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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.

▪ Catalytic Biomass Valorization Research @ CSIR-CSMCRI, Bhavnagar

Biomass is an ideal alternative to fossil resources and, remains the only sustainable carbon source equivalent to petroleum to produce fuels, chemicals, and materials. The institute's activity on the development of catalytic process for biomass valorization is well supported by several patents, and quality publications in national and international journals. To date institute has developed several catalytic processes based on environmentally friendly heterogeneous catalysts that enable synthesis of various high value products such as fatty acid alkyl esters (biodiesel), lubricants, fuel additives, agro-chemical, pharmaceutical intermediates and so forth.
Some of the important catalytic technologies developed at CSMCRI are summarized below.

- Conversion of vegetable oils to their esters was explored with eco-friendly, reusable solid-base catalysts that is relevant to the production of bio-diesel.
- Catalytic epoxidation of edible, non-edible vegetable oils and fatty acid methyl esters (FAME) was also investigated employing ternary-layered double hydroxide catalysts (Srinivasan, K. *Catal. Sci. Technol.***2015**, US Patent, 9029583 B2).
- A novel catalyst was developed incorporating commonly available metal salts & alumina to convert biomass sugars to furanics (Srinivasan, K. *Appl. Catal. A: Gen*. **2017**).
- Conversion of 5-Hydroxymethyl furfural (HMF, a biomass-derived platform chemical) to polymer precursors 2,5-diformyl furan (DFF) and 2,5-furan dicarboxylic acid (FDCA) were also conducted under oxidative conditions. FDCA is particularly relevant as it is touted as the replacement of terephthalic acid in PET bottles.
- The challenging aspect of biomass conversion of sugars to HMF, DFF and FDCA and their extraction was solved by the judicious selection of a solvent system (Srinivasan, K. *ACS Sustainable Chem. Engg*.**2017)**.
- In situ generated ruthenium catalysts were harnessed for hydrogenation reactions to produce various valuable chemicals such as γ-valerolactone (GVL), sorbitol, xylitol in aqueous phase in an energy efficient and sustainable process (Srinivasan, K. *Front. Chem*. **2020**, US10221149B2, WO 2017/060922 A1).

- Similarly, value addition of levulinic acid derivatives to arylated-GVL has also been demonstrated with aromatic compounds using commonly available acidic raisins and zeolites as solid catalysts (Srinivasan, K. *ChemCatChem*, **2019)**.
- The institute has also developed a catalytic process for the preparation of functionalized castor oil derivatives such as ring-opened glyceryl ricinoleates, epoxy alkyl ricinoleates and ring-opened alkyl ricinoleates using commercially available catalysts (Srinivasan, K. *RSC Adv.*, **2015**, US Patent 10260023 B2).
- In recent years the focus has been driven towards development of catalysts which are stable under intensified conditions (e.g., such as those used in flow reactors) to address various process challenges associated with the conversion of biomass streams such as low yields, poor selectivity, low stability/deactivation, and leaching.

Source: *Joyee Mitra, Lakhya J. Konwar and Kannan Srinivasan, CSMCRI, Bhavnagar, India*

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Commercial & Policies

- **India Launches First Coal-to-Methanol plant built by BHEL**

The 0.25 TPD (tonnes per day) capacity Coal to Methanol pilot plant that has been indigenously designed, developed, and installed by BHEL is currently producing methanol with purity of more than 99 per cent from high-ash Indian coal. Significantly, this conversion of high-ash Indian coal to methanol through the gasification route is the first-of-its-kind technology demonstration in India, the release added.

Source: https://energy.economictimes.indiatimes.com/news/power/india-launches-first-coal-to-methanol-plant-built-by-bhel/88921358

Step towards Atmanirbhar Bharat through indigenously developed technology------ CSI

- **BPCL sets up Superabsorbent Polymer Technology Plant in Kochi**

Bharat Petroleum Corporation Limited is setting up a Superabsorbent Polymer technology (SAP) demonstration plant of 200 tonne per annum at Kochi Refinery. SAP Technology is used in various hygiene products such as diapers and other incontinence products. The demonstration project will be followed by setting up a commercial plant of 50,000 tonne per annum capacity.

Source:https://www.thehindubusinessline.com/companies/bpcl-sets-up-superabsorbent-polymer-technology-plant-in-kochi/article

- **GAIL Starts India's First project of Mixing hydrogen into CGD network at Indore**

GAIL (India) Limited has begun India's maiden project of mixing hydrogen into the natural gas system at Indore, in line with the National Hydrogen Mission, GAIL has started hydrogen blending as a pilot project to establish the techno-commercial feasibility of blending hydrogen in the CGD network. This project marks the stepping stone of India's journey towards a hydrogen-based and carbon-neutral future.

Source: https://www.livemint.com/companies/news/mp-gail-starts-india-s-first-project-of-mixing-hydrogen-into-cgd-network-11643630959078.html

- **Pune-based H2e Power to set up 1GW Electrolyser Plant**

Pune-headquartered H2e Power Systems Pvt is setting up an electrolyzer manufacturing plant in Maharashtra, of 1GW capacity, and expects it to be producing solid oxide electrolysers by 2023. The company has been developing vendors for nearly four years. Around 370 components go into the manufacture of electrolysers, which are machines that split water into hydrogen and oxygen. These include the 'stack', (which is the core of the system containing the electrodes and membranes), 'balance of plant' (peripheral components such as blowers and pumps) and power electronics. All these components will be manufactured within 200 km of H2e Power's upcoming plant.
Source: https://www.thehindubusinessline.com/companies/pune-based-h2e-power-to-set-up-1gw-electrolyser-plant/article64852483.ece

- **IICT, BPCL to Collaborate on Agri-biomass Plant**

The Indian Institute of Chemical Technology (IICT) and Bharat Petroleum Corporation Limited (BPCL) research and development center have entered a Memorandum of Understanding to execute an R&D project to demonstrate the potential of anaerobic gas lift reactor (AGR) technology for the generation of methane-rich biogas from agriculture biomass, on pilot basis.

Source:https://economictimes.indiatimes.com/industry/renewables/iit-guwahati-team-develops-efficient-perovskite-solar-cells-to-produce-electricity-fromsunlight/articleshow/8842955

- **Tongsuh Readies Acrylonitrile Production Using Biomass Propylene**

Tongsuh Petrochemical (Seoul, South Korea) will in February start producing acrylonitrile using biomass propylene. Tongsuh will make acrylonitrile using a mix of biomass propylene and fossil-fuel-derived propylene. Source: Chemical Week, 1/21/2022.

- **Technip Energies Acquires Corn-based EG Technology**

Technip Energies (Paris, France) has announced plans to scale up and commercialize technology for the corn-based production of ethylene glycol (EG) that it has acquired from the Iowa Corn Promotion Board (ICPB). Technip Energies acquired the patents, technology, and rights for the process technology through an asset purchase agreement with the ICPB.
Source: Chemical Week, 1/25/2022.

- **Toyo Engineering Eyes Commercialization for CO_2 to Methanol Process**

Toyo Engineering Corp. is looking to commercialize a process for producing methanol from CO_2. Whereas existing methanol processes use carbon monoxide, Toyo Engineering intends for the direct raw materials in this process to be hydrogen from renewables-powered water electrolysis and CO_2 that has been collected from the emissions of facilities such as power plants. The process uses a proprietary reactor that not only instigates efficient reactions to

minimize the amount of catalyst required but also reduces the amount of work required for catalyst replacement. Source: Japan Chemical Daily, 1/20/2022.

CO_2 to methanol is not a new technology; this has been commercialized in Iceland by CRI and now in China. Existing MeOH licensors have also been adopting syngas processes to accept more CO_2 as part of their feedstock----------CSI

Scientific Updates

- **Hiroshima University Develops New NH_3 Method Using Lithium hydride**

Hiroshima University has developed a process for normal-pressure ammonia synthesis using lithium hydride (LiH). The resulting method is a chemical looping process that obtains ammonia (NH_3) from N_2 and molecular hydrogen (H_2), with the LiH serving as an intermediary to break down the inert N2 into its two nitrogen atoms. Further, by preventing the lithium imide (Li2NH) generated in the reaction process from covering the surface of the LiH, the researchers were able to prevent the reaction from being inhibited and allow it to be 100 percent carried out at under 20 atmospheres of pressure. Source: Japan Chemical Daily, 2/9/2022.

- **New, Highly Efficient Catalyst for Propylene Production**

Researchers at Hokkaido University have developed an innovative catalyst comprising three different metals (platinum, cobalt, and indium), to produce propylene that utilizes carbon dioxide (CO_2) efficiently. Platinum was selected as the main active metal because of its ability to break chemical bonds between carbon and hydrogen, enabling the dehydrogenation reaction. Cobalt accelerates CO_2 capture and activation, while indium enhances the catalyst's selectivity. The metals were fixed to a support made from cerium oxide. The researchers tested the catalyst's activity at 550°C and compared the results with existing catalysts. They also performed a mechanistic study to understand the functions of the different components and found the catalyst links the propylene-forming reaction to the deoxygenation of CO_2, and ensures the catalytic activity is specific to propane; water and carbon oxides are formed as by-products. Further, they found that the catalyst increased the reaction rate approximately five-fold compared to the typical values reported from other systems. The reaction produced a higher ratio of propylene and utilized more CO_2 at 550°C compared to previous catalysts. The catalyst also showed good long-term stability and reusability. This study provides new insights into the design of highly efficient catalysts for petrochemical production and has potential benefits for carbon recycling and greenhouse gas reduction. Source: Science Daily, 1/27/2022.

The number of approaches to olefin production which are considered "unconventional", including ODH (per above), is increasing as the push for CO_2 emissions reductions and/or CO_2 utilization support the industry objective of carbon circularity-------CSI

- **Method of Molecular-level Control Can Double the Efficiency of Widely Used Industrial Catalyst**

Researchers from Lehigh University, in collaboration with colleagues from the East China University of Science and Technology (ECUST), proposed a novel method of significantly enhancing the catalytic efficiency of materials already in broad commercial usage, a process they have termed "induced activation." "The surface structure of heterogeneous catalysts is closely associated with their catalytic performance," explains Israel E. Wachs. "Current efforts for structural modification mainly focus on improving catalyst synthesis. Induced activation, on the other hand, takes a different approach—manipulating the catalyst surface by controlling the composition of reducing agents at the catalyst activation stage where the catalyst is transformed to its optimum state." The team says that the use of the "tried and true" industrial catalytic material copper/zinc oxide/aluminum oxide ($Cu/ZnO/Al_2O_3$) enables firms to take advantage of the breakthrough without the need for a costly retooling. "This development effectively doubles the catalytic efficiency of these materials, enhancing their productivity and extending the life of the catalyst," Wachs says. "And importantly, induced activation can provide significant benefit to industry without shutting down a chemical plant—or the building of a new and costly one." Source: Phys.Org, 1/24/2022.

- **US Electrolysis Process Could Simplify Green Hydrogen Production**

A water-splitting electrolysis process developed by researchers at Georgia Tech could simplify the production of carbon free green hydrogen, it is claimed. They have designed and demonstrated a new class of hybrid catalysts that reduce the requirements for these expensive materials and demonstrate superior performance for both oxygen and hydrogen spilling. Source: The Engineer, 1/17/2022.

Catalysis Research out of India

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2. Pooja Chaudhary, Geeta Devi Yadav, Krishna K. Damodaran and Surendra Singh, “Synthesis of new chiral Mn(III)–salen complexes as recoverable and reusable homogeneous catalysts for the asymmetric epoxidation of styrenes and chromenes,” **New J. Chem.,** 2022**,** *46*, 1308
3. Palle Ramana Murthy and Parasuraman Selvam, “Ordered Mesoporous Carbon-supported Morphologically controlled Nano-Gold: Role of Support as well as the Shape and Size of Gold Nanoparticles on the Selective Oxidation of Glycerol, **ChemCatChem,** 2022, doi.org/10.1002/cctc.202200006.
4. Rimita Bose, Jayashree Ethiraj, Palla Sridhar, Jithin J. Varghese, Niket S. Kaisare, Parasuraman Selvam, “Adsorption of hydrogen and carbon dioxide in zeolitic imidazolate framework structure with SOD topology: experimental and modelling studies” **Adsorption,** 2022 https://doi.org/10.1007/s10450-020-00219-2
5. G. Shivudu, T.V.R. Mohan, S. Khan, K. Chandraraj, P. Selvam, “Xylooligosaccharides production from lignocellulosic biomass: Equilibrium kinetics and thermodynamic studies

of endo-1,4-b-Dxylanase adsorbed onto periodic mesostructured materials" **Materials Science for Energy Technologies, 2021, 4. 423–431**

6. Gajanan Y Shinde, Abhishek S Mote, Manoj B Gawande, "Recent Advances of Photocatalytic Hydrogenation of CO_2 to Methanol" **Catalysts,** 2022, 12 (1), 94.
7. Anindya Ghosh, G. Naaresh Reddy, Mohammed Siddhique P. K., Sauvik Chatterjee, Sudip Bhattacharjee, Rahul Maitra, Sergey E. Lyubimov, Ashot V. Arzumanyan, Alexander Naumkin, Asim Bhaumik and Biswajit Chowdhury, "Fabrication of a hollow sphere N, S co-doped bifunctional carbon catalyst for sustainable fixation of CO_2 to cyclic carbonates" **Green Chemistry,** 2022, DOI: 10.1039/d1gc04153c
8. Priya Yadav, Manavi Yadav, Rashmi Gaur, Radhika Gupta, Gunjan Arora, Anju Srivastava, Anandarup Goswami, Manoj B Gawande, Rakesh Kumar Sharma, "Chemistry of magnetic covalent organic frameworks (MagCOFs): From synthesis to separation applications" **Mater. Adv.,** 2022, 3, 1432–1458
9. Pooja Rana, Bhawna Kaushik, Rashmi Gaur, Sriparna Dutta, Sneha Yadav, Kanika Solanki, Bhavya Arora, Ankush Biradar, Manoj B Gawande, Rakesh Kumar Sharma, "Earth-Abundant Cobalt based photocatalyst: Visible light induced direct (Het) Arene CH arylation and CO_2 capture" **Dalton Trans.**, 2022,51**,**2452-2463 https://doi.org/10.1039/D1DT03625D

Upcoming Symposium/ Conferences/Seminars

1. International Conference on Biocatalysis & Green Chemistry Online 04-05 April 2022 https://crgconferences.com/green-chemistry/
2. International Conference on Environmental Materials and Catalysis (CEMC 2022) 22-24 April, 2022, Suzhou, China.
3. 2022-4-22: ICCCSTNE 2022: International Conference on Carbon Capture, Storage Technologies, and Negative Emissions.
4. Alternate Energy Materials-2022, 6-8 April 2022, Imperial College London, England. https://www.aemlondon.com/
5. 12th BENGALURU INDIA NANO 2022, Virtual 7th - 8th March 2022.
6. 2nd Global Summit and Expo on Nanotechnology and Nanomaterials (GSENN2022) Copenhagen, Denmark on June 13-15, 2022. https://www.thescientistt.com/nanotechnology-nanomaterials/2022/speakers.php
7. International Conference on Green, Sustainable & Analytical Chemistry, 07-08 June 2022 Goa, India
8. World Congress on Green Chemistry and Green Engineering (WCGCGE) 26th February 2022, Pune, India
9. International Conference on Electrochemistry (ICE), 10th April 2022 Nagpur, India

▪ Announcements

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

Name	Achievements
Padma Shri 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), ICT Mumbai	Elected as Fellow of the National Academy of Engineering (NAE), USA.

Tribute

CSI pays a tribute to **Prof. Masatake Haruta** passed away on January 25th, 2022. Ph.D. from Kyoto University in 1976 and worked at Osaka National Research Institute (the predecessor of National Institute of Advanced Industrial Science and Technology (AIST), Kansai Center). He worked on the synthesis of mixed oxides of base metals with Ag or Au by coprecipitation (CP). He found that Ag−Co−Mn mixed oxides showed significantly improved catalytic activity compared to Ag2O and single metal oxides for H2 oxidation. He worked on the preparation of homodisperse colloidal NPs of Mo and Co sufides. **Haruta and co-workers found that supported Au NPs catalyzed direct oxidation of propylene-to-propylene oxide using O_2 and H_2, and subsequently O_2 alone in the presence of H_2O.**

Quote of the Month

"Take risks in your life, if you win, you can lead! If you lose, you can guide"
— **Swami Vivekananda**

Editorial Team

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