterials with promising antibacterial and biosensing applications.

Engineering Graphene Oxide Surfaces with Nickel Hydroxide Nanoparticles for High Performance Supercapacitor Electrodes

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The escalating demand for advanced energy storage systems necessitates the development of cost-effective and high-performance electrode materials. This work presents a comprehensive study on tailoring the properties of graphene oxide (GO) through post-growth processing and functional decoration with nickel hydroxide nanoparticles ($Ni(OH)_2$ NPs) to enhance its supercapacitive performance. We systematically modified GO via thermal and plasma treatments, finding that thermal treatment reduces surface roughness to 0.65 nm by removing oxygen functional groups, whereas plasma treatment increases roughness to 5.89 nm via ion bombardment. Subsequent decoration with $Ni(OH)_2$ NPs further amplified the surface roughness to 9.89 nm, with nanoparticles (~90 ± 18 nm in size) aggregating along the GO wrinkles, thereby increasing the active surface area and providing more sites for electrochemical reactions.

Structural characterization via XRD and Raman spectroscopy confirmed partial graphitic restoration after thermal treatment and a significant increase in defect density following $Ni(OH)_2$ incorporation, both of which are favorable for charge storage. BET analysis revealed that surface modifications effectively tune porosity, with thermally treated GO exhibiting a reduced surface area (154.63 m^2/g) compared to pristine GO (525.67 m^2/g). Electrochemically, the GO–Ni composite electrode demonstrated exceptional performance, achieving a remarkable specific capacitance of 1706 F/g and outstanding cycling stability with 94.4% capacitance retention over 6000 cycles. A symmetric supercapacitor device fabricated with the GO–Ni composite delivered a specific capacitance of 278.37 F/g and an energy density of 24.74 Wh/kg at a power density of 400 W/kg. These results underscore the synergistic effect between the tailored GO substrate and the $Ni(OH)_2$ nanoparticles, establishing the GO–Ni composite as a highly promising candidate for next-generation supercapacitors with enhanced surface roughness, optimized porosity, and superior charge storage capability.

Keywords: Supercapacitor, Graphene Oxide, Nickel Hydroxide, Nanoparticles, Surface Modification, Electrochemical Properties.

Studies on Ferroelectric-Assisted Resistive Switching in β-Phase enhanced ITO/PVDF/Ag Memristive Devices

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Ferroelectric memristive devices represent a promising pathway toward flexible and low power non-volatile memories. In this study, we present a two-terminal vertical memristive device using poly (vinylidene fluoride) **(**PVDF) as the ferroelectric insulating layer between a silver (Ag) top electrode and an indium tin oxide (ITO) bottom electrode. The PVDF layer was spin coated onto the ITO substrate and thermally annealed to encourage the formation of the ferroelectric β-phase. The Ag top electrodes were deposited via thermal evaporation, forming an ITO/PVDF/Ag architecture. X-ray diffraction (XRD) analysis revealed a prominent diffraction peak at $2\theta \approx 20.5°$, corresponding to the (110) reflection plane of the β-phase, confirming the semi-crystalline nature of the polymer film. RAMAN spectroscopy results showed the characteristic β-phase peak at 840 cm^{-1}, further verifying the dominance of the ferroelectric phase, which is known to exhibit stronger dipolar alignment and polarization effects than other PVDF phases. FESEM micrograph images of the spin coated PVDF film reveals a uniform and densely packed surface morphology which is a characteristic of well-formed polymeric films. The surface exhibits a fine grain texture with semi-spherical and interconnected domains. This suggests the coexistence of amorphous and crystalline regions within the polymer matrix. Electrical characterization through current and voltage (I–V) measurements across a wide voltage range (from ±2 V to ±30 V) demonstrated bipolar resistive switching (BRS) behavior with excellent reproducibility. The device exhibited SET (V_{SET}) and RESET (V_{RESET}) transitions around +2.5 V to +4 V and –3 V to –5 V, respectively, achieving a stable ON/OFF current ratio of ~10^4 between the low resistance state (LRS) and high resistance state (HRS). The observed switching mechanism is governed by the electrochemical migration of Ag^+ ions combined with the ferroelectric polarization of the β-phase PVDF, which assists in the controlled formation and rupture of conductive filaments within the polymer matrix. The polarization induced local field further stabilizes the switching thresholds and improves endurance. Overall, the results highlight that the synergistic interplay of ionic transport and ferroelectric polarization in the β-phase PVDF layer enables robust, stable and repeatable resistive switching which demonstrates the potential of such organic ferroelectric memristive devices for low power, non-volatile memory applications.

Interface-Engineered Bilayer $HfO_2/Hf_{0.5}Zr_{0.5}O_2$ Thin Films for Stable and Energy-Efficient Memory Devices

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The resistive switching behavior of HfO_2-based and Hf–Zr–oxide thin films are examined using single and bilayer configurations deposited on ITO-coated Corning 7059 glass substrates. Four device architectures—HfO_2 (65 nm), $Hf_{0.5}Zr_{0.5}O_2$ (65 nm), HfO_2 (35 nm)/$Hf_{0.5}Zr_{0.5}O_2$ (30 nm), and HfO_2 (65 nm)/$Hf_{0.5}Zr_{0.5}O_2$ (65 nm)—are fabricated at room-temperature deposition[1]. Structural and optical properties are characterized using X-ray diffraction (XRD) and UV–visible spectroscopy, while current–voltage (I–V) measurements are performed to analyze resistive switching. Bilayer devices exhibited superior performance, showing enhanced endurance, retention, and device-to-device uniformity compared to single-layer films[2]. The improvement in switching behavior is attributed to interface-modulated defect distribution and controlled filament formation across the bilayer. Increased total thickness in the bilayer further improved switching stability and reproducibility [3]. These findings highlight the role of interface engineering and film thickness in achieving reliable, low-temperature-fabricated resistive memory structures suitable for energy-efficient non-volatile memory and neuromorphic computing applications.

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A Photodetection study of Gd_2O_3 thin film using Cerium Oxide as an interfacial layer.

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The performance of a heterostructure photodetector based on gadolinium oxide (Gd2O3) thin film with cerium oxide (CeO2) as interfacial layer has been demonstrated in this work. The study aims to enhance the photodetection capabilities by incorporating an intermediate layer of CeO2 between the Gd2O3 thin film. E-beam evaporation technique was used to deposit the metal oxides on a Si substrate. It was observed that the addition of CeO2 between the two layers of Gd_2O_3 greatly improved the UV detection. The structural and morphological analysis was carried out using X-ray diffraction, field emission scanning electron microscopy, high-resolution transmission electron microscopy, and atomic force microscopy. Also, study on this work showed that the proposed heterostructure thin film has an enhanced photosensitivity of over 35 times greater compared to prior single-layer Gd_2O_3 devices at -2 V. The device also works demonstrated self-biasing property. The overall improvement in the device performance after incorporating an intermediate layer presents an effective strategy for enhancing the performance of an optoelectronic device.

Machine Learning Assisted Multipurpose Terahertz Metamaterial

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The rapid advancement of terahertz (THz) technology necessitates the development of devices capable of fully harnessing the potential of the THz frequency regime. Machine learning (ML) offers a fast and efficient route for designing such devices, particularly multipurpose metamaterials. In this study, five ML models, Neural Network (NN), Ridge Regression (Ridge), Random Forest Regressor (RF), Support Vector Regression (SVR), and XG Boost Regressor (XG Boost), are employed for both forward and inverse prediction of transmission spectra and structural parameters of THz multipurpose metamaterials. In the forward prediction task, the transmission response is predicted from the structural parameters, whereas in the inverse task, the structural parameters are deduced from the desired transmission spectrum. Among the evaluated models, XG Boost demonstrates the highest accuracy for forward predictions, while SVR outperforms all other models in inverse design. The predictions from both forward and inverse networks exhibit strong agreement with full-wave electromagnetic simulations. To further validate the models, metamaterial samples designed from the inverse predictions are fabricated via a photolithography process and characterized using terahertz time-domain spectroscopy (THz-TDS). The experimental transmission spectra show good correspondence with both the predicted and simulated responses, confirming the reliability of the ML-driven design strategy for developing multipurpose THz metamaterials.

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Flexible Self-Powered Photoelectrochemical Photodetector Based on $AgBiS_2$ Nanosheets for High-Performance Broadband Photoresponse

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Nowadays, layered metal chalcogenide-based semiconductors have attracted great interest for next-generation optoelectronic devices due to their outstanding electronic and optical properties. These materials are affordable, compositionally versatile, and feature a direct bandgap, strong light–matter interaction, and quantum confinement effects. In the present work, silver bismuth disulfide ($AgBiS_2$) crystals and compounds were successfully grown using the direct vapor transport (DVT) method. The nanosheets were synthesized by the liquid-phase exfoliation (LPE) approach and subsequently deposited as a thin film onto an indium tin oxide (ITO) coated polyethylene terephthalate (PET) substrate using an electrophoretic deposition technique. We characterized the structural, morphological, and optical properties of the exfoliated nanosheets using various techniques and confirmed the successful formation of $AgBiS_2$ nanosheets. The photoresponse properties of the $AgBiS_2$ film-based photoelectrochemical type photodetector (PEC-PD) were investigated under various wavelengths. We achieved a highest responsivity of 55.34 μAW^{-1} and detectivity of 10.36×10^7 Jones with self-bias operation under a 405 nm light source using a Keithley-2400 source measure unit (SMU). These results highlight the potential of $AgBiS_2$ nanosheets for broad applications in PEC type photodetection and flexible electronics.

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Design and Synthesis of a series of new Donor-π-Acceptor-π-Acceptor/ type of Imidazolinone based Organic Semiconducting Molecules for OLED studies

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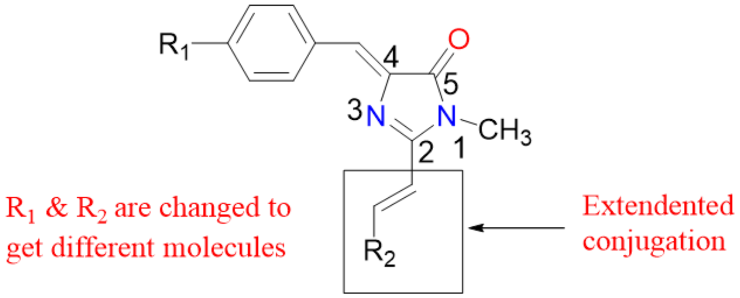
The present proposal aims to design, synthesize, and characterize a new series of *Donor–π–Acceptor–π–Acceptor* (D–π–A–π–A) type imidazolin-5-one based organic semiconducting molecules for Organic Light-Emitting Diode (OLED) applications. Imidazolin-5-one, an electron-deficient, biodegradable, and structurally versatile heterocyclic compound, offers remarkable stability, tunable electronic properties, and strong fluorescence, making it a promising acceptor moiety for sustainable optoelectronic materials. The proposed study integrates computational modeling, organic synthesis, and device fabrication to achieve a comprehensive understanding of structure–property–performance relationships. Density Functional Theory (DFT) calculations at the B3LYP/6-31+G(d,p) level will be employed to evaluate the designed molecules' optoelectronic parameters, including HOMO–LUMO energy levels, ionization potential, electron affinity, reorganization energy, and charge carrier mobility. Based on computational insights, the most promising molecules will be synthesized via Schiff base formation and conjugation extension reactions. Subsequently, the optimized compounds will be incorporated into a multilayer OLED architecture to evaluate their emissive performance and charge-transport behavior. The interdisciplinary nature of this research encompassing computational chemistry, synthetic organic chemistry, and device engineering enables a systematic approach toward developing efficient, stable, and eco-friendly OLED materials. By exploring the largely untapped potential of imidazolin-5-one derivatives in organic electronics, this project aims to advance the design of next-generation n-type or ambipolar semiconductors for high-performance and sustainable optoelectronic devices.



Multiferroic Behaviour of Cr doped CeO_2 Composites: Correlation of Ferroelectric, Magnetic, and Electrical Properties for Data Storage Applications

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The Ce1-xCrxO$_2$ (X = 0%, 3%, 6%, and 9%) composites were synthesised via a solid-state route. The X-ray diffraction (XRD) pattern analysis confirmed double phase in Cr present composites of cubic fluorite structure and hexagonal with space group Fm-3m and R-3c, respectively. The average crystallite size decreases with increasing Cr ion concentration, indicating the effect of Cr ions on the CeO_2 material. Raman spectra revealed an absorption peak at 553.3 cm^{-1}, indicating the presence of oxygen vacancies in the prepared composites. The photoluminescence spectra of the composites revealed the emission spectra in the range of 2.83 eV – 2.40 eV, which indicates the presence of oxygen vacancies in the composites. UV-visible spectroscopy was employed to estimate the band gap and defect energy levels, revealing gradual decreases in band gap energy with increasing Cr content, while defect energy levels increase, highlighting the effect of Cr induced lattice distortions. The composite's spectral features further confirm the splitting of the 3d shell of Cr^{3+} ions, attributed to electronic charge transition from $^4A_{2g} \rightarrow {}^4T_{1g}$ and $^4A_{2g} \rightarrow {}^2T_{2g}$ states of Cr^{3+} ions surrounded by six ligands. Room temperature dielectric measurements revealed an enhanced dielectric constant at lower frequencies, attributed to interfacial polarization, consistent with the Maxwell-Wagner model. The Cole-Cole plots confirmed the contribution from both grains and grain boundaries to the dielectric behavior. AC conductivity increases with frequency, which is ascribed to short-range hopping mechanisms facilitated by the Cr ion doping. Characteristics of polarisation-electric field (P-E) loops indicated ferroelectric behavior in all samples, which became more pronounced with increasing Cr concentrations. All samples exhibited weak room temperature ferromagnetism attributed to oxygen vacancies, while the pure CeO_2 sample exhibits maximum magnetization 1.4×10^{-3}emu/g. The Cr-doped CeO_2 composites thus exhibit diverse multifunctional properties, making them promising materials for optoelectronics, energy storage, and data storage applications.

Keywords: Multiferroic, dielectric, oxygen vacancy, solid-state, and data-storage application.

Lead-Free $Cs_2CuBiCl_6$ Double Perovskite for ReRAM: Electrode Dependent Resistive Switching and Performance Analysis

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Resistive Random-Access Memory (ReRAM) is a promising technology for next generation non-volatile memory and neuromorphic computing due to its scalability, low power consumption, and rapid switching. This study introduces $Cs_2CuBiCl_6$, a novel lead-free double perovskite, as an active layer for ReRAM devices, marking its debut in resistive switching applications. Fabricated via thermal evaporation in a cleanroom environment, $Cs_2CuBiCl_6$ offers environmental sustainability and ambient stability, addressing the toxicity concerns of lead-based perovskites. Devices were constructed using indium tin oxide (ITO) and fluorine doped tin oxide (FTO) as bottom electrodes, with aluminium (Al), silver (Ag), and gold (Au) as top electrodes to explore electrode-dependent switching mechanisms. Some configurations incorporated a PMMA interfacial layer to modulate performance. Current-voltage (I-V) characteristics revealed bipolar resistive switching, with SET/RESET voltages ranging from - 3.92 V to 0.9 V and -2.705 V to 1.5 V, respectively, depending on electrode materials, and ON/OFF ratios up to 2515–12091. Endurance over 1000 cycles demonstrated stable high resistance state (HRS) and low-resistance state (LRS), with SET/RESET resistances varying from $2.42 \times 10^6\ \Omega$ to $4.02 \times 10^7\ \Omega$ and $9.08 \times 10^9\ \Omega$ to $4.81 \times 10^9\ \Omega$, respectively. Film characterization via UV-Vis spectroscopy, photoluminescence, FESEM, AFM, and XRD confirmed $Cs_2CuBiCl_6$'s structural integrity, surface morphology, and optical properties, with XPS analysis for surface chemistry. This work establishes $Cs_2CuBiCl_6$ as a viable, eco-friendly material for high-performance ReRAM, highlighting electrode-specific mechanisms (ECM for Ag/Al, VCM for Au) and PMMA's role in enhancing ON/OFF ratios, paving the way for sustainable memory technologies.

Keywords: ReRAM, Neuromorphic Computing, Double Perovskite, Resistive Switching, Non-volatile Memory, Bipolar Resistive Switching

SERS-Based Detection of Hyperthyroid Drugs Using Bimetallic Core–Shell Nanoparticles

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The quantitative detection of hyperthyroidism drugs poses a significant analytical challenge due to their narrow therapeutic index and the need for precise dose monitoring to prevent toxicity or therapeutic failure. Among these, methimazole (MZZ) and propylthiouracil (PTU) are the most widely prescribed agents for the management of hyperthyroidism. Developing sensitive detection platforms for these drugs is therefore of great clinical and pharmacological importance. Plasmonic nanomaterials, particularly bimetallic nanoparticles, have recently emerged as promising candidates for such applications owing to their tunable optical properties, synergistic plasmonic coupling, and enhanced surface plasmon resonance (SPR) behaviour compared to monometallic systems. In this study, spherical gold–silver (Au@Ag) core–shell nanoparticles were synthesised, where gold acted as the core and silver formed the shell. This design integrates the excellent chemical stability of gold with the strong plasmonic enhancement capability of silver. The nanoparticles were characterised by UV-Vis spectroscopy, X-ray diffraction (XRD), field-emission transmission electron microscopy (FE-TEM), and energy-dispersive X-ray spectroscopy (EDX), where their successful formation is confirmed by a distinct peak at 420nm, and the average particle size is found to be ~ 50nm. These nanoparticles were employed for the detection of methimazole (MMZ), showing pronounced spectral interactions indicative of strong analyte sensitivity. In future studies, propylthiouracil (PTU) will also be investigated using the same nanostructures. Furthermore, Raman spectroscopy, particularly surface-enhanced Raman scattering (SERS), will be utilized to elucidate localised SPR effects and evaluate their enhancement efficiency for hyperthyroid drug detection.

Keywords: Bimetallic core-shell nanoparticles, Hyperthyroidism, Surface Plasmon Resonance (SPR), Methimazole, Propylthiouracil

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Di-aldehyde Nanocellulose-Chitosan based Biocompatible hydrogel for Wound Healing

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Wounds are injuries that result in formation of openings in the skin or underlying tissues; they may range from superficial cuts to severe laceration. Current wound dressings lack infection control, moisture balance, and structural support simultaneously to accelerate healing. Our study aims to synthesize a biocompatible chitosan–nanocellulose hydrogel for wound healing applications. The hydrogel was synthesized using noble di-aldehyde nanocellulose (DANC) as a natural crosslinker. Nanocellulose (NC) was extracted from Bombax ceiba fibre also known as Malabar silk cotton, which is confirmed by different characterization techniques like FTIR, XRD and FESEM. After this, NC was selectively oxidized to form DANC which retained similar shape and crystallinity. The di-aldehyde nanocellulose with chitosan formed Schiff base bonding. This property of DANC exploited to form a dynamic, flexible and mechanically strong hydrogel. This hydrogel shows good swelling property and hence, this makes it a good candidate for wound healing application. In future we are going to test its biophysical properties like antibacterial assay, antioxidant activity and self-healable property. This hydrogel can be a good alternative to conventionally synthetic crosslinker based chitosan hydrogels. The nano structure and Schiff base bonding can be exploited to make a reversible, self-healing, and mechanically stable hydrogel which is also biocompatible and biodegradable.

Keywords: Di-aldehyde nanocellulose, Chitosan, Schiff base, Hydrogel, Bombax ceiba, Wound Healing

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Quantum Dot–Mediated Redox-Responsive Delivery of Berberine for Controlled Nrf2–Keap1–ARE Activation and β-Cell Protection in Diabetic

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Diabetic oxidative stress represents a major pathogenic determinant in the progression of endothelial dysfunction, neuronal injury, and renal impairment, primarily through redox disequilibrium by dysregulation of the Nrf2–Keap1–ARE signalling axis, which serves as the master transcriptional regulator of endogenous antioxidant and cytoprotective responses. Under physiological conditions, Nrf2 activity is tightly controlled by its cytoplasmic repressor Keap1, facilitating ubiquitin-mediated degradation. Hyperglycemia-induced metabolic overload in diabetes profoundly enhances reactive oxygen species (ROS) generation, resulting in oxidative modification and hyperactivation of Keap1. Consequently, the cytoplasmic sequestration and inhibition of Nrf2 nuclear translocation suppresses the expression of antioxidant enzymes such as heme oxygenase-1, glutathione peroxidase, and superoxide dismutase. This culminates in persistent oxidative stress, mitochondrial dysfunction, and cellular apoptosis across the pancreas. Berberine, a naturally occurring isoquinoline alkaloid, exerts robust antioxidative and cytoprotective effects primarily through activation of the Nrf2–ARE pathway. The poor aqueous solubility, chemical instability, and extensive first-pass metabolism substantially hinder systemic bioavailability and therapeutic efficacy of Berberine. To overcome these barriers, nanotechnological approaches employing quantum dot (QD)-based, redox-responsive delivery (redox-cleavable linkages). QD–mediated, redox-responsive nanocarriers enable ROS-triggered Berberine release mechanically within oxidative pancreatic microenvironments. Upon release, Berberine mediates AMPK- and Akt-dependent inhibition of Keap1, thereby promoting nuclear translocation of Nrf2 and subsequent transcription of antioxidant genes. Controlled Nrf2 activation in β-cells is anticipated to attenuate oxidative stress-induced apoptosis, preserve insulin granule integrity, and enhance glucose-stimulated insulin secretion.

Keywords: Nrf2–Keap1–ARE signalling, Oxidative stress, Berberine, Quantum dot, Diabetic cytoprotection

Physico-chemical properties and biological evaluation of graphene quantum dots for anticancer drug susceptibility

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Graphene quantum dots (GQDs) exhibit outstanding optical properties, excellent biocompatibility, and surface tunability, making them promising candidates for biomedical and pharmaceutical applications. In this work, pure GQDs and doped variants—nitrogen-doped (N-GQD) and sulfur-doped (S-GQD) were produced hydrothermally. UV-vis absorption, fluorescence spectroscopy, X-ray diffraction (XRD), field-emission transmission electron microscopy (FE-TEM), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), and Raman spectroscopy were all used to comprehensively investigate the materials. GQDs were produced with homogeneous particle sizes ranging from 2 to 5 nm. Cytotoxicity testing using MTT assays showed that GQDs and their doped analogues exhibited dose-dependent effects on both HeLa cervical cancer cells and normal HEK cell lines. Pristine GQDs exhibited stronger cytotoxicity against HeLa cells compared to N-GQDs and S-GQDs; however, the doped forms demonstrated increased biocompatibility in normal cells, specifically HEK. Co-treatment with methotrexate (MTX) and GQD at IC50 doses had a significant synergistic impact, lowering HeLa cell viability to 5.6%. The addition of folic acid (FA) enhanced cytocompatibility, suggesting the potential for receptor-mediated targeting. Molecular dynamics (MD) simulations demonstrated a compacting impact in the dynamic behaviour of GQDs and their doped counterparts in response to MTX, but fluorescence spectroscopy and computational modelling suggested primarily non-covalent surface contacts. Overall, this multidisciplinary work demonstrates the promise of GQDs as multifunctional nanocarriers for targeted cancer therapy by combining material characterisation, computational modelling, and biological assessment[1].

Keywords: Graphene quantum dots, optical characterisation, molecular dynamics, MTT assay, anti-cancerous activity.

Riboflavin-Modified Graphene–Chitosan Nanocomposite: A Promising Platform for Wound Infection Management

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Wound healing is a complex and regulated biological process comprising four distinct phases, including homeostasis, inflammation, maturation, and remodelling. Wound caused by a puncture of the skin creates hypoxic conditions on the wound site, delays the wound-healing progression and also promote bacterial infection. Nanotechnology-based intervention, such as the tagging or delivery of oxygen-releasing materials (ORMs) with the help of carrier-based formulation, can be an effective way to eradicate such a wound healing hurdle. By diminishing oxygen deprivation, ORMs facilitate oxygen supply to the wound site, which promotes collagen synthesis, cell proliferation, and new blood vessel formation (angiogenesis). The major drawbacks that limit the usage of conventional ORMs in wound healing are high cytotoxicity and have limited biodegradability, whereas some ORMs cause oxidative damage to the cell through the overproduction of reactive radicals. Application of bio-based compounds, like Flavins, includes FMN, FAD, and riboflavin (aka-Vit B2), can be an alternative to conventional synthetic ORMs for wound healing. The advantage of the use of flavin compounds is due to their photosensitizing activity, which produces reactive oxygen species (ROS) in a controlled way in the presence of light. Whereas they also possess antimicrobial, antioxidant, and anti-inflammatory activity, a crucial factor in wound healing progression. In this work, we have prepared a flavin-linked nanocomposite-based wound healing and dressing agent with chitosan and graphene oxide. The main focus of the current work is to replace conventional ORMS with the use of riboflavin and to make noncytotoxic wound healing agents with high stability. Here, the main reason for the choice of chitosan incorporation is the synergistic effect in wound healing progression along with riboflavin. To characterize the synthesized nanocomposite, we have utilized advanced characterization techniques such as FTIR, XRD, RAMAN, TM-AFM, FESEM, and FETEM. Whereas biophysical characterization analysis shows enhanced thermal and physical stability with a good skin adhesive property in flavin-linked nanocomposite, which can be an effective wound healing patch(dried) and gel(liquid). The cytotoxicity measurement against fibroblast cell line, such as human dermal fibroblast (HDF) and rat fibroblast, shows no significant cytotoxicity, whereas the antimicrobial activity was found to be enhanced with flavin incorporation against pathogenic wound site bacteria S. aureus and P. aeruginosa. The cell migration assay(scratch) shows rapid gap closure within 18h of treatment, with complete gap closure within 24h against the fibroblast cell line. All these resulting parameters indicate that flavin, especially riboflavin, can be an alternative to synthetic ORMs for wound healing and dressing applications.

From Nature to Nanotech: Conductive Textiles with Smart Wettability for Advanced Thermal Management

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Severe cold conditions remain a major global health concern, causing significantly higher mortality than heat-related events. Ensuring comfortable and sustained body warmth in such environments demands innovative thermal management solutions that are efficient, portable, and durable. In this study, we present a bioinspired conductive textile that merges nanotechnology with natural design principles to achieve prolonged, energy-efficient heating under diverse environmental conditions. Silver nanowires (AgNWs) with minimal carbon content were uniformly spray-deposited on commercial cotton fabric to create a large-scale, low-resistance, and highly conductive network. To address the common issue of oxidation and moisture-induced degradation, a superhydrophobic coating derived from small molecules was applied, mimicking nature's water-repellent surfaces. This smart coating preserved conductivity while offering exceptional water resistance, thermal stability, and mechanical durability. The resulting textile efficiently converted both electrical and solar energy into heat, demonstrating stable electrothermal and photothermal performance even at low voltages and weak sunlight. Beyond its laboratory performance, this material was successfully integrated into wearable and wrappable prototypes for personalized thermal regulation. Our findings highlight a scalable pathway toward the commercialization of functional, bioinspired textiles that offer a sustainable solution for next-generation wearable thermal technologies.

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Hydroxyapatite Nanoparticles for Targeted Delivery of Repurposed Drugs in Cancer Therapy

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Nanotechnology-based drug delivery has revolutionized cancer therapeutics by enabling precise targeting, improved pharmacokinetics, and minimized systemic toxicity. Recent research emphasizes the use of nanoparticles as effective carriers that can penetrate tumor tissues, enhance drug accumulation via enhanced permeability and retention (EPR) effects, and reduce off-target cytotoxicity. Among various nanomaterials, hydroxyapatite nanoparticles (HAP NPs) have emerged as a promising candidate due to their intrinsic biocompatibility, biodegradability, and chemical affinity towards biomolecules. These calcium phosphate-based nanocarriers exhibit controllable crystallinity, surface charge, and porosity, allowing for efficient drug loading, sustained release, and selective cellular uptake. Studies have shown that HAP NPs interact with both hydrophobic and hydrophilic therapeutic agents through hydrogen bonding, electrostatic, and coordination interactions, thus supporting their versatility in drug encapsulation and delivery.

Drug repurposing, the strategy of identifying new therapeutic applications for existing drugs, has gained significant attention in oncology. Compared to traditional chemotherapeutic agents, repurposed drugs possess established safety, pharmacokinetic, and toxicity profiles, thereby accelerating clinical translation while minimizing the cost and time associated with new drug development. Furthermore, repurposed agents often exhibit multitarget activity, helping to circumvent tumor heterogeneity and drug resistance mechanisms reported in several studies. In the present study, we synthesized and characterized hydroxyapatite nanoparticles as a targeted drug delivery platform. Through computational screening, we identified and repurposed an existing drug for anticancer application. The primary objective of this work was to develop a biocompatible, cost-effective, and efficient nanocarrier system for targeted cancer therapy by integrating hydroxyapatite nanotechnology with drug repurposing strategies.

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Interface Engineered Gold Nanoprobes for Ultra-Sensitive and Rapid Colorimetric Folic Acid Detection

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Folic acid is an essential micronutrient that plays a vital role in human health, and its reliable quantification is crucial in clinical diagnostics and nutritional monitoring. In this work, we report a comparative colorimetric assay for folic acid detection based on gold nanoparticles (AuNPs) functionalized with bovine serum albumin (BSA) or chitosan via a 3,3′-dithiobis(sulfosuccinimidyl propionate) (DTSSP) mediated bioconjugation strategy. BSA and chitosan are both biocompatible and have been used to functionalize AuNPs for folic acid sensing. Monodisperse citrate-stabilized AuNPs (~20 nm) are synthesized and surface-activated with DTSSP to generate amine-reactive N-hydroxysuccinimide (NHS) esters. DTSSP is a water-soluble, bifunctional linker containing reactive N-hydroxysuccinimide (NHS) ester groups on each side. When folic acid is present, it interacts with the functionalized AuNPs, often through competitive or specific binding to the immobilized protein or chitosan layer. This triggers aggregation of the nanoparticles, destabilizing the colloid. The addition of folic acid produces a visible red-to-purple color change and a surface plasmon resonance (SPR) shift of ~ 6–8 nm. Under controlled buffer conditions, the BSA-based platform achieved a limit of detection (LOD) of 12.4 ± 0.3 nM and a limit of quantification (LOQ) of 41.3 nM, while the chitosan-based platform showed an LOD of 18.9 nM and an LOQ of 63.2 nM ($R^2 > 0.98$). The assay demonstrated high selectivity, reproducible signal responses (RSD < 5%), and stability over typical assay time frames. Additionally, this platform offers a label-free, low-cost, and potentially portable approach for folic acid quantification with prospective applications in nutritional monitoring and clinical diagnostics.

Keywords: Folic acid, Gold nanoparticles (AuNPs), Colorimetric assay, Surface plasmon resonance (SPR).

Implementation of Van den Bergh reaction in a PDMS micro channel for bilirubin detection

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Monitoring bilirubin levels is a key indicator of liver function and metabolic health. Conventional bilirubin assays, though reliable, often require bulky instruments and large reagent volumes, limiting their use for rapid or point-of-care diagnostics. In this work, we present a PDMS-based micro fluidic device for efficient bilirubin detection through an on-chip diazotization reaction.

The device enables controlled pressure-driven flow of diazotized sulfanilic acid and bilirubin-containing samples within a microchannel, where the coupling reaction forms a distinct azobilirubin complex that produces a measurable color change. The PDMS microchannel design provides precise control over mixing and reaction time under laminar flow conditions, ensuring reproducible color development.

This microfluidic approach significantly reduces reagent consumption and allows for miniaturization of the conventional bilirubin assay. The visible color shift obtained in the chip demonstrates its potential for integration with compact optical or smartphone-based readout systems.

The developed device thus represents a promising step toward low-cost, portable, and continuous monitoring of bilirubin levels, aligning with the emerging class of theranostic microdevices aimed at real-time biochemical sensing and personalized healthcare.

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Living Probiotic Hydrogel for Accelerated Scarless Healing of Burn Wounds

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Burn injuries present significant clinical challenges, often complicated by persistent inflammation, delayed healing, and high risk of infection. Innovative biomaterials that integrate antimicrobial, immunomodulatory, and regenerative capabilities are urgently required to address the limitations of current therapies. The present study explores the development of a multifunctional lyophilized hydrogel composed of Pluronic F127, fish collagen, and living probiotic Lactobacillus, specifically designed for application in burn wound management. Upon rehydration with water at the bedside, this composite transforms into a thermosensitive gel that conforms to the wound surface, delivering active bioagents precisely at the injury site. The centerpiece of this system is the incorporation of probiotic Lactobacillus strains isolated from natural sources, conferring several advantages over conventional wound dressings. Probiotic lactic acid bacteria (LAB) exhibit broad-spectrum antimicrobial activity, notably by inhibiting pathogenic colonization and disrupting biofilm formation, mechanisms critical for infection control in burn wounds. Furthermore, LAB secrete bacteriocins and organic acids, enhancing the hydrogel's antibacterial efficacy against common burn wound pathogens including Staphylococcus aureus, Pseudomonas aeruginosa, and Escherichia coli. In addition to their antimicrobial role, Lactobacillus species demonstrate potent immunomodulatory effects. Experimental evaluations indicate that LAB can downregulate pro-inflammatory cytokines such as IL-6 and TNF-α, mitigating the excessive inflammatory response that often impairs healing in burn wounds. Moreover, LAB influences macrophage activity and growth factor expression, fostering a pro-regenerative microenvironment conducive to scarless healing. The survival, reactivation, and functional activity of the probiotics post-lyophilization have been confirmed by
CFU counts and in vitro bioassays, ensuring that their biological benefits are preserved until the point of care.

This hydrogel platform leverages the inherent bioactivity of Lactobacillus to accelerate wound closure, reduce the risk of hypertrophic scarring, and decrease reliance on systemic antibiotics. The synergistic combination with fish collagen and Pluronic F127 not only stabilizes the probiotic and optimizes gelation but also supports cellular proliferation and tissue remodeling. Ongoing in vitro and ex vivo studies are quantifying the composite's antioxidant potential, cell compatibility, and immunoregulatory effects, with preliminary results indicating significant promise for translation to clinical practice. The proposed probiotic hydrogel thus represents a novel, living therapeutic approach for advanced burn wound care, uniting antimicrobial protection with enhanced, natural healing dynamics.

Functionalized Lipid Nanoparticles Encapsulated in GelMA Microspheres for Treatment of Osteoarthritis

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Osteoarthritis is characterized by progressive cartilage degradation, synovial inflammation, and altered joint homeostasis. Effective intra-articular therapy requires sustained local delivery of agents that combine anti-inflammatory, chondroprotective, and reparative activities while minimizing systemic exposure. We report a rationally designed, injectable composite delivery system comprising folic acid functionalized gelatin methacryloyl (GelMA) microspheres that encapsulate lipid nanoparticles (LNPs). The LNPs are engineered as bilayer structures carrying the lipophilic disease-modifying agent diacerein within the lipid membrane and the hydrophilic sulphated polysaccharide fucoidan entrapped in the aqueous core. This layered architecture permits dual-drug loading with complementary mechanisms: diacerein attenuate inflammatory cascades and matrix metalloproteinase activity, while fucoidan supports cartilage matrix preservation and modulates synovial inflammation. Folic acid conjugation on the GelMA surface provides targeted retention through affinity for activated synoviocytes and macrophages that overexpress folate receptors in osteoarthritic joints. Microsphere crosslinking density and LNP composition are tuned to achieve injectability in phosphate buffered saline and to control sequential release kinetics. In vitro characterization demonstrates uniform microsphere morphology, stable LNP encapsulation, and high encapsulation efficiencies for both payloads. The GelMA–LNP hybrid microspheres are a versatile, targeted, and injectable platform for combinatorial delivery in osteoarthritis. The system addresses key translational challenges by integrating targeted retention, controlled dual-drug release, and minimally invasive administration. This approach warrants further preclinical optimization and scales translational studies toward clinical application.

Targeting Lysosomal Protease in Cancer Theranostics: A Nanocarrier Based Drug Delivery Approach

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Cancer is such a pre-eminent disease that has emerged as a matter of great concern in the field of healthcare as well as research worldwide, owing to the absence of fully efficient treatment modalities till date. While the conventional therapies for the disease are lacking the ability of reporting any dependable curative phenomenon as well as to establish a new drug to combat the disease, the province of drug repurposing and combination therapy are showing a ray of hope. Cancer is as a whole known for its phenomenal characters of uncontrolled cell proliferation and metastasis, which some lysosomal cysteine proteases have been identified to play a critical role in. Although, several research works are being carried on to establish new drugs targeting these proteases, the process of drug discovery is time consuming and in most of the cases they fall short at any one of the phases of clinical trial. Under these circumstances, drug repurposing is emanating as a convenient as well as promising alternative of drug discovery. Additionally, synthesizing new small molecules for targeting such pro-cancerous proteases with promising theranostic abilities may further strengthen the ground of cancer research. Moreover, to acquire the highest effectivity of a drug, it is important to make sure that the drug preferably reaches the desired target site at an effective amount to minimize undesired toxicity. This is where a suitable drug delivery vehicle plays its role.

Here in this study, we have performed a drug repurposing study targeting a lysosomal protease that has been reported to have critical role in cancer formation and in the progression of the disease. Additionally, we have designed and synthesized an AIEgen based small molecule that can target a similar class of lysosomal proteases. We have further inspected the cytotoxic effects and the mechanisms through which the drug as well as the AIEgen work. We have also developed a COF based nanocarrier to deliver the drug to the desired location.

DC-Field Programmed Engulfment and Contact Line Dynamics in Ternary Emulsion for Core-Shell Drug Encapsulation

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Targeted drug carriers demand monodisperse core–shell droplets that can be sealed and released on command without thermal or solvent stress to labile actives. Electrically driven interfacial control offers precisely this, where fields can trigger capsule shelling and tune leakage resistance by biasing film drainage and rupture pathways. Classical three-phase interaction studies by Torza and Mason established that equilibrium outcomes of two immiscible drops in a third liquid, viz. complete engulfment, partial engulfment, or non-engulfment, are governed by interfacial tensions through the spreading coefficients, and that electrical fields can bias both approach and outcome via Maxwell stresses and film drainage dynamics.

Using DC electric fields, the present study aims to program interfacial outcomes in core–shell drug encapsulation in a ternary drop–film–drop system. The chosen system for investigation is Water (drop)–Silicone Oil (middle)–Olive Oil (drop), where olive oil (OO) spreads on water after localized rupture or drainage of the silicone-oil (SO) film. High-speed imaging and linear stability theory using biharmonic (non-inertial and inertial) limits and Orr–Sommerfeld analysis reveal contacting mode competition between a symmetric squeezing mode and an antisymmetric bending mode that select approach geometries (cone–cone, cone–groove, groove–groove) and govern transitions among coalescence, non-coalescence, and engulfment. Under DC fields in the leaky-dielectric regime, normal Maxwell pressure concentrates across the SO film while tangential electrohydrodynamic shear drives surface convection; together they accelerate film thinning, initiate ripple growth, and create a nascent OO–W bridge. The ensuing contact-line pair, i.e., an advancing OO–W wetting line and a receding SO–W dewetting line, exhibits Cox–Voinov-type kinetics with electric-field-lowered effective contact angles. Depending on viscosity ratio and capillary number, the front advances smoothly or undergoes Saffman–Taylor/EHD fingering, setting shell uniformity. Parametric maps in field strength, viscosity ratio, and spreading coefficient delineate regimes for engulfment with middle-film rupture (continuous OO shells around W cores) and engulfment without rupture (a kinetically arrested W/SO/OO configuration where the SO film persists between core and shell). These phase–field–property diagrams yield practical design rules for DC-assisted fabrication of W(core)/OO(shell) capsules with tunable integrity and triggerable release, which are central to the fabrication of drug delivery systems with dose-uniform and controllable drug encapsulation.

Development of clinically relevant silk-based cartilage regenerative technologies and in vitro osteoarthritis disease model for drug screening applications

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Osteoarthritis (OA) is a prevalent degenerative joint disease that leads to progressive cartilage degradation, subchondral bone remodeling, inflammation, and chronic pain. Current therapeutic approaches, including oral or injectable non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroids, and viscosupplementation, primarily provide symptomatic relief but fail to halt disease progression or promote cartilage repair. Frequent dosing and systemic exposure also increase the risk of adverse side effects. To overcome these limitations, localized and sustained drug delivery systems have gained significant attention, with hydrogels emerging as particularly promising candidates due to their high water content, tunable mechanical properties, and biocompatibility.

Dual drug release hydrogels are designed to deliver two therapeutic agents with distinct but complementary functions, thereby addressing both the inflammatory and degenerative aspects of OA. Typically composed of natural or synthetic polymers such as hyaluronic acid, chitosan, alginate, gelatin, or polyethylene glycol, these hydrogels can be engineered to provide controlled and sequential drug release through mechanisms like diffusion, degradation, or environmental responsiveness (e.g., pH, temperature, or enzymatic activity). For instance, the co-delivery of an anti-inflammatory drug (such as diclofenac, dexamethasone, or celecoxib) with a chondroprotective or regenerative molecule (such as transforming growth factor-β, bone morphogenetic proteins, or glucosamine) can result in synergistic therapeutic outcomes. The anti-inflammatory agent provides immediate relief by suppressing pro-inflammatory cytokines and reducing joint pain, while the regenerative agent promotes extracellular matrix synthesis and cartilage restoration over extended periods.

Recent studies have demonstrated that dual drug-loaded injectable hydrogels can achieve sustained intra-articular retention, reduced burst release, and enhanced therapeutic efficacy compared to single-drug formulations. Moreover, advances in stimuli-responsive and nanocomposite hydrogels enable precise spatiotemporal control of drug release, mimicking the physiological needs of the osteoarthritic joint environment. These systems not only improve local bioavailability but also minimize systemic exposure, thereby reducing toxicity and improving patient compliance. Overall, dual drug release hydrogels represent an innovative and multifunctional platform for osteoarthritis therapy, capable of integrating anti-inflammatory, analgesic, and regenerative treatments within a single localized delivery system. Continued research in material optimization, drug combination selection, and in vivo performance evaluation is essential to translate these promising findings into clinically viable solutions that can effectively slow or even reverse osteoarthritic joint degeneration.

AIE-active D-π-A- π-D Multifunctional Photosensitizers for Efficient Photodynamic Therapy

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Photodynamic therapy (PDT) has gained significant attention as a minimally invasive technique for cancer treatment, utilizing light-activated photosensitizers (PS) to induce reactive oxygen species (ROS) that destroy cancer cells. In this work, three photosensitizers with aggregation-induced emission (AIE) properties were investigated to enhance PDT performance. The optical characteristics were examined using UV-Vis absorption and fluorescence spectroscopy, revealing strong absorption in the visible region and intensified emission upon aggregation, confirming typical AIE behavior. Solvatochromic analysis demonstrated distinct emission variations with solvent polarity, suggesting an efficient charge-transfer excited state and environmental responsiveness. The singlet oxygen generation capability was quantified using 1,3-diphenylisobenzofuran (ABDA) as a chemical probe, indicating efficient ROS formation under light irradiation. Furthermore, extracellular ROS generation was assessed using 2′,7′-dichlorofluorescein diacetate (DCFDA), which confirmed effective photodynamic activity. These combined spectroscopic and biological studies demonstrate that the developed AIE-active photosensitizer holds excellent potential for simultaneous fluorescence imaging and photodynamic cancer therapy, offering a promising approach for next-generation theranostic applications.

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Theranostic Donor-Acceptor based Ligands Targeting Metal-Associated Amyloid-β in Alzheimer's Disease

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Alzheimer's disease (AD) pathology is strongly influenced by amyloid-β (Aβ) aggregation and dysregulated metal ions such as Cu2+ and Zn2+, which accelerate oxidative stress and neurotoxicity. To address these dual pathological factors, we developed donor–acceptor (D-A) based metal-chelating ligands capable of both detecting and inhibiting Aβ aggregation. The D-A electronic framework enhances fluorescence sensitivity for Aβ detection while providing strong coordination sites for selective metal ion binding. Upon interaction, these ligands effectively disrupt metal-Aβ complexes, mitigate aggregation. Spectroscopic and imaging studies confirm their theranostic potential through simultaneous Aβ visualization and inhibition. This integrated design strategy demonstrates a promising approach for developing multifunctional agents that combine metal chelation, aggregation control, and optical detection for AD diagnosis and therapy.

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Smart Microfluidic Platforms for Healthcare Applications

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Microfluidics refers to the science and technology of systems that process or manipulate small volumes of fluids, often in the range of microliters inside a microscale channels with dimensions of tens to hundreds of micrometers. The major advantage of such involvements is having an exceptional capacity to work with tiny sample amount to sidestep the need for expensive reagents involving in diverse fields[1]. By manipulating fluids at such small scales, microfluidics enables rapid heat and mass transfer, conducting fast and controlled chemical reactions[2]. A microfluidic channel finds its application in studying fluid flow behavior, drug delivery devices, separation of contaminants, isolation and biophysical study of cells, among many others[3]. In the context of healthcare services, microfluidics offers a big advantage to replace traditional diagnosis approaches owing to small analyte prerequisite, rapid sample processing, continuous flow reactions, precise control of fluids, and miniaturized 'chip' platform[4]. μ-DOC (diagnostic-on-chip) platforms mimicking the in vivo environs of biofluids like blood, urine and saliva have largely been realized for the separation and detection of biological entities like cells, proteins and small molecules like nucleic acids. Thus, design and development of in vitro prototypes that can carry out the separation process is highly demanding and challenging. In this work, a filtration-based microfluidic channel has been developed and the channel dimensions are optimized. The microfluidic sorter consists of an inlet, an outlet, and an array of equidistant trapezoidal-shaped pillars arranged between the inlet and outlet. For the fabrication part, a layout of the channel was first designed in k-layout software and template of the same was prepared using photolithography. The developed template was used to fabricate a microchannel by using PDMS and a curing agent. Inlet and outlet ports were punched manually followed by surface plasma treatment for binding the channel to a glass slide.

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Liquid Crystal Droplet as a Probe for Detecting Inflammatory Biomaker

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Lipase is a physiologically essential enzyme that catalyzes the hydrolysis of triglycerides, and abnormal lipase activity is strongly associated with inflammatory and metabolic disorders, including acute pancreatitis, obesity, and systemic inflammatory responses. Elevated lipase levels in serum serve as a reliable inflammation biomarker, making its rapid detection crucial for disease monitoring and clinical diagnostics. Conventional analytical methods, such as spectrophotometric or fluorometric assays, often require complex reagent chemistry, long reaction times, and labeling, which limit their applicability in point-of-care testing. In this study, a label-free, liquid crystal (LC)-based optical biosensor was developed for the sensitive detection of lipase activity by exploiting enzyme-mediated interfacial transitions. Nematic 5CB LC droplets are stabilized using the nonionic surfactant Tween 20 to achieve a well-defined radial anchoring configuration at the LC–water interface. The addition of lipase induces the enzymatic hydrolysis of Tween 20, generating surface-active fatty acids that disrupt the stabilizing layer and alter the interfacial balance of the LC droplets. This biochemical event trigger visible optical changes, marked by a transition from a radial (bright cross) to a distorted or bipolar configuration, observable under crossed polarizers. The interfacial disturbance is further analyzed using ImageJ-based image processing and FFT analysis, where the symmetric Fourier patterns characteristic of ordered radial configurations are transformed into diffuse, distorted patterns after lipase action. This optical variation displays a strong linear relationship with lipase concentration, allowing quantitative analysis with a detection limit as low as 1 μM. The proposed LC emulsion-based assay thus provides a simple, rapid, and label-free platform for detecting lipase as an inflammation biomarker, demonstrating the potential of LC droplets as soft, responsive materials for enzyme activity monitoring in biomedical and clinical diagnostic applications.

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J-Aggregation-Induced Donor-Tunable Triplet Harvesters for Image-Guided Photodynamic Therapy from Cells to In Ovo Models

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Pure organic luminogens that can harvest triplet excitons through thermally activated delayed fluorescence (TADF) and room-temperature phosphorescence (RTP) are promising photosensitizers for image-guided photodynamic therapy (PDT), enabling precise cancer treatment with integrated imaging capabilities. Here, we report five AIE active donor-acceptor luminogens with systematic donor modulation, four of which form J-aggregates that induce TADF or RTP depending on ΔEST, intersystem crossing (ISC), reverse intersystem crossing (RISC), and spin–orbit coupling (SOC) rates, while the one with a random arrangement shows only fluorescence. These four triplet-harvesting molecules were applied for image-guided PDT against highly aggressive U87MG glioblastoma cells. Among them, RTP active MPht featuring compact dimeric packing with a delayed lifetime of 134 µs and a photoluminescence quantum yield of 80%, generates the most efficient ROS (both Type I and II), whereas the others primarily mediate Type I ROS. Furthermore, these luminogens demonstrate potent PDT efficacy in 3D spheroids and in ovo glioblastoma tumor models. This study establishes a design paradigm for non-encapsulated small-molecule triplet harvesters and highlights their translational potential for rapid and effective image-guided PDT against resistant tumors such as glioblastoma, beyond conventional 2D cell models.

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PEG-Stabilized AIEgen-loaded MnO_2 nanoparticles for Hypoxia Alleviation and Cancer Therapy

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Cancer treatment remains a significant challenge due to the complex tumor microenvironment, which is characterized by hypoxia and is closely associated with therapeutic resistance, tumor progression, and poor prognosis. Oxygen deficiency compromises the efficacy of many treatment modalities, making hypoxia alleviation a key strategy in enhancing cancer therapy outcomes.

To address this issue, we developed a PEG-3T-MnO_2 nanocomposite system comprising polyethylene glycol (PEG)-stabilized near-infrared aggregation-induced emission luminogen 3T (AIEgen) loaded manganese dioxide (MnO_2) nanoparticles. MnO_2 actively decomposes elevated levels of hydrogen peroxide (H_2O_2) present in the tumor microenvironment to generate molecular oxygen, thereby relieving hypoxia. The synthesized nanocomposite showed good anti-proliferative activity and has been found to be effectively generate oxygen, thereby modulating tumor hypoxia in both monolayer cultures and tumor spheroids. PEGylation improves colloidal stability, biocompatibility, and systemic circulation, leading to enhanced tumor accumulation via the enhanced permeability and retention (EPR) effect.

In vitro assays demonstrated marked hypoxia alleviation, as evidenced by decreased hypoxia-inducible factor-1α (HIF-1α) levels and increased intracellular oxygen. Furthermore, flow cytometry analysis revealed that the nanoparticles could induce intracellular ROS generation, disrupt mitochondrial membrane potential, and trigger apoptotic cell death. These findings highlight the potential of PEG-3T-MnO_2 as an effective oxygen-generating platform to overcome hypoxia-driven therapeutic resistance in cancer treatment.

Drug Repurposing for Microtubules Targeting Cancer Theranostics Using Protein Based Nanocarrier

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Triple-negative breast cancer (TNBC) remains one of the most aggressive and treatment-resistant subtypes of breast cancer, largely due to the absence of specific molecular targets and limited efficacy of conventional chemotherapeutics. In this study, drug repurposing of ergotamine was explored for its potential as a microtubule-targeting agent through molecular docking, molecular dynamics simulations, and subsequent in vitro validation. Ergotamine demonstrated significant downregulation of α- and β-tubulin expression in MDA-MB-231 and MDA-MB-468 cell lines, suggesting its role as a microtubule-destabilizing compound. To enhance drug selectivity and minimize systemic toxicity, ergotamine was incorporated into a gold nanocluster–embedded transferrin–PEG nanoparticle system (LTPNC). The transferrin moiety facilitated receptor-mediated uptake in TNBC cells, while PEG provided biocompatibility and colloidal stability. The synthesized LTPNCs exhibited uniform size distribution, high drug encapsulation efficiency, and stable dispersion characteristics. Cytotoxicity and selectivity assays revealed that LTPNCs significantly improved ergotamine's therapeutic efficacy against TNBC cells while reducing its effect on non-cancerous HEK 293 cells. Overall, this study demonstrates a synergistic approach combining drug repurposing with nanocarrier-based targeted delivery, positioning LTPNC as a promising platform for selective microtubule-targeted therapy in TNBC.

Targeted Delivery of Gliotoxin loaded Nanocarrier Heightens Therapeutic Potential in Hypoxic Environment of Triple Negative Breast Cancer Cells

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Triple-negative breast cancer (TNBC) presents significant therapeutic challenges owing to its aggressive nature and the lack of targeted treatments. The hypoxic tumor microenvironment further ameliorates resistance and promotes cancer stem cell maintenance. Gliotoxin, a potent anti-cancer fungal secondary metabolite, was selected as a therapeutic agent. However, toxicity studies indicate that gliotoxin induces respiratory toxicity, limiting its application in cancer therapy. To address these problems, this study introduces a targeted drug delivery system employing folic acid-functionalized gold nanoclusters conjugated with PLGA nanoparticles (PLGA-AuNC-FA) to deliver gliotoxin to TNBC cells. The nanocarrier was synthesized by encapsulating gliotoxin in PLGA nanoparticles and conjugating them with folic acid-linked gold nanoclusters (AuNC-FA) to achieve a water-dispersible formulation. Comprehensive characterization using various analytical techniques confirmed the structural and functional properties of the drug delivery system. *In vitro* studies demonstrated dose-dependent cytotoxicity of gliotoxin-loaded nanocarrier in the TNBC cell lines MDA-MB-231 and MDA-MB-468. Furthermore, western blot analysis of the treated cells showed downregulation of HIF-1α and alteration of HES1 and P21, the key components of the Notch signaling pathway. These findings suggest that the GTX-loaded PLGA-AuNC-FA nanocarrier may serve as a promising therapeutic strategy against TNBC by offering targeted cytotoxicity while reducing the off-target effects.

Keywords: Triple negative breast cancer; Gliotoxin; HIF-1α inhibition; Notch pathway; Drug delivery; PLGA nanoparticle;

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Non-Enzymatic Uric Acid Detection Using a Micro-Resistive Sensor Fabricated via Micro-Cantilever Printing Technology

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A first-time reported non-enzymatic uric acid (UA) sensor has been developed using a micro-cantilever printing (MCP) technique to fabricate a two-terminal MoS_2 device. This innovative fabrication method enables precise printing of silver nanoparticles (AgNP) electrodes at room temperature without the need for complex lithography, marking a significant advancement in non-enzymatic biosensor technology. The MoS_2 nanosheets, synthesized via the liquid-phase exfoliation method, provide high crystallinity and uniform nanoflake morphology, serving as an efficient transducing layer for uric acid detection. Unlike conventional three-terminal enzymatic sensor configurations, this work introduces a two-terminal resistive, non-enzymatic sensing structure, simplifying the device architecture while enhancing scalability and integration potential. Comprehensive material characterization confirmed high-quality material synthesis and structure: XRD verified the characteristic MoS_2 diffraction peaks, EDX confirmed elemental composition, and FESEM revealed nanoflake morphology with a large surface-to-volume ratio crucial for effective analyte adsorption and charge transfer in non- enzymatic sensing. The I–V characterization revealed excellent sensing performance, exhibiting strong selectivity toward uric acid over urea, sucrose, galactose, Na^+, K^+ and Fe^{2+}. A sensitivity of 1.108 mA mM^{-1} with a high linear correlation ($R^2 = 0.98$) across the dynamic range of 0.1–1 mM, and a limit of detection (LOD) of 0.09 mM was obtained. These findings confirm the sensor's superior precision and response consistency for uric acid detection. Furthermore, the device demonstrated remarkable stability, maintaining minimum current variation even after 30 days. The proposed micro-cantilever-printed, two-terminal, non-enzymatic MoS_2-based sensor establishes a novel, cost-effective, and highly reliable platform for next-generation biochemical sensing applications.

Development of D–A–π–A Featured Near-Infrared AIE Photosensitizers for Effective Photodynamic Therapy in Cancer Treatment

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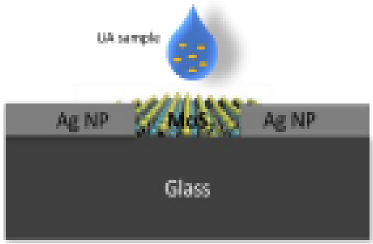
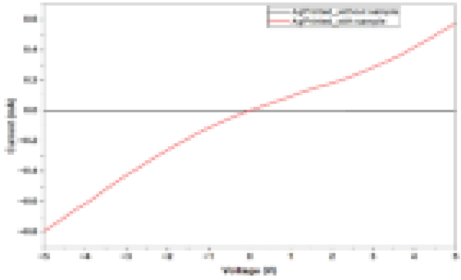
Photodynamic therapy (PDT) is an innovative and promising strategy for treating cancer, relying on photosensitizers to produce reactive oxygen species (ROS) that trigger cell death. The development of near-infrared (NIR) photosensitizers with aggregation-induced emission (AIE) characteristics is a promising advancement in photodynamic therapy (PDT) for cancer treatment.[1] In this study, we synthesized two novel donor–acceptor–π-bridge–acceptor (D–A–π–A) AIE active NIR photosensitizers, TBTI and TBTSO3, both of which exhibit impressive ROS generation capabilities, positioning them as strong candidates for PDT applications. The cationic TBTI operates via a Type II mechanism that produces singlet oxygen, whereas the zwitterionic TBTSO3 functions through a Type I mechanism, yielding radical species. This distinction is crucial because Type I mechanisms can effectively generate ROS in hypoxic tumor environments, where conventional Type II photosensitizers may struggle due to reduced oxygen levels. The synthesis of these D–A–π–A structured AIEgens, along with their unique mechanisms for ROS generation and organelle-targeting potential, highlights their promise as effective agents in photodynamic cancer therapy. Future studies will focus on evaluating their performance in cellular environments to further assess their therapeutic potential.





Naphthalimide Derivatives as Potent Type 1 ROS Generators for Potential Photodynamic Therapy Applications

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Cancer affects millions of people globally, making it a critical area of focus for researchers, clinicians, and public health officials. Photodynamic therapy is a clinically approved anticancer modality that employs a light activated agent (photosensitizer) to generate cytotoxic reactive oxygen species (ROS).[1] There is therefore a growing interest for developing innovative photosensitizing agents with enhanced phototherapeutic performances. In this study, we synthesized and characterized a series of 6 novel naphthalimide derivatives to evaluate their potential as Type 1 ROS generators under photodynamic conditions. The synthesized compounds were subjected to in vitro photophysical and photochemical analyses to assess their ROS generation capabilities. Our results demonstrated that these naphthalimide derivatives efficiently produce Type 1 ROS, which was confirmed by using different chemical trapping assays. Additionally, these Photosensitizers are designed in a way that they are cell organelle targeting which will be beneficial for targeted cancer therapy and can be used for bio-imaging. Given their efficient ROS generation, the synthesized compounds show great promise as photosensitizers for PDT.

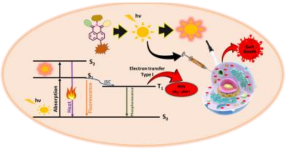

Fig 1. Schematic illustration of Photo Dynamic Therapy through Type I mechanism.

Future research will focus on exploring their therapeutic efficacy in *in vivo* models. The findings suggest that with further development, these compounds could become valuable tools in the advancement of photodynamic therapy for cancer treatment.

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Core–shell gold–silver nanoparticle-based Microfluidic Plasmonic-Electrochemical Sensor for the Sensitive Detection of Immunoanalytes in Serum

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Immunosensors are essential for rapid, specific, and sensitive detection of biomolecules in clinical settings. The highly specific nature of the reaction between antibodies and their corresponding antigens empowers immunosensors to detect disease biomarkers at very low concentrations. Further, immunosensors based on Plasmonic Core-Shell nanoparticles of noble metals have the benefit of easy adaptability, which facilitates integration with advanced technologies such as microfluidics and electrochemical probing for convenient label-free detection. In this work, the authors present a dual-mode microfluidic immunosensor harnessing the unique and sensitive plasmonic and electrochemical properties of Gold-Silver Core-Shell nanoparticles (GSCSNP), functionalized with dithiobis(succinimidyl propionate) (DTSP) and antibodies for target antigen detection. The GSCSNP's are synthesised via a facile two-step method, and are further bioconjugated with (DTSP) and antibodies specific to the targeted disease biomarkers. These bioconjugated nanoparticles are then used as probes to detect the target biomarkers, by observing both shifts in Localised Surface Plasmon Resonance (LSPR), as well as changes in electrochemical properties. The binding of the antigen or biomarker with the antibodies induces the aggregation of the GSCSNP's, which leads to a plasmonic shift in the absorption spectrum, as well as a colour change, which can be detected in a miniaturised, microfluidic setup. Furthermore, the antigen-antibody-GSCSNP complexes are dropcast onto a Glassy Carbon Electrode, and used in conjunction with a medium of redox mediators to detect the antigen. The electrochemical studies may also be performed using screen-printed electrodes using a portable Potentiostat. This miniaturisation paves the way for the easy deployment of the sensor, even to remote locations, and reduces the volume of the sample required, thus enabling a miniaturised, portable dual-modal sensing platform. The sensor demonstrated high sensitivity towards the target antigen in artificial serum, as well as excellent specificity over interfering agents.

A Cost-effective Ultrasensitive Plasmonic Nanobiosensor for Early Prostate Cancer Diagnosis Using Copper-Silver Core-Shell Nanoparticles

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Among men, prostate cancer (PC) remains one of the most commonly diagnosed cancers worldwide and exhibits a broad range of clinical outcomes 1. Early diagnosis of prostate cancer is crucial, as clinical symptoms often remain silent until advanced stages. Conventionally, serum prostate-specific antigen (PSA) testing by ELISA or chemiluminescent assays, digital rectal examination (DRE), histopathological biopsy, and imaging modalities, including transrectal ultrasound (TRUS) and multiparametric MRI (mpMRI) are used for the detection of PC2. However, these methods are often time-consuming, invasive, costly, and limited in sensitivity and specificity. Consequently, there is an urgent need for a rapid, low-cost, and ultrasensitive biosensing platform capable of detecting PSA at trace levels for early diagnosis. This study reports a plasmonic nanosensor based on copper–silver (Cu@Ag) core–shell nanoparticles functionalized with PSA antibodies for label-free optical detection. Cu@Ag nanostructures were synthesized using a wet chemical reduction method reported earlier3. The Cu@Ag nanostructure surfaces were biofunctionalized using 3,3′-dithiobis (sulfosuccinimidyl propionate) (DTSP), enabling covalent attachment of PSA antibodies. The synthesized nanostructure was extensively characterized using UV–Vis spectroscopy, transmission electron microscopy, X-ray diffractometer, Raman spectroscopy, Energy-Dispersive X-ray spectroscopy, and X-ray Photoelectron Spectroscopy. The antibody–antigen interactions were monitored via UV–Vis spectral shifts and surface-enhanced Raman scattering (SERS), showing distinct responses even at low PSA concentrations. This work introduces an ultrasensitive yet straightforward plasmonic nanosensor that utilizes a modified Cu@Ag core-shell nanostructure. The developed sensor outperforms conventional techniques in speed, cost, and detection limit, offering promising potential for early prostate cancer diagnosis and point-of-care applications.

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Detection of Circulating Tumour cells in Biofluid

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This project presents an approach for detecting circulating tumor cells (CTCs) in human blood using vimentin antibody tagged magnetic nanoparticles in microfluidic channel. This approach combines magnetic separation with immunoaffinity and microfluidic trapping, may providing a promising strategy for the non- invasive detection and analysis of CTCs in cancer diagnostics. The detection of CTCs in human blood is a critical step for early cancer diagnosis and monitoring therapeutic efficacy. Current CTC isolation approaches mainly rely on the epithelial cell adhesion molecule (EpCAM), which may significantly reduce the ability to capture CTCs when the expression of EpCAM is lost or down regulate in epithelial−mesenchymal transition. Here, the antibody targeting the vimentin protein on the surface of CTCs has been used for the efficient detection of CTCs. Vimentin is a type III intermediate filament protein that is predominantly expressed in mesenchymal cells and plays a vital role in maintaining cellular integrity, migration, and resistance to stress. In the context of cancer, vimentin has gained significant attention as a biomarker due to its strong association with the epithelial mesenchymal transition (EMT), a process that enables cancer cells to acquire invasive and metastatic properties. In this work the bimetallic magnetic nanoparticles (MNPs) were synthesized using co-precipitation method. The synthesized nanoparticles were characterized by UV-Vis spectroscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), vibrating sample microscopy (VSM), X-ray diffraction (XRD), energy dispersive X-ray spectroscopy (EDX), X-ray photoelectron Spectroscopy (XPS) to assess their structural, optical, magnetic, crystalline properties and the elemental composition. The synthesized MNPs were functionalized with MUA (Mercaptoundecanoic Acid) which further activated by EDC(1- Ethyl-3-(3-dimethylaminopropyl) carbodiimide) /NHS (N- Hydroxy Succinimide). This activation enables the formation of stable amide bond between MNPs and antibody. The modified MNPs used in a microfluidic channel made from polydimethylsiloxane (PDMS) to facilitate the capture of CTCs with magnetic nanoparticles aiding in the separation process under an external magnetic field. This non-invasive immunoaffinity based method shows promise for efficient CTC sorting from blood samples. The approach was validated through the use of MDA-MB-231 cancer cell lines, demonstrating its potential for clinical applications in cancer detection.

Design and Testing of Microrheology-on-a-chip (MoC) platform for biogels

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Multiple Particle Tracking (MPT) stands out as a robust approach for the microrheological characterization of biomaterials [1]. This study leverages an in situ microfluidic platform to systematically investigate the impact of cross-linking density on the viscoelastic properties of polyethylene-glycol-diglycidyl-ether (PEGDE)-modified hyaluronic acid (HA) biogels. In this direction, MPT is employed to extract valuable microscale rheological parameters in real time, offering insights into the gel's mechanical behavior. In addition to MPT, a suite of complementary characterization techniques, including Fourier Transform Infrared (FTIR) Spectroscopy, Field Emission Scanning Electron Microscopy (FESEM), and Confocal Laser Scanning Microscopy (CLSM), is utilized to assess the extent of cross-linking, morphological features, and the porosity of the biogels, respectively. One of the major challenges in biological systems is measuring their localized microrheological properties in real time. This has been attempted by employing the proposed MPT methodology in a model biogel. The results reported in this study provide a deeper understanding of the influence of cross-linking density on the localized and real-time viscoelastic properties of HA-based biogels. The findings can be pivotal for the rational design of HA-based biogels with tailored mechanical properties, which can be applied across a wide range of biomedical applications, including tissue engineering, drug delivery, and viscosupplementation.

Keywords: Microrheology; hyaluronic acid; hydrogels; extra cellular matrix; viscoelasticity

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Next-Generation Molecular Diagnostics: A CRISPR-Cas12a Tool for Rapid Detection of WHO Critical-Priority Antimicrobial Resistance

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The emergence of antibiotics as a clinical practice in the 1940s cured infectious diseases that had eliminated human races over the centuries. Over the years, antibiotics have saved millions of lives. However, decades after its inception, the emergence of antibiotic-resistant bacteria, attributed to the excessive use of antibiotics. Both conventional and non-conventional antimicrobial susceptibility testing take prolonged turnaround times and are unable to detect specific genes, highlighting the need for faster and specific diagnostic alternatives. In this direction, CRISPR-Cas systems have emerged as one of the most promising molecular diagnostic tools. Capitalising on the programmable specificity of the crRNA and collateral cleavage activity of enzymes like Cas12a, these systems offer highly efficient and reliable detection of nucleic acid targets. For instance, AMR genes, like the sulfonamide-resistant gene (sul1), can survive and rapidly multiply in the presence of sulfonamide antibiotics, rendering antibiotics ineffective. In this study, the AMR gene chosen is present in the list of the critical AMR-priority pathogens, as per the WHO, namely, Escherichia coli. Here, we specifically targeted sul1, which encodes a variant of dihydropteroate synthase (DHPS) that is no longer inhibited by sulfonamides. In this research, we report the development of a CRISPR-Cas12a- based fluorescent biosensing platform for the detection of the AMR gene for Escherichia coli. The methods involve molecular cloning, recombinant plasmid construction, and target-specific amplification of protospacer DNA. Subsequently, a ribonucleoprotein complex was employed to collaterally cleave a FAM-BHQ1-labelled ssDNA reporter upon target recognition. Therefore, the developed sensor highlights excellent specificity, as indicated by minimal background fluorescence in non-target controls and a significant signal increase upon detection of the AMR gene. The assay is rapid, operating at an isothermal temperature and generating results within 30 minutes. This work embraces the potential of CRISPR-Cas12a as a next-generation molecular tool for combating AMR genes.

Integrated Hydroponic-Nanotheranostic System for Sustainable Bioconversion of Food Waste, Electricity Production, and Nanoparticle-Based Cancer Treatment

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The study provides a circular bioeconomy solution by converting trash to therapeutic value. It introduces a unique hydroponic-nanotheranostic system that integrates food waste bioconversion, sustainable electricity generation, and phytochemical-based nanomaterial synthesis within an eco-functional platform. A customised 2 L hydroponic setup was designed to grow Ocimum sanctum (Tulsi) using nutrient water derived from food waste. This enabled wastewater purification, bioelectricity production through the Fenton redox process, and simultaneous cultivation of a medicinal plant. Within one week, the system successfully converted turbid organic waste into clear water. A quantifiable bioelectric potential of 1 mV was recorded within four days, showing active microbial-chemical interaction. The pH shifted from acidic to near-neutral, and the UV-Vis spectral improvement verified the progression of deterioration and organic mineralisation. Gram stain revealed a predominance of Gram-positive bacteria, responsible for enzymatic oxidation and nutrient cycling in the system. Extracted Tulsi phytochemicals were used in the green production of chitosan-sodium tripolyphosphate (STPP) nanoparticles. These nanoparticles encapsulate bioactive substances that are stable and biocompatible. UV-Vis, photoluminescence, FTIR, SEM, and TEM investigations fully characterised the nanoparticles' nanoscale shape and functional group interactions. An in vitro MTT assay on cancer cell lines revealed strong cytotoxic and dose-dependent antiproliferative activity. Antibacterial studies against Gram-positive and Gram-negative organisms confirmed broad-spectrum efficacy. Furthermore, prolonged drug release profiling indicated controlled phytochemical release, validating their theragnostic properties. This low-cost, scalable technique offers a green path for nanotheranostic applications in cancer and infection management. It reveals a sophisticated link between environmental sustainability, nanotechnology, and biomedical innovation suitable for next-generation smart bio platforms.

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Multifunctional NIR-responsive nanohybrid Platform for synergistic chemo-photothermal cancer therapy

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Photothermal therapy has emerged as one of the most promising non-invasive strategies for eradicating cancer cells, owing to its ability to achieve deep tissue penetration. Various nanomaterials responsive to near-infrared (NIR) light have been effectively utilized in combination with NIR laser irradiation to induce localized hyperthermia in tumor tissues. When these NIR-active nanocarriers are co-loaded with anticancer agents, they can amplify the photothermal effect and act synergistically with chemotherapy, offering a multifaceted and highly efficient therapeutic approach. In this study, we developed NIR-responsive nanohybrids composed of chitosan and gold-coated iron oxide nanoparticles, loaded with Doxorubicin (DOX). The nanohybrids were synthesized using ultrasonic atomization coupled with a spray-ionic gelation method, enabling uniform particle formation and efficient drug encapsulation.The synthesized nanohybrids exhibited a uniform particle size distribution with a mean diameter of 118 ± 13 nm and an encapsulation efficiency of 82.37 ± 7%. A sustained drug release profile was observed, with approximately 51% of the encapsulated Doxorubicin (DOX) released over a period of 170 hours. Upon irradiation with an 808 nm NIR laser (0.6 W) for 10 minutes, the nanohybrids showed a rapid temperature increase of 45 °C, confirming their strong photothermal conversion efficiency. Moreover, repeated NIR exposure triggered enhanced drug release, indicating laser-responsive behavior. Cytotoxicity assays revealed an IC50 value of 1.05 µg/mL after 48 hours of incubation without laser treatment. Notably, NIR irradiation significantly potentiated the cytotoxic effect, achieving comparable cell killing within 12 hours. The therapeutic potential of the nanohybrids was further validated using a 3D cancer spheroid model, where they effectively suppressed tumor growth through a synergistic combination of photothermal and chemotherapeutic mechanisms. Overall, the CGMD nanohybrids demonstrated a robust dual-mode chemo–photothermal effect, representing a promising platform for minimally invasive cancer therapy.

Multifunctional NIR-responsive nanohybrid Platform for synergistic chemo-photothermal cancer therapy

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In order to target sustainable drug delivery simultaneously, the design of stimulus-responsive hybrid nanogels is crucial. Biodegradable and biocompatible chitosan-based hybrid nanogels, responsive to external environment such as pH, have been synthesized in this work. These nanogels were synthesized through cross-linked gel networks by free radical polymerization, poly (chitosan-co-phenylboronic acid-co-methacrylic acid) responsible for pH sensing. Field-emission Scanning electron microscopy (Fe-SEM), Fourier transform infrared spectroscopy (FTIR) and Dynamic light scattering (DLS) were performed with morphological and chemical analysis and found that stable chitosan-based nanogel was successfully developed. X-Ray Diffraction technique was used to check the crystal structure of prepared nanogels. The hybrid nanogels also deliver outstanding colloidal stability, high capacity for drug loading. Hybrid nanogels could also potentially be used for simultaneous diagnosis, auto - governed delivery of drugs and therapeutic response monitoring. The results from the characterization techniques of nanogels by FTIR and Fe-SEM shows that Fe-SEM is used to determine the morphology of the nanogel. The smallest size of the nanogels we found at pH 5 is 50nm. The size of hybrid nanogel is highly dependent on pH and can response to both acidic and base medium. At high acidic at pH11 and pH12, the size was decreased again, it may be because of the extreme presence of carboxylic group or. More reports are required to ensure all the properties of nanogel. The size distribution was performed with DLS. The size range is obtained 20-200nm.

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Green Tea–Derived EGCG-rich Nanobots: A Bio-Nanomaterial Platform for Cancer Therapy and Antibacterial Activity

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Camellia sinensis, commonly known as green tea, is an established source of bioactive polyphenols, primarily epigallocatechin-3-gallate (EGCG), with evident anticancer and antibacterial potential. We report a facile green-extraction approach to produce nananobots derived from crude green tea leaf extract, with EGCG as the principal constituent alongside epigallate derivatives. The nananobots were characterized for morphology and size by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). Chemical identity and functional groups were assessed by Fourier-transform infrared spectroscopy (FTIR) and UV–Vis spectroscopy. Magnetic susceptibility measurements revealed mild magnetic property, suggesting potential for aided targeting. Biological efficacy was evaluated with MTT cytotoxicity assays against cancer cell line and antibacterial assays against representative Gram-positive and Gram-negative strains. Controlled release kinetics of the bioactive components was studied under physiological conditions to determine sustained release profiles. Results show spherical nananobots in the nanometer range with spectral signatures consistent with EGCG conjugates. The formulation roduced dose-dependent cytotoxicity in cancer cells and significant bacterial growth inhibition in vitro. Release studies exhibited a sustained-release profile over several hours, compatible with prolonged bioactivity. Mild magnetic responsiveness may enable future magnetically assisted targeting. Together, these findings indicate that green tea–derived EGCG-enriched nananobots are a promising, sustainable platform for combined anticancer and antibacterial applications, warranting further mechanistic and in vivo investigations.

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Preparation and Performance Assessment of a Clamshell-Derived Biogenic Adsorbent for Tetracycline Antibiotics adsorption

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The pervasive presence of antibiotics in aquatic ecosystems presents significant threats to ecological systems and human health, hence requiring efficient removal solutions. This study investigated the efficacy of a clamshell powder-derived biogenic adsorbent for eliminating drugs, specifically tetracycline. Clamshell powder was treated with phosphoric acid to produce Beta tricalcium phosphate (**β**-TCP), which functioned as the active adsorbent. The produced material was methodically evaluated utilizing Fourier Transform Infrared Spectroscopy (FTIR), Energy Dispersive Spectroscopy (EDS), X-ray Diffraction (XRD) and Raman Spectroscopy. FTIR and EDS investigations validated the existence of phosphate functional groups and a Ca/P ratio of 1.5:1, respectively, whereas XRD and Raman spectroscopy corroborated the crystalline **β**-TCP phase. The XRD measurements further indicated a significant level of crystallinity in the produced adsorbent. Adsorption investigations utilized tetracycline as a model antibiotic. The **β**-TCP adsorbent had a maximum adsorption capacity of 42.29 ± 0.02 mg L^{-1} g^{-1}, attaining a removal efficiency of 70% under optimal conditions (starting tetracycline concentration: 0.6 mg L^{-1}; temperature: 30 °C; pH 5). These findings underscore the efficacy of clamshell-derived **β**-TCP as a sustainable, cost-effective, and environmentally friendly material for the cleanup of antibiotic-contaminated water. The research illustrates the advantages of reducing antibiotic contamination while converting biowaste into effective adsorbents, presenting a promising sustainable water treatment technology strategy.

Keywords: Clamshell; Tetracycline; β-TCP; Adsorption.

Structural Unraveling and Sensing Potential of Cu-MOF Towards Antibiotic Contaminants

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The continuing presence of antibiotic residues in foodstuffs, water, and biological fluids is a significant healthcare problem because they are known to cause antimicrobial resistance and environmental pollution. It is critical to monitor these residues early, sensitively, and accurately to guarantee human safety and regulatory compliance. Sophisticated nanomaterials, especially metal–organic frameworks (MOFs), have attracted vast interest in this context due to the exceptional structural and functional features at the nanoscale. Herein, we present the synthesis of a copper-based MOF (Cu-MOF) and its prospective application in healthcare-centric sensing of antibiotics. The as-prepared Cu-MOF was extensively characterized via Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and scanning electron microscopy (SEM). The findings established high crystallinity, strong coordination bonding, and well-defined surface morphology for accommodating antibiotic molecules. Due to its exceedingly high surface area, adjustable porosity, and rich active coordination sites, the Cu-MOF was incorporated into electrochemical and fluorescence-based sensing systems. The systems exhibited encouraging selectivity and sensitivity toward model antibiotics, namely tetracycline and ciprofloxacin, and many others which are commonly found in clinical and environmental samples. The hybridization of nanostructured Cu-MOFs with state-of-the-art sensing technologies showcases their promise as future diagnostic materials. Apart from their performance in the laboratory setting, these nanomaterials can be additionally tuned by polymer–MOF hybridization and device miniaturization to empower portable, point-of-care detection systems. This work underscores the indispensable role of nanotechnology-inspired materials in advancing novel sensing strategies for healthcare, food safety, and environmental monitoring.

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Ultrastable Nanostructured MXene/g-C_3N_4 nanocomposites for electrochemical detection of oral cancer

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An ultrathin titanium carbide Mxene-graphitic carbon nitride (Ti_3C_2/g-C_3N_4(TCN)) heterojunction-based electrochemical immunosensor was developed for the ultrasensitive and picomolar level quantification of tumor factor necrosis alpha (TNF-α) as an oral cancer biomarker. The Ti_3C_2 MXene/g-C_3N_4 were synthesized through a one-pot hydrothermal technique which was a simple and relatively eco-friendly process and deposited on screen printed carbon electrodes (SPE). This material was well characterized using several analytical and electrochemical techniques. Monoclonal antibodies with specificity to TNF-α were linked onto the Ti_3C_2 MXene/g-C_3N_4/SPE through EDC-NHS coupling and non-specific binding was prevented by blocking with Bovine Serum Albumin (BSA). The superior coupling interface of the heterojunction provides enhanced surface area and electrochemical properties. The fabricated immunosensor exhibited a linear detection range of 1-200 pg mL^{-1} with a sensitivity of 0.8 μA $(pg/mL)^{-1}$ cm^2 and a detection limit of 1.09 pg mL^{-1}. The fabricated immunosensor exhibits excellent specificity toward the detection of TNF-α in artificial saliva samples along with remarkable reproducibility. Thus, this work holds potential for early, sensitive and non-invasive determination of oral cancer in clinical samples.

Graphdiyne based immunosensor for Oral Cancer Diagnosis

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This study reports the development of an electrochemical immunosensor based on hydrogen-substituted graphdiyne (HsGDY) for the detection of the oral cancer biomarker cytokeratin fragment 19 (CYFRA 21-1) in artificial saliva, enabling a non-invasive diagnostic approach. A novel two-dimensional few-layer transparent HsGDY was synthesized and further functionalized with 3-(aminopropyl)triethoxysilane (APTES) to form a highly porous APTES/HsGDY nanomaterial matrix by exploiting the opposite surface polarities of HsGDY and APTES. This functionalization enhanced hemocompatibility and allowed stable, long-term immobilization of antibodies while preserving their biological activity. The biosensor was fabricated by drop-casting APTES/HsGDY onto a carbon screen-printed electrode (cSPE), followed by sequential immobilization of anti-CYFRA 21-1 antibodies and bovine serum albumin (BSA) to prevent nonspecific adsorption. Structural, morphological, and elemental properties of the synthesized nanomaterial were extensively characterized using techniques such as Fourier transform infrared spectroscopy (FTIR), field-emission scanning electron microscopy with energy-dispersive X-ray spectroscopy (FESEM-EDX), X-ray diffraction (XRD), high-resolution transmission electron microscopy (HRTEM), and X-ray photoelectron spectroscopy (XPS). Electrochemical characterization of the fabricated sensor, performed using cyclic voltammetry and differential pulse voltammetry, revealed exceptional analytical performance, with a broad linear detection range of 0.098–200 ng/mL ($R^2 = 0.985$), high sensitivity of 56.575 µA mL/pg.cm^2, and ultra-low detection (0.0152 ng/mL) and quantification (0.724 ng/mL) limits. Leveraging saliva as a diagnostic medium provides a simple, rapid, and cost-effective platform for early oral cancer screening, as it directly reflects local pathological changes. Overall, this first application of HsGDY in biosensing demonstrates a highly promising route for point-of-care, non-invasive detection and monitoring of oral malignancies.

Synergistic Chitosan-rGO nanocomposite functionalized with NiO nanofiller for targeted drug delivery in MCF-7 breast cancer cells

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The development of intelligent nanocarriers for targeted cancer therapy remains a significant challenge, demanding systems with high biocompatibility, substantial drug loading capacity, and stimulus-responsive release mechanisms. Our work presents the synthesis and characterization of a novel pH-sensitive nanocomposite comprised of chitosan (CS) and reduced graphene oxide (rGO), incorporating nickel oxide (NiO) nanoparticles as a functional nanofiller for enhanced drug delivery to MCF-7 breast cancer cells. Chitosan, a natural biopolymer, provides a biocompatible and biodegradable matrix, while the high surface area of rGO ensures efficient drug loading. Our strategy involves incorporating NiO nanoparticles inspired by promising results from similar multi-component systems using metal oxides like Fe_3O_4 for targeted drug delivery. NiO nanoparticles, recognized for their cytotoxic and synergistic effects against MCF-7 cells, can be incorporated into a polymer matrix to enhance therapeutic efficacy through the controlled modulation of their activity. The integration of these materials forms a stable platform suitable for various biomedical applications. The nanocomposite was synthesized via a facile method, and its structural, morphological, and physicochemical properties were extensively characterized. In-vitro drug release studies confirmed a pH-dependent release profile, with accelerated drug release under acidic conditions mimicking the tumor microenvironment, a critical feature for targeted drug delivery in cancer therapy. Further, cellular uptake analysis and cytotoxicity assays performed on MCF-7 cells demonstrated the nanocomposite's superior efficacy in inducing apoptosis. These findings underscore the potential of this advanced CS-rGO-NiO nanocomposite as a promising platform for breast cancer therapy.

Keywords: Chitosan, rGO, Nickel oxide, nanocomposite, targeted drug delivery, MCF-7 cells

Metal oxide nanoparticles as emerging agents for anticancer therapy

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Cancer remains a leading cause of death worldwide, and novel therapeutic strategies are urgently needed to improve treatment outcomes with reduced side effects. In this work, we report on our systematic study of metal oxide nanoparticles (MONPs) for anticancer activity, combining physicochemical characterization, in vitro cytotoxicity, mechanistic insights, and preliminary in vivo evaluation. Metal oxide nanoparticles have garnered significant attention as multifunctional agents in cancer theranostics due to their unique physicochemical properties, including high surface area, redox activity, and the ability to generate reactive oxygen species (ROS). In recent years numerous studies have reported the anticancer effects of metal oxide nanoparticles. These nanoparticles induce cytotoxicity primarily via ROS-mediated oxidative stress, apoptosis, mitochondrial dysfunction, and cell cycle arrest, with selectivity toward cancer cells over normal tissues. Anticancer efficacy of compound was studied using experimental and theoretical calculations. Characterisation techniques like FTIR, XRD were employed. Further the effect of metal oxide nanoparticles on cancer cells were studied. The formation of transition metal oxide was confirmed by FTIR, FESEM- EDS, Powder XRD.

Keywords: metal oxide nanoparticles, anti-cancer activity, cytotoxicity

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Biosynthesized Silver Nanoparticles for Biomedical Applications

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The search for sustainable and biocompatible routes for nanoparticle synthesis has driven increasing interest in plant-based approaches, particularly for biomedical applications. In this study, silver nanoparticles (AgNPs) were successfully synthesized using aqueous extracts of Citrus lemon offering an eco-friendly alternative to conventional chemical methods. The optimized AgNPs exhibits a strong absorbance peak at ~435 nm, confirmed by UV-Visible spectrometry. X-ray diffraction (XRD) confirmed the crystalline nature of the NPs, with size distribution of ~ 40 nm. Further, the structural and morphological study performed using Fourier-transform infrared spectroscopy (FTIR), dynamic light scattering (DLS), scanning electron microscopy (SEM), and transmission electron microscopy (TEM), validated the successful formation, stability, and nanoscale dimensions of the AgNPs. Biological assays revealed significant antioxidant and anti-inflammatory activities, which demonstrate the therapeutic potential of the AgNPs. In addition, the NPs has significant antimicrobial efficacy against gram positive bacteria such as B.subtilis and gram-negative bacteria such as E.coli which further highlighting their biomedical relevance. Given the central role of oxidative stress and neuroinflammation in the progression of Alzheimer's disease (AD), these findings suggest that biosynthesized AgNPs may serve as prospective candidates for neuroprotective applications.

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NIR-active Biomolecular Nanoassembly for Breast Cancer Theranostics

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Photothermal therapy has demonstrated significant potential for clinical translation in the past two decades. With the advancement in nanotherapeutics, novel nanocomposites have been synthesized to treat tumors via hyperthermia. This research incorporates the use of FDA-approved near-infrared responsive dye, indocyanine green (ICG), in conjugation with plasmonic gold nanoparticles (GNPs) as photothermal agents, for improved photothermal performance and photostability. The additive effect of ICG, primary photothermal agent, and GNPs, secondary photothermal agent, used in 5:1 ratio was exploited to create pronounced localized hyperthermia by loading these in poly-L-lysine nanoparticles. The manuscript further highlights the interaction of ICG with GNPs, with the latter contributing to plasmonic hyperthermia and stability to the nanoassembly. The synthesized PIGNPs showed improved photostability and better photothermal conversion efficiency when compared to free ICG and only ICG-loaded PLL nanoparticles over multiple laser irradiation cycles. The experimental validation of nanoassembly fabrication is supported by functional and morphological characterization done using absorption spectroscopy, emission spectroscopy, scanning electron microscopy with energy dispersive X-ray analysis, dynamic light scattering, and zeta potential analysis. The research findings indicate effective cellular uptake, good retention in tumor cells, and pronounced in-vitro photothermal cytotoxicity, in both 2D and 3D cell culture systems. The synthesized nanoassembly can prove to be an effective candidate to treat solid tumors via intratumoral photothermal therapy.

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EGFR targeting peptide decorated cubosomes as smart Nanocarriers for EGFR-overexpressing Cancer cells

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Targeted delivery of chemotherapeutic agents to cancer cells aids in enhancing drug accumulation within tumor tissues, minimizing the off-target toxicity, hence enhancing therapeutic efficacy. This localized drug delivery approach maximizes the cytotoxic impact on malignant cells. Hence, such strategies become promising for enhancing oncological outcomes and maintaining the patient's quality of life. Among various kinds of cancer, breast tumor has ranked one in females worldwide as well as in India, and death is estimated in every second women diagnosed with breast cancer. This study introduces an innovative liquid crystalline nanoparticles (LCNP) system loaded with chemotherapeutic drug and functionalized with EGFR targeting peptide specifically for targeting EGFR-expressing triple-negative breast cancer cells1. Advantages of using these particles include high surface area, sustained drug release, biocompatibility, and targeted drug delivery. Liquid crystalline nanoparticles (LCNPs) containing chemotherapeutic drug were synthesized using glycerol monooleate, DSPE-PEG, and Pluronic F-127 (GMO/PF127/water) system. These nanoparticles were validated using various characterizations including DLS, TEM, HR-TEM, and FTIR analysis. To analyze the effectiveness of the nanoparticle, different cell culture analysis were done including uptake studies, cytotoxicity, morphology, flow cytometry, and apoptosis2,3. The EGFR-targeting peptide-conjugated cubosomes exhibited selective uptake in EGFR expressing triple negative breast cancer (TNBC) cells, with minimal internalization observed in non-cancerous cells (HEK-293). Following 24 hours of treatment, these cubosomes effectively induced cytotoxicity in BC cells while demonstrating no significant toxicity in HEK-293 cells at equivalent concentrations. Furthermore, targeted drug delivery induced mitochondrial depolarization in TNBC cells, triggering apoptosis within 24 hours. These findings highlight the therapeutic potential of cubosomes as a promising nanocarrier system for enhancing treatment efficacy in breast cancer.

Unveiling the synergy of UiO-66/g-C_3N_4 for electrochemical detection of health altering toxic compound

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There are profound concerns over the effects of bisphenols on human health and marine ecosystems due to their widespread presence in packaged food/beverages and various industries. In this study, a composite of graphitic carbon nitride (g-C_3N_4) and zirconium metal-organic framework (UiO-66) is employed in detecting bisphenol using Cyclic Voltammetry (CV). UiO-66 is synthesized using the solvothermal route, g-C_3N_4 via melamine self-condensation and ultrasonication is used to form their composite for strong harmony [1]. XRD, FTIR, FESEM, XPS and EIS were used to analyze the electrochemical behavior and physicochemical characterizations. The synergistic interplay between UiO-66 and g-C_3N_4 results into lowering of charge transfer resistance compared to the pure counterparts of the composite which results into higher conductivity [2]. Leveraging the 3D structure of UiO-66 [3] and highly charged g-C_3N_4 nanosheets, molecular interactions with the analyte were improved efficiently in case of as-prepared composite [4]. Thus, the resulting sensing platform features a lowered limit of detection, broad linear range and exceptional electrocatalytic activity marking notable advancements in sensing performance. Furthermore, the proposed sensor exhibits excellent sensitivity, reproducibility and long-term stability, underlining its potential for real-world applications.

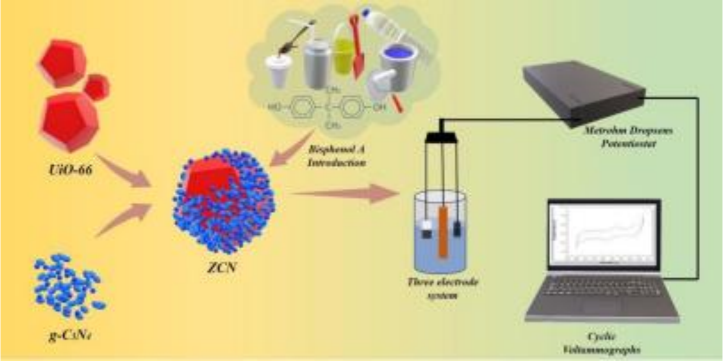

Figure 1. The schematic overview of the as-synthesized composite employed in the electrochemical sensor.

Antimicrobial and Anti-Inflammatory Silver Nanoparticles Coated with Chitosan and Hesperidin for Chronic Wound Healing Applications

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Silver nanoparticles (AgNPs) have been widely exploited for wound healing applications owing to their high antibacterial potential. However, the potential cytotoxicity of AgNPs limit their clinical applications. In this study, a novel combination of AgNPs coated with chitosan (Chi) and hesperidin (Hsd), i.e Ag-Chi-Hsd NPs has been synthesized to synergistically enhance the antibacterial and anti-inflammatory action as well as the selectivity of AgNPs using chitosan and hesperidin. The antibacterial, anti-inflammatory, and wound healing potential of Ag-Chi-Hsd NPs have been evaluated using multiple techniques such as MIC and MBC determination, live-dead assay, anti-biofilm assay, time-kill assay, in vitro cytokine release assay, and in vitro scratch assay. The prepared Ag-Chi-Hsd NPs were characterized using UV-visible spectroscopy, FTIR spectroscopy, XRD, DLS, NTA, TEM and SAED. Physical characterizations of Ag-Chi-Hsd NPs showed a spherical shape with a size ranging between 20-30 nm and large positive zeta potential of +44 mV. Ag-Chi-Hsd NPs exhibited remarkable antibacterial activity against both Gram-positive and Gram-negative pathogens commonly found at the wound sites, viz., S. aureus, B. subtilis, P. aeruginosa, and E. coli, respectively, with MIC of 5 µg/ml which was more potent in comparison with the bare AgNPs with the MIC of 7.5 and 15 µg/ml against Gram –ve as well as Gram +ve bacteria, respectively. It has also been observed that Ag-Chi-Hsd NPs eradicated about 90% of 24 hours and 48 hours old mature biofilms of the aforementioned bacteria. Ag-Chi-Hsd NPs showed excellent selectivity (up to 94) in its action when tested against the mammalian cells—NIH3T3 cells, RAW264.7 and THP-1. The nanoparticle formulation has also exhibited exceptional ability to lower the pro-inflammatory cytokines release such as—IL-6 and TNF-α—from the THP-1 cells stimulated with LPS by more than 90%. Moreover, in the vitro scratch assay, Ag-Chi-Hsd NPs have shown excellent wound healing potential with NIH3T3 cells by facilitating an almost complete closure of wound area by the end of day 2. These results suggest that Ag-Chi-Hsd NPs are highly suitable candidates for wound healing applications, as they combine the advantages of AgNPs, chitosan and Hsd in a single nanosystem.

NCCD: a unique blend of MOF-scaffolded stable luminescent copper nanoclusters (Cu NCs) and carbon dots (Cdots) as a potent antimicrobial agent against *Pseudomonas aeruginosa*

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Infections caused by bacterial biofilms result in large scale mortality and morbidity all over the world. Bacterial cells within the biofilm show remarkable degree of resistance against the conventional antibiotics and easily evade the host immune response. Therefore, there is an urgent need to develop alternative therapeutic strategies in order to combat widespread challenges posed by bacterial biofilm infections. In this regard, we developed a unique combination of MOF-scaffolded fluorescent copper nanoclusters (Cu NCs) with bactericidal and biocompatible carbon dots (Cdots); named as nanocluster-carbon dots (NCCD). The NCCD showed broad spectrum antibacterial and antibiofilm activity against *Escherichia coli, Bacillus subtilis* and pathogenic strain of *Pseudomonas aeruginosa*. CuNCs showed a MIC_{90} value of 7.5 ± 2, 10 ± 3 and 20 ± 2 $\mu g\ ml^{-1}$ against *P. aeruginosa*, *B. subtilis* and *E. coli*, respectively. Cdots exhibited a MIC_{90} value of 160 ± 2 and 200 ± 5 $\mu g\ ml^{-1}$ against *B. subtilis* and *E. coli*, respectively. It was found that NCCD mediated bacterial cell death was due to the loss of cell membrane permeability. Additionally, NCCD demonstrated antibiofilm activity. It reduced the mass of established biofilm in *B. subtilis* and *P. aeruginosa* to 53.09% and 68.43%, respectively. Antibiofilm activity of NCCD against *P. aeruginosa* and *B. subtilis* was increased considerably when it was used in combination with biofilm-degrading enzymes like DNase and α-amylase. Significant increase in the susceptibility of *P. aeruginosa* and *B. subtilis* biofilms to antibiotics was observed in presence of NCCD. Finally, we demonstrated that NCCD-mediated biofilm degradation was due to the transition of cells from biofilm stage to the free-living planktonic state. Therefore, it is conceived that NCCD could be a potent agent against wide range of bacterial infections.

From Electrostatic to Hydrophobic Driving Forces: N-Acetylation Transforms pH-Dependent Peptide Self-Assembly

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Self-assembling peptides have emerged as promising biomaterials for nanotechnology applications, yet precise control over assembly conditions remains challenging. This study investigates the pH-dependent self-assembly behavior of a heptapeptide (Phe-Aib-Leu-Ala-Aib-Leu-Phe) and demonstrates how N-terminal acetylation dramatically modulates assembly conditions. The unmodified peptide with free termini exhibits self-assembly exclusively under acidic conditions (pH 1.4-1.8), driven primarily by intermolecular electrostatic interactions facilitated by protonation of the N-terminal amino group. Remarkably, N-terminal acetylation shifts the self-assembly window to physiological pH 7.4, eliminating the requirement for harsh acidic conditions. Mechanistic analysis reveals that acetylation neutralizes the positive N-terminal charge, fundamentally altering the driving forces governing assembly. Under physiological conditions, the acetylated peptide (Ac-Phe-Aib-Leu-Ala-Aib-Leu-Phe-OH) relies on hydrophobic interactions and π-π stacking between terminal phenylalanine residues for stabilization. The strategic sequence design contributes significantly to assembly behavior: leucine residues promote helical propensity crucial for ordered structures, while Aib residues provide conformational flexibility and reduce steric hindrance, facilitating efficient molecular packing. Spectroscopic and microscopic characterization, supported by computational analysis, demonstrates that the acetylated peptide forms well-defined nanostructures in HEPES buffer through cooperative hydrophobic effects. The aliphatic side chains of leucine and Aib minimize aqueous exposure, while aromatic phenylalanine residues engage in favorable π-π stacking interactions. This work establishes N-terminal modification as a powerful strategy for tuning peptide self-assembly conditions, enabling biocompatible assembly at physiological pH. The transition from electrostatic to hydrophobic driving forces represents a paradigm for designing pH-responsive peptide materials with tailored properties for biomedical applications, drug delivery systems, and tissue engineering scaffolds.

Keywords: peptide self-assembly, N-terminal acetylation, pH-responsive materials, hydrophobic interactions, π-π stacking, biomaterials, nanotechnology

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Structural Modifications of Small-molecule Enzyme Inhibitors for the Enhancement of Anticancer Activity

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Small-molecule enzyme inhibitors have become pivotal in targeted cancer therapy due to the ability to selectively modulate enzymes function in tumor metabolism, proliferation, and immune evasion. Despite significant progress, challenges such as limited solubility, poor bioavailability, off-target toxicity, and drug resistance remain obstacles for many inhibitors. Aldose reductase (AR), a critical enzyme in the polyol pathway, is notably overexpressed in various cancers, contributing to metabolic reprogramming, oxidative stress, inflammation, and chemoresistance. Epalrestat, a selective AR inhibitor approved for diabetic neuropathy, has demonstrated promising anticancer effects by elevating reactive oxygen species and inducing apoptosis in tumor cells. However, its hydrophobic nature and suboptimal pharmacokinetics restrict its therapeutic potential. Similarly, the DNA intercalator amonafide exhibits potent anticancer activity but is limited by solubility and toxicity concerns. To overcome these issues, chemical modifications with mitochondria-targeting moieties such as triphenylphosphonium (TPP) and positively charged pyridine are employed. These modifications enhance mitochondrial accumulation driven by membrane potential, improving cellular uptake, reactive oxygen species (ROS) generation, and selective cancer cell apoptosis. This integrative approach, combining enzyme inhibition with mitochondrial targeting, offers a promising approach for developing next-generation anticancer therapeutics with improved efficacy and safety profiles.

Advancing Diagnostic Reagent Stability: A Novel Reagent-Encapsulated Hydrogel System for Portable Blood Parameter Testing

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Conventional diagnostic reagents, whether in dry or liquid form, face major limitations in stability, shelf life, and cold-chain dependency, restricting widespread blood testing—especially in rural and remote areas lacking laboratory infrastructure. This study presents a reagent-encapsulated hydrogel system designed to enhance reagent stability, portability, and usability under diverse environmental conditions without compromising chemical integrity. A glucose reagent was encapsulated within a polyvinyl alcohol (PVA) hydrogel matrix using a controlled mixing and freeze–thaw process. This encapsulation preserved reagent activity while converting it into a stable, portable format. To evaluate system performance, a custom optical detection unit comprising a light source and LED–LDR sensor was developed. Following baseline intensity (I0) measurements, the hydrogel was exposed to glucose solutions (50–400 mg/dL) at 37 °C for 30 minutes. Glucose diffusion induced a characteristic light-pink color change, producing a measurable shift in transmitted light intensity (Is). Preliminary tests demonstrated successful, stable reagent encapsulation and a distinct colorimetric response, showing a strong linear correlation between glucose concentration and light intensity. This response confirms the platform's suitability for quantitative analysis, with projected accuracy exceeding 60% for blood glucose estimation. Pending clinical validation, the system's high stability and portability offer a promising foundation for reliable, low-cost, and accessible point-of-care diagnostics. By eliminating cold-chain dependence and improving reagent longevity, this hydrogel-based approach can significantly expand diagnostic capabilities in resource-limited settings, enabling efficient and equitable healthcare delivery.

Keywords: Hydrogel, Reagent Encapsulation, Blood Glucose Testing, Point-of-Care Diagnostics, Biosensor.

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Doping of PAAm hydrogel with Ag nanoparticle for anti-bacterial study

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The production, stabilization, and antibacterial assessment of silver nanoparticles (AgNPs) integrated into polyacrylamide (PAAm) hydrogels are the main objectives of this work. AgNPs were created by reducing silver nitrate (AgNO3) with PVP as a stabilizer and sodium borohydride (NaBH4) as a reducing agent. In order to track color transition, particle stability, and morphology over time, different NaBH4 concentrations (100–250 µl) were evaluated in both dark and light situations. UV–Vis spectroscopy, FESEM, and EDX were used to characterize the produced AgNPs to verify their elemental composition and nanoparticle formation. AgNPs–hydrogel composites were then created by loading AgNPs into swelled and shrunken PAAm hydrogels. Using LB and MRS agar plate assays, the antibacterial activity of these composites was evaluated against Gram-positive Lactobacillus and Gram-negative Escherichia coli. The significant antibacterial potential of AgNPs-doped hydrogels was revealed by the results, which showed efficient bacterial suppression. The study emphasizes how the stability, plasmonic characteristics, and antibacterial efficacy of AgNPs–hydrogel systems are influenced by synthesis conditions and nanoparticle concentration.

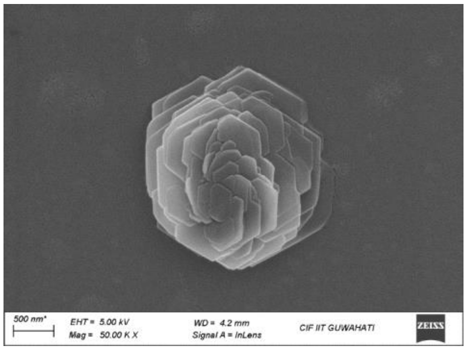

Figure 1. FESEM image of prepared Ag NP.

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Point-of-care detection of biomarkers for respiratory diseases from exhaled breath

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Respiratory diseases account for a huge number of diseased patients, making it the third leading cause of death around the world. Conventional methods for the detection of these diseases involve the use of spirometry, chest imaging, etc. The major limitations of these techniques include the need for manual expertise and financial costs, which make it difficult to reach the masses. To overcome these limitations, there is a requirement to develop point-of-care diagnostic tests that can help in the detection of this disease. One of the non-invasive methods to detect these diseases is to evaluate the biomarkers obtained from the exhaled breath condensate. But the major issue while using the exhaled breath condensate is its demand for appropriate storage conditions, which could be difficult in a rural set-up, thereby leading to the degradation of the samples collected from patients. Several studies have stated that Hydrogen peroxide is the major analyte that is common for the three most concerning respiratory diseases, i.e, COPD, Lung Cancer, and Asthma. The strong oxidising power of hydrogen peroxide is responsible for several structural and chemical changes of various nanoparticles. This property could be utilized to analyse the exhaled breath condensate. This study focuses on developing a nanoparticle-coated surface that could either be utilised on the interiors of the mask or as a form of dip-stick, which could help in the detection of the target analyte, i.e, hydrogen peroxide, by colorimetric or UV-based mode of detection. The extent of colour change could help in detecting the concentration of the analyte present in the exhaled breath condensate quantitatively.

Keywords: Nanoparticles, Respiratory diseases, Exhaled breath condensate, dip-stick, point-of-care

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Engineered Mucus-inspired Hydrogels: Site-specific Functionalization for enhanced Bio-Sensing applications

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Mucus is a dynamic biological hydrogel, composed primarily of the glycoprotein mucin, which exhibits unique biophysical properties including biocompatibility, muco-adhesion, and tunable network structures. This work focuses on chemical modifications and functionalization of these hydrogels, specifically targeting the hydroxyl (OH) groups and disulfide linkages in the mucin backbone. By leveraging these reactive sites, novel strategies have been developed to introduce functional motifs such as thiols, aldehydes, and carboxylates, which optimizes crosslinking density and enables selective bio-sensing capabilities. The advanced engineered hydrogels showcase enhanced mechanical strength, controlled swelling, and improved electrical conductivity thereby making them suitable for real-time sensor applications in physiological environments. Initial evaluations demonstrate stable and sensitive electrochemical detection of biomolecules, highlighting the hydrogels' potential use in diagnostics, wound monitoring, and drug delivery interfaces. This research underscores the importance of site-specific chemical engineering in developing advanced, mucus-inspired materials for next-generation biomedical applications. Overall, this novel mucin-inspired copolymer generates mucus-mimetic hydrogels on a multi-gram scale. These hydrogels can be used as models for disulfide-rich airway mucus research, and as biomaterials.

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Biocompatible Riboflavin-Dispersed Graphene Oxide Nanomaterials: Enabling Enhanced Fluorescence Bioimaging and Cellular Uptake

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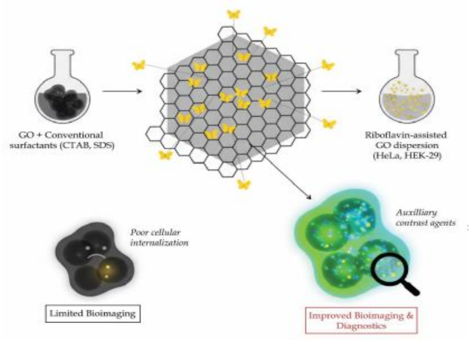
Graphene oxide (GO) nanomaterials offer unique surface chemistries ideal for biosensing and imaging, though their practical use in biological environments is severely restricted by poor aqueous dispersibility. To address this limitation, this study evaluates riboflavin as a biocompatible dispersing agent for GO, benchmarked against conventional surfactants such as cetyltrimethylammonium bromide (CTAB) and sodium dodecyl sulphate (SDS). Employing tapping, electrical, and nanomechanical modes of atomic force microscopy, we characterized how surfactant and biomolecule supplementation modifies GO's surface topography, electrical response, and nanomechanical traits. Notably, riboflavin significantly increases surface roughness and modulates key electromechanical properties, facilitating enhanced cellular interactions. Bioimaging studies using HeLa and HEK-293 cell lines demonstrate that riboflavin-assisted dispersions promote greater cellular internalization than traditional surfactants, resulting in heightened intracellular fluorescence, especially when auxiliary contrast agents (SDS, CTAB) are present. These findings present riboflavin as an eco-friendly, biocompatible alternative for nanomaterial formulation and demonstrate the promise of flavin-dispersed GO as a sensitive fluorescence probe for real-time visualization of cellular processes—paving the way for advanced bioimaging and diagnostic applications.

Keywords: Graphene oxide, Riboflavin, AFM analysis, Bioimaging, Fluorescent probe.

Graphical Abstract



Injectable Matrix-Mimetic GelMA Hydrogel for NIR-Controlled Chemotherapy and Integrin-Mediated Anti-Angiogenic Therapy

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Effective treatment of solid tumors remains challenging due to poor drug penetration, systemic toxicity, and tumor recurrence. To address these limitations, we developed a near-infrared (NIR) responsive, dual drug-loaded Gelatin Methacryloyl (GelMA) hydrogel for synergistic chemotherapy and anti-angiogenic therapy. Gold nanorods (AuNRs), synthesized via a seed-mediated CTAB method with their localized surface plasmon resonance (LSPR) tuned to 808 nm, were conjugated with 5-Fluorouracil (5-FU) for photothermally triggered drug release. Simultaneously, an αvβ3/αvβ5 integrin targeting anti-angiogenic peptide was encapsulated within the GelMA matrix to achieve sustained local delivery. The AuNRs exhibited an average aspect ratio of 4.32 ± 1.50, a hydrodynamic diameter of 34.28 ± 5.22 nm, and a zeta potential of +16.1 ± 2.28 mV (DLS). The optimized hydrogel demonstrated uniform nanorod distribution, high drug encapsulation efficiency, and a reduced degradation rate compared to the hydrogel without gold nanorods. Upon NIR exposure, the hydrogel matrix experienced localized heating, triggering the release of 5-FU from the nanorods and the anti-angiogenic peptide from the hydrogel with precise temporal control. In vitro assays using CAL 33 cells confirmed concentration-dependent cytotoxicity of free 5-FU and AuNRs, while live/dead and ROS (DCFDA) staining revealed pronounced oxidative stress and cell death upon NIR-triggered release from 5FU@AuNR GelMA hydrogels compared to control and blank hydrogels.

The system demonstrated excellent injectability, structural integrity, and photothermal responsiveness, enabling on-demand release under 808 nm irradiation. Preliminary investigations into endothelial modulation indicate the potential of the incorporated anti-angiogenic component to suppress neovascular cues, and detailed anti-angiogenic studies are underway. Overall, this NIR-responsive, dual drug-loaded GelMA hydrogel represents a minimally invasive, physiomimetic drug delivery platform offering superior site-specificity, reduced systemic toxicity, and controlled dual-drug release compared to conventional delivery systems, holding strong translational promise for multimodal solid tumor therapy.

Structural Isomer Engineering: Modulating TADF and RTP Emissions to Enhance ROS Generation and Photodynamic Therapy Efficiency from Cells to In Ovo Systems

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Image-guided photodynamic therapy (PDT) represents a promising and minimally invasive approach for cancer treatment, offering precise therapeutic control with real-time monitoring and reduced side effects. Although thermally activated delayed fluorescence (TADF) and room-temperature phosphorescence (RTP) materials have recently emerged as effective metal-free photosensitizers, their distinct photophysical roles and comparative therapeutic performances remain underexplored.[1,2] In this study, two AIE-active positional isomers 4-CBT2 (para) and 3-CBT2 (meta) were synthesized by varying the carbazole substitution on the phenyl core. This structural modification induced notable changes in molecular conformation and excited-state dynamics, including variations in ΔEST, reverse intersystem crossing (RISC)/ISC rates, spin–orbit coupling (SOC), and radiative decay (Kr). As a result, the isomers exhibited a clear switching of emission behavior from TADF to RTP. The 4-CBT2 isomer displayed TADF characteristics with a lifetime of 259.4 μs and a PLQY of 38%, whereas the twisted 3-CBT2 exhibited RTP emission with a significantly longer lifetime of 29.88 ms and a PLQY of 21.88%. Both isomers were employed as photosensitizers for image-guided PDT and evaluated through in vitro and in ovo assays. Comprehensive studies revealed their efficiency in selective cancer cell targeting, ROS generation, 3D tumor spheroid inhibition, and tumor suppression in an in ovo glioblastoma model. Mechanistic investigations further elucidated their effective cellular uptake, internalization, and light-triggered ROS generation, leading to selective cancer cell apoptosis. Notably, both 4-CBT2 and 3-CBT2 demonstrated high specificity toward glioblastoma cells with negligible cytotoxicity to normal cells, offering a safe and targeted therapeutic strategy. This work provides the first detailed comparison of TADF- and RTP-based isomeric photosensitizers and establishes their potential as next-generation agents for image-guided PDT and multifunctional cancer theranostics.

Synergistic in-vitro Inhibition of Lung Cancer Cells Using L-Carnosine-Capped Copper Nanoclusters

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Metal nanoclusters (MNCs), with atomically precise structures and quantum-confined properties, have emerged as versatile candidates for biomedical applications, particularly in cancer theranostics. Their ultrasmall size, tunable fluorescence, and rich surface chemistry enable simultaneous therapeutic and diagnostic functionality.[1] However, conventional cancer therapies remain constrained by high toxicity and limited selectivity, underscoring the need for safer and more effective alternatives. To overcome these limitations, we developed L-carnosine-capped copper nanoclusters (Cu4L5) that synergistically combine the therapeutic potential of L-carnosine with the anticancer properties of copper. The nanoclusters were synthesized and comprehensively characterized using UV–vis, fluorescence, FT-IR, HR-TEM, HR-MS, and EDX analyses. Cu4L5 demonstrated significant cytotoxicity against A549 lung cancer cells while exhibiting minimal toxicity toward normal Vero-2 cells, as confirmed by MTT assays and IC50 values. Compared to L-carnosine and L-histidine-stabilized CuNCs, Cu4L5 showed nearly twofold enhanced anticancer activity, confirming a synergistic effect. Moreover, the nanoclusters enabled highly sensitive glutathione (GSH) detection in the nanomolar range via the Stern–Volmer relationship, indicating intrinsic diagnostic potential. Computational studies revealed copper–ligand coordination through imidazole N and carbonyl O atoms, leaving carboxylate and amino groups accessible for cellular interactions. This dual therapeutic and diagnostic functionality underscores the potential of Cu4L5 as a promising nanoplatform for targeted, low-toxicity cancer treatment.[2]

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Curcumin–Metal Complexes in Albumin Nanocarriers Enable Mitochondrial Photodynamic Therapy

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Curcumin, a natural compound derived from the Curcuma longa plant, exhibits significant anticancer properties through the regulation of cell signalling, the induction of apoptosis, and the prevention of tumour growth. The clinical application of this compound is restricted due to its low solubility, quick breakdown, and inability to target specific subcellular areas. We developed a curcumin ligand targeted at mitochondria that was functionalized with triphenylphosphine (TPP) to address these challenges. This ligand was used to form photoactive complexes with iridium(III), ruthenium(II), and rhenium(I) metals. Curcumin exhibits anticancer properties, whereas the metals improve light absorption, produce reactive oxygen species (ROS), and facilitate photodynamic therapy (PDT). The most potent complex was encapsulated in Human Serum Albumin (HSA) nanoparticles to enhance stability, circulation, and tumour accumulation. Studies conducted in vitro demonstrated that these nanoparticles effectively transport the complexes to mitochondria, where light exposure initiates ROS production and leads to substantial cancer cell death. This approach brings together curcumin's inherent anticancer properties, mitochondrial targeting, metal-enhanced phototherapy, and HSA-based delivery, resulting in a synergistic effect. Our study introduces a straightforward and efficient nanomedicine system to enhance curcumin-based photodynamic therapy, providing a promising approach for advanced cancer treatment.

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Carboxylated MWCNT-Interlaced HdS-GdO$_3$ Hybrid Nanoplates for Enzyme-Free Electrochemical Uric Acid Detection in Human Physiological Samples

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Mesenchymal stem cells (MSCs) derived from adipose tissue and Wharton's jelly offer significant promise in neurotherapeutic applications due to their regenerative capacity and low immunogenicity. The regeneration of MSCs into different cell lineages largely depends on the presence and activity of bioactive molecules. However, the direct administration of bioactive molecules is often limited by rapid degradation, poor solubility, and controlled release, which could hinder therapeutic progress. In this study, a nanocarrier composed of chitosan and stearic acid was developed for the sustained delivery of retinoic acid (RA), a bioactive compound known for its role in neural development and neuroprotection. The nanocarriers were characterized for particle size, morphology, encapsulation efficiency, and RA release kinetics. Adipose-derived MSCs (AD-MSCs) and Wharton's jelly-derived MSCs (WJ-MSCs) were treated with RA-loaded nanocarriers, and cellular viability was assessed using the MTT assay. The results demonstrated a significant enhancement in cell viability for both MSCs, indicating that sustained RA delivery provides a supportive and protective cellular environment. These findings suggest that chitosan and stearic acid nanocarriers delivering RA may serve as an effective strategy for enhancing stem cell-based interventions aimed at preventing or mitigating neurological disorders.

Keywords: ADMSC, WJMSC, RA, Nanocarrier, Neurological disorder.

Tungsten Disulfide Nanosheet based Electrochemical Immunosensorfor the Detection of Stress Biomarker in Artificial Sweat

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Cardiovascular diseases (CVDs) remain the leading cause of global mortality, increasing the need for stress-related biomarkers such as cortisol in early diagnostics. In this work, tungsten disulfide (WS_2) nanosheets were synthesized using a simple one-pot, low-temperature hydrothermal method and used to develop an electrochemical immunosensor for cortisol. To the best of our knowledge, this is the first report employing WS_2 nanosheets for cortisol-specific immunosensing in the context of CVD detection. The WS_2 nanosheets and anti-cortisol antibodies were immobilized onto a carbon screen-printed electrode (cSPE), followed by electrochemical characterization. Both cyclic voltammetry (CV) and differential pulse voltammetry (DPV) confirmed strong catalytic behavior of the modified electrode. DPV studies showed a detection limit of 0.012 ng/mL, a sensitivity of 36.438 µA (log10ng/mL)$^{-1}$cm^{-2}, and a wide linear range from 0.001 to 1000 ng/mL. The high surface area and conductivity of WS_2 enabled efficient electron transfer, supporting accurate cortisol quantification. Overall, WS_2-based electrodes demonstrate strong potential for sensitive, rapid, and cost-effective cortisol detection, highlighting their applicability in scalable biosensor fabrication and early CVD diagnostics.

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Potential Application of MXene/MWCNT Nanocomposite as an Electrochemical Biosensor

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MXene/MWCNT nanocomposites present a highly promising platform for next-generation electrochemical biosensors due to their synergistic combination of exceptional conductivity, high surface area, and rich surface functionalities. MXenes, a class of two-dimensional transition metal carbides and nitrides, exhibit metallic conductivity and tunable surface terminations that facilitate rapid electron transfer and effective immobilization of biomolecules. Meanwhile, multi-walled carbon nanotubes (MWCNTs) contribute mechanical stability, a high aspect ratio, and effective electron tunneling networks that enhance overall charge transport across the sensing interface. The integration of MXenes with MWCNTs therefore yields a hybrid nanostructure that improves sensitivity, selectivity, and stability in biosensing systems. Such composites have been shown to effectively detect a variety of biomolecules, including nucleic acids, enzymes, and cancer biomarkers, demonstrating wide potential in biomedical diagnostics, point-of-care testing, and personalized medicine. The unique interfacial architecture of MXene/MWCNT-based electrodes not only enhances signal transduction efficiency but also enables multiplexed and real-time detection with high reproducibility. Consequently, this nanocomposite system represents a critical step toward the design of flexible, miniaturized, and high-performance electrochemical biosensors for diverse health monitoring applications.

Keywords: MXene, MWCNT, nanocomposite, electrochemical biosensor, biomarker detection, biomedical diagnostics, point-of-care sensors.

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Anchoring Induced Mode Transition in Nematic–Isotropic Bilayer

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Understanding how interfacial instabilities emerge in thin, confined films is essential for controlling pattern formation [1-3] in microfluidic and nanofluidic devices. When such films involve nematic–isotropic liquid combinations, the scenario becomes markedly more complex and subtle, necessitating a deeper, more nuanced framework to fully characterize the instability landscape. This study explores the dynamic instability mechanisms in a class of free bilayer [4, 5] films composed of a nematic liquid crystal (NLC) atop an immiscible isotropic fluid, as shown in Figure 1, emulating a bilayer configuration. These bilayers are suspended in air, with a rigid bottom substrate, and subjected only to intrinsic elastic and interfacial forces. We formulate a linear stability model based on long-wave hydrodynamics coupled with Frank–Oseen elasticity [6] to analyze how nanoscale perturbations evolve within such systems. In contrast to conventional single-layer instabilities, bilayers introduce multiple interacting modes due to the deformability of both the free surface and the buried NLC–isotropic fluid interface. The results show two dominant instability pathways: (i) deformation is localized near the inner interface, and (ii) is driven by curvature and surface tension at the top interface. The dominance depends on the thickness, anchoring conditions at the boundaries, and relative surface tensions among the interfaces. The present study uncovers the role of anchoring asymmetry. While planar–planar (θ1=π2, θ2=π2) and planar–homeotropic (θ1=π2, θ2=0) anchoring configurations exhibit well-defined transitions between pathways, the planar–angular case results in mixed instabilities across a wide parameter space. This indicates that orientational elasticity can serve as a tuning mechanism for pattern complexity, mode coexistence, and wavelength control.

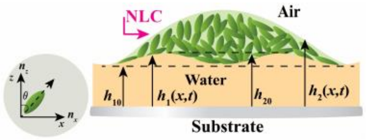

Figure 1. Schematic representation of the NLC-isotropic system emulation the bilayer configurations otop solid substrate and in contact with the bounding air medium. The schematic shows h1(x, t) and h2(x, t) as the local thicknesses with h10 and h20 as the mean thicknesses of NLC and water films, respectively. The θ is the angle that NLC director (n) makes with the positive z-axis direction, as displayed on the left-side circle

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Tailoring Structural and Optical Properties of HfO_2 Thin Films for Neuromorphic and Non-Volatile Memory Applications

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Ferroelectric materials can reversibly switch their polarization, allowing them to modulate the tunneling barrier and making them promising candidates for next-generation nano electronic applications [1]. In this study, we investigated the influence of deposition conditions on hafnium oxide (HfO_2)-based ultra-thin films to evaluate their potential for memristive and neuromorphic device applications [2]. The deposited hafnium oxide films using RF magnetron sputtering at room temperature on silicon and Corning 7059 glass substrates. The film quality and ferroelectric behaviour is optimized by systematically varying the oxygen flow rate and sputtering power [3]. Post deposition annealing done on Si substrate at 550 ºC, and 750 ºC for 2hrs in tubular furnace. Structural, optical, and interfacial analyses done using X-ray diffraction (XRD), X-ray reflectivity (XRR), Ellipsometry, and UV–Visible spectroscopy. XRD shows monoclinic and tetragonal/orthorhombic mixed crystal phase structure in annealed films. Optical bandgap, optical dielectric constant, and Urbach energy to understand the disorder and defect states. The results show that controlling the oxygen flow rate and sputtering power significantly alters the film's density, surface roughness, crystal phase, and optical transitions. Among all samples, the HfO_2 film deposited at 450 W and 5 sccm oxygen flow exhibited optimal transparency, smoothness, and uniform thickness, making it suitable as a switching layer in ferroelectric-controlled tunnel memristors.

These findings demonstrate the tunability of HfO_2-based films and their strong potential for use in low-power neuromorphic and non-volatile memory devices.

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Molecular Dynamics Insight into Polyaniline-Phenylalanine Interactions in Molecularly Imprinted Polymers for Sensing applications

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In this work, we presented a detailed all-atom molecular dynamics (MD) simulations elucidating the interactions between polyaniline (PANI) polymer and phenylalanine (Phe) molecules to support experimental developments in molecularly imprinted polymers (MIPs) for sensing applications. We constructed six computational models using trimeric and tetrameric PANI chains interacting with single Phe molecules in ratios of 1:1, 2:1, and 3:1. The simulations were performed using the OPLS_2005 force field via the Desmond engine for 500 ns, with maintaining a 10 Å edge distance to capture conformational dynamics and polymer-template binding. Root-mean-squared deviation (RMSD) and radius of gyration (Rg) revealed stable compact states predominantly characterized by RMSD values below 3 Å, especially in 1:1 complexes exhibiting larger Rg due to polymer flexibility. Increased molecular crowding in 2:1 and 3:1 ratios induced tighter packing, reduced Rg values, and enhanced noncovalent interactions, particularly π–π stacking and hydrogen bonding between PANI aromatic rings and Phe side chains. In addition to this pearson correlation coefficient (PCC) analysis demonstrated a strong relationship between RMSD and Rg, with hydrogen bonding negatively correlated to Rg (ca. -0.3), indicating compact conformational state. Further crowding effects on binding site accessibility were observed with higher PANI-to-Phe ratios corresponded to increased contact areas and reduced conformational flexibility. Overall, these findings explain the molecular basis of PANI-MIP specificity and stability, reinforcing the critical role of polymer-template interactions in sensor performance. The simulation insights support future optimization of MIP design by tuning polymer chain length and template ratios for enhanced sensitivity. Future work will explore the influence of solvent effects and extended polymer architectures to further refine binding site dynamics and sensor efficacy.

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Molecular Dynamics and Quantum Chemical Insights into the Role of Thiourea in the Evolution of Silver Nanocluster

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The nucleation and growth behavior of Ag nanocluster with a specific focus on the mechanistic role of polyvinylpyrrolidone (PVP) and thiourea (Tu) has been investigated using molecular dynamics (MD) simulations. Structural coordinates of Ag nanoclusters were produced using VESTA, while the chemical structure of the PVP and Tu were integrated through Maestro suit software. Three different model systems containing 1001 Ag atoms and 10 PVP residues: T0 (without Tu), T0.5 (100 Tu molecules), and T1 (200 Tu molecules) were created to elucidate how varying Tu concentration modulates cluster stability, interaction and nucleation efficiency. Complementary quantum chemical calculations were performed using Gaussian software employing the B3LYP functional and LaNL2DZ basis set for geometry optimization and excited energy calculation. Time-dependent DFT (TD-DFT) simulations provided a gas phase electronic absorption spectrum of the applied different models. Further, Symmetry-adapted perturbation theory (SAPT) were employed for decomposition analysis from electrostatic, exchange, induction, and dispersion to noncovalent stabilization between Ag clusters and functionalizing agent. Overall, the computational investigation demonstrated how PVP and Tu synergistically affect the structural and electronic properties into the Ag cluster formation.

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Next-Generation Bioplastics: Harnessing Banana Waste Nanomaterials for High-Performance, Functional Food Packaging

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The increasing environmental problems we're facing make an urgent need to create better packaging materials that can completely break down naturally, instead of relying on the usual petroleum-based plastics. This research tackles that challenge by making a new type of eco-friendly plastic film that's strengthened with two different kinds of nanomaterials made from waste: something called nanocellulose and Carbon Quantum Dots, both coming from leftover banana plant stems that would otherwise be thrown away. The dual reinforcement strategy aims to synergistically enhance the biopolymer film's structural, barrier, and active functional characteristics. CNCs were successfully isolated from the pseudo stem fibers via alkali treatment and sulfuric acid hydrolysis. The effectiveness of this method was validated through testing, where X-ray Diffraction analysis revealed that the cellulose became much more crystalline, jumping from 48% in its original state to 67.52% after becoming nanocellulose. Using Field Emission Scanning Electron Microscopy, researchers also confirmed that the material had the expected interconnected nanofiber structure. At the same time, they created bright fluorescent carbon quantum dots measuring 1-3 nanometres from the leftover juice using a quick and environmentally friendly sustainable hydrothermal method. These bio-nanomaterials were then incorporated into a corn starch/Polyvinyl Alcohol (PVA)/Carboxymethyl Cellulose (CMC) matrix to create the bioplastic film via solution casting. The resulting films were comprehensively characterized for enhanced mechanical properties (Tensile Strength, Elongation at Break), improved barrier performance (Water Vapor Transmission Rate (WTR), Oxygen Transmission Rate (OTR)), and desirable active properties (Antioxidant and Antibacterial Activity, and Biodegradability). This research successfully demonstrates a circular economy approach, transforming abundant agricultural waste into an advanced, bio-based packaging film that is a promising sustainable alternative for the food packaging industry.

Keywords: Bioplastic, Nanocellulose, Carbon Quantum Dots, Banana Pseudo Stem, Food Packaging, Circular Economy, Biodegradable.

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Ultrasensitive Hydrogen Peroxide and Glucose Sensing Using Peroxidase-Mimicking Bimetallic Pt/Pd Nanorattles Featuring Core-Void-Shell Architecture

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Nanozymes, synthetic nanomaterials that mimic enzymatic activity, offer a promising alternative to biological enzymes because of their robustness, stability, and cost-effectiveness. Among them also, noble metal-based nanozymes demonstrate exceptional catalytic properties, due to its high standard electrode potential, demonstrate the effective catalysis of H2O2 to produce •OH radicals, like Fenton-like catalysts. This study presents the synthesis and characterization of novel Au-octa@Pt NRT and previously reported Au-Octa@Pd NRT, consisting of a solid gold octahedral core encapsulated by a porous cubic shell of Pt or Pd, respectively. This distinctive geometry of core@void@shell maximizes catalytic active sites while reducing surface/active site passivation by surfactants hence enhances nanozyme activity. The catalytic efficiency of these synthesised nanorattles was assessed via peroxidase-like activity assays using 3,3',5,5'-tetramethylbenzidine (TMB) as the substrate and H2O2 as the oxidizing agent. Michaelis-Menten kinetics demonstrated that Au-Octa@Pt NRT exhibited higher catalytic efficiency relative to Au-Octa@Pd NRT, Au-NRT and the natural enzyme horseradish peroxidase (HRP). The Porous and rough morphology of Au-Octa@Au NRT, resulted from Stransky-Krastanov (Layer-plus-Island) growth, generates a rough surface that exposes additional atomic sites. This exposure enhances activity due to lattice distortion between Ag and Pt atoms, enhances substrate interaction and catalytic turnover. Furthermore, the Au-Octa@Pt NRT nanozyme was used in a colorimetric cascade assay for the ultrasensitive detection of H2O2 and glucose, demonstrating detection limits of 0.3 µM and 0.01 µM, respectively, along with a pronounced selectivity toward glucose over its analogs. The nanozyme exhibited stability and catalytic activity across a broad temperature range (40–100 °C), outperforming natural enzymes in harsh conditions. The application in intricate biological matrices, including fetal bovine serum and artificial sweat, exhibited a recovery rate of 95-108% with relative standard deviation of less than 5%, indicating reliable glucose detection, highlighting its potential for practical biomedical applications.

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Eco-Friendly Dispersion and Cytocompatibility Enhancement of Graphene Variants Using Riboflavin as a Bio-Dispersant

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Graphene oxide (GO) and its reduced form (rGO) are well-known for their remarkable optical, electrical, and structural characteristics, which make them promising materials for biomedical and sensing technologies. Nevertheless, their strong tendency to aggregate often hinders uniform dispersion and limits practical applications. In this work, riboflavin, a naturally occurring and biocompatible flavin molecule, was employed as an eco-friendly dispersing agent to improve the stability of GO and rGO sheets in aqueous environments. Spectroscopic analyses (UV–vis and fluorescence) combined with molecular dynamics simulations demonstrated a stronger adsorption affinity of riboflavin toward rGO compared to GO, leading to enhanced stability and slower desorption rates. Structural evaluations using X-ray diffraction, Raman spectroscopy, and field-emission scanning electron microscopy revealed that riboflavin adsorption increased interlayer spacing, enlarged flake dimensions, and introduced mild structural disorder without disturbing the crystalline arrangement. Electrochemical studies further indicated that the rGO–riboflavin system exhibited broader redox peaks and higher electrical conductivity, confirming more efficient electron transfer. Antibacterial assays showed reduced toxicity of the riboflavin-treated GO and rGO against Escherichia coli and Bacillus subtilis, while MTT cytocompatibility tests on HEK cells confirmed improved cell viability. Altogether, these results highlight riboflavin's dual role in stabilizing graphene-based nanostructures and mitigating their cytotoxic effects, thereby expanding their potential in biosensing, antimicrobial coatings, and electronic biomedical devices. The study demonstrates the effectiveness of green, biocompatible molecules in tailoring the physicochemical and biological behaviour of graphene derivatives.

Keywords: Graphene oxide (GO), Reduced graphene oxide (rGO), Riboflavin, Biocompatibility, Dispersion stability, Antibacterial activity, Cytotoxicity.

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Design and Characterisation of Heteroatom Doped Luminescent Carbon Dots for Efficient Water Treatment

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Emerging aquatic contaminants, including dyes, pesticides, and oil spillage, necessitate efficient and sustainable removal strategies. Herein, we reported the synthesis of N and Fe doped hydrophilic carbon quantum dots (C-dots) and Cu doped hydrophobic C-dots via a facile hydrothermal route as well as microwave-based method, respectively. Structural and compositional features were elucidated using transmission electron microscopy (TEM), X-ray photoelectron spectroscopy (XPS), and Fourier-transform infrared spectroscopy (FTIR), confirming the successful incorporation of dopants. UV-Vis and fluorescence spectroscopic analyses confirmed successful modulating surface states and enhancing photo physical properties. The hydrophilic C-dots exhibited superior catalytic activity toward toxic dyes and pesticides degradation through hydroxyl radical generation, while hydrophobic C-dots demonstrated strong interfacial affinity for oil adsorption. The overall results proposed that tunable electronic structure and surface chemistry of the doped C-dots underline their potential as multifunctional nanomaterials for advanced water remediation.

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Regulating the Self-Propulsion of Liquid Marbles on a Water Pool

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Regulating droplet motion with minimal energy input and adhesion loss holds significant promise for efficient liquid transportation. One efficient strategy involves the design of non-sticking droplets capable of regulated self-propulsion. However, achieving precise control over the self-propelling trajectory while maintaining non-sticking property is challenging. Here, a series of non-sticking solvent droplets that self-propel on the water pool are developed. These droplets are covered with omniphobic nanoparticles to become non-sticking, namely liquid marble. It is found that the droplet self-propelling behavior, such as velocity and trajectory (i.e., polygonal, circular, spinning, and random), differed based on the liquid property (surface tension, solubility in water, volatility, etc.) owing to the branched underlying mechanism. The self-propelling driving force is not confined to the solute capillary force but extends to other forces, including the non-solute capillary, vapor-induced recoiling, and electrostatic force. The understanding of the self-propelling dynamics offers a basis for regulating the trajectories of self-propelling droplets of solvents from rectilinear to circular, random, stop-and-go motion, with a modulated transition time. Even liquid selective wettability at the perimeter of the water pool influenced the self-propelling behavior of the prepared liquid marbles. Thereafter, such liquid marbles are successfully explored in cargo transportation.

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MXene Nanoribbon Aerogel-Based Gradient Conductivity Electromagnetic Interference Shields with Unprecedented Combination of High Green Index and Shielding Effectiveness

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The growing need to minimize secondary pollution from electronically shielded devices necessitates the development of electromagnetic interference (EMI) shields with a high green index (GI), defined as the ratio of absorption to reflection. Simultaneously achieving a high GI and a shielding effectiveness (SE) greater than 50 dB remains a significant and unresolved challenge. A key factor in reducing reflection and enhancing absorption is minimizing the impedance mismatch between the shielding material and free space, which allows more electromagnetic radiation to enter the shield for absorption. In this work, a sandwich-type architecture with a conductivity gradient is presented, achieving both a high GI (~2) and an SE of 70 dB. The topmost layer features an aerogel composed of low-conductivity MXene nanoribbons embedded in a PEDOT:PSS matrix, which helps increase the GI. This layer also lowers the overall permittivity of the structure, further minimizing impedance mismatch in this nonmagnetic system. The bottom layer comprises a highly conductive MXene nanosheet- polymer composite, contributing to the high SE. This approach demonstrates a promising strategy for engineering EMI shields with conductivity gradients and superior performance.

OPTICAL AND PHOTOLUMINESCENCE EMISSION PROPERTIES OF $Ca_9Al(PO_4)_7:Eu^{3+}$ INORGANIC NANOPHOSPHOR

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$Ca_9Al(PO_4)_7:xEu^{3+}$ (x=0.05mol %, 0.15mol %, 0.25mol %, 0.5mol %, 2mol %, and 7mol %) samples were synthesised using energy- efficient and eco-friendly co-precipitation synthesis method. XRD analysis verified that the structural phase was rhombohedral. Agglomerated nanosized particles were determined through SEM morphological investigations. A comparison between $Ca_9Al(PO_4)_7$ and $Ca_9Al(PO_4)_7:xEu^{3+}$ EDS data suggested the Eu^{3+} ions successfully doped into the $Ca_9Al(PO_4)_7$ host matrix. The photoluminescence spectra exhibited strong red emission at 613nm, which corresponds to the $^5D_0 \rightarrow {}^7F_2$ transition of Eu^{3+} under 395nm excitation. The phosphor depicted efficient emission intensity at 7mol% Eu^{3+}, suggesting its suitability for solid-state lighting and display devices.

Keywords: Co- precipitation synthesis, photoluminescence, X-ray, Eu^{3+}, phosphate, UV.

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Corrosion and Mechanical Properties of ZrO_2/TiO_2 Nanostructured Surface Coatings Deposited by Using RF Sputtering On SS 304

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Nanostructured coatings with exceptional corrosion resistance are essential for underwater vehicles. ZrO_2/TiO_2 composites are sputtered onto the metal surface (SS 304) and investigated for their coating performance in the marine environment (3.5 Wt.% NaCl solution). The XRD patterns of the modified surfaces revealed the formation of ZrO_2 in monoclinic, TiO_2 in tetragonal, and $ZrTiO_4$ in orthorhombic phases. The surface morphologies of the deposited films revealed dense microstructures. The elemental composition of the deposited films reveals the stoichiometry of the target. The strength of the coatings displayed a strong adhesion between the substrate and the film. The impedance of the films showed improved corrosion resistance. The ZrO_2/TiO_2 composite shows better protection efficiency against the marine environment than bare. The smaller grain size of deposited films enhances the microhardness. The ceramic oxide coatings maintain excellent corrosion resistance.

Keywords: Nanocomposite coatings, Corrosion, Electrochemical Impedance Spectroscopy (EIS), Tafel, Microhardness, Contact angle.

UV-Ozone Engineered Nb2O5-x/Plasmonic Hybrid Nanosheets for Ultrasensitive SERS Detection: Experimental and Theoretical Insights

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Defect engineering provides a powerful route to enhance the Surface-Enhanced Raman Scattering (SERS) activity of semiconductor-based substrates by tuning charge-transfer processes. In this work, we introduce controlled oxygen vacancies into two dimensional Nb_2O_5 nanosheets through a cost-effective UV–ozone treatment to optimize their electronic structure for superior SERS performance. The defect-engineered Nb_2O_{5-x} nanosheets were subsequently coupled with plasmonic nanoparticles (Au and Ag) to simultaneously exploit electromagnetic (EM) and chemical (CM) enhancement mechanisms. This synergistic hybrid system exhibited an exceptional SERS enhancement factor (EF) of 6.75 × 108 and an ultralow detection limit (LOD) of 10^{-10} M for Malachite Green (MG) molecules. Furthermore, the same substrates demonstrated excellent sensitivity for detecting the antibiotic Ciprofloxacin (CIP). The excitation wavelength was optimized to balance and maximize the contributions from both EM and CM mechanisms. Complementary Density Functional Theory (DFT) calculations and Finite Element Method (FEM) simulations were conducted to elucidate the role of oxygen vacancies, charge-transfer dynamics, and local field enhancement in governing the overall SERS response. This integrated experimental–theoretical study highlights a robust and scalable strategy for designing highly sensitive semiconductor–plasmonic hybrid SERS platforms.

Size and Edge impact of Nobel Metal Co-catalysts clusters on Photocatalytic Water Splitting for Hydrogen Evolution Reaction

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Energy demanding life style has intensified the search for sustainable and clean energy resources. Various reports have been stated that the magnitude of available solar power at earth surface is equal to 130 million 500 MW power plants. And energy harvested from the sunlight offers multidirectional approach towards fulfilling the energy demand by collecting and storing this in chemical bonds. Solar light driven water splitting for hydrogen generation is the “Holy Grail” of solar energy conversion technology offering high energy density and zero carbon emissions upon utilization. Photocatalytic water splitting presents a sustainable and environmental benign instead of deterioting nature it protects the integrity of our ecosystem. However, the overall efficiency of this process remains limited due to sluggish charge separation and surface reaction kinetics. The proposed project titled “Size and Edge impact of Nobel Metal Co-catalysts clusters on Photocatalytic Water Splitting for Hydrogen Evolution Reaction,” is driven by the need to understand and enhance the role of noble metal co-catalysts—such as Pt, Pd, and Au—in promoting hydrogen evolution reactions (HER). The proposed project completely focuses on the fundamental question of how the size and edge characteristics of noble metal clusters influence photocatalytic activity, aiming to provide design principles for next-generation water-splitting catalysts. Plasmonic nobel metals are known to enhance HER kinetics by providing active sites for proton reduction reaction. Nanostructuring these metals into ultra-small clusters or even single-atom catalysts significantly enhances atom economy, yet the catalytic behavior becomes highly sensitive to parameters such as cluster size, shape, and the nature of exposed edge sites. This study seeks to establish a correlation between the effect of the co-catalyst cluster size and edge configurations on HER performance. The outcomes of the proposed work are expected to the contribution of the rational design of high-performance, low-loading co-catalysts for practical solar hydrogen production systems.

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Anomalous Two-Dimensional Organic Molecular Crystal Formation in an Evaporating Droplet with Different Vibrational Characteristics of the Surface and the Bulk

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2D crystals of organic molecules, bearing in-plane van der Waals interactions and having unique properties, are capable of multifunctional applications. Such crystals would not only pave the ways for new knowledge about molecular organizations but also act as essential components in applications such as low-dimensional molecule-based electronics that include flexible devices, lasers, quantum materials, drug delivery, surface enhanced Raman scattering (SERS) and in chemical and biological sensing. However, there is a significant challenge for the fabrication of 2D crystalline organic materials by conventional evaporation induced crystallization method from saturated solution which often results in 3D or bulk crystallization. Herein, fabrication of 2D crystal of simple organic molecules have been accomplished by utilizing the novel 'coffee-ring' deposition process from evaporating droplets consist of the solutions of analyte molecules. We synthesized 2D single crystals of methyl orange (MO) and methylene blue (MB) at the three-phase contact line (TPCL) of evaporating droplets. The crystallization process at TPCL and the vibrational characteristics were monitored by time-dependent Raman measurements. The 2D nature of the crystal grown at the TPCL have been confirmed from powder X-ray diffraction (PXRD), atomic force microscopy (AFM) and transmission electron microscopy (TEM) measurements. The 2D crystal structures which contain two-dimensional layer by layer arrangements of MO or MB have been obtained from refinement of experimental PXRD data. Interestingly, the vibrational characteristics of the molecules located at the surface and at interior of the 2D as well as 3D crystals have been found to be different. Therefore, the studies revealed that the vibrational characteristics of the surface and bulk of a crystal are fundamentally different at the molecular level.

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Facilitating Electrochemical Overall Water Splitting Through Regulation of Ionic Environment and Gas-Bubble Wettability of Halloysite Nanoclay-Based Nanoarchitectonic

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Electrochemical water splitting is hindered by the unwanted adhesion of gas bubbles on electrode surfaces, leading to disrupted electrolyte access and electron transfer processes. While bubble-repellent coatings promote faster bubble detachment, but the need for a favourable ionic microenvironment for efficient overall water splitting is not realised or overlooked. In this work, we present a halloysite nanoclay-based coating on nickel foam (NF) that synergistically integrates bubble repellence with modulating ionic environment. Besides the experimental observations, theoretical analysis confirms that this dual-functional design enhances both the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) in 1 M KOH. Cationic modifiers induce interfacial water polarization, improving kinetics of water dissociation step (Volmer step) in HER, whereas anionic modifiers enhance local OH-availability, promoting OER. Consequently, overpotentials are reduced by 42% (HER) and 30% (OER) at 100 mA cm^{-2}, leading to over a 60% increase in gas generation compared to bare NF. When employed as electrode pairs (cationic modifiers as cathode and anionic modifiers as anode) in a two-electrode configuration, the system lowers the cell voltage for overall water splitting by 500 ± 6 mV at 100 mA cm^{-2}, which demonstrates the synergistic role of bubble dynamics and ionic microenvironment. Furthermore, the electrodes exhibit oil-repellence, enabling stable water splitting even in oil-contaminated electrolytes.

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Underwater Vibrant Sensor for Automated and Automated and Contactless Voice Recognition

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Individuals suffering from voice disabilities have limited access to currently available automation technologies that operate through voice commands. To address this issue, an alternative voice recognition approach is essential without directly monitoring the audio signals generated from the vocal cord [1,2]. In this work, the design of a chemically reactive and conductive sponge is reported to create an underwater vibration sensor with a fast response time and high sensitivity, through orthogonal modulation of conductivity (40–2150 kΩ), water repellence (0°–154°) and mechanical properties (0.32–2.63 MPa). This class of porous sponge sensors enables the identification of subtle water waves generated at the air–water interface and extends its utility to detecting a variety of locomotion (squatting, jumping, walking, etc.), as well as automated voice recognition using a deep learning model without direct contact with the human body. Overall, this underwater vibration sensor provides a novel basis for remote interaction with automated technologies, which finds use in medical diagnostics, human-machine interfaces, and underwater communication systems.

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Molecular Welding of Delamination Resistant Metal Coordination Sites with Carbon Nitride Framework for Mimetic Artificial Photosynthesis

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Graphitic carbon nitride (g-C_3N_4) has stood up as a highly potent photocatalyst for artificial photosynthesis, primarily due to its high chemical and thermal stability, low toxicity, cost-effectiveness, visible light absorption capacity and ingeniously tunable synthetic routes as compared to other semiconductor platforms. Nevertheless, lower specific surface area, lesser electrical conductivity, fast recombination of photo triggered excitons and narrow visible light absorption window hinder the application of this catalytic material for practical photocatalytic utilization. To address the aforementioned issues and to modulate the photochemical and photophysical properties of g-C_3N_4, molecular doping has been a widely employed strategy. However, the inefficient methods of synthesis and the poor understanding of structure-property relationship in different molecularly doped carbon nitrides has hindered its practical implementation. Pristine carbon nitride suffers from radiative recombination losses and the drawbacks related to the radiative recombination of pristine g-C_3N_4 can be mitigated by disrupting the regular triazine and heptazine repeat units, by introducing disordered zones in the framework by the use of carefully chosen non triazine based molecular precursors. Anchoring of atomically precise metal sites in the form of a π-conjugated ligand heterostructure with proper coordination geometry enables reaction centers for catalysis, without the need of a classical heterojunction cocatalyst, thus bridging the gap between homogeneous and heterogeneous catalysis. As compared to the known homo-catalysts anchored on the carbon nitride photosensitizer-support through a weaker single σ-bond, molecularly welded (fused ring) ligand moieties with double (σ and π) bonds provide a stronger delamination free site with higher propensity of charge transfer through the π bridge and enhanced photo absorption capability due to the extension of conjugation. Added benefits of disruption of the triazine framework are also achieved through this method. This type of photocatalyst platforms pave the way for new generation classical heterojunction free photocatalysis with impact in artificial photosynthesis type applications.

Keywords: Artificial Photosynthesis, Carbon Nitride, Molecular Doping, π-conjugated Ligand Heterostructure

Size-Dependent Catalytic Gold Nanoparticle α-Amylase Hybrids for Rapid and Sensitive Starch Classification

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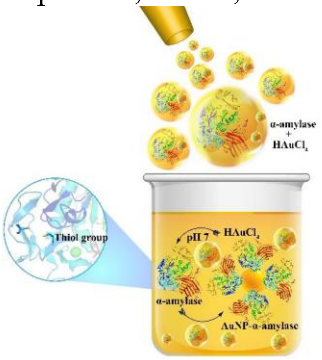
The enzymatic biosynthesis of gold nanoparticles (AuNPs) by directly using -amylase as a reducing and linking agent. The amylase thiol group reduces the AuCl4–ions and binds to the synthesized AuNPs. The biosynthesized AuNP--amylase has different catalytic rates and sizes. The enzymatic activity of AuNP-amylase and free -amylase was determined rapidly and sensitively by Raman spectroscopy. Raman spectra of starch are dominated by three strong bands. Raman intensity decreases progressively with increased enzymatic activity at three different bands, pyranose ring skeletal modes (480 cm^{-1}), OH bend (1640 cm^{-1}), and C-H stretching mode (2910 cm^{-1}). The 6 mg mL^{-1} AuNP--amylase has the highest enzymatic activity than other biosynthesized AuNP--amylase and free -amylase. The classification of starch after 5 minutes of hydrolysis by 6 mg mL^{-1} AuNP--amylase into rapidly digestible starch (RDS), slowly digestible starch (SDS), and resistant starch (RS) based on the amount of maltose produced. The amperometric measurement of maltose produced after hydrolysis using the screen-printed electrode (SPE). Maltose act as reducing sugar, which reduces $[Fe(CN)_6]^{3-}$to $[Fe(CN)_6]^{4-}$. This conversion generates the current signal proportional to the amounts of maltose produced after starch hydrolysis. This method is a simple, fastest, reliable, portable, inexpensive, and powerful tool for the rapid classification of starch. The reported sensor can potentially be used in point-of-care testing to detect glycemic indices.

Keywords: Alpha-amylase; Gold nanoparticle; Starch; Maltose; Biosynthesis.



Schematic illustration of the biosynthesis of gold nanoparticle-α-amylase.

Experimental Investigation in dripping to jetting transition in coflowing liquid streams

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The transition from dripping to jetting in co-flowing liquid streams is a fundamental phenomenon in microfluidics, governing the controlled generation of droplets and continuous jets in a variety of applications. This transition is of critical importance for micro/nano-scale flows and droplet microfluidics, with direct relevance to biomedical diagnostics, drug delivery, inkjet printing, and chemical micro-processing. Despite its significance, the underlying mechanisms and the precise conditions dictating the onset of jetting from a dripping regime remain incompletely understood, particularly for immiscible co-flowing systems in confined geometries. This study presents a comprehensive experimental investigation of the dripping-to-jetting transition in co-flowing liquid streams, aiming to elucidate the interplay of governing parameters and to construct a predictive framework for regime selection. The motivation for this work stems from the increasing demand for precise control over droplet and jet formation in microfluidic devices. In lab-on a-chip and organ-on-a-chip platforms, the ability to switch between discrete droplet generation and continuous jetting enables a wide range of functionalities, from encapsulation and mixing to high-throughput screening. However, the transition is sensitive to multiple factors, including flow rates, viscosity and density ratios, interfacial tension, and channel geometry.

In the present work, a co-flowing micro-capillary device is fabricated using replica moulding. The device consists of an inner capillary through which the dispersed phase is injected, surrounded by an outer capillary carrying the continuous phase. Immiscible liquid pairs such as silicone oil and water are selected to provide a range of viscosity and interfacial tension contrasts. The flow rates of both phases are independently controlled using syringe pumps, enabling fine adjustment of the capillary number and flow rate ratio. High-speed imaging is employed to visualize the interface dynamics, capturing the evolution from periodic droplet pinch-off (dripping) to the formation of a continuous liquid thread (jetting). Image analysis is used to extract quantitative metrics such as droplet size, frequency, and jet length. By systematically varying the governing parameters in both experiments, the critical conditions for the dripping-to-jetting transition are identified. The results show that the transition is governed by the capillary number (Ca), defined as the ratio of viscous to surface tension forces, and the Weber number (We), representing the ratio of inertial to surface tension forces. At low Ca and We, the system exhibits a dripping regime characterized by discrete droplet formation at the capillary tip. As the flow rates increase, a critical threshold is reached where the interface elongates and forms a continuous jet, marking the onset of jetting.

Unraveling Facet and Solvent Effects in IrO_2 Catalyzed Oxygen Evaluation via Deep Machine-Learning Potential

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Iridium oxide (IrO_2) stands as the benchmark catalyst for the oxygen evolution reaction (OER), yet the fundamental origins of its facet-dependent reactivity remain only partially understood at the atomic scale.[1] In this study, we integrate ab initio accuracy with deep neural network potential–driven molecular dynamics to probe the explicit water–IrO_2 interface and uncover the mechanistic nuances of the OER on the (110) and (101) facets. Each reaction intermediate was optimized in the presence of equilibrated interfacial water layers, thereby capturing the dynamic solvation effects that conventional static or implicit models often overlook. To benchmark the solvation influence, complementary fixed-potential simulations within an implicit environment were also performed. The inclusion of explicit solvent interactions was found to deliver a more realistic description of interfacial charge transfer and reaction energetics, yielding overpotentials that exhibit remarkable agreement with experimental data. Comparative analysis of the (110) and (101) surfaces reveals that the elevated overpotential on the (101) facet originates from its less favorable electronic configuration and stronger metal–oxygen bonding in the rate-determining intermediate. Comprehensive evaluations encompassing work function shifts, Bader charge distributions, d-band center alignments, density of states (DOS), and crystal orbital Hamilton population (COHP) analyses collectively delineate the electronic descriptors underlying this facet-dependent OER behavior. Overall, this work establishes a unified framework that couples machine-learning-accelerated ab initio simulations with explicit solvation to unravel the interplay between surface orientation, electronic structure, and catalytic performance in IrO_2-based oxygen evolution catalysts.[2]

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Influence of Surface Wettability on the Morphology and Periodic Deposition of Ag NP Ink Droplet Printed by Inkjet Technology

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The fabrication of conductive silver (Ag) electrodes on different flexible and rigid substrates such as polydimethylsiloxane (PDMS), polyethylene terephthalate (PET), polymethyl methacrylate (PMMA), and glass is of growing importance for applications in flexible electronics, microelectromechanical systems (MEMS), and wearable devices. Inkjet printing provides a rapid, non-contact, and cost-effective approach for patterning Ag nanoparticles onto diverse substrates; however, the quality and uniformity of the printed structures are strongly influenced by the surface wettability and printing parameters, particularly droplet spacing and periodicity. This work investigates the effect of substrate wettability comparing hydrophobic (untreated) and hydrophilic (UV-ozone-, plasma-, or APTES-treated) surfaces on the morphology and periodic deposition of Ag nanoparticle ink droplets using a Dimatix DMP-2850 inkjet printer. Key parameters such as drop spacing, sintering temperature, platen temperature, and nozzle temperature were systematically optimized to enhance print quality and conductivity.

Surface wettability and modification effectiveness were analyzed using goniometry (contact angle measurements), while optical microscopy was employed to study droplet shape, coalescence, and spacing. Field Emission Scanning Electron Microscopy (FESEM) provided high-resolution morphological insights into printed Ag traces, and Energy Dispersive X-ray Spectroscopy (EDS) confirmed elemental distribution and silver content on various substrates. X-ray Photoelectron Spectroscopy (XPS) further validated surface chemical modifications and oxidation states of Ag after printing and sintering.

Results showed that hydrophilic-treated substrates demonstrated enhanced droplet spreading and coalescence, leading to uniform, continuous, and conductive Ag lines, whereas hydrophobic surfaces produced discrete and non-uniform droplet patterns. The optimization of droplet periodicity and surface treatment conditions enabled the fabrication of highly conductive and defect-free silver electrodes. This study highlights the pivotal role of surface wettability, substrate chemistry, and printing parameters in defining droplet morphology and pattern periodicity, providing valuable insights for developing flexible, stretchable, and miniaturized electronic and sensing devices.

Electrochemical Modulation of Active Sites in CoN4-xSx Single-Atom Catalysts for CO_2 Reduction: A Grand Canonical Perspective

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The exploration of atomically dispersed transition-metal centers continues to redefine the conceptual boundaries of heterogeneous CO_2 electroreduction catalysis. Within this context, the $CoN_{4-x}S_x$ (x = 0–3) coordination manifold was examined through grand canonical ab initio protocols to interrogate its electrochemical response under potential control.[1] Departing from the conventional constant-charge formalism, this framework circumvents the inherent limitations of the CHE approximation by incorporating the explicit dependence of electronic structure and reaction thermodynamics on electrode potential. The potential-modulated configurational landscape reveals subtle yet consequential reorganizations within the local coordination environment, which, in turn, dictate the relative stabilization of reactive intermediates and competing pathways. While the hydrogen evolution channel exhibits a nuanced interplay with CO_2 activation processes, the energetics of adsorbate binding and desorption emerge as dynamically correlated with the local potential field. Analysis of the projected density of states further delineates the evolving character of frontier orbitals as a function of potential, providing an electronic structure-based rationale for the observed variations in reaction selectivity. Collectively, these results articulate a broader mechanistic picture in which perturbation of the active site and potential coupling coalesce to determine the emergent catalytic response, thereby offering a generalized perspective on potential-controlled reactivity in Co-based single-atom frameworks for CO_2 electroreduction.[2]

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Role of Molecular Stacking in Excited-State Properties of INVEST Materials

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Inverted singlet–triplet (INVEST) chromophores, though conceptually distinct from thermally activated delayed fluorescence (TADF) analogues, remain hampered in their emissive deployment due to intrinsically quenched radiative pathways.[1] The principal impediment originates from a negligible transition dipole moment associated with the lowest singlet manifold, wherein the $S_n \rightarrow S_0$ decay channel is electronically disallowed, a direct consequence of spatially segregated frontier molecular orbitals and their attendant vanishing HOMO–LUMO overlap integral. Through a systematic interrogation of cyclazine-based π-architectures—augmented by two rationally conceived derivatives—the present investigation elucidates that supramolecular aggregation operates as a perturbative mechanism capable of reinstating higher intensity within such symmetry-constrained manifolds. High-level excited-state computations, encompassing linear-response time-dependent density functional theory with double-hybrid functionals in conjunction with the domain-based local pair natural orbital similarity-transformed equation-of-motion coupled-cluster (DLPNO-STEOM-CCSD) formalism, demonstrate that J-type excitonic coupling embedded in aggregates markedly amplifies the metric relative to both H-type configurations and the isolated monomeric baseline. The emergent aggregation-induced emissive activation of the S_1 manifold thus articulates a transferable design paradigm, advancing the conceptual frontier of bright INVEST emitters and underscoring the role of excitonic coherence as a latent enabler in organic optoelectronic frameworks.[2]

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Efficient Hydrogen Evolution via Structurally Tuned NiFe-LDH@CNT Electrocatalyst

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NiFe-layered double hydroxide (NiFe-LDH) composite is synthesized on nickel foam (NF) using a simple room-temperature electrodeposition method. Subsequently, multi-walled carbon nanotubes (MWCNTs) are deposited onto the surface of NiFe-LDH via drop-casting to form a hybrid electrode NiFe-LDH/CNT. The hybrid structure enhances the catalytic activity of NiFe-LDH with conductivity and hydrophilicity. Structural and morphological evaluation confirms a uniform coverage of NiFe-LDH nanosheets across the electrode surface. It is also noted that the CNTs are well-distributed and have good contact with the NiFe-LDH layer. X-ray photoelectron spectroscopy (XPS) analysis shows that oxidation states of Ni^{2+} and Fe^{3+} are stable before and after the Hydrogen Evolution Reaction (HER). Electrochemical studies reveal that the NiFe-LDH/CNT electrode shows substantially decreased overpotential, low charge transfer resistance (~2 Ω), high current density, and high Faradaic efficiency (~90.02 %) in comparison to NiFe-LDH and bare NF. The NiFe-LDH/CNT electrode attains a hydrogen production rate of ~20 mmol h^{-1} cm^{-2} and demonstrates excellent catalytic kinetics and extended durability. Overall, this work proposes a large-scale and straightforward approach to improve and alter the electrochemical properties of NiFe–LDH-based catalysts.

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Demonstration of a Mist-CVD Grown α-Ga_2O_3 Ultraviolet Photodetector with High Spectral Responsivity

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Ultra-deep UV-C photodetectors (UDUVCPDs) based on ultrawide-bandgap α-Ga_2O_3 exhibit promise for military and civilian applications such as flame detection, missile plume monitoring, and environmental sensing. Here, metal–semiconductor–metal UDUVCPDs fabricated from mist chemical vapor deposition (mist-CVD) grown α-Ga_2O_3 films achieve a spectral responsivity of 2.34 A/W at 220 nm, photo-to-dark current ratios $>10^3$, and pronounced selectivity in the UV-C range. Device response times are on the order of seconds, attributable to persistent photoconductivity. We investigate the underlying material properties of 270 nm-thick α-Ga_2O_3 films deposited on c-plane sapphire via mist-CVD. X-ray diffraction confirms predominantly (006)-oriented α-phase with 82% phase purity and an average crystallite size of 20 nm. UV–Vis transmission and Tauc analysis yield an optical bandgap of 5.24 eV with absorption onset below 240 nm. Field-emission scanning electron microscopy and atomic force microscopy reveal uniform hexagonal grain morphology and a surface roughness of 3.1 nm (RMS). X-ray photoelectron spectroscopy identifies metallic Ga^0 at 18.0 eV and oxygen-deficient regions, while energy-dispersive X-ray spectroscopy indicates a Ga:O atomic ratio of 1:5.0. These results link mist-CVD parameters to high-quality α-Ga_2O_3 films and corresponding deep-UV detector performance, establishing mist-CVD as a scalable, room-temperature method for producing device-grade materials suitable for advanced UDUVCPD applications.

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Controlled Chemical-Patterning of Textile to Accelerate Anti-Gravity Water Flow

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Bio-inspired unidirectional flow of tiny aqueous droplets across the fibrous substrate paved the way for the emergence of various advanced materials. In the past, textiles decorated with noncontact-based wettability-patterns enabled unidirectional water flow—without flooding the top surface by the transferred water. However, such approaches mostly suffer from a low (≈ 0.176 µL mm^{-2} s^{-1}) flow rate and are likely to delay the overall liquid ejection process. Here, a chemically reactive coating capable of tailoring water wettability (121.3° ± 2.4° to 153.3° ± 1.8°) is introduced on commercially available textiles to develop chemically modulated wettability-pattern for achieving a rapid (2.57 ± 0.28 µL mm^{-2} s^{-1}) flow rate of water against the gravity with an ability to roll the accumulated liquids on the top surface. The spatially selected and controlled chemical modification with hydrophilic and hydrophobic small molecules through a 1,4-conjugate addition reaction yielded a 3D channel with a customized wettability gradient. The pinning and depinning of invaded water through such chemically decorated channels enabled unidirectional and fast penetration of liquid, where the water penetration resistance largely depends on the water penetration direction and dimension of the chemically modulated channels.

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Percolation Based Anomalous Proton Transport in 2D Hexagonal Boron Nitride Membranes

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Hexagonal boron nitride (h-BN) is a highly promising material for membrane applications due to its exceptional chemical stability in solvents, outstanding mechanical strength, and excellent thermal stability. We demonstrate that electrical transport in this system depends on water loading. The layered structure of 2D materials creates a matrix with sub-nanometer spacings, allowing for the confinement of water and ions. The presence of water facilitates protonic transport in these systems, even when electronic conduction channels are inactive. Proton transport can be further modulated through appropriate functionalization. Devices configured in a sandwich geometry are studied using frequency-dependent impedance spectroscopy, which reveals the charge transport and accumulation processes occurring both in the bulk and at the electrode interfaces [1]. These findings are corroborated by dynamic vapor sorption studies and micro-structural investigations. Several orders of magnitude change in electrical conductivity is observed as a function of ambient moisture content or relative humidity. Notably, functionalized h-BN membranes exhibit a seven-orders-of- magnitude enhancement in proton conductivity at a very low percolation threshold, accompanied by an 18-fold increase in water sorption. These results are promising for real- world applications such as ultrasensitive humidity sensors, fuel cells and aqueous batteries [2]. The underlying mechanism driving the percolative behavior of conductivity will be discussed. Unique dependence of the transport on the thickness of the films and origin of non-universal critical exponents will also be presented.

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Observation of Room Temperature Ferromagnetism and High Coercivity in Phase Engineered 1T-MoS_2 Nanosheets

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Malaria remains a persistent global health challenge, causing approximately 250 million cases and more than half a million deaths annually, particularly in under-resourced regions. A major barrier to disease elimination is the prevalence of asymptomatic carriers who continue to sustain transmission. Early, accurate, and rapid point-of-care detection—still unmet by current diagnostic methods—is essential for breaking transmission cycles and achieving the UN goal of malaria elimination by 2030. Hemozoin, a crystalline byproduct of the Plasmodium parasite's erythrocytic cycle, has emerged as a robust biomarker due to its unique magnetic and optical properties. Building on this, we have recently developed a cost-effective opto-magnetic detection platform for precise malaria diagnosis. Our lab-scale prototype, along with a portable device currently under development, surpasses conventional light microscopy in sensitivity and delivers results within one minute—an order-of-magnitude improvement over the typical hour-long microscopic process. Additionally, we are advancing NV-center-based magnetometry to probe nanoscale magnetic properties of hemozoin crystals, enabling deeper investigation into parasite biology and the effects of newly developed antimalarial drugs.

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Seed Ru-Assisted Epitaxial Growth of Mn_3Sn Thin Films: Strain-Controlled Pathway to Piezo-Magnetism

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Non-collinear anti-ferromagnetic (AFM) materials are the prime candidates for AFM spintronics[1]. In this regard, growing thin films directly on the substrate distorts the crystal orientation and thanks to the seed layer for serving as a template for crystal growth. Here, we studied the non-collinear AFM material Mn!Sn systematically by varying the seed Ru layer deposition temperature and the post-annealing temperature of the stack (substrate/Ru(13 nm)/ Mn3Sn(42 nm)) on Al2O3(0001) and MgO(111) substrates. The high-resolution X-ray diffraction (HRXRD) results prove their epitaxial relationship with the seed Ru layer on both substrates, as shown in Figure 1 (a). Observing higher-order diffraction and the Pendellösung signals suggests that interfaces are coherent in crystal growth2. The calculated out-of-plane lattice constant and the interplanar d-spacing as a function of the mentioned variables corroborate the plausible strain, which ascertains the rocking curve results. It is observed that crystal distribution, hence called mosaicity, is qualitatively larger on MgO substrate than on Al2O3 substrate as shown in Figure 1 (b). The calculated strain along the growth direction manifests the growth-induced strain due to lattice mismatch. The calculated strain values compared with the bulk values suggest that the strain is larger on MgO than that of the Al2O3 substrate. The static magnetic measurements data indicate that the order parameter can be modulated by controlling the strain via post-annealing temperature conditions. The observed strain-dependent magnetization establishes the piezo-magnetism[3]. Our systematic investigation on seed Ru-assisted epitaxial growth provides a comprehensive understanding of the viable route towards the fabrication of piezo-magnetic devices.

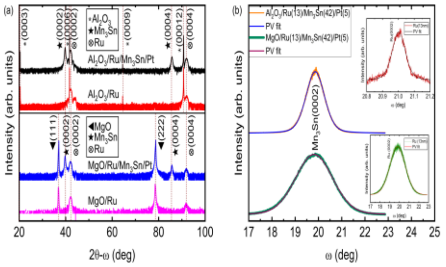

Figure 1 (a): HRXRD patterns show epitaxial growth of substrate/Ru (13 nm)/Mn3Sn (42 nm)/Pt (5nm) stack on Al2O3(0001) and MgO(111) substrates, and (b) comparative rocking curve of Mn3Sn (0002) peak grown on Al"O!(0001) and MgO(111) substrate. The insets show the corresponding rocking curves of Ru (0002) peak on both substrates.

Synthesis of Bismuth Molybdate (Bi_2MoO_6) by Hydrothermal Method and its Photocatalytic Application for Dye Degradation

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Bismuth-based metal oxides have recently garnered significant attention as visible-light- driven photocatalysts due to their narrow band gaps (less than 3 eV), chemical stability, and environmental compatibility. In this work, bismuth molybdate (Bi_2MoO_6) was synthesized via a hydrothermal method, which is a simple, cost-effective, and environmentally friendly route for controlled growth of nanostructures. The synthesized samples were characterized by X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), and UV–Vis diffuse reflectance spectroscopy (DRS) to assess structural, morphological, and optical behavior of the synthesized nanomaterial. The photocatalytic degradation of hydrothermally synthesized Bi_2MoO_6 was evaluated by monitoring the degradation of Rhodamine-B (RhB) dye under visible-light irradiation. Results indicate that the material exhibited efficient photocatalytic performance, achieving significant degradation of RhB within a short irradiation period. The enhanced activity can be attributed to the layered Aurivillius-type structure of hydrothermally synthesized Bi_2MoO_6, which facilitates effective charge separation and light absorption in the visible region. These findings highlight the potential of hydrothermally synthesized Bi_2MoO_6 as a promising material for wastewater treatment applications.

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Unveiling the Potential of Metal-Organic Frameworks: Nucleation-Induced Strain Activating Electrocatalytic Water Splitting

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Metal–organic frameworks (MOFs) exhibit immense potential, provided that we gain a comprehensive understanding of their nature and manipulate the factors to which they respond. Herein, the MOF is engineered and activated by introducing strain into the morphology through a suitable nucleation process. The defect-rich N-reduced graphene oxide (rGO) plays a pivotal role, serving as an uneven platform and tagging the nucleation site for MOF growth on its surface, resulting in a highly active electrocatalyst. The presence of dislocation strain and defects in the catalyst creates new active sites or modifies existing ones on its surface, potentially amplifying its catalytic activity. The catalyst showed excellent activity toward oxygen evolution reaction and hydrogen evolution reaction with a low overpotential of 145 and 51 mV to drive a current density of 10 mA cm^{-2}. Additionally, the catalyst toward the overall water-splitting reaction displayed a cell voltage of 1.37 V at 10 mA cm^{-2} and maintained a high current density of 150 mA cm^{-2} for 200 h without significant degradation. Combining dislocation engineering with other catalytic strategies leads to synergistic effects that amplify the activity. Molecular dynamics simulations also show that introducing N-rGO in FeCo-MOF induces the strain and enhances its activity.

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Harnessing the potential of $NiCo_2S_4$ and Chitosan Nanocomposites for Physical Reservoir Computing

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The exponential growth of data-driven technologies has led to a shift towards unconventional computing frameworks such as reservoir computing (RC) to surpass the von Neumann bottleneck of separate memory and processing units [1]. RC devices with hardware-based machine intelligence are gaining interest due to their biological computational resemblance, along with an easy and efficient training approach. An RC device consists of a reservoir layer, which can be a physical system or a material, and an output readout layer, which is only trained, unlike other neural networks, making RC simpler and efficient [2].. This rapid expansion of RC as a computational paradigm has intensified the search for novel materials and architectures capable of manifesting high-dimensional non-linear dynamics. Hence, in this work, we explored $NiCo_2S_4$ nanocomposites and chitosan-stabilized NiCo2S4 nanocomposites ($CS@NiCo_2S_4$) for their suitability and performance as an active reservoir layer in RC systems. $NiCo_2S_4$, a spinel-structured bimetallic sulfide, has recently attracted interest due to its high electrical conductivity, mixed-valence states, and fast redox kinetics, making it valuable for supercapacitors, electrocatalysis, and sensing. However, its potential in unconventional computing remains unexplored. Here, $NiCo_2S_4$ and $CS@NiCo_2S_4$ thin films were fabricated from stable dispersions to study their nonlinear electrical characteristics for in materio reservoir computing (RC). For the two-terminal architecture, Ag electrodes (20 µm) were deposited on cleaned glass substrates via thermal vapor deposition (TVD) with a shadow mask, followed by drop-casting the active material dispersion. For parallel RC tasks, a 16-terminal configuration was similarly fabricated using patterned shadow masks to enable multi-node signal acquisition. Upon measuring the I-V dynamics, both devices show pronounced non-linear I-V curves with hysteresis (forward/backward sweeps), along with small step-like current modulations at higher bias (Fig. 1). We ascribe these to a combination of redox-mediated charge transfer, trap filling/emptying, and field-driven ionic rearrangements in the composite film. Moreover, higher-harmonic generation, a hallmark of high-dimensional dynamics arising from networks of interconnected, non-linear junctions, has also been observed when an input fundamental frequency of 11Hz was passed through the network [3]. The output spectra exhibit clear harmonic structure at near-integer multiples of the input frequencies 22, 33, 44, 55 Hz, with both odd and even harmonics present. The $CS@NiCo_2S_4$ device shows markedly stronger and more numerous harmonic components than $NiCo_2S_4$, indicating that the carbon shell intensifies non-linear interactions and forms richer recurrent pathways within the material. After establishing the suitability of this material as an active reservoir layer, basic RC tasks such as waveform generation were performed and will be discussed in detail in the upcoming presentation.

Development of rapid and sensitive calorimetric detection kit for Botulinum Neurotoxin in water using Avian IgY-conjugated gold nanoparticles

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Botulinum neurotoxins (BoNTs) are a critical biothreat necessitating the development of rapid, highly sensitive, and field-deployable detection systems. Conventional methods, such as ELISA and the mouse lethal bioassay, are often too slow, expensive, or lack the necessary sensitivity for effective screening in complex matrices. In this study, we report the use of chicken Immunoglobulin Y (IgY) antibodies raised against selected serotypes of botulinum neurotoxin and use it for developing a rapid detection kit by tagging them with gold nanoparticles. The IgY antibodies, specifically produced against specific botulinum neurotoxin, were extracted from egg yolk of immunised chicken and their yield, cross-reactivity and selectivity were measured using the ELISA technique. The selective IgY was purified and conjugated with different sizes of gold nanoparticles with and without HRP conjugate to develop a calorimetric detection kit. The tagged nanoparticles were impregnated onto a nitrocellulose membrane and tested using the sandwich ELISA principle as strips. The sensitivity, cross reactivity and selectivity were determined with respect to time and dose. The HRP–TMB-based system produced a distinct blue colour upon antigen–antibody interaction. The results indicated that the kit could be used to detect specific serotypes up to 100 ng/mL in water.

Keywords: Botulinum neurotoxins, IgY antibodies, gold nanoparticles, detection, test kit.

Fabrication of Au-Incorporated SnO_2@rGO Nanocomposite Based Chemiresistive Sensor for the Detection of Carbon Monoxide at Room Temperature

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In this study, we report the synthesis, structural analysis, and gas sensing capabilities of tin oxide-derived nanocomposites for room-temperature detection of carbon monoxide (CO).The SnO_2, reduced graphene oxide (rGO), SnO_2@rGO, and Au-doped SnO_2@rGO were synthesised and their structures were characterised by employing XRD, Raman and FTIR spectroscopy techniques. The findings indicate substantial interfacial contacts, defect formation, and lattice strain caused by rGO integration and Au doping. The X-ray diffraction (XRD) patterns confirm formation of the tetragonal rutile phase of SnO_2 in all the composites. Au doped SnO_2@rGO gave a 93% response at 50 ppm along with a quick response and recovery durations (2.894 seconds and 1.654 seconds), and ppb-level detection capacity, the Au-SnO_2@rGO nanocomposite demonstrated exceptional CO sensing performance. High discrimination against interfering gases, including SO_2, NH_3, NO_2, and H_2S, was shown by selectivity testing. The increased sensitivity was explained by mechanistic analysis to the development of Schottky barriers and SnO_2@rGO heterojunctions at Au-SnO_2 interfaces, which alter charge carrier dynamics and promote oxygen adsorption and CO dissociation. Due to multilayer water adsorption, the sensor's performance gradually declined at higher relative humidity levels, although it remained at its best between 40 and 50 percent. According to these results, Au-SnO_2@rGO is a viable option for high-performance, room-temperature CO sensing applications in industrial and environmental contexts.

White Light Emission from Zn(II) and DMSO-Induced Copper Nanocluster Assembly

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An assembly of metal nanoclusters driven by appropriate surface ligands and solvent environment may engender entirely new photoluminescence (PL). Herein, we first synthesize histidine (His) stabilized copper nanoparticles (CuNPs) and, subsequently, copper nanoclusters (CuNCs) from it using 3-mercaptopropionic acid (MPA) as an etchant. The CuNCs originally emit bluish-green (λem = 470 nm) PL with a low quantum yield (QY ~ 1.8 %). However, it transformed into a dual-emissive nanocluster assembly (Zn-CuNCs) in the presence of Zn(II) salt, having a distinct blue emission band (λem = 420 nm) and a red emission band (λem = 615 nm) with eight times QY (~9.1 %) enhancement. The temperature-dependent emission spectra of Zn-CuNCs depicted that the blue emission band persists for all the temperature ranges (0 80 °C) while the red emission band vanishes at high temperatures (70–80 °C). Thus, the blue emission may originate from the locally excited state(LES) emission of the nanoclusters, while the red emission originates from through-space interaction (TSI) and Cu(I)...Cu(I)interaction within the assembly. Adding dimethyl sulfoxide(DMSO) further modifies the emission intensities; the red band was amplified four times, while the blue band was diminished by 2.5 times. The transmission electron microscopy (TEM)images unveiled that the Zn-CuNCs are a large assembly of tiny nanoclusters, which become more compact in DMSO. The blue emission possesses steady-state fluorescence anisotropy, while the red emission shows no anisotropy. Further, near-perfect white light emission(WLE) was rendered with CIE coordinates of (0.33, 0.32) by combining the dual emission of the Zn-CuNCs with the original green emission of the CuNCs.

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Electrochemical and Surface Evaluation of Quinoxalinone-Based Heterocycle as a Corrosion Inhibitor for Mild Steel in Acidic Media

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The present work aims to investigate the corrosion inhibition performance of a quinoxalinone-based heterocyclic compound on mild steel in 1M H_2SO_4 solution. The inhibition efficiency was evaluated using conventional weight loss measurements and electrochemical techniques, including potentiodynamic polarization and electrochemical impedance spectroscopy (EIS). Further, Surface characterization was performed using Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM) to assess the effect of the inhibitor on the steel substrate morphology and roughness. The results revealed that the compound acts as an effective corrosion inhibitor under acidic conditions, with inhibition performance primarily attributed to both physical and chemical adsorption of the heterocyclic molecules on the mild steel surface, forming a protective barrier that limits the interaction between the steel and the acidic environment. The study concludes that the quinoxalinone-based heterocyclic compound is a promising corrosion inhibitor for mild steel in acidic media, offering significant potential for industrial applications.

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Modulating Catalytic Activity of Human Topoisomerase II α Enzyme by Fluorescent Gold Nanoclusters

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Precise modulation of enzyme activity represents a key strategy in drug discovery and therapeutic design. Human topoisomerase IIα (Topo IIα), an essential enzyme involved in DNA replication and a well-known anticancer drug target, was explored for modulation using ultra-small fluorescent gold nanoclusters (Au NCs). In this study, mercaptopropionic acid-stabilized Au NCs (<2 nm) were synthesized and characterized using TEM, XPS, fluorescence, and UV–Vis spectroscopy. Molecular dynamics simulations revealed that Au NCs interact strongly with Topo IIα, preferentially localizing at the active site in the holoenzyme and shifting to 0 allosteric sites in the DNA-bound form. Isothermal titration calorimetry confirmed sequential binding with distinct thermodynamic signatures, supporting the dual-site interaction model. In vitro assays demonstrated a concentration-dependent inhibition of Topo IIα catalytic activity, validated by agarose gel electrophoresis of supercoiled DNA substrates. Collectively, these findings provide mechanistic insights into enzyme–nanocluster interactions and highlight fluorescent Au NCs as promising enzyme modulators with potential applications in nanotherapeutics and cancer treatment.

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Room Temperature Activation of Oxygen by Green Synthesized Silver Nanoparticles Using Moringa Leaves: Oxidative Dehydrogenative Coupling of Anilines for Azobenzene Synthesis

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The activation of oxygen under mild conditions is a highly desirable yet challenging goal in sustainable catalysis. In our study, we report the room temperature activation of oxygen using green-synthesized silver nanoparticles derived from Moringa leaves. These nanoparticles efficiently catalyse the oxidative dehydrogenative coupling of anilines, leading to the synthesis of symmetric and asymmetric azobenzene derivatives. The green synthesis approach not only enhances the catalytic performance of silver nanoparticles but also provides an eco-friendly and sustainable alternative for oxidative transformations. This work highlights the potential of biogenic nanoparticles in advancing green chemistry and developing sustainable oxidation methodologies.

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TiO_2-N-Fe-CNF decorated Carbon Bead-Based Photocatalyst for Photocatalytic Degradation of Congo Red Dye and Imidacloprid Pesticide

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Many persistent chemicals in water pose serious risks to living organisms, as they are often resistant to conventional treatment methods. To address this, Fe-phenolic beads were synthesized through suspension polymerization, using phenol as the monomer, formaldehyde as the solvent, and triethylamine as the catalyst. The obtained beads underwent carbonization, activation, and chemical vapor deposition (CVD) in a horizontal electric furnace equipped with gas inlets and outlets. Subsequently, the N-Fe-CNF-decorated carbon beads (CBs) were impregnated with TiO_2 in an aqueous medium. The structural and chemical features of the materials including surface morphology, BET surface area (S_{BET}), pore size distribution (PSD), surface functional groups, crystalline phase, voltammetry, and impedance were evaluated using advanced analytical techniques. Scanning electron microscopy revealed that the average particle size of the N-Fe-CNF/CBs was approximately 0.5 mm (500 μm). Modifications of the beads promoted the formation of a Z-scheme heterojunction, broadened light absorption into the UV-visible range, and reduced the band gap, thereby enhancing photocatalytic efficiency and stability. The optimized TiO_2-N-Fe-CNF/CB system was applied for the simultaneous adsorption and photocatalytic degradation of Congo red dye and imidacloprid pesticide. Remarkably, the photocatalyst achieved nearly 88% degradation efficiency within two days, demonstrating strong potential for water decontamination. Furthermore, it retained high degradation and electrochemical activity even after five reuse cycles, while offering easy recovery with minimal residue and toxicity. In conclusion, the developed beads effectively clean water by breaking down harmful chemicals and can be reused without losing efficiency. Their eco-friendly design makes them a strong candidate for future water treatment technologies.

Keywords: Photocatalyst; Titanium and Iron; Carbon Nanofiber; Composite Carbon Bead; Congo Red; Imidacloprid.

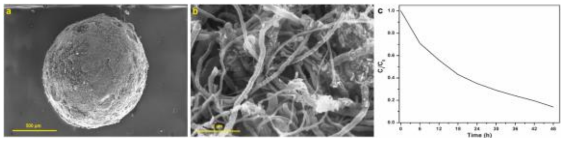

Figure: **(a & b)** SEM images of TiO_2-N-Fe-CNF/CB at different resolution and **(c)** Photodegradation spectrum of Imidacloprid by the same in two days.

Blueprints in Light: The Art and Science of Cyanotype, Toning and UV-Shielding

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This article presents the intersection of artistic expression and photochemical processes through the cyanotype method. The study delves into the fundamentals of cyanotype creation, focusing on the role of UV light, chemical solutions, and exposure time in shaping the final image. Additionally, it investigates the impact of toning agents in modifying the blue hues, offering a range of creative possibilities and enhancing the print's archival qualities. The use of UV shielding, including the application of sunscreen, is also explored as a method to control exposure and manipulate the print's outcome. By combining the artistry of toning with the science of UV protection, this work highlights the versatility of cyanotype photography and its continued relevance in both creative and educational contexts. The findings provide insights into the photochemical processes and encourage further experimentation in alternative photographic techniques.

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Fabrication and Structural Analysis of Surface functionalized Zinc-Metal-Organic Frameworks (Zn-MOFs)

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The demand for advanced porous materials has accelerated interest in metal–organic frameworks (MOFs), which combine high surface area with tunable chemical functionality. Among various candidates, Zn-MOF-74 - constructed from Zn^{2+} centers and 2,5-dihydroxyterephthalic acid linkers—offers an attractive platform for structural modification. In this work, a straightforward ambient-condition stirring route was employed to synthesize Zn-MOF-74, presenting a cost-effective and scalable alternative to conventional high-temperature solvothermal methods. To further improve durability and functional versatility, the MOF surface was engineered with reduced graphene oxide (rGO), producing hybrid composites with synergistic properties. The materials were systematically characterized using X-ray diffraction, Fourier-transform infrared spectroscopy, UV–visible absorption, and electron microscopy, which confirmed the crystalline integrity of the parent MOF and the successful incorporation of rGO. The resulting composites exhibit enhanced stability and multifunctional characteristics, underscoring their potential in a wide range of technological domains. This study not only establishes an accessible synthesis–modification route for Zn-MOF-74 but also highlights its adaptability for next-generation applications, including adsorption-based separations, catalytic transformations, pollutant remediation, biomedical applications and energy-related devices. Looking ahead, the integration of such MOF–nanocarbon systems may open new opportunities for designing sustainable, high-performance materials tailored to real-world challenges.

Enhanced Solar-Light Driven Photocatalytic Potential of Green Synthesized Ag-doped Cobalt-Oxide Incorporated rGO Nanocomposite with Agricultural Applications

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Herein, the facilitation of reduced graphene oxide (rGO) layer accumulation onto Ag@Co_3O_4 nanoparticles achieved via close interaction between the two materials as supported by spectroscopic and microscopic analysis, and the tuned band gap of composite and effective charge transport pathways maximize the synergistic effect in photocatalytic processes synthesized through co-precipitation method using *A. indica* leaves extract as stabilizer for the degradation of methylene blue (MB), Congo red (CR) and Rhodamine B dye (RhB) dyes from wastewater. In comparison to bare Co_3O_4, Ag@Co_3O_4, and rGO, Ag@Co_3O_4-rGO exhibits greater photocatalytic activity at optimum conditions, achieving about 90% elimination of all dyes while adhering to first order kinetics and the Langmuir adsorption isotherm by optimizing different reaction parameters and the degraded products and metabolites were analysed through GC-MS analysis and the degradation pathway was also proposed. The major role of hydroxyl radical in the photoelimination of pollutants was also determined by radical trapping experiment. The green synthesized Ag@Co_3O_4-rGO is cost effective, stable composite and works as excellent photocatalyst with high reusability upto 9 cycles and is also effective in real-time wastewater sample treatment of mixture of dyes spiked in tap water was also photocatalytically degraded along with its toxicity evaluation on *Vigna radiata* and *Okra* plant seeds. This work provides new insight into the creation of extremely effective visible light-active nanocomposite for the removal of various dye contaminants from effluent.

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Biomass Derived Turbostratic Carbon Black as an Efficient Electrocatalyst for HER/OER in Water Electrolysis

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The development of low-cost and efficient electrocatalysts is vital for advancing sustainable hydrogen production via water splitting. In this study, carbon black derived from sugarcane bagasse was synthesized and explored as a potential electrode material for electrochemical applications. The structural and optical properties of the synthesized carbon black were thoroughly characterized. X-ray diffraction (XRD) confirmed its partially graphitized structure with broad (002) and (100) reflections,[1] indicating nanoscale disorder. Raman spectroscopy revealed a characteristic D-band and G-band with an I_D/I_G ratio of 0.84[2], suggesting moderate defect density and disorder favourable for enhancing catalytic activity. UV–Visible spectroscopy demonstrated significant absorption in the UV and visible range, with a Tauc-derived band gap of ~1.3 eV, reflecting its semiconducting nature. These properties collectively highlight the ability of carbon black to facilitate charge transfer and active site generation during electrochemical reactions. Preliminary electrochemical assessments further suggest that the carbon black electrode exhibits promising activity for the hydrogen and oxygen evolution reactions (HER and OER), attributable to its defective carbon framework, high conductivity, and abundant active sites. This work demonstrates that bio-derived carbon black can serve as a cost-effective and sustainable electrocatalyst platform for green hydrogen production.

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Supramolecular Nanomaterials in Photocatalysis: Dual Metal Nanohybrid and Metal-Free TSCT Assemblies for Green Organic Synthesis

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Metal-based nanohybrids have gained significant attention in photocatalysis due to their unique structural and functional characteristics and catalytic efficiency under milconditions. Combining metal nanoparticles with magnetic supports enhances catalytic activity an allows easy catalyst recovery, addressing practical challenges in sustainable synthesis.1 In thpursuit of sustainable and efficient organic synthesis, we reported the development of supramolecular nanohybrid catalyst, HP-T@Au-Fe_3O_4, composed of highly branched hexaphenylbenzene assemblies supporting gold and magnetite nanoparticles.2 This hybrid material exhibits efficient photocatalytic performance in visible-light-driven Kumada and Heck cross-coupling reactions using aryl iodides and chlorides as substrates. Thcooperative interaction between Au and Fe_3O_4 nanoparticles facilitates efficient activation of aryl Halides, while the HP-T oligomeric framework enhances reaction kinetics by promoting key catalytic steps such as reductive elimination. Additionally, the magnetic nature of the catalyst enables facile recovery and recyclability, underscoring its practical utility in green organic synthesis. While effective, metal-based systems raise concerns related to cost, environmental impact, and metal residues in the final products. These limitations have prompted the development of metal-free photocatalytic systems as greener alternatives. Among them, through-space charge transfer (TSCT) assemblies of π-conjugated organic molecules have gained significant attention. These self-assembled nanostructures exhibit excellent photophysical properties, including long excited-state lifetimes and efficient generation of reactive oxygen species—making them ideal candidates for transformations like photooxidation and photoamidation under visible light.3

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Pd/Chitosin nanoparticle catalysed synthesis of 2-phenylfuro[2,3-*b*]quinoxaline

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An efficient protocol for the synthesis of 2-phenylfuro[2,3-b]quinoxaline has been developed using palladium-supported chitosan nanoparticles (Pd/CS NPs) as a heterogeneous catalyst. The nanocatalyst, prepared via in situ reduction and characterized by spectroscopic and microscopic methods, enabled high-yielding transformations under mild and environmentally benign conditions. The catalyst exhibited excellent stability and recyclability, maintaining activity over successive cycles. This study demonstrates the utility of Pd/CS NPs as a sustainable catalytic system for constructing biologically relevant fused heterocycles.

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Efficient Bifunctional Electrocatalysts for Overall Water Splitting

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The upsurge in energy demand, driven by the excessive consumption of fossil fuels and the resulting environmental degradation, has prompted the shift towards clean, renewable, and sustainable energy sources [1]. Among various strategies, electrochemical water splitting is regarded as one of the most efficient and environmentally friendly approaches for hydrogen production. However, the high cost, scarcity, and stability limitations of noble metal catalysts such as Pt, Ru, and Rh have spurred the search for alternative bifunctional materials. Metal-organic frameworks (MOFs), owing to their tunable structures, high porosity, crystallinity, versatile functionalities, and large surface area, have emerged as promising candidates for electrocatalysis and energy storage applications [2]. In this work, MIL-100(Fe) (MOF) was synthesized via a chemical route by varying the molar concentrations of the CoSn(OH)6 environment (denoted as MOF-1, MOF-2, and MOF-3) and systematically investigated for its catalytic activity in the hydrogen evolution reaction (HER) and oxygen evolution reaction (OER). Among the synthesized catalysts, MOF-2 exhibited the best HER performance, achieving the lowest overpotential of 138 mV. Tafel analysis suggests that the Volmer-Heyrovsky mechanism dominates the HER reaction pathway. Similarly, for OER, MOF-2 demonstrated the lowest overpotential of 336 mV, with Tafel analysis confirming that initial OH^- adsorption is the rate-limiting step. The overall water-splitting performance of MOF-2 was further tested in a two-electrode system, achieving water splitting at 1.79 V and maintaining stability for over 10 hours of continuous operation. These findings highlight the potential of MIL-100(Fe)/$CoSn(OH)_6$ as a cost-effective and efficient catalyst for practical hydrogen production, combining high stability, compositional tunability, and excellent catalytic activity.

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Direct growth of vanadium-incorporated CoxSy nanopyramids on conducting substrates: A facile approach for enhanced alkaline hydrogen evolution reaction

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Developing efficient and cost-effective electrocatalysts for hydrogen evolution reaction (HER) in alkaline media is vital for large-scale hydrogen production. Cobalt sulfides (CoxSy) show promise as HER catalysts, but their activity remains still insufficient. Nanostructures with sharp edges are known to enhance H+ adsorption during HER, but the production of such morphologies and additional dopant incorporation require multi-step processes. Here, we developed a one-step hydrothermal method that simultaneously incorporates vanadium into cobalt sulfide nanopyramids (i.e., V: CoxSy), with pointed tip morphology, which ensures synthesis scalability. Vanadium, with lower electronegativity and a smaller ionic radius than cobalt, modifies the catalyst's electronic and adsorption properties. The V: CoxSy nanopyramids

grown on carbon cloth were used as binder-free electrodes for HER in 1 M KOH, demonstrating superior HER performance with an overpotential of 200 mV at 10 mA/cm2 and a Tafel slope of 95 mV/dec, coming close to the Tafel slope of the benchmark Pt/C catalyst.

Keywords: CoxSy nanopyramids, Vanadium incorporation, Electrocatalyst, Self-standing electrode, Hydrogen evolution reaction.

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Probing Ligand Effects on the Thermal Stability and Photophysical Properties of Tb^{3+} Complexes

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Lanthanide complexes combine the high absorption coefficients of organic ligands in the ultraviolet region with the excellent optical features of lanthanide ions, making them attractive for various applications. In this work, we synthesized terbium-based complexes, namely terbium tris(1,1,1-trifluoro-2,4-pentanedionate) dihydrate [$Tb(TFAC)_3 \cdot 2H_2O$], terbium tris(1,1,1-trifluoro-2,4-pentanedionate)(1,10-phenanthroline) [$Tb(TFAC)_3Phen$], terbium tris(2-chlorobenzonate)(1,10-phenanthroline) [$Tb(2\text{-}CIBA)_3Phen$], and terbium tris(acetylsalicylate)(1,10-phenanthroline) [$Tb(ASA)_3Phen$], and examined the influence of ligands on their luminescence, thermal stability, and energy sensitization processes. Raman and FTIR analyses confirmed the coordination of primary and secondary ligands to the central Tb^{3+} ion. The excitation spectra of all complexes showed only broad ligand-based bands without distinct Tb^{3+} peaks, indicating efficient ligand-to-metal energy transfer. While the secondary ligand was not a strong sensitizer, it reduced non-radiative decay channels, leading to higher photoluminescence intensity, longer excited-state lifetimes, and improved photoluminescence quantum yield (PLQY). Thermogravimetric analysis revealed that $Tb(2\text{-}CIBA)_3Phen$ had the highest thermal stability, as well as the strongest luminescence and maximum PLQY (61.7%), attributed to favorable energy matching between the triplet state of 2-CIBA and the $^5D_4$ level of Tb^{3+}. The CIE coordinates LER and color purity values of the complexes were similar. These findings clearly demonstrate the significant role of ligand molecules in determining the optical performance, energy sensitization efficiency, and stability of terbium complexes.

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Design of Electrospun Lead-Free PVDF/Carbon Nanofibre/ZnO Nanocomposites for Advanced Wearable Piezoelectric Energy Harvesting Sensing Applications

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Poly(vinylidene fluoride) (PVDF) has emerged as a promising lead-free piezoelectric polymer for next-generation flexible and wearable electronics. However, its intrinsically low β-phase fraction, weak dipole orientation, and limited charge transport have continued to restrict its practical efficiency in nanogenerator applications. To overcome these challenges, we present a dual-filler engineering strategy that synergistically incorporates surface-functionalized carbon nanofibers (CNFs) and zinc oxide (ZnO) nanorods into electrospun PVDF fibres. The CNFs at an optimized concentration of 0.1wt% form conductive stress-transfer networks that facilitate charge mobility and mechanical reinforcement, while ZnO nanorods (1.5wt%), owing to their polar wurtzite facets, act as highly effective nucleating agents that induce α to β phase transformation through localized electrostatic interactions. Compositional optimization revealed that the 0.1% CNF + 1.5% ZnO hybrid achieved the maximum β-phase content of 85.6% and an enhanced piezoelectric coefficient (d_{33} = 36pC/N). This translated into superior energy harvesting performance, yielding an open-circuit voltage of 80V and a power density of 20mW/cm³ under periodic mechanical excitation. Furthermore, the composite nanogenerator exhibited stable, repeatable, and high-sensitivity responses when integrated into wearable platforms for human joint motion monitoring, demonstrating its robustness for real-time biomechanical sensing.

This study addresses the longstanding trade-off between mechanical flexibility and piezoelectric performance in PVDF-based systems. The proposed dual-filler approach not only enhances polarization alignment and phase transformation but also offers a scalable, lead-free, and environmentally benign route for developing high-performance energy harvesters and self-powered wearable sensors.

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Smartphone-Integrated Paper-Based Fluorescent Sensor Using Chitosan Carbon Dots for Rapid and Selective Detection of Cd^{2+} and Fe^{3+} Ions

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Heavy metal contamination in water poses a severe risk of toxicity and carcinogenicity, highlighting the urgent need to develop rapid, sustainable, and sensitive detection strategies. A sustainable and efficient methodology for synthesizing chito carbon dots (CHCDs) was established using microwave-assisted synthesis. The CHCDs were characterized using various photophysical techniques, revealing an average particle size of 6.8 nm, graphitic crystalline properties, and a quantum yield of 4.56%. These carbon dots demonstrated distinct and selective fluorescence responses toward Cd^{2+} and Fe^{3+} ions, with detection limits of 0.48 µM for Cd^{2+} and 1.19 µM for Fe3+. A comprehensive mechanistic study integrating UV-vis absorption, FTIR, XPS, time-resolved fluorescence, and EIS established that the fluorescence enhancement by Cd^{2+} ions resulted from surface passivation and suppression of trap states. In contrast, fluorescence quenching by Fe^{3+} arises from surface complexation and the creation of trap states, which promote non-radiative recombination. These experimental findings were substantiated by density functional theory calculations, which showed an increased band gap upon Cd^{2+} coordination (due to trap-state passivation) and a reduced band gap for the CHCDs-Fe^{3+} complex (due to trap states). CHCDs were employed in a paper-based device (CHCDs-PAD) integrated with a smartphone app for the rapid and portable detection of Cd^{2+} and Fe^{3+} in water, achieving detection limits of 0.42 µM and 0.50 µM, respectively, with excellent recovery. This study presents a green, rapid, scalable, and application-ready fluorescence sensing platform for heavy metal detection in water, with a primary emphasis on Cd^{2+} and an additional capability to detect Fe^{3+}. By combining sustainability, sensitivity, and applicability, this work offers a powerful tool for real-time monitoring of toxic heavy metals, contributing to environmental and human health safety.

Microwave-Driven Synthesis of 2D Hematene Nanosheets for Efficient NO_2 Gas Sensing

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Two-dimensional (2D) materials are widely recognized as promising candidates for gas sensing due to their large surface-to-volume ratio and tunable electronic properties. However, traditional van der Waals (vdW) 2D materials such as graphene and transition metal dichalcogenides often suffer from low surface reactivity, as their basal planes are largely inert toward gas adsorption. In contrast, non- van der Waals (non-vdW) 2D materials like Hematene, derived from non-layered α-Fe_2O_3, offer inherently active surfaces, abundant defect sites, and robust chemical stability, making them attractive for sensing applications. In this study, Hematene nanosheets were synthesized via a rapid, single-step microwave-assisted exfoliation method, which provides a facile and efficient route compared to conventional strategies. The resulting ultrathin nanosheets exhibited a high density of surface defects and enhanced reactivity, favoring strong interactions with nitrogen dioxide (NO_2) molecules. Gas sensing investigations revealed that the microwave-exfoliated Hematene sensor achieved an excellent response of 71% and a fast response time of 37 seconds at 25 ppm NO_2 under ambient conditions. These superior sensing characteristics demonstrate the ability of microwave synthesis to tailor the physicochemical features of Hematene, enabling improved gas adsorption and charge transfer dynamics. Overall, this work highlights microwave-assisted synthesis as a highly effective route for engineering non-vdW 2D materials and establishes Hematene as a compelling candidate for next- generation NO_2 gas sensing devices.

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Silver Quantum Dot Decorated Graphitic Carbon Nitride for Efficient Hydrogen Evolution: Experimental and Theoretical Study

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Graphitic carbon nitride (CN) is a well-known material for photocatalytic applications because it is active under visible light, non-toxic, chemically stable, and abundant. However, it has some limitations, such as low electrical conductivity, high recombination of charge carriers, low surface area, fewer active sites, and non-ideal band positions for efficient photocatalysis. To overcome these issues, CN needs modification. In this work, CN was first thermally exfoliated to form exfoliated carbon nitride (eCN), which increased its surface area and number of active sites. Researchers have previously tried to improve the light absorption and conductivity of CN by decorating it with plasmonic silver nanoparticles (AgNPs)[1]. However, due to their low surface-to-volume ratio and uneven distribution on the CN surface, AgNPs could not effectively separate electron-hole pairs or significantly improve conductivity. As a result, the full potential of silver was not utilized. To solve this problem, we developed a novel synthesis method where silver quantum dots (AgQDs) were uniformly decorated on eCN using hydrogen peroxide as an oxidative etchant. In this process, less stable silver atoms from larger AgNPs were extracted and converted into AgQDs. These AgQDs had a much higher surface-to-volume ratio and were distributed homogeneously across the eCN nanosheets, as confirmed by high-resolution transmission electron microscopy (HRTEM). The AgQDs helped in extracting electrons from the conduction band of eCN, which was confirmed by photoluminescence (PL) studies. UV-Vis spectroscopy showed improved light absorption, while photoelectrochemical (PEC) analysis confirmed better conductivity and higher photocurrent. Furthermore, ultraviolet photoelectron spectroscopy (UPS) revealed that the high work function of AgQDs shifted the band positions of eCN to more favorable values for photocatalytic hydrogen evolution. Density functional theory (DFT) calculations supported the experimental findings. The calculations showed that the electronic band gap decreased from 3.2 eV for eCN to 2.7 eV after AgQD decoration. The H_2 adsorption energy was calculated to be -0.67 eV, indicating that AgQD-decorated eCN strongly favors photocatalytic hydrogen evolution reactions. The optimized AgQD3@eCN catalyst achieved a high hydrogen evolution rate of 15.2 $mmolg^{-1}h^{-1}$. A detailed comparison between AgNP- and AgQD-decorated eCN showed that AgQDs are more effective for enhancing photocatalytic performance due to their higher surface area, better dispersion, and stronger interaction with eCN. This study demonstrates that AgQD-decorated eCN is a promising material for efficient photocatalytic hydrogen production.

Fast Plasma-Based Synthesis of SiC from Rice Husk for Methanolysis-Driven Hydrogen Production

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Transforming biowaste into functional materials offers a sustainable pathway toward clean energy technologies. In this study, we report a rapid, single-step thermal plasma strategy for converting abundantly available rice husk into highly crystalline, phase-pure β-silicon carbide (β-SiC) nanostructures. The synthesis, carried out in a double-walled, water-cooled plasma reactor operating at 7.5 kW and 500 Torr, delivers a production yield of 1 g within just a few minutes, demonstrating both speed and scalability. Comprehensive structural and morphological analyses confirm the formation of β-SiC nanowires, which were subsequently employed as catalysts for the methanolysis of sodium borohydride ($NaBH_4$). The catalyst exhibits a maximum hydrogen generation rate (HGR) of 8667 mL min-1 g-1 at 320 K, with stable performance maintained over extended operation, underscoring its promise for green hydrogen production. By uniting waste valorization, advanced plasma processing, and catalytic energy conversion, this work establishes a direct and sustainable route to high-value materials for energy applications.

Reductive Amination of Furfural to Furfurylamine using Ru supported Zeolites

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Lignocellulosic biomass (LCB), being a carbon-rich and carbon-neutral source, has received significant attention for producing electricity, fuel, and, particularly, chemicals that cannot be derived from any other alternative source. LCB consists of three major components, i.e., cellulose, hemicellulose, and lignin, that can be utilized to produce various platform chemicals such as 5-hydroxymethyl furfural (5-HMF), furfural (FF), levulinic acid, butanol, and 2,3-butanediol. Particularly, FF derived from the hemicellulose component of biomass holds a significant market size due to its wide range of applications and can also be used to synthesize various value-added chemicals, such as furfurylamine, tetrahydrofuran, furfural alcohol, and furoic acid.[1] The catalytic reductive amination of FF is employed for the synthesis of furfurylamine (FAM), which has applications in the polymer industry, medicine, agriculture, and pharmaceuticals.[2] To carry out the reductive amination of FF to FAM, various materials have been explored, indicating the role of different acidic sites in this transformation. However, the detailed and specific roles of Lewis and Brønsted acid sites have not yet been discussed.[3] To selectively synthesise FAM, the current study focuses on altering the zeolite support, which has both Lewis and Brønsted acid sites. In the presence of NH3 as a nitrogen source, the metal supported on modified zeolite has shown more catalytic activity in terms of FAM production (>80%) than the metal supported on parent zeolite. The structural changes in the modified zeolite and the role of active sites on the catalyst surface are understood through various characterization techniques, such as BET, NH3-TPD, CO2-TPD, HR- TEM, NH3-DRIFTS, and XRD analysis.

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Nanostructured MgO as a Low-Cost Heterogeneous Catalyst for Dehydrogenative Oxidation of Alcohols to Carboxylic Acids

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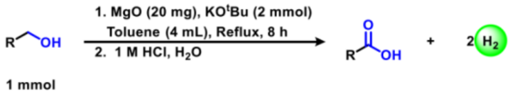
Recently, the rise of sustainable chemistry has given rise to a groundbreaking atom-economical approach for the synthesis of various value-added products from alcohols. This strategy, known as the acceptorless dehydrogenation (AD) reaction, is characterized by its intrinsic ability to proceed without the involvement of external oxidants or sacrificial hydrogen acceptors and produces molecular hydrogen as the sole byproduct, which can be a source of clean alternative energy.[1] This reaction also has received remarkable importance from the outlook of the hydrogen economy, as it enables the use of liquid alcohols, especially those derived from lignocellulosic biomass, as hydrogen storage vectors. Due to the high demand in the industries as well as the basic research areas, the synthesis of carboxylic acids from primary alcohols has emerged as a very important reaction via the acceptorless dehydrogenation reaction. To date, catalytic systems employed for the acceptorless dehydrogenation of alcohols to carboxylic acids have predominantly relied on transition metals, mainly noble metals such as palladium, platinum, iridium, etc., occupying a central role in this domain. On the contrary, the deployment of base metals, including readily available alkaline earth metals such as Mg, as a catalyst in oxidant-free transformations remains exceedingly rare. In recent years, alkaline earth metal oxides have garnered considerable attention in various organic transformations, primarily due to their ready availability and markedly lower cost. Owing to the earth-abundant and economically favorable nature of magnesium compared to conventional transition metals, the strategic derivatization and utilization of magnesium oxide (MgO) as a catalyst offers a promising pathway toward sustainable and cost-effective oxidation methodologies. As a part of our ongoing research work on acceptorless dehydrogenation,[2,3,4,5] here, we have introduced MgO as a low-cost heterogeneous catalyst in the acceptorless dehydrogenative synthesis of carboxylic acids from both aromatic and aliphatic alcohols. The synthesized MgO was characterized by using various characterization techniques like SEM-EDX, PXRD, TEM, XPS, ICP-OES, and FTIR, etc. The catalyst has synthesized carboxylic acids in a very efficient way with moderate to excellent isolated yields of up to 96%. The catalyst exhibits great recyclability with no significant decrease in activity even after the 5th cycle. This catalyst is also capable of facilitating the gram-scalesynthesis of acids.

Keywords: MgO nanomaterial, acceptorless dehydrogenation, hydrogen evolution



Scheme 1. Acceptorless dehydrogenation of alcohols to carboxylic acids.

Temperature Dependent Growth and Characterization of Cobalt-Oxide Thin Films Prepared by Spray Pyrolysis

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Cobalt oxide nanostructures have gained considerable attention as electrode materials for various electrochemical applications, including batteries, supercapacitors, and devices requiring efficient switching performance. This study reports the fabrication of cobalt oxide thin films using the spray pyrolysis deposition method. In this method, an aqueous cobalt chloride solution was sprayed onto glass substrates preheated to temperatures ranging from 350˚C to 450˚C. The effect of substrate temperature on the structural, morphological, and optical properties of the resulting thin films was investigated. A range of characterization techniques, including X-ray diffraction, field emission scanning electron microscopy, UV-Visible spectroscopy, energy-dispersive spectroscopy, and Raman spectroscopy, were employed to investigate the structural, morphological, and optical properties of the films. The XRD patterns confirmed the formation of a phase-pure crystalline cobalt oxide structure under controlled synthesis conditions. The FESEM images revealed the microporous structure with dense, randomly oriented, polyhedral shapes with clear boundaries. Optical analysis revealed that the direct and indirect bandgap values ranged from 1.46 to 2.10 eV and 1.35 to 1.70 eV, respectively. Raman spectroscopy identified five active modes at 186, 472, 514, 612, and 681 cm^{-1}.

Insights Into the Growth of 3D Graphene by Chemical Vapor Deposition: Flow, Heat and Residence Time Analysis

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Unlike conventional two-dimensional (2D) graphene sheets that tend to restack and limit the accessible surface area, three-dimensional (3D) graphene structures provide hierarchical porosity, interconnected networks, and enhanced mechanical stability, making them highly advantageous for energy storage, catalysis, and thermal management. Chemical vapor deposition (CVD) offers a scalable and controllable route to fabricate such architectures, but process optimization is essential to achieve desirable structural and functional properties. In this work, high-quality 3D graphene sheets (3DGS) were synthesized using methane as the carbon source from the CVD method on scarcely explored cobalt, which acted as both a catalyst and template. Characterizations such as Raman spectroscopy (I2DIG≈ 2, IDIG ≈ 0), electron microscopy, and other analyses confirmed the growth of high- quality 3DGS. Flow and heat transfer characteristics inside the CVD furnace were further studied numerically employing FEM solver COMSOL Multiphysics (v6.2) to gain mech- anistic insights and optimize the overall growth conditions. It was observed that there is the formation of recirculation zones inside the reactor even at a relatively low Reynolds number of 30. However, the vortices were stable rather than turbulent, which helps to maintain a uniform hydrocarbon ratio over the catalyst. Furthermore, residence-time analysis was carried out to capture the non-idealness of the reactor. In general, these results emphasize the critical role of transport and operational parameters in CVD and provide engineering guidelines for tailoring 3D graphene architectures to scalable applications.

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Nanoparticles modulated water stress induced responses in tomato

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Water stress is one of the major limiting factor which influences global crop production. Water stress affects vegetative or early reproductive growth, reduces total yield at both qualitative & quantitative trait in tomato plant. Magnesium is crucial for plant biology, especially in improving abiotic stress including water stress tolerance. The present study is an attempt to understand the role of magnesium functionalized curcumin nanoparticles (Mg-CurNPs) in modulating water stress induced damages in tomato plant. The results highlighted the synthesis of Mg-CurNPs and its characterization by Ultraviolet-visible (UV-Vis) Spectroscopy, Dynamic light scattering (DLS), Fourier-transform infrared (FTIR) Spectroscopy, X-Ray Diffraction (XRD), Photoluminescence Spectroscopy (PL), X-ray Photoeslectron Spectroscopy (XPS), Field emission scanning electron microscopy (FE-SEM), Transmission electron microscopy (TEM). The observed average particles size of Mg-CurNPs was (18nm) in TEM with negative (-22.4mV) zeta potential in DLS. The Mg-CurNPs treatment showed increase in length, fresh and dry mass of shoot and root of tomato plant. The interaction of Mg Cur NP and water stress resulted reduction in superoxide anion (O_2^-), hydrogen peroxide (H_2O_2), and Malondialdehyde (MDA) content, whereas total phenolic content and antioxidant enzymes superoxide dismutase (SOD), catalase (CAT) and guaiacol peroxidase (GPx) enzymes activity. Histochemical studies also reveal localization of superoxide anion and H_2O_2 in leave tissues during water stress and Mg-CurNPs application in tomato plant. Confocal microscopy study showed green florescence images indicating localization of Mg-CurNPs in different parts of leave tissues during the water stress relative to control, suggesting Mg-CurNPs modulates water stress damage in tomato plant. This study enriches our understanding of positive modulation of plant growth and biochemical responses by Mg functionalised Cur NP. Thus, opens new dimension in the development of functionalized curcumin nanoformulation for sustainable agricultural and allied application in future.

Keywords: Nanoparticles, water stress, magnesium, curcumin, tomato, mitigation

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Fmoc-Glutamic Acid-Iron Complex: A Self-Assembling Biomimetic Catalyst with Peroxidase-Like Activity

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The development of biomimetic catalysts based on small peptides and metal ions has gained increasing attention as an alternative to natural enzymes, offering stability, tunability, and cost-effectiveness. In the present study, we explored the interaction of Fmoc-glutamic acid with a wide range of metal ions to examine its coordination ability and potential catalytic functions. Initially, first-row transition metals, alkali metals such as Na^+ and K^+, and Cd^{2+} were screened to identify favourable binding partners. Among these, iron was found to form the most stable and distinctive complex with Fmoc-glutamic acid, prompting a detailed investigation of this system. The binding stoichiometry between Fmoc-glutamic acid and Fe^{3+} was determined using Job's plot analysis, which revealed a well-defined ratio, supporting the formation of a discrete complex rather than random aggregation. FTIR spectroscopy provided further evidence of complex formation by showing shifts in characteristic vibrational bands, indicating the involvement of carboxylate and amide functionalities in metal coordination. Morphological features of the assemblies were investigated using optical and scanning electron microscopy, where the Fmoc-glutamic acid–Fe complex displayed micro- and nanostructures, suggesting that metal coordination promotes self-assembly. Beyond structural studies, the functional properties of the complex were evaluated. Remarkably, the Fmoc-glutamic acid–Fe+3 system exhibited peroxidase-like catalytic activity, efficiently catalyzing the oxidation of chromogenic substrates in the presence of hydrogen peroxide. This observation demonstrates that the combination of a simple peptide derivative with a metal center can generate robust enzyme mimics, or nanozymes, with potential applications in biosensing and catalysis. Overall, this work highlights the dual role of Fmoc-glutamic acid as both a self-assembling motif and a ligand for metal coordination, establishing a versatile platform for the design of peptide-based artificial enzymes.

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From Complexity to Chirality: Solvent-Driven Chirality Modulation and Morphology Transitions in Hierarchical Co-Assemblies

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Programming the solvent-mediated hierarchical organization and chirality transition in organic–inorganic co-assembled hybrid materials is attractive but still a challenge.[1-2] The present work demonstrates the development of solvent-responsive **R/S-Pyra-CEA** building blocks which exhibit distinct absorption and chiroptical behavior in the presence of Lewis base co-solvents (THF/1,4-dioxane/DMSO) in self-assembled/co-assembled state in mixed aqueous media. The study reveals a simple strategy to exploit subtle solvent characteristics as external controls to direct the co-assembly of a well-designed organic building block, inorganic component [Au (III) ions], and chiral inducer (cysteine) through multiple hierarchical growth pathways, leading to diverse chiral superstructures in aqueous media. Strikingly, **R/S-Pyra-CEA** assemblies promoted the in situ reduction of Au (III) ions to Au (0) nanoparticles, while in the presence of cysteine the process was regulated to stabilize Au (I) species, leading to the formation of enantioselective chiral assemblies.[3] The outcome of this investigation provides fresh insights for designing solvent-sensitive building blocks to prepare nature-inspired, hierarchically organized chiral hybrid materials with potential applications in nanomaterials research.

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Self-Assembled "Through Space Charge Transfer" Nanostructures as Metal-Free Photocatalysts for Regulated Oxidation of Alcohols and Aldehydes

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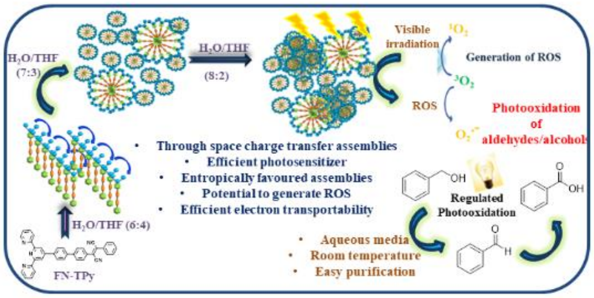
Visible light driven sensitized oxidation of organic compounds is a sustainable approach for preparation of synthetically important building blocks.[1-2] Photosensitization enables activation of oxygen to generate reactive oxygen species (ROS) which eventually act as the potent 'oxidants' in the oxidative organic transformations. Thus, we developed strong acceptor- weak acceptor system, FN-TPy which undergoes solvent dependent self-assembly in mixed aqueous media to generate through space intermolecular charge transfer nanoassemblies.[3] The as prepared entropically favoured assemblies of FN-TPy exhibit excellent photostability and photosensitizing properties in the assembled state to activate aerial oxygen for efficient generation of reactive oxygen species (ROS) through Type-I and Type-II pathways. The FN-TPy exhibits excellent potential for regulated oxidation of alcohols and aldehydes under mild reaction conditions (visible light irradiation, aqueous media, room temperature) using aerial oxygen as the 'oxidant'. The present study demonstrates the potential of FN-TPy as a "metal-free" photosensitizing nanomaterial for catalyzing controlled oxidation of benzyl alcohol to benzoic acid.



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Innovative CuBTC/g-C_3N_4 materials for tetracycline mitigation: adsorption, photocatalysis, and mechanistic perspectives

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The rising prevalence of antibiotic pollutants in aquatic systems necessitates multifunctional materials for sustainable remediation. In this work, CuBTC/g-C_3N_4 heterojunction photocatalysts with varying ratios (1:1, 1:3, 3:1) were synthesized via a hydrothermal route and comprehensively characterized using XRD, FESEM, HRTEM, EIS, UV–DRS, PL, TGA, FTIR, XPS, and BET analyses. Among them, the 3:1 CuBTC/g-C_3N_4 composite exhibited outstanding performance, degrading 97.4% of 25 ppm tetracycline within 60 min under UV illumination with a rate constant of 0.02098 min^{-1}. The composite also displayed excellent reusability, retaining 82.7% efficiency after six cycles. Adsorption followed the Langmuir isotherm ($R^2 = 0.992$) and pseudo-second-order kinetics ($R^2 = 0.968$), while photocatalytic degradation aligned with pseudo-second-order kinetics ($R^2 = 0.993$). Mechanistic studies confirmed superoxide radicals as the dominant reactive species, with hydroxyl radicals, electrons, and holes playing secondary roles. TOC and COD removal efficiencies of 67.8% and 68.6%, respectively, validated effective mineralization, while LC–MS unveiled the degradation pathway via ring-opening and oxidative processes. Thermodynamic analysis indicated spontaneity and exothermicity, with $\Delta G = -92.7$ J mol^{-1}, $\Delta H = -63.84$ kJ mol^{-1}, and $\Delta S = -0.214$ kJ mol^{-1} K^{-1}. These results highlight CuBTC/g-C_3N_4 heterojunctions as robust adsorptive–photocatalytic systems for antibiotic remediation.

Keywords: CuBTC/gC_3N_4 nanocomposite; Tetracycline removal; Wastewater Treatment; Isotherm and Kinetic Studies.

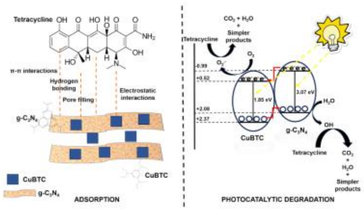

Figure: Possible adsorption and photocatalytic mechanism of tetracycline using CuBTC/g-C_3N_4 nanocomposites.

Synthesis, Experimental and Computational studies on halide double perovskite $Cs_2AgBiBr_6$

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$Cs_2AgBiBr_6$ is a lead-free halide double perovskite (HDP) with promising photovoltaic potential and widely investigated by many workers. This work reports the synthesis and characterization of $Cs_2AgBiBr_6$. The material was synthesized using a solution-based method involving dissolution of cesium bromide, silver bromide, and bismuth tribromide in hydrobromic acid (HBr). The precursor solution was subjected to controlled heating, followed by washing, and drying to yield a crystalline powder. The formation and phase purity of the material were confirmed by X-ray diffraction (XRD). The obtained XRD pattern displayed a prominent peak consistent with the cubic double perovskite structure, and the calculated lattice constant aligned with previously reported values. These results validate the formation of a pure-phase crystalline material with the expected Fm3ͧm space group. The optical properties of the material were characterized using UV-Visible spectroscopy, and the band gap was extracted by analyzing the absorption spectrum and carrying out Tauc plot analysis. The material exhibited strong absorption in the UV and visible regions. This analysis yielded an indirect band gap that ranged from 1.88 to 2.22 eV, and was observed to be dependent on the synthesis temperature. The indirect nature and wide value of this band gap are the limiting factors for the material's efficiency in certain optoelectronic and photovoltaic applications. To gain a deeper understanding of the electronic properties density functional theory (DFT) calculations were performed using Vienna Ab initio Simulation Package (VASP). These calculations provided critical insights into the band structure of $Cs_2AgBiBr_6$. The theoretically obtained band gap values of 1.34 eV (using the GGA-PBE method) and 2.21 eV (using the HSE06 hybrid function) agreed with experimental data. The band structure analysis further confirmed that the material is an indirect bandgap semiconductor, with the valence band maximum (VBM) located at the Γ symmetric point and the conduction band minimum (CBM) located at the L symmetric point within the Brillouin zone. These findings are essential for guiding future research on band gap engineering, such as through elemental doping, to enhance the material's photovoltaic performance for various applications. The results of this investigation will be discussed in detail.

TiO_2 Nanoparticles and ZnS-TiO_2 Nanocomposites synthesized by chemical precipitation technique and their temperature response

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Titania (TiO_2) is a metal oxide semiconductor, which has been a subject of immense study due to its high chemical stability, availability, non-toxicity and ability to decompose pollutants [1, 2]. Titania can form composites, when combined with suitable metals or semiconductors. In this work, TiO_2 nanoparticles and ZnS-TiO_2 nanocomposites have been synthesized by chemical precipitation technique. The synthesized nanocomposites have been characterized by various characterization techniques viz. UV-visible Spectroscopy (UV), Photoluminescence Spectroscopy (PL), X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray analysis (EDAX). The results of UV-visible analysis confirmed formation of nanoparticles of TiO_2 and ZnS-TiO_2 nanocomposite, with clear blue shifting of absorption edges and corresponding band gap enhancement, in comparison to the bulk TiO_2 and ZnS. The PL emission was observed near 291 nm in the UV region. Results of XRD analysis indicated formation of anatase TiO_2 and cubic ZnS in the nanocomposite. SEM analysis also confirmed formation of nanoparticles. The resistance variation of the synthesized samples was studied as a function of temperature. The samples exhibited well defined variation in resistance with increase in temperature.

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Synergistic Molecular- Support Nanocomposites: Copper-Amide Complex Confined in Dendritic Silica for CO_2 Valorization

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The catalytic conversion of carbon dioxide into methanol is a promising approach for sustainable carbon utilization, yet the design of catalysts that are both selective and thermally robust remains challenging. Recently, low-coordinate dinuclear copper–amide complexes have shown remarkable activity for the thermal reduction of CO_2 to methanol through a copper–hydride mediated pathway.[1] However, their fragile coordination environment limits long-term stability under operational conditions. In parallel, dendritic fibrous nanosilica (DFNS) has been established as a robust mesostructured material with exceptional CO_2 adsorption capacity, high surface area, and thermal durability.[2] Here, we propose to integrate these two promising systems into a molecular–support nanocomposite, where copper–amide complexes are immobilized within the fibrous channels of DFNS. The resulting Cu–amide/DFNS nanocomposite is expected to combine the molecular-level reactivity and selectivity of the copper complex with the structural stability and CO2 adsorption properties of the silica support. The dendritic framework will stabilize the reactive Cu–amide motifs, suppressing deactivation, while its inherent CO_2 enrichment ability will enhance substrate availability and catalytic turnover. This nanocomposite strategy is anticipated to deliver superior methanol selectivity, higher turnover numbers, and enhanced thermal robustness compared to the standalone components. Beyond its fundamental novelty, the development of such hybrid nanocomposites provides a scalable pathway for CO_2 valorization into renewable fuels, directly aligning with global sustainability goals in clean energy and climate action.

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Two Dimensional FeSSe a Novel Janus Material

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In this work, with density functional theory (DFT) calculations we study a novel Janus 2D material FeSSe, for its electronic, magnetic and optical properties. We carry out the calculations with GGA-PBE exchange correlation functionals to study the proposed Janus 2D material. 2D FeSSe showed a 1T P-3m1 structure upon optimization with lattice parameter $a=b=2.96$Å, and Fe-S bond length 2.26Å and Fe-Se bond length of 2.41Å, and layer thickness of 3.19Å. The material showed zero-gap bandstructure with significant fermi level crossings near M and K points of the Brillouin Zone. The calculations showed strong UV absorption in the 100-200nm range for the Janus 2D FeSSe, with most significant peaks at 113, 99 and 173nm. The spin resolved charge density studies show the structure has a asymmetric spin charge distribution with a net accumulation of spin up carriers on the Fe atoms and depletion of the same from the chalcogens. These results indicate interesting optical and spintronic properties for the 2D Janus FeSSe.

Designing Plasmonic Nanostructures with dual functionality: Biocompatible Antimicrobial Therapy and Toxic dye detection

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The environment pollution causes major threat to the public health globally. The untreated industrial waste such as toxic dyes and human waste releases infectious bacteria and cancerous elements into the water bodies and atmosphere. Over the time, these bacteria have become antibiotic-resistant, causing millions of disease and hospitalization. Also, the detection and degradation of toxic dyes is very crucial for human health. Plasmonic nanoparticles have proven significant promise in nanoparticle-based therapeutic medicines used against antibiotic-resistant bacteria. These plasmonic nanoparticles have also shown its excellency in the detection and degradation of toxic dyes through surface enhanced Raman scattering (SERS) sensing applications. To fabricate biocompatible plasmonic nanomaterial by a novel and green fabrication approach that functions as antibacterial agent and possess SERS features. Plasmonic Cu nanoparticles are fabricated by Pulsed laser ablation(PLA) in liquid method. Particles are characterized by XRD, TEM and UV-Vis spectroscopy. The antibacterial efficacy of the prepared plasmonic nanoparticle samples wastested against E.coli bacteria by spread-plate method. The cytotoxicity of the prepared nanoparticles was tested on normal Human Embryonic Kidney (HEK) cell lines by MTT assay. Bioimaging of the live cells was also performed. The SERS performance of the prepared samples on a toxic dye (Congo red dye) molecule was tested by using Raman spectroscopy. The cytotoxicity results on HEK cells showed viability of about 80% which indicates biocompatible nature of our sample. The antibacterial test results showed 90 % killing of E.coli bacteria. The Raman spectroscopy results showed an enhancement intensity of 103 in the toxic dye molecule spectra indicating satisfactory SERS performance of our sample. Our work provides an insight of a novel and green approach of plasmonic nanoparticle fabrication. These nanoparticles have excellent antibacterial efficacy and possess SERS characteristics for sensing applications.

Biosynthesis of Fe-Ni Bimetallic nanoparticles and their catalytic activity in Chlorpyrifos

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Nowadays, organic materials are widely explored for green synthesis of nanoparticles because of their ease of scaling compared to conventional approaches. The present research is focused on the synthesis of Iron-Nickel bimetallic nanoparticles using the extracts from the *Azadirachta Indica* (neem) leaves. The effects of operational parameters, including metal salt concentration, pH, leaf broth concentration, and solution temperature, on nanoparticle particle size are reported. Fe-Ni bimetallic nanoparticles were characterized by Uv-Vis, FTIR, XRD, SEM, TEM, DLS, and EDS methods. The presence of phytoconstituents in the extract of *Azadirachta Indica L.* during synthesis is determined by FTIR spectra, and XRD study showed a crystalline structure with a face-centered cubic (FCC) particle size of 8 nm. According to TEM and SEM Spectroscopy, Fe-Ni bimetallic nanoparticles have a core-shell structure and a spherical-to-irregular shape, measuring 7.9 nm. The zeta potential of the synthesized Fe-Ni BMNPs, which exhibits a high peak at -12.2 mV, suggests that the green synthesized NPs are highly stable. These synthesized Fe-Ni BMNPs were applied as the catalyst in the degradation process of Chlorpyrifos (CP) in the presence of peroxodisulphate (PDS). The effect of different experimental conditions, such as initial pH, concentration of PDS, Dye, and Fe-Ni BMNPs, was studied on the degradation process. The degradation of CP in the Fe-Ni BMNPs/PDS system is followed by pseudo-first order kinetics, and the maximum degradation of CP reached 95% in 6-10 hours.

Keywords: Green Synthesis, Fe-Ni BMNPs, *Azadirachta Indica* (Neem), CP.

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Development of Non-Enzymatic Glutamate Sensor Using Self-Assembled Monolayer of poly (ortho-phenylenediamine)/silver Core-Shell Hybrid

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Monosodium glutamates have been used as a common ingredient in the various food products especially fast foods and Chinese foods. However, Indian's Preventions of Food Adulteration sets a limiting value of 1% only due to having adverse effects like unnatural obesity, headache, nausea, birth disorders etc. Sensitive and selective sensing of glutamate are not only relevant for use in clinical diagnosis but also in food industry, bio-processing and safety, drug discovery, environmental monitoring, fermentation monitoring, development of renewable, sustainable fuel cells etc. Here, a single-step process has been demonstrated for the synthesis of core-shell hybrid of poly(ortho-phenylenediamine) functionalized with uniformly distributed silver nanoparticles (PoPD@Ag). The prepared core-shell PoPD@Ag hybrid was self-assembled on a screen-printed carbon electrode to develop selective non-enzymatic electrochemical glutamate sensor in aqueous solutions. The stature features including interfacial interactions of the components in the PoPD@Ag hybrid were investigated from the UV-VIS and FTIR analysis. The uniform wrapping/coating of the PoPD on the silver surface with 3 % loading was observed due to functionalization of silver nanoparticles through the =NH groups of PoPD polymer to form a well-defined core-shell morphology with flower- like structure. Formation of Ag (0) nanoparticles was confirmed from the characteristic X-ray diffraction pattern. The particle size as well as size distribution of the Ag (0) nanoparticles core inside the polymer matrix was analysed by the dynamic light scattering particle size analyser and zeta analyser. The flower -like structure with core -shell morphology of synthesised hybrid well supported from FESEM and HRTEM analysis. Non-enzymatic electrochemical glutamate sensing performances of the self-assembled monolayer of PoPD@Ag hybrid on screen-printed carbon electrode were evaluated in an aqueous solution of pH 4 phosphate buffer electrolyte.

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Novel Carbon Dots as a Green Corrosion Inhibitor for Electrochemical, Gravimetric, and Morphological Studies on Mild Steel in 15 % HCl Solution

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A one-step hydrothermal process synthesized carbon dots, CDLP and CDLT. These carbon dots inhibited the mild steel (MS) corrosion process when dissolved in a 15 % HCl solution. They were water-soluble, low-cost, affordable, and environmentally friendly. The compound that contains a lone pair and π-electron, such as S, N, and O, as well as aromatic heterocyclic rings and other polar functional groups like nitrile(C=N), amine (NH), carbonyl(C=O), and thiol (SH), that are readily available for donation of electrons, act as good corrosion inhibitors for carbon dots for metal surfaces to inhibit the corrosion process. FTIR, UV-Vis, PL, XPS, and HRTEM analysis were used to characterize the synthesized CDLP and CDLT. The inhibitory efficiency of CDLP and CDLT was assessed using potentiodynamic polarization analysis, electrochemical impedance spectroscopy analysis, and weight loss measurement analysis. By using FESEM, EDX, AFM, and XPS analysis, the surface morphology of the inhibited sample was examined, and the presence of a protective layer on the MS surface was verified. At 120 ppm concentration and 303K temperature, the inhibition efficiency of CDLP and CDLT was observed as 96.50 % and 90.21 % respectively, both from electrochemical impedance and weight loss analysis. The adsorption of CDLP and CDLT on the MS surface followed mixed adsorption (physisorption and chemisorption) and obeyed the Langmuir adsorption isotherm.

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Exploring Angle-Dependent Photoluminescence Spectra in Halide Perovskite Nanocrystals

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Metal halide perovskites (ABX3) have attracted immense attention due to their tuneable bandgap, strong light–matter interactions, and excellent optoelectronic performance. Among their various forms, perovskite nanocrystals (PNCs) offer distinct advantages such as quantum confinement, high photoluminescence quantum yields, and enhanced control over emission properties, making them ideal for display and lighting applications. Methylammonium lead bromide (MAPbBr3) nanocrystals exhibit bright green emission and high optical stability, making them a suitable model for studying emission behaviour. This study investigates the angle-dependent optical properties of PNCs to elucidate light–matter interactions and non-radiative recombination mechanisms. By analyzing how emission intensity, polarization, and wavelength vary with observation angle, the work aims to elucidate how structural ordering and dipole alignment contribute to directional emission. Understanding these relationships will provide deeper insight into light–matter interactions in PNCs and help develop strategies to enhance emission directionality and light outcoupling efficiency, paving the way for more efficient perovskite-based optoelectronic devices.

Development and Characterization of Poly(butylene adipate-co-terephthalate)(PBAT)/Graphene Nanocomposite Film

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An effective UV photodetector based on a layered heterostructure employing nanocrystalline silicon (nc-Si) thin films and graphene oxide (GO) is presented in this study. The precise and scalable magnetron sputtering method was used to deposit the nc-Si layers, and optical characterisation verified the clear wide band gaps that are essential for UV response: 2.5eV for the GO films and 2.3eV for the undoped nc-Si. The main focus of the work is simulating the combined absorption of this structure. This validates the structure's potential as an excellent, reasonably priced UV sensor by showing a synergistic effect where the complementary bandgaps of the materials result in significantly improved light-trapping and overall quantum efficiency in the UV spectrum.

Keywords: Graphene oxide, Nanocrystalline silicon, magnetron sputtering, UV spectrum.

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Moiré-Engineered Bio-Reduced Graphene as a Universal Coating for Doped Metal Sulfide Nanocomposites: Toward Sustainable Multifunctional Applications

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A sustainable bio-mediated approach was adopted to synthesize few-layered turbostratic graphene nanosheets using Cocos nucifera (coconut water) as a natural reductant, stabilizer and capping agent. The phytochemical constituents—ascorbic acid, polyphenols and furan derivatives—facilitated partial reduction and exfoliation of graphite oxide, introducing surface functionalities (–OH, –COOH, C=O, C–O–C) that enhanced dispersibility and prevented restacking. Structural analyses confirmed high-quality graphene via XRD, showed a dominant (002) reflection at $2\theta = 26.52°$ ($d = 0.336$ nm), while Raman spectra evidenced of high sp2 retention. HRTEM and SAED revealed turbostratic stacking with Moiré superlattice periodicity ($L_m \approx 0.541$ nm) and twisted angles of ~26.3° and ~42.6°, producing miniband formation, van Hove singularities and interlayer electronic decoupling—properties that make this graphene an excellent charge-transport and coating medium for semiconductor nanostructures. Mn-doped ZnS nanoparticles displayed a blue-shifted absorption edge at 309 nm ($E_g \approx 4.01$ eV) compared to pure ZnS (320 nm, $E_g \approx 3.6$ eV), confirming Mn^{2+} substitution and quantum-confinement effects. HRTEM images showed randomly aggregated nanoclusters (~12–28 nm) with clear lattice fringes ($d \approx 0.28$ nm), while graphene coating (Mn–ZnS@graphene) produced uniformly anchored nanoparticles embedded within a carbon-rich matrix, exhibiting stronger crystallinity and interfacial coupling. The composite showed a red-shifted λmax at 335 nm ($E_g \approx 3.7$ eV), reflecting charge transfer and dielectric screening that enhanced optical activity and suppressed carrier recombination. Similarly, TeO_2-doped SnS nanoparticles exhibited orthorhombic XRD peaks ($2\theta = 22.9°–49.9°$) and uniform nanostructures in HRTEM. Followed by coating with bio-reduced graphene, the TeO_2–SnS nanoparticles are expected to exhibit increased absorption and broadened photoresponse through enhanced exciton separation and π–π coupling between the semiconductor and graphene layer. Altogether, these graphene-coated doped metal-sulphide nanocomposites:Mn–ZnS@graphene and the proposed TeO2–SnS@graphene—highlight the role of bio-reduced graphene as a defect-tuned, Moiré-engineered coating scaffold that can significantly enhance interfacial charge transfer and optical performance. This work establishes a strong foundation for the development of multifunctional optoelectronic, energy storage, sensing and photodetector materials, while future studies will focus on realizing a single-step green one-pot synthesis to achieve scalable integration of doped metal sulphides with bio-reduced graphene for sustainable device applications.

GO/nc-Si: A Dual-Bandgap Layered Structure for Enhanced UV Photodetection

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An effective UV photodetector based on a layered heterostructure employing nanocrystalline silicon (nc-Si) thin films and graphene oxide (GO) is presented in this study. The precise and scalable magnetron sputtering method was used to deposit the nc-Si layers, and optical characterisation verified the clear wide band gaps that are essential for UV response: 2.5eV for the GO films and 2.3eV for the undoped nc-Si. The main focus of the work is simulating the combined absorption of this structure. This validates the structure's potential as an excellent, reasonably priced UV sensor by showing a synergistic effect where the complementary bandgaps of the materials result in significantly improved light-trapping and overall quantum efficiency in the UV spectrum.

Keywords: Graphene oxide, Nanocrystalline silicon, magnetron sputtering, UV spectrum.

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Influence of Annealing Temperature on Structural, Optical, and Dielectric Properties of PLD-grown $Ba_{0.5}Sr_{0.5}TiO_3$ Thin Films

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$Ba_{0.5}Sr_{0.5}TiO_3$ (BST) thin films were deposited on n-type Si and quartz substrates using the pulsed laser deposition (PLD) technique. Post-deposition annealing was performed at various temperatures, to optimize the structural and functional characteristics of the films. X-ray diffraction analysis verified the formation of a single-phase cubic perovskite structure. Field emission scanning electron microscope showed a densely packed microstructure, while optical measurements indicated a wide band gap. The dielectric constant measured across varing temperatures remained stable for the film annealed at 700ºC. These findings highlight a significant influence of annealing temperature on both structural and dielectric characteristics, confirming the material's potential for use in advanced capacitor technologies.

Low-Molarity ZnO Thin Films as Transparent Electrodes for nanocrystalline silicon n–i–p Solar Cells: Experimental and Simulation Study

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Zinc oxide (ZnO) thin films were successfully fabricated by the spin coating method using zinc acetate dihydrate solutions in ethanol of varying molarities: 0.1 M, 0.05 M, and 0.025 M, followed by annealing at 100 °C for 1 hour. The influence of precursor molarity on the structural and optical properties of the films was systematically investigated. X-ray diffraction analysis revealed that the films deposited from 0.05 M and 0.1 M solutions exhibited superior crystallinity with a strong (002) orientation. Optical studies showed that these films possessed a wide and uniform band gap, making them suitable as transparent conductive layers. Based on the obtained material parameters, the optimized ZnO thin films were incorporated as the front electrode in a simulated nanocrystalline silicon (nc-Si) based n–i–p structured solar cell. The simulation results demonstrated improved photovoltaic performance, highlighting the potential of low-molarity ZnO thin films for cost-effective thin-film solar cell applications.

Keywords: Zinc oxide, spin-coating, n-i-p structure, nanocrystalline silicon

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Development of conjugated polymers based on carbazole, fluorene and indolocarbazole units via metal free indophenine polymerization strategy

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The indophenine reaction, recognized for its simplicity and environmentally benign nature, was employed to synthesize a new class of conjugated polymers through a metal-free approach. Initially, isatin-based precursor compounds were synthesized and characterized using FT-IR, NMR, and HRMS analyses. These precursors were subsequently utilized for the preparation of indophenine-based conjugated polymers (IC, IF, and IICZ) via reaction with dialkoxythiophene derivatives. The obtained polymers were thoroughly characterized by NMR spectroscopy to confirm their structural integrity. The synthesized polymers were then integrated into Bottom-gate Top-contact (BGTC) Organic field-effect transistor (OFET) devices to evaluate their charge transport characteristics. The measured hole mobilities for IC, IF, and IICZ were 0.099×10^{-3}, 0.26×10^{-3}, and 0.15×10^{-3} $cm^2\ V^{-1}\ s^{-1}$, respectively. Furthermore, optical and electrochemical studies revealed their low bandgap nature, supporting efficient charge delocalization within the polymer backbone. Surface morphological analyses demonstrated that the IF polymer exhibited the smoothest film surface, as indicated by its lowest RMS roughness value, correlating well with its superior OFET performance. Overall, this study highlights the potential of metal-free indophenine polymerization as a sustainable synthetic route for developing conjugated materials suitable for organic electronic applications.

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Interface-Driven Charge Transport Enhancement in WS_2 FETs Using High-k Polymer Gate Dielectrics

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Two-dimensional (2D) Tungsten Disulfide (WS_2) nanomaterial, including its single-layer and multilayer properties, have sparked considerable interest in electrotonic and optoelectronics device applications. WS_2 nanosheets possess a honeycomb lattice structure held together by weak van der Waals forces, enabling easy exfoliation from bulk nanosheets. While WS_2 nanosheets exhibit a semiconducting nature with an indirect bandgap of 1.2 eV in bulk form, reducing the layer count through exfoliation can transition it to a direct bandgap of 2.1 eV. Despite these intrinsic advantages, WS_2-based FET performance remains constrained when employing conventional SiO_2 gate dielectrics, which exhibit a high density of oxide trap states, resulting in charge trapping, increased leakage current, and reduced carrier mobility. To overcome these limitations, high-k polymer based dielectric material of polyvinylidene-trifluoroethylene P(VDF-TrFE) is useful as a gate-insulating layer and can provide an ultrahigh local electrostatic field in the semiconductor channel. The ultrahigh field not only enhances the modulation of the channel but also changes the energy gap of the channel. The few layer WS_2 nanosheets were obtained by liquid-phase exfoliation (LPE) prepared in an organic solvent and subsequently used for transistor device fabrication. The fabricated WS_2 FET showed nonlinear output responses for both dielectric configurations. The SiO_2-based WS_2 FET achieved a field-effect mobility (μFE) of ~14.3 cm^2/V·s and a current on/off (ION/IOFF) ratio of approximately ~103, reflecting the influence of interface-induced scattering and charge trapping mechanisms. Conversely, the WS_2/P(VDF-TrFE) FET demonstrated a substantially improved μFE of ~84.7 cm^2/V·s along with an elevated ION/IOFF ratio of ~106, along with diminished operating voltage and a superior subthreshold slope. These findings emphasize that the Polymer gate dielectrics significantly enhance the performance of 2D WS_2 FETs, leading to the advancement of versatile and energy-efficient device architectures.

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Green Synthesis of Titanium Dioxide Nanoparticles Using Soursop Leaf Extract for Enhanced Photocatalytic Performance

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This study presents an innovative and sustainable approach for synthesizing titanium dioxide (TiO_2) nanoparticles (NPs) using soursop (Annona muricata) leaf extract. The green synthesis method offers an eco-friendly alternative to conventional chemical routes. Structural characterization confirmed the formation of anatase-phase TiO_2 NPs with enhanced properties. The green-synthesized TiO_2 (GS–TiO_2) exhibited superior crystallinity, with an average crystallite size of 10.66 nm, compared to 9.40 nm for chemically synthesized TiO_2 (CS–TiO_2). Notably, GS–TiO_2 demonstrated improved photocatalytic activity, achieving 83% degradation of methylene blue (MB) under solar irradiation, outperforming CS–TiO_2 at 78%. Additionally, GS–TiO_2 showed faster degradation kinetics, with a half-life of 172.38 minutes versus 190.90 minutes for CS–TiO_2. The enhanced performance is attributed to phytochemicals in soursop extract acting as natural reducing and stabilizing agents, making the process both sustainable and efficient. These findings highlight green synthesis as a promising strategy for producing high-performance photocatalysts for environmental applications such as wastewater treatment.

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Nano Layer Shields: Advanced ZrO_2 and Al_2O_3 Coatings for Extreme Corrosion Resistance

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This research focuses on developing and evaluating **nano-layer polymer/metal oxide composite coatings** to enhance the corrosion resistance of 440C stainless steel in aggressive environments. Nano-scale coatings based on zirconium oxide (ZrO_2) and aluminum oxide (Al_2O_3) were deposited using an electrochemical technique and characterized through SEM, EDS, and electrochemical methods. Morphological analysis confirmed uniform nano-layer distribution and strong adhesion. Electrochemical studies, including potentiodynamic polarization and impedance spectroscopy, revealed significant improvement in corrosion resistance for coated samples compared to bare steel. In 1M NaCl solution, ZrO_2 nano-layer coatings reduced corrosion current density to 0.971 $\mu A/cm^2$, while Al_2O_3 coatings showed 2.692 $\mu A/cm^2$, compared to 3.537 $\mu A/cm^2$ for uncoated steel. Similarly, in acidic media, coated samples demonstrated enhanced stability, with impedance values indicating superior barrier properties. Weight-loss tests further validated the coatings' effectiveness, showing negligible material degradation in saline and marine environments. These findings confirm that nano-layer metal oxide coatings substantially improve the durability of 440C stainless steel, making them promising candidates for marine and industrial applications. Future work will focus on incorporating polymer matrices to further enhance mechanical and anticorrosive performance.

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Process Optimization of Cs_2CuBr_4 bulk needle like crystals to Thin Films via Anti-solvent and Thermal Engineering

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Lead-free metal halide perovskites are promising for sustainable next-generation optoelectronic applications, but their practical use requires thermal stability, controlled physical properties and large surface area. This can be achieved by their thin films. In this work, we report the synthesis of Cs_2CuBr_4 bulk single crystals of sizes 1-3 mm through a chemical route and their transformation into thin films by solution-based spin-coated and vacuum-based thermal evaporation approaches. The synthesis and deposition parameters of the black needle-like crystals and thin films are tuned to enhance their thermal stability, crystallinity and photoconductivity. The simulated single crystal and experimental powder X-ray diffraction pattern analysis reveal the presence of an orthorhombic crystal structure of Cs_2CuBr_4. The presence of localized microstructural discontinuities acts as scattering centers for charge carriers, which improves the photoconductivity. The thin films fabricated with thermal evaporation showed better structural integrity, surface morphology and enhanced electrical responses under dark and illuminated conditions in comparison to those of spin-coated thin films. The photocurrent response underscores the potential of Cs_2CuBr_4 thin films for solar energy conversion, while conductivity modulation under external perturbations indicates promise for photo-assisted gas sensing. This work establishes a controlled route for fabricating high-quality lead-free metal halide perovskite Cs_2CuBr_4 thin films for sustainable optoelectronic devices.

Keywords: Hexagonal microstructure, Thermal stability, Anti-solvent, Thermal evaporation, Thin film, Perovskite compound.

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Electrochemical Conversion of (M)ethanol to Value added product: Leveraging 3*d*-Metal Based Pincer Electrocatalysts

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Fuel cell technologies, especially direct alcohol-based fuel cells (DAFCs) have recently emerged as excellent energy conversion devices and portable power generators having high power density and low emissions of harmful pollutants.[1] To increase the efficiency of DAFCs and produce industrially valuable products with an economically feasible approach, anodic half-cell reaction was carried out. For this purpose, a variety of inexpensive and earth abundant non-noble metal based electrocatalysts were examined in this work. With the use of Ni/Co/Cr based *bis*(iminopyridine) pincer complexes of the type (^{R2}NNN) MCl_2L (M = Ni, Co and Cr; R = ^{i}Pr, Cy and Ph; L = CH_3CN when M = Ni) and their corresponding base metal salts solubilized homogeneously in an alkaline (6 M NaOH) electrolyte and carbon-based electrode assembly, high current densities along with the formation of commercially viable sodium carbonate was achieved. Under an optimized reaction condition incorporating $CoCl_2.6H_2O$ (10 mM) as the best electrocatalyst, the electro-oxidation of bio-mass derived methanol [5 M] and ethanol [5 M] led to generation of current densities as high as 522.5 ± 13.5 $mAcm^{-2}$ at 1.4 V *Vs* Ag/AgCl and 209 ± 25 $mAcm^{-2}$ at 1.34 V *Vs* Ag/AgCl respectively.[2] In addition to high catalytic activity, molecular catalysts have certain limitations accompanied with them, which can be financially distressing at an industrial level and thus requires plausible alternatives. Through precise alternations of the *bis*(iminopyridine) pincer moieties and introducing heterogeneity on treatment with banana leaf extract (reducing and capping agent), pyridine 2,6-dicarbaldehyde linked Ni/Co/Cr oxide nanomaterials were fabricated. A fine tuning of the structural moieties greatly enhanced the efficiency of Ni/Co/Cr oxide pincer nanomaterials for electro-oxidation of alcohols to give current densities as high as 260.06 ± 3.06 mA cm^{-2} for methanol electro-oxidation and 235.03 ± 4.03 mA cm^{-2} for ethanol electro-oxidation at r.t on using (^{iPr2}NNN)$CoCl_2$ NPs as the optimised catalyst.[3] Regardless of the alcohol or the electrocatalyst used, both the homogeneous molecular electrocatalysts as well as their heterogenised versions were efficient enough to completely oxidise alcohols to CO_2 which was gratifyingly trapped as sodium carbonate with yield as high as 97% with $CoCl_2.6H_2O$ (10 mM) and 98.31% with (^{iPr2}NNN) $CoCl_2$ NPs (2 mM). Co being the most active metal both as a salt ($CoCl_2.6H_2O$) and as Co_3O_4 nanoparticles linked to pyridine 2,6-dicarbaldehyde, electro-oxidises to form cobalt(III) oxyhydroxide (CoOOH) which acts as an active catalyst for oxidizing alcohols to the corresponding CO_2 (trapped as sodium carbonate). This methodology not only demonstrates the potential of using earth-abundant metals in energy production through a sustainable alternative for fuel cell applications but also reduces any environmental impact through successful trapping of CO_2 as valuable sodium carbonates.

Doctor’s Bio-sketch

Dr. Jyoutishman Saikia

Assistant Professor, Department of Surgical Oncology, AIIMS, Delhi, India

Dr. Jyoutishman Saikia is an Assistant Professor of Surgical Oncology at the National Cancer Institute (NCI), All India Institute of Medical Sciences (AIIMS), New Delhi. He is a high-volume cancer surgeon with clinical expertise in breast, thoracic, and gastrointestinal oncology, and a strong translational research focus on technology-enabled cancer care. His work integrates surgery with nanotechnology, biomedical engineering, and artificial intelligence to address challenges in tumor localization, intraoperativeprecision, minimally invasive cancer therapy, and early diagnostics.

Dr. Saikia collaborates extensively with leading engineering institutes including IIT Guwahati and IIT Delhi, working on nano-engineered tumor markers, guided tumor localization systems, GMR-based biosensors for rapid oncogene detection, and VR/AI-based surgical planning tools. He has authored multiple scientific papers, contributes to national multi-centre cancer research initiatives, and is actively involved in developing indigenous, cost-effective technologies for improving cancer outcomes in India. Hisoverarching goal is to bridge clinical needs with engineering innovation to advance next-generation cancer care.

Dr. Sridhar Sivasubbu

Senior Consultant, Vishwanath Cancer Care Foundation, India

Dr. Sridhar Sivasubbu, PhD
Scientist, Passionate about improving human health by unlocking the power of the genome.
Senior Consultant, Vishwanath Cancer Care Foundation, India
Adjunct Professor, Gangwal School of Medical Sciences & Technology, IIT Kanpur
Adjunct Professor, Dr. DY Patil Medical College, Hospital & Research Center, Pune
Chief Scientist (Ex), CSIR-Institute of Genomics and Integrative Biology, Delhi, India
Email: sridhar.sivasubbu[at]gmail.com

- Dr Sivasubbu’s research interests are focused on sequencing human genomes for adoption and benefit in healthcare. He has led flagship programs including the first whole human genome sequencing initiative in India, which was then scaled up to India’s first 1000 whole human genomes encompassing representative ethnic groups.
- Dr. Sivasubbu team led the first global field testing for the Illumina developed **COVIDSeq assay on SARS-CoV2** clinical samples. He also led international collaborative human genomics initiatives aimed at understanding the Asian genome diversity through sequencing of the first human genomes from Malaysia and Sri Lanka.
- Dr. Sivasubbu and Dr Vinod Scaria co-founded a clinical collaborative network - Genomics for Understanding Rare Disease: India Alliance Network (GUaRDIAN), which is **one of the largest precision medicines eco-systems in India working on rare genetic diseases.**
- The success of this work became the basis for adoption of COVIDSeq in over 210 countries for genomic surveillance of SARS-CoV2.
- His team’s work on developing “accelerated genome sequencing” on bench-top NGS platforms was adopted by WHO-SEARO for genome surveillance of SARS-CoV2.
- Dr. Sivasubbu served as the chief scientific officer of The Center for Genomic Application. He served as the Head of “Genomics and Molecular Medicine Unit” and the Head of “Business Development” at CSIR-IGIB.
- Dr. Sivasubbu has contributed richly to the research field by publishing over 161 internationally peer reviewed articles.

Dr. Manda Venkata Sasidhar

Chief Scientific Officer
Apollo Hospitals Research Foundation (AHERF), Hyderabad, Telangana, India

CSO, Apollo Hospitals Research Foundation (AHERF)
Founder, Urvogelbio
President, Indian Extracellular Vesicles Society
Neuro-diagnostics & Exosome Innovation
AD & PD Research Leader

- Working as a **Chief Scientific Officer at Apollo Hospital Educational and Research Foundation** (AHERF), with a team of scientists and clinicians in advancing research and innovation in exosome biology and extracellular vesicles.
- Mission is to develop **novel diagnostic and therapeutic solutions** for neurodegenerative diseases, such as **Alzheimer's and Parkinson's**, using cutting-edge exosome engineering techniques.
- **Founder of Urvogelbio**, a biotech startup that specializes in exosome-based diagnostics and therapies.
- **Founder president** of the **Indian Extracellular Vesicles Society**, a platform for fostering collaboration and innovation in this vital field.
- With over 15 years of experience in this field, I hold a Professional Certification in Biomarkers (PCB) and a PhD in Pharmaceutical Biotechnology from Heinrich Heine University, Düsseldorf.
- **Author** of over **25 influential peer-reviewed publications**, I strive to communicate science to diverse audiences and bridge the gap between academia, industry, and society.
- An avid **mentor and educator, supporting emerging scientists and entrepreneurs** through various initiatives and programs.

Mr. Nitin Sisodia

Biodesign Fellowship Director, AIIMS, New Delhi, Delhi, India

Mr. Nitin Sisodia, Co-founder, CEO
Presidential National Award for Innovation, MedTech Founder, Biodesign Fellowship Director- AIIMS

Nitin is a 2010 Stanford India Bio-design fellow and founder of Sohum. He is passionate about ideas at the intersection of technology, business and design. He has designed several products with various national and international companies and successfully helped them launch their products in the market. Nitin has a graduate degree in electrical engineering from National Institute of Technology, Bhopal and a Post-Graduate degree in design from National Institute of Design, Ahmedabad. Nitin is named ‘innovator under 35′ 2013 from MIT tech review.

Mr. Nandish Pethani

Principal Advisor, Health Policy Research, Tata Memorial Centre, Mumbai (Grant-in-Aid Institution of Dept. of Atomic Energy, Govt. of India) & Chief Mentor, Policy Resilience Foundation (PRF)

Dr. Nandish R. Pethani serves as the Principal Advisor for Health Policy Research at the Tata Memorial Centre, Mumbai, a grant-in-aid institution under the Department of Atomic Energy, Government of India. He is also the Chief Mentor at the Policy Resilience Foundation (PRF), a policy research think tank headquartered in Ahmedabad, Gujarat.

He has been involved in global collaborations in healthcare, deep tech, global security, and climate-change resilience policy implementation, research, and advocacy. In his previous role, he served as an Advisor (Projects & Planning) to the Union Minister of Health and Family Welfare, Government of India.

He is an avid professional skydiver and an Ironman 70.3 finisher. His work involves continuous engagement as an evolving policy researcher and advocate, collaborating with multilateral agencies. His focus on policy implementation and health research drives his contributions toward strengthening health systems.

Dr. Areendam Barua

Chief, Department of Surgical Oncology and Robotic Surgery,
Swagat Super Speciality Surgical Institute and NH – Guwahati

- **Dr. Areendam Barua, r**ecognized as the **first robotic surgical oncologist** in **Eastern and Northeastern India**, credited with establishing the region's first robotic surgical oncology program at Swagat Hospital, Guwahati.

- **Eastern India's First Remote Robotic Surgery (September 2025) - On-site surgical team lead for historic telerobotic surgery achievement.**

- Senior Robotic Surgical Oncologist with over 6 years of post MCh experience pioneering advanced laparoscopic and robotic surgical solutions in oncology.

- Spearheaded a hospital-wide quality improvement initiative that lowered surgical complications by **15%**, optimizing **patient safety, satisfaction, and operational efficiency**.

- Proficient in complex robotic and laparoscopic procedures, having **performed 100+ surgeries** for **colorectal, pelvic, gastric, and esophageal cancers**.

- Committed to advancing surgical education, mentoring residents and fostering teams to deliver evidence-based, patient-centric care.

- **Passionate** about **translational research, surgical innovation, and integrating emerging technologies—including AI and data analytics—to refine robotic systems and enhance precision in oncologic surgery.**

- Advocate for **interdisciplinary collaboration to bridge gaps between basic sciences, technology, and clinical practice, driving forward a vision of autonomous, computer-aided surgical advancements.**

Dr Sajal Sen

Chief Operating Officer, Assam Govt-IIT G Healthcare Foundation

Dr. Sajal Sen is a healthcare leader currently serving as the Chief Operating Officer of the Assam Government–IIT G Healthcare Foundation, where he is involved in establishing one of the largest Health Tech Hubs within an IIT campus. He holds a Masters in Hospital Administration from the All-India Institute of Medical Sciences (AIIMS), New Delhi, a Master’s in Management Sciences from Osmania University, and an MBBS from Ravi Shankar University, Raipur. His professional development includes the Strategic Leadership Development Program at IIM Bangalore, a Certificate Course in Advanced Work-Study Management from the Institute of Technology Management Mussoorie, a Diploma in Information Technology from C-DAC, and training in Clinical Tropical Medicine in Bangkok as well as Program Evaluation and Monitoring at the Indian Institute of Public Health. Dr. Sen has authored 28 publications in peer-reviewed journals and serves as a guest faculty member in several reputed institutions.

He previously held several senior leadership roles, including COO of the Assam Cancer Care Foundation, where he led a pioneering statewide cancer care initiative resulting in the commissioning of seven world-class cancer hospitals in April 2022, ensuring affordable and accessible care across Assam. His earlier appointments include Chief Operating Officer of Apollo Hospital Bilaspur—a 300-bed multi-super-specialty cardio-cancer tertiary care center—and Apollo Ispat Post Graduate Superspeciality Hospital; Vice President at Columbia Asia Hospitals; COO at IPE Global Ltd for healthcare consulting in India and abroad; and Senior Advisor (Health) at Ernst & Young. His key interests span healthcare delivery, affordable healthcare models, and infectious and neglected diseases. Dr. Sen has worked extensively on consulting assignments in Bangladesh, Afghanistan, Sri Lanka, Tanzania, Kenya, and Ethiopia, and previously served as Director of HR & Legal for the Armed Forces Medical Services from 1999 to 2009.

Dr. Satyaki Saikia

Senior Consultant, Department of Internal Medicine and Infectious Diseases
Apollo-Excelcare Hospital

- **Dr Satyaki Saikia** is a well-known General Physician currently associated with Apollo Excelcare Hospital, Paschim Boragaon.

- He has 31 years of experience in Internal Medicine and worked as an expert General Physician in different cities of India.

- Dr. Satyaki Saikia has contributed to handling numerous complex medical cases in several hospitals. He is known for his attention to accurate diagnosis and for treating patients empathetically.

- The speciality interests of Dr Satyaki are **Acute illness, Chronic disease, Preventive care and Metabolic disorders.**

- Dr Satyaki Saikia did his MBBS from the University of Guwahati in 1994. He also completed his MD in Internal Medicine.

- He has also participated in research work and various workshops under the Internal medicine department and published many papers.

Prof. Ashok K Puranik

Executive Director, AIIMS Guwahati.

- Before joining AIIMS Guwahati, **Prof. Puranik** was heading the **Department of General Surgery**, as well as super-specialty **Departments of Trauma & Emergency, Gastro-intestinal Surgery, and Plastic Surgery at AIIMS Jodhpur**.

- The specialization of Dr. Puranik includes **acute care surgeries, trauma and surgical critical care, laparoscopic surgeries including laparoscopic inguinal, femoral incision, hernia repair, laparoscopic cholecystectomy, appendectomy and laparoscopic colorectal surgery**.

- Prof. Puranik is an **alumnus** of the renowned **Pt. Jawahar Lal Nehru Memorial Medical College, Raipur.**

- He was commissioned in the **Indian Army** as a **Medical Officer** in 1985.

- Later, in 1992, he completed his post-graduation in **Surgery** from the **prestigious Armed Forces Medical College, Pune.**

- Dr. Ashok Puranik has more than 50 publications.

- Dr. Ashok Puranik is an internationally **acclaimed author, popular keynote speaker, futurist, and a strategic business & technology advisor to governments and companies**.

Dr. Subash Chandra Gupta

Professor and Head of the Department of Biochemistry at AIIMS Guwahati

Dr. Subash Chandra Gupta, Professor and Head of the Department of Biochemistry at AIIMS Guwahati, is an accomplished cancer biologist whose research has substantially advanced the understanding of inflammatory signaling pathways in cancer development. He earned his Ph.D. in Biochemistry from IITR (CSIR) Lucknow and the University of Lucknow in 2008, following his M.Sc. in Biochemistry from the University of Lucknow in 2001. Dr. Gupta's current work focuses on the role of long non-coding RNAs in the diagnosis and prognosis of multiple cancers—including breast, head-and-neck, gallbladder cancer, and glioblastoma—as well as deciphering how the acidic tumor microenvironment drives cancer progression. With more than 120 peer-reviewed publications in high-impact journals, over 30,000 citations, an h-index of 68, an i10-index of 116, and an impressive cumulative impact factor exceeding 816, Dr. Gupta stands out as a leading researcher in molecular oncology.

Dr. Satyajit Mohapatra

Head of the Department of Pharmacology at AIIMS Guwahati

Dr. Satyajit Mohapatra is a distinguished pharmacologist with over 20 years of academic, clinical trial, and research leadership experience, currently serving as the Head of the Department of Pharmacology at AIIMS Guwahati. He previously held key roles at SRM Medical College Hospital & Research Centre, including Professor of Pharmacology and Director of the Centre for Clinical Trials and Research. Trained in clinical research at Harvard Medical School and holding an M.D. in Pharmacology along with an MBBS from MKCG Medical College, Dr. Mohapatra has led numerous national and global Phase I–III clinical trials, particularly in vaccines and infectious diseases, and has secured major funding from ICMR, BIRAC, and other agencies. His work has resulted in impactful publications—including several in The Lancet, Lancet Infectious Diseases, and other reputed journals—and has earned him multiple prestigious awards such as the Best Researcher Award, the Bharat Ratna Mother Teresa Gold Medal, and several institutional honors for high-impact publications. A committed educator and clinical researcher, he continues to contribute to pharmacology, vaccine development, pharmacovigilance, and medical education while actively engaging as a speaker at national and international forums.

Panelist’s Bio-sketch

Dr. Sandip Patil

Founder Director, ESpin Nanotech Pvt. Ltd., Uttar Pradesh, India

Dr. Sandip Patil is an entrepreneur, technologist, philanthropist, and motivational speaker. A PhD in Chemical Engineering from IIT Kanpur with 13+ years of research experience, he founded E-Spin Nanotech Pvt. Ltd. in 2010. His work in nanotechnology has led to widely covered scientific publications (including CNN, Mint, and The Wall Street Journal) and multiple national and international patents. He is known for pioneering reusable, innovative antibacterial/viral SWASA-N95 nanofiber masks during COVID-19 crisis. Under his leadership, E-Spin earned DSIR recognition and achieved several key milestones. Dr. Patil has received numerous awards for his contributions in the field of both science and entrepreneurship, and is also actively involved in social initiatives through IIT Kanpur's Unnat Bharat Abhiyan.

Mr. Ankit Chowdhury

Co-Founder and Chief Operating Officer at Primary Healthtech Pvt Ltd (Mobilab)

Mr. Ankit Chowdhury is the Co-Founder and Chief Operating Officer at Primary Healthtech Pvt Ltd (Mobilab), a health-tech startup specialising in accessible and affordable diagnostic solutions. He holds a Bachelor's degree in Design from the Indian Institute of Technology Guwahati, where he blended human-centered design with innovation strategy. Ankit has played a key role in scaling Mobilab's operations and fostering strategic partnerships across the healthcare ecosystem. Prior to this, he worked in marketing and corporate relations at Alcheringa, IIT Guwahati, where he contributed to brand engagement and stakeholder outreach. His professional interests include healthcare innovation, operational leadership, and expanding access to point-of-care diagnostics globally.

Mr. Amit Mishra

Head - Startup & VC Relations, Yotta Data Services Private Limited, Bengaluru, Karnataka, India

With over 19 years of experience at the intersection of entrepreneurship, technology, and venture capital, Amit Mishra is a seasoned connector and ecosystem enabler. He currently heads Startup & VC Relations at Yotta, India's leading cloud infrastructure company, home to the country's largest GPU infrastructure and a key partner in the IndiaAI Mission. Yotta is also among the few NVIDIA reference architecture partners in Asia, empowering AI-first startups with unparalleled compute power. Before Yotta, Amit led Product GTM initiatives at Jio Platforms, collaborating with internal and external teams to scale multiple products. As Co-founder & General Partner at 3to1 Capital, he backed founders committed to building transformational businesses, especially in emerging markets like India.

Amit has played a critical role in enabling India market entry for global companies such as F6S and Sansan, and advises government bodies on startup policies and innovation frameworks. He has been featured as a TEDx speaker and has contributed strategically to popular startup reality TV shows in India. He is always up for meeting interesting folks and enjoys traveling, playing strategy games, and writing poetry in his leisure time.

With deep relationships across VCs, accelerators, and policy-makers, Amit helps AI startups sharpen their branding, refine GTM strategies, and unlock growth opportunities. He holds advanced training from Harvard Business School, a degree in Economics from Panjab University, and additional certification in Digital Marketing from IAMAI.

Dr. Swapnil Sinha

Chief Executive Officer, BioNEST IIT Guwahati

Dr. Swapnil Sinha is the CEO of BioNEST IIT Guwahati, where she leads one of India's fastest-growing biotech innovation ecosystems. She holds a Ph.D. in Life Sciences from Jawaharlal Nehru University, where her research focused on single nucleotide polymorphisms associated with Plasmodium falciparum malaria susceptibility in the Indian population.

She has over a decade of international research experience, including postdoctoral work at the Institut de Recherches Cliniques de Montréal (IRCM), Canada, and Colorado State University, USA, in gene regulation, chromatin biology, and cardiovascular disease pathways. Before joining IIT Guwahati, she served as Principal Scientist at NIPER-Guwahati and Associate Professor at Assam down town University. Dr. Sinha is also the founder of Altanostics Labs Pvt. Ltd. (formerly BioAptagen), a diagnostics startup developing DNA-based aptasensors. At BioNEST IITG, she has mobilized over ₹25 crore in ecosystem funding and mentored more than 80 early-stage biotech founders. Her work focuses on enabling deep-tech entrepreneurship, strengthening academia–industry collaboration, and translating scientific discoveries into scalable, real-world solutions.

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