July 2024

# CSI Communication

## Monthly Newsletter of Catalysis Society of India

## Circulated to all CSI Member

## Important Announcement:

**CSI newsletter shall be pleased to publish one 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.**

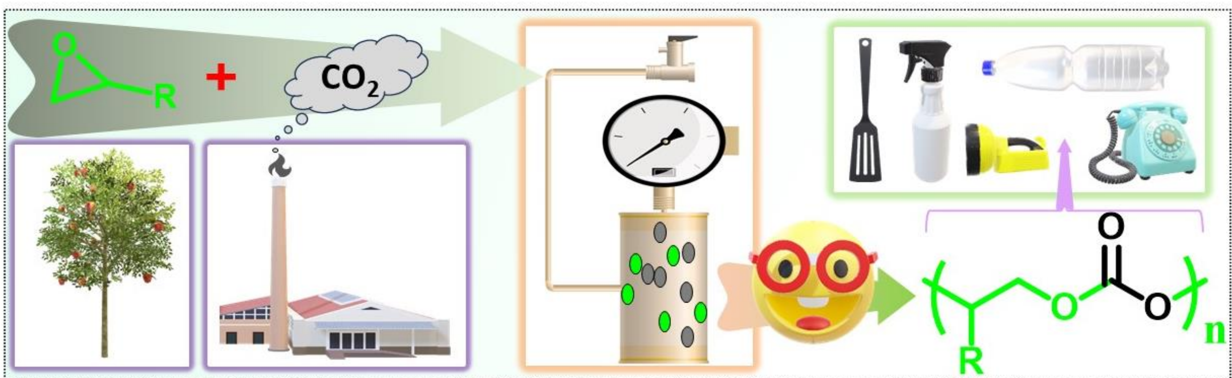
**You can also share your recent happy moments like publications, granted patents, technology commercialization, fellowship, awards, etc. to highlight in the CSI communication.**

## Highlights of This Issue :

- Research Group Activities: Dr. Gulzar Ahmad Bhat, University of Kashmir
- Commercial & Policies
- Scientific Updates
- Catalysis Research out of India
- Upcoming Symposium/Conferences/Seminars/Workshop
- List of New CSI Life Members
- CSI Members: Awards/Recognitions

# Valorization of Carbon Dioxide for Creating Value added Products @ Dr. Gulzar Ahmad Bhat, Centre for Interdisciplinary Research & Innovations University of Kashmir

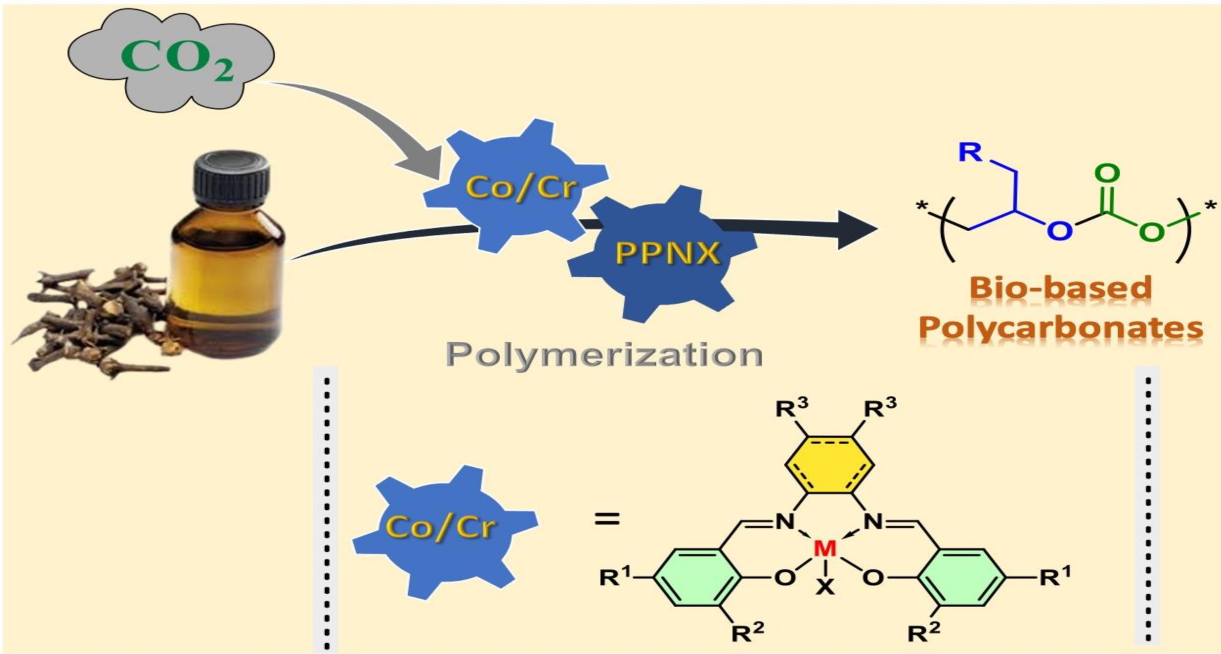
Dr. Gulzar Bhat's research group at the Centre for Interdisciplinary Research & Innovations University of Kashmir is focused on utilizing $CO_2$ as a C1 feedstock through the catalytic coupling of epoxides with $CO_2$, to produce aliphatic polycarbonates. This research aims to address global warming caused by this greenhouse gas through a sustainable approach. Although remarkable progress has been achieved, the lack of functionalities and aliphatic nature of these polycarbonates limit the scope of their application in high value-added and functional polymers (*Green Chem*. **2022**, *24*, 5007-5034; *Coord*. Chem. Rev. **2023,** *492,*215277)




This coupling process produces biodegradable aliphatic polycarbonates, valuable products with diverse applications. The group is also actively involved in the functionalization of these aliphatic polycarbonates to achieve different applications, especially in 3D Printing, self-healing polymers, and micellar catalysis. Recently our lab has also focused on utilizing sustainable resources in the form of epoxides to couple with $CO_2$ to achieve these polycarbonates that can eventually contribute to a circular economy.

To develop these aliphatic polycarbonates in a more sustainable approach, Dr. Bhat's group recently in collaboration with Prof. Donald Darensbourg from Texas A&M University used epoxides derived from an inexpensive, non-food renewable resource, *eugenol,* thereby avoiding petroleum-acquired monomers for obtained these aliphatic polycarbonates (*RSC Sustainability* **2024**, *2*, 1431-1443; *Macromolecules* **2023,** *56*, 2362–2369).

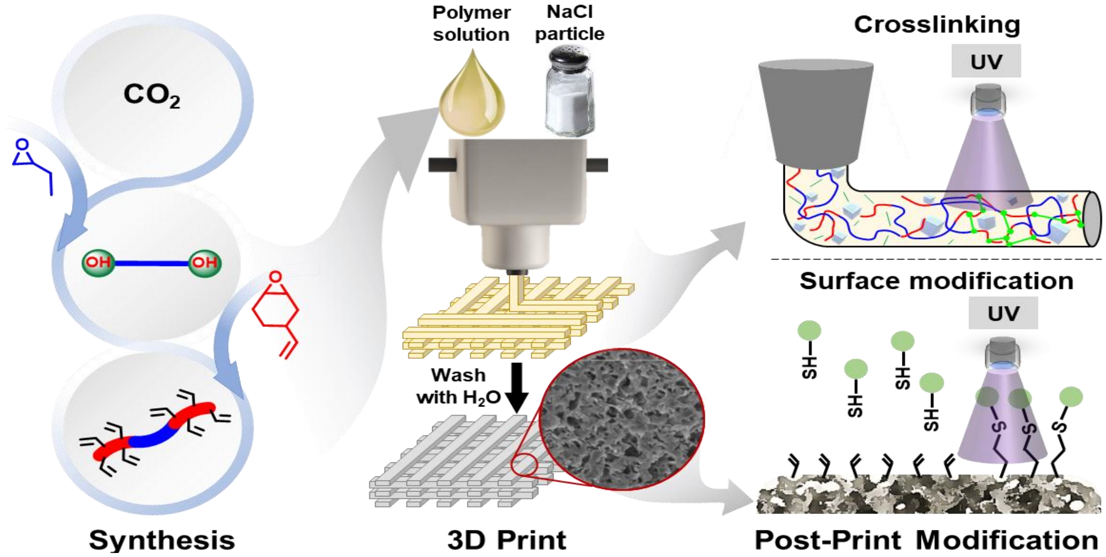
Recently we have demonstrated an efficient one-pot, two-step strategy to synthesize $CO_2$-based block copolymers having hard and soft segments that have been used for formulating inks for 3D Printing and by varying the ratio of soft and hard blocks, thermal and mechanical properties can be tuned as required. Through thiol-ene click chemistry surface modifications of the printed objects can be achieved (*Angew. Chem. Int. Ed.*, **2022,** 61**,** e202208355). We have also recently reported a mini-review on the processing of aliphatic polycarbonates which highlights the recent progress in processing aliphatic polycarbonates, including controlled self-assembly, electrospinning, additive manufacturing, and others (*Angew. Chem. Int. Ed.,* **2023,** *62*, e202307507).

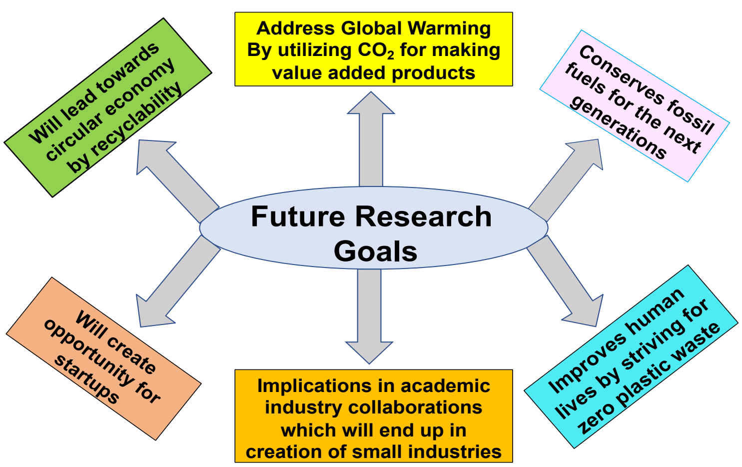



Through chain transfer chemistry during these coupling reactions, we have covalently inserted well-defined metal complexes in the backbone of these polycarbonates, leading to the formation of metallopolymers. Since this procedure is modular in nature, it is applicable to a wide variety of chain transfer agents containing metal complexes or metal-binding sites, thereby providing a pathway to synthesize a wide range of functional polymers that can be employed for pursuing organometallic transformations in water (e.g., micellar catalysis) or drug delivery (*Organometallics,* **2020**, *39*, 1612-1618).

Dr Bhat's team has recently reported a Pd(II) containing complexes as part of the hydrophobic polymer backbone of amphiphilic aliphatic polycarbonates derived from $CO_2$ and epoxides. These polymeric materials were later demonstrated to provide uniform spherical nanostructures (micelles) when added to water. These metallosurfactants (micelles) were later demonstrated as effective catalysts for Suzuki and other carbon-carbon coupling reactions in water at very low catalyst loadings (Proc. Natl. Acad. Sci. **2023**, *120*, e2312907120).

Our research also focuses on microplastics, tiny plastic particles under 5 mm, which are pervasive pollutants in river ecosystems. We analyze water and sediment samples to identify and quantify these particles, study their sources and transport mechanisms, and assess their ecological and health impacts on aquatic life, particularly fish. Advanced techniques like microscopy, spectroscopy, and chemical analysis are employed to understand the distribution, composition, and potential effects of microplastics in aquatic environments.




*Research Group at Kashmir University*


## Contact: Dr. Gulzar Ahmad Bhat

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**University of Kashmir, Hazratbal, Srinagar**
**Email: altafbhat@uok.edu.in**


**Areas of Interest: Catalysis, $CO_2$ valorization, Sustainability,**
**Green Chemistry, Polymers, Aliphatic Polycarbonates, 3D Printing**

## Commercial & Policies

- **MRPL to produce green hydrogen for captive use**

Mangalore Refinery and Petrochemicals Ltd (MRPL) has initiated setting up a 500 tpa green hydrogen production unit within the refinery premises. Currently, MRPL meets its hydrogen needs for hydro-processing units through hydrogen produced by steam methane reforming units. "MRPL aims to continuously produce green hydrogen using renewable energy and the water electrolysis method. This green hydrogen will be blended with the hydrogen currently produced in the refinery for internal use," the annual report stated.

Source: https://www.gleaf.in/news/mrpl-to-produce-green-hydrogen-for-captive-use

- **Nayara Energy Achieves Key Milestone at Petrochemical Unit in Vadinar, Gujarat**

Nayara Energy, a leading downstream energy company, has successfully dispatched its first consignment of Polypropylene from its new petrochemical unit at the Vadinar refinery in Gujarat. The unit, with a capacity of 450,000 tpa, starts this year and is strategically located in Western India.The project, with an investment outlay of ~₹6,000 crores, includes a Propylene Recovery Unit, an upgraded FCC Unit, and a Polypropylene Unit. The Polypropylene Unit is based on an advanced UNIPOL® technology platform, using the latest generation phthalate-free catalyst. The usage of the latest generation phthalate-free catalyst for the production of the entire range of Polypropylene grades aids in producing cleaner products which is advantageous for application in Pharma, Health & hygiene industries.

Source: https://www.polymerupdate.com/pressrelease/details/32819

- **BASF Catalysts India Private Limited inaugurates a new RD&A lab for automotive emissions control**

BASF Catalysts India Private Limited (BCIL), a subsidiary of BASF Environmental Catalyst and Metal Solutions (ECMS), has inaugurated a new Research, Development, and Application (RD&A) lab at its site in Mahindra World City, Tamil Nadu, Chennai. The strategic investment is focused on the development of emissions control catalysts that are tailored to the unique needs of the Indian automotive market. This new RD&A lab will enable the development of market-specific catalyst formulations that meet the unique needs of the Indian market with agility and flexibility.

Source: https://catalysts.basf.com/news/basf-catalysts-india-private-limited-inaugurates-a-new-rd-a-lab-for-automotive-emissions-control-solutions

- **Ohmium Launches Newest PEM Electrolyzer Gigafactory**

Ohmium International ("Ohmium"), a leading green hydrogen company that designs, manufactures, and deploys advanced Proton Exchange Membrane (PEM) electrolyzers, has announced the official launch of its new gigafactory in Doddaballapura, just outside of Bengaluru, India. Covering close to 14,000 square meters of production space, the state-of-the-art manufacturing facility is ramping up to ship 2 gigawatts (GW) of fully assembled and tested

electrolyzer systems to meet the demands of Ohmium's global project pipeline. The new gigafactory is Ohmium's second manufacturing facility in India, and its first to bring together key manufacturing, assembly, quality assurance, testing, warehouse, and shipping facilities under one roof. Ohmium's research engagements with India's CSIR-Central Electrochemical Research Institute (CSIR-CECRI) and IIT Madras Research Park (IITMRP) enable the rapid transfer of innovation into production to meet the growing demand for green hydrogen projects in India and around the world.
Source: https://www.cnbctv18.com/market/gail-share-price-commissions-green-hydrogen-plant-madhya-pradesh-fuel-captive-capacity-19417863.htm

- **BPCL selects Lummus Technologies for new large-scale ethylene plant in India**

A global provider of process technologies and value-driven energy solutions, Lummus Technologies, announced an award for multiple technologies from Bharat Petroleum Corporation Limited (BPCL) for a new world-scale ethylene plant and associated downstream units in Bina, Madhya Pradesh State, India.
The project is part of BPCL's Bina Petrochemicals and Refinery Expansion Plan. Once complete, the expansion will produce polymer-grade ethylene and propylene to supply downstream polymer production units, with a capacity of 1200 KTA of ethylene and 550 KTA of propylene.
Source: https://www.psuconnect.in/news/bpcl-picks-lummus-technologies-for-new-large-scale-ethylene-plant-in-india/43844

- **LOHUM to invest Rs 2,000 cr for a plant at Krishnagiri, Tamil Nadu**

The Greater Noida-based LOHUM will invest Rs 2,000 crore over six years in a new plant at Krishnagiri in Tamil Nadu, towards producing cathode active material (CAM) used in battery manufacture. The company, a producer of sustainable battery raw materials through recycling, repurposing, and low-carbon refining, has 65 acres of land and expects to start work at the 20-GWh plant in 18 months. In the first phase, it will invest Rs 400 crore in two years. The products will be supplied to battery manufacturers, including Ola, Exide, TVS, and Amara Raja. The company has seven plants in Noida, one in Gujarat, one in Krishnagiri, and one in the UAE. The plant will take 20,000 tpa of batteries for recycling and production of cobalt, nickel, and lithium with each 1,000-tonne capacity, a pilot line for the production of CAM, at around 750 MWh. This will be scaled up at the Krishnagiri plant to 20 GWh in phases. The plant will initially produce five to 10 GWh.
Source: https://www.projectstoday.com/News/LOHUM-to-invest-Rs-2000-cr-for-plant-at-Krishnagiri-Tamil-Nadu

- **Lummus supply SRT® heaters to Reliance Industries**

Lummus Technology announced awards from Reliance Industries Ltd. to supply four Short Residence Time (SRT®) ethylene cracking heaters at two facilities in India.Two heaters will be installed at Reliance's gas cracking unit (GCU) in Dahej, Gujarat, India, and the other two at Reliance's GCU in Nagothane, Maharashtra, India. The heaters will also be equipped with

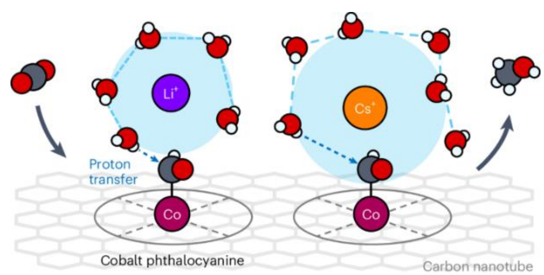
advanced heat recovery systems designed for 100 percent hydrogen firing to maximize energy efficiency.
Source: https://heat-exchanger-world.com/lummus-supply-srt-heaters-to-reliance-industries/

- **Aether Industries to commission 15 MW solar power plant in Gujarat's Bharuch**

Aether Industries will commission a 15 MW solar power project (Auto-Tracker Modules) under the Captive Power Producer (CPP) segment in the Bharuch district of Gujarat to become more sustainable. Earlier, in July 2023, Aether Industries had commissioned a 16 MW solar power project (Fixed Modules) under the CPP segment and this new solar power plant under CPP will add to its renewable energy sources and further move towards sustainability. The solar power farm will be in Gujarat's Bharuch District and spread across 60 acres. The phase-wise commissioning of the solar power plant is set to begin as early as the next financial year starting in April.
Source: https://www.saurenergy.com/solar-energy-news/aether-industries-to-add-15-mw-solar-capacity-to-captive-capacity

## Scientific Updates

- **$CO_2$-to-methanol electro-conversion on a molecular cobalt catalyst facilitated by acidic cations**

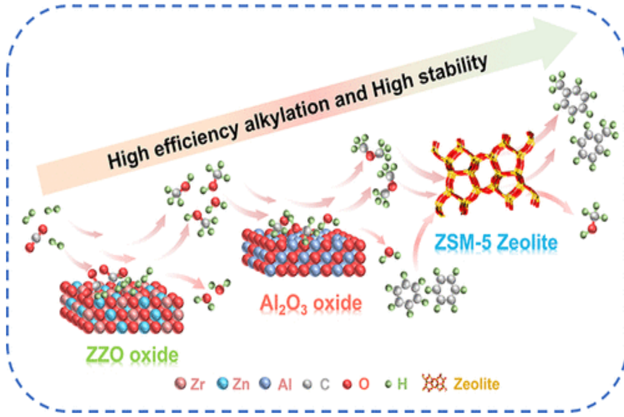



The crucial role of electrolyte cations in $CO_2$ electroreduction has received intensive attention. One prevailing theory is that through electrostatic interactions or direct coordination, larger cations such as Cs+ can better stabilize the key intermediate species for CO and multicarbon (C2+) product generation, for example, on silver and copper, respectively. Here we show that smaller, more acidic alkali metal cations greatly enhance $CO_2$ to methanol conversion kinetics ($Li^+ > Na^+ > K^+ > Cs^+$) on an immobilized molecular cobalt catalyst, unlike the trend observed for CO and C2+. Through electrokinetic analyses and kinetic isotope effect studies along with computational investigations, we show that the hydration shell of a cation serves as a proton donor in the rate-determining protonation step of adsorbed CHO where acidic cations promote the proton-coupled electron transfer. ***This study reveals the promotional effect of the cation solvation environment on $CO_2$ electroreduction beyond the widely acknowledged stabilizing effect of cations.***
Source: Nature Catalysis July 2024 https://doi.org/10.1038/s41929-024-01197-2

- **Boosting Benzene Alkylation Conversion with $CO_2/H_2$ via a Triple Composite Catalyst**

The alkylation of benzene with $CO_2/H_2$ to synthesize toluene and xylene is of great significance for alleviating carbon emissions and upgrading light aromatics toward value-added chemicals.

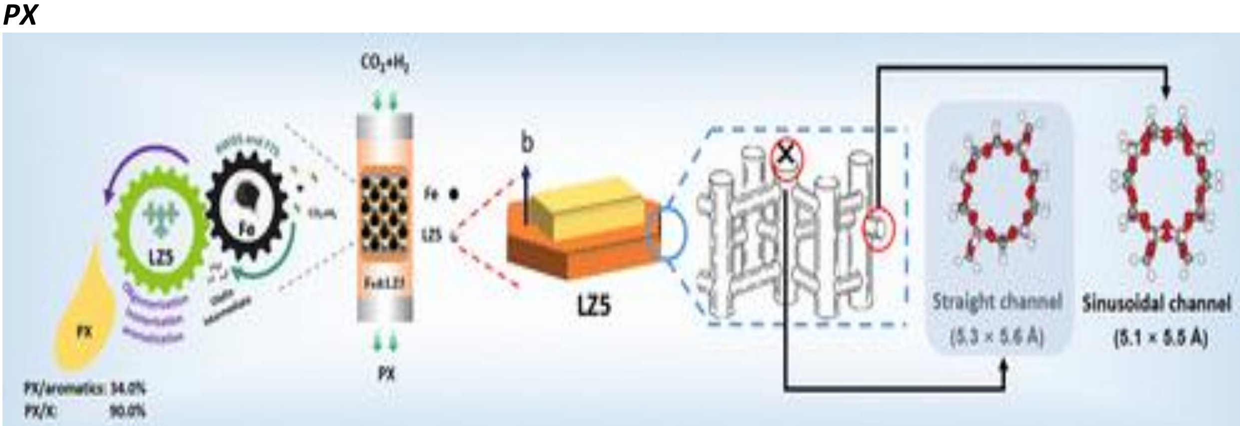
However, the alkylation reagent from $CO_2$ hydrogenation showed relatively weak alkylation activity and severe self-reaction, leading to a low alkylation efficiency. High-performance triple composite catalytic system is reporte using $ZnZrO_x$ oxide, $Al_2O_3$ oxide, and H-ZSM-5 zeolite as catalyst components for the alkylation of benzene with $CO_2/H_2$ to toluene and xylene. According to the results, $CO_2$ is hydrogenated to methanol on oxygen vacancies, methanol is dehydrated to dimethyl ether (DME) on Lewis acid sites, and benzene is then alkylated with the formed DME to toluene and xylene over the acidic sites of the zeolite. ***The combined selectivity of toluene and xylene among all hydrocarbons reached 97% at a benzene conversion of 9.7%, surpassing that of most reported traditional catalysts.***




Source: ACS Catal. July 2024 https://doi.org/10.1021/acscatal.4c02253

- **Iron-Based Catalysts Integrated with Twinned HZSM-5 as Efficient Catalysts for Paraxylene Synthesis by $CO_2$ Hydrogenation**

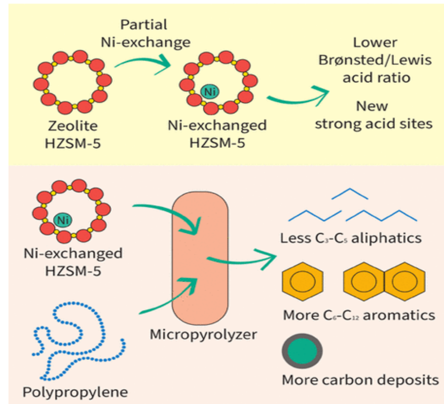
Optimization of zeolite geometries to break through the current selectivity limitations of $CO_2$ hydrogenation for the synthesis of high-value paraxylene (PX) is a promising and challenging topic.Twinned HZSM-5 (LZ5) with a high sinusoidal pore opening ratio was synthesized, and the tandem catalyst formed by coupling it with an iron-based catalyst could realize the highly selective production of PX by $CO_2$ hydrogenation. Under industrially relevant conditions, the $CO_2$ conversion was 31.5%, and the selectivities for PX in aromatics and in xylene (X) were as high as 34.0 and 90.0%, respectively. This good performance was attributed to the high sinusoidal pore opening ratio of the LZ5 in the tandem catalyst, improving its ability to screen xylene isomers. The particle size of LZ5 has a small effect on the selectivity of $CO_2$ hydrogenation to PX. In addition, the proper proximity of the two components also played a crucial role in the continuous and cocatalytic conversion of $CO_2$ to PX. ***The present work realized the improvement in the selective catalytic performance of zeolites through directional modulation of their pore structures. It provided a new idea for the design of efficient catalysts in hydrogenating $CO_2$ to PX***




*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/*

Source: Energy & Fuels, July 2024 https://doi.org/10.1021/acs.energyfuels.4c02194

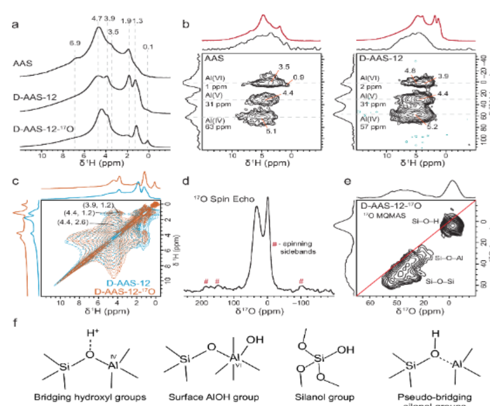
- **Conversion of Polypropylene into Light Hydrocarbons and Aromatics by Metal Exchanged Zeolite Catalysts**




In this study, the parent HZSM-5 zeolite I subjected to post-synthetic partial metal exchange with Fe, Co, Ni, Cu, and Ce cations to perturb Bronsted/Lewis acidity. Thus metal-modified HZSM-5 were investigated on the catalytic pyrolysis of polypropylene (PP) in a micro pyrolyzer connected to a two-dimensional gas chromatograph coupled to a time-of-flight mass spectrometer and flame ionization detector. Whereas Fe-, Co-, Cu-, and Ce-exchanged zeolites (with 2.5, 2.3, 1.9, and 0.8 wt % metal, respectively) had comparable product yields with the parent zeolite, Ni-exchanged zeolites with Ni content of 0.5 to 2 wt % were associated with enhanced BTX formation (28–38 wt %) compared to that of the parent zeolite (22 wt %). ***The higher amount of carbon deposits on Ni-exchanged zeolites compared to the parent and other metal ion-exchanged zeolites was attributed to the enhanced aromatization activity by the simultaneous decrease in the Bronsted/Lewis acid ratio and emergence of strong acid sites.***

Source: Langmuir 2024, 40, 18, 9636–9650; https://doi.org/10.1021/acs.langmuir.4c00453

- **Defects tune the acidic strength of amorphous aluminosilicates**




In this work, authors investigated defect engineering to fine-tune the acidity of amorphous acidic aluminosilicates (AAS). Authors introduced oxygen vacancies in AAS to synthesize defective acidic aluminosilicates (D-AAS). 1 H, 27Al, and 17O solid-state nuclear magnetic resonance (NMR) studies indicated that defects induced localized structural changes around the acidic sites, thereby modifying their acidity. X-ray photoelectron spectroscopy (XPS) and Fourier transform infrared (FTIR) spectroscopy studies substantiated that oxygen vacancies alter the chemical environment of Brønsted acidic sites of AAS. The effect of defect creation in AAS on its acidity and catalytic behavior was demonstrated using four different acid-catalyzed reactions namely, styrene oxide ring opening, vesidryl synthesis, Friedel-Crafts alkylation, and jasminaldehyde synthesis. The defects played a role in activating reactants during AAS-catalyzed reactions, enhancing the overall catalytic process. ***This study demonstrates defect engineering as a promising approach to fine-tune acidity in amorphous aluminosilicates, bridging the porosity and acidity gaps between mesoporous amorphous aluminosilicates and crystalline zeolites.***

Source: Nature Communication, 2024, 15, 6899 https://doi.org/10.1038/s41467-024-51233-9

## Catalysis Research out of India

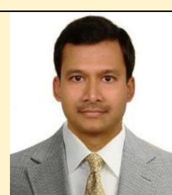
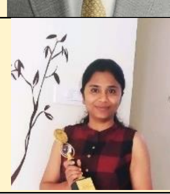

1. S. B. Narendranath, NP Nimisha, S Namitha, K K Shabana, NJ Venkatesha, CP Jijil, A Sakthivel, Ruthenium loaded moderate acidic SAPO-11 for hydrogenation of aromatic derivatives, **Journal of Porous Materials, 2024,** 31(3) 1077.
2. R P Gaikwad, I R Warkad, D S Chaudhari, S Jiang, J T Miller, H N Pham, A Datye, M B Gawande, Harnessing photocatalytic activity of mesoporous graphitic carbon nitride decorated by copper single-atom catalysts for oxidative dehydrogenation of N-heterocycles, **Journal of Colloid & Interface Science, 2024,** 676, 485.
3. A Prakash Tathod, Anjan Ray, S Arumugam, M Rawat, T S Khan, N Viswanadham, "Cascade Process for Coupling Molecular $H_2$-free Hydrogenation of $CO_2$ with Alkylation of Aromatics Using a Single-Bed Catalytic System" **ACS Sustainable Chemistry & Engineering 2024,** https://doi.org/10.1021/acssuschemeng.4c04219
4. R Verma, C Singhvi, A Venkatesh & Vivek Polshettiwar, "Defects tune the acidic strength of amorphous aluminosilicates" **Nature Communication, 2024,** 15, 6899 https://doi.org/10.1038/s41467-024-51233-9
5. R Bose, A Yacham, TK Patra, J J Varghese, P Selvam, N S Kaisare "Molecular Mechanism of Reversible Gas Adsorption and Selectivity in ZIF-90" **J. Phys. Chem. C 2024, 2024,** 128, 31, 13207–13216 https://doi.org/10.1021/acs.jpcc.4c01965
6. V Dosarapu, B Siddaramagoud, K Ramesh, S Mavurapu, M Baithy, M Varkolu, V Ravinder, C Vasam "Catalytic enhancement of biomass-derived furfural via Knoevenagel condensation using $Ru/Al_2O_3$-$ZrO_2$ catalyst for sustainable synthesis of value-added chemicals", **Applied Catalysis O: Open, 2024, 189, 206916** https://doi.org/10.1016/j.apcato.2024.206916
7. S Gonuguntla, A Jamma, B Jaksani, U Pal "Two-Dimensional (2D) Semiconductors for Solar to Hydrogen Fuel" **2D Semiconducting Materials for Electronic, Photonic, and Optoelectronic Devices, 2024 CRC Press**
8. G Perumal, "Production of biodiesel from waste cooking oil using a novel surface-functionalized $CaMoO_4$/ $TiO_2$ solid catalyst", **Renewable Energy, 2024,** 228, 120652 https://doi.org/10.1016/j.renene.2024.120652
9. S Das, G D. Yadav, "Tailored design of novel $Co^0$-$Co^{\delta+}$ dual phase nanoparticles for selective $CO_2$ hydrogenation to ethanol" **Journal of Environmental Science 2025,** 149, 598-615 https://doi.org/10.1016/j.jes.2024.01.047

## 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. **"Catalysis And Reaction Engineering"** Symposium (CARE) at the Indian Institute of Technology Madras (IITM) on 27th-28th, September 2024.
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. **18th Edition of International Conference on Catalysis, Chemical Engineering, and Technology"** (CCT 2024) during June 17-19, 2024, in 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).
8. Conference on **Advances in Chemistry for Energy and Environment (CACEE-2024**) from 16th -20th December 2024 at TIFR, Mumbai.

## List of New CSI Life Members


The Catalysis Society of India welcomes new life members who recently joined.

| Sr.No. | Name | Institute /Orgnaization |
|---|---|---|
| 1 | Dr. Indrajit Shown  | Professor, Department of Chemistry, Hindusthan Institute of Technology, Chennai Email: shownindrajit@gmail.com |
| 2 | Dr. Suverna Trivedi  | Assistant Professor, Indian Institute of Technology, Kharagpur Email: suverna.chemical@gmail.com |

*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/*

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|---|---|---|---|
| 3 | Dr. Naveen Kumar |  | Associate Professor Department of Chemistry Maharshi Dayanand University, Rohtak, India Email: nk944680@gmail.com |
| 4 | Dr. Dashrathbhai Patel |  | Associate Professor, Gujarat Technological University, Gandhinagar Campus, Gujarat, Email: dashrathbhaipatel@gmail.com |
| 5 | Dr. Hemraj Yadav |  | Ramanujan Fellow (SERB Gov. of India) School of Nanoscience and Technology, Shivaji University Kolhapur, Maharashtra, Email: hemrajy@gmail.com |

## Awards/Recognitions

### Shanti Swarup Bhatnagar Award (Rashtriya Vigyan Puraskar) 2024 to Prof. Vivek Polshettiwar


In a significant move to recognize and honor outstanding contributions to science, technology, and innovation, the Indian government has announced the inaugural **Rashtriya Vigyan Puraskars.**

Professor Vivek Polshettiwar who is working at the Department of Chemical Sciences, Tata Institute of Fundamental Research Mumbai announced the **Shanti Swarup Bhatnagar Award** in Chemistry which will be received on 23rd August 2024 from the President of India at Rashtrapati Bhavan, Delhi.


**On behalf of the Catalysis Society of India, we extend heartfelt congratulations to Professor Polshettiwar on this remarkable achievement and best wishes for many more recognitions.**

## Quote of the Month

***" Optimism is a happiness magnet. If you stay positive, good things and good people will be drawn to you."***
*— Mary Lou Retton*



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