May 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 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.

Highlights of This Issue :

- **Research Group Activities: Professor Kamalakannan Kailasam**
- **Commercial & Policies**
- **Scientific Updates**
- **Catalysis Research out of India**
- **Upcoming Symposium/Conferences/Seminars/Workshop**

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Research Group Activities of Professor Kamalakannan Kailasam: "Solar-driven Chemical Circular Economy" @ INST, Mohali

Professor Kamalakannan Kailasam's group is actively working on Advanced Functional Nanomaterials for Energy and Environmental Applications like photocatalytic water splitting, CO_2 photoreduction, and biomass conversion to fine chemical synthesis, gas storage, and chemo-resistive sensing.

Their group's approach mostly depends on creating porosity in functional organic and inorganic materials by soft and hard templating approaches and their extensive characterization. In addition, building the organic porous network by reacting with special tectonics and avoiding their packing in such a way that it opens up the porosity, for eg., Porous Organic Polymers (POPs). As the further step, to fulfill like every scientists dream, of extending the research results to develop prototype devices and finally towards technological applications in collaboration with industry.

They developed new chemistry with heptazine moiety as a building block to develop functional materials like Microporous Polymeric Networks (HMPs) and Liquid Crystals for the first time and applied them in several applications like photocatalytic processes, CO_2 storage and conversion, and OLEDs. They are carrying out reactions under natural sunlight for liquid and gaseous solar fuel synthesis especially successful simultaneous production of H_2/H_2O_2 and Biomass precursor chemicals by sustainably utilizing the charge carriers using visible light semiconductors (**Selective articles: J. *Mater. Chem. A,* 2019, *7,* 5643-5649*;* ChemSusChem, 2022, *15,* e2022004*;* J. *Mater. Chem. A,* 2022, *10,* 14568-14575*;* J. *Mater. Chem. A*, 2018, *6,* 21719-21728**).

Their group employs materials like Porous heptazine & triazine based polymeric carbon nitrides, O-bridged carbon nitrides, and mesoporous metal oxide semiconductors & chalcogenides; D-A conjugated heptazine-based porous polymeric networks (HMPs); and Porous Organic Polymers (POPs) for various energy conversion applications (**Figure 1**). This includes Photocatalytic (Water Splitting, CO_2 & N_2 reduction, and CH_4 oxidation), H_2 & CH_4 gas storage, and Biomass valorization to fine chemicals *(***ACS Catalysis, 2018, *8,* 6751-6759)**.

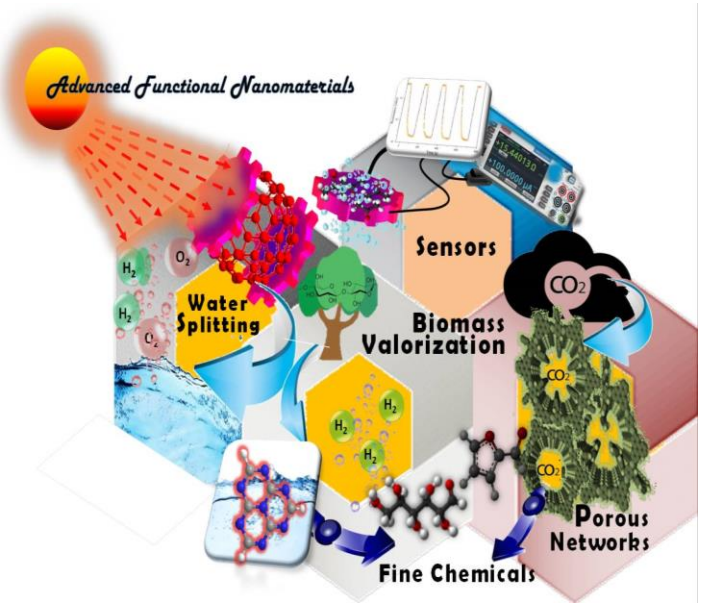

Figure 1: Broad research activities

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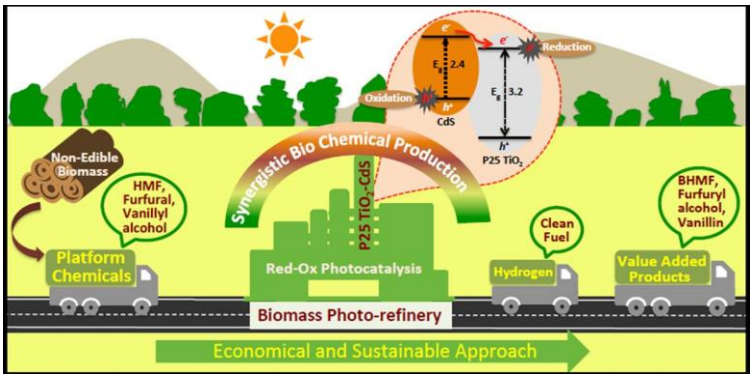

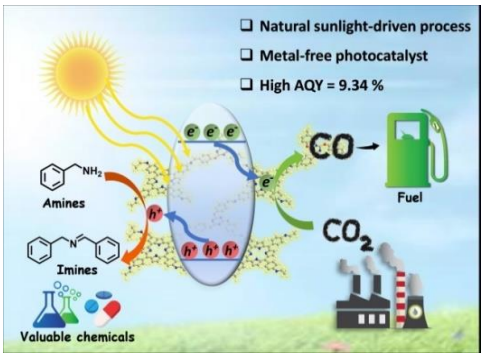

Figure 2: Synergistic (left) biomass valorization to value-added fine chemicals & H_2; (right) CO_2 conversion to CO and biomass valorization to fine chemicals under natural sunlight.

Expertise:

- New sustainable "biomass-based photo-refinery" and cost-effective low carbon-intensity approach for biomass-based selective reduction and oxidized chemicals along with H_2 production, **Figure 2** (**EES Catalysis, 2024, Accepted Manuscript**).
- Deposition of C_{60} over 2D TUCN not only promoted an efficient charge transfer ability, also offered an excellent CO production rate (8.92 mmol $h^{-1}g^{-1}$) and *p*-MBA oxidation rate (0.65 mmol $h^{-1}g^{-1}$), synergistically. A maximum 3.38 % (AQY) was achieved for CO evolution at λ=450 nm (**J. *Mater. Chem. A*, 2023, *11*, 18672–18678**).
- Development of a novel metal-free photocatalyst, composed of porphyrin and a triazine-based porous organic polymeric network (TPT-prop) for the photocatalytic reduction of CO_2 coupled with oxidative benzylamine homocoupling under natural sunlight for the first time (**Figure 2)**. A remarkably high AQY of 9.34% (at λ = 430 nm) was attained for CO production *(***J. *Mater. Chem. A*, 2023, *11,* 25743-25755***)***.
- Pilot scale production of Nanoporous Carbon Nitride Organic Polymers for CO_2 Activation and Conversion to Organic Carbonates on a kilogram scale along with Tata Steel R&D, Jamshedpur, Jharkhand.

Highlights

- Pioneered the "Nanoporous carbon nitrides" as photocatalysts and thermal catalysts for production of H_2 and CO_2 conversion to C_1 chemicals.
- Established the new chemistry with heptazines in the synthesis of porous frameworks catalysis, solar energy capture, and CO_2 conversion to sustainable chemicals.
- Replacing molecular oxygen with CO_2 as oxidant for sustainable organic transformations into fine chemicals and fuels which has vast industrial opportunities.
- Successfully demonstrated the first ever coupling strategy of CO_2 reduction to CO with biomass based aromatic alcohols oxidation using under natural sunlight using metal-free organic semiconductors by effective utilization of charge carriers.

- Our pioneering study opens up unprecedented avenues for the investigation of metal-free photocatalysts capable for dual photoredox processes and these findings offer tremendous potential for advancing the field of sustainable photocatalysis.
- ***Pilot scale production of carbon nitride-based organic polymers for CO_2 activation and organic carbonate production in kilogram scale with Tata Steel R & D.***
- ***Ongoing pilot scale projects Bharat Petroleum Corporation Limited (BPCL) on porous metal-based carbon nitride-based catalysts for photocatalytic H_2 and thermal organic carbonate production.***

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https://scholar.google.co.in/citations?user=CoQiq_sAAAAJ&hl=en

Commercial & Policies

- **Reliance signs technology licensing agreement with Norway's Nel for hydrogen electrolyzers**

Nel Hydrogen Electrolyser AS, a fully owned subsidiary of Nel ASA has entered into a technology agreement with Reliance Industries Limited (RIL). The agreement provides RIL with exclusive Nel's alkaline electrolyzers in India and also allows RIL to manufacture Nel's alkaline electrolysers for captive purposes globally. Both partners will also collaborate on future performance improvements and cost optimization through research and development (R&D), value engineering, standardization, and modularization to improve the competitiveness of the alkaline technology platform.

Source:https://www.business-standard.com/companies/news/reliance-industries-picks-norwegian-partner-for-electrolyser-tech-124052101392_1.html

- **L&T dispatches the world's heaviest ethylene oxide reactors to the BASF project in China**

Larsen & Toubro's Heavy Engineering division has shipped two Ethylene Oxide two Ethylene Oxide (EO) Reactors, each weighing 1,136 metric tonnes, to a BASF chemical plant project in China, marking a significant achievement in the global heavy engineering sector. Manufactured at L&T's A M Naik Heavy Engineering Complex in Hazira, Gujarat, these reactors are the heavies of their kind ever built based on BASF technology.

The reactors play a crucial role in the production of ethylene oxide, a key components used in manufacturing a variety of chemicals. The technology and manufacturing techniques and Industry 4.0 manufacturing technology.

Source: https://energy.economictimes.indiatimes.com/news/power/lt-dispatches-worlds-heaviest-ethylene-oxide-reactors-to-basf-project-in-china/110330339

- **Dow adds 80,000 TPA propylene glycol capacity in Thailand**

Dow announced today the start-up of its propylene glycol (PG) capacity expansion at its integrated manufacturing facility in Map Ta Phut, Rayong, Thailand. The low capital intensity, higher-return, incremental investment increases propylene glycol capacity by 80,000 tons per year, which brings the total output to 250,000 tons per year, making the Dow Map Ta Phut PG manufacturing facility the largest of its kind in Asia Pacific.
Source:https://www.indianchemicalnews.com/chemical/dow-adds-80000-tpa-propylene-glycol-capacity-in-thailand-21831

- **India Poised to Be Third Largest Utility-Scale Battery Market by 2030**

India is poised to become the third-largest market globally for utility-scale battery systems by 2030, with expected capacity reaching almost nine GW. The growth is spurred by declining costs, as highlighted in an International Energy Agency (IEA) report. The report indicates that solar PV coupled with battery storage is more economically viable than coal in India, a trend likely to persist. As India enhances its solar PV infrastructure, the demand for short-term energy flexibility will rise, emphasizing the importance of storage solutions. The Indian government requires wind and solar PV installations to include storage capacity equivalent to at least five percent of their total capacity. The IEA report suggests that with its ambitious storage targets and supportive fiscal policies, India has the potential to become a key player in the global battery storage market.
Source:https://chemindigest.com/india-poised-to-be-third-largest-utility-scale-battery-market-by-2030/

- **Asahi Kasei starts operation of multi-module hydrogen pilot plant in Kawasaki**

The Japanese technology company Asahi Kasei and partners including the Japanese government celebrated the official opening of a new hydrogen pilot plant in Kawasaki, Japan. The operation start of this commercial-scale facility was in March 2024. The trial operation of four 0.8 MW modules is another milestone towards the realization of a commercial multi-module 100 MW-class alkaline water electrolysis system for green hydrogen production. According to the

Hydrogen Council, the cumulative global installed capacity of water electrolyzers is forecasted to reach approximately 300 GW by 2030. To meet this increasing demand, Asahi Kasei is currently developing the Aqualyzer™ alkaline water electrolyzer optimized for the production of green hydrogen.
Source:https://www.asahikasei.com/news/2024/e240514.html

- **Inox Air Products to supply green hydrogen to Asahi India Glass' Chittorgarh plant**

Asahi India Glass Limited (AIS), India's leading glass manufacturer, and INOX Air Products (INOXAP), India's largest manufacturer of industrial and medical gases, have entered into a 20-year offtake agreement for the supply of Green Hydrogen, to AIS' greenfield float glass facility in Soniyana in Chittorgarh, Rajasthan. This will be India's first-ever Green Hydrogen Plant for the Float Glass industry, paving the way for sustainable glass production. The Plant will have the capacity to generate up to 190 Tons of Green Hydrogen per Annum through electrolysis and commissioned by July 2024, the plant will be powered by solar energy.
Source:https://www.indianchemicalnews.com/hyd rogen/inox-air-products-to-supply-green-hydrogen-to-asahi-india-glass-21771

- **Asahi Kasei Announces Port Colborne, Ontario, Canada as Location of Future Lithium-ion Battery Separator Plan**

Asahi Kasei announced today that it will construct its previously announced integrated lithium-ion battery (LIB) separator plant in Port Colborne, which is in the Niagara region of Ontario, Canada. The new manufacturing facility will operate as Asahi Kasei Battery Separator Canada. The start of commercial production is currently slated for 2027.
Source: https://theprint.in/economy/indias-energy-requirement-will-increase-by-2-5-times-by-2047/2036936/

- **EPA bans most uses of methylene chloride**

The US Environmental Protection Agency has banned most uses of methylene chloride, a solvent that has been linked to several adverse health effects and some deaths. Since 1980, at least 88 people have died from acute exposure to methylene chloride, the agency says. Longer-term exposure can also lead to liver damage and the development of at least six different types of cancers, it adds. Methylene chloride is the second compound, after asbestos, to be banned under the revised Toxic Substances Control Act. The ban, which follows a risk assessment and an April 2023 proposal, will phase out all consumer uses within a year and most industrial and commercial uses within the next 2 years. Uses of methylene chloride that are exempt from the ban include as a raw material for producing electric-vehicle batteries and climate-friendly refrigerant chemicals. And methylene chloride can continue to be used as a laboratory chemical.

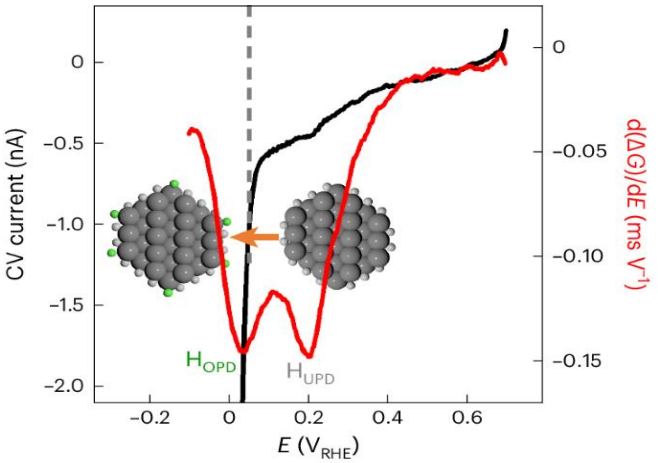
Source:https://cen.acs.org/policy/chemical-regulation/EPA-bans-uses-methylene-chloride/102/web/2024/04

- **Tata Steel signs MoU with Hygenco for green hydrogen and ammonia project**

Tata Steel Special Economic Zone Limited (TSSEZL) has signed a MoU with HHP Five Private Limited (Hygenco) for the development of a green hydrogen and green ammonia project. The project will be located at TSSEZL's Gopalpur Industrial Park located in the Ganjam district of Odisha. Hygenco intends to establish a new plant that will produce green hydrogen, green ammonia, and other related products, with an estimated annual output of 1 million tonnes. The first phase of the plant is scheduled to be up and running by December 2026.
Source: https://renewablewatch.in/2024/05/08/tata-steel-signs-mou-with-hygenco-for-green-hydrogen-and-ammonia-project/

Scientific Updates

- **Edge sites dominate the hydrogen evolution reaction on platinum nanocatalysts**

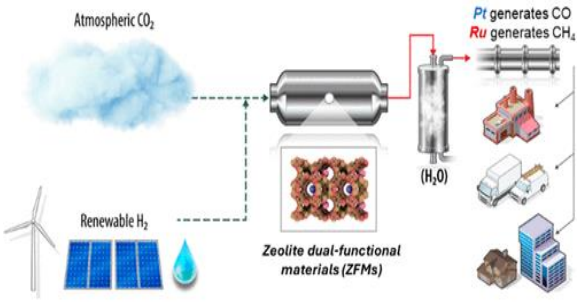


Platinum nanocatalysts facilitate the hydrogen evolution reaction (HER) for renewable chemical fuel generation. These nanostructures encompass diverse surface sites, including (111) and (100) facets and edge sites between them. Identifying the exact active sites is essential for optimal catalyst design, but remains challenging. Combining electrical transport spectroscopy (ETS) with reactive force field (ReaxFF) calculations, authors profile hydrogen adsorption on platinum nanowires and reveal two distinct peaks: one at 0.20 VRHE for (111) and (100) facets and one at 0.038 VRHE for edge sites. Concurrent ETS and cyclic voltammetry show that edge site adsorption coincides with the onset of the HER, indicating the critical role of edge sites. ReaxFF molecular dynamics calculations confirm lower activation barriers for the HER at edge sites, with two to four orders of magnitude higher turnover frequencies. ETS in alkaline media reveals substantially suppressed hydrogen adsorption on edge sites, contributing to the more sluggish HER kinetics. These findings resolve the elusive role of different sites on platinum surfaces, offering critical insights for HER catalyst design.
Source: Nature Catalysis 2024, https://doi.org/10.1038/s41929-024-01156-x

- **High Selectivity Reactive Carbon Dioxide Capture over Zeolite Dual-Functional Materials**

Reactive carbon dioxide capture (RCC) is a process where carbon dioxide (CO_2) is captured from a mixed gas stream (such as air) and converted to products without first performing a separation step to concentrate the CO_2. In this work, zeolite dual-functional materials (ZFMs) are introduced and evaluated for simulated RCC. The studied ZFMs feature high surface area, and crystalline, microporous zeolite faujasite (FAU) as thesupport. Sodium oxide ("Na_2O") is impregnated as an

effective capture agent capable of scavengin g low-concentration CO_2 (1,000 ppm). Exchanged and impregnated sodium on FAU chemisorbs CO_2 as carbonates and bicarbonates but does not promote the conversion of sorbed CO2 to products when heated in hydrogen.

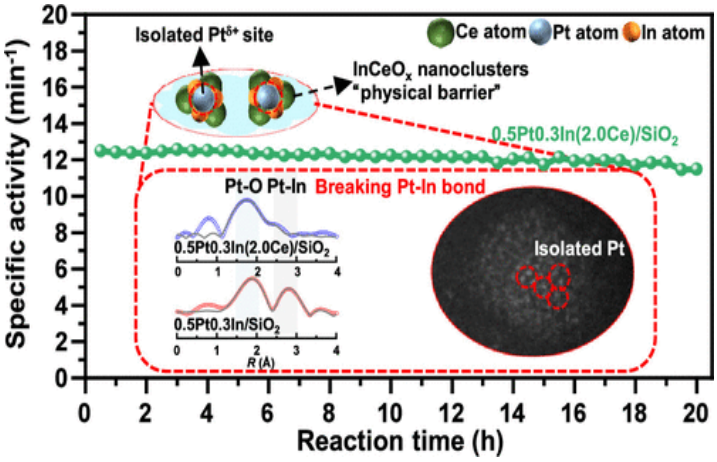


The addition of Ru promotes the formation of formates, while the addition of Pt generates carbonyl surface species when heated in hydrogen. The active metal then promotes extremely high selectivity for CO2 hydrogenation to either methane on the Ru catalyst (~150 °C) or carbon monoxide on Pt catalyst (~200 °C) when heated in reducing atmospheres.

Source: ACS Catalysis 2024, https://doi.org/10.1021/acscatal.4c01340

- **Enhanced PtIn Catalyst via Ce-Assisted Confinement Effect in Propane Dehydrogenation**

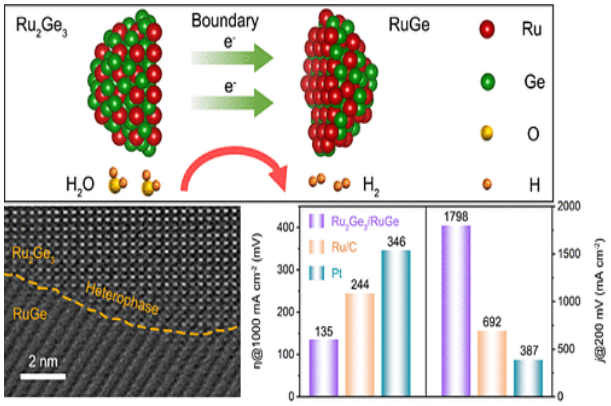
The PtIn nanoalloys with high surface energy are generally in a metastable state during harsh reaction conditions, and the ordered alloy structure is not conducive to exposure to surface Pt active sites. In this work, a strategy for restructuring the unfavorable PtIn alloy structure via heteroatom (Ce) doping is applied to advance an isolated Ptδ+ confined by the InCeOx nanoislands supported on SiO_2. The as-synthesized catalyst with optimizing PtIn(Ce) ternary components exhibits ~92.2% selectivity toward propylene and a stable propane conversion of ~67.1% at 550 °C (kd of 0.010 h^{-1}). This work proposed a facile and efficient strategy to promote the capability against sintering and coking of the Pt-based catalyst in propane dehydrogenation.



Source: ACS Catalysis, 2024 https://doi.org/10.1021/acscatal.4c02517

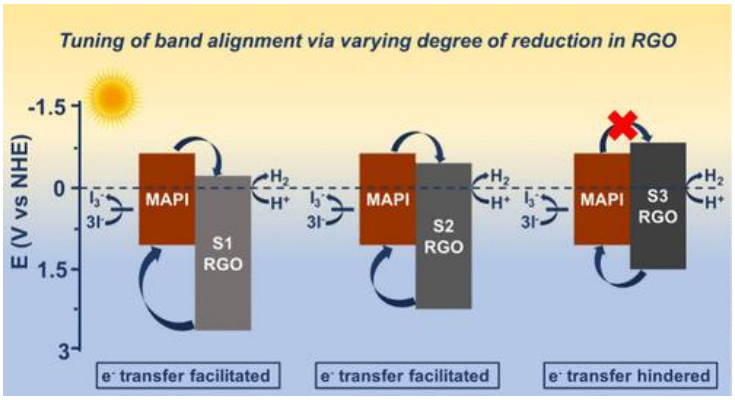
- **Heterophase Intermetallic Compounds for Electrocatalytic Hydrogen Production at**
- **Industrial-Scale Current Densities**

Heterophase nanomaterials have sparked significant research interest in catalysis due to their distinctive properties arising from the synergistic effects of different components and the formed phase boundary. However, challenges persist in the controlled synthesis of heterophase intermetallic compounds (IMCs), primarily due to the lattice mismatch of distinct crystal phases and the difficulty in achieving precise control of the phase transitions. Herein, orthorhombic/cubic Ru_2Ge_3/RuGe IMCs with engineered boundary architecture are synthesized and anchored on the reduced graphene oxide.



The Ru_2Ge_3/RuGe IMCs exhibit excellent hydrogen evolution reaction (HER) performance with a high current density of 1000 mA cm^{-2} at a low overpotential of 135 mV. The presence of phase boundaries enhances charge transfer and improves the kinetics of water dissociation while optimizing the processes of hydrogen adsorption/desorption, thus boosting the HER performance. Moreover, an anion exchange membrane electrolyzer is constructed using Ru2Ge3/RuGe as the cathode electrocatalyst, which achieves a current density of 1000 mA cm^{-2} at a low voltage of 1.73 V, and the activity remains virtually undiminished over 500 h.
Source: J. Am. Chem. Soc. 2024 https://doi.org/10.1021/jacs.4c01985

- **Composites of Reduced Graphene Oxide and MAPbI3 Crystals for Photocatalytic Hydrogen Generation**



Reduced graphene oxides (RGOs) with varied chemical reduction were integrated with MAPbI3 microcrystals by in situ coupling to construct a robust and effective heterostructure resulting in a strong interconnection between MAPbI3 and RGO. Careful selection of cocatalysts with appropriate bandgaps and proper alignment of band positions are the key steps for successful photocatalytic H_2 generation. This work highlights that facile and easy photogenerated charge separation and migration can be achieved for MAPbI3/RGO heterostructures where chemically modified RGOs having favorable bandgap and band positions were incorporated with MAPbI3 via unusually improved in situ crystallization resulting in remarkable mmol scale photocatalytic H2 evolution in aqueous HI medium under white light LED illumination. Under optimal reaction conditions, the H_2 evolution rate can reach 4493 µmol g^{-1} h^{-1}.
Source: *ACS Appl. Nano Mater.* 2024, https://doi.org/10.1021/acsanm.4c01909

Catalysis Research out of India

1. Paresh A Kamble, Chathakudath P Vinod, Virendra K Rathod, Mannepalli Lakshmi Kantam "Hydrogenation of Glucose to Sorbitol by Using Nickel Hydroxyapatite Catalyst", **ChemCatChem 2024,** https://doi.org/10.1002/cctc.202301590

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2. Snehal Gajbhiye, Virendra Rathod, Mannepalli Lakshmi Kantam, "Kinetics of Reductive Alkylation of Aniline with Acetone Using a Ni/Organoclay Catalyst" **Ind. Eng. Chem. Res. 2024,** 63, 18, 8076–8088

3. Nilam Patil, Debarati Das, Bhalchandra Mahadeo Bhanage, "Iridium-Catalyzed Electrooxidative Annulation of Naphthol with Acrylate via C-H Bond Activation for the Synthesis of Naphtho [1, 8-bc] furan" European Journal of Organic Chemistry, 2024, https://doi.org/10.1002/ejoc.202400361
4. Rupali S Prajapati, Anant R Kapdi, Rajesh Sahu, Bhalchandra M Bhanage " Selectivity tuning using Rh/PTABS catalytic system for the hydroformylation of eugenol" **Catalysis Today 2024,** https://doi.org/10.1016/j.cattod.2024.114804
5. Hiroki Nagashima, Farahnaz Maleki, Julien Trébosc, Rajesh Belgamwar, Vivek Polshettiwar, Myrtil Kahn, Yoshihiro Kon, Gianfranco Pacchioni, Olivier Lafon, Jean-Paul Amoureux," Probing the Surface of Oxide Nanoparticles Using DNP-Enhanced High-Resolution NMR of Quadrupolar Nuclei" **The Journal of Physical Chemistry Letters, 2024,** https://doi.org/10.1021/acs.jpclett.4c00563
6. Jacky H Advani, Arjun K Manal, Narasimha Rao Kanna, Pramod Kumar, Rajaram Bal, Rajendra Srivastava, "Synthesis of core-shell structured zeolite nanocomposite comprising ZSM-5 core and zeolite Y shell" **Materials Letters, 2024,** 360, 135994
7. Ritik Mohanty, Kulamani Parida, "Carbamide-mediated facile sol-gel synthesis of porous flower-like $ZnCo_2O_4$ microspheres for high-performance asymmetric coin cell supercapacitors" **Electrochimica Acta, 2024** https://doi.org/10.1016/j.electacta.2024.144327
8. Seema P Patil, Archana S Rajmane, Sanjay N Jadhav, Vijaya S Rajmane, Chandrashekhar V Rode, Arjun S Kumbhar, **Catalysis Letters, 2024,** 154 (6) 3078-3090
9. Maddila Anil Kumar, Nagarathinam Nagarjun, Haresh Manyar, Parasuraman Selvam "Ionic liquid templated synthesis of cobalt-substituted mesoporous aluminophosphates: A novel heterogeneous catalyst for selective oxidation of cyclohexane to cyclohexanol" **ChemCatChem 2024,** https://doi.org/10.1002/cctc.202301729

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.

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4. "19th Edition of **Global Conference on Catalysis,** Chemical Engineering & Technology" at Rome, Italy, from September 19th-21st, 2024.
5. **18th Edition of International Conference on Catalysis, Chemical Engineering, and Technology"** (CCT 2024) during June 17-19, 2024, at Paris.
6. 19th Edition of **Global Conference on Catalysis, Chemical Engineering & Technology,** September 19-21, 2024, | Rome, Italy | Hybrid Event
7. 5th International Symposium on **Catalysis for Clean Energy and Sustainable Chemistry** from 21st -23rd July 2024 at Bilbao (Spain).

ONE-DAY WORKSHOP ON "Catalysis A Key to a Sustainable Future"

In Honour of Prof. Parasuraman Selvam on June 21, 2024, oganized at Chemsittry Department, IIT Chennai. Professor Selvam , Vice-Presient of CSI is an eminet catalysis scientists and made excellent contributions to catalytic materials especially ordered mesoporous oxides.

Become a Life Member of Catalysis Society of India!

For Membership, fees & other details, please visit https://www.catalysisindia.org/

Quote of the Month

"All our dreams can come true if we dare to pursue them.
— Walt Disney

Editorial Team

Dr. Sharad Lande

Dr. Raksh Vir Jasra

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