August 2023

CSI Communication

Monthly Newsletter of Catalysis Society of India

Circulated to all CSI Members

Important Announcement:

CSI newsletter shall be pleased to publish half a page write-up under the title, Centre of Excellence in Catalysis Research in India from any Indian Academics, Research laboratories or Industrial organizations. You may send your brief write-up on your research activities to us which will be published in coming issues of CSI.
You can also share your recent happy moments like publications, granted patents, technology commercialization, fellowship, awards, etc. to highlight in the CSI communication.

Prof. Prakash D. Vaidya's Research Group in the Institute of Chemical Technology Mumbai

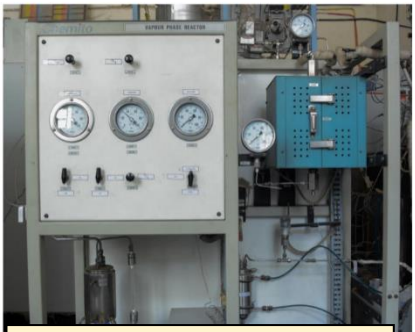
Professor Prakash Vaidya is Rashtriya Chemicals and Fertilizers Chair in the Chemical Engineering Department at the Institute of Chemical Technology in Mumbai. He is an expert in catalysis, separations and reaction engineering. He has been a Humboldtian, Liverpool University's India Fellow, and Fellow of the Maharashtra Academy of Sciences and the Indian Chemical Society. He is Marathi Vidnyan Parishad's Manmohan Sharma Science and Technology Prize Awardee. His work on CO_2 capture and utilization, H_2 production technologies, and waste and biomass valorization to chemicals and fuels has fast-tracked India's AatmaNirbhar aspirations (self-reliant India campaign) and Panchamrita strategy (CoP26 policy) for net zero emissions by 2070 and advanced the energy transition to a low carbon economy.

❖ CO_2 Capture and Utilization

In the last two decades, Vaidya's group made significant effort toward the optimization of CO_2-capturing technologies (CCS) by finding well-suited solvents. They explored green absorbents (such as ethanol-based amines, amino acid salts and amino sugars), easily regenerable organic solvents and cheap, high-loading sterically hindered amines. They suggested novel catalysts (such as transition metal oxides, amino acid salts, and clays) for easier desorption of amines. Especially, they applied alumina and acid-treated bentonite for improved amine desorption.

The economic feasibility of CO_2 separation can be improved by utilizing CO_2 for the synthesis of commercial products (CCU). Vaidya's group studied CO_2 utilization via high-temperature reverse water gas shift using ZnO/Al_2O_3 catalyst (for producing CO and subsequently methanol via CAMERE

process), dry reforming and bi-reforming of methane using Ni and Pt catalysts (for producing metgas), biogas reforming over Ni/CaO/Al_2O_3 (for producing H_2), and Pt-catalyzed aqueous-phase reforming of microalgae and seaweeds (for producing H_2).


High Pressure Reactor Facility

The integration of CO_2 capture and CO_2 utilization (ICCU) can avoid the high energy constraint and cost penalty for amine regeneration and CO_2 compression in the usual CCS/CCU methods. Vaidya's group developed dual-functional materials for this new promising concept of ICCU, especially for methanation (ICCU-Methanation) and bi-reforming (ICCU-BRM). Tandem amine-based CO_2 capture and hydrogenation to methanol is another good example of such integrated processes. This group is currently working on integrated one-pot systems based on concurrent CO_2 capture using amines (usual, tertiary, or sterically hindered) or amine derivatives in aqueous/organic solutions and heterogeneous catalytic hydrogenation of captured CO_2.

❖ Hydrogen Production by Reforming Processes

H_2 is a clean energy carrier that can help decarbonize the energy system. Vaidya reported carbon-neutral production of H_2 from steam reforming of renewable resources such as bioethanol, biobutanol and biooil. He reported the formation of syngas and H_2 from chemical looping reforming of methane and biooxygenates over novel perovskite oxygen carriers.

❖ Waste and Biomass Valorization

Vaidya produced H_2-containing gas from aqueous-phase reforming of waste activated sludge and sewage wastewater using Pt-based catalysts. Currently, Vaidya is working on the production of paraffins by aqueous-phase reforming of wastewater streams.

Vaidya produced the drop-in biofuel HVO (or hydrotreated vegetable oil, which can be mixed with usual diesel in all proportions) from the catalytic hydrotreatment of two non-edible feeds, viz. karanja and jatropha oil. Especially, his group reported the performance of traditional (Co-Mo and Ni-Mo) and newer catalysts. Vaidya's group worked on the production of valuable chemicals from biomass, viz. 2,5-furandicarboxylic acid (FDCA) via oxidation of 5-hydroxymethyl furfural (HMF), which is producible from sugars.

Recent Selected Publications:

1) Kalekar, V.N.; Vaidya, P.D. Hydrogen production by aqueous-phase reforming of model compounds of wet biomass over platinum catalysts. Ind. Eng. Chem. Res. 61 (2022) 10004-10013
2) Karemore, A.L.; Sinha, R.; Chugh, P.; Vaidya, P.D. Syngas production by carbon dioxide reforming of methane over Pt/Al_2O_3 and Pt/ZrO_2-SiO_2 catalysts. Chem. Eng. Sci. 249 (2022) 117347
3) Jain, A.B., Vaidya, P.D. Kinetics of hydrogenation of furfuryl alcohol and γ-valerolactone over Ru/C catalyst. Energy Fuels 34 (2020) 9963-9970

4) Ghungrud, S.A.; Vaidya, P.D. Sorption-enhanced reaction process for glycerol-to-hydrogen conversion over cobalt catalyst supported on promoted hydrotalcites. Int. J. Hydrogen Energy 45 (2020) 9440-9450

5) Yadav, A.K.; Vaidya, P.D. Renewable hydrogen production by steam reforming of butanol over multiwalled carbon nanotube-supported catalysts. Int. J. Hydrogen Energy 44 (2019) 30014-30023

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Prof. Prakash Vaidya's research group in ICT Mumbai (From left – Akash Chandole, Vinayak Kalekar, Prof. Vaidya, Rohini Zambre, Namrata Upreti and Shaurya Mohan)

Commercial & Policies

Recent Developments in Bioethanol Market

Bioethanol, also known as ethanol, is a type of renewable biofuel produced from plant materials such as sugarcane, corn, wheat, or cellulose-rich feedstocks. It has a wide range of applications and is used in various industries. some of the primary applications of bioethanol are Transportation Fuel, Fuel Oxygenate, Industrial Solvent, Energy Generation, etc. The global ethanol market is approximated to be USD 83.4 billion in 2023, and it is projected to reach USD 114.7 billion by 2028 at a CAGR of 6.6%. Some of the leading companies involved in the manufacturing of bioethanol are POET LLC (US), Archer Daniels Midland Company (US), Green Plains (US) and Valero Energy (US), Pacific Ethanol (US) The Anderson Inc. (US), Flint Hills Resources (US), and Tereos (France) among others.

- In January 2022, Wolf carbon solutions and Archer Daniels Midland Company (US) partner to advance the decarbonization of ethanol production.
- In October 2021, Archer Daniels Midland Company (US) announced that it has reached an agreement to sell its ethanol production complex in Peoria, Illinois, to BioUrja Group.
- In April 2023, POET LLC. (US) announced the signing of an exclusive partnership agreement with Midwest Commodities in Detroit, Michigan. Midwest Commodities will provide DDGS truck-to-container transload services solely to the company so that the company can more efficiently serve its global customer base.

- In January 2023, United Airlines, Tallgrass, and Green Plains Inc. (US) today announced a new joint venture – Blue Blade Energy – to develop and then commercialize a novel Sustainable Aviation Fuel (SAF) technology that uses ethanol as its feedstock.

Source: https://www.marketsandmarkets.com/pdfdownloadNew.asp?id=131222570

- **Govt. plans 100-mt coal gasification by 2030**

The Ministry of Coal has set a target to gasify 100 million tonnes of coal by the financial year 2030. A comprehensive scheme amounting to ₹6,000 crore is under consideration to promote coal and lignite gasification projects for both government Public Sector Undertakings (PSUs) and the private sector, as per a recent ministry announcement. The ministry believes that adopting gasification technology will transform India's coal sector and decrease its dependence on imported natural gas, methanol, ammonia and other key products. As it stands, India imports about 50% of its Natural Gas, over 90% of its Methanol consumption and roughly 13-15% of its total Ammonia consumption to meet domestic demand. The deployment of coal gasification will support India's 'Aatmanirbhar' vision, stimulate job creation and significantly reduce imports by 2030.

Source: https://www.livemint.com/industry/energy/govt-plans-100-mt-coal-gasification-by-2030-draws-rs-6-000-crore-scheme-11689326292253.html

- **Indian Oil Awards Polybutadiene Rubber Plant Contract to Thyssenkrupp India**

Indian Oil Corporation Ltd. (IOCL) has awarded a contract to develop a Polybutadiene Rubber (PBR) plant worth approximately USD 100 million to Thyssenkrupp Industrial Solutions India (TKIS) Private Limited. This PBR plant will have a production capacity of 60 Kilo Tonne Per Annum (KTPA) and will be executed under EPC mode at IOCL's Panipat refinery & petrochemical complex in Haryana. PBR is produced by polymerization of butadiene using Zeigler- Natta type Cobalt, Nickel or Neodymium catalyst.

Source: https://cablecommunity.com/indian-oil-awards-polybutadiene-rubber-plant-contract-to-thyssenkrupp-india/

- **Innovative Naphtha Cracking Technology "M-Cracker" Using Microwave Heating**

M-Cracker® developed by Microwave Chemical Co., Ltd. converts the energy source of the naphtha cracking technology, the basic chemical production process, to microwave heating. This will result in a new concept of cracking process that differs from conventional methods by directly heating the reaction field, which is a characteristic of the microwave process. Furthermore, the M-Cracker® will be further improved in near future by adopting the advanced catalytic naphtha-cracking technology, which has been developed by Chiyoda Corporation.

Source: https://jp.mitsuichemicals.com/en/release/2023/2023_0801_1/index.htm

- **LanzaTech Enter Strategic Partnership to Explore Biorecycling Carbon Waste into Fuels and Chemicals**

GAIL (India) Limited, India's largest natural gas company and LanzaTech Global, Inc., (Nasdaq: LNZA)—an innovative carbon capture and utilization ("CCU") company that converts waste carbon into products that people use in their daily lives—have entered a partnership to explore

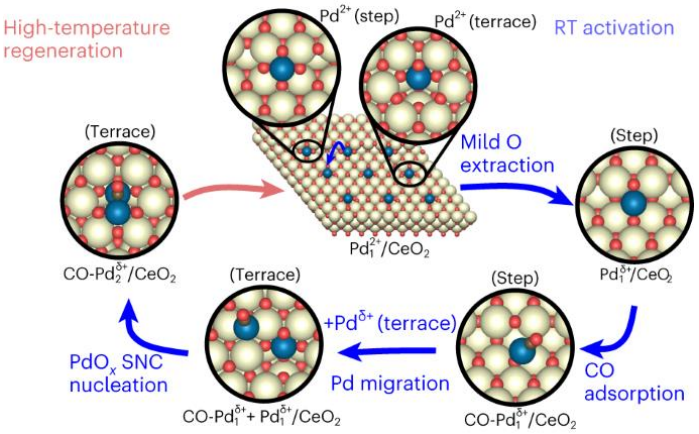
innovative technology solutions that advance GAIL's Net Zero 2040 goals and have the potential to support wider decarbonization applications globally. GAIL and LanzaTech will explore setting up a pilot scale CO_2 capture and conversion project that has the potential to be a role model for converting CO_2 into useful materials instead of emitting it to the atmosphere. Combining LanzaTech's carbon capture and utilization technology with GAIL's renewable H_2 and CO_2 gas streams, the project will enable resource utilization where the building blocks of everyday consumer goods, from fuels to packaging and clothing, can be made from biorecycled material instead of virgin fossil fuel.
Source: https://ir.lanzatech.com/news-releases/news-release-details/gail-lanzatech-enter-strategic-partnership-explore biorecycling#

- **The Anusandhan National Research Foundation Act 2023 brough to steer Indian R esearch by Govt of India.**

The Anusandhan National Research Fou

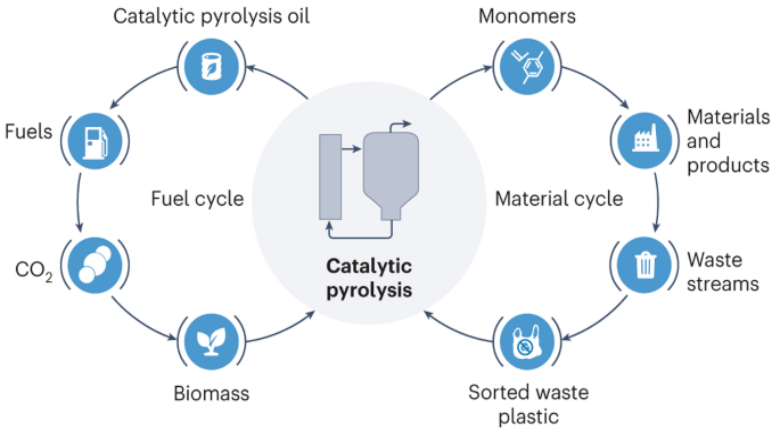
Scientific Updates

- **New catalyst could dramatically cut methane pollution from millions of engines**



The reaction-environment-modulated transformations of subnanometre-sized Pd on CeO_2 for efficient methane removal, leveraging the reaction environments at different stages of automotive exhaust aftertreatment are reported. During the cold start of vehicles, inactive Pd1 single atoms are readily transformed into PdOx subnanometre clusters by CO even at room temperature with excess O_2, resulting in boosted low-temperature CH_4 oxidation. At elevated temperatures, dispersion of PdOx cluster into Pd1 against metal sintering renders outstanding hydrothermal stability to the catalyst, to be activated during the next vehicle start. Combined experimental and computational studies elucidate the dynamically evolved Pd speciation on CeO_2 at an atomic level. Modulating the reversible nature of supported metals helps overcome the long-existing trade-off between low-temperature activity and high-temperature stability, also providing a new paradigm for designing intelligent catalysts that brings single-atom/cluster catalysts closer to real applications.
Source: *Nature Catalysis* , 2023, 6, 618–627 https://doi.org/10.1038/s41929-023-00983-8

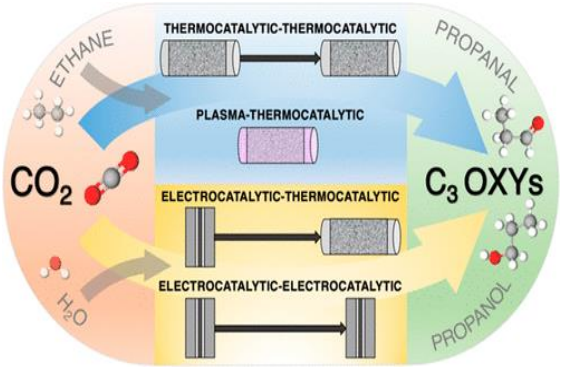
- **Catalytic pyrolysis as a platform technology for supporting the circular carbon economy**



Catalytic pyrolysis, a process that combines pyrolysis and vapour-phase catalytic upgrading, is a versatile technology platform capable of direct liquefaction of biomass and waste plastic into intermediates that can enable the decarbonized production of chemicals and/or transportation fuels. Recently, catalytic pyrolysis has attracted substantial research and commercialization attention, with over 15,000 journal articles and patents published in the past decade alone. In this Perspective, authors chart a path towards commercial-scale catalytic pyrolysis of waste plastic and biomass by identifying key short-term and long-term technological barriers. Within the proposed development roadmap addressing these barriers, catalytic pyrolysis can move from the demonstration scale to integrated biorefinery networks producing fuels and plastics precursors at a scale of between 0.1 and 1 billion tonnes of carbon per year.

Source: Nature Catalysis, 6,563–573 (2023) https://doi.org/10.1038/s41929-023-00985-6

- **Utilizing CO_2 as a Reactant for C3 Oxygenate Production via Tandem Reactions**

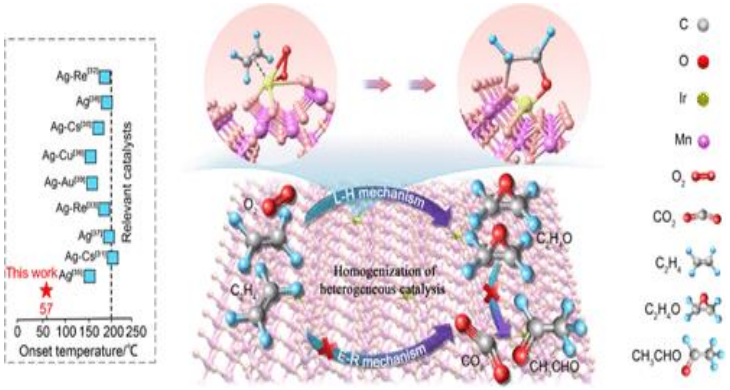


One possible solution to closing the loop on carbon emissions is using CO_2 as the carbon source to generate high-value, multicarbon products. In this Perspective, paper descries four tandem reaction strategies for converting CO_2 into C_3 oxygenated hydrocarbon products (i.e., propanal and 1-propanol), using either ethane or water as the hydrogen source: (1) thermocatalytic CO_2-assisted dehydrogenation and reforming of ethane to ethylene, CO, and H_2, followed by heterogeneous hydroformylation, (2) one-pot conversion of CO_2 and ethane using plasma-activated reactions in combination with thermocatalysis, (3) electrochemical CO_2 reduction to ethylene, CO, and H_2, followed by thermocatalytic hydroformylation, and (4) electrochemical CO_2 reduction to CO, followed by electrochemical CO reduction to C_3 oxygenates. Proof-of-concept results and key challenges for each tandem scheme, is discussed. A comparative analysis of the energy costs and prospects for net CO_2 reductionis conducted. The use of tandem reaction systems can provide an alternative approach to traditional catalytic processes, and these concepts can be further extended to other chemical reactions and products, thereby opening new opportunities for innovative CO_2 utilization technologies.

Souce : JACS Au 2023, 3, 2, 293–305; https://doi.org/10.1021/jacsau.2c00533

▪ Heterogeneous Iridium Single-Atom Molecular-like Catalysis for Epoxidation of Ethylene

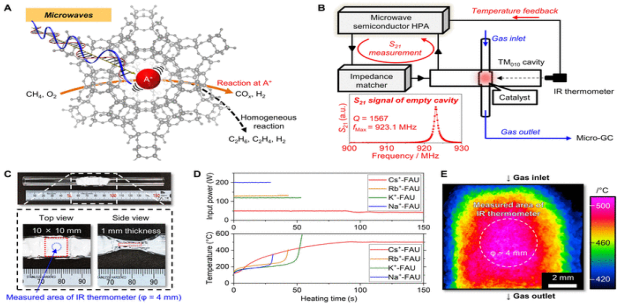
Authors report a strategy for selective epoxidation of ethylene, which exploits a heterogeneous catalyst comprising iridium single atoms to interact with the reactant molecules that act analogously to ligands, resulting in molecular-like catalysis. This catalytic protocol features a near-unity selectivity (99%) to produce value-added ethylene oxide. We investigated the origin of the improvement of selectivity for ethylene oxide for this iridium single-atom catalyst and attributed the improvement to the π-coordination between the iridium metal center with a higher oxidation state and ethylene or molecular oxygen. The molecular oxygen adsorbed on the iridium single-atom site not only helps to strengthen the adsorption of ethylene molecule by iridium but also alters its electronic structure, allowing iridium to donate electrons into the double bond π* orbitals of ethylene. This catalytic strategy facilitates the formation of five-membered oxametallacycle intermediates, leading to the exceptionally high selectivity for ethylene oxide.



Source: J. Am. Chem. Soc. 2023, 145, 12, 6658–6670 https://doi.org/10.1021/jacs.2c11380

▪ Direct microwave energy input on a single cation for outstanding selective catalysis

This study unlocked direct and selective heating of single alkali metal cations in the pores of aluminosilicate zeolites under MW. Selectively heated Cs+ cations in FAU zeolite exhibited selective CH4 combustion performance, that is, COx generation at the heated Cs+ cations selectively occurred while side reactions in the low-temperature gas phase were suppressed. The Cs-O pair distribution function revealed by synchrotron-based in situ x-ray total scattering gave us direct evidence of peculiar displacement induced by MW, which was consistent with the results of molecular dynamics simulation mimicking MW heating. The concept of selective



monoatomic heating by MW is expected to open a next stage in “microwave catalysis” science by providing physicochemical insights into “microwave effects.”

Reference: SCIENCE ADVANCES,18 Aug 2023, Vol 9, Issue 33.
https://doi.org/10.1126/sciadv.adi1744

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Catalysis Research out of India

1. Ramdas S Kadam, Ashwini B Nirukhe, Ganapati D Yadav "Energy saving in Cu-Cl thermochemical cycle for green hydrogen production: Use of heat integration approach and simulation tools" **Energy Conversion and Management, 2023,** 293,117431
2. Prafull A Jagtap, Manjunath S Lokolkar, Bhalchandra M Bhanage "Cu-Mediated Tandem 2,3-Disubstituted Indole Synthesis from Simple Anilines and Internal Alkynes via C–H Annulation" **The Journal of Organic Chemistry, 2023,** 88, 15, 10960–10973
3. Abhijeet B Kshirsagar, Varsha G Kankani, Indraneel B Chatterjee, Channamallikarjun S Mathpati, Prakash D Vaidya, J.B. Joshi, "Process Intensification of Absorption of Nitrogen Oxides in the Manufacturing of Nitric Acid and Techno-economic Assessment: Use of Ozone", **Industrial & Engineering Chemistry Research, 2023,** https://doi.org/10.1021/acs.iecr.3c00855
4. Sayan Pal, Amol A Kulkarni "Settling and spreading behaviour of particle clusters in quiescent liquids in confined vessels" **Particuology, 2023, 83, 91-100**
5. Rajashri B Jundale, Atul H Bari, Amol A Kulkarni, "Insights into the Synthesis and Kinetics of Silver-on-Silica Core–Shell Particles" **Langmuir, 2023,** 39(28) 9681–9692
6. R. Aniruddha, S. A Singh, Benjaram M Reddy, I. Sreedhar," Sorption enhanced reforming: A potential route to produce pure H2 with in-situ carbon capture" **Fuel, 2023,** 351,128925
7. Priyadarshi K Ray, Ritik Mohanty, Kulamani Parida, "Recent advancements of NiCo LDH and graphene based nanohybrids for supercapacitor application, **Journal of Energy Storage" 2023,** 72,108335
8. Nishita Lucas, Chandrashekhar V Rode, "Marine waste derived chitin biopolymer for N-containing supports, catalysts and chemicals" **Tetrahedron Green Chem, 2023,** 100013
9. A. V. Ramteke, D. Bhatia, K.K. Pant, "Conversion of light cycle oil to benzene and alkylated monoaromatics over monometallic and bimetallic CoMo catalysts in the presence of hydrogen donor", **Fuel, 2023**, 342, 127737
10. Prashant Ram Jadhao, Snigdha Mishra, Aditya Singh, KK Pant, KDP Nigam, "A sustainable route for the recovery of metals from waste printed circuit boards using methanesulfonic acid", **Journal of Environmental Management, 2023**, 335, 117581

Upcoming Symposium/Conferences/Seminars/Workshop

1. SusChemE 2.0, International Conference on Sustainable Chemistry & Engineering 2023 is being organized in Institute of Chemical Technology (ICT) Mumbai, India along with the Catalysis Society of India during **14th-16th September 2023. Last date for Abstract Submission is 15th August 2023**
2. Workshop on **Functional Materials & Heterogenous Catalysis** from 11th-15th, December, 2023 at IIT (ISM) Dhanbad. The details are available on https://gian.iitkgp.ac.in/GREGN/index
3. Indian Membrane Society is organizing an International Conference on "Membrane based Separations: Past, Present & Future" during **16th-18th October 2023** at MS University of Baroda along with CSIR-CSMCRI, Bhavnagar.

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4. 6th International Oil & Gas Chemistry, Chemicals & Additives Conference (IOGCA 2023) from **12-13th September 2023** at Ahmedabad http://oilfieldchemical.org/
5. 15th European congress on Catalysis [Europacat-15] Prague, Czech Republic, **August 27th – September 1th, 2023.** https://www.europacat2023.cz/
6. International Conference on Organometallics and Catalysis from **30th – 2nd Nov 2023** at Goa, India https://www.icoc2023.com
7. 2nd International Conference on Catalysis and Chemical Engineering, November 09-10, 2023 Millennium Hotel Paris Charles De Gaulle, Paris, France https://scisynopsisconferences.com/catalysis/
8. 4th International, Refinery & Petrochemical Technology, Conference & Exhibition on **8th & 9th August** 2023 in New Delhi.
9. International Catalysis Conference ICC 2023 from **15th-17th September 2023** at Miami USA https://www.catalysisworldconference.com/
10. 17th Edition of International Conference on Catalysis, Chemical Engineering and Technology" (Catalysis 2023) as Hybrid Event during **October 26th-28th, 2023,** at Boston, Massachusetts, USA.

- **Achievements/Recognitions**

CSI congratulates the following CSI members on the recognition they have received recently.

Name	Achievement
Dr. Kshudiram Mantri Assistant Vice-President (R&D), Reliance Industires Ltd. Vadodara, Gujarat, India 	Elected as Fellow of Indian Chemical Society (ICS) August 2023
Dr. Arun Kumar, FRSC Head, Department of Chemistry, School of Physical Sciences, Doon University, Dehradun-248001, Uttarakhand, India 	Elected as Fellow of Indian Chemical Society (ICS) August 2023

❖ Quote of the Month

" The people who are crazy enough to think they can change the world are the ones who do."

Steve Jobs

Editorial Team

Dr. Sharad Lande

Dr. Raksh Vir Jasra

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