May 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.

- **Novel Nanomaterials for Catalysis, Solar Energy Harvesting, & CO_2 Capture Conversion @ Prof. Vivek Polshettiwar Group, TIFR-Mumbai**

Prof. Vivek Polshettiwar Group works on the development of novel nanomaterials for catalysis, solar energy harvesting, and CO_2 capture-conversion to tackle "climate change". He has developed next generation nanocatalysts via the morphological control of nanomaterials, dendritic fibrous nanosilica (DFNS). The uniqueness of DFNS is its high surface area produced by its fibrous structure instead of the formation of pores, making the large surface area easily accessible **(*Nature Protocol*. 2019, *14*, 2177-2204, *Indian Patent Appl. 201621004089*).** DFNS is now being used for various applications, such as catalysis, photocatalysis, CO_2 capture-conversion, RNA extraction from viruses, energy harvesting & storage, drug delivery, etc.

By using the techniques of nanotechnology, his team has transformed DFNS based yellow gold to black gold by changing the size and gaps between gold nanoparticles. Similar to the real trees, the developed black gold acts like an artificial tree that uses CO_2, sunlight, and water to produce fuel. This work on "*Black (nano)Gold*" is *one-of-its-kind* and a way forward to develop "*Artificial Trees*" which captures and converts CO_2 to fuel and useful chemicals and CO_2 may then become our main source of clean energy **(*Chemical Science*, 2019, *10*, 6694-6603, *Indian Patent Appl. 202021001441*).**

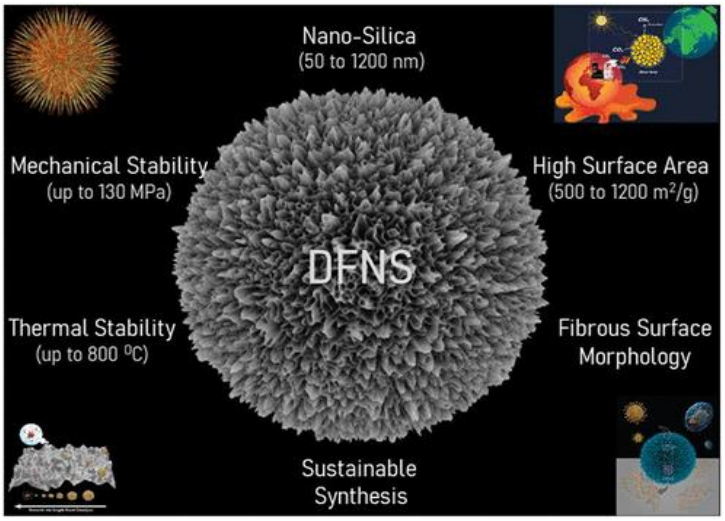
His group also showed that "*Defects in DFNS*" convert CO_2 to fuel with excellent productivity and selectivity (*an entirely new concept in the field*). Neither metal nor complex organic ligands were required, and the defect alone acted as catalytic sites. Surprisingly, the catalytic activity for methane production increased significantly after every regeneration cycle, which they explained by a detailed mechanistic study. **(*Proc. Natl. Acad. Sci. U.S.A* 2020, *117*, 6383-6390, *Indian Patent Appl. 202021001440*).**

They also developed "*Acidic Amorphous Aluminosilicates (AAS)*", which possesses Brønsted acidic sites like in zeolites and porous textural properties and was used for catalysis, plastic degradation

and CO_2 to fuel conversion. Conventional and DNP-enhanced SS NMR provided a molecular-level understanding of these materials **(*Nature Commun.* 2020, *11,* 3828, *Indian Patent Appl. 202021040554.*).** His work on "*Capturing CO_2 before its Release*" using lithium silicates nanosheets with excellent capture capacity, kinetics and stability can provide a novel path to capture CO_2 inside the reactor itself and stopping their release to the environment **(*Chem. Sci.,* 2021, *12,* 4825, *Indian Patent Appl. 202021008717*).**

Recently they came up with a new concept of "CO_2 Mitigation on Earth and Magnesium Civilization on Mars". We showed that "Bubble the Air in Water with a pinch of Magnesium and you will get Fuel (methane, hydrogen) and green cement". No heat, electricity, or light energy was required, simply the use of water and magnesium in just a few minutes. This protocol can even be used for hydrogen production (940 liter per kg of Mg), which is nearly 420 times more than hydrogen produced by the reaction of Mg with water alone (2.24 liter per kg of Mg). Also, this process could potentially be the first step towards a magnesium-driven civilization on Mars where CO_2, water (ice), and magnesium are abundant. **(*Chem. Sci., 2021, 12, 5774, PCT App. No. PCT/IN2020/50458*).**

Prof. Polshettiwar developed his own research field on "*Fibrous Nanosilica*" and more than 150 groups worldwide are now working in the field that Vivek started. This is one of the very few examples of such widespread use of material invented by Indian researchers. In addition to fundamental research on DFNS, he is also trying to commercialize it with the help of industries to create a real societal impact of his research; a step towards **"*Atmanirbhar Bharat*".**



His work is recently summarized in **Acc. Chem. Res. (Polshettiwar, v. 2022, 10.1021/acs.accounts.2c00031)**

Source: Prof. Vivek Polshettiwar, Department of Chemical Sciences (DCS), Tata Institute of Fundamental Research (TIFR) Mumbai 400005, India

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Commercial & Policies

- **Godavari Biorefineries Ltd. inaugurated new Research and Development (R&D) Centre at Navi Mumbai**

Godavari Biorefineries Limited (GBL) inaugurated new R&D laboratory at TTC Industrial state Mahape, Navi Mumbai. The new state-of-the-art facility center is in line with GBL's strategy to focus on research and innovation to address the significant and growing demand for chemical products made from renewable feedstock. This new facility covers area of 7500 sq. feet & will house 30 employees working on various research areas such as chemistry, biotechnology, microbiology, and molecular biology. Padma Vibhushan Prof. M.M. Sharma ex-Director of ICT, Mumbai inaugurated the research center and provided insights of the chemical industry in India in his inaugural speech.

Source: https://godavaribiorefineries.com/news/godavari-biorefineries-ltd-inaugurated-new-research-and-development-rd-centre-navi-mumbai

- **Greenko, John Cockerill to set up 2 electrolyser giga factories for green hydrogen**

Greenko Group and Belgium's John Cockerill has finalized the terms of a 50:50 joint venture to set up a two akaline electrolyzer factories of a gigawatt each in India over the next 12 to 18 months to make the lowest cost hydrogen in the country for industrial users. The facility, likely to come up on the east coast with a planned $500 million investment, as per people in the know, will be one of the world's largest, and the largest till date outside of China. Greenko ZeroC (GZC), a subsidiary of Greenko Group and Jon Cockerill, a leading designer and manufacturer of high-capacity alkaline electrolyzers signed the agreement on Monday, both companies said in a joint statement. The 2 GW units can potentially help replacing 8% of India's annual liquified natural gas (LNG) imports.

Source: https://economictimes.indiatimes.com/industry/renewables/greenko-john-cockerill-to-set-up-2-electrolyser-giga-factories-for-green-hydrogen/articleshow/90784080.cms

- **IIT Guwahati partners with NTPC for development of plant to capture CO_2**

The Indian Institute of Technology, Guwahati has partnered with NTPC to design and develop a highly energy-efficient plant for CO_2 capture from power plants. After successful completion of test studies, the pilot plant has been shifted to NTPC's NETRA facility. This development has the potential impact to combat global climate change. The next phase of the study will involve the testing of pilot-pant using industrial flue gas. This technology, which works on flue gas using a newly activated amine solvent (IITGS), consumes up to 11% less energy compared to the commercial activated MDEA (Monoethanolamine) solvent and up to 31% less energy compared to benchmark MEA (Monoethanolamine) solvent.

Source: https://economictimes.indiatimes.com/industry/renewables/iit-guwahati-partners-with-ntpc-for-development-of-plant-to-capture-co2/articleshow/90812872.cms?from=mdr

- **JSPL plans to set up India's second coal gasification plant at Raigarh**

JSPL has plans of setting up a coal gasification plant -- the second in the country -- at its Raigarh plant in Chhattisgarh. The company is already using the coal gasification technology to produce steel at its plant in Angul, Odisha. The 2 million tonne per annum production capacity plant, inaugurated in 2018, holds the distinction of being India's first and the only plant producing steel from 'swadeshi' coal using the coal gasification technology.

Source: https://www.business-standard.com/article/companies/jspl-plans-to-set-up-india-s-second-coal-gasification-plant-at-raigarh

- **Praj Industries developing binder to blend ethanol with diesel**

Praj Industries Ltd. is in collaboration with the Pune-based Automotive Research Association of India (ARAI), and is developing a binder that will help blend ethanol with diesel, the company's top official has said. Praj is collaborating with ARAI, setting up three plants to use cellulosic feedstock and the project (binder) is in the testing phase currently.
Source: https://www.biofuelsdigest.com/bdigest/2022/04/10/praj-industries-developing-binder-to-blend-ethanol-with-diesel/

- **IOC, L&T, ReNew power form joint venture to develop green hydrogen sector**

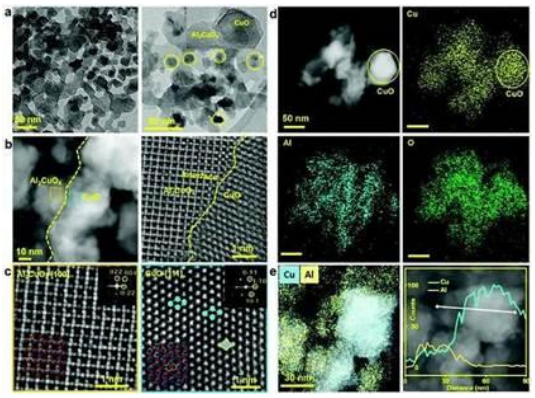
To enable decarbonization push, Indian Oil Corporation Ltd, Larsen & Toubro (L&T), ReNew Power announced signing of a binding term sheet for the formation of a Joint Venture (JV) company to develop the nascent green hydrogen sector in India. Additionally, IndianOil and L&T have signed a binding term sheet to form a JV with equity participation to manufacture and sell Electrolyzers used in the production of Green Hydrogen.
Source: https://www.newindianexpress.com/business/2022/apr/05/ioc-lt-renew-power-form-jvto-develop-green-hydrogen-sector-2438098.html

- **Clariant Completes Divestment of 50% Stake in Scientific Design Joint Venture**

Clariant has announced that it has completed the divestment of its 50% stake in the joint venture which owns Scientific Design Company Inc. Clariant's 50% share in Scientific Design was valued at USD 130 million. Clariant intends to use the proceeds of the divestment to invest into growth projects within the core Business Areas, execute the strategy along sustainability and innovation, fund the performance improvement programs as well as strengthen Clariant's balance sheet to reach and defend a solid investment grade rating.
Source: Clariant, 4/14/2022.

Scientific Updates

- **Researchers Develop Electrochemical Catalyst Capable of Producing Ethylene from Carbon Dioxide**



Courtesy of UNIST

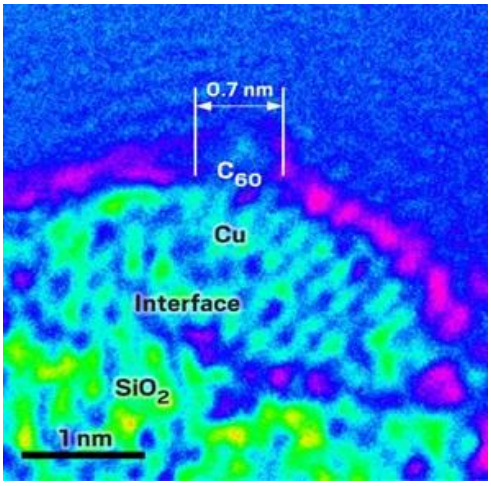
A joint team of researchers has developed an electrochemical catalyst using a copper-aluminum alloy that can create ethylene from CO_2. They have created an electrochemical catalyst made of a copper-aluminum alloy that can convert CO_2 into ethylene. Electrodes coated with the catalytic material showed a current efficiency of 82.4 percent, which is regarded as the top efficiency rate among catalysts. Researchers said that the high current efficiency rate of 421 milliamperes per square centimeter is about double of commercialization standards of 200 milliamperes per square centimeter. Electrodes can be simply submerged in a heated special solution to create ethylene. Source: Aju Business Daily, 4/25/2022.

- **Researchers Develop Non-metallic Photocatalyst Capable of Producing Green Hydrogen**

South Korean researchers have developed a non-metallic photocatalyst that can use sunlight to produce green hydrogen which does not emit any kind of greenhouse gases (GHGs) during the production process. Photocatalysts absorb bright light to cause chemical reactions, but they are mainly made of metallic materials and can damage the environment if they are not retrieved properly after use. The photocatalyst can use sunlight to break water down into hydrogen and oxygen. The light-sensitive catalyst is very cheap to manufacture and is non-toxic. Researchers found that by using an eco-friendly method of adding water and steam during the creation process of the carbon nitride photocatalyst, they were able to produce the device with about 12 times higher photocatalytic efficiency than conventional metallic catalysts. The newly developed catalyst was also more stable and durable than conventional devices. Source: Aju Business Daily, 4/18/2022.

- **Buckyballs Boost Ethylene Glycol Synthesis from Syngas**

Adding a dash of the fullerene C60—that iconic ball of carbon atoms—to a copper catalyst, boosts yield of ethylene glycol under mild conditions, potentially opening a route to manufacture this commodity chemical from sustainable feedstocks such as biomass. Researcher has now found that loading the copper-silica catalyst with 10% C60 by weight dramatically improves its performance, boosting yields 10-fold to about 98% at ambient pressure. The reaction forms only 2 by-products, far fewer than the 20 or so generated under conventional conditions, and the catalyst can be reused with no loss of activity. In principle, the syngas that feeds the process could come from the gasification of biomass, rather than coal, making it a more sustainable route to ethylene glycol, they found that C60 molecules offer a reservoir of electrons to maintain the right balance of copper oxidation states. Team is now working with a company to scale up the reaction. Source: Chemical & Engineering News (C&EN), 4/21/2022.



This false-color electron micrograph reveals a C60 molecule anchored to the surface of a copper catalyst nanoparticle sitting on a silica support. Credit: Science

- **NewHydrogen's Breakthrough Single-atom Catalyst Shows Better Performance than Platinum in Lab Studies**

NewHydrogen, Inc., the developer of a green hydrogen generator, recently provided an update on the progress of its catalyst technology aimed to reduce the cost of producing green hydrogen. The latest results from New Hydrogen's sponsored research at UCLA show significant progress toward the goal of producing low-cost green hydrogen by replacing or drastically reducing the use of precious metals in electrolyzers. In the recent tests, single-atom catalysts for hydrogen evolution reactions (HER) that do not use platinum were directly compared to commercial platinum-based HER catalysts. Within the practical range of metal loading, the single-atom catalyst has consistently shown to have lower overpotential with higher mass activity. In the stability test, the catalyst was significantly more stable than a commercial platinum based HER catalyst. "The high durability over prolonged usage as well as its superior catalytic ability over the commercial platinum-based HER catalysts makes catalyst an ideal drop-in replacement for platinum in alkaline hydrogen electrolyzers, and more importantly, in the anion exchange membrane (AEM) electrolyzers in the future. Source: NewHydrogen, 4/20/2022.

- **Moving beyond bimetallic-alloy to single-atom dimer atomic-interface for all-pH hydrogen evolution**

Single-atom-catalysts (SACs) afford a fascinating activity with respect to other nanomaterials for hydrogen evolution reaction (HER), yet the simplicity of single-atom center limits its further modification and utilization. Obtaining bimetallic single-atom-dimer (SAD) structures can reform the electronic structure of SACs with added atomic-level synergistic effect, further improving HER kinetics beyond SACs. However, the synthesis and identification of such SAD structure remains conceptually challenging. Herein, systematic first-principal screening reveals that the synergistic interaction at the NiCo-SAD atomic interface can upshift the d-band center, thereby, facilitate rapid water-dissociation and optimal proton adsorption, accelerating alkaline/acidic HER kinetics. The obtained NiCo-SAD-NC exhibits exceptional pH-universal HER-activity, demanding only 54.7 and 61 mV overpotentials at −10 mA cm^{-2} in acidic and alkaline media, respectively
Source: https://www.nature.com/articles/s41467-021-27145-3

Catalysis Research out of India

1. S.S. Vedula, G.D. Yadav, "Superior efficacy of biocomposite membranes of chitosan with montmorillonite and kaolin vs pure chitosan for removal of Cu (II) from wastewater" **Journal of Chemical Sciences,** 2022, 134 (2), 1-12
2. N.H. Margi, G.D. Yadav, "Pseudoionone synthesis from citral and acetone in a fixed bed catalytic reactor with lanthanum modified calcium oxide", **New Journal of Chemistry,** 2022, 46 (3), 1111-1119
3. Farzaneh Besharat, Fatemeh Ahmadpoor, Zahra Nezafat, Mahmoud Nasrollahzadeh, Nilesh R Manwar, Paolo Fornasiero, Manoj B Gawande, "Advances in Carbon Nitride-Based Materials and Their Electrocatalytic Applications", **ACS Catalysis,** 2022,12, 5605-5660
4. Arun D Kute, Rahul P Gaikwad, Indrajeet R Warkad, Manoj B Gawande, "A review on the synthesis and applications of sustainable copper-based nanomaterials" **Green Chemistry,** 2022, https://pubs.rsc.org/en/content/articlelanding/2022/gc/d1gc04400a/unauth
5. A Sreenavya, P Aswin, V Ganesh, NJ Venkatesha, A Sakthivel, " Facile Water-Free Synthesis of Noble Metal Containing Hydrotalcite Derived Materials and Their Application for Hydrotreatment of Anisole", **Materials Today Sustainability,** 2022 https://www.sciencedirect.com/science/article/pii/S2589234722000458
6. PP Neethu, P Aswin, A Sreenavya, S Nimisha, PS Aswathi, A Sakthivel, "Ruthenium on α-$Ni(OH)_2$ as potential catalyst for anisole hydrotreating and cinnamyl alcohol oxidation" **Reaction Kinetics, Mechanisms and Catalysis,** 2022, https://link.springer.com/article/10.1007/s11144-022-02211-z
7. L. Souza Brandão, M. Barbosa, R. Jesus, P. A. Bharad, Á. Lima, C. Soares, R. Yerga, M. Bilal, L. Fernando R. Ferreira, H. Iqbal, C. S. Gopinath, R. Figueiredo, "Enhanced hydrogen fuel production using synergistic combination of solar radiation and TiO_2 photocatalyst coupled with Burkholderia cepacia lipase" **International Journal of Hydrogen Energy,** 2022, 47 (32)14483-14492

Upcoming Symposium/ Conferences/Seminars

1. May 15-18, 2022-Advances in Surfaces, Interfaces, and Interphases 2022, online, Any Location (Virtual event)
2. 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
3. The 12th International Conference on Environmental Catalysis (ICEC2022) will be held during July 30-August 2, 2022, in Osaka, Japan.
4. World Hydrogen 2022 - Sumit, 9 -11 May 2022, Rotterdam Ahoy, Netherland https://www.world-hydrogen-summit.com/
5. International Online Conference on Nano Material [ICN 2022] 12-14 August 2022 Mahatma Gandhi University, Kottayam, Kerala, India.

Announcements

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

Name	Achievement
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 	**Lifetime Achievement Award-2022** by MSME Chamber of Commerce and Industry of India on 25th April 2022 at Vigyan Bhavan, Rajpath Central Secretariat, New Delhi, India

Editorial Team

Dr. Sharad Lande

Dr. Raksh Vir Jasra

Quote of the Month

""Dream, dream, dream. Dreams transform into thoughts and thoughts result in action". — **Dr. APJ Abdul Kalam**

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