September 2022

CSI Communication

Monthly Newsletter of Catalysis Society of India

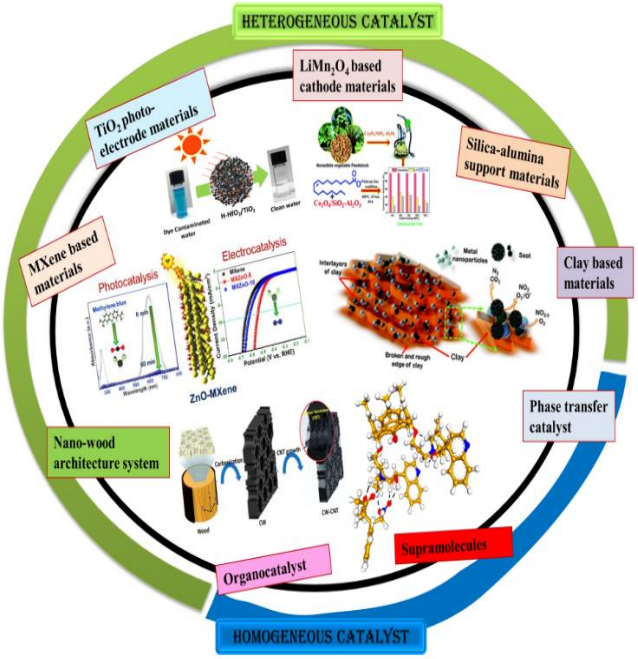
Circulated to all CSI Members

Important Announcement:

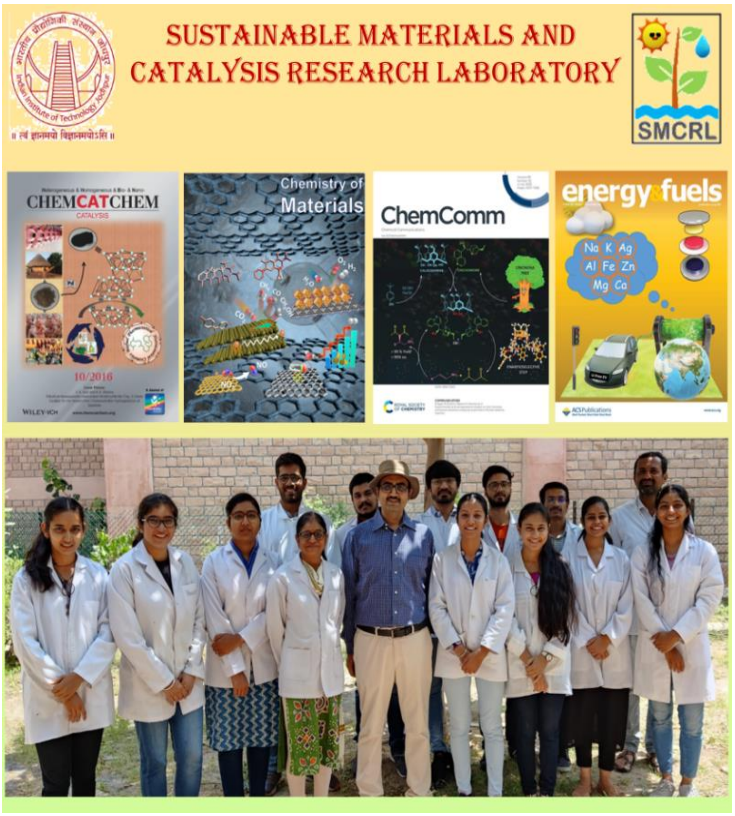
CSI newsletter shall be pleased to publish half a page write-up under the title, Centre of Excellence in Catalysis Research in India from any Indian Academics, Research laboratories or Industrial organizations. You may send your brief write-up on your research activities to us which will be published 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.

▪ SUSTAINABLE MATERIALS & CATALYSIS RESEARCH LABORATORY@ Prof. Rakesh K. Sharma, IIT Jodhpur

Prof. Rakesh K Sharma's research integrates chemistry and nanomaterials with expertise in the realm of sustainable energy future in energy harvesting and storage, environmental remediation, and biomass-tailored biofuel conversion. The research undertaken in his group is intended to have far-lasting implications for utilizing and designing materials for applications that are required by a booming technology minding the effect on the environment. The group's major research theme includes the catalytic conversion of biomass/bioplateform molecules into green fuel, electrocatalysts for water splitting, lithium oil batteries and supercapacitor, asymmetric catalysis (symmetric hydrogenation, allylation, and hydrovinylation of C=N and C=C), and environmental remediation (fluoride removal, uranium removal, water purification and biofortification). Our main aim is to develop a reproducible and scalable fundamental chemical process using highly efficient materials inspired by nature for sustainable science. The group has introduced the first **"clay-based technology"** for the development of pharmaceutical, nutraceutical, cosmetics, and advanced biofuel applications.



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/



- The group has successfully utilized the naturally occurring clay as an eco-friendly and cost-effective catalyst for several applications, i.e., Pd intercalated clay catalyst for chemoselective hydrogenation of squalene (*ChemCatChem., 216, 8.10, 1763-1768*), surfactant modified clay for photocatalytic water remediations (*J. Mater. Sci., 2018,* 53, 10095–10110), cobalt-nickel transfigured clay for catalytic converters applications (*New J. Chem., 2021, 45, 14751-14758*) and microalgal biofuel production via hydrodeoxygenation (*ACS Sustainable Chem. Eng.* 2017, 5, 6, 5351–5359). His group developed **amorphous silica-alumina support** material having excellent textural properties and Brønsted acidic sites which successfully applied for the potential transformation of biomass into green diesel fuel and aviation fuel via surface decorated with non-novel metals such as Co, Ni, Fe etc. (Fuel*, 2020, 266, 117065; Sustain. Energy Fuels, 2020, 4,3308-3317).*
- Recently the group came up with the novel concept to explore the **advanced 2D functional materials** (transition metal carbide) for environmental remediation, electrochemical hydrogen-oxygen evolution reactions, and biomass conversion (*ACS Appl. Nano Mater. 2022, 5, 7, 9319–9333, Catal. Sci. Technol., 2022, 12, 4413-4441).* The group has been actively involved in developing surface chirality enhanced highly enantioselective heterogeneous catalysts for hydrogenation and C-C bond formation reactions (*Chirality*, *2019, 31,91-96*; *New J. Chem., 2016, 40, 9038-9041*): a series of recyclable asymmetric homogeneous catalysts for C-C and C-X bond formation with extremely high enantioselectivity (*ChemComm, 2022, 58, 7249-7252; Chemical Science, 2015, 6, 3994-4008*). They also developed the rare-earth doped $LiMn_2O_4$ cubic spinal cathode material for lithium oil batteries, giving high recyclability at high temperature (*J. Electroanal. Chem. 802 (2017): 94-99, Compos. B. Eng. 2018, 139, 55-63*). The other projects involve developing nanowood architecture systems for crop biofortification and micronutrient delivery system (*ACS Omega* 2021, 6, 37, 23654–23665).

- **Research Publications**

  Published papers in international journals 102, Reviews 07; Book/book chapters 15; Patents 10; Technology transfer to industries 06.

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Commercial & Policies

- **Mitsui Chemicals Selects Ethylene Oxide Catalyst from Shell Catalysts & Technologies**

Mitsui Chemicals has asked Shell Catalysts & Technologies for its Shell S-896 catalystfor their ethylene oxide (EO) refinery in Osaka, Japan. The use of Shell S-896 catalyst will enable Mitsui Chemicals to maximize their assets without having to make an investment in refinery hardware revamps. The high-performance family Shell S-896 catalyst can deliver an average selectivity advantage of +0.8% compared to Shell S-893 catalyst which provides an operational savings. Selectivity of an EO catalyst has a significant impact on the reduction of CO_2 produced by the ethylene reaction. Therefore, in addition to the economic benefit from ethylene savings, Shell believes the higher selectivity catalyst will help Mitsui Chemicals to see a reduction in CO_2 output. Source: Hydrocarbon Processing, 9/14/2022.

- **BASF Introduces PuriCycle® Portfolio of Catalysts and Adsorbents to Enable Plastics Recycling BASF, Sabic, and Linde to Test Electric Cracker Designs**

In a step toward making the petrochemical industry less carbon intensive, BASF, Sabic, and Linde have embarked on the world's first large-scale demonstration of an electrically heated steam cracker. The demonstration unit, to start up next year at BASF's flagship complex in Ludwigshafen, Germany, will use 6 MW of renewable electricity to produce the heat needed to process 4 t of hydrocarbons per hour. The companies claim that an electrified system could reduce CO_2 emissions by at least 90% versus conventional cracking. Source: Chemical & Engineering News (C&EN), 9/12/2022, p.8.

- **Tata Steel to invest in hydrogen-based steel manufacturing**

Tata Steel has inked pacts with three firms -- McDermott, Danieli and Hatch -- for hydrogen-based steel manufacturing in the Dutch city of Ijmuiden by investing more than 65 million euros. Danieli will oversee the engineering design of the plant and technology that delivers the Direct Reduced Iron (DRI), the first step in the iron-making process. Hatch is the technology licensor of the electric

furnaces that melt the DRI and help reduce the oxygen content further, thereby improving the final steel quality.
Source: https://www.constructionworld.in/steel-news/tata-steel-to-invest-in-hydrogen-based-steel-manufacturing/36195

- **Reliance Industries to acquire US-based software firm SenseHawk**

Reliance Industries will acquire a majority stake in US-based software developer SenseHawk Inc for $32 million, in a bid to boost RIL's solar energy plans. SenseHawk is a developer of software-based management tools for the solar energy generation industry.
Source: https://www.financialexpress.com/industry/reliance-industries-to-acquire-us-based-software-firm-sensehawk-to-boost-mukesh-ambanis-solar-energy-plan/2656602/

- **India's Future Crude Oil Supplies Will Mostly Come from Gulf**

India's minister of petroleum and natural gas, Hardeep Singh Puri, said most of his country's crude oil supplies soon will come from the Gulf countries, including Saudi Arabia and Iraq, as it seeks a secure and affordable energy base. Crude oil imports from Saudi Arabia by the world's third biggest oil importer and consumer rose in July by more than 25% after Saudi Arabia lowered the official selling price in June and July compared with May. Saudi Arabia stayed at the No. 3 spot among India's suppliers. Source: Hydrocarbon Processing, 9/6/2022.

- **Huntsman Commissions 180 KW Rooftop Solar Facility at Chakan, Pune**

Huntsman India, manufacturer, and marketer of differentiated chemicals has commissioned a 180 kilowatts (KW) rooftop solar facility at its state-of-the-art polyurethanes manufacturing plant in Chakan, Pune as part of the company's commitment towards building a sustainable and low-carbon economy to support carbon neutrality. The solar facility is expected to generate 3,00,000 kilo watt hour of power annually, about 60 percent of the plant's total energy requirement. The system is connected with the state government run power grid via net metering, which ensures a balanced load and feeds surplus power back into the grid.
Source: https://chemindigest.com/huntsman-commissions-180-kw-rooftop-solar-facility

- **Expansion of Indian Oil Corporation's Panipat refinery**

IOCL is implementing the Panipat Refinery Expansion (P-25) Project to enhance refining capacity from 15 MMTPA to 25 MMTPA to meet the growth in demand of petroleum products and to increase their profitability and competitiveness in the long run. The residue hydrocracker unit (RHCU is) licensed by Axens (France) with a capacity of 2.5 MMTPA and will upgrade the Vacuum Residue (VR) to high-value commercial products (mainly diesel). Source: L&T, 8/22/2022.

- **Aemetis India Plant Selected to Supply $41 Million of Biodiesel in Two Month Period to OMCs and Other India Oil Refiners**

Aemetis, Inc. announced that its Universal Biofuels subsidiary in India, owner and operator of a biodiesel plant located near the Port of Kakinada on India's east coast, was selected by the three government-controlled oil marketing companies (OMCs) and a major oil refiner to

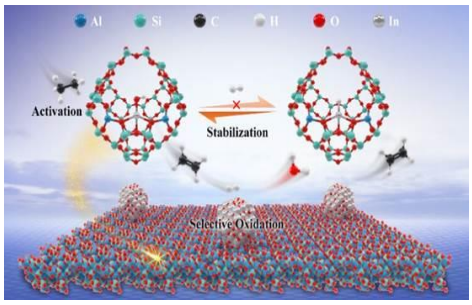
supply approximately 8,000,000 gallons of biodiesel over the next two months. The combined revenues from the shipments are expected to be about $41 million and are scheduled to require the Aemetis biodiesel/glycerin production plant to operate near 100% capacity. About 70% of the diesel and gasoline in India is supplied by the OMCs, with the remaining fuel supplied by large non-government refineries. Source: AP News, 8/29/2022.

Scientific Updates

- **New Catalyst for Affordable Way to Produce Hydrogen from Seawater**

Researchers are reporting a significant advance, a two-electrode catalyst that relies on one compound to efficiently produce hydrogen and oxygen from both seawater and freshwater. Previous attempts at such bi-functional catalysts to split water into hydrogen and oxygen have generally resulted in poor performance in one of the two functions. Using two separate catalysts works but increases the catalysts' manufacturing cost. A nickel/molybdenum/nitrogen compound, tweaked with a small amount of iron, and grown on nickel foam to efficiently produce hydrogen and then, through a process of electrochemical reconstruction sparked by cycling voltage, converted to a compound that produced a similarly powerful oxygen evolution reaction. The researchers said using a single compound for both the hydrogen evolution reaction (HER) and the oxygen evolution reaction (OER) – albeit slightly changed through the reconstruction process not only makes water splitting more affordable, it also simplifies the engineering challenges. Source: University of Houston, 9/8/2022.

- **Researchers Tailor Main-group Catalyst with Atomically Dispersed Indium Sites for Highly Efficient Oxidative Dehydrogenation**



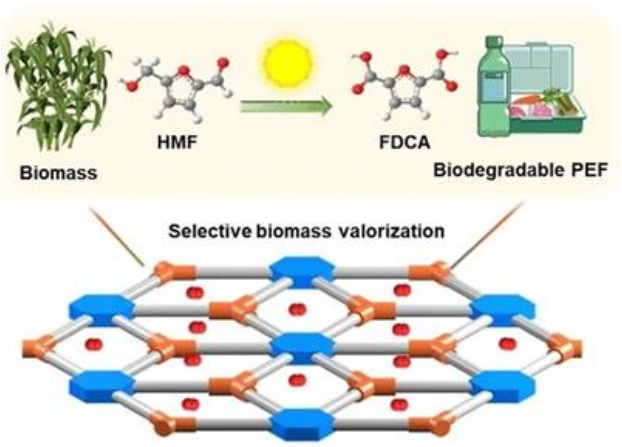
The researchers designed a main-group catalyst with atomically dispersed In sites to disentangle the dilemma of trade-off between activity and selectivity in oxidative dehydrogenation (ODH) process. This novel catalyst exhibited exceeding 80% C_2H_4 selectivity at around 80% C_2H_6 conversion, thus achieving more than 60% C_2H_4 yield, which outperformed the state-of-the-art transition metal oxide catalysts.

Moreover, the researchers found that atomically dispersed $[InOH]^{2+}$ sites anchored by substituting the protons of supercages in HY enabled the activation of ethane via significantly lowering the barrier of ethane dissociation and their structure could be stabilized by H_2O formed from selective oxidation of hydrogen by In_2O_3 nanoparticles, thus exhibiting excellent performance for oxidative dehydrogenation of ethane. Source: Chinese Academy of Sciences (CAS), 8/31/2022.

- **Efficient Titanium-based Catalyst Used to Produce PEF, Bio-based Alternative to PET**

One possible replacement for drink containers made from PET is polyethylene furandicarboxylate (PEF), made from renewable resources. However, the production of the raw material for PEF from biomass is still rather inefficient. A titanium component in conjunction with an organic oxidizing group forms flat, crystalline nanosheets from an organometallic framework.

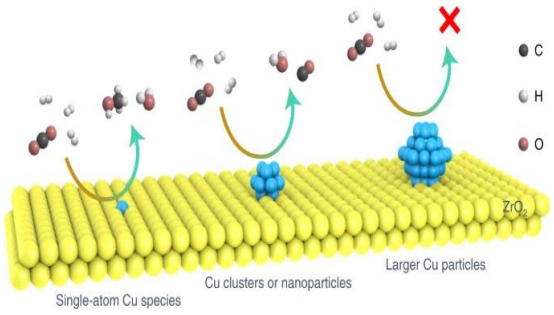
By chemically linking the titanium with the organic components, the light absorption shifts from the UV to the visible range, considerably increasing efficiency, say the team. The reaction is also highly selective, as relatively few reaction partners are required and virtually no waste is formed. The authors suggest that tailor-made photocatalysts like this could also be used to make several other reactions more sustainable.



Source: Phys.org, 8/26/2022.

- **The role of Cu1–O3 species in single-atom Cu/ZrO2 catalyst for CO_2 hydrogenation**

Copper-based catalysts for the hydrogenation of CO_2 to methanol have attracted much interest. The complex nature of these catalysts, however, renders the elucidation of their structure–activity properties difficult. It is revealed that the single-atom Cu–Zr catalyst with Cu_1–O_3 units contributes solely to methanol synthesis around 180 °C, while the presence of small copper clusters or nanoparticles with Cu–Cu structural patterns are responsible for forming the CO by-product. Furthermore, the gradual migration of Cu_1–O_3 units with a quasiplanar structure to the catalyst surface is observed during the catalytic process and accelerates CO_2 hydrogenation. The highly active, isolated copper sites and the distinguishable structural pattern identified here extend the horizon of single-atom catalysts for applications in thermal catalytic CO_2 hydrogenation and could guide the further design of high-performance copper-based catalysts to meet industrial demand.



Source: https://www.nature.com/articles/s41929-022-00840-0

Catalysis Research out of India

1. D.S. Desai, G.D. Yadav, "Synthesis of energy rich fuel additive from biomass derived levulinic acid and furfuryl alcohol using novel tin-exchanged heteropoly acid supported on titania nanotubes as catalyst", **Fuel,** 2022, 331,

2. B Debnath, SM Hossain, A Sadhu, S Singh, V Polshettiwar, S Ogale , "Construction of a 2D/2D g-C_3N_5/NiCr-LDH Heterostructure to Boost the Green Ammonia Production Rate under Visible Light Illumination", **ACS Applied Materials & Interfaces,** 2022, 14 (32), 37076-37087
3. Riza Paul, Indrajeet R Warkad, S Arulkumar, S Parthiban, Harsh R Darji, Mu Naushad, Ravishankar G Kadam, Manoj B Gawande, "Facile synthesis of nanostructured TiO2-SiO2 powder for selective photocatalytic oxidation of alcohols to carbonyl compounds", **Molecular Catalysis,** 2022,530, 112566
4. R G Kadam, T Ye, D Zaoralová, M Medveď, Priti Sharma, Y Lu, G Zoppellaro, O Tomanec, M Otyepka, R Zbořil, H Hosono, Manoj Gawande, "Intermetallic Copper-Based Electride Catalyst with High Activity for C–H Oxidation and Cycloaddition of CO2 into Epoxides" **Small,** 2022, 2201712

Upcoming Symposium/Conferences/Seminars

1. Conference on Advances in Catalysis for Energy and Environment (CACEE -2022) & CO_2India Network 1st Annual Meet from 31st October to 4th November 2022 at Tata Institute of Fundamental Research (TIFR), Mumbai, INDIA, https://www.cacee.org/
2. "International Conference on Catalysis and Chemical Science (ICCS 2022)" at Rome, Italy, 03-05, October 2022 (https://irisscientificgroup.com/conferences/catalysis-and-chemical-science/home/)
3. The 2nd International Conference on **"NanoMaterials and Sustainable Applications" (NANO-SA-2023)** organized by the Institute of Chemical Technology Mumbai, Marathwada Campus, Jalna (ICT-MARJ), India on 10th–11th January 2023, https://www.ictsusnanomaterials.com/speakers/

Webinar Organized by CSI, Baroda Chapter on 13th September 2022

The Catalysis Society of India, Baroda Chapter organized Webinar on **"Opportunities of Catalysis for Sustainable Energy Technologies and More**" by **Eminent Scientist Prof. Matthias Beller** (Director for the Leibniz-Institute for Catalysis (LIKAT)) Baroda Chapter on 13th September 2022. The webinar was very informative, well appreciated & received huge response from academia and industries. The Professor Beller presentation copy will be soon available on CSI website. (http://www.catalysisindia.org)

Announcements

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

Name	Achievement
Prof. Ramesh Deka, FRSC Professor of Chemistry at Tezpur University, Assam, India 	Appointed as a Vice - Chancellor of Cotton University, Guwahati, Assam, India on September 16, 2022
Professor K.K. Pant, FRSC, FNAE, FNASc, FIE(I), FIIChE, FBRSI Dean Faculty & Professor, Department of Chemical Engineering, Indian Institute of Technology Delhi & PETROTECH Chair (Federation of Indian Petroleum Industries) 	Appointed as a Director of The Indian Institute of Technology, Roorkee on September 29, 2022

"The only way to discover the limits of the possible is to go beyond them into the mpossible."

— Arthur C. Clarke

Editorial Team

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