April 2024

CSI Communication

Monthly Newsletter of Catalysis Society of India

Circulated to all CSI Members

Important Announcement:

CSI newsletter shall be pleased to publish 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 the 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.

▪ Water Science Laboratory (WSL) @ Dr. Pooja's Group, CSIR-CSIO, Chandigarh: Photoactive Materials for Green Hydrogen Generation & Environmental Remediation

Dr. Pooja's group at CSIR-CSIO, Chandigarh works on developing photoactive catalyst materials for green energy and environmental remediation. The group is focusing on 2D materials including MXenes (transition metals carbides, nitrides, carbonitrides, etc.), Transition metal dichalcogenides (TMDs), and Transition metal oxides/nitrides. These catalyst materials are engineered for their active sites, composition, heterostructure, for efficient charge separation and channelization, for utility in green hydrogen production, wastewater treatment and air purification (i.e., volatile organic compounds (VOCs) degradation) via photo electrocatalysis and photocatalysis. The materials engineering and scaling aspect is also taken up by their group for providing the practically viable solution. The group is also working towards sensor material development for water pollutants detection such as organic pollutants, heavy metals, etc., based on surface enhanced Raman scattering (SERS) active substrate, colorimetry, and electrochemical sensing.

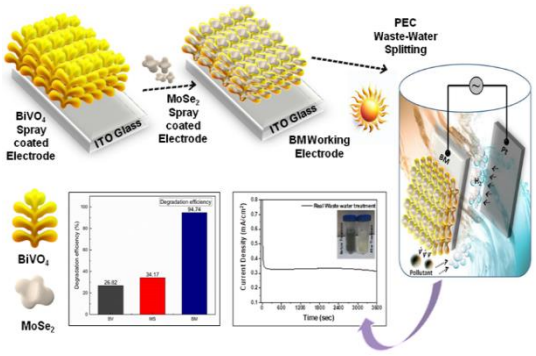
- **Photoelectrochemical hydrogen generation:**

Hydrogen is a cleaner energy solution to meet global energy demand, while green hydrogen production methods such as photoelectrochemical water splitting is a sustainable approach as it uses solar energy and water as feedstock. Our group has expertise in design of photoelectrode

having capability to split water at lower bias utilizing its inherent photovoltage to drive the reaction. We have designed and demonstrated photoelectrodes based upon TiO_2 nanofibers, ZnO, ordered nitrides nanostructures (GaN, InGaN, InN, etc.) and their heterostructure with TMDs for PEC H2 generation at low biased voltage (*Solar Energy* 193 (2019): 715-723; *International Journal of Hydrogen Energy* 45.1 (2020): 103-111; *ACS applied materials & interfaces* 12.12 (2020): 13797-13804). In addition, we also developed flexible polymer coated paper photoelectrodes and demonstrated them for the first time for PEC water splitting at lower photovoltage (*International Journal of Hydrogen Energy* 46.12 (2021): 8444-8453; *Carbon Letters* (2024): 1-10.). A patent is also filed for same.

- **Multifunctional Catalyst for Wastewater to Hydrogen generation:**

Wastewater is a rich source of energy, but its improper handling leads to contamination of water bodies, soil, etc. Several organic pollutants categorized as emerging pollutants (EPs) such as textile dyes, antibiotics, drugs, personal care products, etc., are making their ways into water bodies. While requirement of fresh water supply for PEC H_2 generation also puts lots of stress on water. To address this issue, our group is focusing on designing multifunctional photoelectrically for textile wastewater to hydrogen generation along with its treatment. We are working on both photoanode and photocathode design to generate hydrogen at cathode and pollutants oxidation at anode, both utilizing solar lights. We have smartly engineered and demonstrated 2D material (MXenes, TMDs, etc.) heterostructure with semiconductor oxides as efficient, stable, scalable, and cost-effective photoelectrodes as a multifunctional system. The developed electrodes are capable to achieve more than 90 % pollutants degradation along with hydrogen production (Journal of Cleaner Production (2024): 141502; Journal of Industrial and Engineering Chemistry 118 (2023): 119-13). Alternatively, the multifunctional catalyst based upon MXene and carbon are also designed for scalable textile WW to H2 generation with good stability (Journal of Physics and Chemistry of Solids 173 (2023): 111106.).



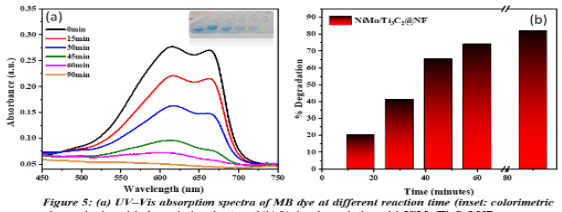


Figure 5: (a) UV–Vis absorption spectra of MB dye at different reaction time (inset: colorimetric change in dye with degradation time) and (b) % dye degradation with NiMo/Ti_3C_2@NF.

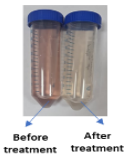


Table 1: Parameters calculated before and after real waste water treatment.

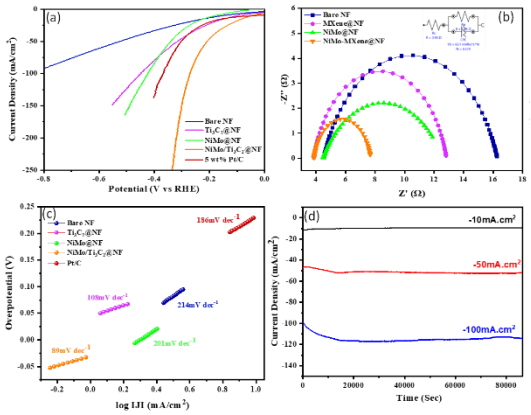
Parameters	Before treatment	After treatment
COD	208 mg/l	124 mg/l
TOC	25.15 mg/l	18.74 mg/l
Turbidity	12 ntu	4 ntu

82% Dye degradation in 90 minutes & 0.361mmolh^{-1} H_2 generation with NiMo/Ti_3C_2@NF

- **Engineered MXenes for Electrocatalytic Hydrogen Generation:**

Engineered MXenes, a class of 2D materials derived from layered ternary transition metal carbides, nitrides, or carbonitrides, are emerging as promising catalysts for electrocatalytic

hydrogen generation due to their active basal planes and rich surface chemistry. Our group is working to design various Mo, Ti, V, and Nb based MXene and engineer their surface, composition, defects to understand its impact on electrocatalytic performance. Through surface modification and hybridization with other materials, we have demonstrated commonly used and highly stable MXenes i.e. Ti_3C_2 with excellent electrocatalyst properties i.e. a low overpotential of 38 mV, stability at high current densities, etc. exhibit enhanced catalytic activity and stability, while remaining cost-effective compared to traditional noble metal catalysts. Their durability under wide pH range further underscores their potential for sustainable hydrogen production technologies. Continued research efforts are ongoing on optimizing MXene-based catalysts and elucidating their underlying catalytic mechanisms to realize their full potential in practical applications in electrolyzers (Green Energy Harvesting: Materials for Hydrogen Generation and Carbon Dioxide Reduction (2022): 46-74).



- **2D/2D heterostructure Photocatalyst and Device for VOCs Degradation:**

Indoor Air is known to have a higher level of Volatile Organic Compounds (VOCs) than outdoor environments, which are hazardous to human health. With increased awareness of air qulity in COVID times, there is demand for developing safe solutions for VOCs treatment. Among various approaches for VOC degradation, photocatalytic oxidation is a promising approach as it mineralizes the pollutants instead of its adsorption. Our group has designed a scalable process for synthesis and coating of semiconductor photocatalyst onto various kind of substrates including stainless steel (SS) and ceramic, serving as effective filters. Additionally, a controlled test setup specifically tailored for visible PCO testing is designed and available for evaluating both powder and thin film catalysts for VOCs degradation (design Registration Filed).

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Commercial & Policies

- **India has $78 billion green hydrogen electrolyzer potential by 2050: Report**

India's potential in green hydrogen electrolyzers is forecasted to surge to $78 billion by 2050, a significant increase from $4 billion in 2030, according to the latest report titled 'Green Hydrogen for Decarbonizing Asia's Industrial Giants' by the Asia Society Policy Institute.

The report examines the future demand for electrolyzers necessary to meet the rising green hydrogen (H2) demand across China, India, Japan, and South Korea. It highlights that the net zero targets set by Asia's top four economies could drive substantial growth in the market for green hydrogen electrolyzers, with a combined projected potential of $180 billion by 2050 for critical industrial applications. According to the report, the collective market potential for electrolysers is expected to skyrocket to $180 billion by 2050, with a compound annual growth rate as high as 12 per cent between 2030 and 2040. This is nearly five times as large as the market potential under a business-as-usual scenario. China's potential is projected to reach $85 billion by 2050, up from $22 billion in 2030, Japan to $9 billion by 2050, up from $1 billion in 2030, and South Korea to $8 billion potential by 2050, up from $1 billion in 2030.

Source: https://bioenergytimes.com/indias-green-hydrogen-electrolyser-potential-to-reach-78-billion-by-2050-report/

- **18th FGI Research Excellence Award to Reliance Industries Ltd.**

Reliance Industries Ltd. received the 18th Federation of Gujarat Industries (FGI) Research Excellence Award, which was given by Shri Suresh Prabhu, Former Union Minister at Vadodara on 23rd April 2024 for "In-house Development and Commercialization of Next Generation Reliance Oxidation Catalyst Technology for Nitrogen Gas Purification used for PET Resin Production at HMD & DMD RIL manufacturing sites.

The indigenously developed catalyst has a 40 % lower cost than the imported catalyst, higher activity, low-temperature operation, and 25 % higher life in the commercial operation.

The award is received by Shri Mahesh Marve, Dr. Raksh Vir Jasra, Dr. Sharad Lande & Dr. Hanmant Gurav from Reliance Research & Technology Group.

Source: https://www.fgiindia.com/awards_introduction.php

- **Hartek Power secures Rs 474 crore contract for 300MW solar project in Rajasthan**

The project comprises the construction of a large 300 MW ground-mount solar PV power facility spanning 1209 acres in Rajasthan. This massive undertaking not only improves the state's energy infrastructure, but also precisely matches India's long-term energy goals, as defined in the

Ministry of New and Renewable Energy's (MNRE) visionary plan. Hartek Group's power and renewables infrastructure arm Hartek Power has received an EPC contract worth Rs 474 crore for the development of a 300 MW solar project in Rajasthan, the company informed through a statement.
Source: https://energy.economictimes.indiatimes.com/news/power/hartek-power-secures-rs-474-crore-contract-for-300mw-solar-project-in-rajasthan/109232492

- **India's energy requirement will increase by 2.5 times by 2047**

The energy requirements of India will be increased by 2.5 times by the year 2047, and right now around 84 percent of India's energy is produced using coal, as per Shri Venu Gopal Mothkoor, Senior Specialist- Energy, NITI Aayog. He further added that achieving CO_2 emission targets necessitates a focus on energy efficiency and demand electrification, which could potentially reduce CO_2 emissions by 51 percent by 2047. The government aims to reduce 686 million tonnes of CO2 by 2030, with a focus on industries such as steel, cement, pulp & paper, petrochemicals, and aluminum, targeting 250 million tonnes of CO_2 reduction.
Source: https://theprint.in/economy/indias-energy-requirement-will-increase-by-2-5-times-by-2047/2036936/

- **20 Coal mines likely to come into operation by year-end**

Twenty coal mines are likely to become operational by the end of this year, a move that will reduce coal imports and help meet rising power demand. Peak power demand in India is likely to cross 400 GW by 2030. According to an official source, these 20 coal blocks will include seven from Coal India and three from Singareni Collieries Company Ltd (SCCL). They will contribute another 100 million tonne (MT) in three to four years. India's total coal and lignite output was 937 MT in FY2022-23, data shows. In FY24, about 22.20 MT of coal was imported for blending, as compared to 30.80 MT in 2022-23.
Source: https://www.thehindu.com/business/Industry/20-coal-mines-likely-to-come-into-operation-by-year-end/article68049267.ece

- **Government Plans Recycling Plant for Lithium-Ion Batteries and E-Waste in Uttarakhand**

The Technology Development Board (TDB) has joined forces with startup Remine India to inaugurate a commercial plant dedicated to recycling lithium-ion batteries and e-waste in Uttarakhand. Rising utilization of lithium-ion batteries across various sectors, including electronics, electric vehicles, and renewable energy storage, has led to a surge in e-waste generation, as highlighted by the Ministry of Science. The ministry underscored the import of addressing the growing challenge posed by spent lithium-ion batteries, which constitute a significant portion of e-waste. Despite the burgeoning market for lithium-ion battery recycling, with projections reaching $14.89 billion by 2030, only a mere 5% of these batteries undergo recycling, with the remainder ending up in landfills. This alarming statistic underscores the pressing need for concerted efforts to promote responsible e-waste management practices.
Source: https://www.newsonprojects.com/news/government-plans-recycling-plant-for-lithium-ion-batteries-and-e-waste-in-uttarakhand

- **Novoloop & Aether achieve continuous operations of plastic waste to adipic acid pilot plant**

Novoloop, a prominent player in plastic circular economy technology, is thrilled to announce the successful launch of its pilot plant in India. In a partnership with Aether Industries, a publicly listed specialty chemicals manufacturer, the groundbreaking ceremony for the pilot plant in Surat was announced in January 2024. Subsequently, the pilot plant has undergone equipment testing and solvent runs, achieving seamless continuous operations using commercially representative waste feedstock. This achievement signifies the transition from batch reactions to an integrated and automated plant, validating Novoloop's pioneering Lifecycling™ technology. Novoloop's Lifecycling™ process is designed to convert post-consumer polyethylene plastic waste into virgin-quality monomers for performance materials, boasting a substantial reduction in carbon footprint of up to 91% compared to conventional methods of producing adipic acid.
Source: https://www.chemanalyst.com/NewsAndDeals/NewsDetails/novoloop-and-aether-successfully-achieve-pilot-plant-continuous-operations-27280

- **Hindustan Zinc says it becomes 3rd largest Silver producer globally**

A Vedanta group company in the zinc-lead-silver business has now become the 3rd largest* silver producer globally as per the World Silver Survey 2024 conducted by 'The Silver Institute', USA. The company's Sindesar Khurd Mine now stands as the world's 2nd largest silver-producing mine moving up from last year's 4th position. Hindustan Zinc's silver refinery at Pantnagar Metal Plant aligns seamlessly with the company's pledge towards achieving net-zero emissions by 2050 or sooner. Globally, solar – the fastest growing of all the sources of renewable energy with about 440 GW installed in 2023 is poised to elevate silver demand.
Source:https://www.businesswire.com/news/home/20240418029009/en/Vedanta%E2%80%99s-Hindustan-Zinc-Becomes-the-3rd-Largest-Producer-of-Silver-Globally

- **BASF, SABIC, and Linde celebrate the start-up of the world's first large-scale electrically heated steam cracking furnace**

BASF, SABIC, and Linde have inaugurated the world's first demonstration plant for large-scale electrically heated steam cracking furnaces. Following three years of development, engineering, and construction work, the regular operation of the demonstration plant is now ready to start at BASF's Verbund site in Ludwigshafen, Germany. Steam crackers play a central role in the production of basic chemicals and require a significant amount of energy to break down hydrocarbons into olefins and aromatics. Typically, the reaction is conducted in furnaces at about 850 degrees Celsius temperatures. The demonstration plant aims to show that continuous olefin production is possible using electricity as a heat source. By using electricity from renewable sources, the new technology has the potential to reduce CO_2 emissions of one of the most energy-intensive production processes in the chemical industry by at least 90% compared to technologies commonly used today.
Source: https://www.basf.com/global/en/media/news-releases/2024/04/p-24-177.html

- **Sinopec starts production at 3 MMtpy PTA plant**

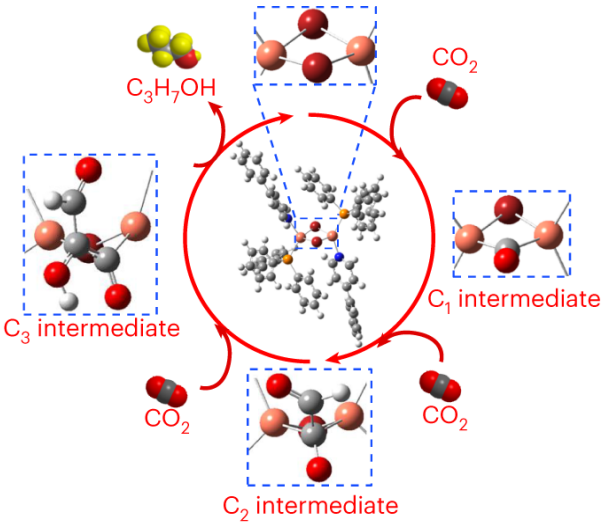
Chinese state-owned oil and gas giant Sinopec has started production at a 3 MMtpy PTA plant in eastern Jiangsu province. The facility has the largest single-unit PTA production capacity in the world and required an investment of more than $691 MM, the company said. China's refiners have invested heavily in petrochemical production capacity in recent years to cater to increased

demand from high-end manufacturing industries. PTA is a petroleum derivative product used to create polyester synthetic fibers used in the production of goods ranging from clothing to solar panels and EVs.
Source: https://www.hydrocarbonprocessing.com/news/2024/04/sinopec-starts-production-at-3-mmtpy-pta-plant/

Scientific Updates

- **Dinuclear Cu(I) molecular electrocatalyst for CO_2 to C3 product conversion**

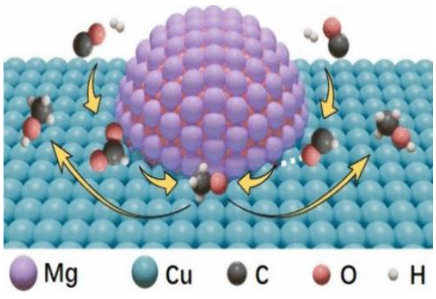
Authours show a CO_2 reduction reaction catalyzed by a Br-bridged dinuclear Cu(I) complex that produces C_3H_7OH with high robustness during the reaction. The C–C coupling reaction mechanism was analyzed by experimental operando surface-enhanced Raman scattering analysis, and theoretical quantum-chemical calculations proposed the formation of a C–C coupling intermediate species with substrate incorporation between the two Cu centers. Molecular design guidelines based on this discovery offer an approach to developing next-generation catalysts that generate multicarbon CO_2 reduction products.



Source: Nature Catalysis 2024, https://www.nature.com/articles/s41929-024-01147-y

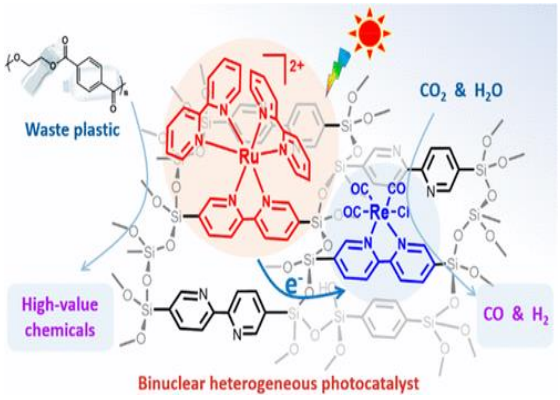
- **Revealing the Interaction between Cu and MgO in Cu/MgO Catalysts for CO Hydrogenation to CH_3OH**

In this work, the structure–performance relationship of Cu/MgO catalysts was established to unravel the role of MgO and the active sites for CO hydrogenation to CH_3OH synthesis, by intrinsic kinetics, chemical titration, and a series of in situ (operando) spectroscopic characterizations. The turnover rates of CH_3OH formation on Cu/MgO catalysts, especially when the Mg/(Mg + Cu) atomic ratio is 0.67, were significantly higher than that on monometallic Cu particles. We have demonstrated that the rates were insensitive to the particle size of Cu but depended linearly on the quantity of Cu–MgO interfacial sites. The interaction between Cu and MgO particles improved the dispersion of Cu particles and formed more highly active Cu–MgO interfacial sites as identified by precise characterization.



Moreover, this study has also unraveled that both the HCO* and HCOO* species are predominantly reactive intermediates, and their sequential hydrogenation occurs concurrently for CH_3OH formation over Cu/MgO catalysts during the CO–H_2 reaction.
Source: ACS Catalysis https://doi.org/10.1021/acscatal.4c00077

- **Coupling Waste Plastic Upgrading and CO_2 Photoreduction to High-Value Chemicals by a Binuclear Re–Ru Heterogeneous Catalyst**



Researchers propose a tandem process of waste Poly(ethylene terephthalate) (PET) plastic degradation and CO_2 photoreduction on a chelating-ligand-anchored binuclear Re–Ru molecular heterogeneous catalyst. Specifically, waste PET plastics are depolymerized and photo-oxidized to monomers and formic acid on the molecular Ru sites, while the CO_2 gas externally purged and generated in situ is photoreduced to CO with an impressive TON of 115 on the molecular Re sites. Compared with the corresponding homogeneous catalyst, the product selectivity is significantly improved from 65 to 95% in water-containing systems, and the TON is also greatly increased by nearly 19 times. Experiments and density functional theory calculations reveal that the high photocatalytic performance is attributed to the significantly enhanced light-capture capability, efficient photogenerated electron transfer between bimetallic Re–Ru sites, and substantially enhanced CO2-trapping capacity by finely regulating the chelating-ligand-based organosilica nanotube framework structure. The real-world application in nature seawater indicates that this work will provide a practical and feasible technical route for the disposal of waste plastics and mitigating carbon emissions under environmental conditions.
Source: ACS Catalysis, 2024 https://doi.org/10.1021/acscatal.4c00444

- **Recent advances in noble metal-free electrocatalysts to achieve efficient alkaline water splitting**

This paper reviews the activity, stability, and durability of recently reported noble metal-free electrocatalysts such as oxides/hydroxides/(oxy)hydroxides/layered double hydroxides, sulfides, selenides, phosphides/phosphates, nitrides, carbon-based electrocatalysts, and alloy/B/V/F/Si based electrocatalysts for the HER and OER in an alkaline environment, including the strategies used to achieve high activity and stability/durability at a current density of $1000 mA cm−2. Moreover, this paper discusses the various promising strategies including the fabrication of nanostructured, ultrathin, porous, and nanoporous materials, preparing superaerophobic surfaces, construction of hollow structures, core–shell structures, heterostructures,heterojunctions, or Mott–Schottky heterojunctions, designing facile and/or scalable synthesis routes,creating doping and/or vacancies/defects, fabricating catalysts with high valence state sites, designing medium or high-entropy alloys, and tuning the atomic packing structure, electronic structure, orconductivity to enhance the activity and stability for the HER and/or OER. Sources: Journal of Materials Chemistry A DOI: 10.1039/d3ta07418h

International Conference on Catalysis for Clean Energy Technologies and Sustainable Development

The International Conference on Catalysis for Clean Energy Technologies and Sustainable Development was successfully organized by Dr. SSB UICET, Panjab University Chandigarh in collaboration with the Catalysis Society of India on 5th & 6th April 2024. The conference brought together more than 250 eminent scholars, researchers, industry professionals, and policymakers from around the globe to exchange ideas, share insights, and foster collaborations in the field of catalysis. The inaugural ceremony started with the ceremonial lighting of the lamp followed by the welcome address by Prof. Sharma. Prof. Sushil Kansal, Organizing Secretary, CCETSD shared details of the conference.

The Guests of Honour of the event were Prof. Y. P. Verma, Registrar, Panjab University, Chandigarh, and Prof. Vasundhara Singh from PEC, Chandigarh. Dr. R.V. Jasra, Senior Vice President, Head of Reliance R & D Centre, Vadodara, and President of the Catalysis Society of India, graced the occasion as the chief guest, bringing his invaluable insights and expertise to the discussions. The vote of thanks was delivered by Dr. Surinder S. Bhinder, Organizing Secretary of CCETSD.

The conference provided a platform for showcasing cutting-edge research through poster presentations and oral sessions, offering attendees the opportunity to engage with groundbreaking studies and network with peers from around the globe.

Catalysis Research out of India

1. Sunesh S Mani, Sivaraj Rajendran, Pushkaran S Arun, Aparna Vijaykumar, Thomas Mathew, Chinnakonda S Gopinath, "Bimetallic and plasmonic Ag and Cu integrated TiO_2 thin films for enhanced solar hydrogen production in direct sunlight", **Energy Advances, 2024, 3, 829-840**
2. Swanand R Patange, Poonam R Sutar, Ganapati D. Yadav, "New frontiers in thermal energy storage: An experimental analysis of thermophysical properties and thermal stability of a novel ternary chloride molten salt", **Solar Energy Materials and Solar Cells, 2024** https://doi.org/10.1016/j.solmat.2024.112866
3. Subhasis Das, Ganapati D Yadav "Tailored design of novel Co0-Coδ+ dual phase nanoparticles for selective CO2 hydrogenation to ethanol", **Journal of Environmental Sciences, 2024, https://doi.org/10.1016/j.jes.2024.01.047**
4. D. Badghaiya, J. K. Parikh, Parimal A Parikh, "Valorization of bio-renewably available ethanol over alkali-exchanged ZSM-5: Improved aromatic selectivity and catalyst life", **Reaction Kinetics, Mechanisms and Catalysis, 2024**, https://doi.org/10.1007/s11144-024-02612-2

5. Ganesh Parsai, Priansh Patel, Parimal A Parikh, Jigisha K Parikh, "Synthesis and characterization of composite films derived from lemon grass leaves: a valorization approach", accepted for publication in **Bioresource Technology Reports 2024**
6. Digvijay Badghaiya, Jigisha K Parikh, Parimal A Parikh, Ethanol upgrading via alkali-exchanged KL-zeolite: Unravelling catalytic behavior, reaction mechanism and thermodynamic effects, accepted for publication in **Journal of Chemical Sciences 2024**
7. F. M. Bagwan, Pavan Dongapure, Amol A. Kulkarni, Satyam Naidu Vasireddy, "Experimental and kinetic modeling studies for the design of fixed bed methanol reactor over CuZA catalyst" **Chemical Engineering Research & Design, 2024** https://doi.org/10.1016/j.cherd.2024.03.032
8. Priyanka Priyadarshini, Kulamani Parida, " Two-dimensional metal-organic frameworks and their derived materials: Properties, synthesis, and application in supercapacitors field" **Journal of Energy Storage, May 2024,** 111379; https://doi.org/10.1016/j.est.2024.111379

Upcoming Symposium/Conferences/Seminars/Workshop

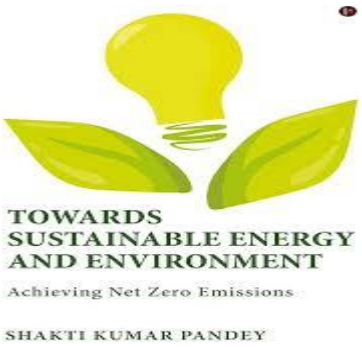
1. Conference on Catalysis for Energy, Environment & Sustainability (CEES-2024) & 3rd CO_2 India Network Meet organized by the Catalysis Society of India from 18th-20th September 2024 at IICT, Hyderabad.
2. 18th International Congress on Catalysis from July 14-19, 2024, LYON, France.
3. XXIII International Symposium on Homogeneous Catalysis at Trieste, July 21-26, 2024.
4. "19th Edition of Global Conference on Catalysis, Chemical Engineering & Technology" at Rome, Italy, from September 19th-21st, 2024.
5. Decarbonizing the chemical industry and 2nd Sustainable feedstocks for the future of chemicals and plastics, 23-24, May 2024 – Antwerp, Belgium.
6. 18th Edition of International Conference on Catalysis, Chemical Engineering, and Technology" (CCT 2024) during June 17-19, 2024, at Paris.
7. 19th Edition of Global Conference on Catalysis, Chemical Engineering & Technology, September 19-21, 2024, | Rome, Italy | Hybrid Event
8. 5th International Symposium on Catalysis for Clean Energy and Sustainable Chemistry from 21st -23rd July 2024 at Bilbao (Spain).

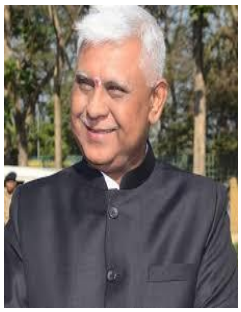
Announcements

- CSI Congratulates the following CSI members on the recognition they have received recently.

Name	Achievement
Professor Ganapati D. Yadav, *FTWAS, FNA, FNASc, FRSC (UK), FIChemE (UK), FIIChE* Emeritus Professor of Eminence & Former Vice Chancellor & R.T. Mody Distinguished Professor J.C. Bose National Fellow (Govt. of India) 	Selected Asia's Top 100 Most Outstanding Researchers by **Asian Scientist Magazine**

A book on **Towards Sustainble Energy and Environment: Achieving Net Zero Emission** by Shri Shakti Kumar Pande, former executive director ONGC and Head Uran Industrial plant, New Mumbai is published. The book is available at Amazon, Flipkart, and e-version on Amazon Kindle, Google Play, Kobo and i Book.





The Book is intended to educate the reader on India's past energy consumption trends, its future in terms of energy needs, sustainable options and challenges associated with it to achieve its ambitious goal of Net Zero emissions.

In initial chapters, It introduces Fossil Fuel and various studies done to estimate its impact on the environment including concepts like the Keeling Curve, Koya Identity, Kuzent Curve and initiatives of UNFCCC. It further addresses the India specific situation and the Energy Trilemma index – Security, Equity and Sustainability.

It talks about alternative sources of energy like Solar, Wind, Biomass and Geothermal Energy and its perspectives. It talks about their potential in meeting India's energy needs, their feasibility in terms of cost and other constraints and challenges associated with harnessing their full potential. It has dedicated chapters on Nuclear Energy and Hydrogen Energy as alternative sources. It has further deep dived into Hydrogen as an energy source and discussed in detail its technical and financial aspects of being used at scale. It also discusses the various studies and deliberation done by global agencies in this area, India's National Hydrogen Energy Mission (NHEM) and whether this can play a major role in India's energy sustainability.

Quote of the Month

"You must expect great things of yourself before you can do them".
—Michael Jordan

Editorial Team

Dr. Sharad Lande

Dr. Raksh Vir Jasra

For further information of CSI please visit, http://www.catalysisindia.org, https://www.begellhouse.com/journals/catalysis-in-greenchemistry-and-engineering.html & https://www.linkedin.com/groups/13923122/