International Conference on

Petroleum, Hydrogen and Decarbonization

Indian Institute of Technology Guwahati

03-05 November 2023

ABSTRACT BOOK
ICPHD 2023

Organized by

Department of Chemical Engineering, IIT Guwahati

IIT Guwahati SPE Student Chapter

International Conference on Petroleum, Hydrogen & Decarbonization

IIT Guwahati | 03-05 November 2023

Indian Institute of Technology Guwahati SPE Student Chapter

Event Schedule

	Time	S	Hall-II						Poster Session-I	Hall-I						Hall-III	Hall-IV
Day 1- 3rd Nov 2023	08:00-09:00	Breakfast & Registration															
	09:00-11:30	S-01	Inaugural	PL-01	PL-02												
	11:30-12:00	High Tea Break															
	12:00:-13:30	S-02	PL-03	KL-01	KL-02	KL-03											
	13:30-14:30	Lunch Break															
	14:30-16:00	S-03	KL-04	KL-05	KL-06	KL-07											
	16:00-16:30	Tea Break															
	16:30-18:00	S-04	IL-01	IL-02	IL-03	IL-04	IL-05			S-05	IL-06	IL-07	IL-08	IL-09	IL-10		
	18:30-19:30	Cultural Program at Mini Auditorium															
	19:30-21:30	Gala Dinner															
Day 2- 4th Nov 2023	08:00-09:00	Breakfast															
	09:00-11:00	S-06	PL-04	KL-08	KL-09	KL-10				S-07	IITG-TIC Event					S-08	IITG-TIC Event		
	11:00-11:30	High Tea Break															
	11:30-13:00	S-09	KL-11	OP-01	OP-02	OP-03	OP-04	OP-05	OP-06	S-10	KL-12	OP-07	OP-08	OP-09	OP-10	OP-11	OP-12	S-11	KL-13	OP-13	OP-14	OP-15	OP-16	OP-17	OP-18	S-12	KL-14	OP-19	OP-20	OP-21	OP-22	OP-23	OP-24
	13:00-14:00	Lunch Break																															
	14:00-16:00	S-13	PL-05	KL-15	ST-1	ST-2	ST-3																										
	16:00-17:30	Tea Break																															
	16:30-18:00	S-14	KL-16	OP-25	OP-26	OP-27	OP-28	OP-29	OP-30	S-15	KL-17	OP-31	OP-32	OP-33	OP-34	OP-35	OP-36	S-16	KL-18	OP-37	OP-38	OP-39	OP-40	OP-41	OP-42	S-17	KL-19	OP-43	OP-44	OP-45	OP-46	OP-47	OP-48
	18:30-19:30	Cultural Program at Auditorium (SPICMACAY event)																															
	19:30-21:30	Dinner																															
Day 3- 5th Nov 2023	08:00-09:00	Breakfast																															
	09:00-11:00	S-18	KL-20	OP-49	OP-50	OP-51	OP-52	OP-53	OP-54	S-19	KL-21	OP-55	OP-56	OP-57	OP-58	OP-59	OP-60	S-20	KL-22	OP-61	OP-62	OP-63	OP-64	OP-65	OP-66	S-21	IL-11	OP-67	OP-68	OP-69	OP-70	OP-71	OP-72
	11:00-11:30	Tea Break																															
	11:30-13:00	S-22	Panel Discussion							S-23	OP-73	OP-74	OP-75	OP-76	OP-77	OP-78		S-24	OP-79	OP-80	OP-81	OP-82	OP-83	OP-84	OP-85									
	13:00-14:00	Lunch Break																															
	14:00- 16:00	S-25	PL-06	Valedictory																													

S-Session | PL- Planery Lecture | KL- Keynote Lecture | IL- Invited Lecture | OP- Oral Presentation | TIC - Technology Incubation Centre | ST- Stall

International Conference on
Petroleum, Hydrogen and Decarbonization (ICPHD 2023)

Indian Institute of Technology Guwahati | 03-05 November 2023

ABSTRACT BOOK

Organized by:
Department of Chemical Engineering
&
IIT Guwahati SPE Student Chapter
Indian Institute of Technology Guwahati
Guwahati-781039, Assam, India

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भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

Dr. Parameswar Krishnan Iyer
Officiating Director, IIT Guwahati

20 October 2023

Message from the Patron

I am highly delighted for the conduct of the International Conference on Petroleum, Hydrogen and Decarbonisation 2023 (ICPHD-2023) during November 3 to 5, 2023 at IIT Guwahati. Organized by the Department of Chemical Engineering along with the student chapter of Society for Petroleum Engineers (SPE) of IIT Guwahati, the conference title certainly reflects upon the advocation of interdisciplinary and transdisciplinary research and educational frameworks in both conventional and novel energy resources and their interface. Thereby, it will serve as a pivotal entity for rapid advances in scientific and technological sectors and their smart integration and application for the betterment of sustainability and energy efficiency in the oil, gas and related renewable energy sectors.

Conferences such as ICPHD-2023 will stimulate the growing emphasis to amalgamate the diversified thinking patterns of fundamental and applied science, technology and management. Accordingly, the conference needs to delve deep into the core research strategies that shall be focussed in petroleum, hydrogen and decarbonization segments. Thereby, it shall strive towards the affirming of translational ideas for the Indian energy industry. In this regard, the conference can draw great strengths from the peripheral domains to supplement the core topics of interest as such domains are highly sensitive to influence the sustainability and profitability of Indian oil and gas industry and relevant sustainable resources.

I wish that the conference organizers encourage one and all participating in the conference be it post docs, doctoral students, professors, scientists, entrepreneurs, managers etc. to engage in much needed strategies for the customized resolution of issues and challenges in the context of our country's needs and ambitions.

I wish a grand success to organizers of the ICPHD-2023 conference.

Dr. Parameswar Krishnan Iyer
Officiating Director,
Professor, Department of Chemistry
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भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
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रसायन अभियांत्रिकी विभाग
DEPARTMENT OF CHEMICAL ENGINEERING

Dr. Kaustubha Mohanty
Professor & Head

Message from the Chair

I am delighted to extend my warmest greetings to all of you attending the *International Conference on Petroleum, Hydrogen, and Decarbonization (ICPHD) 2023* being held at Indian Institute of Technology Guwahati. As the Chair of this event, it is my honor to welcome you to this gathering of brilliant minds, innovative ideas, and groundbreaking research. The Department of Chemical Engineering at IIT Guwahati is at the forefront of research in traditional petroleum engineering, green hydrogen generation, and carbon capture, storage and utilization. ICPHD 2023 is an effort in the pursuit of these objectives of the department. ICPHD 2023 aims to bring together experts from diverse fields to discuss the latest advancements in petroleum, hydrogen, and decarbonization technologies. In the face of pressing global challenges, your contributions and insights are invaluable in shaping the future of the energy industry. By sharing your knowledge, experiences, and findings, you are playing a crucial role in driving sustainable practices and fostering a greener planet. As we embark on this exciting journey of knowledge exchange and discovery, I wish you all fruitful discussions, innovative insights, and lasting connections. Together, let us explore new horizons, challenge existing paradigms, and pave the way for a more sustainable and decarbonized future.

(Kaustubha Mohanty)

Chair, ICPHD 2023

भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
रसायन अभियांत्रिकी विभाग
गुवाहाटी-781039, असम, भारत

Indian Institute Technology Guwahati
Department of Chemical Engineering
Guwahati-781039, Assam, India

Dr. Anugrah Singh
Professor, Department of Chemical Engineering

Message from the Co-Chair

The International Conference on Petroleum, Hydrogen, and Decarbonization (ICPHD 2023) is being organized with an aim to bring together scientists, academicians and industry professionals under one roof to interact and discuss the recent advances in the petroleum engineering and the pathways towards energy transition, hydrogen energy and decarbonisation. I extend a hearty welcome to all the participants visiting IIT Guwahati to attend the conference. Our goal is to involve major stakeholders of energy sector leading to a reliable, economically viable, and sustainable energy future. I hope that this event will provide a stimulating forum for discussions, professional networking, research collaboration, interdisciplinary education and dissemination of the most recent scientific advances to the participants.

(Anugrah Singh)
Co-Chair, ICPHD 2023

International Conference on
Petroleum, Hydrogen and Decarbonization (ICPHD 2023)
Indian Institute of Technology Guwahati
3-5 November, 2023

Message from the Conveners Desk

It is with immense pleasure and pride for us to convene the conference. We extend a warm welcome to all the participants of the International Conference on Petroleum, Hydrogen, and Decarbonization (ICPHD) 2023. The ICPHD 2023 is being organized by the Department of Chemical Engineering, IIT Guwahati in association with SPE Students Chapter IIT Guwahati from 3rd Nov-5th Nov 2023. The petroleum industry has been the lifeblood of our global energy infrastructure for decades. However, in this era of environmental consciousness and the imperative to combat climate change, we find ourselves standing at a critical juncture. The petroleum, hydrogen and decarbonization topics are highly overlapped and need coordinated multidisciplinary efforts. The transition from petroleum to hydrogen goes through the path of Decarbonization. The challenges and opportunities we face today require us to think innovatively, adapt swiftly, and work collectively to address the critical issues of our time.

ICPHD 2023 has a comprehensive agenda that covers a broad spectrum of topics, from the latest advancements in exploration and production to the challenges and innovations in environmental sustainability in the realm of energy transition. Throughout this conference, the participants will have the privilege of engaging with experts, thought leaders, and visionaries who will share their insights and experiences. Our collective goal is to foster an environment of learning, collaboration, and knowledge-sharing. It is an opportunity to connect with peers, challenge existing paradigms, and envision a brighter future for our industry. With different sessions and presentations, the conference delves into diverse topics, from traditional petroleum engineering to decarbonization. It offers comprehensive coverage of industry-relevant subjects, catering to both public curiosity and industry interests, including advancements in hydrogen generation, carbon capturing and storage, data analytics, artificial intelligence etc. We encourage you all to actively participate, ask questions, and share your insights. The success of the conference is measured not only by the quality of presentations but by the depth of discussions and the connections we make.

We extend our heartfelt appreciation to our distinguished speakers, advisory committee members, local organizing committee, enthusiastic team of volunteers, supportive sponsors, and each participant who has contributed to making this conference a reality. Your passion and commitment are truly commendable. May we leave here with a deeper understanding of our industry, a broader network of colleagues and friends, and a renewed commitment to making the sector more sustainable, responsible, and resilient.

!! Thank You!!

Prof. Pankaj Tiwari
Convener

Prof. Sumit Kumar
Co-Convener

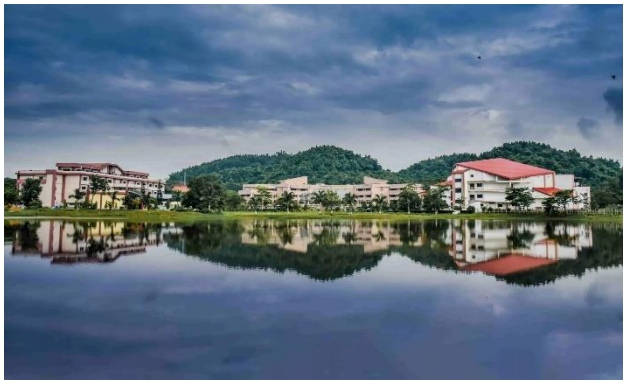
Prof. Abhijit Kakati
Co-Convener

About IIT Guwahati

Indian Institute of Technology Guwahati, the sixth member of the IIT fraternity, was established in 1994. The academic programme of IIT Guwahati commenced in 1995. At present the Institute has eleven departments, seven inter-disciplinary academic centres and five schools covering all the major engineering, science, healthcare, management and humanities disciplines, offering B.Tech., B.Des., M.A., M.Des., M.Tech., MS(R), M.Sc., MBA and Ph.D. programmes. Within a short period of time, IIT Guwahati has been able to build up world class infrastructure for carrying out advanced research and has been equipped with state-of-the-art scientific and engineering instruments. Besides its laurels in teaching and research, IIT Guwahati has been able to fulfil the aspirations of people of the North East region to a great extent since its inception in 1994. Indian Institute of Technology Guwahati's campus is on a sprawling 285 hectares plot of land on the north bank of the river Brahmaputra around 20 kms from the heart of the city. With the majestic Brahmaputra on one side, and with hills and vast open spaces on others, the campus provides an ideal setting for learning.

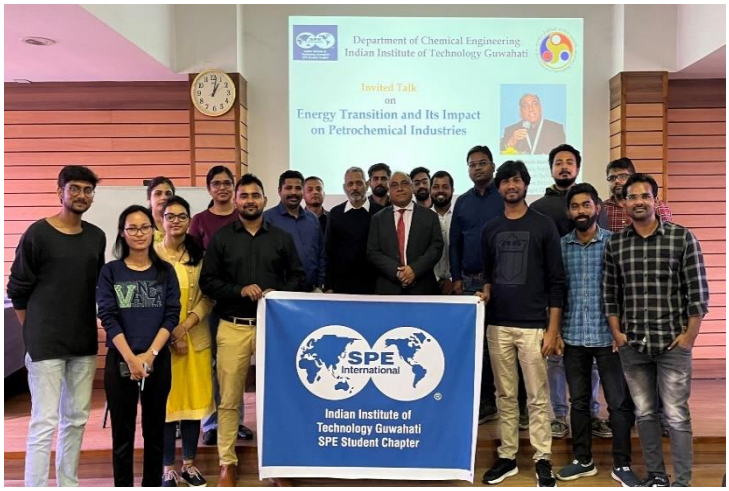
IIT Guwahati is the only academic institution in India that occupied a place among the top 100 world universities – under 50 years of age – ranked by the London-based Times Higher Education (THE) in the year 2014 and continues to maintain its superior position even today in various International Rankings. IIT Guwahati ranked 41 globally in the ‘Research Citations per Faculty’ category and overall 384 rank in the QS World University Rankings 2023. IIT Guwahati ranked 7th in Engineering, 9th in Overall & Research institute of the country in the ‘India Rankings 2023’ by the National Institutional Ranking Framework (NIRF), Union Ministry of Education, India. IIT Guwahati has been also ranked 2nd in the ‘Swachhata Ranking’ conducted by the Govt. of India. Recently, IIT Guwahati has been ranked as the top-ranked University in 2019 for IT developers by Hacker Rank in the Asia-Pacific region.

About Department of Chemical Engineering



The Department of Chemical Engineering at IIT Guwahati started functioning in 2002 with the initiation of an undergraduate program (Bachelor of Technology) in Chemical Engineering. Currently, the department offers masters as well as doctoral degrees in chemical engineering. The master’s program in chemical engineering is offered in three different specializations, namely, (1) Petroleum Science and Technology (PST), (2) Material Science and Technology (MST) and (3) Computer Aided Process Engineering. In addition, an international joint M. Tech degree in Food Science and Technology is offered jointly with GIFU University, Japan. The Department has very strong research profile with faculty members engaged fundamental and translational research in conventional as well as interdisciplinary domains ranging from separation processes, transport processes, chemical reaction engineering, nanotechnology with applications in energy, water and environment, enhanced oil recovry, carbon capture storage and utilization, flow through porous media etc . The Department has state-of-the-art research facilities established through funding from various Government Agencies as well as Industry.

About IIT Guwahati SPE Student Chapter



The IIT Guwahati SPE Student Chapter was founded in 2016 with a vision to fulfil the mission of SPE International - "To collect, disseminate, and exchange technical knowledge regarding exploration, development and production of Oil & Gas resources, and related technologies for the public benefit and to provide opportunities for students & professionals to enhance their technical and professional's expertise. We aim to foster an environment that nurtures talent, sparks creativity and encourages students to take up exciting careers in the oil and gas industry. It hopes to bridge the gap between industry and academia through a series of events, competitions and industrial visits. IIT Guwahati SPE Student Chapter will always strive to improve the quality of petroleum engineering education not just within the institute but also in the whole of north-east India. IIT Guwahati SPE Student Chapter was re-established in 2022 and conducted workshop, symposium, and invited talk in recent year.

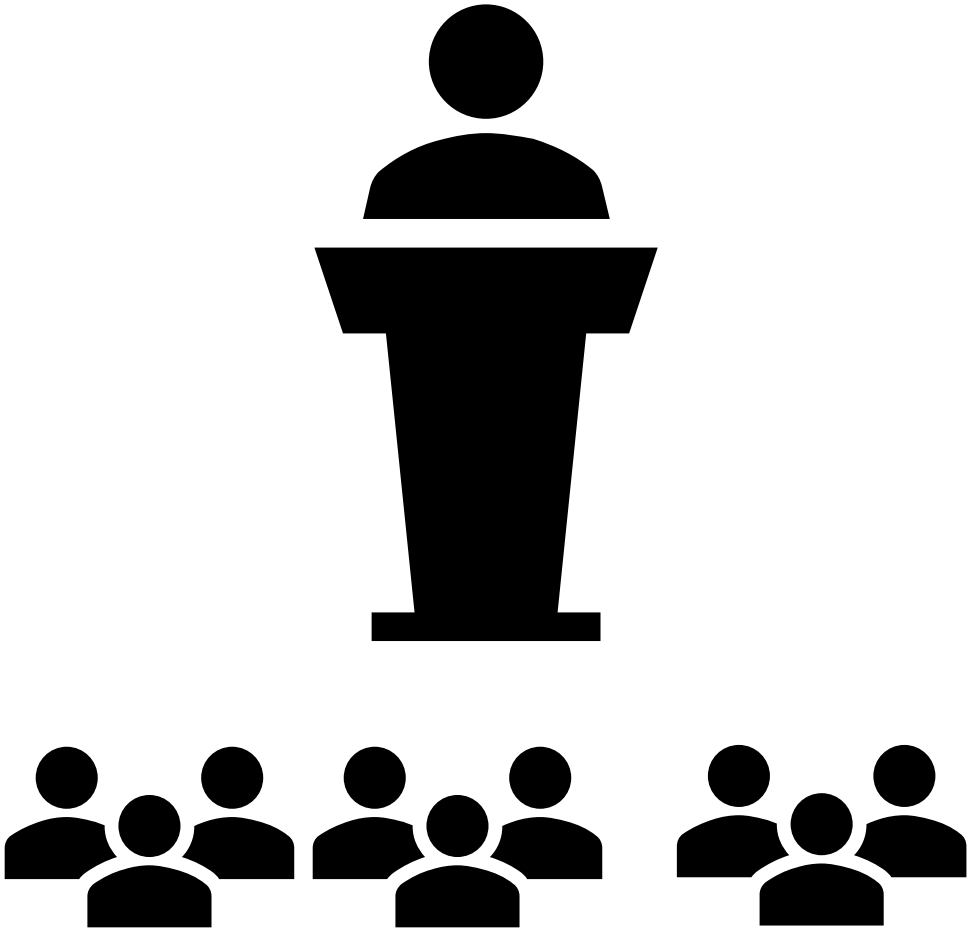
Welcome to ICPHD 2023

Sustainable and economic energy resources are the primary need for energy security. Hydrogen is a promising source of energy while petroleum dominates the present energy basket. The path of energy transition need to be in the frame of decarbonisation to meet stringent environmental regulations. With this aim, an International Conference on Petroleum, Hydrogen and Decarbonisation (ICPHD) 2023 is being jointly organized by the Department of Chemical Engineering, IIT Guwahati and IIT Guwahati Society of Petroleum Engineers (SPE) Student Chapter. The ICPHD 2023 will bring together students, researchers, industry leaders, innovators and policy makers to discuss technology, policy and strategy needed for sustainable petroleum production and energy transition. The conference will feature renowned keynote speakers from academia, industry, and policymaking bodies, offering their expertise and insights into the conference themes along with panel discussions and exhibitions, and will provide ample opportunities for networking.

Conference Themes:

- Petroleum Exploration & Production
- Petroleum Reservoir Engineering
- Rock-Fluid Interaction
- Flow Through Porous Media
- Improved or Enhanced Oil Recovery (IOR/EOR)
- Data Analytics & Artificial Intelligence for Petroleum, Hydrogen & Decarbonization
- Hydrogen Generation or Production, Transportation, Storage & Usage
- Unconventional Hydrocarbon Resources
- Sustainable Formation Water Management

- Geo-Thermal & Geo-Energy Exploration & Exploitation
- Carbon Capture, Utilization & Storage
- Health Safety and Environment (HSE), Policy & Regulation
- Process Design & Engineering for Petroleum, Hydrogen & Decarbonization
- Corrosion management for Petroleum, Hydrogen & Decarbonization



PLENARY LECTURES | ICPHD 2023

List of Plenary Lectures

Conference ID	Title and Authors
Inaugural Session	09:00-11:00 Day1, 3rd Nov, 2023
PL-01	Emerging Trends in Sustainable Carbon Management: An Approach Towards Net Zero Carbon *Prof. K K Pant*
PL-02	Energy Transition: Hype, Reality and Possibilities. What do we do with Oil and Gas? Are they still Relevant? Is CO_2 sequestration for Enhanced Oil and Gas Recovery a Viable Option? *Prof. Hemanta Sarma*
Session-02	11:30-13:30 Day1, 3rd Nov, 2023
PL-03 12:00-12:40	Hydrogen Production in 3D-Printed Micro Electrolyzer *Prof. Suddhasatwa Basu*
Session-06	09:00-11:00 Day2, 4th Nov, 2023
PL-04 09:00-09:40	The Net Zero Goal & Sustainability: Green Hydrogen Technologies, CO_2 refineries, Biomass Valorization & Waste Plastic Recycling *Prof. Ganapati D. Yadav*
Session-13	14:00-16:00 Day2, 4th Nov, 2023
PL-05 14:00-14:40	Machine Learning for Subsurface Energy Resource Management: Example State-of-Art Applications and Future Prognosis *Prof. Srikanta Mishra*
Session-25	14:00-16:00 Day3, 5th Nov, 2023
PL-06 14:30-15:10	Hidden Hydrogen: The New Frontier *Prof. Shalivahan*

Prof. K K Pant
Director, Indian Institute of Technology Roorkee
Uttarakhand- 247667, India

Speaker Profile

Professor K. K. Pant is currently serving as the Director at IIT Roorkee (on deputation), following his previous role as the Dean of Faculty at IIT Delhi. He holds the esteemed position of Petrotech (FIPI) Chair Professor and also serves as Adjunct Faculty at the University of Saskatchewan in Canada, Joint Faculty at CRDT IIT Delhi, and Honorary Faculty at the University of Queensland in Australia. His research encompasses catalysis and reaction engineering, with specific expertise in coal to methanol conversion, e-waste and plastic management, hydrogen generation, CO_2 capture and conversion, biomass valorization, among others. Prof. Pant's outstanding contributions to the field of chemical engineering have earned him recognition worldwide. With over 30 years of academic and industrial research experience, he has published more than 240 papers, over 13,361 citations and achieving an impressive h-index of 60 and an i10-index of 182. Additionally, he holds numerous patents and has successfully completed over 50 high-impact projects.

Prof. Pant has also been conferred twice with the prestigious Gandhian Young Technological Innovation (GYTI) award, besides several other honors such as CHEMCON distinguished speaker award, Herdilia Award by Indian Institute of Chemical Engineers, thrice with Dr. A V Rama Rao award for best Ph.D. supervision, Dr. S. S. Deshpande Award, etc. He has also been conferred fellowships from several national and international academies such as Royal Society of Chemistry, London (FRSC, London), National Academy of Science India, (NASI), Indian National Academy of Engineering (INAE), Biotech Research Society of India (BRSI), Institution of Engineers India (FIE(I)), Indian Institute of Chemical Engineers (FIIChE), Fellow of Indian Desalination Association (InDA), etc. which are testimonial of his expertise in basic research and remarkable position in the scientific community.

Title of the Talk

PL-01: Emerging Trends in Sustainable Carbon Management: An Approach Towards Net Zero Carbon

India is the third highest energy related CO_2 emitter country in the world. There has been a surge of global interest towards CO_2 utilization via CO_2 rich syngas/pure CO_2 to produce fuels such as methanol, dimethyl ether and chemicals. However, the conversion technologies for CO_2 using thermo-catalysis, photocatalysis are still in their nascent stages, hindered with poor product yields and challenging process economics. Major scientific advances, especially in catalyst development for sustainable CO_2 management and process scale-up, are needed for their implementation.

With this aim, a comprehensive summary of the recent research hotspots, related to value-added products including methanol/dimethyl ether (DME) and other C^{2+} oxygenates has been presented. An overview of fundamental science regarding thermos-catalysis is provided with special emphasis on high entropy materials/aerogels, porous/core shell structured materials, single atom catalysis and associated factors affecting CO_2 capture and utilisation. Through critical discussion about above mentioned factors, major shortcomings and their remedial strategies, this talk discusses unique design criteria, specific catalytic features and potentials opportunities for different products. Finally, the way forward for CO_2 capture and conversion considering the challenges and opportunities in the development of emerging materials has been addressed.

These approaches can work parallelly on different goals in a nexus and can be well aligned with sustainable goals such as affordable and clean energy and climate actions. Advancement in these areas would be helpful in potentially utilizing CO_2 from industrial sectors such as cement, steel, and iron. Overall, such strategies will also provide a real foundation for sustainable solutions.

Keywords: Sustainable; Carbon management; Net zero; Thermo-catalysis; Clean energy.

Prof. Hemanta Sarma
Professor, Department of Chemical and Petroleum Engineering
Schulich School of Engineering
University of Calgary, Calgary, Alberta , Canada

Speaker Profile

Dr. Hemanta Sarma is a Professor of Oil and Gas Engineering at the University of Calgary where his research activities pertain to EOR processes, reservoir engineering and CO_2 sequestration in petroleum reservoirs and coal beds. An Honorary Member of the SPE and the American Institute of Mining, Metallurgical, and Petroleum Engineers since 2020, he has worked internationally in Canada, Japan, Australia, UAE and India in academia, R&D and industry. As the research project leader for CO_2 sequestration through enhanced petroleum recovery and enhanced coal-bed methane recovery, he was among the proponents of the CO2CRC, a major Australian Cooperative Research Centre for Greenhouse Gas Technologies. Currently he serves as the Western Hemisphere Director in the SPE CCUS Committee, as a member of three SPE international award committees, and as the International External Advisor for petroleum engineering department at the UTP, Malaysia.

Title of the Talk

PL-02: Energy Transition: Hype, Reality and Possibilities. What do we do with Oil and Gas? Are they still Relevant? Is CO_2 sequestration for Enhanced Oil and Gas Recovery a Viable Option?

This presentation will be centered around a broad overview of certain contemporary issues pertinent to energy transition -- a much talked about topic today, its impact on the oil and gas sector and potential of using the depleted petroleum reservoirs, with a special emphasis of Assam's ageing oilfields. Parallel to our efforts towards the energy transition, we possibly cannot abandon out oil and gas sector in the short term; it will still remain an important source in the energy mix.
The aim of this presentation will be to deliberately provoke a lively follow-up interactive question-answer and brainstorming session to take cognizance of the key issues on the ground: reality, limitations and the way forward. A case will be made for viability and need of the oil and gas sector to cater India's energy needs as a dominant contributor, and how our efforts could be strategized to optimally harness this energy source with due compliance with environmental rules and needs. The feasibility of sequestering green-house gases (CO_2, in particular) into depleted (and mature) petroleum reservoirs and coal seams in Assam while producing oil and gas from them will be discussed and the possible key challenges in CO_2 sequestration in them will be highlighted.

Keywords: CO_2 Sequestration; Energy transition; Enhanced oil recovery; Reserves and resources; Sustainability.

Prof. Suddhasatwa Basu
Professor, Department of Chemical Engineering
Indian Institute of Technology Delhi
New Delhi-110016, India

Speaker Profile

Prof. Suddhasatwa Basu completed Ph.D./MS in Chemical Engineering from Indian Institute of Science, Bangalore, and B.Tech. (Chem. Eng) from Calcutta University. He holds Federation of Indian Petroleum Industry Chair Professor on Clean Energy at the Department of Chemical Engineering, IIT Delhi. Earlier, He was the Director of CSIR-Institute of Minerals & Materials Technology, Bhubaneswar and the Director of Central Institute Mining & Fuel Research, Dhanbad. He has vast work experience on development of materials for energy conversion and storage devices – H_2 & Fuel Cells and Battery, electrofuels, magnetic materials, wastes to wealth technologies for circular economy. He has published more than 260 articles in high impact journals with H-index 46, 14 patents and 2 technologies transferred to various industries. He is a Fellow of National Academy of Science of India, Indian National Academy of Engineering, Royal Society of Chemistry UK and received Herdillia Award, Dr A. V. Rama Rao Foundation's Research Award, SMC Gold Medal, MSRI Medal. He is Editor/Assoc Editor/Ed Board member of several international journals published by Willey, Springer, Oxford University Press and Am Chemical Soc.

Title of the Talk

PL-03: Hydrogen Production in 3D-Printed Micro Electrolyzer

Hydrogen as an energy vector is bringing tremendous scope in near future due to reduced environmental impact and efficient energy transformation. In the first part of the presentation, we will discuss about the policy and strategy for hydrogen technologies. Membrane-less microfluidic reactors for water electrolysis can serve as a disruptive technology for the sustainable production of hydrogen utilizing excess electricity from intermittent renewable energy sources. The state-of-art water electrolyzer is condensed to a single chip by exploiting the benefits of microfluidics. The components required in a conventional electrolyzer, for instance, flow plates, liquid/gas diffusion layer, and membranes, is eliminated by downsizing to the micron scale. A 3d-printing technique is used for the fabrication of the microchannels and non-noble microelectrodes. The microfluidic electrolyzer (µE) is membrane-less and demonstrated flexibility in operation concerning the choice of pH. The µE is characterized by a low Reynolds number and a high Peclet number, which implies laminar flow and negligible diffusion of species by dissolution across the microelectrodes. The membrane-less µE is operated in both acidic and alkaline pH. Improvement in the kinetics of water splitting is attained by using an asymmetric electrolyte configuration (acidic catholyte and alkaline anolyte). However, in either acidic or alkaline electrolyte, it is possible to use µE with micro fuel cell in tandem. The water splitting enhancement is attributed to the excess energy from electrochemical neutralization arising from the pH difference. The current density comparable to the conventional electrolyzer can be achieved by using ~ 12 µE with 25% less manufacturing cost owing to fewer components. A fluid dynamic approach by optimizing the electrolyte flow rate was implemented to achieve the separation of H_2 and O_2 in the membrane-less configuration. The crossover of gas products across the microelectrodes is negligible, as confirmed by gas chromatography. The membrane-less µE exhibited potential as a disruptive future technology for low-cost sustainable generation of H_2 and O_2.

Keywords: Electrochemical neutralization; Micro hydrogen generation; Micro fuel cell; Tandem operation.

Prof. Ganapati D. Yadav
National Science Chair (GOI), Emeritus Professor of Eminence
Institute of Chemical Technology
Mumbai - 400019, India

Speaker Profile

Professor Ganapati D. Yadav is one of the topmost, highly prolific, and accomplished engineering-scientists in India. He currently the National Science Chair and Emeritus Professor of Eminence and is a former Vice Chancellor, ICT, Mumbai. He has personally won over 150 national and international honours, awards, fellowships, editorships by prestigious organizations. Prof. Yadav was conferred Padma Shri Award by the President of India in 2016. He was inducted as the Fellow of the United States National Academy of Inventors in 2023 and happens to be the only second Indian to get this prestigious and rare honour. Professor Yadav is the inventor of 123 patents and his recent work on green hydrogen production from water splitting with cost of hydrogen of less than a dollar, carbon dioxide valorisation into fuels and chemicals such as methanol, dimethyl ether, methane and higher hydrocarbons, and waste biomass into 14 different value-added chemicals has caught the attention of the world. He is an elected fellow of national academies and US Academy of Engineering, TWAS. He has guided 110 Ph.Ds., 147 M. Techs. & 48 Post-docs and published 551 papers

Title of the Talk

PL-04: The Net Zero Goal & Sustainability: Green Hydrogen Technologies, CO_2 refineries, Biomass Valorization & Waste Plastic Recycling

The net zero goal by 2050 is a cherished dream of all world economies. In achieving the 49000 TWh of energy by 2050 will have 73% of its contribution from renewables. In that hydrogen will have a share of 25%. The new trinity for science will be solar, wind and hydrogen. The leading economies of the world should go for production of green hydrogen in pursuit of the Net Zero goal of the Paris Agreement of 2015. Hydrogen is best suited for converting any biomass and carbon dioxide emanated from different sources, into fuels and chemicals. Hydrogen will also lead, on its own as energy source, to the carbon negative scenario in conjunction with other renewable non-carbon sources such as solar, wind, tidal, geothermal, nuclear or the like. Hydrogenation of biomass leads to many valuable products. So, tomorrow's refineries will be literally carbon dioxide refineries- converting it into hydrocarbons, methanol, dimethyl ether (DME), formic acid, alcohols, syn gas, electricity, hydrogen vehicles, fuel cells, ammonia, and fertilizers, etc. using hydrogen which should be obtained from water splitting. DME is the best replacement for diesel and LPG and the same infrastructure could be utilized. That will lead to carbon-negative economy bringing down the temperature of the globe below 1.5 °C. Today's crude oil-based economy for the manufacture of fuels, chemicals and materials will not have a sustainable future. Faced with the twin challenges of sustaining socioeconomic development and shrinking the environmental footprint of chemicals and fuels manufacturing, a major emphasis is on either converting biomass into low-value, high-volume biofuels or refining it into a wide spectrum of products. Using carbon for fuel is a flawed approach and unlikely to achieve any nation's socioeconomic or environmental targets. In controlling CO_2 emissions, hydrogen will play a critical role. Hydrogen is best suited for converting waste biomass and carbon dioxide emanated from different sources, whether fossil or biomass into fuels and chemicals as well as it will also lead, on its own as energy source, to the carbon negative scenario in conjunction with other renewable non-carbon sources. This new paradigm for production of fuels and chemicals not only offers the greatest monetization potential for biomass and shale gas, but it could also scale down output and improve the atom and energy economies of oil refineries. There is also a need to rethink on the ban on single use plastic (SUP) and a new policy is required to encourage general public to pay a deposit on every single article irrespective of size and get it refunded when it is returned which will allow segregation at source. Several hydrogenation reactions can be used to depolymerize or to make fuels from waste plastic and the nasty atoms in the plastic such as Cl, S, N can be converted into HCl, H_2S and NH_3 and absorbed. Waste plastic is a great source of fuel and chemicals.

Keywords: Biomass; Carbon dioxide; Hydrogen; Net Zero; Plastic chemical recycling.

Prof. Srikanta Mishra
Research Professor, Texas A&M University, USA

Speaker Profile

Dr. Srikanta Mishra is A Research Professor at Texas A&M University, where he specializes in subsurface data analytics and energy transition related applied research and teaching. He also serves as Honorary Faculty in the Department of Chemical Engineering at IIT Guwahati. He is the recipient of the SPE 2022 International Award for Data Science & Engineering Analytics, the SPE 2021 Distinguished Member Award, and the IIT(ISM) Dhanbad 2022 Distinguished Alumnus Award for Research & Academic Excellence. He is the author/editor of 4 books and ~250 technical publications. He holds degrees in Petroleum Engineering from Stanford University (PhD), The University of Texas at Austin (MS), and IIT(ISM) Dhanbad (B.Tech).

Title of the Talk

PL-05: Machine Learning for Subsurface Energy Resource Management: Example State-of-Art Applications and Future Prognosis

Data-driven models that are built using machine learning (ML) algorithms are becoming increasingly common place in subsurface energy related domains such as oil and gas development and geologic carbon sequestration. The impetus for adopting this emerging technology comes from its success in multiple fields such as consumer marketing, finance, design and manufacturing, health care, etc. ML methods are particularly well suited for capturing hidden patterns and complex input-output relationships automatically from large multivariate datasets without specifying an a priori functional model form. The use of ML is especially attractive for characterizing, describing, and forecasting the behavior of subsurface systems where typical data analysis challenges include: (a) incomplete and/or sparse data, (b) unreliable and/or immature physics-based models (if they exist), and (c) application of data-driven models using conventional statistical methods that are not robust.

The goal of this paper is to provide an overview of ML applications for subsurface energy resource management via representative state-of-art examples along with a look to the future. It begins with discussion of a model-building and validation framework (and thought process) for extracting insights from data and making robust predictions, rather than concentrating on the mechanics of model fitting. This is followed by examples from multiple areas of subsurface science and engineering specific application such as: (a) reservoir characterization, (b) drilling operations, (c) production data analysis,

(d) reservoir modeling, and (e) predictive maintenance. Next, the paper discusses several over-arching challenges and roadblocks associated with the previously summarized ML applications, i.e., (a) data acquisition, generation, and filtering, (b) ML model building and generalization, and (c) model deployment and stakeholder engagement. The paper ends with some predictions about possible outcomes and advances in ML-based subsurface data analytics.

Keywords: Data-driven modeling; Future prognosis; Machine learning; State-of-art; Subsurface applications.

Prof. Shalivahan
Director, Indian Institute of Petroleum and Energy
Visakhapatnam, Andhra Pradesh-530003, India

Speaker Profile

Prof Shalivahan, is presently the Director, Indian Institute of Petroleum and Energy, Visakhapatnam. He is also a professor at Indian Institute of Technology (IIT-ISM) Dhanbad. He was the Deputy Director and Dean of Research and Development at IIT-ISM Dhanbad. He is in the field of geophysics with research interest in swarm intelligence, petrophysics, mineral exploration and tectonics etc. He has published numerous research papers in national and international journals, conferences and book chapters. Prof. Salivahan has owned several awards such as: National Geoscience Award 2010 by Ministry of Mine, Government of India, Outstanding Educator Award 2020 by Society of Exploration Geophysicists, USA and INSA Best Teacher Award 2021.

Title of the Talk

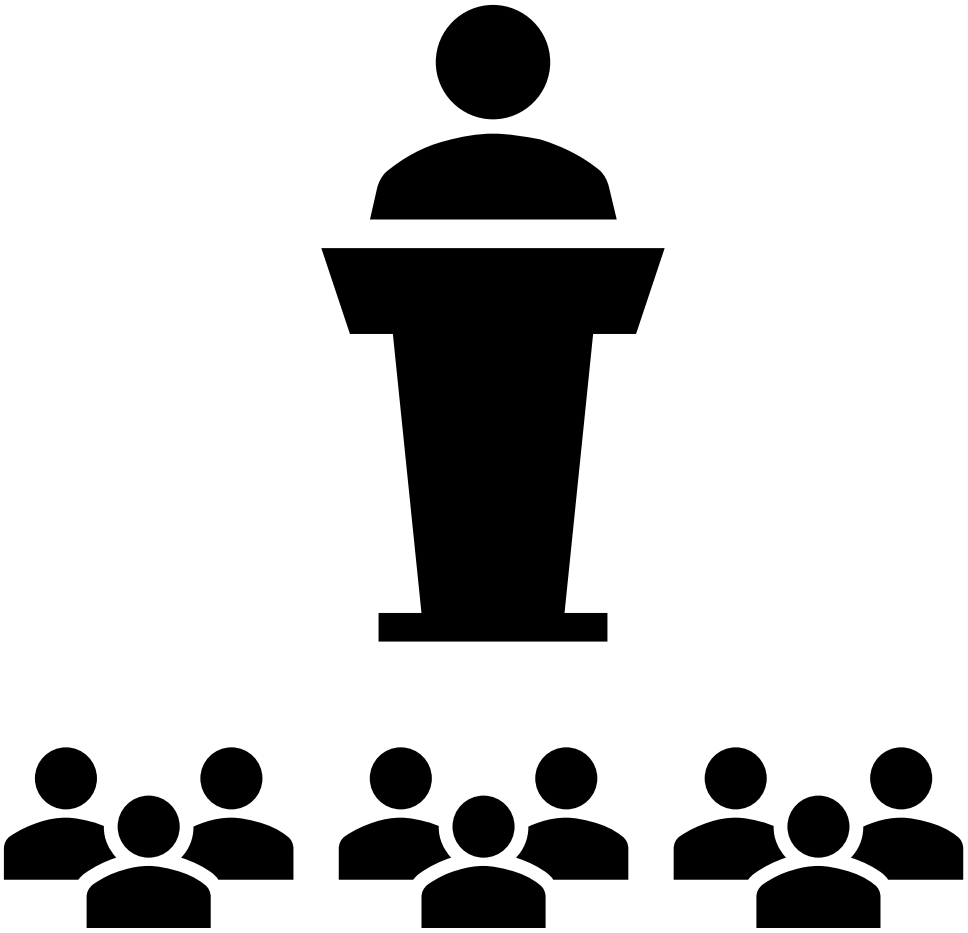
PL-06: Hidden Hydrogen: The New Frontier

Hydrogen shows promise as a low-carbon fuel. Current debate centers on whether green hydrogen will compete with blue hydrogen and the carbon is captured and stored, or grey hydrogen generated from natural gas, without carbon capture. However, one promising source – naturally occurring or geological hydrogen – has largely been overlooked because it was assumed rare or too difficult to extract.

If natural hydrogen can be exploited economically, it would remove the need for clean water, which is used during green hydrogen electrolysis, and eliminate the need for expensive Carbon Capture and Storage (CCS) associated with blue hydrogen. Natural hydrogen is observed in many different geological environments, including rifts, back-arc basins, intra-cratonic basins, cratonic areas (usually Precambrian in age), within Banded Iron Formations or mineralised zones and ore deposits, mid-ocean ridges, and orogenic settings. Natural hydrogen is often found in association with brines that also contain helium, carbon dioxide, nitrogen and methane. Some key processes for hydrogen production include: (a) deep hydration and radiolysis of water associated with the radioactive decay of uranium, thorium and potassium-bearing minerals; (b) oxidation of ferrous to ferric iron and mineral hydration, for example, during the serpentinization of olivine (e.g. ophiolites); (c) decomposition in metamorphic areas; (d) very late organic matter maturation; and (e) primordial hydrogen originating from Earth's core and mantle. Hydrogen is viewed as a seep, which can be tapped and produced, the also possibly being trapped in the sub-surface in a similar way to how oil and gas accumulate. Hydrogen trapping and storage in the sub-surface, at least temporarily, is an important component of the future hydrogen storage business. Natural hydrogen is periodically replenished via migration of hydrogen through fractures and then the subsequent diffusion into a host rock. While there is a debate whether or not hydrogen is stored over geological timescales, salt or halite are recognised as viable sealing lithologies, and it is possible that igneous rocks could also work as seals. Clay-rich rocks could also act as barriers to hydrogen migration.

"Natural hydrogen has the potential to cause the biggest disruption to the global energy system in the coming decades". Time will surely tell! (Michael Webbar, ENGIE, France)

Keywords: Hydrogen system; Hydrogen terrains; Natural hydrogen.



KEYNOTE LECTURES | ICPHD 2023

List of Keynote Lectures

Conference ID	Title and Authors
Session-02	**12:00-13:30 Day1, 3rd Nov, 2023**
KL-01 12:40-13:00	Machine Learning and Big Data: It's Utility and Challenges *Rakesh Kumar Vij*
KL-02 13:00-13:20	CCUS-Plus: An integrated chemical looping platform for Clean Energy and CO_2 mitigation *M. Rafiqul Awal*
KL-03 13:20-13:40	Solving the Net Zero Equation *Baroruchi Mishra*
Session-03	**14:30-16:00 Day1, 3rd Nov, 2023**
KL-04 14:30-14:50	Success Story of Earliest Monetization of Oil & Gas Field – Future of Greater Recovery Using Technology from North Eastern Fields *K. K. Nayak*
KL-05 14:50-15:10	Bioinspired Technologies for Sustainable Petroleum Production from Depleted Reservoirs *Ramakrishna Sen*
KL-06 15:10-15:30	Nanoparticle-Enhanced Surfactant-Stabilized Nanoemulsions for Enhanced Oil Recovery *Avantika Kaushik; Ajay Mandal*
KL-07 15:30-15:50	Atmospheric and Vacuum Distillation Curves of Shale Oil Compared with TGA Weight Loss Data *Omar S. AlAyed, Oliver Jarvik, Hamza Hmidat*
Session-06	**09:00-11:00 Day2, 4th Nov, 2023**
KL-08 09:40-10:00	Hydrogen geo-storage: an overview and new insights *Stefan Iglauer*
KL-09 10:00-10:20	Fischer-Tropsch Reaction Over Kmofe/Cnts Nano-Structured Catalyst in A Fixed Bed Reactor: Reaction Mechanism and Kinetic Study *Ajay K. Dalai*
KL-10 10:20-10:40	Recent developments in the application of microfluidic in oil and gas industry *Prem Bikkina, Sushobhan Pradhan, Imran Shaik, Rupom Bhattacherjee, Ayush Joshi*
Session-09	**11:30-13:00 Day2, 4th Nov, 2023**
KL-11 11:30-11:50	Capillary Driven flow in Heterogeneous Porous media *Shabina Ashraf, Jyoti Phirani*
Session-10	**11:30-13:00 Day2, 4th Nov, 2023**
KL-12 11:30-11:50	Assimilation of Dynamic Data into Subsurface Reservoir Models Using a Model Selection Approach *Sanjay Srinivasan*
Session-11	**11:30-13:00 Day2, 4th Nov, 2023**
KL-13 11:30-11:50	Compact Membrane Reformer for On-Site Hydrogen Production: A Technical Prospect toward Commercialization *Rajesh K Upadhayay*
Session-12	**11:30-13:00 Day2, 4th Nov, 2023**
KL-14 13:30-13:50	Microbial Stimulation: An Emerging Technology for Enhancing Coalbed Methane Recovery *Keka Ojha, Suman Saini*
Session-13	**14:00-16:00 Day2, 4th Nov, 2023**
KL-15 15:10-15:20	Current trends in the Russian oil and gas industry during the period of decarbonization of global energy *Alexandra Saitova, Alexander Iliynsky*
Session-14	**16:30-18:00 Day2, 4th Nov, 2023**
KL-16 16:30-16:50	Empowering Chemical Engineering for a Net Zero Process Industry *Kevin Van Geem*
Session-15	**16:30-18:00 Day2, 4th Nov, 2023**

KL-17 16:30-16:50	Carbon neutrality through combined CO_2 capture and novel H_2 technology with production of non-conventional fuels *Subrata Borgohain Gogoi*
Session-16	**16:30-18:00** **Day2, 4th Nov, 2023**
KL-18 16:30-16:50	CO_2 Sequestration as Hydrate in Subsea Conditions *Yogendra Kumar, Jitendra Sangwai*
Session-17	**16:30-18:00** **Day2, 4th Nov, 2023**
KL-19 16:30-16:50	Optofluidic Devices for the Conversion of Solar Energy to Green Hydrogen *Nageswara Rao Peela*
Session-18	**09:00-11:00** **Day3, 5th Nov, 2023**
KL-20 09:00-09:20	Machine Learning Applications for Safe and Sustainable Energy Transition *Prof. Mayank Tyagi*
Session-19	**09:00-11:00** **Day3, 5th Nov, 2023**
KL-21 09:20-9:40	Reducing Carbon Footprint of Plastics Via Lignocellulosic Fibers-Based Composite Materials Design *Rameshwar Adhikari*
Session-20	**09:00-11:00** **Day3, 5th Nov, 2023**
KL-22 09:00-09:20	Data analytics and machine learning for oil and gas exploration and production optimization *Sunil Kumar Khare*

Prof. Rakesh Kumar Vij
Adjunct Professor, Department of Petroleum Engineering, School of Energy Technology
PDEU, Gandhinagar- 382 007

Speaker Profile

Dr. Vij currently an adjunct professor at the Department of Petroleum Engineering, School of Energy Technology, PDEU, Gandhinagar is dynamic professional and well recognized leader with 44 years of experience in various facets of E & P industry mainly in exploration, exploitation and production management of oil and gas fields of India with specializations in reservoir engineering & management, Asset management, production engineering, water flooding and production optimization techniques. Also in the last 4 year, he served as Director of School of Petroleum Technology, where he facilitated the development of Hydrogen & Bio-Diesel research. He was responsible for developing the first Geo-Cellular Model of Mumbai-High field, implementing first miscible EOR in Gandhar, Gujarat, and immiscible gas injection Enhanced Oil Recovery in Borholla, Assam. He has played a pivotal role in formulating development and redevelopment plan for 15 fields of onshore and offshore in ONGC. Dr. Vij has been awarded for his various accomplishments in the organization, among others, Awards from Honorable President of India, Vice-President of India, and C&MD, ONGC are worth mentioning. He also received L. P. Mathur Memorial Lifetime Achievement Award for Contribution to Oil and Gas Sector of India.

After his superannuation from ONGC, Dr. Vij joined Pandit Deendayal Petroleum University (PDPU) as Director of the School of Petroleum Technology (SPT) in 2019. He was responsible in tailoring the academic courses of SPT, PDPU as per ongoing demands of the industry. Being highly respected professional for his industrial engagements, he is making significant efforts to strengthen the industry-academia relation.

Title of the Talk

KL-01: Machine Learning and Big Data: It's Utility and Challenges

Machine learning help us in real time decision making and increasing operational efficiency by learning from data. It helps us in predicting faults in equipment and prescribing suitable process to optimize the production of hydrocarbons. As oil business is having high inherent uncertainty, it is a need of an hour to find more and more insight from the data. In oil and gas, massive datasets impose a variety of challenges because traditional algorithms were not designed to meet such requirements. Big data enables ML algorithms to uncover more fine-grained patterns and make more timely and accurate predictions than ever before; on the other hand, it presents major challenges to ML such as model scalability and distributed computing. ML can be used in entire E&P life cycle. ML help us in classification and regression problem as well as clustering of unstructured data. Convolution neural network (CNN) can be used for rock and mineral classification from automation for live well drilling and maintaining the core repository. ML help us in optimizing production system by leveraging intelligent well completion and ensuring at most safety in hydrocarbon production. In our paper, we will discuss its utility and challenges in oil and gas.

Keywords: Big data; Machine learning; CNN; Digitalization; Intelligent well completion.

Prof. Rafiqul Awal
Founder Director, Yosef Geo-Energy Pvt. Ltd., Bangalore, IN.

Speaker Profile

Dr. Rafiqul Awal is a distinguished petroleum engineer and researcher known for his contributions to the field. He holds B.Tech degree in petroleum engineering from Indian Institute of Technology (ISM) Dhanbad, an MS degree from King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia, and a Ph.D. from University of Oklahoma, USA. He started his career as production engineer at ONGC and later worked at ConocoPhillips, USA as R&D engineers. He also worked as Kerr-McGee Professor of Petroleum Engineering, at Texas Tech University, USA, Research Professor at King Fahad University of Petroleum and Minerals, Saudi Arabia, Head and Professor of Chemical and Petroleum Engineering at American University of RAK, UAE. He is also a member of various professional societies such as SPE, EAGE, Dhahran Geological Society and · Saudi Environmental Society. He has authored several research papers in national and international journal of high repute and book chapters. He also has invented many technologies for oil and gas industry such as: Pulsed-power Plasma Shockwave Fracturing, · Time-lapse Gravity Drainage for Enhanced Oil Recovery, Super Hydrogen Technology for CCUS etc.

Title of the Talk

KL-02: CCUS-Plus: An Integrated Chemical Looping Platform for Clean Energy and CO_2 Mitigation

Since the advent of the Age of Petroleum circa 1870s, the industrial world has gradually shifted gear from coal to petroleum as the primal source of energy for automotive, shipping, power generation, fertilizer, and chemical resources. The negative environmental impacts have also snowballed from environmental pollution via spills, fugitive CH_4 and CO_2 emissions leading to climate change.

We propose a new concept, called the CCUS-Plus, as a robust pathway. This pathway uses the existing fossil power and industrial hydrogen infrastructure and hence entails minimal Capex, and can be deployed by 2030. It avoids the climate risk of CCUS Blue hydrogen, intrinsic in the CO_2 injection in geological structures.

The CCUS-Plus entails utilizing the CO_2 emitted above the green threshold 4 kg CO_2 per kg H_2, on an integrated thermochemical process engineering involving power generation and syngas production as feedstock for industrial chemical production. The integrated process engineering ring are: chemical looping in combustion, steam methane reforming and dry methane reforming. The CO_2 emission threshold is controlled via an innovation syngas feedback control.

Keywords: Carbon capture, utilization and storage (CCUS); Net zero; Biomass fuels; Super hydrogen.

Mr. Baroruchi Mishra
CEO, NET Enterprise Group

Speaker Profile

Baroruchi Mishra is techno-commercial leader with 32+ years of experience in Oil & Gas and New Energies sector. Dr. Mishra currently works as Partner and Group CEO of NET Enterprise Group of companies which provides Engineering (Front End and Detail Engineering) EPC, EPCM and PMC and Domain Consultancy services in Oil and Gas and Energy Transition Projects globally. He started in this role in Sept 2023 and would be based in Abu Dhabi. Before the above role, he worked with Shell as its Project Director for Growth and Transition Project for India. He has worked with BG Group as the Technical Director for BG Asia Pacific Ltd based in Bangkok and as Director for Projects and Operations for BG Exploration and Production India Ltd. based in Mumbai.

Title of the Talk

KL-3: Solving the Net Zero Equation

The net-zero equation remains unsolved – globally of course but more so for India where the actions thus far have mostly been around increasing the share of Renewable Energy (Wind and Solar) while the greenhouse gas emissions continue unabated . Our ecosystem is not currently geared up towards removals. So in summary while we are making efforts towards transitions, the removals have not yet started; Nature Based Solutions are of course naturally doing it to whatever degree they can. And yet the efforts towards Decarbonisation for India needs to consider the Energy Trilemma that India faces: 1.**Energy Security**: Ability to access reliable and modern energy sources. Heavy reliance on imports exposes India to oil shocks/ price volatilities.2.**Energy Equity**: All citizens have access to affordable, reliable and clean energy. 3.**Environmental Sustainability**: Need to reduce the energy related greenhouse gas emissions and other local pollutants. A structured approach will be needed and any vision and mission statement related to Transition, especially our Nationally Determined Contributions, will need to be backed by detailed resource loaded plans and schedules. Resolution of the Energy Trilemma has to be at the centre of it. This trilemma creates another dimension for body corporates as the returns on Transition Projects do not come close to that from development and production of fossil fuels. With 1.4 billion people, a disorderly and uncoordinated transition, done in fits and starts will impair access to energy for day-to-day use and would cause significant social unease, especially for those in the low income group; societal resistance to energy transition would be an immediate outcome of such a situation. And yet the transition cannot be delayed beyond a point as it would mean that we would have truly and completely baked in a breach of our ambition to get to Net Zero by 2070 and put at significant risk any chance that the rest of the globe has of meeting the Paris Goals of 1.5C.

A sector wise analysis (and recommendation) is the subject of this talk – majority of the Net Zero pathways, other than Wind and Solar, will be discussed while attempting to understand how (and how far) they would help India resolve its Energy Trilemma. In this context, 3Cs become key – Collective, Coordinated and Comprehensive actions – all with a clear visualization of what success would look like in that pathway,

Keywords: Decarbonisation up; Energy trilemma; Net zero equation; Net zero pathways.

Mr. K K Nayak
CEO, Kiri Group
Barmer, Rajasthan-344001, India

Speaker Profile

Mr. K K Nayak is the CEO of Kiri Group. He has transformed a struggling startup into a global energy giant. With a background in Energy engineering, he navigated challenges with innovation and strategic partnerships. His relentless drive, exceptional leadership, and customer-centric approach steered the company to unprecedented growth, expanding its market share and profitability. Adept at fostering a dynamic corporate culture, his legacy extends beyond financial success, inspiring a new generation of business leaders to push boundaries and create lasting impact.

Title of the Talk

KL-04: Sucess Story of Earliest Monetization of Oil & Gas Field – Future of Greater Recovery Using Technology from North Eastern Fields

The success story of the earliest monetization of oil and gas fields represents a pivotal moment in industrial history, marking the dawn of an era that shaped global energy dynamics. This abstract explores the evolution of this achievement and its future implications – Radial Drilling, EOR, Early monetization of site from scratch to production in just less than a month. The only possible reason is Proper Planning.

The early monetization of oil and gas fields emerged as a response to growing energy demands in the late 20th century. Pioneering entrepreneurs and engineers leveraged rudimentary drilling techniques to tap into vast underground reservoirs, revolutionizing the world's energy landscape. This success story underscores the transformative power of innovation and risk-taking in unlocking previously untapped resources.

Additionally, the abstract explores the contemporary implications of this triumph and its potential ramifications for future hydrocarbon recovery strategies. Fast-forward to the present, technology has catalyzed a new era of oil and gas recovery. Advanced seismic imaging, data analytics, and robotics have enabled precise reservoir characterization and optimized extraction techniques. As a result, the future of greater recovery is within reach, promising enhanced efficiency and sustainability. The synergy between technological advancements and sustainable practices heralds a promising trajectory for the industry, ensuring its resilience in an evolving global energy ecosystem. In conclusion, the earliest monetization of oil and gas fields laid the groundwork for an industry that continues to evolve through technological advancements. The journey from humble beginnings to cutting-edge recovery methods exemplifies the industry's ability to adapt, innovate, and contribute to the energy needs of the future.

Keywords: Future prospect of energy sector; IDS – Integrated drilling services; Lowest OPEX; Radial drilling; Surface facility upgradation.

Prof. Ramkrishna Sen
Professor, Dept. of Bio-Technology and Bio-Sciences
IIT Kharagpur, India

Speaker Profile

Dr. Ramkrishna Sen is a Professor and Former Head, Department of Biotechnology, IIT Kharagpur. He served as a Fulbright Visiting Professor in the Columbia University, New York, USA and as Manager (R&D-Biotech), Cadila Pharma Ltd., Ahmedabad. Prof. Sen has been engaged in R&D activities in the areas of Energy, Environment, Water and Healthcare, with a major focus on Bio-Process and Product Development in Microbial-and Microalgal Biorefinery models. His academic credentials are as follows: total publications ~ 225 with more than 12000 citations and h-index of 56; total patents: 14; PhD completed: 28; Projects completed: 30. Prof. Sen has also earned several academic accolades and awards.

Title of the Talk

KL-05: Bioinspired Technologies for Sustainable Petroleum Production from Depleted Reservoirs

The Paris Accord on Climate Change, a hallmark agreement that was signed by 180 odd countries in Paris during UNFCC in 2015, coupled with the mandates of the G-8. G-20 and BRICS countries including India revolved around a unanimous resolve to provide Governmental policy support and administrative boost to encourage scientific and industrial communities to develop more advanced, cost-effective and eco-friendly technologies not only for renewable energy resources, but also for enhanced petroleum recovery using bio-inspired green technologies like Microbial Enhanced Oil Recovery (MEOR). MEOR scores over other Chemical-EOR processes on two accounts. Firstly, the microbial cell factories need little input of energy to produce the MEOR agents and secondly, the application of microbial processes does not directly depend on the global crude oil price. In an *in situ* process, stimulation of the indigenous microflora by injecting suitable nutrients serves to enhance oil mobilization. The exponential nature of microbial growth facilitates the production of useful biochemical agents for MEOR at higher rates from inexpensive renewable resources. In this context, our study illustrated the efficacy of a biosurfactant-biopolymer driven MEOR process that was developed with the help of a partially simulated reservoir in the form of a packed sandstone column employing a judiciously designed bacterial consortium. This may lead to develop a model to assess the role of MEOR as a bioinspired technology for sustainable petroleum production from depleted reservoirs, while adequately addressing the energy-environment-water nexus.

Keywords: Bioinspired technology for petroleum recovery; Energy-environment-water perspective; Lab-scale bioprocess development; Microbial enhanced oil recovery (MEOR); MEOR agents; Mechanisms and modeling.

Prof. Ajay Mandal
Professor, Department of Petroleum Engineering,
IIT(ISM) Dhanbad, India

Speaker Profile

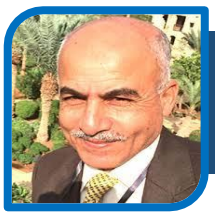
Dr. Ajay Mandal is a distinguished professor in the Department of Petroleum Engineering at Indian Institute of Technology (IIT-ISM), Dhanbad Dhanbad. He focuses his research on reservoir engineering and enhanced oil recovery, with over 220 research papers, books, and book chapters. Dr. Mandal has received accolades, including the 2015 SPE South Asia Regional Distinguished Achievement Award, the 2017 IIChE Award for Excellence in Oil/Gas Plant Design, and the 2019 SPE Reservoir Dynamics and Description Regional Award. He has collaborated globally, supervised 24 doctoral students, and serves on India's Ministry of Petroleum and Natural Gas Enhanced Recovery Screening committee.

Title of the Talk

KL-06: Nanoparticle-Enhanced Surfactant-Stabilized Nanoemulsions for Enhanced Oil Recovery

The present study deals with the development, characterization, and efficacy of nanoemulsions (NEs) as promising injection fluids for enhanced oil recovery (EOR). NEs possess several remarkable properties that make them a compelling choice for this purpose, including their ability to reduce interfacial tension, modify rock wettability, enhance the mobility ratio, achieve miscibility with trapped crude oil, and permeate and block pore spaces within reservoir rocks. In this examination, particular focus is placed on the formulation of NEs incorporating alumina (Al_2O_3) nanoparticle in conjunction with alpha-olefin sulfonate (AOS) surfactant, their subsequent characterization, and their performance in advancing the process of oil recovery. Dynamic light scattering (DLS) measurements were employed to determine the average droplet size in these emulsions. The results revealed an average droplet size of 192 nm for NEs stabilized solely by AOS surfactant, whereas NEs fortified with Al_2O_3 nanoparticles exhibited even smaller droplets, with an average size of 172 nm. The significance of this finding is that smaller droplets provide a larger interfacial area for oil displacement, which can enhance the oil recovery. Another key parameter in evaluating the stability and performance of NEs is their zeta potential (ζ). This parameter reflects the electrostatic charge at the interface of the droplets, and a higher negative zeta potential is indicative of enhanced kinetic stability. In this study, NEs stabilized with AOS surfactant exhibited a zeta potential of -60.2 mV, while those aided by Al_2O_3 nanoparticle achieved an even higher zeta potential of -63.4 mV. The superior kinetic stability of the latter holds substantial promise for their successful application in oil reservoirs. Furthermore, the phase behavior of these NEs was scrutinized to ascertain their stability and efficacy under reservoir conditions. It was observed that a stable middle-phase emulsion could be achieved with 0.75 wt. % surfactant concentration at an optimal salinity of 0.5 wt. % NaCl. Additionally, the interfacial tension (IFT) between decane and the nanoemulsion was analyzed. The IFT value was initially measured as 33.56 mN/m, which was notably reduced to 15.45 mN/m upon the introduction of nanoparticles into the nanoemulsion. Lower IFT values are particularly advantageous as they improve the capacity of the fluid to displace entrapped oil within the reservoir. Another remarkable attribute of these NEs is their capacity to influence the wettability of sandstone rock. The study demonstrated that the formulated NEs possess the capability to transform the rock's wettability from oil-wet to water-wet. This wettability alteration can play a pivotal role in enhancing the effectiveness of water-based recovery methods by promoting improved contact and displacement of oil from porous rock formations. Moreover, the miscibility of these NEs with crude oil and their impact on oil viscosity were examined. It was observed that the NEs exhibited commendable miscibility with crude oil, and their introduction led to a significant reduction in crude oil viscosity. This reduction in viscosity has significant implications.

Keywords: Enhanced oil recovery; Nanotechnology; Nanoemulsion; Wettability alteration; Chemical flooding.



Prof. Omar Al-Ayed
Professor, Dept. of Chemical Engineering
Al-Balqa Applied University, Jordan

Speaker Profile

Dr. Omar Al-Ayed is a Professor at the Department of Chemical Engineering, Faculty of Engineering Technology, Al-Balqa Applied University, Jordan. He holds B.Tech, M.Tech and Doctoral degree in Chemical Engineering from Indian Institute of Technology, Kanpur. He has served as Professor & Head of Chemical Engineering Department and Vice Dean of Scientific Research & Innovation at Al-Balqa Applied University. With a robust educational background and extensive research expertise, Dr. Al-Ayed has made significant contributions to the understanding of oil shale pyrolysis kinetics and retort design, as well as the cracking of vacuum gas oil and used lubricating oils. His research interests also include chemical kinetics and reaction engineering. He has chaired several prestigious conferences, including the Jordan International Chemical Engineering Conference in 2017 and the International Oil Shale Conference in 2023.

Title of the Talk

KL-07: Atmospheric and Vacuum Distillation Curves of Shale Oil Compared with TGA Weight Loss Data

Crude oil, Kukersite (Estonia) and Attarat (Jordan) shale oils are subjected to atmospheric and vacuum distillation. The volume percent distilled against vaporization temperature are generated in two intervals. The first interval from room temperature to 350 ^{o}C at 1 atmospheric pressure as recommended by researchers. The second interval is from 180 ^{o}C to 410 ^{o}C under 40 mm Hg vacuum pressure.

The existing relationship to extrapolate the vacuum pressure distillation data to normal conditions for crude oil is tested successfully and good results are obtained. It's tried to use the same procedure to extrapolate the shale oil distillation data at vacuum conditions to normal atmospheric data, but the results did not fit the data. The application of conversion parameter, Q, which was developed by Riazi 2002, for crude oil when employed for shale oils data resulted in large deviation.

It is found that multiplication of the $Q = \frac{5.994296 - 0.972546\log(P)}{2663.129 - 95.76\log(P)}$, which to be used in $T_b' = \frac{748.1QT}{1+T(0.3861Q - 0.00051606)}$ with a Correction Factor = 1.04961 resulted in a good fit of the shale oil of Kukersite and Attarat where the vacuum distillation data was extrapolated to atmospheric conditions (M.R. Riazi Characterization and Properties of Petroleum Fractions, 1st First Edition, ASTM manual series: MNL50, 2002).

Keywords: Distillation; Shale oil; TGA.

Prof. Stefan Iglauer
Professor, Centre for Sustainable Energy and Resources, Edith Cowan University, 270 Joondalup Drive, 6027 Joondalup, Western Australia

Speaker Profile

Dr. Stefan Iglauer is a Professor of Energy and Resource Engineering, research leader of the Energy and Resources discipline, and Director of the Centre for Sustainable Energy and Resources. His research interests are in petro-physics and interfacial phenomena, mainly at pore-scale with a focus on H_2 geo-storage, CO_2 geo-sequestration and improved hydrocarbon recovery. Stefan has authored more than 400 technical publications; he holds a PhD degree in Material Science from Oxford Brookes University (UK) and a MSc degree in Chemistry from the University of Paderborn (Germany).

Title of the Talk

KL-08: Hydrogen Geo-Storage: An Overview and New Insights

Hydrogen is a clean fuel which can decarbonize the energy supply chain and thus drastically mitigate climate change. However, hydrogen is highly volatile and therefore difficult to store at the large scales required. One solution to this problem is hydrogen geo-storage, where large amounts of hydrogen are temporarily stored in large, subsurface geological reservoirs. This process is commercially established for hydrogen storage in underground salt caverns; however, such salt caverns are not widespread, and it is necessary to test other geological formations for their hydrogen storage potential.

In this presentation new results are displayed and discussed. Formations which were evaluated include sandstone and limestone reservoirs, deep coal seams, and shale and basalt formations. A focus is on petrophysical parameters and how they vary with geo-thermal conditions. One example is the water-rock-hydrogen contact angle (and thus the wettability), and how it varies with temperature, pressure and the rock type itself. It is clear that the surface chemistry of the rock plays a key role here, and any organic matter on the rock surface strongly reduces the water-wetness of the rock. Hydrogen is also less wetting than CO_2, mostly driven by the larger CO_2 density – these relations are discussed in more detail in the talk.

Based on the results of these fundamental investigations, it can be concluded that hydrogen geo-storage is feasible from a petrophysical perspective, and can potentially be implemented industrially at reservoir scale in various geologic formations. This work provides key data and therefore further enables the decarbonization of the energy supply chain.

Keywords: Hydrogen; Hydrogen geo-storage; Reservoir; Storage capacity.

Prof. Ajay Kumar Dalai
Distinguished Professor and Canada Research Chair, Department of Chemical and Biological Engineering, University of Saskatchewan, SK Canada S7N 5A9

Speaker Profile

Professor Dalai is a Distinguished Professor and Canada Research Chair (Tier 1) in Bioenergy in the Department of Chemical and Biological Engineering at the University of Saskatchewan. He has served as Head of Chemical Engineering and as Associate Dean, Research and Partnership in the College of Engineering. Prof. Dalai's research focus is on the novel catalyst development for gas to liquid technologies, biodiesel production, hydrogen/syngas production, hydroprocessing, value-added products from biomass, and pollution control. He has published over 600 research papers mostly in heterogeneous catalysis and catalytic processes in international journals and conference proceedings. His ground-breaking research has led to over 41,500 citations of his work, H-index of 97 and i10-index of 448. Professor Dalai has received fellowship from different societies such as Royal Society of Canada, Royal Society of Chemistry in UK, International Association of Advanced Materials, American Institute of Chemical Engineering, Canadian Academy of Engineering, Chemical Institute of Canada, Engineering Institute of Canada, Indian Institute of Chemical Engineers, and Indian Chemical Society. Professor Dalai is also a Fulbright Fellow from USA, DAAD Fellow from Germany and JSPS Fellow from Japan. Professor Dalai has received several awards. Recently, he has received Indian Institute of Chemical Engineers DRC Life Time Achievement Award, Canadian Society of Chemical Engineering R.S. Jane Memorial Award for outstanding contributions to Chemical Engineering Profession, Royal Society of Canada's Miraslow Romanoswki Medal for Outstanding Contribution to Environmental Science, University of Saskatchewan's George Ivany Internationalization Award, and University of Saskatchewan's Distinguished Researcher Award.

Title of the Talk

KL-09: Fischer-Tropsch Reaction Over Kmofe/Cnts Nano-Structured Catalyst in A Fixed Bed Reactor: Reaction Mechanism and Kinetic Study

To decrease fossil fuel consumption and reduce the emission of greenhouse gases, Fischer-Tropsch synthesis (FTS) can be an important industrially process for conversion of syngas (H_2 + CO) to hydrocarbons. This gas-to-liquid (GTL) technology is a series of heterogeneous polymerization reactions by means of active metals (Fe, Co, Ru and Ni) to produce a variety of longer chain hydrocarbons such as paraffins, olefins, waxes and oxygenates. Unsupported and supported Fe-based catalysts are most commonly used for FTS owing to their low cost, high resistance to sulfur, and flexibility to the syngas ratio caused by high water-gas-shift (WGS) activity. To enhance active phase dispersion and sintering resistance, Fischer-Tropsch (FT) catalysts are often supported on metal oxides. However, oxide supports fail to provide an adequate carburization of Fe species with small particle sizes for application in FTS. Carbon supports such as carbon nanotubes (CNTs) have been widely used in FTS due to their surface inertness, stability, thermal conductivity, and tunable chemical and physical properties. Furthermore, the addition of structural promoter such as K and Mo can improve the mechanical stability of the catalyst and catalytic activity. The present study aims to investigate the mechanism prevailing in CO activation and rate equation for CO consumption during FT reactions over 0.5K5Mo10Fe/CNTs catalyst. The kinetic tests were conducted in a fixed bed reactor under industrially relevant operating conditions (P = 100–600 psi, T = 270-290 °C, H_2/CO = 1, GHSV = 2000 h^{-1}). Due to the synergistic effects of Fe, Mo, and K phases on the catalyst activity, both fresh and spent catalysts were thoroughly characterized using XRD, XPS, SEM-EDS, TEM, XANES, and EXAFS to ascertain the different phases (active sites) present and relevant interactions. In this presentation, detailed reaction mechanism and kinetics for KMoFe/CNTs for FTS will be discussed.

Keywords: Activation energy; Fischer-tropsch synthesis; Fixed-bed reactor; Carbon nanotubes; Iron-molybdenum-potassium nanocatalyst; Kinetic model; Mechanism.

Prof. Prem Bikkina
Associate Professor, School of Chemical Engineering, Oklahoma State University, Stillwater, Oklahoma-74078, USA

Speaker Profile

Dr. Prem Bikkina is an Associate Professor, Harold Courson Chair, and Petroleum Program Director at Oklahoma State University. He obtained B.S. and M.S. in Chemical Engineering, Ph.D. in Petroleum Engineering, and Postdoctorate from NIT Warangal, IIT Guwahati, University of Tulsa, and Lawrence Berkeley National Laboratory, respectively. His research in EOR, CCUS, and Phase Separations has led to high impact journal publications and patents, with funding from diverse sources. Dr. Bikkina serves as an Associate Editor for Petroleum Science and Technology, and has extensive peer-review experience. He's received prestigious awards and is a member of several professional organizations.

Title of the Talk

KL-10: Recent Developments in the Application of Microfluidics in Oil & Gas Industry

In recent years, microfluidics has been gaining acceptance for fundamental and applied research in the oil and gas industry. Microfluidics has been used for PVT analysis, emulsion characterization, and enhanced oil recovery studies. Recent advancements in microfluidics manufacturing made it possible to prepare microfluidic chips that could replicate various pore and chip scale features of real porous media, including minerology, and other patterns that are of relevance to petroleum engineering applications. The major advantages of microfluidics-based studies include flexibility in porous media and other related chip designs in a highly controlled and reproducible manner, easy and accurate control of fluid flow, and most importantly the ability to visually study the involved oil recovery mechanisms both at pore and chip scales. Very recently, nanofluidics is being considered to understand the flow and phase behavior of fluids in unconventional reservoirs where pore size distributions are in the nanoscale range. This presentation discusses the state-of-the-art of micro- and nano-fluidics in petroleum industry.

Keywords: Geomaterial; Low salinity water flooding (LSWF); Microfluidics; Nanofluids; Wettability.

Prof. Jyoti Phirani
Associate Professor, Department of Chemical Engineering,
Indian Institute of Technology Delhi, India

Speaker Profile

Dr. Jyoti Phirani is a Senior Data Scientist at Baker Hughes, UK. She has held academic positions for 10 years as a Chancellor's Fellow at the University of Strathclyde, UK in the Department of Civil and Environmental Engineering, associate professor in the Department of Chemical Engineering, IIT Delhi. She led research in PROMISE (PoROus Media Investigations for Sustainability and Energy). She has worked in oil and gas industry as reservoir engineer and knows the challenges of working with large scale porous media such as geological reservoirs and aquifers. She tries to overcome these challenges using her research. She has several publications to her credit.

Title of the Talk

KL-11: Capillary Driven Flow in Heterogeneous Porous Media

Energy storage in the form of hydrogen can potentially lead us in the direction of net-zero. For storage geological reservoirs provide a viable option as they are stores of energy of fossil fuels which has catered to the world's energy demand. In similar way, for long-term storage of CO_2, geological porous reservoirs will be required for the huge amount that needs to be stored. Capillary driven flow becomes important in the geological gas storage, especially when no external forces are applied after injection. The inherent heterogeneity in the porous media is known to cause the invading fluid front to move at different speeds in various pores. The heterogeneity is predominantly because of the presence of various layers of different porosity and permeability. For example, in geological porous media the sediment deposition at various geological times leads to vertically stacked porous layers. Therefore, it becomes pertinent to understand the capillary driven flow dynamics in these layers. Previous understanding is that the invading fluid or wetting fluid will lead in the narrow pore. However, I will show using our experimental results that the invading fluid advances more in the narrow pores. We developed a one-dimensional lubrication approximation model based on the experimental observations, which predicts the imbibition dynamics in the layers seen in the experiments. We predict using our model that the volume imbibed in the layered porous medium cannot be determined by using the effective porous medium properties and a detailed knowledge of the characteristics of the layers is required to accurately predict the overall imbibition of the layered porous medium. This is useful to understand long term storage capacity of the geological reservoirs.

Keywords: Capillarity, CO_2 sequestration; Gas storage, Geological reservoirs; Porous media flow.

Prof. Sanjay Srinivasan
Professor, Pennsylvania State University,
University Park, PA 16802, U.S.A.

Speaker Profile

Prof. Sanjay Srinivasan holds the John and Willie Leone Family chair in Energy and Mineral Engineering and is the director of the energy institute within the college of earth and mineral sciences at Penn State. Sanjay's primary research focus is in petroleum reservoir characterization, assimilation of multiscale, multiphysics data in reservoir models. He has pioneered algorithms for early appraisal of ultra-deepwater plays in the Gulf of Mexico and for characterizing natural fracture networks in conventional as well as unconventional reservoirs. He was until recently, a task leader in the Center for Frontiers of Subsurface Energy Security at UT Austin where he directed research focused on field scale characterization of geological CO_2 sequestration.

Title of the Talk

KL-12: Assimilation of Dynamic Data into Subsurface Reservoir Models Using a Model Selection Approach

Iterative adjustment of stochastic random fields (such as spatial variation of permeability in a reservoir) so as to match measured dynamic data can be treated as a classical, ill-posed inverse problem. A host of both heuristic and exact optimization techniques have been applied to problems with both discrete and continuous parameter spaces. Typically, these approaches yield model parameters that provide the best fit to the observed data and any remaining discrepancy between the estimated and observed values is regarded as uncorrelated noise. The underlying theory of most optimization approaches is that this noise must follow the form of uncorrelated errors drawn from zero-mean, Gaussian distributions. In addition, the process of iteratively adjusting the large number of parameters (permeability nodes) renders the computation process expensive and time consuming.

In lieu of this grid-based model updating process, we present a model selection algorithm that refines an initial suite of subsurface models representing the prior uncertainty to create a posterior set of subsurface models that reflect the dynamic performance consistent with that observed. The process involves creating an initial suite of subsurface models that captures all the possible geological scenarios for the reservoir/aquifer under study; running all the models through a fast proxy; grouping models on the basis of the proxy responses; assigning a probability value to the most likely group of models by comparing the results after applying a transfer function for each group with the observed dynamic response; and repeating this grouping method to iteratively create a posterior set of most probable models (a subset of the initial set). Such posterior models can be used to represent uncertainty in the future dynamic performance of the reservoir.

The model selection approach represents a clear departure from the iterative model perturbation approaches for dynamic data assimilation. It also offers the advantage of yielding a suite of models at the end of the data assimilation process. This permits assessment of residual uncertainty that enables making probabilistic statements regarding value of information etc. We demonstrate the method for tracking the migration of CO_2 plume in the subsurface during sequestration. In that case, because only injection data is required, the method provides a very inexpensive method to map the migration of the plume and the associated uncertainty in migration paths. We subsequently, demonstrate an application of the method to obtain a set of posterior models for fractures in a reservoir constrained to micro-seismic data.

Keywords: Data assimilation; History matching; Model selection; Model calibration physical proxies.

Prof. Rajesh Kumar Upadhyay
Professor, Department of Chemical Engineering and Technology, IIT (BHU), Varanasi, Uttar Pradesh-221005, India

Speaker Profile

Dr. Upadhyay is currently a Professor at the Department of Chemical Engineering & Technology at Indian Institute of Technology (BHU). Previously he worked as Assistant Professor and Associate Professor at the Department of Chemical Engineering, IIT Guwahati during 2010-2019. Dr. Upadhya holds a PhD degree from IIT Delhi. His research majorly focuses in the areas of hydrogen production, multiphase Flows, Radioactive Particle Tracing, Tracer Study, Membrane Reactors, Catalysis, Dense Membrane Synthesis etc. Prof. Upadhyay has published several papers in high impact journals, national and international conferences and book chapters.

Title of the Talk

KL-13: Compact Membrane Reformer for On-Site Hydrogen Production: A Technical Prospect toward Commercialization

The production of hydrogen for commercial purposes is often accomplished by conventional methods such as steam reforming of methane and naphtha, and coal gasification. However, it is worth noting that small-scale users (<5 kg_(H_2) h^{-1}) continue to utilize compressed high pressure hydrogen cylinders, necessitating regular replacements. Moreover, this practice presents a significant safety concern for H_2 transportation and in-house storage. Therefore, the utilization of a membrane reformer (MR) for on-site H_2 production emerges as a potentially cost-effective alternative. The MR is a compact device designed for EV charging, power backup, and H_2 refueling stations. However, the opposing conditions necessary for reforming and separation makes the integration challenging. Additionally, the deactivation of the catalyst, concentration polarization, process intensification, and scale-up further aggravate the challenges aforementioned.
In order to overcome these challenges and develop a more robust MR for practical application we are working on the development of the suitable membrane, reforming catalyst for a variety of feedstock, and innovative design of the MR module. The thin Pd-alloy-based membranes exhibiting high permeation flux and selectivity are being developed to separate H_2. The membrane performance and stability are examined with the mixture gases before assembling into the MR. In addition to this, different catalysts are developed for various feeds such as methane, and methanol. The activity and long-term stability of the catalysts are tested at different temperatures and pressures to investigate their viability. These membranes and catalysts are further integrated into the multi-tube MR to optimize the process conditions and enhance overall efficiency.

Keywords: Hydrogen production; Membrane reformer; On-site; Palladium membrane; Scale up.

Prof. Keka Ojha
Professor, Department of Petroleum Engineering,
IIT(ISM), Dhanbad

Speaker Profile

Dr. Keka Ojha, Head & Professor of the Department of Petroleum Engineering, Indian Institute of Technology (IIT-ISM), Dhanbad has about 20 years of research, and teaching experience in India and overseas. As the recognition of her work, she is the conferred "SPE Distinguished Achievement Award for Petroleum Engineering Faculty, for South Asia and the Pacific Region, 2019". Prof. Ojha, a graduate in Chemical Engineering (Hons.) from Jadavpur University, India has received her Masters and Doctoral degree from Indian Institute of Technology, Kharagpur, India in Chemical Engineering. Before joining IIT (ISM) Dhanbad, she has worked as Research Associate in University of Notre Dame, USA. She is actively involved in R &D in the fields of Unconventional Hydrocarbon Resources, Reservoir Engineering, EOR Techniques, hydraulic fracturing sponsored by various agencies like ONGC, OIL, EOGEPL, JTI, OilMax, DST, CSIR, UGC, MoC, OIDB etc. Dr. Ojha has published more than 150 papers including 85 in peer reviewed national/international journals and others in conferences. She is the reviewer of many international journals of repute and member of editorial bord of MGMI.

Title of the Talk

KL-14: Microbial Stimulation: An Emerging Technology for Enhancing Coalbed Methane Recovery

India has a longstanding goal of achieving energy security by harnessing its abundant indigenous energy resources. To realize this ambition, the government has implemented several strategic initiatives. These efforts encompass diversifying the energy mix, expanding exploration and production activities, exploring alternative energy sources, and transitioning towards a gas-based economy, green hydrogen, and electric vehicles. Notably, coalbed methane (CBM) reservoirs hold a significant place in our exploration and production strategy due to their considerable potential. India possesses substantial coal resources, within which methane and other gases are trapped through thermogenic and biogenic processes, existing in adsorbed states under pressure. However, extracting CBM presents unique challenges, given the complexities associated with coalbeds, heterogeneity, low permeability, unique mechanical properties, and the necessity for water disposal prior to gas production. Primary recovery rates remain modest, prompting the exploration of enhanced recovery methods. One promising avenue is the injection of CO_2, which not only enhances methane production but also serves as a viable option for geological CO_2 storage, provided we can address the operational challenges inherent in this process. Microbial stimulation represents a green technology that can stimulate microbial colonies within coal seams to generate methane gas, in addition to certain favorable changes in the coal matrix. This process involves methanogenetic bacteria and archaea communities initiating various activities to produce methane and CO_2 by decomposing organic polymers in coal. However, coal formation waters contain a diverse range of microorganisms beyond methanogens. Uncontrolled stimulation of these non-methanogenic microorganisms may lead to various problems like formation of unwanted gas, blocking of permeable path which may obstruct in production, instead of facilitating it. Thus, achieving optimal results requires careful selection of nutrients to stimulate the right microorganisms and a vigilant monitoring system to control their growth. These critical factors will be discussed in my presentation.

Keywords: CBM, Energy security; Enhanced recovery; Methanogens; Microbial stimulation.

Prof. Alexandra Saitova
Professor, Graduate School of Production Management, Institute of Industrial Management, Economics and Trade, Saint Petersburg, 195251, Russia

Speaker Profile

Dr. Alexandra Saitova completed postgraduate studies in Russia (Chemical Technology/Physical Chemistry), as well as in Germany (Oil and Gas Engineering). She has more than 10 years of experience in the oil and gas industry, both in large industry companies such as Lukoil, Wintershall Dea, Gazprom Neft, and universities. Author of more than 50 publications, a number of patents, monographs, textbook "Fundamentals of decarbonization of the oil and gas industry." Areas of scientific interests: reducing the carbon footprint of the oil and gas industry, strategic management of companies during the period of decarbonization, methods and technologies for achieving carbon neutrality.

Title of the Talk

KL-15: Current trends in the Russian oil and gas industry during the period of decarbonization of global energy

Global changes have shaped two trends that most strongly influence the current and future appearance of energy – decarbonization of the global economy and changes in energy flows. Decarbonization efforts have taken place across multiple countries, with more than 150 governments presenting plans to reduce carbon emissions by 2030 as part of the Paris Agreement. The possibilities for low-carbon development of modern global energy, along with the availability of fuel reserves, have become the main component of the investment attractiveness of the energy industry. Stimulating the transition of global energy from the use of fossil fuels to non-carbon energy resources, achieving the economic competitiveness of solar and wind energy, and the electrification of road transport will slow down the growth of world millet and prices for fossil fuels. Russia is a leader in oil and gas production. The country is in the top 3 in terms of proven hydrocarbon reserves. However, the conflict with Ukraine led to the refusal of European countries from Russian hydrocarbon resources. As a result, the global energy market has undergone significant changes: Russian resources instead of European countries went to Asian markets, payments for procedures began to be carried out in national currency, and the cost of gas increased sharply. Despite unprecedented geopolitical tensions in 2022, demand in the global oil market maintained its upward trend, with oil prices remaining consistently high throughout the year. The International Energy Agency estimates global oil demand will be 102.3 million bbl/d in 2023 as consumption continues to recover in China, which accounts for about 60% of rising demand. The embargo of the European Union and G7 countries on the import of Russian oil and petroleum products has not led to a decrease in supply volumes on the world market, but has radically changed supply chains and commodity flows. Russian hydrocarbons in the EU and G7 countries were replaced by supplies from other regions (mainly the Middle East and the USA), while exports of oil and petroleum products from the Russian Federation were successfully redistributed to new markets in Asia, Africa and Latin America. The report presents changes in global demand for the production and consumption of energy resources as a result of the implementation of decarbonization policies, as well as the military conflict between Russia and Ukraine. The trends and directions of development of the Russian oil and gas industry in modern realities are also presented.

Keywords: Energy flow; Decarbonisation; Oil and gas industry; Russia.

Prof. Kevin Ven Geem
Professor, Department of Materials, Textiles and Chemical Engineering
Ghent University, Belgium

Speaker Profile

Prof. Kevin Ven Geem is a Professor at Department of Materials, Textiles and Chemical Engineering, Ghent University, Belgium. He was the Director of the board of LCT and Director of Centre of Sustainable Chemistry (CSC). He has doctoral degree in Chemical Engineering from Ghent University and was a Fullbright post-doctoral fellow at Massachusetts Institute of Technology. His research interest is thermochemical reaction engineering in general and in particular the transition from fossil to renewable resources. He is the author of more than hundred scientific publications and has recently started his own spin-off company. He is involved in on-line and off-line analysis of complex petrochemical and biochemical samples using comprehensive two-dimensional gas chromatography. Pyrolysis, detailed kinetic modeling, process, scale-up, modeling, and anti-fouling technology belong to his main expertise.

Title of the Talk

KL-16: Empowering Chemical Engineering for a Net Zero Process Industry

Due to our increasing awareness of the impact of climate change on our society, unit operations in our manufacturing processes, including those in chemical industry, have to be greenified and made less dependent of fossil resources. One option is to use plastic waste or biomass, but this is less straightforward than what is generally believed. Additionally, there is so-called electrification of the chemical industry. This is still in its infancy but there are many scientific and technological challenges to be solved. These important but far from trivial energy and materials transitions require not only the introduction of new ways of heat management and other, often not yet fully explored, chemical conversion processes in which green electrons are used, but also the development of new materials including large-scale heating coils, easily chargeable battery systems as well as catalyst materials. For each of these developments, there is the issue of materials scarcity as well as durability as the introduction of these production processes should also be cost effective and overall more sustainable than the existing ones.

Keywords: Chemical industry; CO_2 utilization; Process intensification; Plastic waste; Catalysis.

Prof. Subrata Borgohain Gogoi
Department of Petroleum Technology,
Dibrugarh University, Dibrugarh, Assam-786004, India

Speaker Profile

Professor Subrata Borgohain Gogoi is the Dean of Faculty of Earth Sciences and Energy and the Head, Department of Petroleum Technology of Dibrugarh University. She was awarded the prestigious Indo-US 21st Century Knowledge Initiative Project by UGC in 2015 with the University of Louisiana at Lafayette, USA, the DST-India-Tunisia project with Sfax University in 2017, UGC-UKIERI Joint Research Programme (UKIERI-III) project with The University of Edinburgh, UK in 2018 and DST-IC IMPACTS; Indo-Canadian project with the University of Ontario, Institute of Technology in 2020. Her notable works were published in Springer, Elsevier, SPE, ACS, Taylor and Francis and many more. To her credit she has 83 peer journal publications, 79 technical papers in conferences, 54 book chapters, 4 patents and two books, Petroleum Technology – Enhanced Oil Recovery Techniques, Pub. Oxford & IBH and Advances in Petroleum Technology – Enhanced Oil Recovery Techniques, pub. Jenny Stanford Publishing, New York. She supervised and produced 14 PhD students in the area of Enhanced Oil Recovery, flow through porous media, flow through pipeline and oil field produced water treatment.

Title of the Talk

KL-17: Carbon neutrality through combined CO_2 capture and novel H_2 technology with production of non-conventional fuels

This paper aims at converting CO_2 into valuable synthetic, non-conventional and non-renewable fuels which is one of the most practical routes for reducing CO_2 emissions and boosting the deficient energy sector. Therefore, the idea of reducing CO_2 by H_2 from solar, to synthetic fuels appears as a technology able to face the ever-increasing demand for alternative, environmentally-friendly fuels and energy carriers. Methanol (CH_3OH) is an alternative fuel for internal combustion and other engines, either in combination with gasoline or directly. While the future market perspectives of use of Dimethyl ether (CH_3OCH_3) as fuel are alternative fuel for diesel engines; fuel for power generation in gas turbine plants; chemical intermediate for olefins and synthetic gasoline production. Four moles of H_2 are required per mole of CH_4, three moles of H_2 are necessary per mole of CH_3OH and CH_3OCH_3, while six moles of H_2 are necessary per mole of CH_3OCH_3. Hence, there are no real advantages to adopt this pathway to produce CH_3OH, C_2H_5OH and CH_3OCH_3 via CO_2 hydrogenation, since H_2 is usually produced from fossil hydrocarbons (mainly from natural gas or light hydrocarbons). Therefore, only if H_2 is produced from non-fossil sources, the production of $CH_3OH/C_2H_5OH/CH_3OCH_3$ Economy Theory will be a reliable option; in particular, if H_2 is directly produced from solar, CO_2 hydrogenation will become a valuable strategy for renewable energy utilization in the transport sector. H_2 production from renewables by using thermal, photonic and electrical methods offers great opportunities. In this paper, the following methods will be considered in hydrogen production, namely: (i) solar electrolysis by using electricity, (ii) solar thermochemical cycle by using thermal heat in principal, and (iii) solar photoelectrochemical process by using the light in principal.

Keywords: CO_2; Electrolysis; H_2; Solar; Synthetic fuels.

Prof. Jitendra Sangwai
Professor, Department of chemical engineering, Indian Institute of Technology, Madras,600036, Tamil Nadu, India.

Speaker Profile

Dr. Jitendra S. Sangwai is a Professor of Chemical Engineering at the Indian Institute of Technology, Madras (Institute of Eminence). He has published about 165 research articles in peer-reviewed international journals and has several patents to his credit. He has been recognized as the Top 3% Highly Cited Authors from India by the American Chemical Society. He received the National Award for Technology Innovation and the National Geoscience Award from the Government of India for excellence in research and development. He has been currently assigned as associate editor in prestigious American Chemical Society Journal "Energy and Fuel".

Title of the Talk

KL-18: CO_2 Sequestration as Hydrate in Subsea Conditions

Immediate actions are required to address global warming and climate change, which may involve storing large amounts of anthropogenic CO_2 in geological and oceanic repositories. In terrestrial storage sites, CO_2 tends to rise due to the underground temperature profile. Therefore, if the reservoir is not properly sealed, stored CO_2 can escape from geological formations. On the other hand, oceanic sequestration holds great potential for long-term CO_2 storage beneath the seabed, supporting the broader scientific and industrial community in achieving carbon neutrality. Subsea CO_2 sequestration holds significant promise for ensuring stable, long-term CO_2 storage and, consequently, can make a substantial contribution to achieving global carbon neutrality and mitigating the challenges of global warming. These dimensions offer a vast landscape for discussion, paving the way for future technological innovations. Consequently, there exists a broad scope for discourse in this field that will drive the development of novel technologies in the years to come. However, there is extensive room for discussion in this area, opening new possibilities for future advancements. Additionally, we emphasize the critical role of negative buoyancy and hydrate-forming zones (NBZ/HFZs) and analyze the depth criteria in oceanic settings. Sequestration in the NBZ region offers stable storage for many years, even in the presence of geological disturbances and earthquakes.

Keywords: Additives; Carbon dioxide; Gas hydrates; Macroscopic parameters; Subsea sequestration.

Prof. Nageswara Rao Peela
Professor, Department of Chemical Engineering,
Indian Institute of Technology Guwahati, India

Speaker Profile

Dr. Nageswara Rao Peela is a Professor in the Department of Chemical Engineering at Indian Institute of Technology Guwahati. He received his M.Tech. and Ph.D. from Indian Institute of Technology Kanpur in the years 2004 and 2011, respectively. He completed his post-doctoral studies at the University of Delaware, USA. He has over 20 years of academic research experience in the field of chemical engineering, specializing in biomass to value-added chemicals and fuels, green hydrogen production, micro-structured and optofluidic devices, multifunctional reactors, washcoating, supported bimetallic catalysts, bifunctional catalysts, reaction kinetics, microkinetic modeling, reactor design, high throughput experimentation. He has supervised one Post-Doc, seven Ph.D., and twelve M.Tech students.

Title of the Talk

KL-19: Optofluidic Devices for the Conversion of Solar Energy to Green Hydrogen

The generation of green hydrogen from solar energy via photocatalytic overall water splitting reaction is a Holy grail in the research community. If we develop this process with high efficiency, then we can replace the existing “photo-voltaic solar to electrical energy conversion followed by water electrolysis” with this new technology, which directly converts the solar energy to chemical energy (i.e., hydrogen). Optofluidic microreactors are highly promising for this process. In this presentation, I would like to give an overview of the research work going on in our laboratory in this area. In brief, we developed various strategies for the photocatalytic overall water splitting reaction. The photocatalysts, such as metal doped and co-catalyst loaded photocatalysts (Ag/TiO_2, Pt/TiO_2, IrO_2/TiO_2 and $Pt/IrO_2/TiO_2$), binary (CdS/MnO_x $BiVO_4$ and $CdS/g\text{-}C_3N_4$) and ternary heterojunctions ($Ag/g\text{-}C_3N_4/g\text{-}C_3N_4$), and facet-selective ($MnO_x$ $BiVO_4$), were developed for the photocatalytic water-splitting to produce hydrogen and oxygen simultaneously. Various optofluidic microreactor configurations, such as planar, serpentine, corrugated and micropillared, were designed, fabricated in-house and tested for photocatalytic water-splitting to produce hydrogen and oxygen. The insights obtained from the materials and optofluidic device testing studies will be discussed in the presentation.

Keywords: Green hydrogen; Optofluidic microreactor; Photocatalysts; Solar energy; Water electrolysis.

Prof. Mayank Tyagi
Professor, Petroleum Engineering, Louisiana State University, Baton Rouge, LA 70803, USA

Speaker Profile

Prof. Mayank Tyagi is Chevron #3 professor at the Craft & Hawkins department of petroleum engineering with a joint faculty appointment at the Center for Computation & Technology (CCT), LSU since 2007. He obtained his Ph.D. in mechanical engineering from LSU and B.Tech. in mechanical engineering from Indian Institute of Technology (IIT), Kanpur. His current research interests span data-driven machine learning models, and physics-based simulations using high performance computing (HPC) for a wide range of petroleum engineering applications such as pore-scale flow phenomena, computational fluid dynamics (CFD), and geothermal reservoir engineering. He has published over eighty (80+) peer-reviewed technical publications

Title of the Talk

KL-20: Machine Learning Applications for Safe and Sustainable Energy Transition

Increasing emissions of greenhouse gases (GHGs) have resulted in pressing concerns about climate change and increased investments in decarbonization. Therefore, it is imperative that the currently prevalent petroleum resources must make way for several alternate (and hopefully sustainable) energy solutions for society. However, the challenges for the safer and sustainable energy transition will require addressing not only the technological issues but also the socio-political concerns. Progress in artificial intelligence (AI) and machine learning (ML) has provided a strong economic motivation to many industrial sectors such as healthcare, retail etc. Applications of machine learning to petroleum engineering during the energy transition provide a unique opportunity to help train the workforce on translational skillsets and yet achieve the goal for safer and sustainable energy transition. In this talk, several examples of machine learning applications will be discussed to highlight Smart decision-making, Safety of operations, and Sustainability of subsurface energy resources that will be relevant to the energy transition. Rig state identification to reduce the invisible lost time (ILT) on offshore drilling platforms will be presented as ML example of smart decision making. Early kick detection (EKD) using ML based multi-class alarm system for an offshore drilling platform is shown as an example of operational safety. Lastly, the physics-informed neural networks (PiNNs) for the production datasets of an offshore reservoir field will be shown as an example for reduced-order models (ROMs) for waterflooding operations. Future directions of ML applications to geothermal reservoir engineering will be presented as an example of sustainable energy transition.

Keywords: Machine learning; Energy transition; Safety; Sustainability; Petroleum.

Prof. Rameshwar Adhikari
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Speaker Profile

Former Executive Director at RECAST (2017-2020), served as visiting Professor at Rouen University (France), Mahatma Gandhi University (India), the Kyoto Institute of Technology (Japan); now serving as Adjunct Professor at the Indian Institute of Technology (IIT), Guwahati and SRM Institute of Science and Technology, Tamil Nadu, India. Graduated from Martin Luther University Halle, Germany in 2001; Fellow of International Union of Pure and Applied Chemistry (IUPAC) and recipient of Alexander von Humboldt (AvH) Fellowship, POLY-CHAR International Materials Science Prize; and Technology Award of Nepal Academy of Science and Technology (NAST) .(Co)authored 200+ research papers in peer-reviewed journals and 8 books; guided 15 Ph.D. researchers (8 completed); Research areas: polymers, biomaterials, traditional materials, and natural products. He has been passionately working in promoting Young Scientists' Activities in the country for the last 20 years

Title of the Talk

KL-21: Reducing Carbon Footprint of Plastics Via Lignocellulosic Fibers-Based Composite Materials Design

An approach to decrease significantly the overall carbon footprint of plastics is, besides limiting the use of traditional petroleum-based polymer, to utilize natural products (for example the substances of plant origin such as polysaccharides and their derivatives) based wastes to design the novel composite materials. In this work, we present a review of the use of lignocelluloses as reinforcing fillers in composite materials with a matrix made up of completely biodegradable materials as well as recycled commodity plastics. We particularly present examples of natural fibers-filled biodegradable copolyester and polypropylene. It has been shown that utilizing the polysaccharide based fillers (such as chitosan and micro- or nanofibrillated cellulose) into the copolyester matrix yields quite interesting composite materials suited for low-load-bearing packaging applications while the use of lignocellulosic biomass as the reinforcement in commodity plastics (such as polypropylene and polyethylene) opens up promises of being used as materials for insulation to outdoor applications. We present the reuse and refurbishment of plastics products particularly processed using a locally fabricated molding machine. The mechanical properties of the materials will be discussed on the basis of the influence of processing conditions and their microscopic structures. We will further underline the need for policy in the South Asian region promoting middle-sized enterprises based on local renewable resources and waste materials.

Keywords: Biobased and biodegradable polymers; Carbon footprint; Composites; Electron microscopy

Prof. Sunil Kumar Khare
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Speaker Profile

Dr. Sunil Khare is Professor of Petroleum engineering at UPES, Dehradun. After completion of PhD from IIT Dhanbad in year 2000, he worked in Geoservices, Singapore and Schlumberger, Oman as field engineer and SIS data analyst. He was global offshore product owner of Halliburton InSite suite of applications during his stint with Wipro technologies, Bangalore as upstream managing consultant. Dr Sunil has two global patents on drilling automation and has to his credit more than 30 research publications in the reputed SCI and Scopus indexed journals. His research interests include application of digital technologies in upstream, drilling automation, sustainable development goals and energy transition. Dr Sunil is member of EOR committee and digital task force formed by ministry of Petroleum and natural gas Govt. of India to enhance oil and gas production and to implement digital technologies in upstream sector. He is also faculty advisor of SPE North India section and faculty advisor of UPES SPE student chapter.

Title of the Talk

KL-22: Data Analytics and Machine Learning for Oil and Gas Exploration and Production Optimization

Petroleum exploration and production is a data driven industry primarily due to occurrence of hydrocarbons in deep subsurface reservoirs. The hydrocarbon reservoirs are difficult to locate, and the drilling of well bore into the reservoir is plagued with inefficiencies. The recovery of hydrocarbon from reservoirs is poor despite deployment of Enhanced Oil Recovery (EOR) techniques. Exploration and production projects have low success rates despite multibillion dollar budget due to uncertainties related to reservoir characteristics. The health and safety of workers in upstream operations is at risk due to hostile working conditions such as deserts of middle east, cold places like Siberia and Canada, and deep-water offshore workplaces in North Sea. The consistent low and fluctuating oil and gas prices for years has led to migration of skilled oil and gas sector workforce to other sectors of economy. Therefore, there is an urgent need to optimize upstream industry with next gen digital technologies. Application of data analytics and machine learning in exploration and production can optimize the discovery of reservoir, reduce drilling nonproductive time (NPT) and inefficiencies, improve hydrocarbon recovery, protect the health of workers, and enable safe operations. Exploratory Data analytics can provide better interactive dashboards and provide more business intelligence (BI) to exploration and production workforce. Machine learning models such as single and multiple linear regression can help predict rate of penetration during construction of well bore. Clustering techniques can help optimize production from aging reservoirs. Data analytics run on health data of workers can help understand better utilization of workforce keeping in mind their health constraints. Safety issues can be handled proactively with machine vision and video analytics technologies. Predictive maintenance of equipment can optimize supply chain and logistics management. Automation and robotics implemented from RTOC and RTO can automate drilling and production operations, enabling management of operation from lesser work force in the field. Implementation of digital technologies can save this industry from uncertainties related to its future.

Keywords: Data analytics; Hydrocarbon; Machine learning; Upstream; Petroleum.

INVITED
LECTURES | ICPHD 2023

List of Invited Lectures

Conference ID	Title and Authors
Session-04, 16:30-18:00	**Day 1, 3rd Nov 2023**
IL-01	CO_2 Foam Flooding in Hydrate Reservoir: Assessing Foam Stability in Reservoir Conditions with Nano-Particle Integration *Vishnu Chandrasekharan Nair*
IL-02	EOR Opportunities in Depleted Reservoirs of Assam Arakan Basin: A Laboratory EOR Approach in Tengakhat Area of Assam *Kuladip Sarma, Sushovan Hens, Debasish Baishya, Rajib Sarmah, Vishal Dhar Pankaj Tiwari*
IL-03	Green Hydrogen for Decarbonization: Challenges and Future Perspectives *Rohit Shrivastav*
IL-04	Application of Seismic Exploration Techniques in Exploration of Unconventional Hydrocarbons and CCS projects *Ajay Malkoti, Nimisha Vedanti*
IL-05	Characterization of Polymers for Selection of Effective Candidate in Enhanced Oil *Achinta Bera*
Session-05, 16:30-18:00	**Day 1, 3rd Nov 2023**
IL-06	Direct Thermal Liquefaction of Rice Husk to Produce Bio-Oil and High-Purity Amorphous Silica Nanoparticles *Manvendra Singh and Shushil Kumar*
IL-07	Structure and Energetic Behaviour of Light Crude Oil Molecules and Asphaltene Molecules at Rock-Oil Interface *Prashil Badwaik, Shubham Chobe, Bipasha Samantha, Meena Singh, Ateeque Malani*
IL-08	Fabrication of Composite Sponge Structure for Mitigating Oil Spill over Marine Water *Saurabh Mishra, Geetanjali Chauhan*
IL-09	Application of Bio based novel pour point depressants (PPDs) for flow assurance of Indian waxy crude oil *Tarun Kumar Naiya, Sampa Guin, Biswadeep Pal, Shirsendu Banerjee*
IL-10	A comprehensive approach towards execution of Sustainable, Eco-friendly and Energy Efficient Automobile Workshop and Transportation of Oil India Limited *Dipankar Deka, Sushant Kumar Gupta, Amorjit Bhardwaj*
Session-21, 9:00-11:00	**Day 3, 5th Nov 2023**
IL-11 09:00-09:15	Decarbonising the Indian Power Grid: Requirement, Opportunities and Challenges *Mohammad Rihan*

IL-01: CO_2 Foam Flooding in Hydrate Reservoir: Assessing Foam Stability in Reservoir Conditions with Nano-Particle Integration

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The exploration and production of methane gas from natural gas hydrate reservoirs hold great promise as an energy source but are accompanied by numerous challenges, including sediment production, subsurface subsidence, and environmental risks. Traditional field trials have encountered significant setbacks due to these issues, necessitating innovative solutions to tap into the vast potential of methane hydrate reserves. One innovative technique involves the injection of CO_2 foam to stabilize reservoir conditions, ensuring efficient methane recovery. However, a unique challenge arises from the endothermic nature of CO_2 hydrate formation, resulting in temperature drops near the injection point that can lead to methane hydrate reformation and ice accumulation. This solid layer can obstruct further CO_2 injection, impeding the overall process. To address these challenges, our project focuses on identifying gas mixtures that facilitate the exchange between CH_4 and CO_2. Rather than directly injecting CO_2 and the gas mixture, we propose the injection of optimally stabilized CO_2 foam, incorporating nano-particles for enhanced stability. This foam-based approach allows for the gradual destabilization of the foam within the reservoir, facilitating a progressive CH_4-CO_2 exchange process, ultimately leading to methane gas production. As a crucial initial step in implementing this method, we have conducted comprehensive studies on foam stability under reservoir conditions, utilizing various nano-particles at reservoir pressure and temperature to ensure the feasibility and effectiveness of our approach.

Keywords: CO_2 foam flooding; Foam stability assessment; Hydrate reservoirs; Methane hydrate production.

IL-02: EOR Opportunities in Depleted Reservoirs of Assam Arakan Basin: A Laboratory EOR Approach in Tengakhat Area of Assam

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Oil India Limited (OIL) is a fully integrated Exploration & Production company in the upstream sector, with origin dating back to the glorious year (1889) of crude oil discovery in India. A Maharatna Company, and a state-owned enterprise of the Government of India, under the administrative control of the Ministry of Petroleum and Natural Gas, OILis the second largest national oil and gas company in India. The company has operating interests across the country as well as in several foreign countries. Since inception OIL has drilled more than 1100 wells, produced about 200 MMTOE and accreted more than 300 MMTOE oil & gas. OIL has been able to maintain a production of around 3+ MMT oil /year over the last several decades notwithstanding the fact that the fields have been steadily on decline. Since most of the crude oil and gas produced by Oil India Limited (OIL) is from its matured and ageing fields, OIL has been continuously scouting for IOR/EOR opportunities including new fit-for-purpose technologies to be tested in the producing fields. Recent discoveries are small and geologically complex in structures. Structured approach towards intensification and integration of geo-scientific studies has led to sustained production over the decades. It has also helped in finding some new oil in old fields under its areas of operation. However, with decreasing size of new discoveries, implementation of EOR strategies with best reservoir management practices holds the key in sustaining the production level in the future. EOR has been implemented in OIL in past in different forms *viz.* polymer flooding, Microbial EOR, Low Salinity Water Injection (LSWI) in Oligocene, Miocene and Eocene reservoirs. LSWI has been implemented in OIL since 1966 till date (~40% STOIIP of OIL). In FY 2021-22, Contribution from LSWI has been ~5% of total OIL's production, whereas

the global average EOR production stands at 3% of the world oil production. Incremental Recovery factor from LSWI (low saline water injection) over primary depletion ranges from 10-15%.

As the continuous approach towards development of EOR techniques for betterment of oil recovery and sustainability, laboratory studies were carried out of Polymer screening, Asphaltene-Surfactant-Polymer (ASP) screening for maximum recovery of OOIP. Core flooding experiments were carried out through conventional core samples of two selected oil fields of Oil India Limited in Assam Arakan Basin. Furthermore, CO_2 flooding experiments were carried out using those core samples to measure the efficacy of CO_2 EOR in these areas. Among all three EOR methods applied in those core samples, the incremental oil recovery was experienced more in optimized ASP flooding than optimized polymer flooding and found maximum recovery of OOIP (original oil in place) during CO_2 flooding. These findings have been reported in this note as laboratory outcomes in three types of EOR methods.

Keywords: ASP flooding; Chemical flooding; CO_2 flooding; Core flooding; Enhanced oil recovery.

IL-03: Green Hydrogen for Decarbonization: Challenges and Future Perspectives

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Climate finance, green development and lifestyle for the environment are among the key priorities of India's presidency of the Group of Twenty (G20), under its chosen theme, Vasudhaiva Kutumbakam ("One Earth, one family, one future"). A drastic modification of our energy system and industrial processes is required to address the effects of climate change by moving from fossil fuels to low-carbon energy sources. There is need for technologies capable of converting electricity into energy carriers like chemicals and fuels, suitable for heavy transport at high efficiencies. The development of green hydrogen generation technology through renewable energy source may fulfill the current demand and play a significant role to achieve net zero by 2070. As is well known that most of the countries in the world are dependent on the fossil fuels-based economy as they use predominantly gasoline-based fuels. The transport sector such as automobile, trains, and planes are fueled by petroleum-based product such as gasoline and diesel across the world. The heavy power plants use fossil fuels such as oil, natural gas and coal for their fuel. The iron and steel industry are a major contributor to the overall anthropogenic CO_2 emissions worldwide, and therefore a significant driver of climate change. The steel industry uses coal as a source of energy to blast furnace for the conversion of iron ore to iron followed by steel. Green hydrogen is one of the most environmentally friendly energy sources, emitting almost no carbon. As a result, it is regarded as a potential fuel for vehicles and steel production in the future. Green hydrogen as a potential fuel may be consider to decarbonize the various industrial sector and address the major issues associated with fossil fuel-based economy. The transition from fossil fuel-based economy into hydrogen-based economy would lead to resolve the major issues such as (Emission of greenhouse gases (b) Continuous increase in temperature through burning of fossil fuels (c) Hazard development from fossil fuels and (d) Economic dependent. According to a 2020 analysis by the Council for Energy, Environment, and Water, solar-powered electrolyzers currently produce green hydrogen at a cost of USD 3.5-5.5 per kg. Currently, noble metal-based electrodes in electrolyser cells are used for efficient hydrogen production, which raises the cost of the electrolyser and thus the cost of hydrogen production. The cost of producing hydrogen, on the other hand, can be significantly reduced in two ways: by lowering the cost of cell electrodes and by extending cell life by avoiding the effect of hydrogen embrittlement. As a result, a new strategy for lowering hydrogen production costs is required and need of R&D work.

Keywords: Decarbonization; CO_2 emission; Green hydrogen; Hydrogen production.

IL-04: Application of Seismic Exploration Techniques in Exploration of Unconventional Hydrocarbons and CCS projects

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The present world is facing two big challenges, first, satisfying the increasing energy demand and second, mitigating climate change. In the past decade, there are only a few new oil reserves were discovered and out of them none is a giant oil reserve. The existing oil reserves are being depleted at a fast rate and thus there is an imminent need for new unconventional energy resources. The other problem of climate change is associated with large CO_2 emission from industries and thermal power plants. While we look for viable alternate energy sources, lowering CO_2 emission from such plants is another challenge. The carbon capture and sequestration (CCS) technique offers one such solution by permanently storing the CO_2 in the existing geological reservoirs.

To address the above two problems, the first requirement is a high-resolution subsurface image that can be obtained using seismic methods. The seismic method has been extensively used in hydrocarbon exploration and it is equally useful for the exploration of unconventional resources. In context of India, CSIR-NGRI has taken various initiative to address these two problems. For former problem, one of such initiative is the exploration of Coal Bed Methane (CBM) and Shale gas, unconventional hydrocarbon resources, which can cater to energy requirements of India. In this work, we present a systematic study for delineation of coal seams in Patratu valley, Jharkhand, and shale formations in Raniganj, WB. Further, we will also discuss some of the recent works related to CCS studies.

Keywords: Coal bed methane; Carbon capture; Sequestration; Seismic; Unconventional resource.

IL-05: Characterization of Polymers for Selection of Effective Candidate in Enhanced Oil Recovery

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Polymer characterization is one of the important steps for selection in enhanced oil recovery. All polymers are not suitable for field application. Therefore, systematic experiments are required for the proper characterization of polymer for field use. This study aims to evaluate the different polymer samples of PAM (polyacrylamide) to select suitable one for enhanced oil recovery techniques in production enhancement applications. Five polymers (A1, A2, B1, B2, and C) were used to select the suitable candidate for enhanced oil recovery application. Their performances in terms of oil recovery applications were investigated through rheological properties like viscosity measurement, thermal stability tests at different time periods (days), moisture content analysis, the particle size distribution of polymers by sieve analysis, bulk density measurements, intrinsic viscosity measurement through Oswald's viscometer test, and filtration ratio tests. Rheological studies revealed shear thinning characteristics with sample C of PAM showing superior rheological behavior at an evaluated temperature of 62 oC. Short-term stability tests on all samples from day zero to day 60 at 65 ^{o}C revealed some percentage loss of viscosity from the initial day to the final day. It has been found that the bulk densities of samples A1, A2, B1, B2 and C are 0.663, 0.676, 0.741, 0.744 and 0.716 g/ml respectively. The avg. moisture content of samples A1, A2, B1, B2 and C is 9.58, 9.33, 9.86, 10.06, and 9.46% respectively. The average particle size distributions of samples A1, A2, B1, B2 and C are 99.98, 99.85, 99.62, 99.49 and 99.53% respectively for 0.15 mm sieve size and 0.0153, 0.0325, 0.1874, 0.0655 and 0.127% respectively for 1.4 mm sieve size while nearly 0% for 2.3 6 mm sieve size. It has been found that the highest intrinsic viscosity of sample C at 2500 ppm concentration while the lowest intrinsic viscosity of sample A2 at 500 ppm concentration. In the rheological testing, we found the maximum viscosity of the B1 sample and the lowest viscosity of sample A2. The viscosity decreases from samples B1, B2, C, A1, and A2 respectively. The thermal stability of all samples has been checked by measuring the viscosity of all samples at different days' time spans such as on day 0, day 1, day 2, day 7, day 15, day

30, day 45, and day 60 at 62 ºC and shear rate from 1 to 1000 1/s. Based on the study B1 can be selected for enhanced oil recovery.

Keywords: Bulk density; Enhanced oil recovery; Polyacrylamide; Rheology; Thermal stability.

IL-06: Direct Thermal Liquefaction of Rice Husk to Produce Bio-Oil and High-Purity Amorphous Silica Nanoparticles

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Rice husk is a major by-product of rice milling, containing an approximate composition of 72-85 wt.% lignocellulose and 15-28 wt.% silica. The lignocellulosic part of the rice husk can be utilized to produce value-added products such as fuels, chemicals, etc., while silica can be utilized to produce silicon-based materials. Further, the produced bio-oil can be converted into green hydrogen by using gasification technology. Herein, we report a process route that utilizes the complete rice husk wherein the lignocellulosic part is converted into bio-oil while the silica part is recovered as amorphous silica nanoparticles. The process resulted in almost complete conversion of the lignocellulosic part of rice husk into a bio-oil with an exceptional yield of ~90 wt.%, thus leaving behind mainly ash in the solid residue with > 90 wt.% silica in it. Investigation of process parameters, such as temperature, reaction time, water concentration, and biomass loading, reveals a liquid yield of ~90 wt.% and solid residue with ~93 wt.% ash content can be achieved at 280 – 300 ºC for 20 to 30 minute reaction time. Most of the minerals in the rice husk landed in solid residue. The resulting solid residue was found to contain mainly silica in it with a concentration of ~ 98 wt.% (excluding organics). The solid residue upon further treatment, produced amorphous silica nanoparticles with high purity (99.64 wt.%), high surface area (~29 m^2/g), and narrow particle size distribution (40-50 nm).

Keywords: Biomass, Bio-oil; Liquefaction; Rice husk; Silica.

IL-07: Structure and Energetic Behaviour of Light Crude Oil Molecules and Asphaltene Molecules at Rock-Oil Interface

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The adsorption behavior of crude oil on the reservoir surface has a significant impact on the extraction efficiency of the solvent used to de-laminate crude oil from the reservoir surface. Therefore, a detailed understanding of crude oil-rock interactions and the specific role of exposed surface atoms is essential for designing efficient solvents. Here, we have investigated the structural and energetic behavior of light-oil (dodecane) adsorption on the calcite, mica, and silica surfaces, representing carbonate, clay, and sandstone reservoirs, respectively. We found that the structure of adsorbed light-oil has interfacial layers followed by a liquid-like behavior. We observed a strong bound layer of the light-oil on the calcite surface, which is absent in mica and silica surfaces. The dodecane molecules in the contact layer lie parallel to the surface and are epitaxially adsorbed on the calcite, near silicate chains on silica surfaces, whereas structured adsorption was observed on the mica surface. We investigated in details the reason for the observation by analyzing energetics of molecules in layer, with surface atoms and pair correlations functions.

The residual and heavy crude-oil has significant presence of asphaltene molecules due to which extraction of such crude-oil becomes difficult. In this work, we have studied energetics of asphaltene molecules of crude-oil with mica mineral surface in the presence of dodecane solvent, using molecular dynamics simulations. Five different types of asphaltene molecules (3-island type and 2-archipelago type) containing one heteroatom (oxygen, nitrogen, and sulfur) were considered. We have calculated the potential of mean force using an umbrella sampling technique. The adsorption free energy of saturate molecule is significantly lower compared to asphaltene molecules due to the presence of the heteroatom. Asphaltene molecules with a polar heteroatom (oxygen and nitrogen) interact with mica surface strongly as compared

to asphaltene molecules with a non-polar heteroatom (sulfur). The structural behavior of asphaltene molecules at the mica-oil interface is governed by the balance of enthalpic interactions between aromatic core atoms and the steric hindrance of aliphatic chain atoms with the mica surface. Asphaltene molecules with smaller aliphatic chains are arranged parallel to the mica surface.

Keywords: Asphaltenes; Dodecane; Molecular simulations; Potential of mean force.

IL-08: Fabrication of Composite Sponge Structure for Mitigating Oil Spill over Marine Water

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For numerous years, the global community has observed the consequences brought about by oil spills, leading to significant environmental challenges and negative impacts on human life. Various approaches and remedial strategies have been employed to effectively address oil spill clean-up; however, these methods have faced constraints and environmental concerns, resulting in their limited efficiency. The effects of oil spill vary depending on type of material spilled, the location of the spill, and the environment surrounding the spill. Oil spill in freshwater are a nasty mess that can cause a lot of problem for wildlife for a while. The nature of the problems is the best determined by the specific spill and location. Freshwater usually moves the spill away from the shore fairly quickly. The immediate effects on marine wildlife for a period of time due to damage to their skin, respiration, and the ability to float, among other things.

As a result of these environmental challenges, there is a pressing need to develop an environmentally friendly and economically feasible solution for reducing oil spills on water surfaces. The present paper highlights an innovative attempt in which a unique composite sponge structure was precisely fabricated in the laboratory. This novel sponge structure was remarkably effective at capturing and recovering spilled oil on the water's surface. Extensive experimental study was conducted to investigate the trapping efficacy under simulated oil spill scenarios. The experiment used a variety of oils, including diesel oil, mustered oil, and crude oils. The investigation includes a thorough examination, including the evaluation of contact angles with water and crude oil in order to determine the sponge surface and liquid interaction. The sponge structure that was fabricated displayed outstanding super hydrophobic and super oleophilic properties. Furthermore, the produced sponge structure's recyclability was rigorously tested, highlighting its sustainable nature. This fabricated sponge structure has the ability to protect the maritime environment from the devastation caused by oil spills.

Keywords: Human hair; Oil spill; PDMS; Sorption; Sponge; Sustainable.

IL-09: Application of Bio Based Novel Pour Point Depressants (PPDs) for Flow Assurance of Indian Waxy Crude Oil

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Precipitation of wax crystal during production or transportation of crude oil at lower temperature specifically below WAT is a serious flow assurance problem faced by the oil industry. Among several wax mitigation method, treatment of crude oil with polymeric additives known as Pour Point Depressants (PPDs) are extensively used to decrease the pour point as well as rheological properties of crude oil. However, the commercial PPDs are not effective on all types of crude oil and most of them are not environment friendly. Therefore, a continuous study of environmentally friendly PPDs is very important and the demand for research on green PPDs in the petroleum industry is increasing day by day. PPDs developed from natural

sources are biodegradable as well as nontoxic for environment. Present study has focused on synthesis of three bio based PPDs from Coconut oil, Shikakai and Amla fruit. Coconut oil ethyl ester (BPPD) was synthesized by transesterification reaction of coconut oil and ethyl alcohol in presence of KOH as catalyst. Shikakai Extract (SE) and Amla Extract (AE) were prepared using solvent extraction method in Soxhlet apparatus. All the synthesized PPDs were characterized by FTIR spectroscopy, GC-MS spectroscopy, CHNS analysis, DLS and TGA studies. Effectivity of these bio additives were measured by measuring pour point, viscosity, viscoelasticity, thixotropic area, yield stress of both virgin and bio based PPD treated crude oil. As well as a comparative study with commercial PPD was also carried out with same crude oil. From these investigations it was observed that BPPD was able to decrease the pour point by 12°C and viscosity by 94% after dosing of 800 ppm concentration. Other two PPDs i.e., SE and AE were also showed significant reduction of pour point and viscosity. Reduction of pour point and viscosity were achieved by 12°C and 9°C after addition of 1000 ppm SE and AE respectively. Rheological properties such as viscosity, yield stress, viscoelastic property and thixotropic area of PPD treated crude oil are also greatly decreased. Wax depositional thickness after addition of SE and AE with crude oil was investigate using Cold Finger Apparatus. Morphological analysis of wax after treatment with BPPD, SE and AE, it was shown that the wax crystals were dispersed and reduced in size after interacting with PPDs. Similar studies with commercial PPD (PPD-A) did not show influencing result. Hydrophobic long alkyl chain of synthesized PPDs adsorbed on to wax crystals and polar part i.e., ester group prevent the formation of three -dimensional network by steric hindrance. Therefore, the oil can easily flow through pipelines. From biodegradability test it was confirmed that BPPD, SE and AE are all biodegradable. As these are not harmful, so no special treatment will be required to separate these PPDs before send to the refinery.

Keywords: Environment friendly; Flow assurance; BPP; SE and AE; PPDs; Wax crystal.

IL-10: A Comprehensive Approach Towards Execution of Sustainable, Eco-friendly and Energy Efficient Automobile Workshop and Transportation of Oil India Limited

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The detrimental effects of conventional automobiles on the environment become increasingly apparent and hence there is a pressing need to develop sustainable alternative fuels as well as efficient mechanism that minimize greenhouse gas emissions, reduce reliance on fossil fuels, and mitigate other negative environmental impacts. The automobile workshops, being an integral part of transportation systems that keep these vehicles in roadworthy conditions, also generate various environmental pollutants and waste materials if not properly managed. Research across the globe on smart and sustainable auto workshops focusing on different aspects, including pollution, safety, working conditions, and efficiency are going on. Studies have investigated the emission of pollutants, including volatile organic compounds (VOCs), particulate matter (PM), nitrogen oxides (NOx), and carbon monoxide (CO), from automobile workshops. Various research aims to identify the sources of emissions, assess their impact on air quality, and propose strategies to minimize pollution levels with eco-friendly practices and green initiatives in automobile workshops. The in-depth study on the environmental impact of improper waste management and to suggest best practices for recycling used materials, such as oils, fluids, and fuels etc. is need of the hour.

This research paper investigates the concept of sustainable automobile workshop dedicated to scientific and innovative solutions for achieving environment friendly transportation. Key topics will include after treatment of disposed lubricating oil used in vehicles and thereby to promote circular economy; filtration and reuse of hydraulic oil used in mobile equipment and vehicles; External fuel filtration unit for enhancement of engine efficiency; replacement of conventional workshop illumination with LEDs and solar powered lights, replacement of roof top CGI sheets with heat insulated puff panels to reduce consumption of electricity. It also includes assessment of utilization of compressed natural gas (CNG) as alternative fuels and comparative study on associated reduction of carbon-di-oxide emission, evaluation of viability and environmental impact of CNG and other clean energy sources for automobiles, implementation challenges

related to distribution and infrastructure. This paper also analyze the overall impact of enhanced automobile efficiency on environment throughout their lifecycle achieved by implementing sustainable and innovative preventive maintenance practices.The findings will contribute to the broader goal of achieving sustainable transportation systems that mitigate climate change, reduce pollution, and promote a greener future.

Keywords: Alternative fuels; Electric mobility; Environment friendly transportation; Sustainable automobile workshop.

IL-11: Decarbonising the Indian Power Grid: Requirement, Opportunities and Challenges

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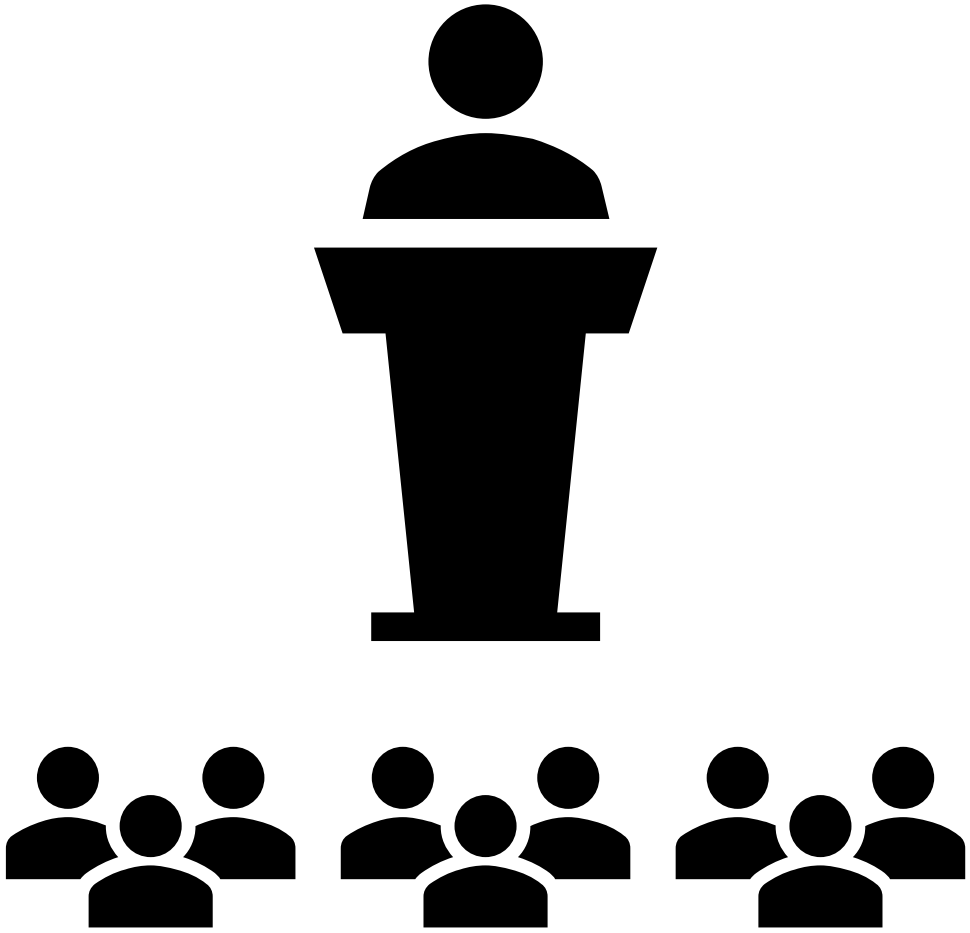
In view of the ongoing transition to green energy, many new challenges have come up. These challenges offer numerous opportunities for multidisciplinary and work. This talk shall be centred on the importnce of decarbonizing the Indian electric power grid in meeting the national goals declared in the 26th Conference of Parties at Glasgow as well as the updated nationally determined contributions of the country. The talk will address the challenges of electricity distribution in the presence of high penetration of green sources of electricity like solar energy. The research challenges arising out of the changing nature of the power grid shall be elaborated and the national initiatives on reducing the carbon footprint of the conventional electricity generation as well as on green hydrogen shall be covered. The emerging power grid with high penetration of solar and wind energy needs collaborative efforts from different engineering sectors. The engineering education has to be reviewed in the light of these developments. This shall also be discussed in the talk. The successful integration of solar energy in the distribution network of AMU and important lessons learned shall also be shared. The case study of a new joint M.Tech program started at AMU with the National Institute of Energy, Ministry of New and Renewable Energy shall also be discussed.

Keywords: Conventional electricity; Green energy; Hydrogen.



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OP-01: Enhanced Rock Physics Understanding for Bassein Formation Characterization Plant-based Phytochemicals for Synthesis of Z-scheme In_2O_3/CdS Heterostructure for Photocatalytic CO_2 Reduction to Fuels

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The energy demand has been increasing drastically due to industrialization and the improved living standard of human society. Global energy consumption has been estimated to rise by 28 % in 2040[1]. The boom in energy demand is largely fulfilled by the burning of non-renewable fossil fuels, and if this trend continues, existing fossil fuels will be depleted in the near future. Furthermore, excessive burning of fossil fuels leads to increasing greenhouse gas emissions in the environment. CO_2 is the primary driver of greenhouse emissions and contributes around 76%. Global CO_2 emission has reached over 36 billion tons per year with an atmospheric concentration of 412.5 ppm (source: International Energy Agency). Therefore, developing sustainable energy resources is highly imperative to fulfill the energy demand and control the greenhouse gas effect. Different technologies have been employed to reduce CO_2 emissions, such as biological conversion, catalytic conversion, thermochemical conversion, electrocatalytic conversion, photocatalytic conversion, and photoelectrocatalytic conversion. Among them, photocatalytic reduction has been considered one of the most effective techniques for the utilization of CO_2 due to its use of readily available abundant solar energy and economical reactant (H_2O) to convert value-added chemicals such as methanol, ethanol, formic acid, methane, carbon monoxide in an environmentally friendly process[2]. This process could mimic natural photosynthesis in the plant. Therefore, photocatalytic reduction of CO_2 is like killing two birds with one stone to solve energy and environmental issues simultaneously. Bio-based synthesis methods for semiconductor nanoparticles (NPs) offer several advantages over chemical-based approaches, including eco-friendliness, cost-effectiveness, one-pot synthesis, and abundant biomaterial sources[3]. Green pathways for NPs synthesis and utilizing them in CO_2 photo-reduction to useful chemicals could be a potential strategy for controlling industrial CO_2 emission. With their diverse tropical and subtropical plants, the Northeastern states of India could supply environmentally benign phytochemicals, which could act as potential capping and reducing agents for the efficient synthesis of semiconductor nanomaterials[4].In this study, we report the synthesis of phytochemical-based CdS nanoparticles found in *Aegle Marmelos*. Subsequently, CdS nanoparticles were modified to minimize their oxidative photo-corrosion and high electron/hole pair recombination. A bio-based method was employed to infuse In_2O_3 into the CdS semiconductor to enhance the separation and transportation of charge carriers and CO_2 adsorption, minimizing electron/hole recombination and photo-corrosion. The synthesized catalyst was evaluated for photocatalytic reduction of CO_2 under visible light, yielding formic acid and carbon monoxide as the products. The heterostructure also demonstrated stability and reusability.

Keywords: Bio-based heterostructure; CdS nanoparticles; Carbon monoxide; Formic acid; In_2O_3 nanoparticles; Photocatalytic CO_2 reduction

OP-02: Numerical Investigations on the Characterization of a Leaky Deep Saline Aquifer for Storing sc-CO_2

Tummuri Naga Venkata Pavan[1], Srinivasa Reddy Devarapu[2], Suresh Kumar Govindarajan[3]

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The increase in the emissions of greenhouse gases is driving the rapid climate change in the earth's environment. Carbon dioxide is one of the abundant greenhouse gasses emitted into the earth's atmosphere. Dealing with CO_2 emissions is a challenge for mitigating climate change. Capturing CO_2 gas is essential to limit gas emissions released into the surrounding environment. Carbon dioxide sequestration into deep

geological formations is a popular method of storing CO_2. Among these geological formations, deep saline aquifers are known to possess higher compatibility for better storage of CO_2. However, the leakage pathways prevailing in the aquifers reduce the CO_2 storage efficiency. The leakage paths in the aquifers are formed due to poorly sealed abandonment wells, faults and fracture networks in the caprock. Diffusive gas loss and induced migration with increased capillary pressure in the caprock also contribute to CO_2 leakages. Determining the leakage rates is essential for understanding the storage efficiency of the aquifer. Therefore, a numerical model is developed to evaluate the leakage rates economically. The present study considers a domain consisting of two interconnected aquifers with a leak in the caprock with an emphasis on understanding the influence of the distance of the leakage path from the injection source and the permeability of the leak on the CO_2 leakage rates. Further, two-phase fluid flow equations are considered for gas and water phases consisting of Brooks-Corey capillary pressure and relative permeability relationship. The evolving pore pressures and saturation within the domain are observed during the injection period. The results depicted that with an increase in the distance of the leakage path from the injection well, the pore pressure buildup increased, whereas the leakage rate reduced. In addition, the leakage rate was observed to decrease with a decrease in the permeability of the leakage path in the caprock. Overall, the study ascertained the influence of leakage path on the efficacy of the aquifer for storing CO_2.

Keywords: CO_2 Sequestration; CO_2 Storage; Deep saline aquifer; Leakage rate; Numerical modelling.

OP-03: Enhancing Carbon Mineralisation in Serpentinised Peridotite for Sustainable CO_2 Storage and Utilisation

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Carbon mineralisation is a promising approach for large-scale CO_2 storage and utilisation, with efforts focused on enhancing its cost-effectiveness by producing value-added products such as carbonates and critical energy metals. Carbon mineralisation entails the fixation of gaseous CO_2 into solid carbonate minerals by enhancing natural silicate weathering. This research investigates the integrated influences of CO_2 partial pressure (P_{CO_2}), temperature, and reaction time on carbon mineralisation efficiency in serpentinised peridotite. A high pressure-temperature batch reactor system was used to carry out direct carbon mineralisation reactions. The post-carbonation solid products were characterised using X-ray diffraction, X-ray photoelectron spectroscopy, and scanning electron microscopy. Additionally, inductively coupled plasma atomic emission spectroscopy was utilised to analyse the post-carbonation liquids. This enables the examination of critical metal mobilisation from the mineral matrix during the carbonation process and its consequential impact on water chemistry through leaching into the aqueous solution. Carbon mineralisation efficiency of ~24% was achieved at P_{CO_2} of 35 bars, a reaction temperature of 155 °C, and a reaction duration of 5 hours in the presence of 2 molal $NaHCO_3$ and 0.1 molal Na_2EDTA. Higher carbonation efficiencies (49% and 76%) were observed with extended reaction times of 10 and 18 hours at 185 ℃ under similar P_{CO_2} and solvent concentrations. A second set of experiments was performed to probe the effect of increased P_{CO_2} on the extent of carbon mineralisation. Reactions were carried out at 185 °C with P_{CO_2} of 50 bars for 1, 3, 6 and 10 hours under consistent solvent concentrations. An increase in the extent of mineralisation over longer reaction times was observed with carbonation extent of 44%, 63%, 70%, and 73% for reaction times of 1, 3, 6, and 10 hours, respectively. Magnesite was consistently formed in all experimental cases confirming the conversion of magnesium silicates to magnesium carbonates during the carbonation process. Significant morphological changes were observed in all the reacted samples, with carbon mineralisation efficiency correlating with the aging process of magnesite crystals. The post-carbonation liquid analysis of serpentinised peridotite showed the presence of metals, including nickel and iron, in aqueous solution. The mobilisation of these metals from the rocks into the aqueous phase was attributed to the addition of an organic ligand, EDTA, during the carbonation process. Nickel exhibited the highest extraction rate at 80%, followed by iron at 33%. The stability of metal-ligand complexes and the

mineralogy of the host rock play significant roles in metal extraction. These findings reveal the importance of elucidating simultaneous chemical and morphological changes in magnesium-bearing silicate minerals and rocks when exposed to CO_2. Additionally, the study offers insights for developing engineered pathways to accelerate carbon mineralisation process while leaching energy critical metals into aqueous solution, thus enabling a pathway for sustainable solution mining with inherent carbon mineralisation.

Keywords: Carbon mineralization; Carbonate Formation; Metal recovery; Serpentinised peridotite; Ultramafic rocks

OP-04: An Innovative Biphasic Amine Blend for Post-combustion Carbon Dioxide Capture

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Carbon Capture and Storage (CCS) holds significant importance to address climate change. Currently, among the various carbon capture methods, liquid absorption-based processes emerge as the most practical and effective means of capturing post-combustion carbon dioxide. However, state of the art amine-based solvents demands substantial energy input, that results in high operational expenses. The concept of utilizing biphasic solvents for carbon dioxide capture has attracted considerable attention due to its potential to substantially reduce the energy burden on power plants. Here, we proposed a novel biphasic aqueous solvent consist of two types of polyamines: primary/secondary (PS) and tertiary (T). We tested three different ratios of PS amine: T amine (4 M total concentration) at 40 °C absorption temperature. We measured the CO_2 uptake, volume, phase separation time and density of each phase. The best ratio was 3:7, which achieved a high CO_2 capture capacity of 0.71 mol CO_2 per mol total amine. Interestingly, the lower phase, which was only 60% of the total volume, captured 74% of the CO_2. Moreover, the phase separation was very fast, within 7.5 minutes. We used ^{13}C NMR technique to study the reaction mechanism between CO_2 and amine blend. Furthermore, speciation study was performed to know the product formed. It was observed that PS amine formed primary carbamate with CO_2, while T amine was protonated and facilitated the reaction between PS amine and CO_2. The lower phase mainly contained PS amine carbamates and HCO_3^-/ CO_3^{2-}, while the upper phase had mostly unreacted/protonated T amine. It is observed that, the density difference between the phases is responsible for phase separation.

Keywords: Biphasic amine blend; Carbamate; Carbon capture; Separation time.

OP-05: Supercritical Carbon Dioxide Fracturing of Shale Reservoir and Geological Sequestration: An Approach for CO_2 Utilization and Storage

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Hydraulic fracturing has brought a transformative approach to tapping into shale resources for hydrocarbon extraction. Hydraulic fracturing using water has become a prevalent method for enhancing shale gas production. This technique is plagued by significant water usage and environmental apprehensions. Moreover, growing concerns about sustainability and the environment have driven interest in exploring alternative fracturing methods. Recently, the utilization of CO_2 as a fracturing fluid has emerged as a promising alternative, offering a range of advantages, such as carbon storage and improved shale gas recovery. Supercritical carbon dioxide ($ScCO_2$) fracturing has emerged as a novel technique to stimulate the shale reservoirs. This technique requires CO_2 in its supercritical state (7.38 MPa and 31.1°C) to create fractures within shale formations, consequently enhancing the permeability of reservoirs. $ScCO_2$ shows strong permeability, low viscosity, and extremely low surface tension, like gas, because of which it can

infiltrate any space larger than its kinetic diameter (0.330 nm). It can fracture rock at a lower fracturing pressure than slick water. This work delivered recent advancements, technical prospects, applications, and the impact of $ScCO_2$ on shale reservoirs during the fracturing procedure.

The urgent need to combat climate change and transition to sustainable energy sources has amplified the significance of carbon capture, utilization, and storage (CCUS) technologies. In this context, $ScCO_2$ fracturing serves a dual purpose: enhancing reservoir permeability to enable efficient CO_2 injection and providing a mechanism for secure CO_2 storage within the fractured shale reservoir. Shale reservoirs, recognized for their low permeability and intricate pore networks, emerge as promising candidates for securely sequestering CO_2 emissions. While storing CO_2 effectively within shale gas reservoirs is challenging due to their limited permeability and storage capacity, fracturing shale to expand pore space and surface area offers a promising solution. This approach facilitates secure storage of a portion of the CO_2 injected for shale gas extraction within shale formations. This reduces carbon emissions and paves the way for achieving a zero-carbon footprint. This study also aims to achieve sustainable CO_2 storage in shale reservoirs that have been fractured using ScCO2 as the fracturing fluid.

Moreover, gaining a comprehensive understanding of the interplay between $ScCO_2$ and shale rock and the potential for sustained CO_2 storage in shale formations remains a formidable challenge. This is attributed to a need for more research and more knowledge in this domain. Therefore, advancing the field of $ScCO_2$ fracturing and comprehending CO_2 interaction with shale rock demands further rigorous investigation and developmental efforts.

Keywords: Carbon Emissions; Geological Storage; Hydraulic Fracturing; Shale Gas; Supercritical CO_2; Zero-carbon footprint.

OP-06: Carbon-Neutral Vehicular Fuel Production: Innovations in CO_2 Hydrogenation with MEA and Electrolysis

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Carbon neutrality is a critical goal in the fight against climate change, aiming to balance carbon dioxide (CO_2) emissions with removal and offset measures, effectively resulting in no net increase of CO_2 in the atmosphere. One innovative approach contributing to carbon neutrality is the production of non-conventional vehicular fuel through the hydrogenation of CO_2. Hydrogenation of CO_2 involves using renewable hydrogen (H_2) gas to convert carbon dioxide into hydrocarbon fuels, such as synthetic gasoline, diesel, or aviation fuel. This research targets handling the CO_2 liberated in the flue gas from the Cracker Unit of Brahmaputra Cracker & Polymer Limited (BCPL) and utilizing the stored CO_2 to produce non-conventional vehicular fuel to reduce CO_2 in the environment, hence taking a step forward towards carbon neutrality. Experimental studies show the use of Silica Nanoparticles (SiNP) obtained from the burning of the raw rice husk in the open air (RHSA) and in a Muffle Furnace at 540 °C (RHSO) has an efficiency of the two SiNP samples (5 to 450 nm) in adsorbing CO_2 from flue gas when SiNP was added to MEA (Monoethylamine). Absorption of CO_2 from flue gas on MEA increases upon adding SiNP because of the Brownian motion in the base fluid and velocity disturbance. CH_3OH & C_2H_5OH from hydrogenation of CO_2 was produced in an autoclave reactor, while production of DME from dehydrogenation of CH_3OH was attempted in a tubular reactor. The results from the conducted research for CH_3OH, C_2H_5OH & DME produced were qualified & quantified by NMR & GC-MS. In conclusion, the hydrogenation of CO_2 to produce non-conventional vehicular fuel represents a promising pathway toward carbon neutrality. As efforts to combat climate change intensify, innovations like hydrogenation play a pivotal role in transitioning toward a more sustainable and environmentally friendly energy future.

Keywords: GC-MS; Hydrogenation; NMR; Silica nanoparticles.

OP-07: Investigating Oil Recovery through Miscible and Immiscible Displacement of Oil by Polymer Alternating Gas Injection

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In light of depleting conventional oil reserves and rising global warming, CO_2 -EOR has garnered global attention among stakeholders for its potential to evolve into a net carbon-negative technique for extracting residual oil. Among CO_2-EOR methods, water alternating gas (WAG) injections have been adopted in over 90% of CO_2-EOR projects worldwide due to improved mobility control and better volumetric sweep efficiency as compared to conventional gas and water injection. However, the sweep efficiency can be further improved by substituting water with polymer, owing to its greater viscosity. This paper aims to study the mechanism involved in miscible and immiscible displacement of oil by polymer alternating gas (PAG) injection. To start with, the miscibility of Indian crude oil with CO_2 was assessed using empirical correlations and the vanishing interfacial tension (VIT) technique. The oil displacement mechanism by CO_2 injection was studied using IFT measurements and rheology of crude oil under different CO_2 equilibrium pressure conditions. Observations revealed that as CO_2 equilibrium pressure increased, there was a reduction in the interfacial tension (IFT) between the crude oil and CO_2 system, attributed to the exchange of CO_2 and intermediate hydrocarbons (HCs) across the interface. It has been further observed that IFT value decelerated at a slower rate at higher CO_2 equilibrium pressure due to asphaltenes coming out of the oleic phase and depositing on the interface. Subsequent rheological studies on crude oil indicated a decreasing trend in oil viscosity with increasing CO_2 equilibrium pressures, thereby improving oil mobility. The rheological and injectivity studies of the polymer were conducted using hydrodynamic dimension analysis, resistance factor, and residual resistance factor to assess the flowability of the polymer within the core. Ultimately, PAG flooding was conducted on two low-permeable carbonate cores with CO_2 injected at both miscible and immiscible modes. Post-waterflood, the additional oil recovery was around 23% for immiscible-CO_2 PAG flooding whereas miscible-CO_2 PAG recovered 41% of OOIP. During supercritical CO_2 (sc.CO_2) injection in miscible-CO_2 PAG, the increase of permeability of the core from 10.3 mD to 23.1 mD did not yield additional oil recovery. This phenomenon could be explained by the fact that a stable diffusion coefficient for sc.CO_2 is achieved after an initial increase with increasing permeability of the core. Conversely, when injecting gaseous CO_2 during immiscible-CO_2 PAG, an additional 4% oil recovery was observed post-waterflood in 23.1 mD core as compared to 10.3 mD core. Moreover, the CO_2 utilization factor was found to be highest for CO_2-miscible PAG in a 10.3 mD core. In conclusion, the effectiveness of PAG is highly dependent on the mode of CO_2 injection, the permeability of the core, and the difference in the dimensions of the pore throat and polymer hydrodynamic dimensions.

Keyword: CCUS; CO_2-EOR; Miscible flooding; PAG.

OP-08: Assessment of Geological Carbon Sequestration Potential in Deccan Traps Basaltic Formations: Transforming Emissions into Resources

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This study provides a brand-new technique for geological carbon sequestration in India's basaltic Deccan Traps. The primary objective is to present a novel method for converting carbon dioxide (CO_2) emissions into stable carbonate minerals using software tools and computer-based simulations. By utilizing computer models of mineral processes, the initiative aims to successfully remove carbon while producing carbonate resources. The project's scope includes addressing knowledge gaps, evaluating the practicality of the simulation-based method, and examining its application in developing nations. The study technique is focused on computer-based simulations and software tools for modelling mineralization processes in the basaltic rocks of the Deccan Traps. The selection of adequate geological data and pertinent physical phenomena is the first step in building computer models. The minerals in the formations that are most

conducive to CO_2 mineralization are found through virtual geochemical analysis. The monitoring of mineralization processes over a variety of timelines is made possible by the subsequent injection of supercritical CO_2 into computer-based models of basaltic materials. Numerical modelling is utilized to estimate mineralization reactions and predict CO_2 behavior within the simulated formations. When determining economic feasibility, the technique also considers prospective resource generation. It may be used to track the social, policy, and environmental implications through virtual scenarios, which enables a complete evaluation of the recommended simulation-based solution. The research produces notable findings and observations. The simulations successfully show how CO_2 is transformed into stable carbonate minerals by virtual mineralization within the basaltic Deccan Traps formations. A variety of temporal scales are used to monitor the virtual conversion process, providing insights into reaction kinetics. The research is significant in that it highlights commercially viable features of simulation-based methodology, demonstrating the possibility for resource creation through virtual mineralization. The study also sheds light on the wider applicability of carbon sequestration techniques, particularly in underdeveloped countries. The conclusions drawn emphasize the simulation-based mineralization's ability to change the world and highlight its special advantages for the world of carbon sequestration. In this work, carbon storage and resource generation are combined through computer-based simulations to give a novel viewpoint on carbon sequestration. The novel mineralization procedure virtually creates commercial value in addition to addressing environmental issues. This strategy offers a transformative solution that is in line with economic and sustainability objectives, thus practicing engineers stand to earn significantly from it. The application of this research provides a promising path toward a more sustainable future, making it an important contribution to the body of knowledge on carbon sequestration techniques.

Keywords: CO_2 mineralization; Deccan traps; Geological carbon sequestration; Simulation-based approach; Sustainable resource generation.

OP-09: Capture of CO_2 by Choline Chloride and DL-menthol based Deep Eutectic Solvent: A Molecular Dynamics based Investigation

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Deep eutectic solvents (DESs) are the newest edition in carbon capture solvents which are effectively utilized to capture CO_2. Usually, amine and aqueous alkali-based liquid solvents are reported heavily in the literature. However, higher toxicity and complex regenerative process act as hindrances making the process unsustainable and costly. Deep eutectic solvents (DES) can act as a suitable green alternative as CO_2 is highly soluble in DES and are capable of physically absorbing CO_2 resulting in higher conversion. We have investigated several choline chloride and DL-menthol based DES systems for CO_2 absorption. The present study addresses the CO_2 absorption and solubility performance of the selected DESs in pure CO_2 as well as in air mixtures, mimicking real-world conditions with a composition of 400 ppm CO_2, 21% O_2, 79% N_2, with theoretical validation by molecular dynamics (MD) simulation study. Key parameters of interest include the diffusivity of CO_2 within the DES phase, various structural properties such as radial, combined, and spatial distribution functions, transport properties like mean square displacement and diffusion coefficient, and additional properties such as hydrogen bonding and non-bonded interactions encompassing electrostatic and van der Waals forces. Our comprehensive analysis demonstrates that DES-CO_2 interactions exhibit favorable characteristics, encompassing charge transfer and non-covalent interactions. These interactions contribute to greater dissolution properties, ultimately resulting in superior conversion rates and highlighting the potential of deep eutectic solvents as a sustainable and efficient solution for CO_2 capture. Overall, we can say, these DESs are a promising class of materials for CO_2 capture. They offer a number of advantages over other CO_2 capture materials, including high CO_2 absorption capacity, fast CO_2 absorption kinetics, reversible CO_2 absorption, stability, hydrophobic nature, low toxicity, and low cost.

Keywords: Carbon capture; CO_2 absorption; deep eutectic solvents; molecular dynamics.

OP-10: Numerical Simulation Advances in Carbon Capture, Utilization, and Storage (CCUS) in Shale Gas Reservoirs: A Comprehensive Review

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The confluence of escalating global concern over anthropogenic carbon dioxide (CO2) emissions and the dynamic energy landscape has underscored the pivotal role of Carbon Capture, Utilization, and Storage (CCUS) techniques in mitigating greenhouse gas emissions. In particular, the unique attributes of shale gas reservoirs have positioned them as promising repositories for CO_2 sequestration. This review presents an in-depth investigation into the advancing domain of numerical simulations applied to CCUS within shale gas reservoirs. Comprehending the significance of such simulations in elucidating intricate processes, optimizing injection strategies, and addressing environmental implications is imperative for fostering effective and sustainable CO_2 storage solutions. The review encompasses a multifaceted exploration of ten key sections. These sections traverse the landscape of CCUS techniques, the role of numerical simulations in modeling fluid flow, CO_2 migration, and reservoir behavior, the underpinning advancements in reservoir characterization through micro-seismic monitoring and 3D seismic imaging, as well as diverse CO_2 injection strategies and their ensuing effects on reservoir behavior. Additionally, the geo-mechanical and geo-chemical considerations pertinent to CO_2 injection within shale gas reservoirs are critically examined. Environmental ramifications and risk assessment within the CCUS framework are scrutinized, with an emphasis on the role of numerical simulations in predicting potential impacts.Moreover, the review encapsulates success stories through case studies, spotlighting the efficacy of numerical models in predicting CO_2 plume migration, pressure behavior, and enhancing overall reservoir management strategies. Gaps in understanding and the future research trajectory are presented, encompassing knowledge gaps in CO_2 storage mechanisms, geochemical interactions, and induced seismicity. Additionally, the review emphasizes the role of numerical simulations in bridging these gaps and driving advancements in CCUS strategies. Amidst this context, the review amalgamates vital research insights, illustrating the interconnection among numerical simulation applications, objectives, models, optimization techniques, and findings. Moreover, the abstract underscores the vital role of numerical simulations in enhancing our comprehension of CO_2 behavior within shale gas reservoirs. This contribution will help propel the progression of CCUS strategies, which are crucial for achieving sustainable carbon management.

Keywords: Carbon capture and storage; Geo-mechanical considerations; Geo-chemical interactions; Numerical simulations; Shale gas reservoirs.

OP-11: Experimental Study on CH_4 Gas Production from Simulated Methane Hydrate Reservoir using Depressurization and CO_2 Injection

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The energy scenario in India is highly strained due to growing industrialization and a significant increase in population. At present, India is reliant on other countries for importing most of its energy needs. India constitutes 17% of the world population whereas it has only 0.6% and 0.4% of world gas and oil. Therefore, the Government of India has decided to reduce the import energy burden to 10% by 2022 and also increase the gas contribution in the Indian economy by 6 to 15%. This can be efficiently be achieved by either relying on renewable sources of energy or by developing existing unconventional sources of energy such as Natural gas hydrate and Shale oil/gas. Harnessing methane from gas hydrate becomes vital for the energy security of India. A huge deposit of gas hydrate has been found in expeditions done by various companies in India

under the national gas hydrate program (NGHP). About 1900 TCM of methane is expected to be trapped in gas hydrate marine settings in India which are about 1500 times more than all conventional resources combined. National has hydrate program-1 (NGHP-1) was successful in finding gas hydrate in India with the highest gas saturation compared to world, mostly found in Krishna-Godavari and Mahanadi Basin. However, the sites carrying gas hydrates were delineated mostly in filling fractures and fine-grained. As methane production from hydrate depends on intrinsic properties such as permeability, porosity, water content, and saturation, at present, with available technologies it difficult to propose these sites for production activities. Many production trials have been attempted in different countries but commercial production is still a challenge. The objective of work performed is to study the effect of depressurization and CH_4- CO_2 exchange method on CH_4 recovery from simulated CH_4 hydrate reservoir. We estimated the methane production rate, and CO_2 hydrate formation at variable depressurization pressure and extent of replacement. During the whole process, the effect of particle size, porosity of sediments taken on hydrate saturation, permeability, and rate of CH_4 gas production was studied. Sand and water production also studied to find the stability of simulated reservoir before and after exchange.

Keywords: Krishna-Godavari and Mahanadi basin; Permeability; Shale oil/gas.

OP-12: Simulation of Trapping Indexes for CO_2 Sequestration in Heterogeneous Saline Aquifers

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Carbon dioxide (CO_2) sequestration is a pivotal strategy in mitigating greenhouse gas emissions and combating climate change. While there are multiple potential sites for CO_2 sequestration, saline aquifers stand out for their superior performance owing to their greater storage capacity and the advantageous solubility of CO_2 with brine. This paper introduces the various geological and hydrogeological parameters that intricately impact the trapping index, a vital metric for assessing storage efficiency. The work done delves into the complex interactions between key parameters porosity, permeability, residual gas saturation, depth, heterogeneity, thickness, salinity and their collective influence on the trapping index. A simulation for 10 years of injection and 300 years of monitoring was conducted by using generalized equation-of-state model compositional reservoir simulator (GEM), which can simulate the flow of the CO_2 to verify major trap mechanisms and sequestration characteristics in the system. Porosity and permeability are the foundational properties that determine the potential for CO_2 storage within saline aquifers. Higher porosity provides a more extensive storage capacity for CO_2, while increased permeability facilitates its migration within the formation. The heterogeneity within a saline aquifer, represented by variations in porosity and permeability, can significantly affect the trapping index. Heterogeneous formations may result in uneven trapping patterns, impacting overall storage efficiency. The thickness of the saline aquifer is another determinant of the trapping index. A thicker formation can accommodate more CO_2, potentially enhancing the trapping index. Salinity levels in the brine have a notable influence on CO_2 sequestration. As brine salinity increases, the solubility of CO_2 decreases, potentially diminishing overall trapping efficiency. In summary, CO_2 sequestration in saline aquifers is a multifaceted process shaped by various parameters. Porosity, permeability, residual gas saturation, depth, heterogeneity, thickness, and salinity all play crucial roles in determining the trapping index. By capitalizing on the advantageous attributes of saline aquifers, such as their greater storage capacity and CO_2 solubility, and by understanding the interplay of these parameters, we can optimize CO_2 storage projects, achieving efficient and long-term sequestration to significantly contribute to global climate change mitigation efforts.

Keywords: CMG-GEM; Heterogeneous reservoir; Residual trapping; Saline aquifer; Solubility trapping.

OP-13: Investigation on the Formation of Instabilities during Fluid Injection through Porous Media

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Understanding the mechanics of fluid flow through porous media is of paramount importance in various engineering applications, including oil extraction, contaminant transport, hydraulic fracturing, and grouting. The mechanisms involved during fluid injection into porous media are influenced by several factors, including the packing density, rheology of the injected fluid, injection rate, and other boundary conditions. During fluid injection, the porous medium transitions from solid-like to fluid-like behavior due to large deformations leading to the formation of instabilities. Although prior research has explored instability pattern formation and various displacement regimes, a fundamental knowledge gap persists concerning the transition from cavity to finger-like formation and the underlying factors that shape this phenomenon. The present study investigates the fluid injection induced cavity expansion and finger formation in porous medium by performing a suite of controlled laboratory scale experiments using a modified Hele-Shaw setup along with imaging. During onsite fluid injection (consisting of drilling mud), the dynamic particle migration process results in the formation of very low-permeability filter cake on the surface of the porous medium. This impermeable and low stiffness filter cake governs the deformation process leading to the formation of instabilities. To simulate this phenomenon in the laboratory, a rubber membrane is adopted through which the fluid is injected using a syringe pump at a constant injection rate. Further, the effect of various parameters such as injection rate, grain size distribution and packing on the cavity expansion and transition from cavity to finger formation is systematically examined. Analysis of the captured images using Digital Image Correlation (DIC) provides detailed quantification of the deformation field near the cavity and finger. Investigation on the evolution of cavity size, finger shape and size, and injection pressure results in better interpretation of the instabilities at specific boundary conditions. These findings contribute to a collective understanding of the complex coupled-physical mechanisms driving cavity expansion and finger formation.

Keywords: DIC; Filter cake; Hele-Shaw; Instability; Transient.

OP-14: Modeling the Transport and Retention of Nanoparticles in a Single Partially-Saturated Pore in Soil

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Pore-network models are powerful tools for studying particle transport in complex porous media, and investigating the role of interfaces in their fate. The first step in simulating particle transport using pore-network models is to quantitatively describe particle transport in a single pore, and obtain relationships between pore-averaged deposition rate coefficients and various pore-scale parameters. So, in this study, a 3D mathematical model is developed to simulate the transport and retention of nanoparticles within a single partially-saturated pore with an angular cross-section. The model accounts for particle deposition at solid-water interfaces (SWI), air-water interfaces (AWI), and air-water-solid contact regions (AWS). We provide a novel formulation for particle diffusive transport from AWI to AWS, where particles are assumed to be retained irreversibly by capillary forces. The model involves twelve dimensionless parameters representing various physicochemical conditions. The 3D model results are averaged over the pore cross section and then fitted to breakthrough curves from 1D advection-dispersion-sorption equations with three-site kinetics to estimate 1D-averaged deposition rate coefficients at interfaces. We find that half-corner angle, particle size, radius of curvature of AWI, and mean flow velocity have a significant effect on those coefficients. In contrast, chemical parameters such as ionic strength and surface potentials of particles and interfaces have

negligible effects. AWS is found to be the major retention site for particles, especially for hydrophobic particles. We develop algebraic relationships between 1D-averaged deposition rate coefficients at interfaces vis-à-vis various pore-scale parameters. These relationships are needed for pore-network models to upscale nanoparticle transport to continuum scale.

Keywords: Air-water interface; Deposition; Nanoparticles; Partially-saturated soil; Pore-scale modeling.

OP-15: Numerical Characterization of Capillary Driven Flow in Layered Porous Reservoirs

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For gas storage in the geological porous reservoirs, it is important to understand fluid flow behaviour when capillary forces are dominant i.e., after the gas injection stops. In this work, we use MATLAB Reservoir Simulation Tool (MRST) for numerically simulating unidirectional flow assuming horizontal displacement in co-current mode to understand the phenomenon of spontaneous imbibition in layered porous reservoirs at Darcy scale. Using our model, we want to predict if capillary breakthrough is possible and how the gas distribution takes place in layered reservoirs. The core dimensions of 5 m x 1 m x 1 m are used for two-layered reservoirs. We placed an additional grid cell of pore volume ten times to that of the core at one end of the setup which acts as a water tank. The boundary conditions in simulation are controlled using the wells. We positioned one injector well in the water tank and one production well at the other side of the core with pressures of both the wells being the same to allow for capillary driven flow. For a single layered, homogeneous system, we compared the obtained saturation profiles from the simulation with the analytical solution published in the literature. Comparisons are provided for three different wettability states for oil-water systems. For mixed wet and weakly water wet cases, the numerical solutions show an excellent match with the analytical solutions. We validated our simulation model using several cases of the homogeneous reservoirs of different petrophysical properties, relative permeability, capillary pressure - saturation curves, and varying mobility ratios. Using our model for homogeneous porous media, we observed that the fluids propagate with different velocity in the sediments and wetting fluid reaches farther through the larger permeability layer. However, in the case of layered reservoirs, the fluid propagation velocity seems to be similar in high and low permeability layers. We observed that the interaction of layers has a significant impact on fluid flow and there is a fluid transfer between layers. One of the applications of this model is to estimate gas migration in layered sediments for determining the long-term CO_2 storage capacity and security.

Keywords: Capillary pressure; Darcy scale; Saturation profiles; Spontaneous imbibition; Wettability.

OP-16: Multiphase Flow Modeling using Reduced Order Model and Full Scale Model: A Comparison

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The rise in atmospheric CO_2 level causes global warming, melting of ice in the polar regions and, consequently, climate change. In order to store a large quantity of CO_2 in a subsurface the best possible solution is injecting it into deep saline aquifers. Thus, the injected CO_2 will get trapped over time in the saline aquifer by means of four distinct stages of trapping mechanisms—hydrodynamic trapping, residual trapping, solubility trapping, and mineral trapping. The present study focusses only on the first stage when the CO_2 rises to the top of the formation i.e. hydrodynamic trapping. In this paper, the salient features of the Element Free Galerkin (EFG) method are presented with the method being applied to a study on the vertically averaged multiphase flow of CO_2 and brine numerical simulation in the deep saline aquifer. In

this EFG method, interpolation (approximation) is carried out based on nodes without using elements and hence an arbitrary aquifer shape can be modeled by locating the field nodes on the domain. The numerical approach solves two governing partial differential equations namely pressure and saturation equations sequentially (implicit pressure and explicit saturation) which were developed using vertically averaged two-phase flow model by combining mass conservation (continuity equation) and multiphase extension of Darcy's law. The bottom pressure and saturation are discretized using the EFG shape functions. The Bubnov–Galerkin method weak form is used to create the discrete system of equations and a Crank-Nicolson method used for discretization in the time domain. Implementation of Dirichlet (or first-type) boundary conditions is based on the Lagrange multipliers method. In order to capture the asymptotic pressure behaviour near to the injection wells, a local nodal refinement zone was introduced around the well. The heterogeneous interface was captured using functionally graded materials. The computed pressure and saturation were compared with existing approximate grid based FEM and XFEM (extended FEM) numerical solutions to demonstrate the validity of the developed model and its capabilities. The model successfully simulated the vertically averaged two-phase flow process in the aquifer with less number of nodal density saving computational time. The evolution of bottom pressure diffusion near to the well and evolution of average saturation profiles due to injection of supercritical CO_2 in the aquifer system was obtained. These results could be used to study the integrity of caprocks and storage capacity of the aquifers. This model could easily be extended for varying aquifer depths, heterogeneous aquifer properties with multiple sources and sinks. Thus the above obtained reduced order model results are compared with the full scale EFG multiphase flow model results and LANL's (Los Alamos National Lab) FEHM (Finite Element Heat and Mass) computer code. The key difference between these two models for large scale problem is also discussed in this research work.

Keywords: Caprock integrity; CO_2 sequestration; Deep saline squifer; Element-Free-Galerkin (EFG) method; Finite element method; Full scale model; Vertically averaged multiphase flow model.

OP-17: Isolation and Characterization of a Probiotic from Panitenga- An Assamese Fermented Food and Exploring its Potential for Biosurfactant Production

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Fermented food products have known to be rich in diverse range of probiotics, since ages. "Panitenga", an Assamese fermented food product was explored for the potential probiotic isolation. A potential lactic acid bacteria (LAB) strain was isolated following serial dilution, giving their confirmatory growth into deMan Rogosa Sharpe (MRS) agar, as a selective media. The isolated strain was further screened and characterized via microscopy (simple and gram staining) and various biochemical and functional tests. The isolated bacterial strain was found to be gram negative bearing mainly bacillus shaped, non-motile cells. Further, the growth kinetics of the isolated probiotic strain was studied for seven days, bearing an exponential phase on second to third day, followed by a stationary phase. Various environmental parameters were optimized including pH (2, 3, 4, 5, 6, and 7), temperature (4°, 15°, 25°, 30°, and 37°), revolutions per minute (rpm-100, 130, 170, and 200), carbon sources (dextrose, lactose, maltose, molasses, and crude oil), and nitrogen sources (yeast extract, peptones, ammonium sulfate, and urea) to obtain maximum cell growth. The best optimized conditions for the isolated strain were found to at pH 5, 30° C, 200 rpm, dextrose as a carbon source, and yeast extract as a nitrogen source. Moreover, the LAB strain was determined for its ability to produce biosurfactants by performing preliminary tests like emulsification index test, oil displacement test, drop collapse assay, and surface tension measurement. The isolated strain produced convincing results for biosurfactant production i.e., 9.088 g/L yield at the best optimized parameters. The extracted biosurfactant reduced the surface tension to 38.512 ± 0.100 mN/m, oil displacement activity was detected with a diameter of 7.4 cm, and an emulsification index value of 41.66% was found. The biosurfactant obtained was then characterized using FTIR and HRMS for their structural and chemical composition confirmation. Therefore, the isolated strain can act as a promising biosurfactant producing microbe, that can be further utilized for an effective crude oil bioremediation purpose.

Keywords: Bioremediation; Biosurfactant; LAB; Panitenga; Probiotic.

OP-18: Enhanced Rock Physics Understanding for Bassein Formation Characterization through Ultrasonic Velocity and Attenuation Analysis

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Seismic rock property investigations bridge the gap between laboratory-based models and field reservoir characterization, which is critical for efficient hydrocarbon exploration and production. This research focuses on the Bassein Formation, a large hydrocarbon deposit in India's Western Offshore. This study examines the ultrasonic velocity and attenuation behavior in homogeneous, intermediate, and heterogeneous carbonate rocks to analyze the complex interplay between the composition of the rock, the pore structure, the fluid saturation, and its interaction with the rock which contributes to the alteration in the propagation of ultrasonic waves. Initial dry ultrasonic measurements were used to create baseline velocity data for each group of samples. Following brine saturation, additional observations revealed distinct patterns in compressional and shear wave velocities. It is noteworthy that homogeneous samples showed a 2% increase in compressional-wave velocity from dry to saturated states while shear velocity experienced a 7% decrease. Intermediate samples displayed a 9% increase in compressional velocity with shear velocity dropping up to 6.5%. Heterogeneous samples exhibited the most significant alterations in velocities indicating a 9.3% jump in compressional velocities and a 10.7% decrease in shear velocities understandably due to the complexity of the texture. Consequently, the Vp/Vs ratio, which is a direct diagnostic for fluid and its interaction with the host rock, demonstrated notable alterations in samples saturated with brine. While intermediate and heterogeneous samples exhibited an increased Vp/Vs ratio, homogeneous samples displayed no discernible changes. Utilizing the Fast Fourier Transform (FFT) and frequency-domain analysis, we were able to demonstrate frequency-dependent wave behavior variations with the dominant frequency shifting to the lower frequency range in saturated samples as compared to dry samples, further supporting our observations. These trends were further confirmed by amplitude attenuation analysis, which showed that post-saturation, attenuation intensified in heterogeneous samples and showed mild and marginal alterations in intermediate and homogeneous samples. These findings have significant ramifications for improving rock physics models for characterization of the Bassein Formation. The forecasting accuracy of elastic properties, fluid behavior and its interaction with the rock matrix is greatly increased by using this knowledge. This technique underscores the critical significance of categorizing carbonates based on varying degrees of heterogeneity, a pivotal aspect in unravelling the intricate dynamics of rock-fluid interaction within complex carbonate reservoirs. This also pave the way for sophisticated rock physics models with a deeper comprehension of ultrasonic wave behavior and attenuation patterns, improving reservoir prediction, geomechanical parameter optimization, and hydrocarbon recovery not only in the Bassein Formation but also in related carbonate reservoirs.

Keywords: Attenuation; Dominant frequency; Fast Fourier Transform; Ultrasonic measurement.

OP-19: Novel Application of Self-degradable Particulates as Fluid Diverters during Hydraulic Fracturing Horizontal and Vertical Wells

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The application of self-degradable particulates as fluid diverters during hydraulic fracturing is an evolving technology and has become popular amongst E&P operators over the past few years. These solid particulate materials degrade after the treatment from a solid-state to a non-damaging liquid state in the presence of water at reservoir temperature and therefore, eliminating the need for further treatment for their removal. The advantages of chemical diverters are simple injection without any pumping system modification and

negligible increase in treatment time. Their chemical composition can be tailored according to the reservoir properties. The primary objective of the fluid diverter is to improve hydraulic fracturing treatment by increasing stimulated reservoir volume and improving hydrocarbon recovery. For horizontal wells, this is possible by achieving any of the following objectives: creating a uniform distribution of treatment slurry within the target zone; treating unstimulated and under-stimulated zones; or by increasing fracture density by creating a complex fracture network. The particulate diverters are also helpful in decreasing the number of stages (by increasing stage length) for multi-stage plug-n-perf (PnP) fracturing treatment. It is also applied to prevent fracture-driven interactions between adjacent wells, which is currently a major issue, especially in Shale. In addition, for successful refracturing treatment, the diverter application is essential for isolating the existing fractures and redirecting the treatment slurry to the desired unstimulated zones. Thus, diversion of treatment fluid is the major attribute of successful multi-stage hydraulic and refracturing treatment. They are also successfully applied to prevent fracture-driven interactions between adjacent wells. During hydraulic fracturing in vertical wells, the diverters are injected in the beginning of the treatment to provide an additional stress barrier between producing interval and adjacent layers by depositing at the layer boundaries where higher leak-off is expected. The restricted height growth helps to create optimized fracture geometry, i.e., longer, wider, and contained fracture in the producing zone. In addition, it also prevents the production of undesired water from the nearby water-bearing layers. Various application and treatment conditions present challenges with respect to selection of the diverter chemicals, particle size distribution, proportions of diverter and proppant, and total quantity of diverter. This paper provides significant insight into the diversion technology and the guidelines for its successful application to help engineers to increase the effectiveness of hydraulic fracturing treatments.

Keywords: Diverters; Fluid diversion; Hydraulic fracturing; Improved oil recovery; Particulates.

OP-20: Rheological Studies of Organically-Crosslink Gel Systems for Water Shutoff Applications for High-Temperature Reservoirs

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The objective of this work is to develop an organically cross-linked gel system for water shutoff operations for high-temperature reservoir conditions (90 ℃-150 ℃). The gelation dynamics and the evolution of gel strength in time –temperature domain was studied by oscillatory and continuous shear approach under isothermal conditions in an advanced rheometer. First-order kinetics was applied to model the time-temperature dynamic response. Two synthetic-water soluble polymers (MW: 2.5-4 Million DU and DoH: 6-10%) were polymerized using free radical polymerization. Two low-toxic organic cross-linkers were added to the polymer solutions to develop a polymer-cross linkers based gelant system. The gelation dynamics of the polymer-cross linker-based gelant system was investigated by analyzing the aged fluid samples at various temperatures for different time durations of up to 18 hours. The aged fluid samples were analyzed based on storage modulus (G') evaluation under oscillatory conditions and viscosity evaluation under continuous shear conditions. The properties of the cross-linked gel systems which include gelation time, kinetics, and gel strength were studied for the variation in the governing parameters. Gelation kinetics of the two different studied polymers demonstrated that the gelation time was prominently a function of the aging temperature and was independent of the polymer composition. The observed acceleration in the gelation time with rise in temperatures was explained on the basis of the kinetics of polymer hydrolysis; the acrylamide group in the polymer gets converted into acrylic acid – a hydrolysis reaction governed by first-order kinetics. The study suggested that the polymer hydrolysis response, which accelerates with temperature, could be an underlying mechanism of the cross-linking gelation dynamics.

Keywords: Continuous shear; Crosslinking kinetics; Gel strength; Gelation time.

OP-21: Implication of Engineered Nanoparticle Low Salinity Solution Towards the Wettability Alteration of Mineral Surface

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Wettability has a vital role in enhanced crude oil recovery. Altering the wettability of a reservoir from oil wet to water-wet increases the oil recovery. The state of wettability alteration in a reservoir depends on many factors, such as the minerals composition of the rock, crude oil properties and fluid dynamics of inherent fluids present in the subsurface formation. Though there are various measurements are available to study the wettability alteration of rock or mineral surface, contact angle measurements are one of the accurate and uncomplicated technique. This paper discussed about the wettability alteration of quartz substrate in the presence of silica nanofluid prepared using the low salinity-surfactant solution. We observed that the contact angle of pure hydrocarbon and crude oil decreases in the presence of engineered silica nanofluid. Further, increasing the concentration of silica nanoparticle, enhances the wettability alteration of the quartz substrate. The reason behind the observed contact angle variation from the oil-wet to water-wet nature of the substrate is discussed using the disjoining pressure.

Keywords: Contact angle; Disjoining pressure; Quartz; SDBS; Silica nanoparticle.

OP-22: Improved Oil Recovery Performance of Polymer/Nanoparticle assisted Low Salinity - Smart Water Systems in Sandstone Reservoir

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The global petroleum sector is currently intent on meeting the ever-increasing energy needs, and is looking for newer, more effective methods to boost hydrocarbon production. The Smart Water technology has gained interest among the scientific community as a promising, yet cost-effective method for improved oil recovery (IOR). "Smart water" refers to an injectable fluid with modified ion content capable of producing oil at a desirable rate in the porous reservoir. The paper aims to combine LSW in secondary mode and a robust polymer/polymeric nanofluid in tertiary mode to design the strategy for a fast-response "Smart Water". The potential of the proposed LSW "Smart water" enhanced with partially hydrolyzed polyacrylamide (PHPA) and/or silica (SiO_2) nanoparticles is tested using physicochemical evaluation and core-flooding experiments in the laboratory. Zeta potential investigations corroborated the stability of the injected fluid system(s), and their compatibility with sandstone rock. The introduction of polymer and polymer/silica into the LSW altered the wettability of rock to a strongly water-wet state, as confirmed via dynamic contact angle investigations. Dramatic improvements in the recovery effect were observed during LSW flooding and LSW + polymer/polymeric nanofluid flooding during core-flooding experiments. During secondary water injection (salinity same as formation water composition), approximately 33% of the original oil in place (OOIP) was produced. This improved to ~45% oil recovery during secondary LSW flooding. Tertiary flooding studies showed additional recoveries of the order of 25-32% OOIP in the presence of polymer/nanoparticle, which confirms the technical feasibility of the "Smart water" injection system. The necessity of the research is gauged from the oil saturation data and re-distribution phenomenon within the pore spaces of the reservoir model. In summary, the combination of LSW with polymer and nanofluid flooding has significant prospects for future IOR applications.

Keywords: Improved oil recovery; Low salinity water (LSW); Nanoparticle; Polymer; Smart water.

OP-23: Synthesis and Characterization of a Non-ionic Gemini Surfactant Derived from Mustard Oil

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Surfactants are widely used in enhanced oil recovery (EOR) because they reduce the interfacial tension between oil and water, assist emulsification, and improve the oil recovery from the sub-surface. However, the environmental concerns associated with conventional surfactants have led to a growing interest in developing natural alternatives. To address this issue, we have synthesized a non-ionic Gemini surfactant using mustard oil and explored its potential application in enhanced oil recovery (EOR). Fourier-transform infrared spectroscopy (FTIR) confirmed the chemical structure of the Gemini Surfactant. Surface tension measurements were employed to investigate the efficacy of the Gemini surfactant as a surface-active agent. According to the results, the synthesized non-ionic Gemini Surfactant has a very low critical micelle concentration (CMC) value of around 50 ppm. A low critical micelle concentration (CMC) value demonstrates the enhanced self-aggregation ability of Gemini surfactant molecules. Surface active parameters, including; effectiveness, adsorption efficiency, surface excess concentration, and minimum area per Gemini surfactant molecule, were calculated, indicating superior inter-facial properties. Furthermore, we have also evaluated the ability of Gemini Surfactant to alter the wetting behavior of the rock from oil-wet to water-wet. The experimental results provide insights into the effectiveness of the Gemini surfactant for improving oil recovery. The use of natural alternatives such as naturally synthesized non-ionic Gemini Surfactant, can contribute to sustainable practices in the oil industry and mitigate the potential environmental impact associated with the use of synthetic surfactants. By exploring the synthesis, characterization, and application of the non-ionic Gemini surfactant derived from mustard oil, this study offers a novel approach to enhanced oil recovery (EOR).

Keywords: Critical micelle concentration (CMC); Enhanced oil recovery (EOR); Gemini Surfactant; Interfacial tension.

OP-24: Hydrothermal Gasification of Pine Needles for Co-synthesis of H_2-rich Gaseous Fuel and Nanometal Carbon Hybrid using Metal Effluent

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Heterogeneous catalysts are important for improving the hydrogen gas yield in the supercritical water gasification process. This study targeted an integrated hydrothermal treatment of simulated aqueous metal effluents (Ni/Cu) with pine needles and co-synthesize of H_2-rich fuel gas and nanometal carbon hybrid. Temperature is the key parameter that decides the quality and quantity of product yields of both hydrogen and nanometal carbon hybrid, and the same was varied from 300 to 600 ºC to optimize gaseous fraction and solid products. With an increase in temperature (300 to 600 °C), hydrogen gas yield improves from 1.67 to 17.2 $mmol.g^{-1}$ with Ni metal effluent while 0.17 to 10.64 $mmol.g^{-1}$ with Cu metal effluent. During supercritical water gasification (SCWG) of metal effluents with pine needles, the metal (M) present in wastewater gets dehydrated to form the metal oxide (MO), which further gets reduced to pure metal ($M^{(0)}$) with increase in temperature. The result shows that the in-situ reduction of nanometal during hydrothermal treatment catalyzes the reforming and thermal cracking, promoting the water gas shift reaction and methanation reaction, thereby increasing the yield of H_2 and CH_4. The hydrogen yield was improved to about 3.3 times with Ni metal effluent followed by Cu metal effluent (2 times) in comparison with non-catalytic supercritical water gasification at temperature (600 °C), biomass to effluent ratio 1:10 with a reaction time of 60 min. During SCWG, the metal in wastewater gets attached to biomass, resulting in metal removal of > 99% from metal effluent and recovered as a nanometal carbon hybrid. In addition, these generated nanometal carbon hybrids have quasi-spherical and cubical-shaped morphology of size < 30nm identified by Field scanning electron microscope (FESEM) and Transmission electron microscope (TEM)

analysis, respectively, while the vibrating sample magnetometer (VSM) analysis was performed to determine the superparamagnetic characteristics of nanometal carbon hybrid.

Keywords: Biomass; Hydrogen; Nanometal carbon hybrid; Wastewater.

OP-25: Synthesis of a Novel Catalyst for Natural Gas-based Membrane Reformer to Produce Ultra-pure Hydrogen

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Membrane reformers emerge as an efficient technology for 'on-site' production of ultra-pure hydrogen. The membrane reformer can be integrated with the PEM fuel cell to provide the power and hence has potential to replace the diesel generators. However, as the PEM fuel cell works at lower temperature and requires hydrogen purity (>99.99%). Hence, such integration requires a low temperature operation and a high hydrogen selective membrane. Palladium is generally a choice for membrane which gives high hydrogen selectivity and flux. However, CO presence in the reformate gases reduces the hydrogen permeability through palladium membrane due to its competitive adsorption. Natural gas is another alternative for the on-site production of hydrogen by using membrane reformer. However, such reformers are not well studied and high temperature operation of natural gas steam reforming makes the integration difficult. Further, the main product of natural gas steam reforming is CO and H_2. Therefore, it is vital to synthesize a low temperature and low CO selective catalyst for a suitable integration and long-term operation of membrane reformer. In literature, several catalysts are proposed for methane/natural gas steam reforming which perform in the range of 600-900 °C. Various metals or their combinations, mainly from group 8-10 of periodic table, are used as a catalyst supported on Al_2O_3, CeO_2, and/or ZrO_2. However, most of these catalysts provide stable operation at high temperature and susceptible to the coking. Further, CO selectivity for these catalysts is relatively high (~15-20%). Hence, they are not suitable for membrane reformer for on-site hydrogen generation. In current work, bimetallic and trimetallic catalyst supported on Al_2O_3 and CeO_2 are synthesized by using wet impregnation method. A complete characterization of catalyst is performed. Bimetallic and trimetallic catalysts, Ni-La, Ni-Co, Co-La, Ni-Fe, Co-Fe and trimetallic catalysts Ni-Co-La, Ni-Fe-La, Co-Fe-La, are synthesized on Al_2O_3 and CeO_2 support by using wet impregnation method. The performance of bimetallic and trimetallic catalyst on Al_2O_3 and CeO_2 support are compared in a packed bed reactor at different temperature, pressure, feed flow rate, catalyst to feed ratio, and metal compositions. The results show that La promoted catalyst on ceria support gives high conversion even at low temperature. It also shows high CO_2 selectivity at low temperature. The response time for this catalyst was also higher compared to the other synthesized catalyst.

Keywords: Catalyst synthesis and testing; Hydrogen production; Membrane reformer; Steam reforming of methane.

OP-26: Investigation of Circular Baffles on the Performance of Pd-Ag Membrane Module for Hydrogen Separation: Effect of Baffle Pitch and Aperture Ratio

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In recent times, there has been a growing interest in the advancement of a compact and mobile H_2 generator that can be conveniently utilized on-site or on-board. This generator is designed to be combined with a proton exchange membrane (PEM) fuel cell and can operate utilizing several feedstock options such as methanol, ethanol, ammonia, and other similar light organic hydrocarbons. However, extraction of high-grade pure hydrogen further necessitates the downstream purification of product gases including CO_2, CH_4, CO, etc. generated via the thermochemical reaction of these feedstocks. Consequently, in order to effectively recover H_2, downstream purification through a Palladium-based membrane is a trusted choice due to its high H_2 permeability and ideally infinite selectivity over a wide range of temperatures and pressure. Nevertheless, the continuous permeation of H_2 results in the formation of a mass transfer boundary layer near the membrane surface due to the accumulation of non-permeable gases, this phenomenon is commonly referred to as concentration polarization. Hence, to overcome this challenge we have designed a novel baffle with an array of circular rings mounted over each other. Multiple sets of experiments are conducted to investigate the effect of baffle pitch (distance between consecutive rings) and aperture ratio (ratio of the area of the circular aperture in the ring to the total area of the circular ring) on the performance of the Pd-Ag membrane prepared via an electroless plating technique. The parameters of the baffle pitch and the aperture ratio are adjusted within the range of 0.5-2 cm and 0.15- 0.50, respectively to minimize the extent of concentration polarization. Moreover, the feed flow rate per unit membrane area is varied from 400-1000 L min^{-1} m^{-2} membrane. The performance of the membrane is evaluated by considering various metrics, such as H_2 recovery, membrane utilization, and extent of concentration polarization coefficient (ECPC), to analyze the effect of the baffles. The performance is optimized with a single membrane at a particular condition of T = 673 K, ΔP = 300 kPa, and 70% H_2 / 30% N_2 feed mixture gas composition. It is observed that the incorporation of baffles significantly improved the H_2 recovery, thereby countering the effect of concentration polarization. This is mainly attributed to the intermixing of the feed gas near the membrane caused by the turbulence created in the feed flow pathway. As a result, more H_2 is pushed from the bulk of the retentate to the membrane surface which successfully enhanced the H_2 recovery. The results demonstrated that the baffle's pitch of 0.5 cm has a maximum incremental impact on H_2 recovery compared to the baffle pitch of 1, 1.5, and 2 cm. In addition to this, increasing the aperture ratio from 0.15 to 0.50 enhanced the H_2 recovery by successfully reducing stagnant regions near the membrane, and thereby a more uniform concentration profile is achieved. However, increasing the feed flow rate reduced the H_2 recovery due to the low residence time of the feed gas along the membrane surface. The optimized geometry is further selected to perform the scale-up study with multiple membranes at a high feed flow rate.

Keywords: Aperture ratio; Baffle pitch; Circular baffles; Concentration polarization; H_2 separation.

OP-27: Green Hydrogen and Oxygen Production over IrO_2/Pt/TiO_2 via Photocatalytic Overall Water Splitting under Visible Light Illumination

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With the increasing demand for renewable energy and the need to reduce carbon emissions, the development of efficient photocatalysts for overall water splitting has become a subject of significant research interest.

In this context, we report the successful development of a photocatalyst based on a single semiconductor, TiO_2, with Pt and IrO_2 as cocatalysts for the overall water splitting under visible/simulated light irradiation for the sustainable hydrogen production. The $2.5IrO_2/0.5Pt/TiO_2$ photocatalyst exhibited ideal POWS, producing hydrogen and oxygen from pure water with a H_2/O_2 ratio of 1.96 under visible light irradiation, and a H_2/O_2 ratio of 1.82 under simulated solar light (SSL). The rate of hydrogen and oxygen production were 9.73 and 5.32 μmol g^{-1} h^{-1}, respectively, under SSL with intensity 101.4 mW cm^{-2}. The photocatalyst showed long term stability with the POWS activity for 10 h of continuous operation. The accumulation of the generated gas on the catalyst surface and catalyst aggregation were found to be the major reasons for the decrease in the photoactivity after 10 h.

Keywords: Green hydrogen; photocatalysts; water splitting.

OP-28: Metal Additive Manufactured Bipolar Plates for Membrane-Based Electrolyzer for Hydrogen Production

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Additive manufacturing (AM) technology has gained increasing interest in recent years and has been employed in various industrial fields. One of the potential applications of AM is manufacturing bipolar plates for membrane-based electrolyzers. This paper aims to discuss the additive manufacturing of bipolar plates for hydrogen production using membrane-based electrolysis. There are two popular membranes available for membrane-based electrolysis. Anion Exchange and Proton exchange membranes are promising for hydrogen production due to their high efficiency, high hydrogen purity and low energy consumption compared to other electrolysis processes. A bipolar plate is an essential component of a Membrane-based electrolyzer as it plays a significant role in electrolysis by separating the anode and cathode compartments and helps distribute the electrolyte and products to the electrode surfaces. Usually, bipolar plates are made of graphite or metals such as stainless steel, titanium, and nickel alloys. However, these materials have limitations such as high cost, low durability, and difficulty manufacturing complex shapes. Additive manufacturing offers several advantages over conventional manufacturing methods, including manufacturing complex shapes with high precision, reduced waste, and increased design flexibility.

AM techniques such as powder bed fusion (PBF) and binder jetting (BJ) have been explored to produce bipolar plates for PEM electrolysis. PBF involves melting metal powders layer by layer, while BJ consists in depositing a liquid binder on a metal powder bed to bind the particles together. Both techniques have advantages and limitations in terms of cost, quality, and production speed. The material properties of the bipolar plates play a critical role in the performance of the PEM electrolyzer. The bipolar plates should have high electrical conductivity, good corrosion resistance, and low contact resistance with the electrode surfaces. Several materials have been investigated for producing bipolar plates using AM, including titanium alloys, stainless steel, nickel alloys, and copper. Titanium alloys have excellent corrosion resistance and mechanical properties but are relatively expensive. Stainless steel and nickel alloys are cheaper than titanium but have lower corrosion resistance. To improve the performance of the bipolar plates, various surface treatments have been explored, including coating, plating, and polishing. Coating and plating techniques on the surface of the bipolar plate enhance its properties. In contrast, these surface treatments can improve the corrosion resistance, electrical conductivity, and durability of the bipolar plates.

In conclusion, additive manufacturing can potentially revolutionize the production of bipolar plates for PEM electrolysis. AM techniques such as PBF and BJ can produce complex shapes with high precision and reduce waste compared to conventional manufacturing methods. The material properties of the bipolar plates play a critical role in the performance of the PEM electrolyzer, and various materials and surface treatments have been investigated to improve their properties. However, further research is needed to optimize the AM process parameters, improve the material properties, and reduce the cost of production.

Keywords: Additive manufacturing; Bipolar plates; Hydrogen production; Metal 3d printing; PEM electrolyser.

OP-29: Exploring the Role of Vinyl Copolymers in Next-Generation Water-Based Drilling Fluids for Geothermal Wells

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The demand for sustainable and efficient energy solutions has driven significant interest in geothermal energy production. The successful extraction of geothermal resources relies on effective drilling techniques, which in turn depend on the properties and performance of drilling fluids. Traditional oil-based drilling fluids, although effective, pose environmental concerns and operational limitations. As an alternative, water-based drilling fluids have gained traction due to their eco-friendliness and potential for enhanced performance. In this context, this study delves into the utilization of a novel vinyl copolymer TVCP synthesized through emulsion polymerization of four monomers as a pivotal component in the formulation of next-generation water-based drilling fluids tailored for geothermal well drilling. Vinyl copolymers, characterized by their versatility and tunable properties, offer a promising avenue for addressing the challenges associated with geothermal drilling which are usually thermally induced. This investigation involves a comprehensive evaluation of the role of TVCP in enhancing various aspects of water-based drilling fluids, including rheological properties, fluid loss control, and thermal stability. Through a systematic approach, the study examines the influence of the varying concentrations of TVCP on the fluid's ability to maintain optimal performance under the demanding conditions encountered during geothermal well drilling. The research encompasses a combination of laboratory experiments, including rheological measurements, fluid loss tests, and thermal stability assessments at 150 °C. Moreover, the cost-effectiveness of utilizing vinyl copolymer-enhanced water-based drilling fluids is evaluated to ensure practical viability. Ultimately, the findings of this study shed light on the potential of vinyl copolymers to revolutionize the formulation of water-based drilling fluids for geothermal wells. At a differential pressure of 500 psi and a temperature of 150 °C, there was a reduction of 28% in fluid loss. The viscosity profile also showed an incremental trend and lesser thermal degradation as compared to the conventional bentonite/polymer drilling fluids. The insights gained contribute to the ongoing efforts in optimizing drilling practices for geothermal energy extraction, aligning with the broader goal of sustainable energy production and minimizing environmental impact.

Keywords: Copolymers; Drilling fluids; Geothermal; High temperature; Viscosity.

OP-30: Process Parameter Correlation Analysis and Microstructural Investigation for Laser-Assisted Rock Drilling of Jalore Granite

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Conventional oil and gas drilling technologies are century-old and need serious reformations to adapt to transitioning global energy requirements. The drill bits used in conventional processes are tremendously complex in design, rugged, expensive, and subjected to high wear and tear. They are inefficient in ultra-hard rock formations, speculated to hold high natural gas and fossil fuel reserves. In the past decade, combined thermo-mechanical drilling technologies (CTMD) employing unconventional thermal power sources such as plasma, fluid-jet, flame, and laser have emerged as potential solutions. They are non-contact type and capable of generating high power. However, limitations such as long-distance power transmission, formation damages, complex purging, and adverse downhole conditions inhibit their real-time implementation in industry and production. However, their power is abundant for crack initiation in hard rocks. Hence, researchers are advertently working on finding an intermediate solution pertaining to

including the benefits of both convention and unconventional technology. Amongst the unconventional power sources, drilling assisted by laser has given prominent results and is rigorously being analyzed by researchers. Lasers are highly monochromatic, highly intense, and coherent. This aids in generating a substantial concentrated power, which is beneficial for crack generation. Further drilling can be done by the conventional tri-cone or Polycrystalline Diamond Compact (PDC) bits. This will help reduce the wear and tear of the traditional bits and increase their lifetime. However, multiple aspects of this integration are yet to be analyzed for efficient industrial implementation.

In laser-assisted rock drilling, input parameters such as laser power, scanning speed, and irradiation time play significant roles in determining the output performance parameters such as penetration depth, material removal, and specific energy. However, little information is available on the quantitative relationship between these parameters.

In this work, a correlation analysis has been done to analyze the prime influential factor having a significant role in performance parameters such as drilling depth and material removal. Based on the same, a mathematical analogy between process parameters is developed. Further, experimentations have been performed to validate the analogy. The influence of process parameters on altering microstructure has been presented as well. Based on the microstructural analysis, the impact of elements and morphology on the fracture mechanism and crack propagation in Jalore granite has been discussed.

Keywords: Drilling; Data analysis; Granite; Laser; Optical microscopy.

OP-31: Biohythane Production from Integrated Brewery Waste using MIL 88(Fe) MOF Nanoparticles

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Treating industrial waste and its disposal is an energy-intensive process. The depletion of fossil fuels and increased energy demand need an alternate sustainable way to tackle this problem. Biohythane is a high calorific value fuel comprised of a mixture of Hydrogen and methane. The present paper uses brewery wastewater as a substrate, and inoculum was prepared using cow dung and brewery wastewater. The HRT was found to be 20 days, and then a decrease in overall gas production was observed. The SRT was found to be 56 days. The optimized pH and SRT were 8 and 56 days, respectively. The maximum biohythane production was found after 44 days, with a gas composition of 71% methane, 16% hydrogen and 11% CO_2 observed at room temperature. From the above results, it can be concluded that there is a low population of Hydrogenotrophic microorganisms. This suggests that the system follows the hydrogenophillic methanogenesis pathway. The wastewater degradation was studied through COD and Total carbohydrate reduction. Further, the effect of iron-based MOF catalyst on Biohythane production was studied. Fe-MIL-88 nanoparticles were synthesized through the Solvothermal method. The synthesized catalyst was characterized using FE-SEM, XRD, EDAX and UV spectrometer. The band gap of the synthesized catalyst was found to be 2.8 eV using Tauc's plot. An appreciable amount of increase in Biohythane production was observed. This was likely due to the large surface area to volume ratio and a well-known fact of iron ion centers in ferredoxin, which are responsible for hydrogen production. This process not only treats the brewery wastewater, which is rich in organic loading and extremely harmful for water bodies but also produces biofuel and compost. The unique aspect of this research is that it uses very little water for dilution as compared to other processes of biogas production. Requires no additional pretreatment process, which is eco-friendly, cost-effective, and easy to handle. All the experiments were done in duplicate.

Keywords: Biohythane; Hydrogenotrophic; Solvothermal; Metal-Organic Framework; Methanogenesis.

OP-32: Enhancing Gas Hydrate Saturation Estimation using Forward and Inverse Rock Physical & Petrophysical Mapping of Complex Morphologies

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For the exploitation of any natural energy resource, conventional or unconventional, characterization and quantification of the prospect are crucial yet essential. Unlike conventional hydrocarbons, which occupy the pores of the hydrocarbon-bearing sediments, gas hydrates – still an unconventional energy resource, are observed to occur not just inside the pores but in diverse morphologies viz. pore-filling, grain-displacing, fracture-filling, and cementing. Each morphology affects the sediments' mechanical properties following their respective saturation and critical petrophysical identity (porosity and permeability). Grain-displacing and cementing morphologies evidently make the sediments' pore space reduce to make the arrangement stiffer than the pore-filling morphology, further reducing the wave attenuation and leading to increased elastic wave velocity. Due to the presence of the complex (set of) morphologies, utilizing Archie's saturation estimation actually gives an averaged saturation which is purely contributed by the pore-filling morphology, and the accurate contribution of other morphologies is not captured by deep-resistivity (Rt) only. A coupled ratio method comprising of resistivity and elastic velocity (Dt) was used to extract coefficients (A and B) which may be hydrate-morphology and/or lithological factors coded in the form of coefficients. And the hydrate saturation estimated with the help of rock physics modeling of various morphologies making up an effective medium for Gas-hydrate-bearing-sediments (GHBS) was correlated with the saturation estimated with an analytical method and was further used to invert for the sensitivities of morphologies on hydrate saturation. The results have shown that the combination of a set of cementing, matrix-supporting, and pore-filling morphologies constitute high-saturation GHBS and matrix-supporting, fracture, and pore-filling morphologies constitute mostly the low-saturation GHBS. Moreover, the insights from this research illuminate the criticality of considering not just the generalized cementing, pore-filling, or grain-displacing morphologies but a combination of all of them to get closer to the precise saturation estimation.

Keywords: Elastic properties; Hydrate morphology; Natural gas hydrate; Rock physics.

OP-33: Temperature-Constrained High-Frequency Evaluation of Damodar Valley Shales

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In view of the prevailing environmental and energy concerns, understanding and carefully utilizing unconventional resources like shales becomes paramount. The depositional process and the varied depositional environments make the shales a complex system to characterize. Despite constituting two-thirds of the volume of sedimentary rocks, they are some of the least understood among unconventional rocks. Here, the paramount significance lies in being able to understand shale's petrophysical and rock physical characteristics and to use the insights in making feasibility models for sustainable exploitation. This understanding is crucial due to their potential for subsurface storage and efficient hydrocarbon extraction. This investigation focuses on the Barren Measures, and Raniganj Formation shales in the Damodar Valley of Eastern India. These predominantly consist of carbon and iron-rich materials originating from fluvio-lacustrine processes. Because of the inherent anisotropy in shale that ranges from nano-scale organic hosted porosities to micro cm scale fractures and discontinuities, it becomes imperative to look at it from various scales. These multiscale discontinuities, combined with other parameters like organic matter, maturity, etc., affect the elastic properties of the rocks, which is evident from the measured compressive and shear wave velocities. In this study, acoustic characterization of the samples was carried out using

benchtop ultrasonic wave propagation setup. Compressive and shear wave velocities were determined for samples subjected to progressive heating up to 200°C (gas window), and the consecutive changes in the elastic parameters were derived. Inputs from other methods employing different physics, like FE-SEM, BET, and XRD, were incorporated to constrain our interpretation. Notable changes in elastic properties, particularly in samples with elevated organic content, are observed in compressive and shear wave velocities variations. This study enhances comprehension of the impact of temperature on shale's elastic properties, an aspect less explored than factors like stress and pressure. Thoroughly characterizing these parameters using acoustic methods offers critical insights into shale's storage capacity, carbon sequestration potential, and additional hydrocarbon recovery.

Keywords: Elastic parameters; Organic-rich shales; Rock physics; Ultrasonic velocities; Unconventional energy resources.

OP-34: Process Engineering Strategy for Improved Methanol Production in *Methylosinus trichosporium* through Enhanced Mass Transfer and Solubility of Methane and Carbon Dioxide

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The emission of greenhouse gases, such as methane and carbon dioxide, has been rising at an alarming rate. The present work exploits the potential of methanotrophic bacteria to utilize methane and CO_2, and simultaneously produce methanol (a clean and renewable potential fuel alternative). Methanol was produced in a two-stage integrated process using *Methylosinus trichosporium* NCIMB 11131. The first stage involved sequestration of methane to produce methanotrophic biomass, which was utilized as biocatalyst in the second stage to convert CO_2 into methanol. A combinatorial process engineering approach of design of micro-sparger, engagement of draft tube, and supplementation of mass transfer vector in an airlift reactor addressed the key challenge of mass transfer and solubility limitations of methane in the first stage. Employment of 5-µm pore size micro-sparger, draft tube, and 10 % v/v silicone oil as mass transfer vector, in airlift reactor resulted in maximum volumetric mass transfer coefficients for oxygen ($k_L a_{O_2}$) and methane ($k_L a_{CH_4}$) of 98.5 h^{-1} and 87.5 h^{-1}, respectively. Maximum biomass titer, productivity, and methane fixation rate attained were 7.68 g L^{-1}, 1.46 g L^{-1} d^{-1} and 0.80 g L^{-1} d^{-1}, respectively. In the second stage, elevation of operating pressure to 4 bar in a high-pressure stirred tank reactor, increased CO_2 solubility, resulting in a maximum methanol titer of 1.98 g L^{-1}. The corresponding CO_2 fixation percentage was estimated to be 7.7 %. This concept can be implemented in potential industries for sustainable sequestration of CO_2 and methane present in exhaust off-gases and flare gases, offering an eco-friendly biological route for decarbonization, and value-addition through methanol production.

Keywords: Carbon dioxide; High-pressure stirred tank reactor; Methane; Methanol; Methanotrophs.

OP-35: Optimal Design and Operation of CO_2 Transport Pipelines with Impurities

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Carbon capture and storage (CCS) presents a viable pathway towards achieving carbon neutrality. This study addresses the pivotal aspect of transporting varied-purity carbon dioxide (CO_2) within CCS frameworks and presents a comprehensive optimization model for pipeline design in the Middle East, coupled with impurity management considerations. The objective is to minimize costs while accounting for

impurity effects on design, pressure drops, and capacity. A 350 km onshore trunkline fitted with one booster station transporting 300 kg/s of impure CO_2 is examined. Our novel approach integrates thermodynamic, hydrodynamic, and economic models to optimize the pipeline's configuration, namely booster station location, its capacity, and diameters of the two resultant pipeline segments. The Peng Robinson equation of state, modified Lohrenz-Bray-Clark model, and fanning friction factor equations are used for density, viscosity, and pressure drop calculations. The optimization process focuses on minimizing the Levelized Cost of Transport (LCOT), considering constraints on design and operation. The non-linear optimization problem is tackled using Matlab's Interior-Point method.

Analysis of sensitivity of optimal design to impurities encompasses concentrations of 0-4% for group 1 impurities- argon (Ar), methane (CH_4), hydrogen (H_2) and nitrogen (N_2), and ppm range for group 2 impurities- water (H_2O), hydrogen sulfide (H_2S), oxygen (O_2) and sulfur dioxide (SO_2), in binary CO_2-rich streams. Optimal designs primarily suggest a 0.56 m diameter for both segments and a 1.6-2 MW booster capacity, except for 3% and 4% H_2 and 4% N_2 cases requiring a 0.61 m diameter for the first segment to check pressure losses, and a 1.3-1.5 MW booster. The 'optimal under purity uncertainty' design is identified as that for 4% H_2. When transporting different streams through it, booster operating power adjusts according to the pressure drop to minimize LCOT. LCOT increases linearly with impurity concentrations due to reduced transport capacity, while operating power increases for group 1 and O_2 but decreases for others as they reduce pressure losses (hydrodynamically beneficial).

Furthermore, a groundbreaking mechanism is introduced, enabling operators to levy charges compensating for increased pressure drops and capacity losses due to impurities. The cost and power penalties, quantified against baseline values for pure CO_2, demonstrate peaks of 60.3% and 3.9% for 4% H_2 and 4% Ar, respectively.In conclusion, this study breaks new ground by developing an optimization model for pipeline design under purity uncertainties, which is crucial given the dearth of such studies in the field, and unreasonable assumptions of fixed booster location and capacity, constant fluid density and pressure gradient, etc. of existing studies. The proposed mechanism for impurity-related charge imposition presents a pioneering approach to maintain transport efficiency and profitability. This research significantly contributes to the advancement of carbon capture transport strategies, fostering progress towards carbon neutrality goals.

Keywords: CO_2 impurities; Cost-optimal design; Optimization model; Penalty scheme; Pipeline transport.

OP-36: ASPEN PLUS Simulation Process Model of the Production of CH_3OH, C_2H_5OH and CH_3OCH_3 with the help of Captured CO_2 and H_2

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The world needs more energy than ever before. This means we need a sustainable system that can meet these growing demands, whilst also addressing CO_2 emissions and overall impact on the environment. Carbon capture and storage is a verified technology that has proven to be able to remove CO_2 emissions by enabling the mitigation of CO_2 emissions from large point sources such as power plants, refineries, and other industrial facilities or the removal of existing CO_2 from the atmosphere. Moreover, hydrogen is not only the most abundant element in the universe but also a colorless clean fuel which can be considered as a clean energy carrier similar to electricity. Traditional method of extracting H_2 from natural gas creates 10 tons of CO_2 for every ton of H_2. Thus, this paper aims to create a more sustainable way to produce H_2 without the emission of any greenhouse gases. Furthermore, Aspen plus is a process modeling tool used for process monitoring, optimization and conceptual design especially by chemical process industries where users can build models of industrial chemical processes and simulate them. In this experiment we use the Aspen Plus V11 to capture carbon (CO_2) from air and to separate hydrogen gas (H_2) from water (H_2O) and then use these two materials to produce fuels which are renewable, non-conventional and alternatives. In the Aspen Plus software we use reactors where CO_2 is used as a reactant to produce CH_3OH, C_2H_5OH, and then CH_3OCH_3. First, CH_3OH is produced by the hydrogenation of CO_2 ($CO_2 + 3H_2 = CH_3OH + H2O$) later C_2H_5OH is produced by reacting CH_3OH and CO_2 ($CH_3OH + CO_2 + 3H_2 = C_2H_5OH + 2H_2O$) followed by dehydrogenation and hydrogenation ($2CH_3OH = CH_3OCH_3 + H_2O$) ($2CH_3OH + H_2 = CH_3OCH_3 + 2H_2O$) respectively. Methanol, Ethanol, and dimethyl ether can minimize the dependency on fossil fuels when used

as an alternate, non-conventional fuel, it will help reduce dependency on foreign oil and greenhouse gas emissions as they are significantly less carbon-intensive.

Keywords: ASPEN PLUS software; Carbon capture and storage; Modeling and simulation; Non-Conventional; Renewable fuel.

OP-37: Techno-Economic Analysis of Absorber Enhanced Ammonia Synthesis Process

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Ammonia, a vital chemical compound, plays a pivotal role in modern society, serving as a key component in fertilizers, pharmaceuticals, and various industrial applications. The Haber-Bosch process has been the cornerstone of ammonia production for over a century. However, this conventional method has several drawbacks, including high energy consumption, greenhouse gas emissions, and inefficient use of feedstock resources. This abstract explores the importance of ammonia in various sectors and highlights the advantages and disadvantages of the existing Haber-Bosch-based process. While the Haber-Bosch process has been remarkably successful in meeting the global demand for ammonia, its drawbacks have prompted the search for alternative production methods. One promising approach is the Absorber Enhanced Ammonia Synthesis (AEAS) process, which seeks to improve the efficiency and sustainability of ammonia production. By integrating an absorber into the synthesis loop, this process enhances ammonia yield by removing the product from the reaction zone, thus reducing the tendency for reverse reactions. Additionally, the AEAS process allows for the capture and recycling of unreacted reactants, minimizing waste and energy consumption.

To assess the viability of the AEAS process and its potential as a replacement for the traditional Haber-Bosch method, a comprehensive techno-economic analysis is essential. This analysis will consider factors such as capital and operational costs, energy consumption, environmental impact, and long-term sustainability. By comparing the economic and environmental performance of the AEAS process to the Haber-Bosch process, this study aims to provide valuable insights for decision-makers in the chemical industry.

The results of the techno-economic analysis will play a critical role in determining the feasibility of transitioning from the Haber-Bosch process to the AEAS process for ammonia synthesis. Ultimately, this research seeks to contribute to the advancement of sustainable and economically viable ammonia production methods, addressing the pressing global challenges of resource efficiency and environmental sustainability. The findings will be of significant interest to researchers, engineers, and industry stakeholders involved in the ammonia production sector and beyond, paving the way for a more sustainable and efficient future in chemical manufacturing.

Keywords: Ammonia synthesis; Decarbonizing ammonia; Haber-Bosch process.

OP-38: Taylor Flow in U-Bend Microchannel for Sustainable Hydrogen and Decarbonization

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Gas-liquid flows in microchannels have shown tremendous application in cooling devices, microreactors, medical devices, etc. due to their high interfacial area density. Based on flow rates of gas and liquid phases different flow regimes are formed such as bubbly, slug, annular, and churn flow. Taylor flow or slug flow has gained special attention over the past decade for hydrogen production and CO_2 absorption in microchannels in terms of control and predictability. The introduction of meandering or U-bend in microchannels is required in order to achieve larger path length and residence time, and design compact

lab-on-chip technologies. It is important to understand the flow behavior at the U-bend in order to design such reactors. The liquid film between the gas phase and wall, along with the physical properties of surrounding liquid plays an important role in designing such reactors. In this study, the behavior of liquid film along with the change in bubble shape and length at a U-bend is investigated in the case of slug flow at low to moderate Capillary number (*Ca*). A glass microchannel with a circular cross-section of diameter 1 mm and length ~2 m is selected for the experiments. Microchannel consists of 20 straight channels and 21 U-bends. All the experiments are done at the middle U-bend (11^{th}) to avoid the start and end effects. Different percentages (0%, 12.5%, 25%, 37.5%, 50% EG) of water and ethylene glycol (EG) mixture are used as the liquid phase. Gas and liquid flow rates are controlled with a gas mass flow controller (for gas) and a syringe pump (for liquid). Preliminary experiments are done using Nitrogen as a gas phase to understand the effect of U-bend and liquid film. At gas (U_{SG} = 0.15 m/s) and liquid (U_{SL} = 0.21 m/s) superficial velocities Taylor flow is observed. High-resolution (1280×1024) images at 2000 frames per second (fps) are recorded with a high-speed camera and high-intensity LED light and analyzed using ImageJ (open-source software). Image analysis consists of calibration, selection of the region of interest (ROI selection), removal of noises, segmentation, and thresholding. The length of the bubble is observed to increase with an increase in *Ca*. The inner liquid film is thinner than the outer for all cases. Further, experiments are planned with CO_2 gas in order to understand the flow physics of the absorption around the U-bend microchannel.

Keywords: Decarbonization; Hydrogen production; Microchannel; Process design; Taylor flow; U-bend.

OP-39: Formation Water Analysis to Examine the Scale Formation and Wettability Alteration Behavior and its Treatment Thereof for Sustaining Crude Oil Production from Porous Media of the Upper Assam Basin

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Formation water analysis is a crucial step in the evaluation of oil and gas reservoirs. Formation water is the water that exists with hydrocarbons in the sub-surface. The analysis involves determining the chemical composition and salinity of the formation water. The ions in the formation water can affect the extraction and quality of crude oil, as well as the environmental impact of the water that is produced. This paper gives an overview of the methods and techniques that are used to measure the ions in the formation water. The analysis showed that for the three formation water samples that were analyzed, sodium ions had the highest concentration in all of them (1007.23 ppm, 2921.544 ppm, and 670.8375 ppm respectively), followed by potassium and calcium ions. Two of the formation water samples also had strontium ions. The paper discusses the influence of these ions in crude oil recovery, especially in water flooding operations. The paper also examined the significant effects of the ions in the formation water on crude oil extraction, such as scaling, corrosion, and wettability alteration. For this, crude oil analysis was also done for the reservoir, and wettability analysis was carried out with favorable ion concentrations to see the results. Lastly, the paper also describes how to treat the produced formation water in an effluent treatment plant (ETP) to meet the discharge standards and reduce the environmental risks. The paper discusses in detail the various methods for treating the formation water and shows the feasibility of using STOAT software and GPS-X software for treating the produced formation water. The paper presented the results and analysis of this in detail.

Keywords: Crude oil analysis; Environment; ETP; GPS-X; STOAT.

OP-40: Study on the Flow Behavior of Heavy Crude Oil- Microfibrillated Cellulose for Enhanced Oil Recovery

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Cellulose, the primary structural element of plant cell walls, is the source of the substance known as micro fibrillated cellulose (MFC). MFC is made from cellulose fibers that have been reduced to significantly smaller fibrils, usually on the nanoscale, by mechanical or enzymatic methods. The strength, biodegradability, and availability of cellulose are still present in these fibrils but in a more usable and adaptable form. It is quite interesting to observe that Microfibrillated Cellulose suspension exhibits extreme pseudo-plastic behavior and viscoelastic properties even at low concentrations. Depending on the concentration of MFC, the unique characteristics of the heavy crude oil, and the additive's intended use, various interactions and effects can happen when MFC is added to heavy crude oil. Some possible outcomes include viscosity reduction, Emulsion stabilization, flow assurance, and Enhanced oil recovery.

The 2 wt% cellulose has been used to obtain 0.4%,0.6%,0.8%,1%,1.2%,1.4%,1.6%, and 1.8%. The web-like structure of MFC is suspended in water without ultrasonication. When water suspension was subjected to ultra-sonication by the probe, its morphology showed no noticeable changes. This may be because the sample network had time to rebound after being held in place for extended periods. Characterization of crude oil originated from Gamiz field, Mehsana district, Ahmedabad. The present work deals with the emulsification of heavy crude oil 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90% in a given 100ml with the help of ultrasonic homogenizer. Adding cellulose leads to a reduction in the viscosity of heavy crude oil. Measurements using oscillation were made to examine the MFC added in heavy crude oil viscoelastic characteristics. The linear viscoelastic region (LVR) is where the storage modulus remains constant as the strain increases. The storage and loss moduli crossover is known as the gelation point. The frequency associated with the storage module G's network-like structure of entangled fibrils does not significantly alter it (at least at the lower end of the frequency area), as determined by dynamic mechanical testing.

Keywords: Crude oil; Microfibrillated cellulose; Rheology; Viscoelastic.

OP-41: High-Performance Carbonated Water Injection using Novel Tetrapolymer and ZnO Nanoparticles: A Sustainable Approach for Improved Oil Recovery and Decarbonization

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Injecting carbonated water (CWI) could serve as a viable alternative to the carbon dioxide (CO_2) injection method. Within CWI, carbon dioxide is present in a dissolved state rather than a free phase. This characteristic addresses several issues associated with CO_2 injection, including deficiencies in sweep efficiency and the occurrence of gravity-based separation. With CWI, the presence of dissolved CO_2 leads to elevated water density and viscosity compared to standard conditions. As a result, the effects of gravity separation and channeling are mitigated. Moreover, the efficiency of CWI can be boosted by adjusting the properties of the injection slug to offer a hybrid solution for improved sweep efficiency, higher oil recovery and a sustainable CO_2 sequestration strategy. This experimental study utilizes a lab-synthesized thermally stable and salinity tolerant tetrapolymer which is employed as a durable mobility-modifying agent for the designed slug while delaying the release of CO_2. In addition, Zinc Oxide Nanoparticles (ZnO NPs) were added to effectively alter the wettability of oil-wet rock grains and provide adsorption sites for CO_2 in the

porous media. The ZnO NPs would also generate a steric barrier upon interaction with the polymer chains, which in turn would stabilize the entire slug and improve its CO_2 absorption capacity. A comparative analysis is presented with a commercial polymer, Polyacrylamide (PAM) in terms of rheology, contact angle and core flooding studies. The investigation revealed that the formulated CWI slug achieved superior ultimate oil recovery compared to traditional slug injection, irrespective of whether it is employed in secondary or tertiary recovery modes. The infusion of CO_2 into the oil phase from the slug resulted in the displacement of its lighter constituents, leading to the creation of a gaseous phase with significantly heightened swelling capacity compared to the typical expansion caused by CO_2 dissolution in crude oil. This elevated swelling effect exhibited by the new phase surpasses the efficacy of alternative oil recovery mechanisms considered within the context of carbonated water injection. It stands as the predominant factor dictating the extent of oil retrieval and shaping the performance of the oil recovery process. As the transfer of CO_2 from water to oil continues, the newfound phase gains weight, concurrently reducing the interfacial tension (IFT) between the oil and the newly formed gaseous phase. This performance evaluation and mechanistic interpretation of a complex hybrid ZnO NPs enhanced-polymeric CWI slug promises a substantial sustainable solution for reducing the carbon footprint while improving the oil recovery from mature sandstone formations.

Keywords: Carbon dioxide; Carbonated water injection; Nanoparticles; Oil recovery; polymers.

OP-42: Synergistic Effect of Silica Nanoparticles in Hybrid Binary-Surfactant-Polymer Solution for Enhanced Oil Recovery

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Nanoparticle-assisted surfactants have garnered substantial attention within the realm of enhanced oil recovery (EOR), attributed to their remarkable capacity to enhance surface tension and interfacial tension (IFT) while concurrently lowering the critical micelle concentration (CMC) of surfactants. However, a pivotal challenge persists in effectively addressing IFT and surface tension in nanoparticle-assisted surfactants for EOR. This study focuses on the deliberate integration and influence of silica nanoparticles (SiO_2 NPs) within an anionic/nonionic surfactant amalgamation, complemented by a 1000 ppm polymer additive. The principal objective is to ascertain the optimal nanoparticle concentration achieved through a comprehensive experimental approach. The research endeavour commences by delving into the impact of SiO_2 NPs on the CMC of the binary surfactant system. Subsequently, a meticulous analysis of the surfactant blend's interfacial properties ensues, encompassing surface tension and IFT and the rheological characteristics. Introducing SiO_2 NPs into the binary surfactant system yields a discernible enhancement in performance, surpassing that of the binary surfactants in isolation. Specifically, incorporating 2 vol. % SiO_2 NPs leads to a notable reduction in the surfactant's CMC—an impressive feat at 1509 ppm. Additionally, the integration of 2 vol. % SiO_2 NPs into the solution increases viscosity to 0.00775 Pa-s. Furthermore, introducing 0.5 vol. % SiO_2 NPs translates to a significant decrease in surface tension to 29.69 mN/m and an IFT value of 0.812 mN/m. This study marks a significant advancement in comprehending the intricate interactions between SiO_2 NPs and surfactant behaviour, thereby paving the way for potential breakthroughs in refining EOR methodologies. The elucidation of the interdependent dynamics involving nanoparticles, surfactants, and EOR contributes substantially to the broader landscape of oil extraction and production strategies.

Keywords: Binary surfactants; Critical micelle concentration (CMC); Enhanced oil recovery (EOR); Interfacial tension (IFT); Nanoparticles (NPs).

OP-43: Numerical Modelling and Sensitivity Analysis of Slim Tube Experiment for Minimum Miscibility Pressure Estimation in CO_2 - Reservoir Oil Systems

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Enhanced Oil Recovery (EOR) is a set of processes of altering the properties of rock or fluids within an oil reservoir to cause additional crude oil recovery from mature oilfields. Miscible gas injection is an EOR method where gases are injected into the reservoir to mix evenly with the crude oil, resulting in improved mobility within the reservoir. CO_2 is often used as the miscible gas for this technique. Besides being less expensive than other similarly miscible gases, it creates opportunities for Carbon Capture, Utilization and Storage (CCUS) projects.

For any miscible gas injection project, the Minimum Miscibility Pressure (MMP) is a critical parameter because it indicates the pressure threshold below which the gas mixing will not be uniform and efficient. The slim tube experiment is one of the most commonly used methods of estimating the MMP of gas-oil systems. However, this laboratory method has consistently posed challenges due to its excessive cost and time requirements. This work focuses on estimating the MMP using numerical simulation of the slim tube experiment.

Utilizing CMG software's GEM® module, a Cartesian one-dimensional (500×1×1) model was developed to simulate CO_2 injection through a slim tube apparatus, initially saturated with crude oil. The phase behaviour of the crude oil was modelled using CMG's WinProp® module. The base case model was validated with existing literature and sensitivity analysis was performed by adjusting key parameters such as reservoir temperature, CO_2 injection rate, slim tube length, porosity, and permeability. This provided insights into the influence of these parameters on MMP value. The model will ultimately serve as a quicker and cheaper alternative to conventional experimental methods for MMP estimation.

Keywords: CO_2 injection; EOR; MMP; Slim tube; Simulation.

OP-44: CO_2 Microbubble Suspension and Stabilization Using Natural Surfactant for Advancing Tertiary Oil Recovery

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Carbon dioxide (CO_2) microbubbles have recently been employed to restrict the high permeability zone in heterogeneous reservoirs in Improved/ Enhanced oil recovery. CO_2 is considered an excellent solvent for miscible flooding applications. In this fluid, CO_2 gas is dispersed as microbubbles within a water-based solution containing surfactants. The surfactants help stabilize the microbubbles and maintain their dispersion over time. CO_2 microbubbles reduce the effective viscosity of the displacing fluid, making it easier to move through the porous rock. They also help counteract capillary forces that trap oil in small pores, facilitating its mobilization. In this study, the application potential of microbubble suspension created with a natural surfactant produced from Soxhlet extraction in tertiary oil recovery was examined. Acacia concinna, commonly known as Shikakai, is a plant native to the Indian subcontinent used for this application. It has been traditionally used for its natural cleansing and foaming properties. They act as surface-active compounds that can reduce interfacial tension between oil and water phases. The IFT at the oil/water (O/W) interface showed a significant reduction from 18.0 to 2.01 mN/m indicating the surfactant's efficacy in mobilization of trapped oil from the reservoir rock. The size distribution of microbubbles directly affects the stability of the foam. A finer microbubble size distribution results in more interfacial area, and influences processes like mass transfer, displacement, and wettability alteration. The microbubbles were generated using a sparger which can introduce gases into liquids in the form of fine bubbles. The current work assessed the effects of surfactant concentration, brine oil ratio, and gas flow rate on the stability and

bubble size distribution of CO_2 microbubbles based on this framework. The stability of microbubbles in a foaming system was measured by the half-life time which suggests the time it takes for the foam to lose half of its initial height. Results showed that the foam stability increases with an increase in the concentration of foam formed using this non-ionic surfactant at 2 wt %. The optimum brine-oil ratio of 3:4 suggests that the increased ionic strength from the brine might affect the micelle formation of the non-ionic surfactant, leading to more effective foam stabilization. At a low gas flow rate of 1 lpm, smaller and more stable microbubbles are typically generated. This can lead to longer half-life times as these microbubbles are better at resisting coalescence and drainage. With the help of the Digimizer program, the resulting microbubble size distribution data is examined in the current study. In all sets of data, it was found that the Weibull distribution function accurately implied the microbubbles. The foam exhibits a narrower distribution of bubble size implying greater stability and resistance to coalescence. The findings from this study strongly demonstrate that utilizing a microbubble suspension stabilized by a natural surfactant offers a promising avenue for enhancing tertiary oil recovery. The superior performance of this approach underscores its potential as an effective flooding agent in such applications.

Keywords: Bubble size distribution; CO_2 microbubbles; Natural surfactant; Stability; Tertiary oil recovery.

OP-45: Thermal Behaviour of Methane Hydrate Bearing Sediments - A field Perspective

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Amidst declining conventional energy and rising environmental concerns, exploiting relatively clean unconventional resources like Natural Gas Hydrates (NGHs) is on the uptrend. Being an endothermic process, the efficacy of the methane gas extraction through depressurization or thermal injection primarily depends on the amount of heat supplied by the surrounding sediment. As thermodynamics drives the equilibrium of the hydrate phase, understanding the thermal characteristics of Methane Hydrate Bearing Sediments (MHBS) is of utmost relevance. Effective Thermal Conductivity (ETC) characterizes the collective heat conduction capability of this multi-phase system. The intricacy of MHBS is due to the diverse thermal conductivity exhibited by the different components present in it. Additionally, the specific heat of methane hydrate is approximately half that of water while the thermal diffusivity is over two times higher than that of water. Due to these disparities in thermal properties, and their significant impact on MHBS extraction, it is vital to understand the thermal behaviour of MHBS especially due to the influence of porosity (ϕ) and hydrate saturation (S_h). Several experimental studies on field samples have been conducted to determine thermal properties, however, the range of ϕ and S_h for a particular location is relatively constrained in these researches. Hence, in this study, the data on thermal properties obtained from multiple MHBS reservoirs are combined and analyzed to determine the variation of thermal behaviour with ϕ and S_h. Further, the thermal conductivity predicted by classical series, parallel and distribution models that possess simple parameters are compared with the field data. Compared to the thermal conductivity of sediment soil which varies from 1.9 to 7 W/mK for shale and sand respectively, the thermal conductivity of hydrates (0.613 W/mK), gas (0.0313 W/mK), and water (0.565 W/mK) is significantly lower. Thus, the ETC of MHBS decreases as ϕ increases. For water-saturated specimens, the dependence of ETC on S_h is minimal due to the presence of water or hydrates in the pores which have almost similar thermal conductivity. The specific heat increases with an increase in ϕ for S_h less than 50 % primarily driven by the higher specific heat of water (4.237 MJ/m^3K). In contrast, it decreases with ϕ when the S_h is greater than 50% due to the slightly lower specific heat (2.027 MJ/m^3K) of hydrates compared to sediment matrix. With respect to the thermal conductivity models, it is observed that the series model with 11% error and parallel model with 13.3% error portrayed the lower and upper limits respectively. This error in the predictions is primarily due to non-consideration of the impact of the hydrate distribution pattern and mode of hydrate growth in these models. Thus, an effort has been made to modify series and parallel models by incorporating weighting parameters. The modified parallel model (2.3% error) and distribution model (2.4% error) exhibit the lowest percentage of error that can predict ETC with reasonable accuracy.

Keywords: Hydrate saturation; Multi-component; Porosity; Thermal conductivity models.

OP-46: Molecular Insights into the Methane Hydrate Dissociation: Effects of Hydrophilic Silica Nanoparticle and Formation of Methane Nanobubble

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The carbon stored as methane (CH_4) gas hydrates is thought to be twice the amount in conventional fossil fuels and thus, natural gas hydrates have gained attention in the past few decades as a potential energy resource. However, for extraction of CH_4 from a hydrate reservoir, it is important to understand the dissociation mechanism of CH_4 hydrate. In this study, we investigate the dissociation of CH_4 hydrate in the presence and absence of hydrophilic silica nanoparticles via MD simulation at pressure and temperature condition of 100 bar and 310 K. Three sizes of nanoparticles of 1, 2, and 3 nm diameters are considered in the study as shown in Fig-1. Nanoparticles are potential additives that can act as thermodynamic or kinetic inhibitors of hydrate growth, we have selected silica nanoparticle for this study as it is environmentally benign. All-atom forcefields are used to provide a more accurate description of the interactions present in the system. Local order parameters for the host molecules, hydrogen bonding, interface analysis, cluster size distribution, and density plots are used to quantify the dissociation process. Interface analysis is important for understanding growth or dissociation phenomena in a system consisting solid phase in contact with a liquid phase. We have used $F4_\varphi$ order parameter to identify hydrate(solid)-like and liquid-like water molecules to compute the fraction of solid (Fs) along with Z coordinate of the simulation box. Curve fitting of the Fs v/s Z data is done to determine the interface location, width of the interface, and hydrate thickness at each time frame; these data help to understand the dissociation trend of hydrate structure. We observe the wider distribution of interface width in the presence of nanoparticle compared to its absence (Fig-2), indicating the effect of hydrophilic silica nanoparticle on hydrate structure. Hydrogen bonding between the nanoparticle and water molecules and the average $F4_\varphi$ value of water molecules in the hydration shell of the nanoparticle confirms the influence of the nanoparticle. Gibbs ensemble Monte Carlo (GEMC) simulation is used to find the solubility of CH_4 in water. Through the clustering algorithm, we observe the appearance of a number of CH_4 clusters and report the evolution of the cluster size distribution over time. We hypothesize that the dissociation mechanism of hydrate is affected by the formation of CH_4 nanobubble. Through this study, we have captured the dissociation mechanism of CH_4 hydrates and the influence of hydrophilic silica nanoparticle and formed CH_4 nanobubble on hydrate dissociation.

Keywords: Gas hydrates; Molecular dynamics; Silica nanoparticles; Unconventional hydrocarbon.

OP-47: Enhance Recovery of Methane from Coal and Shale Beds Through CO_2 Injection and Mineralization using Physical, Chemical, and Spectroscopic Techniques

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CO_2 injection is an emerging process for enhancing the recovery of methane gas from coal seams and oil and gas from conventional reservoirs. However, limited information about CO_2 behavior in coal, shale, and rock during and after injection restricts the implementation of large-scale projects. Additionally, the lack of commercially available concentrated CO_2 captured from various industries such as refineries, combustion units, thermal power stations, and others hinders the progress of enhanced recovery projects. Injecting CO_2 into coal requires comprehensive information about coal parameters, including physical characteristics, organic content, thermal maturity, pore distribution and structures, pore connectivity, porosity, surface area, adsorption capacity, and permeability. CO_2 possesses a significantly larger adsorption capacity than

methane. Consequently, injecting CO_2 into coal seams replaces methane molecules. The injected CO_2 in the coal seam reservoir always remains in a supercritical fluid state due to its strong affinity for the dry reservoir. Typically, CO_2 dissolves with the aquifer associated with coal seams and strata under supercritical conditions and becomes adsorbed within pores. After recovering CH_4 from coal seams, the supercritical phase of CO_2 might lead to leakage through groundwater, structural features, and future mining activities. Therefore, finding a solution for the permanent sequestration of CO_2 in solid mineralized form within coal and shale is imperative. Groundwater contains active cations and anions, as do associated coal and shale strata. These ions, such as Na, Ca, Al, K, and others, react with CO_2 to form carbonate minerals. However, initiating mineralization reactions requires specific attention and established kinetics tailored to particular coal and shale seams. Identifying and examining subsurface geological and geochemical conditions, aquifer pH, and the type of catalyst or catalytic minerals are essential in this regard. In this study, 20 coal and shale samples were collected from the Raniganj and Jharia coalfields. Diverse physical and chemical analyses, including XRF, proximate and ultimate analyses, optical microscopy, XRD and scanning electron microscopy (SEM) were employed. The results of this study highlight the presence of active interactive minerals and metal oxides within shale and coal. These elements could aid in the mineralization of shale and coal oxides into stable carbonate products.

Keywords: Coal; CO_2; GHG; Mineralization; Shale.

OP-48: Enhancing Drilling Fluid Performance using Synthesized Chitosan Derivative for Effective Shale Inhibition

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During drilling when easily hydrated shale formations are encountered, the problems generated by these shale hydrations are often severe and may result in wellbore instability. Wellbore instability also causes bit balling, borehole collapse, formation damage, stuck pipe, and low drilling rates. The purpose of this study is to design a water-based drilling fluid system for effective shale inhibition, ensuring enhanced wellbore stability and drilling efficiency. Chitosan derivative was synthesized to increase the water solubility and used as an additive for shale inhibition in a drilling mud system. The product formed was characterized by Field emission scanning electron microscopy (FESEM), Thermogravimetric analysis (TGA), and Fourier-transform infrared spectroscopy (FTIR). The potential use of synthesized chitosan derivative as an additive of drilling fluid was examined through filtration and rheological tests in bentonite dispersion. The results showed improvement in rheological and filtration properties after hot rolling at 100°C in comparison to a conventional shale inhibitor, polyethylene glycol (PEG). As we increase the concentration of synthesized chitosan derivative from 0.3% to 1.5% the filtration loss decreased from 40% to 65% as compared to the base fluid. Shale recovery tests were also done using shale samples collected from an Indian oil field. When 1.5 wt. % additive was added, the shale recovery test showed that the synthesized chitosan derivative has a high shale recovery above 90% at 100°C compared to polyethylene glycol which has only a 64% shale recovery, which shows that the synthesized product is an effective shale inhibitor. It has been found that the additive prevents shale swelling by intercalating into the shale layer, and as the concentration of synthesized chitosan derivative increases, so does the recovery rate of the shale sample.

Keywords: Chitosan; Drilling fluids; Filtration properties; Rheological characteristics; Shale Inhibitor.

OP-49: Production of Naphtha Grade Hydrocarbons from Fast-Pyrolysis of Post-Consumer Mixed Plastics

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Sustainable and economic recycling of waste plastics has emerged as a major challenge for researchers around the world. Recycling of plastic waste has the potential reduce the production of virgin plastics from petroleum products, thus reducing the energy utilization, and emission of greenhouse gases, and minimizing the overall impact on the environment over the life cycle of the product. Therefore, clean, sustainable and economic recycling of plastic waste has gained significant interest in recent times. One such promising method is the thermochemical conversion of waste plastic into lighter and simpler molecules by pyrolysis, and subsequent steam cracking of the pyrolytic products to monomers for production of virgin plastics. In this study, post-consumer mixed plastic waste were subjected to continuous fast pyrolysis at 450 and 500°C in a novel plastic-pyrolysis pilot-plant (Pryme Cleantech - Ghent University) to investigate the composition of the produced hydrocarbons. The produced yield were thoroughly characterized using refinery gas analyser (GC-RGA) and 2-D Gas chromatography-Mass spectrometry (GCxGC-MS) analysis. Characterization of the gas samples showed high concentration of C3 and C4 gases at pyrolysis temperature of 450°C. However, the concentration of C4 compounds decreased significantly at 500°C. The carbon number distribution of the pyrolysis oils ranged from C5 to C33, with high concentration of light and middle distillate compounds. The GCxGC-MS analysis showed the pyrolysis oil showed high concentration of olefins (>50 wt%). The benchmarked pyrolytic liquid samples will be used as feed for steam cracking to investigate their possibility of being used as a precursor for producing virgin plastics, thus help establish a complete process for plastic circularity.

Keywords: Fast pyrolysis; Mixed waste plastic; Plastic circularity; Refinery gas analyser; Thermochemical conversion2-D gas chromatography-mass spectrometry.

OP-50: Effect of Alloying on Hydrogen Production from Formic Acid Decomposition

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The quest for sustainable and green hydrogen (H_2) production systems fuels catalysis research. Formic acid (FA) catalytic decomposition is a potential reaction for on-site H_2 production due to the renewable sourcing, low toxicity, high H_2 density, and flash point above the room temperature of FA. Pd-Ag alloy catalysts are more selective when compared to metals such as Pd, Au, and Ag for H_2 production from FA dehydrogenation than dehydration to H_2O. This study explains how alloying Pd and Ag affects the selective production of H_2 from FA with mechanistic insights for the FA reaction over Pd-Ag catalysts supported on Al_2O_3, CeO_2 and TiB_2 under ambient conditions without promoters. Supported Pd-Ag nanoparticles (1 wt % loading; 3 – 8 nm particle size) on Al_2O_3, CeO_2 and TiB_2 with varying Pd to Ag atomic ratios (1:0, 20:1, 0.5:1, 0:1) are prepared by incipient wetness co-impregnation. The catalysts were tested in a batch reactor in an aqueous phase using gas chromatography to quantify products.

Pd-Ag (0.5:1) nanoparticles over Al_2O_3 provide a higher selectivity (98%) to H_2 formation from FA when compared to Pd-Ag (20:1) (38%) and Pd (13%). Similarly, Pd-Ag (0.5:1) nanoparticles provide higher selectivity (22%) to H_2 formation from FA than Pd-Ag (20:1) (9%) and monometallic Pd (19%) supported on CeO_2. Pd-Ag alloy formation likely disrupts Pd ensembles, modifies the FA adsorption configuration, and favours H_2 formation over H_2O production from FA. Pd-Ag (0.5:1)-TiB_2 maintains a 55% H_2 selectivity for more than 6 h compared to Pd-TiB_2, which primarily dehydrates FA. Pd nanoparticles are electronically modified in the presence of Ag and weakly bind CO, which increases catalyst stability. Overall, a

combination of electronic and ensemble effects makes Pd-Ag catalysts more selective for H_2 formation from FA reaction than the corresponding monometallic Pd and Ag supported over Al_2O_3, CeO_2 and TiB_2.

Keywords: Catalysis; Formic acid; Hydrogen; Nanoparticles; Palladium.

OP-51: Investigation of NiMoSe/ $Ti_3C_2T_x$ on Carbon Cloth as Effective Electrocatalyst for Hydrogen Evolution Reaction in Acidic Medium

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Hydrogen as an energy vector is believed to play a crucial role in decarbonizing the energy sector. Electrochemically produced hydrogen involves oxygen evolution reaction (OER) and hydrogen evolution reaction (HER) at anode and cathode using catalysts such as IrO_2 and Pt/C, respectively. These noble metals are costly and limited in nature. Hence, there is a need to have low cost stable electrocatalysts. The current study investigated the performance of cost-effective hydrothermally synthesized nickel molybdenum selenide/$Ti_3C_2T_x$ (MXene) composite grown on activated carbon cloth (CC) towards HER in acidic medium (0.5 M H_2SO_4).

The synthesis on CC was confirmed by performing X-Ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS) and scanning electron microscope (SEM), and the atomic ratio of Ni:Mo:Se:Ti was found to be 1:2.78:3.12:1.06. The electrochemical characterization using three-electrode setup revealed an overpotential of 403 mV at -10 mA (η_{10}) as compared to 202 mV for commercial Pt/C (40%). The Tafel slope for the composite was found to be 33 mV dec^{-1} as compared to 28 mV dec^{-1} for Pt/C. The stability of the composite was found to be very high (49 mV increase in overpotential at η_{100} after 1000 cycles), due to the use of MXene. The charge transfer resistance determined using electrochemical impedance spectroscopy (EIS) was found to be 4.88 Ω at η_{10}. The synthesized electrocatalyst can hence be used as an alternative to the Pt/C at cathode. The future scope of the study lies in testing the performance of the catalyst in an actual polymer electrolyte membrane electrolyzer setup.

Keywords: Electrocatalyst; Hydrogen evolution reaction; MXene; NiMoSe/Ti_3C_2Tx@CC; Water splitting.

OP-52: Feasibility of Green Hydrogen Production from Aligarh Muslim University's Solar Farm for Vehicular Application.

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The transition towards sustainable energy sources has become paramount in addressing global climate challenges. This theoretical study explores the feasibility of green hydrogen production utilizing the abundant solar energy generated by Aligarh Muslim University's 3.3 MW solar farm. The proposed system integrates solar photovoltaic technology with a Proton Exchange Membrane (PEM) electrolyzer to efficiently produce hydrogen (H_2) and oxygen (O_2) via water electrolysis. This green hydrogen is then channeled into a comprehensive energy ecosystem, serving as a clean fuel source for mobile applications, particularly for transportation purposes. The target of the study first involves harnessing solar energy through the solar farm, strategically located in a region with high solar irradiance. This energy is directed towards the PEM electrolyzer, which converts excess electricity into green hydrogen and oxygen. The PEM electrolyser's adaptability to varying solar power inputs ensures continuous and efficient hydrogen production throughout the day, thereby maximizing the utilization of renewable energy. Further, the produced hydrogen is subsequently stored and transported to a hydrogen fuel station. The results indicates that the green hydrogen produced through PEM electrolyzer is about 228kg via electricity generated by solar farm is around 14000kwh. This innovative approach eliminates greenhouse gas emissions, reduces dependence on fossil fuels, and addresses the challenges of energy storage and mobility.

The integration of Aligarh Muslim University's solar farm with PEM electrolysis technology presents a promising opportunity to produce green hydrogen sustainably. The generated hydrogen serves as a clean and versatile energy carrier, addressing the challenges of energy storage and mobility in an environmentally friendly manner. The findings of this study contribute to the advancement of renewable energy integration and the promotion of green hydrogen as a viable solution for a sustainable future.

Keywords: Hydrogen; Fuel; PEM Electrolyzer; Solar PV; Vehicular application.

OP-53: Impact of Pyrolysis Reaction Temperature and Intrinsic Heating Effects on Co-Pyrolysis of Coal and Sawdust Blend

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In this study, feed samples used are a low-grade coal and sawdust subjected to thermal pyrolysis in a fixed-bed horizontal tubular reactor from 773–873 K temperature with nitrogen as purge gas (300 mL min^{-1}) under atmospheric pressure conditions. Coal pyrolysis revealed negligible liquid oil with higher production of coal char residue and very less evolved gas product. The char residue revealed that graphitic multilayer sheets were formed having 70.28% carbon content with hexagonal single crystal lattice structures. However, with the addition of sawdust to coal in a 1:1 ratio in a non-catalytic thermal pyrolysis process, effect of temperature (773-873 K) on liquid oil yield increased from 16.45-19.19 % while char yield decreased from 63.75-62.65 % with increase in conversion from 36.24-37.35 %. These results in higher liquid oil might be due to the hydrogen donating capacity of biomass to polyaromatic hydrocarbon clusters of coal. DSC analysis of liquid oil revealed that peak glass transition temperature of the pyrolytic liquid oil obtained at 773 K temperature ignited faster. The heat flow curves for pyrolytic oil from 773, 823 and 873 K manifested a directional heat pathway in an exponential rise of heat flow with respect to temperature increase until a steady-state condition was achieved, T_s = 411.55 K. GC/MS analysis of pyrolytic oil stated the presence of aldehydes, ketones, alkanes, phenols, alcohol, and furans. Char residue from co-pyrolysis of coal-sawdust blend revealed rod like nano-structures with an amorphous-ring like structure from FETEM image and SAED pattern respectively. Smaller porous structures were seen in the micro-structured images of the char residue with a pore diameter of 10.56 μm from FESEM analysis. From ultimate analysis and Van Krevelen diagram, the char residue produced at 773 K and 823 K showed lesser carbonization, demethanation and decarboxylation reactivity as compared to char residue obtained at 873 K which had a higher carbon content of 82.099 %. XRD diffractogram showed a sharp peak at 27.54° (2θ°) and a small peak at 21.23° (2θ°) portraying the presence of carbon in the char residue samples. From FTIR analysis, two small peaks were perceived at 2918 cm^{-1} and 2575 cm^{-1} indicating aliphatic C-H, asymmetric Ar-CH_3 stretching and S-H stretching, whereas a small sharp peak was indicated at 1720 cm^{-1} imbuing carbonyl group (C=O group) cleavage. A small peak was observed at 1300 cm^{-1} wavenumber indicating C-N stretching. This indicated the presence of heterocyclic -CN char form; however, a strong and intense broad peak was observed at 1073 cm^{-1} wavenumber indicating C-O-C bonded groups. From fuel gas analysis with the increase in pyrolysis temperature, hydrogen yield enhanced, concentration of CO levels, CO_2 (%) and O_2 (%) increased at 873 K with presence of negligible hydrocarbons as compared to that of fuel gas obtained from coal pyrolysis.

Keywords: Char residue; Coal-sawdust blend; Co-pyrolysis, Evolved volatile gas; Pyrolytic liquid oil

OP-54: Energetic and Exergetic Assessment of a Solar Hybrid Trigeneration System for Cooling, Electricity and Green Hydrogen Production

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With the well-documented long-term effects that conventional sources of energy have on the climate and the environment, it is of utmost priority to move towards sources of fuel that have minimal impact on our surroundings and, on top of that, to produce them in a way that is sustainable. As the energy sector is the major contributor to greenhouse gas emissions, the emphasis is on making this sector more sustainable and producing energy from sources that are green and renewable. The current study aims to design a new solar and wind hybrid system in which a wind turbine and a parabolic trough collector (PTC) operate a trigeneration system to produce electric power, green hydrogen, and provide cooling. Dowtherm A Oil is used as a heat transfer fluid in the PTC, and a wind turbine with a specification of G14-0.5 is employed to run the trigeneration system to produce electricity. The electricity produced by the combination of the wind turbine and the PTC is split into three parts: the first part is fed directly to the electric grid, the second is used to run an electrolyser to produce green hydrogen (via water electrolysis), and the third part is used to provide cooling (through a vapour compression cycle). The hydrogen produced is fed to a fuel station to be used as fuel for vehicles. The cooling produced by the vapour compression cycle is used to preserve food and milk and provide room comfort. The effects of several factors, such as direct normal irradiation (DNI) and wind speed, are also studied.

Keywords: Cooling; Electricity; Electrolyzer; Hydrogen; PTC.

OP-55: Thermo-Kinetic Studies of Petroleum Refinery Oil Sludge and Waste Biomass

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Co-pyrolysis of Bongaigaon petroleum refinery oil sludge (BRS) and rice straw as biomass waste (RS) was carried out at a weight ratio of 1:1 using thermogravimetric analysis under a nitrogen flow. Two main peaks were observed in the TGA profile within the temperature range of 150 to 400°C and 400 to 550°C. The maximum conversion was observed for the mixture sample at 317°C. Kinetic parameters, including the activation energy and pre-exponential factor, were determined for these two sections using the Coats-Redfern model.

Kinetic parameters were estimated for various reaction mechanisms, such as the chemical reaction model, parabolic law model, Valensi equation, Avrami-Erofeev equation, Shrinkage geometry column model, and power law model. The chemical reaction order 1.5 model was found to best fit the experimental data. The activation energy was determined to be 76 kJ mol−1, and the pre-exponential factor was 5.1x106 min-1 for section I using this mechanism. However, for section II (400 to 550°C), the Power law model was observed to be the best-fitting one. Using this model, the corresponding activation energy value for section II was 8.6 kJ mol−1.

Furthermore, thermodynamic parameters, including the changes in enthalpy (ΔH), entropy (ΔS), and Gibbs free energy (ΔG), were also determined. For section I, ΔH was calculated as 71.5 kJ/mol, ΔG was found to be 148.6 kJ/mol, and the change in entropy ΔS was 0.13 kJ/K/mol. On the other hand, for section II, the values were calculated as follows for the chemical reaction order 1.5 model: ΔH = 9.2 kJ/mol, ΔG = 164.3 kJ/mol, and ΔS = 0.23 kJ/K/mol, respectively.

Keywords: Co-pyrolysis; Kinetics; Petroleum refinery oil sludge; Rice straw.

OP-56: Optimization and Molecular Insights of Naphthalene Biodegradation by *Enterobacter ludwigii*NS12 Isolated from Petroleum Contaminated Sites of Northeast India

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Naphthalene is a harmful contaminant that discharged into the environment by various industries, including petroleum, agriculture, and pharmaceuticals, posing a substantial threat to ecosystems. Recognizing the seriousness of this issue, the Environmental Protection Agency has found the necessity of eliminating naphthalene from the environment. Bioremediation has emerged as a greater alternative to physico-chemical methods for the removal of naphthalene from contaminated sites. In the pursuit of effective bioremediation, strains capable of biodegrading naphthalene were isolated through a rigorous screening process. The strains NS6, NS12, and PT34 exhibited promising potential in the biodegradation process of naphthalene. Subsequent experiments were accurately executed to optimize key process parameters like pH, concentration, and temperature for naphthalene biodegradation. After the process was optimized among all these strains, NS12 demonstrated exceptional proficiency, achieving a remarkable 62.12% reduction in chemical oxygen demand (COD). After conducting 16s rRNA sequencing studies, NS12 was identified as *Enterobacter ludwigii*. To confirm naphthalene degradation various analyses, including Fourier-transform infrared (FTIR) and GCMS analysis, were employed, confirming the presence of various metabolites such as Dibutyl phthalate, 1-Octanol, 2-butyl, and 1-Hexadecanol. Furthermore, this study investigated gene targeting studies, focusing on key enzymes involved in naphthalene biodegradation, such as Catechol 2,3 dioxygenase and Naphthalene dioxygenase. Molecular Docking was also conducted to determine the binding energy of the enzyme responsible for naphthalene degradation to naphthalene. The findings of this study have implications, for the field of bioremediation in dealing with the problem of naphthalene pollution in the environment. By utilizing the capabilities of NS12 and gaining an understanding of the biochemical processes it is involved in we can effectively reduce the harmful effects of naphthalene contamination.

Keywords: Catechol 2,3 Dioxygenase; *Enterobacter ludwigii;* GCMS; Molecular Docking; Naphthalene.

OP-57: Analysis of Offshore Topside under Hydrocarbon Fire

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Offshore oil extraction and processing structures are susceptible to fire incidents due to the abundance of combustible materials. Such incidents can lead to the release of excessive heat, smoke, and harmful gases, posing a significant risk to the personnel on board. Therefore, it is crucial to anticipate the fire load and the reaction of structural components during the design phase itself. This study focuses on calculating the fire load and heat release rate of a hydrocarbon fire on an offshore platform's topside, which is located in the Gulf of Mexico. The simulation layout has been taken as smaller sections because the entire offshore platform area is relatively large for simulation. The fire load is estimated under various scenarios, taking into account changes in the fire source location and different fuel types. The Fire Dynamic Simulator (FDS), a Computational Fluid Dynamics (CFD) simulation tool, is used for the estimation of the time-temperature curves. The mesh size is determined based on a mesh convergence analysis, with refined meshes employed near the fire source regions for enhanced result accuracy. The influence of wind is also compared in the analysis. The FDS simulation yields data on heat release rate and temperature, which are then inputted into Abaqus for an in-depth examination of the structural members' response. A heat transfer analysis is performed on the structure to simulate the temperature of each node when it's subjected to fire. Subsequently, a thermal-structural analysis is performed considering the material properties under high

temperatures. The structural members are considered to have the environmental loads already acting on them when the fire load is taken into analysis. The structural response at critical points with maximum temperature and loading is closely monitored and discussed extensively. This estimation method's validity is confirmed by comparing it with prior studies, demonstrating a satisfactory level of agreement.

Keywords: Fire load; Heat transfer analysis; Hydrocarbon; Safety; Thermal-structural analysis.

OP-58: Degradation Kinetics Study of Diesel by Mixed Culture of *Acinetobacter baumannii IITG19* and *Klebsiella michiganensis RK*

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Diesel is a major contributor to petroleum hydrocarbon pollution in soil and water, posing a significant environmental challenge. Bacterial biodegradation has emerged as a promising approach to address diesel pollution. Understanding the kinetics of diesel degradation by bacterial strains is crucial for understanding the biodegradation process. This present study aimed to determine diesel degradation using a mixed culture of two previously reported bacteria, *Acinetobacter baumannii IITG19* and *Klebsiella michiganensis RK* (Kumar & De, 2023). Kinetics studies were conducted for both individual bacteria and their mixed culture to determine degradation rate constants and half-lives. Experiments were conducted using 4% v/v diesel-contaminated water, supplemented with Bushnell Hass media. Mixed culture inoculum was prepared by combining equal ratios of *Acinetobacter baumannii IITG19* and *Klebsiella michiganensis RK*. The experiments were carried out at 35°C, pH 7, with a 1% v/v bacterial inoculum, and the incubation period of 15 days.

The degradation rate of diesel was notably higher for the mixed culture compared to pure cultures. The first-order kinetics for diesel degradation in the presence of individual bacteria and their mixed culture. The rate constant for first-order degradation was observed as 0.094 day^{-1} for *Acinetobacter baumannii IITG19* and 0.059 day^{-1} for *Klebsiella michiganensis RK*. In contrast, the mixed culture showed rate constant (k) of 0.112 day^{-1}. Consequently, the half-life of diesel degradation for the mixed culture was shorter (6.3 days) than that for individual bacteria. The half-lives for *Acinetobacter baumannii IITG19* and *Klebsiella michiganensis RK* were determined as 7.4 and 11.7 days, respectively. The mixed culture proved to be more effective for diesel degradation compared to pure cultures. This study concludes that both the individual bacteria and their mixed culture are capable of effectively degrading diesel in polluted sites.

Keywords: Bacteria; Degradation Kinetics; Diesel; Mixed culture.

OP-59: Numerical Modeling and Control of Sustainable Offshore Energy Systems under Meto-Ocean Environment

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This paper systematically presents a theory for controlling nonlinear dynamics of guyed platforms supporting wind turbines. Offshore wind turbines supported on guyed towers are inherently complex and respond nonlinearly under wind and wave loading. The motions on the top of the towers structure may be considerably high in severe environmental conditions and therefore they need to be controlled for operational as well as maintenance. Moreover, as they are exposed to combined wind and wave loading and are themselves mechanisms, therefore they manifest chaotic behavior owing to the parametric nonlinearities. In this paper, the response of a model guyed platform subjected to wave forces only is investigated which is analogous to survival condition. Only the first-order forces due to the waves have been considered. The undesired chaotic motions are eliminated using the geometrical control methods and thereby the behavior is synchronized.

A 5MW NREL wind turbine is considered for the study. The turbine is assumed to be installed on a guyed platform with water depths of 250 m. To keep the response in safe operating regime, the controlled

response of offshore structure is essential. The focus of this paper is to develop a robust control technique so as to regulate the vibration and synchronization of support structures for an offshore wind turbine. The work is restricted to understanding the nonlinear motions of guyed platforms, due to slackening of a guylines and thereby controlling the motions for safe operations. The restoring force of the multiple guylines is idealized as a nonlinear spring whose stiffness changes depending on the position of the structure. In particular, a control mechanism based on backstepping method is being proposed. The performance of the algorithm is illustrated in this paper by designing the controllers for controlled response of the structures supporting guyed wind turbines in the chaotic regime which can be modelled as a Duffing-van-der-Pol equations.

Keywords: Controls; Energy; Offshore systems; Waves.

OP-60: Data-driven Methodology for Enhanced Oil Recovery Screening

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With much of the easy-to-produce oil already recovered from oil fields around the world, producers have tried several recovery strategies that offer opportunities for extracting the residual oil. Therefore, design and selection of practical enhanced recovery methods have become increasingly significant in field development planning. This paper describes a novel EOR screening workflow based on the state-of-the-art machine learning or statistical pattern recognition methods which are well-established in the field of computer science. In this approach, universally accepted screening criteria are integrated with successful field EOR cases worldwide to reduce arbitrariness in making decisions. The proposed algorithms are high-performance data-driven classifiers developed using Machine Learning algorithms like random forests, support vectors, nearest neighbors and so on. Based on limited information on reservoir and fluid properties, these classifiers are designed to select the most appropriate EOR method. In this study, six of the most popular EOR techniques currently being implemented in the upstream oil and gas industry are considered. In order to perform feature selection, fluid and reservoir characteristics such as nature of formation, porosity, permeability, depth, oil gravity (API), temperature, residual oil saturation and viscosity are taken into account. Data cleaning, feature ranking and hyper parameter tuning have been incorporated into the classification process to improve the performance of the developed screener. The proposed EOR screening algorithm is able to accurately forecast the appropriate EOR method in over 90% of instances. Multiple Machine Learning-based screening algorithms are ranked according to their screening efficacy. Random Forests outperform other algorithms because of its ability to handle classification problem dataset well. Upon reducing model overfitting, accuracy up to 98% is achieved on validation dataset. The developed model presents an opportunity to utilize the potential of Machine Learning in the oil and gas industry, and how it can be of great assistance in predicting the optimal EOR process for a given reservoir, thereby maximizing asset value and providing energy security to the nation.

Keywords: Enhanced Oil Recovery; EOR Screening; Field development planning**;** Machine Learning.

OP-61: Development of Various Machine Learning Algorithm for The Prediction of CO_2 Adsorptivity with the help of Bio-Waste Derived Porous Carbons

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One of the most crucial issues to address in the modern world is the increasing global warming effect due to the emissions of different kinds of greenhouse gases (GHGs) such as CO_2, N_2O, CH_4, etc. Although Carbon dioxide is highly emitted GHG, it is mostly released due to the utilization of fossil fuels in different industrial, commercial, and automobile sectors. It was found that in the year 1750, over 277 parts per million

(ppm) of CO_2 were present on average in the atmosphere over the world. And by 2020, that number had risen to 414 ppm (up 49%). This problem has led to the enhancement of the average temperature of our planet Earth by 1.1°C, increasing sea level. CO_2 emissions also result in many health problems such as respiratory problems, cardiovascular diseases, premature deaths, and many more. Several techniques address the issue of extreme carbon emissions. Among them, carbon capture, utilization, and storage (CCUS) stand out as efficient and widely adopted. CCUS is applied via post-combustion and pre-combustion methods. Pre-combustion is highly efficient, while post-combustion prevails in current industries due to its cost-effectiveness, easy upgrades, and installation. Post-combustion CCUS employs various methods like solvent membranes, adsorption, and absorption, with adsorption being prominent due to its versatile absorbent regeneration capability. Different absorbents based upon biomass waste-derived porous carbons are highly used for carbon capture, due to their ease of availability.

This research article investigates the application of machine learning algorithms for predicting CO_2 adsorptivity using Bio-Waste derived Porous Carbons (BWDPCs) as adsorbent material. Three supervised learning algorithms, namely Multi-Layer Perceptron (MLP) Regressor, LGBoost, and XGBoost models, were developed and extensively tuned to model CO_2 capture levels. Comparative performance analysis confirmed the superior modeling and generalization ability of the MLP algorithm for the carbon capture process. A comprehensive dataset of 402 data points was compiled from peer-reviewed publications, and machine learning techniques were applied to systematically investigate the relationship between CO_2 adsorption and the textural, compositional, and adsorption parameters of BWDPCs. The results show that LGBoost gave regression coefficient (R^2) value of 95% on train dataset and 83% on test dataset. While XGBoost has R^2 of 99% on train dataset and 79% on test dataset. MLP model exhibits the best predictive performance, with an R^2 of 99% and 90% on the training dataset and testing dataset respectively. Feature importance analysis done with the help of SHAP analysis revealed that adsorption parameters, textural properties, and compositional properties are significant predictors of BWDPC-based CO_2 adsorption in order of precedence.

Keywords: Bio-waste derived porous carbons; Carbon capture; Machine Learning; Post-combustion; SHAP analysis.

OP-62: Prediction of Carbon Capture in MOFs by Machine Learning

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Increased greenhouse gas (GHG) emissions have resulted in various global warming consequences as a result of human activity. GHGs of several sorts, including CO_2, CH_4, N_2O, and others. However, of all of them, CO_2 presents the biggest threat to our planet's long-term health if it continues to accumulate unregulated in the atmosphere. CO_2 has been recognized as a main driver of global warming, with fossil fuel-based power plants contributing significantly to the problem. There are several methods for capturing carbon, the most common of which are carbon capture, utilization, and sequestration (CCUS). CCUS is the most cost-effective and scalable option for decarbonization in sectors with substantial carbon emissions during the manufacturing of various materials such as steel, cement, and others.

The post-combustion approach is one of the well-known methods that can be used in existing facilities where components can be updated and enhanced. For the post-combustion process, many technologies have been developed, including solvent absorption, membrane-based separation, and solid adsorption. The absorption mechanism is also thought to be quite efficient. The sole downside of utilizing absorption is the necessity for a high enthalpy of heat during the regeneration process. It also leads to a high running cost. The rapid kinetics and good energy efficiency are two significant advantages of the adsorption process. Adsorption for carbon capture may be accomplished using a variety of materials such as zeolite, carbons, metal-organic frameworks (MOF), covalent organic frameworks (COF), and others. MOFs are favored over others due to their high storage capacity, large surface area, and high CO_2 selectivity.

The MOF database contains hundreds of thousands of experimentally synthesized and hypothetically prepared MOFs. About 324,426 computationally accessible hypothetical MOFs with various physical and chemical properties are used in this work. Testing 324,426 MOFs experimental and computationally is not viable due to the high expense of resources and capital. As a result, we introduce a rapid screening workflow by using machine learning (ML) to select the best performing MOF for carbon capture applications. ML is a field of artificial intelligence that focuses on the use of data and other types of algorithms to mimic the way humans learn. Chemical engineering uses ML extensively in a variety of applications, including fault detection, real-time optimization, and many more. Flexibility, precision, and execution speed are only a few of the important benefits that machine learning offers over traditional modeling approaches. For the prediction of CO_2/N_2 selectivity, various ML techniques are applied in this study such as neural network, support vector regression, etc. Physical and chemical characteristics of MOFs are used as input features and CO_2/N_2 selectivity is used as output features to train and test the models. In conclusion, we recommend the outstanding MOF for carbon capture by accurate ML models in this study.

Keywords: Adsorption; Carbon capture; Machine learning; Metal organic framework; Rapid screening.

OP-63: Decarbonization of Alkaline Surfactant Polymer Flooding Enhanced Oil Recovery Process with Green Hydrogen: Uncertainty Quantification and Probabilistic Prediction Studies by Monte Carlo Simulation

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Global energy demand is rapidly increasing due to industrial developments and lifestyle advancements. Crude oil remains a dominant source of energy to meet the increasing global energy demand. However, the rate of discovery of new oil reserves has declined over the past few years, which compels us to produce more oil from existing oil reservoirs. So, Enhanced Oil Recovery (EOR) techniques such as chemical, thermal and Gas EORs are implemented to recover remaining oil. Among the existing EOR techniques Alkaline Surfactant Polymer (ASP) flooding EOR process (i.e., chemical EOR) is one of the most successfully implemented techniques to improve oil recovery. But during the field operations of ASP flooding EOR process, large quantities of CO_2 is observed to be emitted which contributes towards global warming. Hence the objective of this work is to decarbonize the field operations during ASP flooding EOR process and energy transition with green hydrogen, which reduces the CO_2 emissions in the atmosphere. In the present study, evaluation metrics such as Exergy Invested (EI), Exergy Return over Exergy Invested (ERoEI), Carbon Intensity (CI), and Hydrogen Intensity (HI) were used to identify the best efficient ASP flooding EOR method among continuous, alternate and tapered methods. The evaluation metrics (EI, ERoEI, HI and CI) were calculated based on the exergy consumed during manufacture and transport of chemicals, production, treatment and transport of produced reservoir fluids. The ASP flooding EOR method having least EI, HI, CI and highest ERF values was considered as best energy efficient flooding strategy. Subsequently, using Monte-Carlo simulation, probabilistic prediction (P10, P50, P90) of evaluation metrics were performed by considering the uncertainty in operational and reservoir parameters ranging from 0% to 25%. Finally, scenario analysis was conducted to quantify the effect of uncertainty on prediction of evaluation metric values. It was observed that compared to continuous and tapered ASP methods, alternate ASP EOR method was less exergy and carbon intensive. Further, ERF of ASP EOR method was found to be 18.74% and 9.74% more than continuous and tapered methods. Hence, among other methods, alternating ASP EOR method was found to be the best energy efficient. On subsequent exergy analysis on alternate ASP EOR method, it was found that increase in unit percent of uncertainty in operational and reservoir parameters had increased the resultant uncertainty of EI, HI and CI parameters by 1.57%.

Keywords: Alkali surfactant polymer EOR flooding; Decarbonization; Energy transition; Probabilistic prediction; Uncertainty quantification.

OP-64: Anodic Dissolution Mechanism of Molybdenum in the Presence of Oxidizer by Reaction Mechanism Analysis

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The application of molybdenum (Mo) in various industries has been already known for years, among which its use as valve metal, lithium-ion batteries, and electrochromic and refractory materials is worth mentioning. Research is going on to integrate Mo as a barrier metal and interconnect in the semiconductor industries, replacing W and Cu, respectively, in recent years. Prior to employing Mo in these applications, it needs to be planarized using suitable oxidizers. To date, the anodic dissolution of Mo is reported in acidic and alkaline solutions, and it was observed that Mo dissolves in the solution with a +6 oxidation state. However, the effect of oxidizer on the anodic dissolution of Mo is not reported yet. The present work focuses on understanding the dissolution behavior of Mo in hydrogen peroxide (H_2O_2) solution at higher pH by potentio-dynamic polarization and electrochemical impedance spectroscopy (EIS). Before all the electrochemical experiments were performed, the open circuit potential (OCP) was kept until the system reached stability. The EIS was carried out at various overpotentials, such as 0.1 v, 0.2 v and 0.3 v, with respect to open circuit potential. The EIS data was analyzed by the electrochemical equivalent circuit (EEC) fitting, and an electrical circuit was proposed. The EEC fitting was performed using ZSimpwin software. The prediction of the dissolution mechanism is not feasible in detail using EEC fitting. Hence, reaction mechanism analysis (RMA) was implemented. A dissolution mechanism is predicted for Mo dissolution in H_2O_2, and the data was validated with the results obtained from EIS analysis.

Keywords: Anodic dissolution; EEC; EIS; Molybdenum; RMA.

OP-65: Investigative Studies on CO_2 Trapping Mechanisms in Saline Aquifer Sandstone Reservoirs for Carbon Sequestration: A Prospective Solution for Saline Aquifers

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The urgent need to combat climate change has driven extensive research into carbon capture and storage (CCS) technologies, with carbon sequestration in saline aquifer sandstone reservoirs emerging as a promising approach. This study highlights a comprehensive investigation into the trapping mechanisms of CO_2 in saline aquifer sandstone reservoirs, with a particular focus on its potential application for carbon sequestration, especially in Indian aquifers. In this study, an experiment involving CO_2 flooding in a brine-saturated sandstone core was conducted to assess the feasibility and efficacy of carbon sequestration. The investigation sought to replicate real-world conditions, providing valuable insights into the behaviour of $_{CO2}$ within saline aquifer sandstone reservoirs. Critical aspects of the study include the analysis of different trapping mechanisms and a quantitative assessment of the amount of $_{CO2}$ sequestered. The experiment results reveal a multifaceted trapping mechanism involving structural, residual, dissolution, and capillary trapping, which collectively contribute to the effective sequestration of CO_2 in saline aquifer sandstone reservoirs. These findings provide valuable insights into the potential for long-term CO_2 storage and mitigation of greenhouse gas emissions. Furthermore, this research highlights the significance of these findings in the context of Indian aquifers, which face unique challenges and opportunities for carbon sequestration. India, one of the world's most populous countries, is experiencing escalating concerns regarding greenhouse gas emissions and climate change impacts. The application of carbon sequestration techniques in Indian aquifers could significantly contribute to the nation's efforts to reduce carbon emissions and mitigate climate change effects. In conclusion, this investigation on CO_2 trapping mechanisms in saline aquifer sandstone reservoirs emphasises their applicability for carbon sequestration. The quantitative analysis of CO_2 sequestration and the potential benefits for Indian aquifers underscore the importance of this research in advancing sustainable solutions for mitigating climate change and ensuring a greener future.

Keywords: Carbon sequestration; Climate change mitigation; CO_2 trapping mechanisms; Indian aquifers; Saline aquifer sandstone reservoirs.

OP-66: Aqueous Amine Blend of 1,4-Butanediamine and 2-Dimethylaminoethanol for Post-Combustion CO_2 Capture: An Approach Towards Carbon Neutrality

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In this era of globalization, ample human activities are hampering the climatic conditions. These numerous human activities cause massive CO_2 emission, which is responsible for many hazardous issues. CO_2 capture by aqueous amine blend finds itself a potential solution to battle the scenario of huge CO_2 emission. Therefore, in this work, an aqueous amine blend of 1,4-Butanediamine (BDA) and 2-Dimethylaminoethanol (DMAE) was prepared, and the equilibrium CO_2 solubility was calculated. The performance of the aqueous amine blend was judged by performing CO_2 absorption and desorption experimental investigations. The entire experiments were performed in the range of pre-defined operating conditions of the process variables. Based on such process variables, a reliable semi-empirical model was developed, and the CO_2 solubility results were validated through this developed model equation. A deviation between the experimental and calculated values of CO_2 solubility was calculated, and a fabulous deviation of 3.77 % was found. Equilibrium CO_2 solubility, cyclic equilibrium CO_2 solubility, pH, cyclic capacity, absorption capacity, etc., are some of the major research findings of this experimental work. The formation of intermediate complexes like bicarbonate, carbonate, BDA, and DMAE complexes was characterized by adopting the ^{13}C NMR spectroscopic technique. The heat of absorption was calculated to determine the suitability of the aqueous amine blend of BDA+DMAE, and it was calculated by using the Gibbs–Helmholtz equation. Finally, the equilibrium CO_2 solubility of the amine blend was optimized by adopting response surface methodology (RSM). The value of process parameters, along with the final response, was optimized. The main purpose of this study is to provide an amine solvent that will strongly contribute to carbon neutrality from major industrial sectors like coal-fired thermal power plants.

Keywords: Amine blend; Carbon neutrality; Climate change; Empirical modeling; Equilibrium CO_2 solubility.

OP-67: Role of Primary, Secondary, and Tertiary Amines on Carbon Dioxide Capture

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Carbon dioxide emissions have grown in importance as a result of growing concern over global warming and greenhouse effects. This led to the need for energy-intensive carbon dioxide capture. Carbon dioxide capture technologies that are energy efficient and economically viable are sought as options for future industrial processes to adsorb carbon dioxide. As Zeolite-Y has well-defined pores of the comparable size as CO_2 molecules, they are expected to have a good affinity for CO_2 capture. The article evaluates amine-loaded Zeolite-Y adsorbents for the improvement of carbon dioxide adsorption. First, the article provides an overview of current adsorption technology for capturing carbon dioxide. Additionally, recommendations for future research on adsorption are provided as part of the research conducted on emerging technologies. Thus, the objective of this article is to synthesize, characterize, and adsorb carbon dioxide in light of current capture technological trends. The purpose of this study is to investigate the ability of amine-loaded Zeolite-Y to adsorb carbon dioxide based on three different loadings: ethanolamine, diethanolamine, and triethanolamine. A number of techniques including X-ray diffraction pattern (XRD), thermogravimetric analysis (TGA), Fourier Transform Infrared Spectroscopy (FTIR), and Field Emission Scanning Electron Microscope (FESEM), Brunauer–Emmett–Teller (BET) have been applied to the study of Zeolite-Y and

amine-loaded materials. Therefore, monoethanolamine-loaded adsorbents can be considered a promising and cost-effective carbon dioxide sorbent. Using adsorbents in the range of 1-10 wt% amine, maximum carbon dioxide adsorption was achieved (1.14-2.26 mmol g-1) at 30°C and 1 bar. Hence, the sorbent can effectively adsorb carbon dioxide from flue gases.

Keywords: Adsorption; Monoethanolamine; Diethanolamine; Triethanolamine, Zeolite-Y.

OP-68: Synthesis, Evaluation and Application of a Terpolymer as Kinetic Hydrate Inhibitor for THF-hydrates using Low-Temperature Differential Scanning Calorimetry Studies

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Given the constantly growing global energy demand, unconventional hydrocarbon resources like gas hydrate reservoirs hold significant potential for the future of the petroleum industry. Gas hydrates, which contain around 170 ft^3 of gas per 1 ft^3 of hydrate, represent a substantial natural gas resource. However, drilling, production, and transportation of natural gases from these reservoirs may be critical and challenging. These challenges manifest as blockages in choke and kill lines, disrupting well-killing operations. Furthermore, hydrate formation during gas transportation through pipelines can lead to pressure buildup and pipeline failures. To address these issues, chemical methods for hydrate prevention, such as Thermodynamic Inhibitors (THIs) and Low Dosage Hydrate Inhibitors (LDHIs) are employed. The THI requires in higher concentrations (10-50 w/v%) and demands careful management for field application due to its regeneration and disposal needs. LDHIs are categorized as Kinetic Hydrate Inhibitors (KHIs) and Anti-Agglomerates (AAs). KHIs are mainly water-soluble polymers which hinder the growth of hydrate crystals by integrating themselves into the developing crystal structure, thereby impeding the ongoing expansion of hydrate crystals. AAs prevent hydrate crystals to form large occluding masses by agglomerating to each other. This study explores the viability of a terpolymer called ANP, synthesized using Acrylic Acid, N, N dimethyl-acrylamide, and N-vinylpyrrolidone, as a KHI for THF-water hydrates. Structural information of ANP was analyzed via FTIR & ^{1}H-NMR analysis and molecular weight of the polymer was determined by Advance Polymer Chromatography (APC). Through Low-Temperature Differential Scanning Calorimetry (LT-DSC) study, it was observed that the isotherm for hydrate formation in the THF-water system was approximately 254 K. However, with ANP concentrations of 0.1, 0.5, and 1.0 w/v%, the temperatures shifted to approximately 253 K, 251 K, and 249 K, respectively. This data indicates that higher ANP concentrations correlate with lower hydrate formation temperatures. This suggests the potential use of ANP as a kinetic inhibitor to mitigate hydrate-related challenges during field applications.

Keywords: ^{1}H-NMR; KHIs; LT-DSC; Terpolymer; THF-hydrate.

OP-69: Development of Machine Learning Model for the Oxidative Conversion of Methane to Light Olefins

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Methane (CH_4), one of the primary components of natural gas, is to be converted by a chemical process called oxidative coupling of methane (OCM) into a variety of higher hydrocarbons, principally ethylene (C_2H_4), propylene (C_3H_6), ethane (C_2H_6), and other compounds. Ethylene and propylene, commonly known

as light olefins, have a variety of uses in petrochemical processes, including the manufacture of plastics, auto components, lubricants, and other products. The most important commodity in the world and a key component of the chemical industry is ethylene. While methane-to-ethylene conversion has various advantages, it also poses a significant scientific problem. Light olefins are made using a variety of techniques, including steam cracking, fluid catalytic cracking, hydrocarbon catalytic cracking, and more. Although steam cracking is one of the most used methods, it is difficult to sustain due to the significant energy consumption. OCM converts CH_4 into C_2 products, a process that is primarily referred to as "direct methane conversion." However, achieving C_2 selectivity through this method is a significant technological challenge. High selectivity for C_2 and C_3 products under various reaction circumstances and with various catalysts continues to be a difficult task. Despite yet, it has been discovered that the OCM method has enormous potential for turning methane directly into priceless C_2 and C_3 hydrocarbons. This study uses a variety of Machine Learning (ML) approaches, including the regression method, neural networks, and others, to predict C_2 and C_3 selectivity in OCM. Datasets covering a variety of operating circumstances, including temperature, feed composition, catalyst type, composition, and more, have been gathered for this purpose from diverse literature. To extract pertinent descriptors from all of the inputs available, feature engineering, and data pre-processing were also done for the efficiency enhancement of the model. Then, these descriptors were fed into ML models that were being trained and tested. Using performance assessment criteria like coefficient of determination (R_2) and root mean squared error (RMSE), the predictive performance of the ML models was thoroughly evaluated. The models produced impressive generalisations of trends and patterns across many catalysts and environments, offering insights into the intricate interaction of factors impacting C_2 and C_3 selectivity. It was found that the model gave best R^2 value for the gradient boost model with R^2 value of 78% for C_2 selectivity and 60% for C_3 selectivity, with a very least RMSE value. For this k-fold cross validation (k=5) method was also applied for the proper validation of the developed model. A feature significance analysis using the Shapley additive explanation (SHAP) was also conducted, which provides insight into the major variables affecting product distribution. Overall, this study advances our knowledge of the variables influencing C_2 and C_3 selectivity in OCM and emphasises the use of ML to the prediction of complicated reaction outcomes. The knowledge gathered from this research may open the door for focused experimentation and innovation in the field of methane conversion, bringing us one step closer to the creation of effective and sustainable methods for the production of high-value hydrocarbons.

Keywords: Ethylene; Machine learning; Methane conversion; Oxidative coupling; Propylene.

OP-70: Valorization of Aqueous Phase from Hydrothermal Liquefaction of Lignin

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Zero waste discharge is a promising strategy for any process to be cost-efficient. Biofuels serve to be a potential candidate for non-conventional energy sources. Different thermochemical routes like pyrolysis, hydrothermal treatment, and gasification are available for processing biomass and converting it into solid liquid and gaseous fuels. Hydrothermal liquefaction (HTL) is the depolymerization of biomass with or without catalyst in a highly pressurized solvent (5-20 MPa) at around 250-350 ºC to yield biocrude as the major product, along with gas and hydrochar as a by-product. Better yield and quality of products in terms of higher heating value (HHV), and oxygen content can be obtained in this process. HTL takes advantage of processing wet biomass feedstock as it is carried out in sub or supercritical water (or solvents) conditions to produce solid, liquid, and gaseous products. During the process, water is used as a solvent and yields an aqueous phase (AP) as a byproduct that needs to be valorized. In this study, lignin was used as a feedstock which is generally considered a byproduct stream in the paper and bioethanol industry. The lignin considered for the study was obtained through different pretreatment methods from bamboo. The HTL of lignin was performed in a 100 mL high-temperature high-pressure stirred autoclave reactor. Reaction conditions of 280-300 ºC temperature, lignin to solvent 1:10, 2.5-7.5 MPa initial pressure, 15-60 min residence time, 320 rpm, and N_2 atmosphere were employed during the liquefaction process. After the reaction, ethyl acetate and acetone were used as an extracting solvent to separate the organic phase from the reaction mixture that produced the AP as a byproduct. From LC-MS and HPLC analysis, the presence of methanol, phenols, etc. was detected in the AP. These compounds were used as hydrogen donor solvents during HTL in different literature that increased the yield and enhanced the quality of bio-oil. The

recirculation of the aqueous phase was investigated in this study. The increase of 5 wt.% in bio-oil yield was observed with first-recycling with no major effect in oil yield was observed with second-recycling. Further recycling of the aqueous phase was seen to negatively impact the bio-oil yield. The enhancement in the quality of oil yield in terms of oxygen content was also observed after the first and second recycling of AP.

Keywords: Aqueous phase recirculation; Bio-oil; Hydrothermal liquefaction; Lignin.

OP-71: Numerical Investigations on The Impact of Layered Heterogeneity on the Hot Water Flooding Performance

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The global energy demand is increasing owing to the increase in industrialization and population. On the other hand, the potential conventional energy sources are decreasing rapidly. It is highly necessary to explore reserves other than conventional reserves, such as heavy oil and unconventional oil reserves, to fulfill the energy gap. However, the challenge is associated with the exploration of these reserves owing to high viscosity and heterogeneity. With this intent, a numerical model is developed to investigate a layered permeability reservoir possessing heavy oil by coupling energy transport and multiphase flow. A Multilayer reservoir is considered to possess increasing and decreasing permeability from top to bottom directions. Vertical well configurations are used to understand the homogeneous and layer permeability reservoir effects on the energy transport and displacement sweep efficiency during hot water flooding. The homogeneous reservoir has been observed to have a higher displacement sweep efficiency than the layer permeability reservoir. The layer heterogeneity degraded the overall displacement sweep efficiency. The difference in displacement sweep efficiency has been found 6.8 % in the reservoir possessing permeability increasing in the upward direction and 8.07 % in the reservoir possessing permeability decreasing in the downward direction with respect to the homogeneous reservoir. The difference in the displacement sweep efficiency can arise owing to the layer arrangement and their impacts on temperature propagation within the porous media. The heat transport has been observed 0.88 K larger in the reservoir possessing permeability increasing in the upward direction than the homogeneous reservoir, whereas it is 2.85 K degraded in the reservoir possessing permeability decreasing in the downward direction. The temperature of the reservoir at 10 m from the injection well has been observed reaching to injection temperature along the total cross-section in the homogeneous media at the end of 320 days, which is causing effective viscosity reduction of the oil phase near the injection well, whereas it has been observed reaching to injection temperature only the top or bottom cross-section of the reservoir in layered media at the end of 320 days. The ineffective heat transport near the injection well is reducing the overall displacement sweep efficiency in the layered heterogeneity reservoir. From the present investigation, it can be analyzed that the layer permeability can cause ineffective heat transport in porous media in comparison to the homogeneous media, which can reduce the displacement sweep efficiency.

Keywords: Displacement sweep efficiency; Heat transport; Heterogeneity; Hot water flooding; Viscosity reduction.

OP-72: PET Derived Carbon Quantum Dots as Nanoparticle Tracers for Oil Fields

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There is an incessant increase in worldwide demand for oil and gas from past few decades. In order to meet such an accelerating demand, the future supply will entirely depend on the tertiary recovery and non-conventional resources. One of the most predominant problems for promising tertiary scrutiny of crude oil is related to mapping and probing subsurface reservoirs to improve the decision making in the reservoir management. However, cross-well electromagnetic imaging, seismic methods and well-logs like reservoir

characterization technologies have their own limitations in terms of detection range and resolution. Therefore, nanoparticles were tried as traces in oil fields. After a detailed study on their transport behavior, it was asserted that nanoparticles which flow through long distances in oil reservoirs are required. However, under harsh reservoir conditions of high salinity and high temperature, nanoparticles fail to show tracer-like ability. Recently, carbon quantum dots have been used as tracers in the oil fields but their study is very limited. We propose a pioneering work to use PET (Polyethylene terephthalate) derived carbon quantum dots as nanoparticle tracers. When transported through the reservoir, they act as sensors and provide the flow information functioning as conventional tracers. PET is a thermoplastic, non-biodegradable and polyester waste material. The carbon quantum dots were synthesized hydrothermally from PET bottles of daily use. The optical properties of carbon quantum dots were analyzed using UV-Vis and photoluminescence (PL) spectroscopy. FT-IR, TEM and DLS were used to obtain functional groups, size and hydrodynamic radius respectively. Zeta Potential of the carbon dots turned out to be -52.17mV, ensuring high colloidal stability. The stability of these particles was assessed extensively. The as synthesized carbon quantum dots show high colloidal stability at higher brine concentration of 10wt%NaCl and high temperature of 65ºC. They do not partition in oil as the optical properties changed minimally irrespective of brine concentration and temperature. Hence, they act as conservative tracers. The transport and retention behavior of the synthesized carbon quantum dots were studied by injecting them through the glass bead and sand packed columns at room temperature. The flow behavior was totally unimpeded in both the packed columns with nearly zero retention. Oil saturation was quantitatively detected in both the columns using breakthrough curves based on their interaction with oil phase. It was observed that in presence of oil the carbon quantum dots showed early breakthrough as can be justified by their hydrophillic nature and consequent decrease in the aqueous pore volume.

Keywords: Brine; Carbon quantum dots; Oil saturation; Tracer; Transport behavior.

OP-73: Silica Coated Magnetically Recyclable Demulsifier for Efficient Separation of Crude Oil-Water Emulsion

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The produced fluids from an oil well commonly exit as an intimate mixture of crude oil, water, and natural gas. These fluids are separated into respective phases at surface processing facilities involving various steps. The crude oil obtained after the primary gross separation of gas and water exits as an emulsion containing up to 15% of water. These water-in-oil emulsions require demulsification in order to meet the regulatory specifications before being dispatched to end users. The most common demulsification technique is the application of chemical demulsifiers coupled with heat treatment. This study explores the application of two nanomaterials: silica nanosphere (SN)-coated Cobalt ferrite ($CoFe_2O_4$) and polydiallyldimethylammonium chloride (PDDA) grafted silica nanosphere (SN)-coated Cobalt ferrite denoted as $CoFe_2O_4$@SN and $CoFe_2O_4$@SN@PDDA respectively for crude-water demulsification process. The two nanomaterials were synthesized by co-precipitation method in the presence of varying concentrations of silica precursor and PDDA. The $CoFe_2O_4$@SN and $CoFe_2O_4$@SN@PDDA nanoparticles were characterized by X-ray diffraction, transmission and scanning electron microscopies, Fourier transform infrared spectroscopy, thermogravimetric−differential thermogravimetric analyses, and vibrating sample magnetometry. The demulsification efficiencies were carried out through bottle tests. The demulsification tests were performed for a wide range of emulsions containing varying amounts of water content at different temperature conditions. Also, the nanomaterials were used at different concentrations in the demulsification process to find an optimum concentration. The results show that both the nanocomposites were able to efficiently demulsify the stable water in crude oil emulsions at all temperatures. The results show that the nano-materials were able to perform a complete demulsification within 10 minutes of time. The $CoFe_2O_4$@SN nanoparticles also exhibited good magnetic recyclability with almost very little change in the demulsification efficiency of the recycled $CoFe_2O_4$@SN.

Keywords: Dumulsification; Emulsion; Magnetic recovery; Nanoparticle.

OP-74: Investigation on Wettability Alterations on Carbonate Rock Samples using Natural Additives for Enhanced Oil Recovery

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The primary objective of this study is to overcome the challenges faced by chemical surfactants in EOR and present innovative use of natural additives. By leveraging naturally derived leaf extracts and egg white, we aim to reduce the interfacial tension (IFT) and alter the wettability on a carbonate core sample collected from Odisha, India and to make a comparative study at different reservoir temperature conditions and concentrations to develop sustainable surfactants for production of hydrocarbon.

Our research encompasses a comprehensive study of IFT and contact angle at different concentrations. We conducted extensive laboratory experiments to extract surfactants from the leaves of hibiscus, lotus, papaya plants and egg white to validate the effectiveness of the proposed natural surfactants in wettability alteration and IFT reduction between oil and surfactant solutions. Also, contact angle has been measured in the presence of above-mentioned proposed surfactant solutions for the IFT reduction between the crude oil and carbonate rock sample. These approaches were implemented at different increasing temperatures in order to understand real world case studies.

The results demonstrated that hibiscus extract was able to lower the IFT from 32.8 to 16.28 mN/m, while for lotus extract from 36.97 to 17.52 mN/m, for papaya extract from 35.05 to 18.48 mN/m and for egg white surfactant its from 25.57 to 19.4 mN/m between oil and distilled water respectively. Our study showcases the successful application of naturally derived surfactants in wettability alteration to water wet and increase oil recovery factor. Out of all these surfactants, egg white showed maximum wettability alteration by contact angle reduction of 17.8%. Also, it showed improvement in the contact angle with increasing in temperature of the proposed reservoir solutions. Moreover, our research highlights the potential of adopting natural surfactant solutions.This study provides valuable insights into the use of natural additives in EOR processes and underscores the potential benefits of utilizing natural extracts as a safer and more environmental friendly alternative to chemical surfactants. The incorporation of these natural extracts has the potential to revolutionize traditional practices and drive the industry towards a more sustainable and productive future.

Keywords: Carbonate core; Contact angle; Enhanced oil recovery (EOR); Interfacial tension (IFT); Wettability Alteration.

OP-75: A Review of Biochemical Applications for Green Enhanced Oil Recovery in Indian Petroleum Fields

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Green Enhanced Oil Recovery (GEOR) has gained widespread recognition as an environmentally responsible approach to augmenting oil recovery. This technique has been used for enhanced oil recovery (EOR) in several oilfields globally, with promising results. This article comprehensively analyzes the potential and challenges in utilizing biochemicals, specifically biopolymers and biosurfactants, for GEOR in Indian oilfields. It investigates their effectiveness based on reservoir and formation fluid characteristics, drawing parallels between foreign oilfields that have successfully implemented these techniques and the challenges and opportunities faced by Indian oilfields. Despite the numerous benefits of biochemicals in EOR, Indian oilfields have not yet adopted these methods. The review highlights the untapped potential of utilizing biopolymers and biosurfactants in GEOR to increase oil recovery and improve overall production

efficiency in Indian oil reservoirs. By presenting a comprehensive overview of the current state of biochemical applications in EOR, this article identifies the gaps and opportunities in the field, paving the way for further research and development in sustainable oil recovery methods. Since hydrocarbons account for over 70% of global fuel consumption, finding environmentally friendly and economically viable approaches to enhance oil recovery becomes imperative. The review underscores the significance of integrating green EOR methods, like biochemicals, in the quest for sustainable energy production while mitigating the adverse environmental impacts associated with conventional EOR methods reliant on synthetic chemicals. This article contributes to the literature by consolidating and evaluating the existing knowledge on applying biochemicals, including biopolymers and biosurfactants, in chemical EOR and microbial-enhanced oil recovery (MEOR) methods. It sheds light on the unique challenges and opportunities specific to Indian oilfields, encouraging further research in this underexplored area.

Keywords: Biopolymers; Biosurfactants; Green enhanced oil recovery (GEOR); Indian oil fields; Microbial enhanced oil recovery (MEOR).

OP-76: Enhancing Recovery of Low Acidic Number Crude Oil using Nanoparticles assisted Alkali-Driven Spontaneous Imbibition using Berea Sandstone core

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Spontaneous imbibition process plays a crucial role in the upstream petroleum engineering operation by providing considerable driving force for enhanced oil recovery operation. Also, the crucial role of imbibition process was proven evident for maximizing the crude oil production from the mature and fractured fields. Despite the availability of a variety of enhanced oil recovery techniques, chemical-based oil recovery operations are the most advantageous since they increase both microscopic and macroscopic displacement efficiency. On the other hand, the introduction of nanoparticles in the displacing fluid is one of the emerging fields in enhanced oil recovery process. In the field of enhanced oil recovery nanoparticles and nanofluid are developing technologies. Nanofluids, which are base fluids suspended in nanoparticles, can improve fluid recovery, change viscosity, and improve heat transfer in EOR processes. The addition of this technology along with chemical enhanced oil recovery process can maximize the oil recovery operation. Recent research interest on the synergistic effect of alkali with nanofluid has given rise to hybrid nanofluid formulation for enhanced oil recovery methods. In this work, silica nanofluid of varying concentrations was dispersed in a NaCl (lowsal) solution with sodium carbonate (alkali) and polyacrylamide (polymer) as the base solution. The mechanisms of spontaneous imbibition were studied by interfacial tension (IFT) measurement, contact angle, surface roughness and solid-liquid interfacial force using F-D mode in AFM analysis. The imbibition efficiency of the designed low saline alkaline polymer-nanofluid (LSAP-NF's) were conducted in an Amott cell at 50° C using Berea sandstone core. The spontaneous imbibition results showed that the imbibition efficiency of formulation with silica nanoparticles is higher than the low saline alkali formulation without silica nanoparticles. Also, this LSAP-NF's formulation can effectively increase the oil recovery of low acidic number crude oil which usually requires high amount of surfactant to reduce the IFT. The interface mechanisms of this investigation using IFT, wettability and solid-liquid interfacial forces confirmed that the imbibition process is equally controlled by the gravity and the capillary force. Further, the solid-liquid interfacial force exposed a fully hydrophilic surface with silica nanofluid confirming the capillary force dominated imbibition. This work reveals the fundamental mechanism of the influence of spontaneous imbibition on a sandstone surface and its use in enhanced oil recovery.

Keywords: Alkali; Contact angle; Imbibition; Interfacial tension; Silica nanoparticles.

OP-77: Experimental Study on Methane Hydrate Formation using Single Step TiO_2 Nanofluids

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Gas hydrate is a crystalline solid that forms under specific conditions of temperature and pressure when gas molecules become trapped within a lattice of water molecules. It has the potential to serve as a significant source of clean energy, a potent greenhouse gas, in a stable and compact form. It is considered an excellent method of transportation of natural gas. However, there is a major problem in hydrate formation (slow process). This problem can be addressed by manipulation of temperature and pressure conditions by introducing nanoparticles to promote the hydrate formation faster. The use of TiO_2 nanoparticles in the pipeline can alter the thermodynamics and kinetic behavior of gas hydrate.

TiO_2 (Titanium Oxide) nanofluid contains TiO_2 nanoparticles suspended in a PAM base fluid. A HTHP (high temperature and high pressure) reactor was used to form gas hydrate with different concentrations of TiO_2 nanofluids. Each experiment was conducted at least three times to verify the results, the duration of each experiment was 25 hours. The initial temperature and pressure was kept at 80 Bar and 275 K. The rotator speed was maintained at 550 rpm throughout the experiment.

Single step TiO_2 nanoparticle was prepared in the lab and used in this study to see the effect of gas hydrate formation. The results show that by adding nanofluid, the formation of gas hydrate was faster and decreased in the induction timing of formation of gas hydrate. Results also show that by adding nanoparticles the heat transfer increases resulting in change in the hydrate phase diagram. For this concentration of 5 ml of nanoparticles in the solution, the induction time decreases about 81.70% compared to the pure water at the same conditions.

In summary, the use of nanofluids has the potential to improve the efficiency and effectiveness of promoting gas hydrate formation. The nanoparticles with TiO_2 nanofluid have shown faster formation of gas hydrate under certain temperature and pressure. Further research is needed to fully understand the benefits and limitations of this technology, as well as to develop practical and cost-effective methods for its implementation.

In recent years, there has been growing interest in the use of nanofluids to facilitate the production of gas hydrate. Nanofluids are suspensions of nanoscale particles in a liquid medium, and they have the potential to enhance the heat and mass transfer properties of the fluid. By incorporating nanomaterials, such as nanoparticles, into the fluid, it is possible to increase the thermal conductivity, convective heat transfer coefficient, and viscosity of the fluid.

Keywords: Gas hydrate; Gas consumption; Induction time; Kinetic and thermodynamic properties; Single step nano-fluid.

OP-78: Cellulose Nanoparticle with Mustard Oil Methyl Ester as Environment Friendly Pour Point Depressants for Flow Assurance of Indian Waxy Crude Oil

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Deposition of wax crystal in pipeline can cause severe problem during production and transportation of crude oil. Among several methods, addition of polymeric additive known as Pour point depressants (PPDs) can be effective way to mitigate this wax deposition problem. However, most of the available PPDs are synthesized from chemicals which are not eco-friendly. So, present study has focused on the extraction of natural carbohydrate polymer mainly cellulose from easily available Sugar cane bagasse and then converted it into nano particle by acid hydrolysis. Produced nanoparticle are then blended with Mustard oil methyl

ester (MOME) and used as PPD to assure the flow of Indian crude oil. Formation of the PPD is characterized by FTIR, DLS, TGA, CHNS and XRD study. Reduction of pour point was achieved by 9℃ after mixing of 600 ppm MOME and this reduction is enhanced up to 15℃ when MOME blended with cellulose nanohybrid was used. This nanoparticle blending mixture is also an efficient viscosity reducer. Investigation of rheology, prove that, crude oil behaves as a Newtonian fluid after mixing of cellulose nanoparticle blended MOME. Study of wax crystal morphology through Cross polarized microscope (CPM) is also in line with pour point and viscosity result. Micrographs of PPD treated crude oil showed that, significant reduction of wax crystal's size and dispersion of these agglomerated wax crystals throughout the crude oil. Phase analysis of crude oil and X-ray diffraction study of MOME-Cellulose nanoparticle treated crude oil also support this result. This article also studies the wax deposition through laboratory designed wax depositional set up, Cold Finger Apparatus. The thickness of deposited wax on Cold finger was decreased up to 85% after dosing with MOME blended with cellulose nanoparticle mixture than that of pure crude oil. Adsorption of wax molecules on to alkyl chain of PPD changed the morphology of wax crystals by preventing the formation of 3-dimensional network of wax molecules and interaction of nanoparticle with asphaltene and resin reduced the viscosity of crude oil. As a result, crude oil can flow very easily through pipeline. Therefore, MOME blended with carbohydrate nanoparticle can be used as an effective environment friendly, cost-effective pour point depressants as well as flow improver of Indian waxy crude oil. No special treatment is required to send these PPD treated crude oil to refinery.

Keywords: Environment friendly; Flow assurance; Nanoparticle; Pour point depressants; Wax crystal.

OP-79: Analysis of Anisotropy in Fracture Network Geometry by Application of Optimized Waterflood-Patterns in Fractured Reservoirs

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Anisotropy may be observed in rock masses that contain fractures and affects several properties including flow behavior which is controlled by how fractures are clustered in space. While Rose diagrams are often used for delineating "fracture sets" in different directions, it is a challenge to quantify anisotropy in terms of fracture clustering that controls fluid flow. This research attempts to answer the question by capturing the anisotropy in fluid recovery and production rates of fracture networks and its correlation with fracture clustering anisotropy. A set of three fracture maps collected from the Devonian sandstone of Hornelen Basin, Norway and Carboniferous sandstone at Telpyn Point, UK are considered in this study. These maps are flow simulated considering the fracture continuum model (FCM) and using a streamline simulator, Trace3D. A set of structured computational grids were constructed for the FCM such that each pixel of a map was considered a cell which was assigned porosity and permeability values based on whether it represented a fracture or matrix. In order to determine recovery in the x-direction, a series of injection and production wells were placed along the two boundaries parallel to the y-axis, while the ones parallel to the x-axis were considered no-flow boundaries. The flow system was then rotated by 90-degrees for evaluating the recovery in y-direction. In a later analysis, a modified inverted five-spot water flooding pattern is implemented to check the production anisotropy in two mutually perpendicular directions. The results from both the "dynamic modeling" approaches are compared with the anisotropy in fracture clustering for a set of natural maps. Coefficient of variation that can differentiate between clustered, random, and anticlustered fractures in 1-dimensional fracture data is used for quantifying the "clustering" anisotropy in 2-dimensional fracture networks. We employ this parameter for evaluating directional clustering in such networks by moving a set of scanlines in two mutually perpendicular directions and finding the respective arithmetic averages. The results show that overall fluid production values tend to be higher in the direction of highly clustered fractures. Also, the production anisotropy using the modified inverted five-spot water flooding pattern fits better than the recovery anisotropy in describing anisotropy in fracture geometry. It implies that a properly designed "dynamic" approach can be successfully used for evaluating the anisotropy of a reservoir and larger ratio in production values in two mutually perpendicular directions suggests the presence of fracture clusters. If such anisotropy is taken into account, it can help in building more realistic DFN models which are more advanced in depicting the reservoir performance.

Keywords: Anisotropy; Flow simulation; Flooding-patterns; Fracture clustering; Reservoir performance.

OP-80: Integrating Advanced Strategies and Software for Optimal Drilling Operations and Well Integrity in Hydrocarbon Extraction

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The efficient and safe extraction of hydrocarbon resources from subsurface reservoirs necessitates a comprehensive approach that encompasses various drilling and well construction considerations. This work delves into a multifaceted strategy for optimizing drilling operations while minimizing environmental impact. The key components of this endeavour include the development of a Non-Damaging Drilling Fluid Formulation, a Mud Program design, meticulous Well Planning, and Casing Seat Selection through the utilization of Halliburton's Landmark software suite, encompassing Stress Check, Casing Seat, and Well Plan modules. The primary objective of this study is to establish a drilling fluid formulation that effectively balances the imperative to maintain wellbore stability and integrity, while simultaneously mitigating potential damage to reservoir formations. By employing advanced rheological and chemical analyses, the Non-Damaging Drilling Fluid Formulation aims to improve wellbore stability and minimize formation damage, thereby enhancing drilling efficiency and reservoir productivity.The design and implementation of an optimized Mud Program further contribute to successful drilling operations. The program entails the selection and deployment of drilling fluids, additives, and procedures that align with the specific geological and operational conditions of the well. This approach maximizes the efficiency of drilling, minimizes drilling-related challenges, and ensures minimal impact on the surrounding environment. The Well Planning phase encompasses a meticulous assessment of geological data and operational requirements to determine the ideal well trajectory. The trajectory planning accounts for factors such as reservoir depth, target zones, geological formations, and potential drilling hazards. The goal is to achieve optimal reservoir access while minimizing drilling complexities and risks. The Casing Seat Selection process relies on Halliburton's Landmark software suite, employing Stress Check, Casing Seat, and Well Plan modules. This software integration facilitates a comprehensive analysis of mechanical stresses and forces acting on the casing, aiding in the selection of appropriate casing seat depths. This, in turn, enhances wellbore integrity and overall drilling success.In conclusion, the integrated approach presented in this work strives to revolutionize drilling operations within the hydrocarbon industry. By addressing the critical aspects of drilling fluid formulation, mud program design, well planning, and casing seat selection, operators can achieve enhanced drilling efficiency, reduced environmental impact, and improved wellbore integrity. The utilization of Halliburton's Landmark software provides a technologically advanced platform for informed decision-making, contributing to the overall success of hydrocarbon extraction endeavours.

Keywords: Casing seat selection; Drilling fluid formulation; Mud program design; Well planning; Wellbore integrity.

OP-81: Exploration for Hydrocarbons in the Fluvial Environment through a Remotely Operated Vehicle (ROV)

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Exponential growth in energy consumption, has lead to an increased focus to enhance hydrocarbon production. Post development of mega oil and gas structures, new hydrocarbon prospects are located in challenging and sensitive geographic locations. Fluvial environments, often conceal oil reserves beneath the river waters and the offshore exploration strategy must be safe as well as economic. This paper outlines fluvial hydrocarbon exploration through a specialized Remotely Operated Vehicle (ROV) engineered for fluvial oil and gas exploration. The ROV's features are tailored to meet the unique challenges presented by riverine hydrocarbon reservoirs. Objective of this ROV is to facilitate preliminary oil exploration and

reservoir evaluation in fluvial settings. Before carrying out the full-fledged seismic survey, a visual survey of the riverbed (like aerial survey in onshore), study of marine organisms, inspection of natural oil and gas seepages, and collection of rock and fluid samples of interest are critical. Further various geochemical analysis of these samples like Source rock evaluation (Total Organic Carbon, Vitrinite Reflectance, Hydrogen Index etc.) along with chromatography studies, SEM analyses, Pyrolysis studies and fluorescence tests may help pinpoint an area of interest where further exploration maybe planned with higher precision. Additionally, results of these studies help as inputs for constructing the basin model. Basin modelling will enhance knowledge of the riverine depositional environment specially in the totally unexplored riverbed by clearly illustrating the petroleum system viz. generation and migration. A special focus has been given to utilize the ROV for two purposes: (1) inspection and study of the riverbed for underwater exploration (2) collection of various rock and fluid samples for analysis; further scope of utilization of ROV for in-situ analysis of natural seepages is worked on. Accordingly, robotic manipulators are integrated into the model. The basic model of the ROV is illustrated in the paper. The vehicle incorporates subsea imaging equipment, geological sensors, and real-time data transmission, to facilitate data acquisition and interpretation. Its modular design and control system is optimized for precise navigation in turbulent river currents, ensuring safe deployment of sensors and instruments in challenging riverine conditions. Additionally, the user interface is designed for intuitive operator control, allowing real-time interaction with the ROV. Robot vision is designed considering the riverine environment. A special emphasis has been given to the Brahmaputra River system prevalent in the Northeast Area of the Indian Subcontinent which is one of the largest rivers in the world by discharge and is believed to have good untapped hydrocarbon potential beneath the riverbed. The exploration strategy has hence been conceptualized considering dimensions of the river, depth elevations, salinity, pressure, marine life and several factors. The outcome is a comprehensive model of the riverbed and a conceptual model of the subsurface constructed using data inputs collected through the ROV. This model will help oil sectors to carry out hydrocarbon exploration under the river in an accurate and cost-effective manner. This concept represents a significant advancement in the field of riverine oil & gas exploration, offering a sustainable approach to harnessing these energy resources.

Keywords: Geological sensors; Hydrocarbon exploration; Remotely operated vehicle (ROV); Riverine reservoirs; Robotics and AI.

OP-82: Extraction of Carbon from Low-Grade Graphite Ore using Alkali-Hydrothermal Treatment as a Hybrid Physiochemical Method

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Graphite is a crucial carbon raw material extensively utilized across various industries. In addition to its traditional applications such as metallurgical extraction and nuclear reactors, graphite plays a pivotal role in the production of carbon nanomaterials like graphene, carbon nanotubes, and fullerene. These nanomaterials are of paramount importance in renewable energy technologies and various emerging sustainable innovations. Graphite is obtained through the beneficiation of graphite ore using physical separation methods, which effectively separate high-grade graphite from tailings and reject samples. However, in many cases, even the reject samples and tailings may contain trace amounts of small flake graphite (less than 10%). Separating graphite at such low concentrations solely through physical means becomes challenging. Similarly, in India, numerous graphite mines yield ores with graphite concentrations below 10 wt. %, making it imperative to employ physiochemical and chemical treatments for these low-grade graphite ores. We have devised a process for separating carbon from impurities such as silicates and ash compounds in these low-carbon mine samples. These samples typically contain an average of 7.7% carbon, with the remainder being impurities like silicates and ash compounds. The process involves subjecting the samples to alkali treatment under hydrothermal conditions, which effectively separates approximately 5.1% of the initial 7.7 wt. % carbon content, leaving behind the ash compounds.To validate the results, all samples underwent thorough examination through techniques such as Energy Dispersive X-Ray Analysis (EDX), Thermogravimetric Analysis (TGA), and Raman Spectroscopy.

Keywords: Carbon extraction; Coal beneficiation; Graphite extraction; Hydrothermal treatment; Waste cessing.

OP-83: Synthesis of MOF Embedded Metal Sulfide for Electrocatalytic Overall Water Splitting

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Water electrolysis for green hydrogen production is crucial to combat diminishing fossil fuel reserves and mounting environmental problems. Pt and other noble metals show the most efficiency toward hydrogen evolution reaction (HER) and oxygen evolution reaction (OER), but their large-scale application is hindered by high cost and low abundance. Therefore, inexpensive, highly active and stable electrocatalyst needs to be developed to overcome the kinetic barrier of the half reactions, OER in particular. Transition metal dichalcogenides (TMD) have potential to be low-cost substitute of Pt based catalysts as they are stable, earth abundant and easy to synthesize. The intrinsic poor selectivity of TMDs can be addressed with heterojunction formation with metal organic frameworks (MOF) where the MOFs provide great surface properties and widely distributed active sites. Herein, we designed a core shell with VS_2 and ZIF-67 on Ni foam for water electrolysis for overall water splitting under alkaline condition. The structure, morphology and electronic properties of the synthesized materials were analyzed using XRD, FTIR, SEM, TEM and XPS. The synthesized VS_2@ZIF-67 catalyst have shown low overpotential of 143.03 mV at 10 mA cm^{-2} with Tafel slope of 123 mV dec^{-1} for HER. The catalyst has also shown good OER activity with overpotential of 117.25 mV at 10 mA cm^{-2} with Tafel slope of 119 mV dec^{-1}. High durability electrocatalyst was observed using chronoamperometry analysis (up to 30 h). The synergy between VS_2 and ZIF-67 was also studied at the same reaction conditions which showed the composite structure is promising for bifunctional catalyst.

Keywords: Electrocatalysis; Heterojunction; Water splitting; MOF; TMD.

OP-84: A Novel Eutectic Mixture of Biphenyl and Diphenyl Ether Derivatives as Potential Liquid Organic Hydrogen Carriers: An Experimental and Computational Study

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Depleting nonrenewable fuel reserves and deteriorating environmental conditions have compelled our society to pursue alternative energy sources and chemicals. Hydrogen as an energy carrier represents one of the promising alternatives to fossil fuels. Chemically bound hydrogen to a liquid carrier has attracted significant attention as a safe and cost-effective method of storage and transport utilizing existing fossil fuel infrastructures. Hydrogen storage in Liquid Organic Hydrogen Carrier (LOHC) systems is appealing for the secure storage and distribution of excess energy to end-users. In accordance with this concept, a LOHC is hydrogenated during production and dehydrogenated when the hydrogen is required. Due to their reasonable storage capacity, biphenyl and diphenyl ether are a viable option as potential LOHC. In this study, the feasibility of a eutectic mixture of biphenyl and diphenyl ether derivatives as a novel LOHC candidate was investigated. In the first stage, a eutectic mixture was created experimentally by combining biphenyl and diphenyl derivatives in various molar ratios. Using a variety of analytical techniques, the physical and chemical properties of the eutectic composition were evaluated in the subsequent step. In the subsequent step, quantum chemical calculations were performed on the eutectic mixtures (at various molar ratios) to characterize their intermolecular interactions, charge transfer behavior, and thermodynamics in relation to

their application as a potential LOHC system. Utilizing the BP86 density functional along with the triple-def2-TZVP basis sets, preliminary geometry optimizations were performed. By performing harmonic vibrational frequencies at the same level, energy minima on the potential energy hypersurface were determined for the resulting stationary points. The resolution-of-identity (RI) approximation was used in conjunction with suitable auxiliary basis sets to facilitate rapid computations. Dispersion effects were taken into account by employing atom-pair-wise correction techniques with Becke-Johnson damping (D3BJ). The geometries were then reoptimized with the M06-2X density functional, which was deemed appropriate for evaluating thermochemical parameters for analogous systems. The interaction energies of investigated eutectic mixtures were calculated using quantum chemical calculations, and the counterpoise procedure was used to eliminate the basis set superposition error (BSSE) at this stage.

Keywords: Hydrogen storage; Liquid organic hydrogen carrier; Diphenyl ether; Biphenyl; Quantum chemical calculations.

OP-85: Investigation of rock/fluid interactions in smart water flood for offshore carbonate reservoirs

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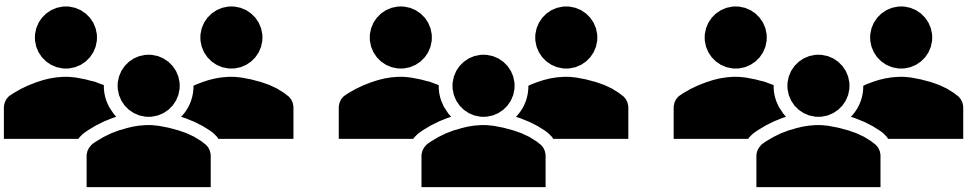
The dwindling pressure scenario, high salinity and high reservoir temperature of offshore carbonate reservoirs remained a challenge for conventional EOR implementation. Low salinity water flood (LSWF)/Smart Water Flood (SWF) is a promising Enhanced oil recovery (EOR) technique because of their simple design, cost-effectiveness and high efficiency in improving both microscopic and macroscopic displacement efficiency, along with taking care of its offshore field challenges. The study validates the positive effect of Potential determining ions (PDI) through a wettability alteration mechanism in one of the Giant offshore fields of ONGC. The study involves assessing both rock/fluid and fluid/fluid interaction thoroughly viz. spontaneous and sequential imbibition, characterization of the rock samples, crude oils, and injection/formation water, screening and Optimization of Brine Compositions for Zeta Potential Studies, effect on surface charges through zeta potential by variation in the composition of potential determining ions (PDIs i.e. $SO4^{2-}$, Ca^{2+}, and Mg^{2+}), contact angle measurement, deriving oil-water relative permeability curve for core flood simulation and examining the effect of smart water brine in the offshore field. The main conclusions of the study are 1) Smart flooding tests proved conclusively that LSWF with certain specific ionic compositions yields a higher oil recovery 2) In the Spontaneous imbibition experiment, the change in contact from the angle of oil droplets signifies the change in wettability from an oil-wet state (weakly water-wet) to a water-wet wet state.3) Fluid/Fluid and Rock/Fluid interaction suggested there is an optimal SW salinity with optimum recovery. 4) Divalent anions such as $SO4^{2-}$ tends to adsorb on the rock surface which increases the surface charge to a more negative value, which helps to achieve a higher incremental recovery for the oil by increasing the repulsive forces between oil-brine and rock-brine surface 5) By increasing the hydrophobicity of oil by dilution of injected brine which seems to be responsible for increasing the zeta potential and detaching the oil from the rock surface. This can be attributed to electrical double-layer expansion which is principally caused by reduced ionic strength. 6) A single porosity 1D simulation history-matched model was prepared that can replicate the experimental results and predict the performance of smart brines.

The findings of this study may be used as guidelines for carbonate reservoir screening & science of rock-fluid interactions at the pore scale in LSWF.

Keywords: Enhanced Oil Recovery (EOR), Low salinity water flood (LSWF), Oil and Natural gas Corporation Limited (ONGC), Potential determining ions (PDI), Smart Water Flood (SWF),



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PP-01: Experimental Investigation of the H_2 Generation by Using Chemical Method

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Environmental dilapidation owing to the use of fossil fuel in various sectors for harnessing power has drawn the attention of the global community in the last few decades. The limited availability of the mines of fossil fuel is another shortcoming of the fuel. The utilization of alternate sources of energy can reduce the use of traditional fuels and decrease the emissions due to their combustion. At present, various sources of alternate energy have been explored viz. solar energy, tidal energy, geothermal energy, biogas energy, wind energy, hydrogen energy, etc. However, the conversion efficiency of the different energy sources is not satisfactory to be utilized in industrial applications. H_2 energy in this context has gained importance from researchers and scientists as (a) the energy density is high, (b) the lightest element exists on the earth's crust, (c) abundantly available, etc. Hydrogen gas can be produced by different methods. The most popular methods of production are (i) water electrolysis, (ii) partial combustion of hydrocarbons, (iii) biogas reforming, (iv) reactions of active metal with alkaline solution, etc. Among all these methods the production of H_2 gas by the reaction of scrap Al and water in the presence of aq. KOH is a promising technique in terms of emission and productivity. The Al-H_2O reaction is characterized by good conversion efficiency at the expense of no harmful emissions. The process is simple and uses scrap aluminium as the raw material. This feature added novelty to this method. The work is, therefore, adopted to scale up the generation of hydrogen gas by the Al-H_2O reaction for various industrial uses. The reactions are carried out in the presence of aq. KOH at temperatures of 328K-348K at a step of 10K. The concentrations of aq. KOH used are 3.5M, 4.5M, and 5.5M. The pellet sizes and the masses of Al pellet used in the reaction are 0.5cm, 1.0cm, 1.5cm, and 0.5g, 1.5g, and 2.5g respectively. The experimental hydrogen generation rate at 348K, 338K, and 328K for a fixed concentration of 4.5M are measured to be 21.6 ml/min, 19.0 ml/min, and 16.36 ml/min respectively. The activation energy for the reaction is found to be 43.41 kJmol-1. The reactions are carried out with distilled water and tap water separately to observe the effect of the quality of water on the hydrogen generation rate. The Al hydrolysis efficiency is also compared by using another two alkaline solutions viz. NaOH and $Ca(OH)_2$.

Keywords: Activation energy; Environment friendly; H_2 gas; KOH; Rate constant.

PP-02: Development and Assessment of a New Energy System for Green Steel Production

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Steel has profound importance in modern society owing to its enormous applications in transportation, drinking water, food production, buildings, and infrastructure. However, due to its energy-intensive processes, the iron and steel industry is one of the largest greenhouse gas (GHG) emitters. For a sustainable future, innovative energy systems must be investigated to facilitate the generation of carbon-free steel. One of the promising interventions is the direct reduction of iron using hydrogen generated from renewable sources. This paper proposes an approach to generate carbon-free steel using a multigeneration system integrating biomass and solar. The system contains eight sub-systems: fluidized bed gasifier, syngas clean up, water gas shift (WGS) reactor, Hydrogen separation and storage, carbon capture, shaft furnace, Solar PV, and Heat Recovery Steam Generator (HRSG). The proposed configuration utilizes a fluidized bed gasifier to generate hydrogen from biomass, which is used in a shaft furnace to make Direct Reduced Iron (H_2-DRI). Direct Reduced Iron is then fed to an electric arc furnace to produce Green Steel. Solar PV compensates for all the electricity needs, making the entire system self-sustaining, and a carbon capture unit captures all the post-combustion CO_2. The waste heat streams are utilized to generate process-heat using a Heat Recovery Steam Generator. A thermodynamic assessment of the proposed plant is done, and the overall energy efficiency of the plant is 50%, and the overall exergy efficiency is 46%. This study would be useful in the design and operation of a biomass-based energy system for the iron and steel industry.

Keywords: Carbon Capture; Fluidised bed gasifier; Green steel; Hydrogen; Multigeneration systems; Solar PV.

PP-03: Miscible EOR: Workflow from Lab to Field

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Enhanced oil recovery (EOR) using CO_2 not only increases ultimate oil recovery but also helps in sequestering the greenhouse gas CO_2. EOR recovers oil by altering the chemical composition of reservoir fluid which makes oil to be easily extracted. The main mechanism of CO_2-EOR is mass transfer (diffusion and absorption), by interfacial tension reduction, oil swelling, oil viscosity reduction, the lighter components of the crude oil are mobilized. The process of screening, design and field implementation of CO_2-EOR is complicated, which requires expertise. Fundamentally the screening criteria for EOR depends on the reservoir's rock and fluid characteristics. CO_2-EOR can be applied to reservoirs having medium to light gravity oils. Crude oil is a complex mixture of hydrocarbons, regular and special compositional analysis are done in the laboratory. The PVT analysis for the CO_2-crude oil interaction is performed to calculate minimum miscibility pressure (MMP), swelling, diffusion rate and asphaltene deposition. To calculate relative permeability, recovery and displacement design, core flooding experiments are performed using ~~s~~ reservoir core samples with live and synthetic crude oil. Before performing EOR technique to field or conducting the experiment in laboratories, modelling and simulation approach is performed to evaluate EOR potential. These simulation results are helpful in designing the laboratory experiments and pilot scale field testing. From the literature, it can be summarized that the miscible EOR gives more recovery than immiscible EOR. Water alternating gas (WAG) injection controls mobility, decrease viscous fingering, leading to improved oil recovery with the combination of gas flooding and water injection. In this article a detailed review on CO_2-EOR selection and design will be presented.

Keywords: CO_2; EOR; Miscible EOR.

PP-04: Development of Low Cost Sustainable and Efficient Electro-Catalyst and Proton Exchange Membrane for Electrolyser Assembly for Producing Green Hydrogen

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The shift towards sustainable energy sources demands innovative solutions to curtail carbon emissions. Green hydrogen production through water electrolysis stands as a transformative avenue. Yet, the impediment of costly electrocatalysts has curbed the progress of PEM water electrolysis commercialization. Although the cost-effective and high-efficiency electrocatalysts and high proton conductivity containing proton exchange membranes (PEM) fabrication present a breakthrough, holding the promise to surmount this obstacle. This holds the potential to elevate proton exchange membrane (PEM) water electrolysis into a practical and compelling choice for efficient hydrogen generation.This study aims to synthesise Polyether Ether Ketone (PEEK) based PEMs and carbon-supported transition metal-based electrocatalysts. The sulfonated PEEK (sPEEK) was prepared by gradually introducing polymer into concentrated H_2SO_4 for sulfonation. The process involves subsequent immersion in ice-cold water to halt sulfonation. The strands of sPEEK polymer are filtered and vacuum-dried. For membrane fabrication, 10 wt.% SPEEK- DMAc solution was used and cast onto a glass plate. The fabricated membrane was characterized by an X-ray diffractometer (XRD), field emission scanning electron microscope (FESEM) and atomic force microscopy (AFM). The average surface roughness of the membrane was calculated by AFM and its value is 13.4 nm. The physicochemical properties of the sPEEK membranes, such as ion exchange capacity (IEC) is 0.7 meq/gm, water uptake (28%), swelling ratio (5%) and proton conductivity were measured. Based on the IEC value, the degree of sulfonation was achieved as 21.7%. The transition metals supported on carbon were prepared by wetness impregnation method followed by the reduction in H_2/Ar environment in a

horizontal furnace. All the electrocatalysts were prepared with the loading of 20 wt.% of metal on carbon support. The activity of prepared electrocatalysts was analyzed for hydrogen evolution reaction (HER) by calculating their overpotential in the range of 0 to -0.6 V Vs RHE by linear sweep voltammetry.

Keywords: Electrocatalyst; Hydrogen evolution reaction (HER); Proton exchange membrane; sPEEK.

PP-05: Rheology of Hydrolyzed Polyacrylamide (HPAM)-Layered Double Hydroxide (LDH) Nano-Composite for Enhanced Oil Recovery

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Polymer Flooding is an enhanced oil recovery (EOR) technique that uses polymer solutions to increase the viscosity of displacing fluid in order to increase oil recovery. Out of all chemical EOR projects more than 80% of projects are polymer flooding. Although polymer flooding is widely used it has serious challenges such as: vulnerability to mechanical shear and thermal degradation. In this study, nanocomposite based on Mg-Al layered double hydroxide (LDH) together with HPAM polymer were tested with the objective of improving the rheological properties of HPAM as well as its thermal and shear tolerance. HPAM is a water-soluble polyelectrolyte with negative charges on the polymer chains due to the presence of carboxylate group (COO^-). The polymer used in this study is provided by SNF Flopam India Pvt Ltd with molecular weight of 18.5-23.5 MDa. The positive charge on Mg-Al LDH helps it to be used as crosslinkers with HPAM polymer to improve its rheological properties. The Mg-Al LDH nanoparticles were synthesised in the lab with the help of magnesium salt (e.g., magnesium chloride, $MgCl_2$) and aluminium salt (e.g., aluminium nitrate, $Al(NO_3)_3$) followed by their characterization using X-ray diffraction, electron microscope and FTIR to analyse the primary structure of LDH. The prepared LDH is dispersed in the HPAM polymer solution and rheological characterization is done to investigate the effect of LDH on the polymer's rheology. The solutions are prepared by keeping the polymer concentration constant with varying nanoparticle concentrations and again keeping the constant nanoparticle concentration in different concentrations of polymer. Rheological experiments are conducted for all the prepared solutions over a range of shear rates ($1\text{-}100s^{-1}$). Effect on the polymers viscoelastic property is determined by conducting oscillatory test such as amplitude sweep test and frequency sweep test.

Keywords: Enhanced oil recovery; Nanoparticle; Polymer rheology.

PP-06: Characterization of Jackfruit Peel for Biomass Gasification

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The exploration for sustainable energy solutions has led to the investigation of unconventional biomass sources. The present study investigates the potential of jackfruit peel, a significant waste product, as a viable feedstock for hydrogen and syngas production through the process of gasification. Jackfruit is widely available in tropical regions such as Southeast Asia, India, and Bangladesh. The annual production exceeds millions of tons, leading to a significant amount of peel waste, making it a promising candidate for biomass energy conversion. The characterization of the biomass was carried out using various analytical techniques such as Proximate analysis, Ultimate analysis, Thermogravimetric Analysis (TGA), Fourier Transform Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD), and Scanning Electron Microscopy (SEM). Proximate analysis revealed moisture (8.5%), volatile matter (74.6%), ash (5.9%), and fixed carbon (11%). Ultimate analysis determined carbon (44.7%), hydrogen (6.1%), nitrogen (0.5%), sulfur (0.1%), and oxygen (48.6%) content. The high carbon content and other elements rendered the biomass suitable for gasification. Compositional analysis confirmed extractives (7.5%), lignin (22.86%), cellulose (56.07%), and hemicellulose (13.57%) presence, especially cellulose and lignin, crucial for syngas production during gasification. TGA indicated three major mass loss zones: (i) water vapor loss, (ii) hemicellulose, cellulose, and lignin devolatilization/oxidation, and (iii) carbonaceous solid and lignin degradation. Most mass loss

(40–85%) occurred during the second zone (180 - 500°C), corroborated by DTG showing two peaks, signifying rapid jackfruit peel degradation. SEM analysis depicted the jackfruit peel's morphology, characterized by a folded structure with a rough surface and various-shaped pores, likely due to its diverse components. This rough structure could enhance gas-solid interactions during gasification, potentially improving reactant penetration and product escape. These morphological features are likely to enhance the gasification process by facilitating the penetration of reactants and the escape of products. FTIR identified functional groups, including -OH and C-H stretching vibrations (3432 cm^{-1}, 2922 cm^{-1}), and carbonyl stretching (1742 cm^{-1}), crucial for biomass conversion reactions. XRD patterns revealed the biomass's high carbon content and crystalline nature with significant peaks at 2θ values of 21° Cellulose II, 16° Cellulsoe I and 35° Hemicellulose, which indicating higher thermal stability. Based on these comprehensive analyses and the promising characteristics of jackfruit peel, such as high carbon content and suitable morphological features, it can be concluded that the gasification of jackfruit peel biomass can lead to efficient energy extraction in the form of hydrogen and syngas.

Keywords: Characterization; Gasification; Hydrogen production; Jackfruit peel; Sustainable energy.

PP-07: Enhanced Oil Recovery using Iron Oxide Nanoparticles Coupled with Low Salinity Waterflooding in a Part of Hapjan Oil Field of Upper Assam Basin

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Due to declining reserves and a sharp decline in the discovery of new oil reservoirs, Enhanced Oil Recovery (EOR) method has emerged as a crucial part of oil production. Numerous techniques have been developed in this field however, the application of the nanoparticles (NPs) in combination with Low Salinity Waterflooding (LSW) in the recovery process is comparatively a new Hybrid EOR technique. Earlier studies have shown that nanoparticles can alter the rock's wettability towards a more water-wet state, decrease oil viscosity, increase the Mobility Ratio, decrease the Oil-Brine Interfacial Tension (IFT), regulate Fine Migration, and increase Displacement and Sweep Efficiency which can improve oil recovery. It has been discovered that iron oxide (Fe_2O_3/Fe_3O_4) nanoparticles work effectively to increase oil recovery in sandstone reservoirs by altering rock wettability, reducing IFT, and lowering oil viscosity. Additionally, it has been found that LSW EOR can decrease the reservoir's Residual Oil Saturation through mechanisms such as Fine Migration, Multicomponent Ion Exchange (MIE), pH Increases in the bulk fluid, and the expansion of Electrical Double Layer (EDL). Recent studies have found that the application of nanoparticles in conjunction with LSW can provide benefits from both nanoparticles and LSW. This study covers the effects of Iron Oxide (Fe_2O_3) nanoparticles coupled with LSW on oil recovery in a part of Hapjan Oil Field of Upper Assam Basin. The analysis of the components of the Crude Oil/Brine/Rock (COBR) system of the study area shows the presence of polar organic compounds, certain clay minerals, and certain multivalent cations which are essential for successful LSW. Iron Oxide has also been observed in the reservoir rock. The results of the study demonstrate that Iron Oxide (Fe_2O_3) nanofluid (NPs concentration from 0.05 wt. % to 1 wt. %) prepared with Low Salinity Water (< 1000 ppm as NaCl) can improve the recovery of oil from the area under study through Wettability Alteration towards more water wetness, reduction of oil-Fe_2O_3 nanofluid IFT and reduction of crude oil viscosity. Therefore, the application of Iron Oxide (Fe_2O_3) nanoparticles coupled with LSW can be a suitable Hybrid EOR technique in the study area.

Keywords: Enhanced oil recovery; Interfacial tension; Low salinity water-flooding; Nanoparticles; Wettability.

PP-08: Exploring the Energy-Efficient Possibility of a Highly-Correlated Compound of Vanadium-Dioxide and its Potential Applications

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In a rapidly growing world of material science, the necessity of energy-efficient material is also realized, a material that can fulfill the requirement of the sustainable development. Vanadium-Dioxide (VO_2), in particular, has the potential that cannot be ignored. This correlated-oxide is known for its peculiar phase transition called metal-insulator transition (MIT), at a transition temperature of 340 K. Such a structural phase transition (SPT), where it exhibits a transformation from monoclinic-insulating phase to tetragonal-conducting phase, is the onset of many interesting properties. Its reflectivity gets suddenly enhanced in the infrared zone at a temperature greater than the transition temperature, while it shows drastic improvement in absorption in the ultraviolet zone at a temperature lower than the transition temperature. This feature makes it unique to be applied for the Smart-Window application. Further, VO_2 is also a promising candidate to be served as a clean-energy resource due to its capability of Hydrogen storage. In an attempt to occupy the stable configuration of VO_2, several oxides of vanadium demonstrate defect via oxygen-vacancies which provide a suitable environment for Hydrogen storage. Evidently, all these attributes are directly dependent to the transition temperature and which is why, nowadays, inclination is mainly on tuning the transition temperature of vanadates. Interestingly, vanadates have been classified into two categories based upon MIT, i.e., Magneli (VnO_{2n-1}) and Wadsley (VnO_{2n+1}). Nevertheless, V_6O_{13} is the only compound that exhibits MIT/SPT from Wadsley group. On the contrary, all the compounds from Magneli group demonstrate this peculiar phase transition. In the hunt of a smart material that can fulfill the criteria of sustainable development, VO_2 must not be overlooked.

Keywords: H-storage; Metal-insulator transition; Oxygen-vacancies; Smart-window; Vanadium-dioxide.

PP-09: A Simplified Scalable Fabrication Approach for Optofluidic Microreactors in Photocatalytic Hydrogen Production

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As global energy needs grow against the backdrop of diminishing fossil fuels, sustainable hydrogen production becomes a key element of future energy solutions. Photocatalytic water splitting stands at the center of these efforts, but its large-scale implementation hinges on the efficiency and scalability of the reactor designs in use. Tackling this critical challenge, our research outlines a thorough, cost-effective, scalable fabrication method for optofluidic microreactors, optimized for enhancing photocatalytic hydrogen production. Our thorough fabrication protocol utilizes commercial window glass sheets, offering both economic and scalability benefits. The start of the process, coating the glass with a consistent epoxy paint layer, is crucial in ensuring a uniform substrate, which subsequently aids in accurate microchannel etching. With the substrate ready, a large area diode laser engraver is used, carefully crafting detailed microchannel patterns, which are further supplemented with specific microstructures. These patterns, varied in geometry and dimensions, have a twofold objective: increasing the overall reactor surface area and, in turn, boosting the photocatalytic reactions inside. A two-stage wet chemical etching process, using different concentrations of hydrofluoric acid, ensures depth distinction between the main microchamber and the embedded microstructures. Understanding the complex challenges presented by diverse parameters in reactor fabrication, a comprehensive set of optimization experiments were undertaken. These experiments assessed interactions across various areas: epoxy coating uniformity, laser engraving accuracy, and etching procedures. The end result of these experiments provided ideal conditions for each parameter, ensuring consistent reactor fabrication. To confirm the reliability and accuracy of the process, a set of characterization methods, notably scanning electron microscopy and profilometry, were deployed. These diagnostic

assessments not only verified the intended microchannel designs but also highlighted the desired surface finishes achieved.Transitioning from fabrication to application, the water splitting reaction was initiated using a potential photocatalyst—Platinum (Pt) modified graphitic carbon nitride (gC_3N_4) nanosheets prepared by calcination method followed by photodeposition. This material, anchored firmly using a binder of negatively charged monodispersed colloidal silica, exhibited superior photocatalytic activity for hydrogen generation. Conducted evaluations confirmed the stability of this immobilized catalyst film throughout the reaction duration (5 hours), under varied testing conditions. The reactor's design significantly ensured efficient transport dynamics for the evolved hydrogen bubbles, showcasing its operational superiority. In summary, our research presents a sturdy, comprehensive, and repeatable framework for the scalable, cost-effective fabrication of optofluidic microreactors. As a cornerstone, it holds the capability to guide the direction of photocatalytic water splitting, harmonizing them with the urgent demands of sustainable, green hydrogen production.

Keywords: Green hydrogen; Optofluidic microreactors; Photocatalyst immobilization; Photocatalytic water splitting; Scalable fabrication.

PP-10: Synchronized Redox Pairs in Metal Oxide/Hydroxide Chemical Analogues for an Efficient Oxygen Evolution Reaction

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In response to the growing concerns surrounding fossil fuel utilization and its environmental implications, there is a pressing need for sustainable and environmentally friendly energy alternatives. Hydrogen, recognized for its high calorific value and eco-friendliness, holds promise as a replacement for conventional fuels. Among the various hydrogen production methods, electrocatalytic water splitting powered by renewable energy sources has emerged as a leading strategy. However, this approach faces the challenge of substantial energy consumption due to the high electrolysis potential barrier. Addressing this hurdle requires an efficient oxygen evolution reaction (OER) catalyst with exceptional conductivity, enduring electrochemical activity, and cost-effectiveness. While noble metal catalysts like RuO_2 and IrO_2 exhibit remarkable OER performance under acidic conditions, their steep cost and limited stability in alkaline environments inhibit their large-scale application. Consequently, the spotlight has turned to cost-efficient non-noble metal electrode materials, including transition metal oxides, sulfides, nitrides, carbides, and metal hydroxides. Transition metal-based electrocatalysts, particularly those employing Ni, Co, Fe, Mn, W, Mo, and Cu, have garnered significant interest due to their auspicious catalytic activity. Spinel-structured mixed valence transition metal oxides, such as $CoMn_2O_4$, $NiCo_2O_4$, and $FeCo_2O_4$, are viewed as promising alternatives for water oxidation due to their adaptable oxidation states supporting redox reactions, amplified electrochemically active surfaces, and enhanced structural robustness. In this work, we present a straightforward and efficient two-step electrodeposition method to achieve superior electrochemical water oxidation under alkaline conditions. This involves depositing the $CoMn_2O_4$ (CMO) spinel structure directly onto pre-cleaned Ni foam, followed by electrodeposition of a $CoMn(OH)_x$ (CMOH) layer as a mixed metal hydroxide analog. The rationale behind this approach is to improve charge transfer kinetics during the OER, facilitated by synchronized redox pairs involving the metal ions (Mn and Co) undergoing reversible redox changes ($Mn^{3+} \leftrightarrow Mn^{4+}$ & $Co^{2+} \leftrightarrow Co^{3+}$). Notably, our composite electrode, Ni/CMO/CMOH, benefits from identical metal ions in both oxide and hydroxide phases, thereby experiencing redox changes within the same potential range during the electrocatalytic process, resulting in enhanced charge transfer kinetics yields an excellent water oxidation overpotential of 260 mA cm^{-2} with a Tafel slope of 29 mV dec^{-1} and a four-fold increase in turnover frequency.

Keywords: Electrochemistry; Hydrogen production; Synchronized redox pair; Water electrolysis.

PP-11: Syngas Fermentation using *Clostridium carboxidivorans* and *Clostridium ragsdalei* for Bioethanol Production

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Increasing energy demands and fossil fuel usage have led to environmental pollution and climate change such as global warming, novel renewable energy sources that could substitute fossil fuels are being aggressively researched. Syngas (CO, CO_2, and H_2) has received particular focus due to the dual benefit of syngas fermentation in carbon sequestration (pollution reduction) and energy generation. The syngas fermentation route is advantageous as it involves low pressure conditions compared to the chemical conversion route, less sensitivity to poisoning caused by syngas contaminants, and less dependence on fixed gas ratios (CO:H_2). Syngas can be generated by gasifying biomass or as a by-product of various industrial processes. Multiple microorganisms can convert CO rich waste gases into value-added products like alcohols, short-chain fatty acids, fuels, and other valuable products. This study examined twelve different combinations of CO, CO_2, and H_2 for bioconversion to ethanol using *Clostridium* strains. Ethanol production rates of 18.25 mg $L^{-1}h^{-1}$ (80% CO, 10% CO_2, 10% H_2) and 14.45 mg $L^{-1}h^{-1}$ (80 %, 20% CO_2) were achieved by using *Clostridium carboxidivorans* and *Clostridium ragsdalei*, respectively, in a batch system. Furthermore, CO utilization reached 99.98% of 42 mML^{-1} and 94% of 33.29 mML^{-1}, respectively using *Clostridium carboxidivorans* and *Clostridium ragsdalei*. Additionally, the production of other valuable C_4-C_6 containing metabolites, such as, hexanol, butanol, propionic acid, butyrate, caproic acid, and valeric acid, were confirmed through Gas Chromatography-Mass Spectrometry analysis. However, their concentrations were significantly lower compared to the main products, ethanol and acetic acid. Optimization of syngas composition to enhance biomass growth and product formation is necessary for efficient bioconversion to produce value-added products.

Keywords: Bioethanol; *Clostridium carboxidivorans; Clostridium Ragsdalei;* CO bioconversion; Syngas fermentation.

PP-12: *De novo* Design of Peptide Catalyst as a Hydrolase Model for Carbon dioxide Hydration and Conversion

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Recent advancement in biomimicry has led to the development of peptide catalysts with intrinsic enzyme-like activity due to their remarkable catalytic efficiency at low cost. The concept of mimicking the hydrolase model by utilizing short peptides has gained interest due to its significant role in carbon dioxide sequestration. Previous studies have shown that peptides with amyloid-like architecture can self-assemble via different non-covalent interactions to form active sites. These active sites can co-ordinate with Zn (II) to create tetrahedral geometry and catalyze an esterase reaction. Here, we designed, synthesized, purified and characterized a series of heptapeptides as a mimetic of human carbonic anhydrase II (hCAII) enzyme. This work reports that these peptides display esterase-like activity by hydrolysis of a chromogenic substrate, p-nitrophenyl acetate. Its catalytic activity significantly increased with an increase in pH and temperature, whereas natural hCAII effectively works at optimum pH and temperature, further validating its promising application in industrial biotechnology. These peptides catalyzed hydrolysis of a series of substrates with varying side chains at different rates, further validating its substrate specificity, a vital enzyme feature. We also demonstrated these peptide catalysts' applicability to carbon dioxide sequestration in the form of carbonated materials. Such a biomimetic approach uses a peptide catalyst to create an efficient model for the capture of carbon dioxide and conversion, contributing to mitigating carbon dioxide emission and reducing its negative impact on climate change. This innovative strategy is developed to overcome the

limitations of using natural carbonic anhydrase enzymes to acquire highly stable structures and cost-effective techniques.

Keywords: Biomimicry; Carbon dioxide sequestration; Hydrolase; Kinetics; Peptide catalyst.

PP-13: Underground Hydrogen Storage: Geological Sites and Influencing Parameters

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Globally, energy is a basic requirement for economic development. The economics of demand and supply of energy has always been a challenging area to address, considering various technical as well as geopolitical factors. The global energy demand is accelerating daily to satisfy the human needs and even today, fossil fuels are the main energy source. One of the important environmental issues due to the use of fossil fuels is the emission of greenhouse gases (GHGs) and carbon dioxide (CO_2), resulting in the global warming and creating significant negative impact from a climate change perspective. To reduce the use of fossil fuel-based energy sources for meeting climate goals require an increase in energy production from renewable sources. Presently available renewable energy sources like solar and wind energy are very much dependent on sunlight and wind velocity and directions. So, an alternate source of renewable energy is deemed necessary. Hydrogen (H_2) is regarded as a carrier of renewable energy with a huge potential for the transition of energy. Being a carrier and not an energy source, it can deliver or store a significant amount of energy. Moreover, there is no impurities in it and useful for its flexibility and efficiency in conversion of energy. Hydrogen can be utilized for the generation of power, electricity and heat. It (H_2) is the most abundant element in nature, totaling about 75% of the mass of the universe. It can be generated from natural gas through the process of (steam methane reforming - SMR) by using fossil fuels (blue and grey hydrogen) or by electrolysis of water by renewable energy sources (i.e., power to gas). Numerous literature reviews reports that H_2 can be stored in physical manner, such as – in compressed, liquid or cryogenic tanks or in chemical storage manner, such as- like sorbents, metals, or chemical hydrides. However, little work has been done on underground hydrogen storage (UHS), which is considered as a potential alternate solution, and based on it a large-scale economy can be built. In UHS, substantial quantity of hydrogen gas (H_2) is kept in different geological formations such as- salt caverns, deep aquifers, depleted hydrocarbon reservoirs, or underground coal seams. As UHS is a new area, a critical review is done in this work, which is based on the existing data with respect to properties of solid, properties of fluid and interactions between solid-fluid within the storage reservoir, relevant to UHS. The work further emphasizes on different geological sites and relevant influencing factors that impact UHS.

Keywords: Hydrogen; Steam methane reforming; Underground hydrogen storage.

PP-14: Ultrasound Assisted Separation of Heavy Oil from Soil Contaminated

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In this study extraction of heavy oil from oil contaminated soil during transportation of crude oil has been investigated. Heavy oil, which is a bottom product of crude oil has an API gravity between 10^0 and 23^0, is highly viscous and sticky in nature. The crude oil when exposed to soil due to leakage, heavy oil which has asphaltene content suspended in it will reside in the soil pores for a prolonged time due its physical and chemical nature, and creates environmental problem. The recovery of heavy oil from the contaminated soil can be used as a valuable resource. Generally, surfactant has been used as an effective chemical recovery method for oil. Ultrasound technique is an environmentally friendly and effective method which could be used for enhanced oil recovery. In this work, investigation has been done for the feasibility of ultrasonic waves as a substitute for conventional process to reduce the consumption of surfactant and to increase the

extraction efficiency of oil from contaminated soil. The influence of sonication time, sonication intensity, critical micelle concentration (CMC) of surfactant and the effect of surfactant concentration on oil recovery has been reported. Ultrasound waves are more vibrant at higher concentration of surfactant preferably above CMC and at higher intensity. Compared with surfactant, surfactant assisted ultrasonication method provided higher percentage of oil recovery at minimum surfactant concentration. The mechanism behind the oil recovery was the formation of micro-emulsion by the addition of surfactant in the presence of ultrasound.

Keywords: Heavy oil; Oil extraction; Surfactant; Ultrasound.

PP-15: In Silico Investigation of Molybdenum Oxide as a Potential Catalyst for Electrochemical Oxygen Evolution

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Hydrogen (H_2) has emerged as a promising alternative to fossil fuels. Its applications extend far beyond fuel cells, encompassing many industries such as fertilizer manufacturing, metal processing, and steam reforming. However, efficiently producing green and clean H_2 at a commercial scale to meet the growing demand represents a crucial challenge. The electrochemical water-splitting method offers a promising way of enabling the conversion of renewable electricity into H_2, thereby facilitating effective energy storage and conversion. The hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) are the fundamental half-cell reactions involved in water splitting. Notably, the OER exhibits sluggish kinetics due to the involvement of four proton-coupled electron transfer steps, which hinder both the advancement and scalability of water-splitting technology. Developing and exploring stable, economically viable, and highly efficient catalysts for the OER beyond the conventional iridium and ruthenium-based oxide catalysts is of utmost significance in generating environmentally friendly H_2. Therefore, our work is focused on exploring transition metal-based catalysts that could serve as viable alternatives to Ru and Ir-based catalysts in terms of cost, activity, and stability. Specifically, we present our findings on molybdenum oxide (MoO_3) and doped MoO_3 catalysts for the OER. Quantum-mechanical density functional theory is utilized to analyze the free energetics of the intermediates in the OER mechanism on various active sites. This approach allowed us to identify the most favorable active site and dopant that can significantly enhance the OER activity of MoO_3. Among all the explored dopants (iron, nickel, manganese, and cobalt) and active sites (symmetric oxygen, asymmetric oxygen, terminal oxygen, and metal), the Co-doped MoO_3 catalyst demonstrated the highest OER activity at the symmetric oxygen active site. The findings are rationalized using oxidation state changes at the active transition metal centers. Our research primarily centers on using computational methods to explore novel materials for enhancing electrochemical water splitting, ultimately leading to cleaner hydrogen generation.

Keywords: Density functional theory; Hydrogen evolution reaction; Oxygen evolution reaction; Water splitting.

PP-16: Nanoparticle-Aided Biosurfactant Flooding in the Application of Enhanced Oil Recovery: Emulsification, Interfacial Tension, and Wettability Alteration Characteristics

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Microbial-enhanced oil recovery (MEOR) has been proven implicit and lucrative for crude oil systems due to its ability to accomplish reduced interfacial tension, altered viscosity, and wettability. Nanoparticles (NPs) have a larger surface area to volume ratio, intensifying their mobility ratio and other properties responsible for MEOR. Biosurfactants (rhamnolipids) have been utilized in a wide range of applications because of their outstanding surface and interfacial properties, particularly in interactions involving fluid and solids. This study addressed the stability, emulsification, interfacial tension (IFT) and contact angle (C.A.) characteristics of different nanoparticle-aided biosurfactant flooding. The optimum concentration of NPs was added to the optimized Rhamnolipid-salts system to develop a nanofluid. The rheological behaviours of prepared nanofluids were also investigated at different temperatures. The stability of the NPs - biosurfactant system was evaluated by zeta potential. The IFT and C.A. measurements were done using a spinning drop tensiometer and goniometer, respectively. The commercial (SiO_2, $Al2O_3$ and TiO_2) NPs and synthesized SiNPs were characterized using various analytical techniques. The FESEM images revealed the morphology of commercial NPs and produced SiNPs were spherical and agglomerated. Furthermore, the ability of commercial and synthesized SiNPs to alter the wettability of oil-wet sandstone rock was measured based on C.A. values. The C.A. value was reduced by 29 % for the rhamnolipid-0.02 (w/v) % SiNPs system. The IFT between crude oil-water, crude oil-rhamnolipid at CMC and crude oil- 0.02 (w/v) % SiNPs aided rhamnolipid were found to be 21 mN/m, 0.33 mN/m and 0.10 mN/m, respectively. This reduced interfacial tension and wettability alteration makes the approach favourable for MEOR applications in sandstone reservoirs.

Keywords: Contact angle; Interfacial tension; Rheology; Rhamnolipid; Zeta-Potential.

PP-17: Molecular Doping Approach towards the Photoabsorption Enhancement of g-C_3N_4 Analogues for Efficient Photocatalytic Water Splitting to Produce Clean H_2

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With the swift depletion of non-renewable energy sources like fossil fuels, the race to meet the global demand for clean and sustainable energy sources having least environmental degradation issues has presented a staggering concern to the researcher fraternity all across the globe. The Sun is one of the major sources of energy on earth. The earth experiences a massive 3.5–7.0 kWh-m^{-2} per day of solar power input in terms of both light and heat, which plays a very crucial role for the evolution of life and survival on it. Humans have tried to harness the solar power since a long time: the solar cell is one such device which can engross the solar energy for converting it into electrical energy. Moreover, researchers across the globe also intend to translate solar energy into chemical energy form like hydrogen, from photocatalytic splitting of water which has high calorific value as fuel and is clean by nature as well. In the initial phase of

semiconductor mediated water splitting research, photoactive systems based on metal oxides, metal chalcogenides and metal pnictides and active catalysts based on platinum group metals (PGMs) have been explored. The inorganic semiconductors like ZnO or TiO_2 often suffer from limited visible light absorption owing to the large optical bandgap. Along with poor absorption of light, it is often very difficult to manipulate the bandgap of such materials significantly using standard strategies like doping. On the other hand, use of platinum group elements and compounds thereof as active co-catalysts are neither environmentally sustainable, nor economically viable at production scales despite their immense effectiveness and activity. Recently, 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, elemental as well as molecular doping has been a widely employed strategy. However, the inefficient methods of elemental doping 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, or by using heteroatomic dopants.

Keywords: g-C_3N_4, Hydrogen; Molecular doping; Photocatalysis; Water splitting.

PP-18: Techno-Economic Comparison of Combustor Integrated Steam Reforming and Sorption Enhanced Chemical Looping Steam Reforming of Methanol

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Keeping in mind the energy crisis in the world and its environmental impact, it is required to search for alternative sustainable and green sources of energy. Hydrogen is a potential candidate that can serve as an alternative source of energy. But unlike other conventional fuels, hydrogen is not a naturally occurring fuel- it is to be produced using different methods. Methanol steam reforming (MSR) has gained significant attention for in-situ hydrogen (H_2) production. To overcome the high energy requirement in the process, two modified methods such as combustor integrated steam reforming (CISR), and sorption-enhanced chemical looping steam reforming (SE-CLSR) are widely used for the production of H_2. In the present work, a techno-economic comparison of CISR and SE-CLSR models has been carried out using Aspen Plus V11 to assess the economic viability of hydrogen generation by the MSR process. SE-CLSR model is developed considering NiO as an oxygen transfer material (OTM). Cu/ZnO/Al_2O_3 has been used as a catalyst in both processes. Simulations have been performed to observe a strong dependence of methanol conversion, hydrogen yield, CO selectivity with different operating conditions like temperature, steam to methanol (S/M) ratio, catalyst weight to methanol molar ratio. The sensitivity analysis of the considered models is performed to obtain the optimum operating conditions. An economic analysis has been carried out to know the economic feasibility of both processes. The total operating is calculated considering the assumptions made in the present study and found to be 10.59 million and $10.84 million for the CISR process and SE-CLSR process respectively. The total production cost (TPC) which comprises annualized capital cost and annualized operating cost, for both processes, are estimated to be $10.68 million (for CISR) and $11.01 million (for SE-CLSR). The hydrogen production cost is estimated as 2.66 $/kg and 2.79 $/kg from CISR and SE-CLSR processes, respectively.

Keywords: Aspen plus; Chemical looping; Methanol steam reforming; Sorption enhanced; Techno-economic analysis.

PP-19: Isolation and Screening of Biosurfactant Producing Strains from Oil Refinery Sludge and its Applicability in MEOR

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The global expansion in population, economic growth, energy demand, and intensive industrialization has led to the constant depletion of petroleum from conventional crude oil reservoirs. This as a result escalated various research to extract the remaining two-thirds of the trapped original oil in place (OOIP). Tertiary oil recovery methods such as thermal, chemical, microbial etc. have been researched as a strategy in this regard to scale up and speed up the extraction of unrecovered crude oil. The present study describes elaborately the isolation of a potential biosurfactant producing and crude oil degrading strain isolated from the petroleum sludge of Guwahati Oil Refinery. Total seven strains were isolated and their growth in Bushnell Haas agar was studied. For further studies one strain (S1) was chosen based on the growth profile and surface-active properties. Isolate S1 reduced the surface tension and interfacial tension to 47.67 ± 0.13 and 8.87 ± 0.34 mN/m respectively along with a moderate emulsification index of 34.28 %. Morphological analysis of strain S1 concluded it to be as a gram-negative coccobacillus. The growth kinetics study of isolated strain was carried out by varying growth parameters i.e., carbon source, temperature, pH and salinity. The biosurfactant produced from S1 was chemically identified to be a glycolipid and characterized using various analytical techniques to establish its suitability for microbial enhanced oil recovery. Further the biosurfactant production was optimized adopting RSM-CCD considering carbon source (1–5%), pH (3–11) and temperature (35–65 °C) as matrix parameters. By separating mixed carbon sources using strains and optimizing waste substrates from the oil/soap stock and sugar/corn syrup sectors in media, cost-effective manufacture of biosurfactant that has excellent yield and productivity may be made possible.

Keywords: Biosurfactant; Growth kinetics; Optimization; Strain isolation; Surface active properties.

PP-20: Energy Economic Study of Microencapsulated Phase Change Material (PCM) Embedded Building Wall

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At CSIR-CBRI microencapsulated phase change material are prepared by in situ-polymerization technique with its thermo physical properties as Melting point(C): 34.5, Heat of fusion (KJ/Kg): 103.80, Thermal conductivity(w/m K) : 0.31(s)/0.22(L), Bulk density (kg/m^3) : 497.10, Particle size(μm) : 10.41,Specific Heat (KJ/Kg K) : 1.32(s)/2.05(l) .In this paper an office building is designed in TRNSYS 16 software, the hourly weather data of Delhi city is used in this study. The study focuses on the economies of energy to provide thermal comfort in office buildings under three different scenarios. Scenario-1: simple office building wall without microencapsulated Phase Change Material (MPCM) and a heat pump is used to maintain thermal comfort in the building space. Scenario-2: office building wall with MPCM material embedded as outer layer of wall and a heat pump is used to maintain thermal comfort in the building space. Scenario-3: office building wall has PCM material embedded in its inner layer and a heat pump is used to maintain thermal comfort in the building space for the required thermal comfort as per ASHRAE 55. Transys built-in library components: Multizone building (Type 56), Thermal Storage Wall (Type 36), Weather file (Type 15-6), Data reader (Type 9e), Plotter (Type65), Integrator (Type 55) along with TESS HVAC addon library component air conditioner (Type 651) is used in this simulation study. The Projected average power tariff of India by Statista Research Department for the year 2021 is considered in this study

to evaluate the energy costs in all these scenarios and conclusions are drawn accordingly to suggest an economically sustainable configuration.

Keywords: Buildings; Energy density; Energy economics; PCM; Thermal Comfort.

PP-21: Biochar as Filler for CO_2 Sequestration in Incorporated Cement Based Material

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Emission of Carbon dioxide from human activities is the main reason for global warming which caused change in climate, drought, heavy rain and heat waves. Carbon dioxide is the greenhouse anthropogenic gas, which urgent need to capture or reduce. Researchers and technology experts are being attempted with supplementary cementitious materials (SCMs) such as fly ash, slag, granite, agricultural residue etc. Agricultural residues are biochar is derived through in absence of oxygen by pyrolysis method. Among the SCMs, Biochar has high surface area, porous structure and high-water absorption capacity. In present study, mixture of biomass (80% Sawdust + 20% rice husk) is pyrolysis at the temperature of 550℃ for 2 hours in the muffle furnace. The obtained biochar is grinded with help of mixer which passed through < 45 µm. The powdered biochar was mixed into pure cement at the water to binder ratio 0.3 with replacement dosage of 3 wt. %, 5 wt. % and 10 wt. % and made 25 mm x 25 mm x 25 mm cubes. After one day, the cubes were placed in a carbonation camber for 7 days and 28 days for CO_2 sequestration and determined CO_2 sequestration and thermo-mechanical properties. The CO_2 sequestration 15-20% and compressive strength 10-15% improvement observed after 28 days than control at 3 wt.% of biochar. The present research shows the benefits of optimally integrating biochar with cement in the development of low carbon, sustainable cementitious materials that have potential to convert building materials like concrete, mortar into carbon sink in the future.

Keywords: Biomass; Cement; CO_2 sequestration; Mechanical property; Pyrolysis.

PP-22: Preparation of Fe-I co-doped TiO_2 Photocatalyst for Efficient Photocatalytic Degradation of Direct Yellow-11 Dye

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The research on the use of photocatalysts with exceptional stability and activity in the degradation of dyes has garnered significant interest. Among various photocatalysts titanium dioxide (TiO_2) has gained considerable research attention in treating textile wastewater because of its various properties such as low cost, abundance, non-toxicity, availability and photostability. Though, TiO_2's photocatalytic activity is inadequate since it exclusively absorbs incoming light in the ultraviolet (UV) range. In this study, TiO_2 nanoparticles were synthesized via the solution-combustion process, incorporating iron and iodine as dopants. Ferric oxide and iodic acid were employed as precursors for iron and iodine, respectively. The synthesized photocatalysts underwent comprehensive characterization. Scanning Electron Microscopy (SEM) examined nanoparticle morphology, Fourier Transform Infrared Spectroscopy (FTIR) identified functional groups, and X-ray Diffraction (XRD) determined crystal structure. Diffuse Reflectance Spectra (DRS) analysis gauged band gap energy. The prepared photocatalysts exhibited the anatase phase, with a crystalline size of 19.32 nm and a band gap energy of 2.83 electron volts. The experimental investigation demonstrated enhanced TiO_2 performance via co-doping with Fe and I, notably improving the photocatalytic degradation efficiency of direct yellow-11 dye. Using a UV photochemical reactor with a quartz tube, approximately 87.65% degradation of direct yellow-11 dye was achieved within 60 minutes.

Keywords: Codoped TiO_2; Direct yellow-11; Nanoparticles; Photodegradation.

PP-23: Wetting Dynamics of Spontaneous Imbibition in Porous Rocks

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The understanding of multiphase flow of fluids in porous rocks is important in many applications, particularly for oil recovery from petroleum reservoirs due to viscous, gravitational, and capillary forces. This study examines the spontaneous imbibition process, which is the invasion of the wetting liquid into a porous solid displacing resident non-wetting fluid by capillary action. Here, we present a numerical solution in 1-D using fractional flow theory assuming horizontal displacement in co-current mode. It can be understood as the capillary analog to the classical Buckley Leverett solution and is valid with arbitrary fluid viscosities, as well as for capillary pressure and relative permeability curves dependent on saturation. We measure the saturation profiles as a function of distance and time with some initial wetting fluid saturation for strongly water wet, mixed wet and weakly water wet cases. The simulation results obtained using MATLAB Reservoir Simulation Tool (MRST) show good match with the results of analytical solution provided in the literature. The fluid propagates with different velocities in non-interacting layers of different wettability conditions and with different petrophysical properties such as permeability and porosity. We also examined the effect of the interactions of the layers in two- and three-layered reservoirs on the fluid flow and saturation front. For a single layered case, using a particular dataset the WWW (Weakly Water wet) reservoir has a leading front, and the MW (Mixed Wet) reservoir has a lagging front. However, when both these layers are in interaction with each other, the front of the layer which has MW wettability (having lagging front when non-interacting), has a sharp increase while the layer which has WWW wettability (having leading front when non-interacting), the front has reduced length. Also, in the interacting layers case, both the fronts are almost at same location. The solution can also be used to understand fluid flow behavior when capillary forces are dominant i.e., after the gas injection stops during the geological CO_2 sequestration in the petroleum reservoirs.

Keywords: Capillary pressure; Fractional flow; Permeability; Saturation profiles; Wettability.

PP-24: Improving CO_2/N_2 gas Separation Efficiency: Crafting of UIO-66 MOF with Amino Acid for Advanced Chitosan Mixed Matrix Membrane

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In the pursuit of efficient CO_2 capture, the adoption of thin film composite mixed matrix membranes, characterized by a selective layer comprised of CO_2-selective polymers and nanofillers, has garnered significant attention owing to their myriad advantages. These advantages encompass easy processing, cost-effectiveness, and exceptional separation performance. Metal-organic frameworks (MOFs) have attracted substantial scientific and technological interest as a filler material in recent years, primarily due to their pivotal role in the domain of carbon dioxide (CO_2) capture and sequestration. Amine-functionalized MOFs have emerged as promising candidates for enhancing both the mechanical and transport properties of these membranes. Studies have shown that MOF nanoparticles, covalently bonded with amino acids, exhibit significantly heightened affinity for carbon dioxide (CO_2) when compared to their non-amino acid-functionalized counterparts. Furthermore, the introduction of amine groups reinforces the hydrogen bonding interactions between the MOFs and the Chitosan (CS) matrix, thereby improving the dispersibility within the polymer matrix. The study was focused on the development of a composite membrane with the aim of enhancing CO_2/N_2 separation performance. This involved the incorporation of amino acid-modified UIO-66 into a Chitosan/Polysulfone matrix. The fabricated MOFs and membranes systemically characterized using various analytical techniques, including Thermogravimetric Analysis (TGA), Fourier-Transform

Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), Energy Dispersive Spectroscopy (EDX), Field Emission Transmission Electron Microscopy (FETEM), Atomic Force Microscopy (AFM), and others. The membrane's performance was assessed under humid conditions using a 20/80 vol% CO_2/N_2 mixed gas stream. To identify the optimal conditions for post-combustion carbon capture, an extensive investigation was conducted to evaluate the effects of various operational parameters, including filler loading, temperature, pressure, and relative humidity.

Keywords: Amino acids; Biodegradable polymer; CO_2 capture; Mixed matrix membrane; UIO-66.

PP-25: Effect of Salinity on the Characteristics of CO_2 Foam Stabilized using Anionic, Cationic and Non-Ionic Surfactants

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Carbon dioxide (CO_2) flooding is one of the Enhanced Oil Recovery (EOR) techniques used by the petroleum industry to keep up with the ever-growing global energy demand. But gravity override and viscous fingering decreases the potential of CO_2 based gas flooding for improving hydrocarbon production. Foams, on the other hand could increase the apparent viscosity of CO_2 significantly and reduce the mobility contrast. This in turn enhances the sweep efficiency of the injected fluid. The foamability and stability of the generated foams depend largely on the salinity of the reservoir in which it is injected. In this study we investigated the effect of different salt concentrations on the stability of CO_2 foams generated using three different types of surfactants viz. anionic (Sodium dodecyl sulfate), cationic (Pyridine) and non-ionic (Triton X-100). The salts used in the study were NaCl and $CaCl_2$, commonly found salts in the reservoir. The stability of the foam was examined by measuring the changes in foam height over time in presence of wide salinity range (1, 5, 8 10, 12%). The results showed that the different types of surfactants show different effect on the stability of the CO_2 foams when the salt concentration is varied. The effect of salinity on the interfacial tension (IFT) reduction and wettability alteration capacity of the different surfactant solutions was further investigated. The finding demonstrated that increasing salinity aids in the process of IFT reduction and wettability change to a certain extend but it is again dependent on the type of surfactant used in the process.

Keywords: CO_2 flooding; Foam; IFT; Salinity; Wettability.

PP-26: Gasification of Coconut Husk using Ni-Fe Electroplating Industry and Synthetic Water with a Recycle Stream and 2-Step Feeding System Gasifying Medium for Production of Syngas

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The main objective of this study was to investigate the impregnation of native green coconut husk (NGCH) with metal constituents using both electroplating industry wastewater ($MICH_w$) and synthetic water ($MICH_s$) containing Ni-Fe. The purpose was to generate syngas in an updraft fixed-bed gasification column with a part of recycle of syngas to increase the tar decomposition with a CO_2 as gasification medium in a two-step feeding system. There were various experiments conducted to explore the influence of temperature, recycle ratio, bed height, and ratio of biomass to Ni-Fe containing water (gm/ml) on fuel gas composition, gross calorific value, and gasifier performance. The gross calorific value (GCV) of coconut husk was determined through ultimate analysis, and calculated to be 15.70 MJ/kg. The wastewater had Ni and Fe concentrations of 27.95 g/L and 5.06 mg/L, respectively, with a pH value of 6.57. The XPS and BET analysis used to determine the elemental composition and the surface area of the material before and after the experiment at optimized condition. The results showed that the hydrogen (50.7%) and CO (65.1%) composition was higher at 900°C for wastewater containing biomass ($MICH_w$). Whereas, the composition

of hydrogen and CO was found at 20.2% and 60.26% for NGCH and $MICH_s$ respectively. The yield of gaseous products was higher 65.2% for $MICH_w$, 61.4% for $MICH_s$ and 58.6% for NGCH. The liquid yield was minimum for all sample due to recycle stream. It clearly shows that the process of tar decomposition taking place in the gasification reaction due to the recycle streams into the gasifier. Based on result of this study, it can be concluded that the coconut husk impregnated with wastewater is significantly sufficient for production of hydrogen rich syngas.

Keywords: Electroplating wastewater; Gasifier; Native green coconut husk; Recycle ratio; Synthetic water.

PP-27: A Study of Periodic Vibrations of Triplex Plunger Pumps Handling Crude Oil Transfer Attributed by Suction-discharge Process Parameters and In-line Pair Operation of Multiple Pumps

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Crude Oil from oil fields to tank farms and from tank farms along cross-country pipelines is a crucial activity for making availability of raw crude to refineries for processing. The most common and best choice for transfer of variable density crude oil over long distances in trunk lines from tank farms to refineries in use of plunger pumps. Among different configuration of plunger pumps triplex plunger pumps are most commonly used and preferred. Though plunger pumps are cost effective, easy to operate and maintain but it has a severe problem of vibration due to its reciprocating nature and its inherent working principle. But to counter its vibration problem due to its inherent reciprocating working mechanism triplex plunger pumps are most commonly used. The basis of this literature is practical vibration scenario faced at site conditions. The scope of this literature is to study the causes of vibrations observed in Crude Oil transfer pumps attributed by suction-discharge process parameters and in-line pair operation of multiple pumps. Also, the proposed remedies to the vibration issues. The inputs to this study are real life practical observational values, process parameters and damage assessment of each pump and pump ancillaries. The study will be focused more on the attributes of suction side affecting the pump vibrations. The parameters at suction side that will be considered are variable tank height, flow variations at suction of pumps, internal dynamics of fluid side of the pump (especially at suction side), use of booster pumps and piping configurations. The parameters that will be in consideration for delivery side are discharge dampener characteristics and effects on delivery side vibration, effects of system back pressure on delivery side vibration, piping and supports arrangement of amplification of vibration, position and number of injection points for number of pumps working in unison, number of pumps operating in unison.

Keywords: Booster pumps; Cavitation; CODP (Crude Oil Dispatch Pumps); Dampeners; NPSHA; NPSHR Pulsations.

PP-28: Review and Recommendation on CO_2 Problems for Petroleum Industry

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The increase in green-house gas (GHG) emission is a global concern as it is causing severe damage to the environment due to global warming. Capturing and sequestration of CO_2 is a most recognized strategies to reduce the GHG emission. Global oil and gas are directly or indirectly responsible for the increase in half of all GHG emission. CO_2 not only environmentally but also harmful to the oil and gas industry in several ways like: contamination of drilling fluids by reducing the pH, corrosive in nature, increasing the surging pressure, etc. Therefore, to help achieve the global aim of reducing carbon emission by CO_2 capturing and CO_2 sequestration. The techno-economic efficiency for CO_2 capturing and sequestration methods presently used are made for the modern cycles. They sum up to around 4 Gt/yr: 1 Gt/yr for the iron and steel area,

around 2 Gt/yr for the concrete area, and 1 Gt/yr for petrol processing plants. The genuine organization level would be a lot of lower because of different imperatives, around 0.8 Gt/yr, in a tough outflow decrease situation. Therefore, the novel strategy that displayed in this work to find a sustainable solution for reducing CO_2 emissions from the subsurface region of petroleum industry through gas hydrates using low-cost promoters. These promoters can optimize the gas hydrate formation at around room temperature condition unlike low temperature which is the natural condition to form the gas hydrates. Therefore, this shows that gas hydrate technology can be a breakthrough for achieving net zero by installing either in the drilling rig site or surface facilities site.

Keywords: Gas hydrate; Greenhouse gases; Net zero; Sequestration.

PP-29: Insight Review on the Comparison between Blue Hydrogen and Green Hydrogen for Petroleum Industry

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As the world intensifies its efforts to transition towards a sustainable and carbon-neutral energy landscape, hydrogen has emerged as a promising clean energy carrier. Among various hydrogen production methods, two prominent contenders are blue hydrogen and green hydrogen technologies. Green hydrogen refers to hydrogen gas that is produced using renewable energy sources, such as water, wind, solar, or hydroelectric power, in a process called electrolysis. Blue hydrogen refers to hydrogen gas produced from natural gas using a process called steam methane reforming (SMR) or autothermal reforming (ATR) with carbon capture and storage (CCS) technology. In this study, we find that the production cost of green hydrogen is higher than that of blue hydrogen due to the current costs of renewable energy technologies. The analysis reveals that blue hydrogen, with its reliance on existing natural gas infrastructure and lower production expenses, presents a more economically viable option compared to green hydrogen in the current energy landscape. As in Blue hydrogen, the produced CO_2 is used for storage purpose in petroleum industry and that can be via gas hydrates technology which can be used for applications in future by flooding for enhanced oil recovery or can be stored further in geological formation, such as depleted oil and gas reservoirs or saline aquifers. Both green and blue hydrogen offer sustainable solutions for a low-carbon energy future. However, due to the lower production costs and utilization of existing infrastructure, blue hydrogen is currently favored as a more economically sustainable option for transitioning towards a decarbonized hydrogen economy. Despite green hydrogen's ultimate goal of complete sustainability, the pragmatic preference for blue hydrogen underscores its pivotal role as a transitional step towards achieving broader environmental objectives. Based on the available literature data, green hydrogen production costs include renewable energy (50%), electrolyzer CAPEX (30%), O&M and water (12%), margin/ROE (8%), totaling 100%. In comparison, blue hydrogen costs encompass natural gas/coal (50%), CAPEX (17%), OPEX (5%), carbon cost (2%), CO_2 transport & storage (7%), totaling 81%. This implies blue hydrogen holds a 19% profitability advantage over green hydrogen. Overall, green, and blue hydrogen both holds promise for a sustainable energy future, blue hydrogen stands out as the more favorable option in terms of economic feasibility, applicability in the petroleum industry, and utilization of existing infrastructure. Although green hydrogen remains the ultimate goal for complete sustainability, blue hydrogen's lower production costs and ability to reduce carbon emissions through CCS technology make it a pragmatic choice in the current energy landscape. However, it is essential to acknowledge the disadvantages of green and blue hydrogen, where green hydrogen faces higher costs and infrastructure challenges, while blue hydrogen's reliance on natural gas remains a transitional solution with inherent carbon emissions that need mitigation.

Keywords: Blue hydrogen; CO_2; Gas hydrate; Green hydrogen; Sustainability.

PP-30: Advancing Oilfield Intelligence: Exploring Machine Learning Operations in Volve

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Importance of oil and gas in the energy mix makes accurate prediction of subsurface and operational data essential for economic evaluation and process optimization. Historically, simplistic analytical and tedious and complex numerical methods have been used. Machine Learning (ML) helps strike a middle ground and can be deployed for various exploration and production (E&P) activities. Thus, in this study, to enhance oilfield intelligence and aid upstream operations, we have built ML models to predict the well drilling rate on-the-go as a precursor to a drilling rate optimization model, predict sonic logs for a new well by learning from existing data, and forecast oil and gas production days in advance. Real-world open-source data from the Volve oilfield in Norway was used for training and validating the models. Drilling rate and production forecasting models learn continuously and are based on Random Forest (RF) Regression and Long Short-Term Memory (LSTM) respectively, while the sonic log model learns in batches and is based on RF. Prior to model training, the data is cleaned and pre-processed. The continuous models make predictions on-the-go by learning from a small initial corpus of data to make initial predictions, and gradually replacing old data in the training set with newly acquired operational data. The sonic log model is trained on data from two wells and validated for a third one to ensure sound performance when deployed for new wells. A comparison of the actual and predicted drilling rates yields a mean absolute percentage error (MAPE) and R^2 of 20.7% and 0.683 respectively. The predictions are accurate except for abrupt drilling rate changes, the causality of which is beyond the capacity of data-driven models. Next, the sonic log model very accurately predicts compression wave travel times for the validation well with an MAPE and R^2 of 3.92% and 0.85 respectively. For shear wave travel times, the R_2 is 0.54 (low) but the model's predictions are accurate except at lower depths, yielding an encouraging MAPE of 6.43%. Lastly, the actual and forecasted oil and gas production agree very well barring instances of sudden production changes (MAPE=14.75% and R^2=0.79 for oil, MAPE=15.5% and R^2=0.76 for gas). Thus, an end-to-end ML workflow which satisfactorily performs on real-world data has been developed for application to drilling, characterization and production activities. The models can further be used to optimize target variables such as drilling rate and production. Increasing algorithm complexity and amount of data used could augment model performance. Technical contributions: This study discusses end-to-end ML modelling of major activities spanning from well drilling to hydrocarbon production and is one of the very few to work with Volve data. Further, it closely emulates real-world scenarios as opposed to flawed studies which for instance have employed random training-testing dataset splits for continuous learning scenarios, allowing the model to learn from data that must be withheld. Unlike elsewhere, the workflow has been clearly and reproducibly described here.

Keywords: Data-driven models; Production forecasting; Sonic log prediction; Volve oilfield; Well drilling rate prediction.

PP-31: Understanding Enablers for Transport of Hydrogen through Pipelines

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Hydrogen fuel is an efficient, clean, secure, affordable, and versatile form of energy. According to the International Energy Agency (IEA), the demand for hydrogen will rise fivefold to 500-680 million metric tonnes (MT) by 2050 globally. Currently, nearly 90% of the hydrogen consumed in India comes from fossil fuels and is categorized as black and gray hydrogen. In the race to develop clean energy systems, hydrogen production pathways are enjoying unprecedented momentum with full support from the government. India is the 4th largest consumer of energy in the world after the USA, China, and Russia. However, India is not

endowed with abundant energy resources. One of the major challenges faced by India is meeting its energy needs while achieving 8% economic growth and also meeting the energy requirements of its population, (which is the world's second largest, at affordable prices). It requires a sustained effort to increase energy efficiency while increasing domestic production, especially in clean energy systems. In India, the National Hydrogen Mission was announced in the Union Budget 2021-22 with the aim of transforming the transportation sector and transporting hydrogen at scale is one of the primary objectives. Through a combination of transport phenomena-based analyses and employing computational fluid dynamics flow of blends of natural gas and hydrogen has been investigated. The data for developing simulations has been sourced from literature sources. The typical conditions investigated for natural gas are for 100 km long duct carrying natural gas at a pressure of 50 bar at steady and unsteady flow conditions using COMSOL Multiphysics software. The detailed analysis also includes numerical solution of impact of increasing and decreasing natural gas pipeline inventory. Our analysis indicates reproducibility of literature results on natural gas transport. The pressure-drop studies on steady and unsteady state analysis by varying the demand at the outlet will also be shown including the effect of increasing and decreasing the packing and drafting of natural gas pipeline. Technical contributions: This poster will showcase the results of ongoing work on developing models of hydrogen and natural gas transport through pipelines. The impact of gas inventory, pressure fluctuations, transient and steady state flow scenarios will be presented in this poster.

Keywords: Computational fluid dynamics; Hydrogen; Natural Gas; Pipeline transport; Process design.

PP-32: Simulation of Cuttings Distribution in Deviated Wells using Computational Fluid Dynamics with ANSYS Fluent

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The CFD model encompasses key drilling parameters, including drill pipe and annulus radii, boundary conditions, wellbore inclination (ranging from 0 to 90 degrees), cutting size (ranging from 3 to 9 mm), cutting density (ranging from 2300 to 2500 kg/m³), mud velocity (ranging from 0.5 to 3 ft/s), and rate of penetration (ROP) (50 and 100 ft/min). By systematically adjusting these parameters, we thoroughly examine cuttings behavior under different scenarios, facilitating optimized drilling operations tailored to specific well conditions. To enhance the accuracy of our simulations, we prepared a specialized drilling mud in the laboratory. This mud underwent rigorous testing of its rheological properties, including viscosity and shear stress, to ensure its reliability as a representative fluid in the simulations. The mud's rheological behavior was best described by fitting it with the power law model, yielding its Consistency Coefficient and Flow Behavior Index. Eulerian Model Simulations were performed under transient conditions to provide practical insights. The gathered data on cutting concentrations in the annulus at different depths underwent meticulous analysis. Notably, the simulations unveiled the formation of cutting beds over the casing, with the transport of cuttings within the annular section occurring in the form of stratified flow. Furthermore, this study extends its analysis to incorporate the influence of pressure drop and cutting velocity profiles. The impact of fluid flow rate, wellbore inclination, rate of penetration, pressure drop, and cutting velocity on cutting concentrations was found to be substantial. Precisely predicting and controlling these parameters is essential to prevent the formation of cutting beds and ensure efficient drilling. It was observed that drill pipe rotation can enhance cutting transport, particularly exerting a more pronounced effect on smaller-sized particles. In the results, a remarkable decrease in pressure drop was observed with increasing well inclination and particle size, whereas pressure drop increased with higher cutting density and mud velocity. Interestingly, pipe rotation exhibited minimal influence on pressure drop. By integrating the analysis of pressure drop and cutting velocity profiles into the CFD simulations, this research contributes to a comprehensive understanding of fluid-solid interactions in deviated wells. These insights provide valuable tools for drilling engineers to optimize drilling parameters for specific well conditions. Leveraging the capabilities of ANSYS Fluent and CFD simulations, this study facilitates safer and more cost-effective drilling operations, making significant strides towards enhancing the efficiency and reliability of wellbore drilling in deviated wells.

Keywords: CFD; Cutting behaviour; Drilling parameters; Pressure drop; Wellbore inclination.

PP-33: Chemically Treated Plant-Based Adsorbents in Oil Spill Remediation – A Comparative Study

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Crude oil's inherent toxicity poses a significant threat to both aquatic and terrestrial ecosystems. Oil spills, a major concern, frequently arising from industrial mishaps and transportation accidents, not only endanger marine life directly but also imperil habitats and ecosystems indirectly, solidifying their classification as hazardous waste and a paramount concern for environmental preservation. Strict prevention measures and prompt, effective cleanup is crucial to minimize environmental damage caused by spills; and therefore, plant-based adsorption techniques offer an effective method to mitigate the adverse effects of crude oil spills, due to its ecological sustainability, biodegradability and economic viability. Plants contain various organic and inorganic compounds, such as cellulose, hemicellulose, pectin, lignin, etc. as well as functional groups, such as hydroxyl, carboxyl, amino, nitro, etc., which can represent the binding sites in adsorption processes and these make them effective adsorbents. A wide variety of these cellulosic materials have shown good results, making them potential candidates for oil spill treatment. In order to improve their characteristics, the sorbents can be modified using mechanical, thermal, and chemical modification methods. This paper involves a comparative analysis of three chemically treated natural adsorbents, namely 'coconut coir, 'rice husk' and 'saw dust', in the context of oil spill remediation. A sequence of controlled laboratory experiments was conducted and reviewed to assess the morphological and adsorption properties, and a comparative analysis was performed among the three natural adsorbents. The series of experiments encompassed SEM characterization analysis to examine surface morphology and structural features, Settling Experiments to evaluate hydrophobicity and settling tendencies, and Sorption Experiments to determine the adsorption capacities of the three biosorbents. The morphological and structural traits, as well as the oil adsorption efficiency of the three plant-based adsorbents, were compared throughout the batch adsorption experiments.

Keywords: Adsorption experiments; Chemical modification; Comparative analysis; Oil spill remediation; plant-based adsorbents.

PP-34: Enhancing Crude Oil Flow in Challenging Climates: Innovative Nanoparticle Pour Point Depressant for Waxy Crude Oil of North-East India

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The efficient transportation of waxy crude oil extracted from the North East region of India presents a significant challenge due to its elevated pour point, leading to undesirable viscosity at lower temperatures. This paper presents a novel approach to address this concern by synthesizing a nanoparticle-based pour point depressant using polyacrylamide and nano silicon dioxide. The aim of this study was to formulate a pour point depressant tailored to the specific characteristics of waxy crude oil from the North East India region. The synthesis process involved the dispersion of nano silicon dioxide within a polyacrylamide matrix, resulting in a well-blended nanoparticle-based compound. The effectiveness of the synthesized pour point depressant was evaluated through comprehensive laboratory tests, including characterization of its physicochemical properties, dispersion stability, rheology and pour point depression performance. Additionally, the study explored the influence of varying concentrations of polyacrylamide and nano silicon dioxide on the performance of the pour point depressant. The findings of this study hold valuable implications for the advancement of tailored solutions aimed at enhancing the efficiency of waxy crude oil transportation. The pour point depressant made of nanoparticles shows its ability to ease transportation difficulties by successfully lowering the pour point and consequent viscosity of the crude oil, particularly in colder climates prevalent in the North East India region. This innovative approach promotes regional economic development in addition to improving the operational effectiveness of the energy sector. Ultimately, the integration of such specialized pour point depressants holds promise for revolutionizing the transportation of waxy crude oils, ensuring a more sustainable and cost-effective energy supply chain.

Keywords: Crude oil; Flow assurance; Pour point depressant; Rheology; Viscosity; Wax formation.

PP-35: Synthesis of ZnO Nanoparticle and its Effect on Water Based Drilling Mud

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There have been numerous studies on the effect of nanoparticles (NPs) on drilling fluid properties like rheology, fluid loss control, thermal and electrical conductivity. Studies show that addition of various nanoparticles with drilling fluids improves their rheological and filtration properties at various temperature and pressure levels. Ahasan et al. studied on the effect of zinc oxide (ZnO) nanoparticles on water-based drilling fluids (WBDF) in absence of KCl at temperature conditions of 40°C and 80°C. In this study, ZnO nanoparticles were synthesis in the laboratory using a sol-gel method with Zinc Nitrate Hexahydrate ($Zn(NO_3)_2.6H_2O$) as a precursor. It reacted with NaOH with Ethanol as solvent to form ZnO. Talam et al. conducted studies on this sol-gel method for the preparation of ZnO nanoparticle. The effects of ZnO nanoparticles on water-based drilling fluids at ambient condition were studied. Base mud was prepared with 3 wt% Bentonite, 0.25 wt/v% XG used as viscosifier, 0.5 wt/v% PAC-R used as fluid loss reducer, 6 wt/v% KCl used as clay stabilizer in 400mL deionized water. A Hamilton beach mixer was used to prepare the mud. In the base mud, 1 wt% ZnO nanoparticle were thoroughly mixed and KOH was added to maintain the pH level at 9-10. This nano-based drilling mud was tested for rheological properties and filtration properties and results were compared with that of base mud. Final results show that there have been improvements in the rheological properties and slightly reduced fluid loss and reduction of mud cake thickness with the nano-based drilling mud.

Keywords: Drilling mud; Filtration properties; Fluid loss; Rheological properties; ZnO nanoparticle.

PP-36: Preparation of a Novel Oil-in-Water Emulsion using Bio-Surfactant for the Application of EOR

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Waxy crude refers to those Crude Oils that contains a significant amount of wax like compounds. They solidify at lower temperatures which can cause several challenges in the context of Enhanced Oil Recovery (EOR) processes. EOR techniques aim to increase oil recovery from reservoirs by altering reservoir rock or fluid properties. Preparing emulsions using surfactants is a common approach in EOR to improve oil recovery from reservoirs. The first function of emulsion is to lower the interfacial tension between the crude oil-water system and the second function is to stabilize the presence of the droplets phase within the continuous phase to prevent the coalescence action of the droplets phase. Emulsions can also alter the interfacial tension between oil and water, improve fluid mobility, and aid in mobilizing trapped oil. Surfactant, short for "Surface-Active-Agents", plays a vital role in preparation of such Emulsions by altering the Interfacial Tension (IFT) and wettability between oil, water and the reservoir rock. In this experiment, we used bio-surfactant. Biosurfactants are naturally occurring surfactants produced by microorganisms such as bacteria, yeast, and fungi. To prepare an oil-in-water emulsion using a biosurfactant, first we dissolved the biosurfactant in water to create a surfactant solution. Then we mixed this solution with our crude oil samples by agitating it vigorously to achieve stable emulsification using Homogenizer. After this, we tested for the emulsion stability. Emulsion stability testing refers to the analysis and evaluation of emulsions over a period of time to assess their stability, performance, and other characteristics. The oil-in-water emulsion prepared using this bio-surfactant exhibited a stable and homogeneous appearance. No visible phase separation or oil droplets were observed, indicating successful emulsification. Thus, our experimental result demonstrates the successful preparation of a stable crude oil-in-water emulsion making it suitable for our operations in EOR.

Keywords: Bio-surfactant; Crude oil; Emulsion; Enhanced oil recovery; Interfacial tension.

PP-37: Polymer-Integrated Silica Nanofluid Synthesis: Unveiling New Frontiers in Performance Enhancement and Applications in EOR

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To boost oil production enhanced oil recovery (EOR) techniques are commonly used in today's oil fields. EOR methods facilitates the retrieval of a greater portion of the residual oil that proves challenging to extract through conventional means. Nanofluids offer promising possibilities for enhancing the efficiency and effectiveness of EOR methods, leading to increased oil recovery rates and more sustainable oil production practices. The application of Silica nanofluids in EOR signifies a pioneering approach, fostering advanced techniques to maximize oil recovery while promoting more sustainable and efficient practices within the oil production industry. This paper explores a groundbreaking approach to producing polymer-based silica nanofluids, holding significant promise for enhanced oil recovery application using the sol-gel method. As nanofluids become increasingly recognized in EOR, this study takes a deep dive into the untapped possibilities of polymer-based silica nanofluids, a domain ripe for further exploration. The study details an inventive synthesis method for these nanofluids and examines their viability for EOR. Given the challenging conditions of EOR reservoirs, the paper employs Dynamic Light Scattering (DLS) to measure zeta potential and particle size - crucial for nanofluid stability. Once stability is achieved, the study evaluates the nanofluid's effectiveness in EOR through a progressive series of tests measuring wettability, surface tension, and interfacial tension (IFT). Detailed analysis of the collected data underscores the efficiency of this innovative approach, marking it as a highly promising advancement in the field. Subsequent Scanning Electron Microscopy (SEM) tests further corroborate the potential of the nano particles. Overall, the wealth of data amassed promises to provide invaluable insights that could revolutionize EOR practices.

Keywords: Dynamic light scattering; Interfacial tension; Sol-gel method; Scanning electron microscopy; Wettability.

PP-38: An Overview of Chemical Enhanced Oil Recovery processes

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By increasing worldwide energy demand and reducing reserves, the Chemical enhanced oil recovery (EOR) from current fields has become more and more important. The large amounts of oil are unrecovered after the application of traditional oil recovery methods. Chemical EOR is an efficient oil recovery technique to recover bypassed oil and residual oil trapped in the reservoir. Moving from polymer to surfactant flooding and currently with the advent of nanotechnology, nanomaterials have enhanced the mechanism of IFT deduction, wettability alternation, foam stability, viscous foams, lower adsorption on the rock surface and hence proposed to be used for EOR. Therefore, Chemical EOR relies on the injection of chemicals to boost the residual oil recovery from uncovered and trapped reservoirs. This review paper tried to discuss with a detailed explanation of the chemicals used in past research studies and the mechanisms related to their oil recovery techniques. The aim of this study was to highlight the challenges encountered in the application of various conventional chemical EOR techniques, and provide solutions to overcome these obstacles. Additionally, the recent trend of incorporating nanotechnology and its synergistic effects on conventional chemicals stability for EOR was investigated and analysed. A review of experimental studies has shown that nano technology can enhance the pore-scale mechanisms of conventional chemical EOR, resulting in higher efficiency, based on the laboratory results and a review of experimental studies. The overview provides detailed information about the chemical applications of EOR to Sustainable energy production.

Keywords: CEOR; Foam stability; IFT; Oil recovery; Wettability.

PP-39: Assessing Ecosystem and Land Cover Changes in the aftermath of the 2020 Baghjan Oil and Gas Leak Fire in Assam

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The Baghjan area in Tinsukia, Assam, witnessed a catastrophic incident in 2020 when an uncontrolled release of gas from the Baghjan-5 oil-producing well, operated by Oil India Limited (OIL), resulted in a prolonged fire that lasted over five months. The incident had far-reaching ecological and societal implications, particularly due to the well's proximity to the Dibru Saikhowa National Park (DSNP) and the Maguri-Motapung Beel wetland, both ecologically sensitive areas. This project aims to comprehensively assess the ecological and land cover changes in the Baghjan area caused by the blowout and subsequent fire. Three sets of satellite imagery from different time points—January 2020, October 2020, and February 2023—were acquired from Earth Explorer. These images were processed and analyzed using ArcMap 10.2 software. The digitization process involved categorizing the land cover into distinct classes such as settlement areas, vegetation, wetlands, and agricultural lands. The main focus of this project is to quantify and visualize the alterations in land cover due to the Baghjan-5 blowout. The analysis revealed significant changes in the impacted area. The DSNP experienced a reduction of 12.07 sq km, wetlands were diminished by 16.32 sq km, grassland cover decreased by 5.23 sq km, river/stream areas were reduced by 1.76 sq km, and forest areas shrank by 2.13 sq km. The extent of damage varied based on the proximity of ecosystems to the blowout site. The blowout incident of May 27, 2020, followed by the subsequent fire on June 9, 2020, led to severe degradation of the natural ecosystem. This degradation resulted in the temporary displacement of communities, including the evacuation of 1500 households, and disrupted the habitability of adjacent areas. The findings from this study provide critical insights into the environmental and social impacts of industrial accidents in ecologically sensitive regions. The detailed land cover analysis contributes to a better understanding of the immediate and lasting effects of such incidents, aiding in future mitigation strategies and ecosystem restoration efforts.

Keywords: Dibru Saikhowa National Park; Ecological assessment; Ecological implications; Land cover changes; Satellite imagery arcmap10.

PP-40: Low Salinity Waterflooding in Carbonate and Sandstone Reservoir

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Low Salinity Waterflooding (LSWF) has been extensively studied as a promising enhanced oil recovery (EOR) technique for sandstone and carbonate reservoirs, involving injection of low salinity water which alters the wettability and interfacial properties of the reservoir rock and crude oil, leading to improved oil recovery. In this paper, the overview of the current state of knowledge on LSWF in both sandstone and carbonate reservoirs, including the various mechanisms, experimental studies, and field applications have been done. Moreover, the experimental studies have shown that LSWF can significantly increase the oil recovery factor in both sandstone and carbonate reservoirs, with reported incremental oil recovery ranging from 5% to over 40%. However, the efficacy of LSWF is dependent on various factors, such as the reservoir properties, injection water composition, and operating conditions. For example, sandstone reservoirs typically exhibit improved oil recovery with low salinity water due to the change in wettability, while in carbonate reservoirs, the primary mechanism is believed to be the dissolution of calcium carbonate minerals in the rock. Field applications of LSWF conducted in both sandstone and carbonate reservoirs have shown mixed results. Successful implementation of LSWF requires a thorough understanding of the reservoir properties and the LSWF mechanism, as well as proper design and optimization of the injection water composition and operating parameters (PVT). Overall, LSWF is a promising EOR technique for both sandstone and carbonate reservoirs, and continued research is required to further optimize and refine the process. This paper provides a comprehensive review of the current state of knowledge on LSWF in sandstone and carbonate reservoirs, highlighting the potential benefits and challenges associated with the technique.

Keywords: EOR; IFT; Low salinity waterflooding; Sandstone and carbonate reservoir; Wettability.

PP-41: A Comparative Analysis of Shear Rate Models to Predict Accurate Rheology and Frictional Pressure Drop

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An accurate estimation of rheological properties are essential for designing efficient drilling fluid system. In general field practice Fann VG meter, a concentric cylinder viscometer, is used to determine rheological properties of the drilling fluids and subsequently for designing mud hydraulics systems. Typically, the rheology plots are generated by converting measured torque into shear stress, and supplied rotor rotation is converted into shear rate. The conversion of the shear rate is based on an *a-priori* assumption of Newtonian behavior fluid. However, the drilling fluid used in industry are mostly non-Newtonian and thus, making the process inaccurate and can produce serious well control problem in unconventional wells with narrow mud window. Over the years, several studies have been conducted to accurately estimate the shear rate of non-Newtonian fluids using concentric cylinder viscometers. The present article evaluated ten such shear rate models (Margulus, Reiner–Riwlin, Middleman, Krieger, Apelblat, Kumar and Guria, Sisodia and Gautam and Guria) to predict shear rate. The shear rate models are evaluated by estimating the frictional pressure drop using the predicted shear rates models and comparing them with the experimental frictional pressure drop values for two drilling fluids representing low and high-viscosity mud. On comparing the various shear rate models a significant difference in the predicted shear rate values were obtained in comparison with conventional Fann VG meter equation i.e., $\dot{\gamma} = 1.7\ N$, where N represents rotor rotation of Fann VG meter. The results indicate that the Gautam and Guria model estimates frictional pressure drop most accurately with $R^2 > 0.999$ and MSE < 0.3 kPa^2.

Keywords: Fann VG meter; Frictional pressure drop; Mud hydraulics; Rheology; Shear rate.

PP-42: Performance Analysis of Electrical Submersible Pumps under Variable Operating Conditions

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In the oil and gas industry, Electrical Submersible Pumps (ESP) are widely used, reliable and efficient artificial lift technology to enhance the production of hydrocarbon resources. This research aims to analyse the performance of Electrical Submersible Pumps (ESP) under variable reservoir conditions and operational parameters. ESPs are widely used for artificially lifting fluids in moderate to huge volumes from oil and gas wells. This method is considered safe in offshore and harsh environments. Still, various factors can affect their performance, such as changes in reservoir pressure, fluid properties, and pump operating conditions. The efficiency and reliability of ESPs may be compromised, leading to decreased well productivity, increased downtime, and higher operating costs. The study was conducted using nodal analysis, which simulates the performance of ESPs under variable operating conditions. The model was calibrated using field data from wells equipped with ESPs, including information such as pump flow rate, motor current, fluid temperature, and pump efficiency. The developed model was used to investigate the impact of changing operational parameters such as pump speed, frequency, and voltage on the performance of the ESP. This study provides insights into the behaviour of ESPs under variable conditions and will help to identify potential improvements in pump design and operating practices. The study results will be useful for oil and gas companies in optimising their production operations, reducing downtime, and improving well performance. Overall, the study analyses the performance of ESPs under variable conditions, which will contribute to the effective deployment of artificial lift systems in the oil and gas industry.

Keywords: Artificial lift; Electrical submersible pumps; Operational parameters; Optimization; Production enhancement.

PP-43: Influence of Reservoir Conditions in the Performance of Sucker Rod Pumped Wells

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Artificial lift techniques reduce the flowing bottom hole pressure and bring oil wells to production due to natural pressure depletion to maintain the flow. For over a century, sucker rod pump has been one of the most widely used artificial lift techniques for onshore applications. The output of the sucker rod pump primarily depends on the stroke length, pumping speed and the plunger diameter. However, the performance of the sucker rod pump is influenced by the conditions in the reservoir, like operational depth, tubing size, inflow performance, water cut, reservoir pressure, wellhead pressure, and reservoir fluid characteristics. The sucker rod pumping system is affected by the stretching in the rod and tubing, causing a reduction in the effective stroke length. The lift volume also depends on the strength of the material used for manufacturing the sucker rod string. In the case of deeper wells, the cost of the sucker rod strings also becomes a dominant factor. The inflow and tubing performance are obtained using nodal analysis to determine the operating under variable conditions in the reservoir and the completions. Hence, it is essential to design and optimise the sucker rod pumping system's performance by considering these conditions to minimise the operation cost and improve the recovery and net present value (NPV). In the current study, the operational parameters like the stroke length and pumping speed are optimised to maintain the overall production rate due to a decline in reservoir pressure and an increase in water cut. The outcome of this study shall assist the exploration and production companies to effectively deploy the artificial lift system in the field through an improved understanding of parameters influencing the lift design and well performance.

Keywords: Artificial lift; Operational parameters; Optimization; Production enhancement; Sucker rod pump.

PP-44: A Review on Rheology of Indian Waxy Crude: Challenges, Insights, and Enhancements

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Crude oil holds significant importance in nations that possess a pressing requirement for fuel, be it for industrial usage, electricity generation, or even transportation mobilization. India is known to be one of the largest consumers of oil in the world. Crude oil accounts for a significant portion of the country's total energy consumption. In terms of production, both on-shore and off-shore fields are found in India. Some major on-shore oil fields are located in the Brahmaputra valley, Barmer area of Rajasthan and the Gujarat coast, while off-shore fields are found in both Eastern and Western Coasts of India. Indian waxy crudes are known for their high paraffin content, posing challenges for efficient flow in pipelines and requiring specialized handling techniques. Hence understanding their rheology at different conditions is essential for the behavior of crude. Rheology holds a critical position in the realm of crude oil activities encompassing extraction, refining, and conveyance. This influence is particularly pronounced when considering waxy crude oil, which is defined by its substantial concentration of paraffin compounds. The intricate nature of the rheological behaviors exhibited by such crude oils is a direct result of the interplay between their inherent composition and a variety of external conditions and factors. These factors can include temperature, pressure, shear rate, and the presence of additives or contaminants. The high paraffin content in waxy crude oil leads to phenomena like viscosity variations with temperature changes, wax deposition on pipeline walls, and potential flow disruptions. This intricate interdependence of elements underscores the significance of understanding and optimizing rheological conditions to ensure efficient and reliable crude oil extraction,

processing, and transportation. Addressing these complexities in rheological behaviors is integral to devising effective strategies to mitigate operational challenges and ensure the smooth movement of waxy crude oil through pipelines while maintaining process efficiency. Through an extensive review of existing research, this abstract delves into the intricate relationship between Indian waxy crude oil's rheology and key parameters such as temperature, pressure, shear rate, wax content, and composition. These parameters collectively influence the oil's viscosity, yield stress, and flow behavior. A comprehensive understanding of these effects is crucial for optimizing operational processes and minimizing potential challenges related to its transportation and processing. This paper will diligently examine a range of pertinent works focused on achieving optimal flow parameters or conditions with the intent of enhancing the rheological characteristics of crude oil. The comprehensive review will be presented to underscore the valuable insights garnered from prior research endeavors in this domain.

Keywords: Flow parameters; Indian waxy crude; Rheology; Wax deposition.

PP-45: Unraveling E-Waste Complexity: Exploring Engineering and Legal Dimensions for Comprehensive Solutions

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One of the most pressing challenges in the current digital age is e-waste, which has a catastrophic effect on the environment. This paper examines this issue in depth and identifies its underlying causes. It makes an effort to offer a solution from both a legal and engineering standpoint. Primary and secondary sources were used in the research process for this work. The opinions of numerous specialists in the disciplines of engineering and law, including MNC corporate executives and Supreme Court attorneys, served as the primary sources. The multiple research papers, case studies, and articles that are published on the subject, as well as the different government records that are readily available, are examples of secondary sources. In this paper, we attempt to analyse the numerous e-waste causes and offer remedies from both ends. The answers offered are rationalised scientifically and legally in light of numerous domestic and international legislation. The goal is to suggest changes to the current legislative and technological frameworks. It is anticipated that proper management of e-waste will be possible by resolving these issues.

Keywords: Environment; E-waste; Health; Waste management.

PP-46: Development of an EOR Technique to Improve Recovery by Using a Vacuum Chamber in the Wellbore

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Enhanced Oil Recovery (EOR) techniques have gained significant attention in recent years as conventional extraction methods have led to diminishing crude oil production rates. This paper presents a novel approach to EOR by introducing a Vacuum Chamber Enhanced Oil Recovery (VCEOR) technique aimed at improving crude oil recovery rates from reservoirs. The proposed method involves the utilization of a vacuum chamber deployed in the perforation site to create an ultra-low-pressure region, thereby facilitating the flow of crude oil to the surface. This abstract provides a concise overview of the development, mechanism, and potential benefits of the VCEOR technique.The VCEOR technique leverages principles of fluid mechanics and pressure differentials to enhance the recovery of crude oil. By creating a controlled low-pressure environment within the perforation site, a significant reduction in the backpressure is achieved. This reduction in backpressure results in a higher-pressure gradient between the reservoir and the wellbore, promoting improved fluid mobility and enhanced crude oil production. The vacuum chamber is designed to withstand harsh reservoir conditions and maintain the desired pressure differential. The mechanism of the VCEOR technique relies on the concept of differential pressure-driven flow. In a conventional reservoir, the presence of high backpressure within the perforation site can hinder the flow of crude oil towards the

wellbore. The introduction of the vacuum chamber effectively counteracts this backpressure, allowing the oil to migrate more freely from the reservoir matrix into the wellbore. Additionally, the low-pressure region within the vacuum chamber creates a favourable environment for the expansion of gas bubbles within the crude oil, further reducing its viscosity and promoting easier flow. This innovative approach to EOR offers several advantages over traditional methods. Firstly, the VCEOR technique is adaptable to a wide range of reservoir types and characteristics, making it a versatile solution for different geological formations. Secondly, the controlled pressure differential provided by the vacuum chamber can lead to a substantial increase in the overall recovery factor of the reservoir. Thirdly, the reduced backpressure minimizes the risk of reservoir damage and sand production, resulting in longer well life and reduced maintenance costs. In conclusion, the Vacuum Chamber Enhanced Oil Recovery technique presents a promising avenue for improving crude oil recovery rates from reservoirs. By strategically utilizing a vacuum chamber to create an ultra-low-pressure region within the perforation site, the VCEOR technique addresses the limitations of traditional extraction methods. This paper offers a preliminary insight into the development, mechanism, and potential benefits of this innovative approach. Further research, experimentation, and field trials are required to fully comprehend the operational feasibility and economic viability of the VCEOR technique in real-world scenarios.

Keywords: Crude oil; EOR; Fluid mobility; VCEOR.

PP-47: Carbon Capture and Utilisation for Hydrogen Production in Petroleum Industry

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As the world advances closer to net zero emissions, carbon capture, utilization, and storage (CCUS) technologies are a key alternative for decarbonizing the energy system. In recent years, global warming has received increasing attention, with CO_2 emissions being the main cause of the problem. CO_2 capture and utilization are an effective solution to the problem of CO_2 emissions, and a combination of amine-based CO_2 capture and it is a highly feasible strategy. However, the uses of conventional technologies have resulted in a high demand for energy, with limited use of hydrogen. The issue of CO_2 emissions can be effectively solved through CO_2 capture and usage. Combining amine-based CO_2 capture with its usage for electrolysis- based hydrogen synthesis can be a highly practical approach. The procedure entails trapping CO_2 through amine absorption treatment. Later on, CO_2 is regenerated from the amine solution in the regenerator at low pressure. Carbonic acid (H_2CO_3) is produced when captured CO_2 reacts with water at favourable conditions of high pressure and low temperature. Further, carbonic acid is electrolyzed to hydrogen ions (H^+) and bicarbonates (HCO_3^-) where Aluminium is used as anode. When CO_2 is injected into the aqueous electrolyte, it reacts with the cathode, turning the solution more acidic, which in turn generates electricity and creates hydrogen, which has the potential to be the most useful type of clean energy in the future. Since hydrogen has a high energy content per weight, it is an effective fuel for many different types of applications, particularly those requiring longer ranges or more energy.

Keywords: Amine; Carbon capture; CO_2 regeneration; Electrolysis; Hydrogen energy.

PP-48: Application of Nano Particles for Improving Properties of Bio-Diesel produced from used Cooking Oil

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The rapid growth of world's population has resulted in the increased demand of limited fossil fuels. This energy crisis leads to significant research work on sustainable green energy. At current scenario, bio-fuel is one of the best alternate sources to cope up with this energy crisis. A very large amount of used cooking oil across different cafes, restaurants, shops are left over. In order to remove the amount of such waste disposal,

increased recycling and waste minimizing initiatives should be taken. A major recycling method is to convert the used cooking oil to bio-diesel. Bio-diesel obtained from used cooking oil is utilised in many countries as an alternative for fossil fuel. The conversion processes are generally very expensive and require high temperature and pressure. The research work involves the principle of green chemistry to convert used cooking oil to bio-diesel. The used oil is settled and later filtered by sieves of hole size 100nm. Transesterification process takes place to convert the filtered oil to bio-diesel. Further nano particles (Aluminium Oxide, Silica etc.) are added to the bio-diesel to study the properties like cetane number, calorific values, rheological properties etc.

Keywords: Bio-diesel; Cetane number; Filtration; Green energy; Nano-particles; Transesterification.

Optimizing Carbon Capture Efficiency with Neural Networks in CCUS

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Greenhouse gas emissions are significant contributors to global climate change. Average annual atmospheric CO_2concentration has increased to ~412.5 ppm in 2020, owing to CO_2 emissions of up to ~31.5 billion tones, with a growth rate of ~5% during 2021. Increased emissions of greenhouse gases have led to an increase in global warming, and the threshold of 1.5 ◦C is about to be crossed before 2030. Even with aggressive CO_2 reduction measures, this dangerously increased global temperature might take the next 80 years or more to limit to 1.5 ℃. Carbon capture, utilization, and storage (CCUS) technology is a promising approach to curb CO_2 emissions while mitigating greenhouse gas emissions. Artificial Neural Networks (ANNs) and Convolutional Neural Networks (CNNs) are crucial for leveraging data processing, pattern recognition, and optimization techniques for intricate CCUS processes. By examining historical and real-time data, ANNs identify valuable trends and relationships among various process parameters. Through continuous training, operators gain the ability to make real-time adjustments, enhancing capture efficiency while reducing energy consumption and operational costs. ANNs and CNNs can be used to predictively model and optimize solvent selection and the performance of carbon absorption systems for carbon sequestration based on feed composition, temperature, and pressure, enabling proactive judgements. Additionally, neural networks offer fault detection capabilities, promptly identifying malfunctions in CCUS equipment by comparing the sensor data with the operating norms and issuing alerts when deviations occur. This aids in problem detection, quick repairs, minimizing downtime. CNNs find use in image processing and analyses for geoscience and infrastructure monitoring applications related to carbon sequestration by evaluating the storage site potential. To provide a comprehensive view of CCUS operations, ANNs and CNNs combine data from various sources, including sensors, satellite imagery, and historical records. This integrated data enhances decision-making and optimization efforts. Energy consumption optimization within the CCUS process is another forte of ANNs. By analyzing historical consumption trends, these networks recommend energy-efficient operating settings, thereby reducing operational costs and the carbon footprint of CCUS systems. In CCUS systems that involve carbon utilization, ANNs play a critical role in optimizing chemical reactions and processes for converting captured CO_2 into valuable products. These networks directly control processes, enhancing reaction kinetics and product yield. ANNs and CNNs contribute to the modeling and prediction of hazards associated with carbon leakage from storage sites. Analyzing geological and environmental data, they assess the long-term integrity of storage structures. ANNs and CNNs have a substantial impact on CCUS operations, optimizing efficiency, detecting errors, facilitating solvent selection, and aiding geoscience analysis. They empower data-driven decision-making, ultimately contributing to climate change mitigation.

Keywords: Artificial neural networks; Carbon sequestration; CNNs; Greenhouse gases; Sustainability.

PP-50: Saturation Pressure Prediction in Reservoir using Machine Learning Algorithms

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Oil recovery is a process that involves key components, including geophysical exploration, drilling, reservoir engineering, and production management. Many factors influence oil recovery, such, as the characteristics of the reservoir well design, fluid properties, and economic considerations. Enhanced Oil Recovery (EOR) refers to the process of increasing the amount of oil that can be extracted from an oil reservoir beyond what can be achieved through primary and secondary recovery methods. Characterizing oil's PVT (pressure volume temperature) behavior is crucial for designing recovery methods. One important aspect is estimating the bubble point pressure or saturation pressure. While there are laboratory methods and Equation of State (EOS) approaches to determine this pressure point they can be time-consuming and costly. Additionally, relying on correlations developed in these methods can sometimes lead to errors. The saturation pressure depends on factors like the composition of the oil (including H_2S, CO_2, C_1 to C_7 hydrocarbons) reservoir temperature, and specifications related to heptane plus (C7+) compounds such as molecular weight and specific gravity. To create a model for estimating saturation pressure using these parameters as features and saturation pressure as a label or target, different machine learning models were tested in this study. These models include support vector machine (SVM), decision tree (DT) network, Artificial Neural Network (ANN) as well as boosting methods, like Ada Boosting, Gradient Boosting, and XG Boosting. Different metrics such as percentage relative error (APRE%), root mean square error (RMSE) standard deviation (SD), and coefficient of determination (R^2) are used to assess and compare the performance of different models. The results show that the ANN model gives the best-fit model with a good correlation coefficient. The performance of these models was compared with different empirical correlations and then validated. Finally, the model is evaluated with different experimental values.

Keywords: Enhanced oil recovery; Equation of state; Machine learning; Saturation pressure.

PP-51: Development of Sizing Correlations for Equipment in Amine Based Absorption Process for Carbon Capture

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Carbon capture and utilization techniques are needed to be improved to achieve net zero targets of India. Post-combustion carbon capture techniques, especially Amine based absorption process, is one of matured technologies to capture carbon dioxide from the flue gases of industries. For the efficient design of the whole carbon capture plant, sizing of various important units in the process such as DCC (Direct Contact Cooler), absorber, stripper 1 and stripper 2 are critical. In this work, correlations for the sizing of DCC, Absorber and strippers were developed using the data obtained from the simulation. Aspen Plus is used to simulate the amine-based carbon capture plan operating for 8000 hours per year to capture 90, 95 and 99 percent from flue gas as a base case. The flue gas has 0.0408 mole fraction of CO_2 along with H_2O, O_2 and N_2 in 0.0875, 0.12 and 0.7428 mole fractions respectively. 30% Monoethanolamine (MEA) is used as a solvent. Various simulations were carried out along with the sizing of the equipment under consideration by varying the mass flow rates of CO_2 in feed flue gas. Each simulation will provide the required MEA for the desired separation to be possible and diameters of the critical equipment. Data obtained from the simulations are processed through the MATLAB optimization tools such as 'fminunc' to optimise the coefficients of correlations for calculating the diameter of the DCC, absorber, stripper 1 and stripper 2 as a function of mass of CO_2 processed per hour, percentage of CO_2 in flue gas. Validation of correlations developed is performed by calculating AARD (Average Absolute Relative Deviation) values. Results obtained by using the developed correlations show less than 5% of deviation from simulation results.

Keywords: Amine based absorption; Aspen plus; MEA; Optimization; Simulation.

PP-52: Exploring Agro-Industrial Waste as an Asset for the Production of Biosurfactants and Application in the Microbial Enhanced Oil Recovery

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Microbial biosurfactants are the substitutes for traditional chemical-enhanced oil recovery (EOR). Microbial surfactants, often known as biosurfactants, are amphiphilic, surface-active chemicals produced by microorganisms such as yeast, bacteria, and unicellular fungi. Biosurfactants exhibit eco-friendly qualities as it has the ability of total biodegradability, low eco-toxicity, and generation from bio-renewable sources. Moreover, improved surface properties can be attained by biosurfactants in a number of ways, including by lowering surface tension and interfacial tension, improvement in mobility by increasing emulsification capacity, decreasing critical micelle concentration (CMC), and changing wettability (contact angle). Microbial EOR is being implemented to eliminate the restrictions of other EOR methods. However, the amount of biosurfactant produced by the microbes is inadequate to use in the reservoir field, and the whole process became expansive. The objective of this study is to explore agro-industrial waste as a substrate for the production and enhancement of biosurfactants for the application of microbial-enhanced oil recovery (MEOR). Different waste substrates as nutrient sources, such as paneer whey, waste cooking oil, waste engine oil (WEO), molasses, and corn steep liquor (CSL), compared for the biosurfactants production with commercial carbon sources such as mustard oil, paraffin oil light, paraffin oil heavy, and glycerol using two isolated bacterial strains RSL-2 Bacillus subtilis RSL-2 and Pseudomonas aeruginosa P7815 from the oil-contaminated site. The isolated strains show potential results for the substrates like molasses, waste cooking oil, corn steep liquor, with the fixed parameter (temperature 37 °C, pH 7, RPM 180, inoculum size 5%, substrate 5%), in the preliminary test, such as surface tension, oil displacement test, contact angle, emulsification test, and their growth kinetics. These preliminary results ensure the further optimization of the biosurfactant production using these substrates for the enhancement of the metabolite product.

Keywords: Biosurfactants; Corn steep liquor; Critical miscall concentration (CMC); Microbial enhanced oil recovery (MEOR); Surface tension.

PP-53: Comparative study of Silica-Gel at Variable Particle Size

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Colloidal micro-particles of silica gel anticipated via sonication at different time scale reveals that the shape and size of the micro-particles are strongly dependent on the initial and final time frame—the maximum variation in the particle size of the silica gel recorded at the initial five minutes. Further, we observed, the size reduction of silica gel particles was less rather than increasing the time scale. It can be estimated that after maximum degradation gel particles cannot reduce their size as much. This stage is directly denoting gel particle stability, evidenced by the morphological study of Field Emission Scanning Microscope (FESEM) images. At the smaller particle size (40 - 75 µm), the surface morphology consisted of particle agglomeration, whereas the bigger particle size (75 – 200 µm) shows an equally distributed surface morphology. At this stage, gel particles were homogeneously distributed and constructed an isomorphous phase. The particle size in the range of 75 - 200 µm shows higher thermal stability with ~ 95 % residue, as compared to the particle size range of 40 - 75 µm having ~ 85 % residue. Besides we have observed that the mass loss of gel particles was maximum in the initial 50 minutes. We observed the Brunauer Emmet Teller (BET) surface area of gel particles at the particles size 75–200 µm and 40-75 µm are 284.19 m2 g-1 and 471.51 m2 g-1, respectively. It is predicted that smaller particle size shows a high surface-to-volume

ratio. Hence, the results reveal that the smaller particle size of the gel is attributed to the maximum surface area.

Keywords: Brunauer emmet teller; Particle size; Silica gel; Surface area.

PP-54: A Comparative Scale-up Analogy of Traditional Vs Multi-pass Membrane Separator Module for Enhanced H_2 Recovery

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The application of Pd-Ag membranes in the field of hydrogen purification is particularly appealing owing to their cost-effectiveness and high energy efficiency. The efficacy of the membrane separator module is significantly affected by both the geometry of the separator and the conditions under which it operates. Nevertheless, the use of multiple membranes is associated with the issue of concentration polarization, which occurs due to restricted mass transfer caused by the presence of several tubes and the development of a boundary layer of non-permeable gas near the membrane surface. Therefore, a comprehensive understanding of mass transfer restrictions, radial H_2 concentration profile, and flow patterns, is required for performance optimization. To address the issue of concentration polarization, the membrane separator is designed to include three longitudinal baffles, which in turn create four separate channels, thus implementing a multi-pass configuration. The performance of the multi-pass membrane separator is optimized by adjusting several factors such as the positioning of the membrane within the separator, the proximity of the baffles, and the feed load. Following the obtained results, a study is conducted to scale up the process by utilizing four and then ten membranes. The study is conducted at T = 673 K, ΔP = 300 kPa, 70% H_2 / 30% N_2 feed gas composition, and feed load of 320 L min^{-1} $m^{-2}_{membrane}$. Additionally, the feed load is augmented from 194 to 1290 L min^{-1} $m^{-2}_{membrane}$ to investigate the effect of convective feed flow. The multi-pass separator is further compared to the same configuration in the traditional separator. The results demonstrated that the H_2 recovery improved by 9% for a single membrane whereas it improved by 18% for four membranes compared to the same configuration without baffles. When the feed flow rate is increased from 48 Lh^{-1} to 240 Lh^{-1}, a decrease of 46% in H_2 recovery is seen for a single membrane whereas it is 35% for four membranes with baffles. This observation implies that while the H_2 recovery decreases at a higher feed flow rate, the extent of this decrease is far less pronounced for multiple membranes in comparison to a single membrane. To facilitate scale-up, the membrane-to-pass ratio (MPR, ratio of the number of membranes to the number of passes) is increased from 0.25 to 2.5 by adding multiple membranes in different passes. The H_2 recovery exhibited a small decline of 2% when the MPR increased from 0.25 to 1.5. However, a significant reduction of 7% and 12% in H_2 recovery is noted when additional membranes are placed at the inlet (MPR = 2.0) and outlet (MPR = 2.5) of the separator, respectively, as compared to the MPR of 0.25. A notable enhancement of 17% in H_2 recovery for distributed feed is observed compared to the same configuration without baffles. Therefore, this study offers an in-depth investigation of the multi-pass membrane separator and approaches for scaling up using multiple membranes.

Keywords: Feed distribution; Longitudinal baffles; Membrane-to-pass ratio; Multi-pass; Scale-up.

PP-55: Effect of Residual Oil Saturation on Hydrogen Geo-storage and Recovery from Depleted Oil Reservoirs

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Global climate change induced by the anthropogenic emission of CO_2 has become a major concern of the globe. Among the various decarbonization techniques, hydrogen has marked its position in the transition to

green energy economy. Hydrogen itself is a fuel as well as a storage option for renewable energies for future. Large scale storage of hydrogen in geological formations is inevitable to maintain its uninterrupted supply during seasonal fluctuations of demand and to ensure long term energy security. Ensuring effective extraction of hydrogen from porous media after extended periods of storage remains one of the primary hurdles in the realm of underground hydrogen storage. In an ideal condition the recovered volume of hydrogen should be equal to the injected volume. The interaction of hydrogen with the residual oil saturations in the depleted reservoirs during the storage period can lead to the recovery of undesirable amount of oil during the extraction of hydrogen. Hence, understanding how the remaining oil in these reservoirs interacts with the stored hydrogen, and how it affects both storage efficiency and the subsequent recovery of hydrogen, is crucial. This work focuses on the laboratory scale wettability studies along with injection and recovery studies on sandstone core samples for hydrogen geo-storage. Experiments are conducted under in-situ storage conditions. Saturation studies are conducted to estimate the amount of oil that is produced along with hydrogen recovery. The effect of varying residual oil saturations and soaking period are also studied along with varying injection pressures. This laboratory scale experimental study provides a qualitative and quantitative understanding on the efficient storage capacity and the effective recovery of hydrogen stored in depleted oil reservoirs.

Keywords: Depleted reservoir, Hydrogen geo-storage, Recovery, Residual oil saturation, Wettability.

PP-56: Unleashing Subsurface Potential: Breakthroughs in Wettability and Permeability for Elevated Subterranean Hydrogen Storage

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The geological storage of hydrogen holds promise for addressing energy challenges and reducing greenhouse gas emissions. Yet, its viability pivots on comprehending intricate interplays involving gas phases, brine, and reservoir rocks. This research proposition strives to scrutinize the influence of gas blending on wettability and permeability within hydrogen/brine and methane/brine contexts. The exceptional Jharia shale formations are enlisted as an exclusive experimental platform. The objective is to reveal transformative understandings capable of reshaping strategies for hydrogen geological storage. Wettability and permeability stand as crucial elements shaping fluid dynamics within subterranean structures. This research initiative acknowledges the notable impact of gas amalgamation on these characteristics and seeks to uncover the complexities therein. Leveraging the diverse mineral composition and organic makeup of Jharia shale, which emulates real-world scenarios, provides an ideal experimental platform. This choice is driven by the aspiration to explore these intricate dynamics comprehensively. The research strategy employs a dual-track methodology. Laboratory tests entail core flooding experiments, utilizing Jharia shale specimens and introducing blended gases to brine systems. Rigorous analysis will quantify wettability and permeability influences on subsurface reservoirs. Molecular simulations will supplement these findings, enabling micro-level comprehension of gas-brine-rock interactions. Anticipated outcomes encompass a comprehensive wettability dataset for hydrogen/brine and methane/brine in Jharia shale. Findings will clarify the influences of wettability and permeability in shaping reservoir behavior and fluid movement. Moreover, the study will enrich knowledge about hydrogen storage feasibility in geological formations, potentially refining storage strategies. In conclusion, this research proposal envisions a transformative investigation into wettability and permeability alterations through the entire experiment utilizing Jharia shale formations. The outcomes of this study have far-reaching implications, potentially revolutionizing hydrogen geological storage strategies and offering innovative solutions to pressing energy and environmental challenges.

Keywords: Geological storage formation, Hydrogen, Jharia shale, Permeability, Wettability.

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22. ZELLE Biotechnology Pvt. Ltd., Thane
23. Biotech Desk Pvt. Ltd., Hyderabad
24. IKON Instruments, Delhi
25. Hyclone Life Sciences Solutions (I) Pvt. Ltd., Kolkata
26. Centyle Biotech Pvt. Ltd., Uttarakhand
27. Topclass Enterprices LLP, New Delhi
28. Genaxy Scientific Pvt. Ltd., New Delhi
29. Secure Diagnostics Pvt. Ltd., Bhopal
30. REMI Sales and Engineering Ltd., Kolkata
31. Redcliffe Lifesciences Pvt. Ltd., Noida(UP)
32. ACS Chemicals, Ahmedabad
33. Nice Chemicals Private Limited, Ernakulam, Kerala
34. FILTROS (UK) Ltd., (A Unit Of Neeraj Exports), Jaipur
35. Microlit India, Lucknow etc

optical contact angle measurements and drop contour analysis of e.g, oil-rock-brine interfaces

force tensiometry, dynamic contact angle measurements, and determination of critical micelle concentration (CMC)

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