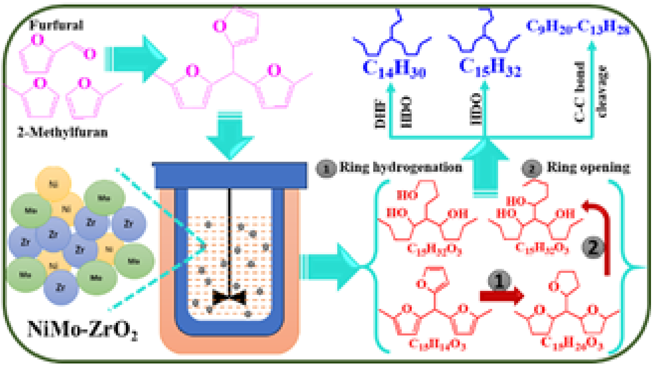

Figure-1: Sustainable aviation fuel from furanics

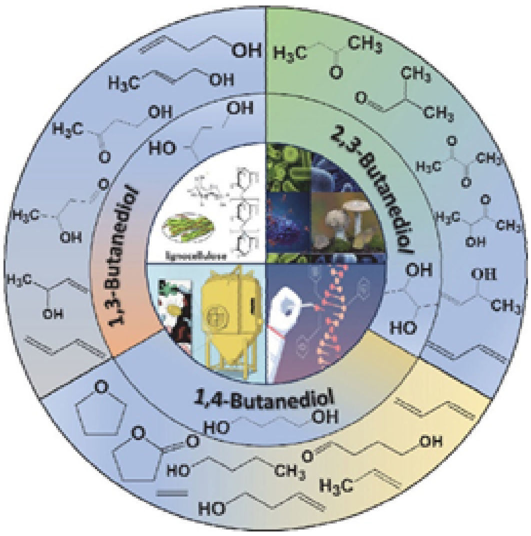

Figure-2: Biorefinery via butanediols platform

These kinds of breakthroughs will eventually mitigate dependence on fossil reservoirs for fuels/chemicals and carbon emission/waste management challenges. Expanding food production by around 70% from alternative sources is another need to overcome the futuristic challenge of feeding the massive global population. Microalgae could be a promising alternative to plant and animal-based food/feed sources, such as protein. However, the success of biorefining technologies depends mainly on techno-economic viability and environmental sustainability concerning existing petroleum technologies. Our work also encompasses techno-economic and life cycle analysis of the biorefining processes. Though environmental benefits are evident, economics are currently not favourable for all biorefining processes but will be eventually viable when petroleum scarcity reaches its peak. The policy should be framed to deploy successful biorefining processes systematically to meet long-term sustainability goals for fuels, commodity products, and food.

Dr Sunil Kumar Maity
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Use of Earth-abundant Metal Catalysts for sustainable and atom-efficient Reactions Synthetic Organometallic Chemistry and Catalysis Lab (SOMCC Lab)

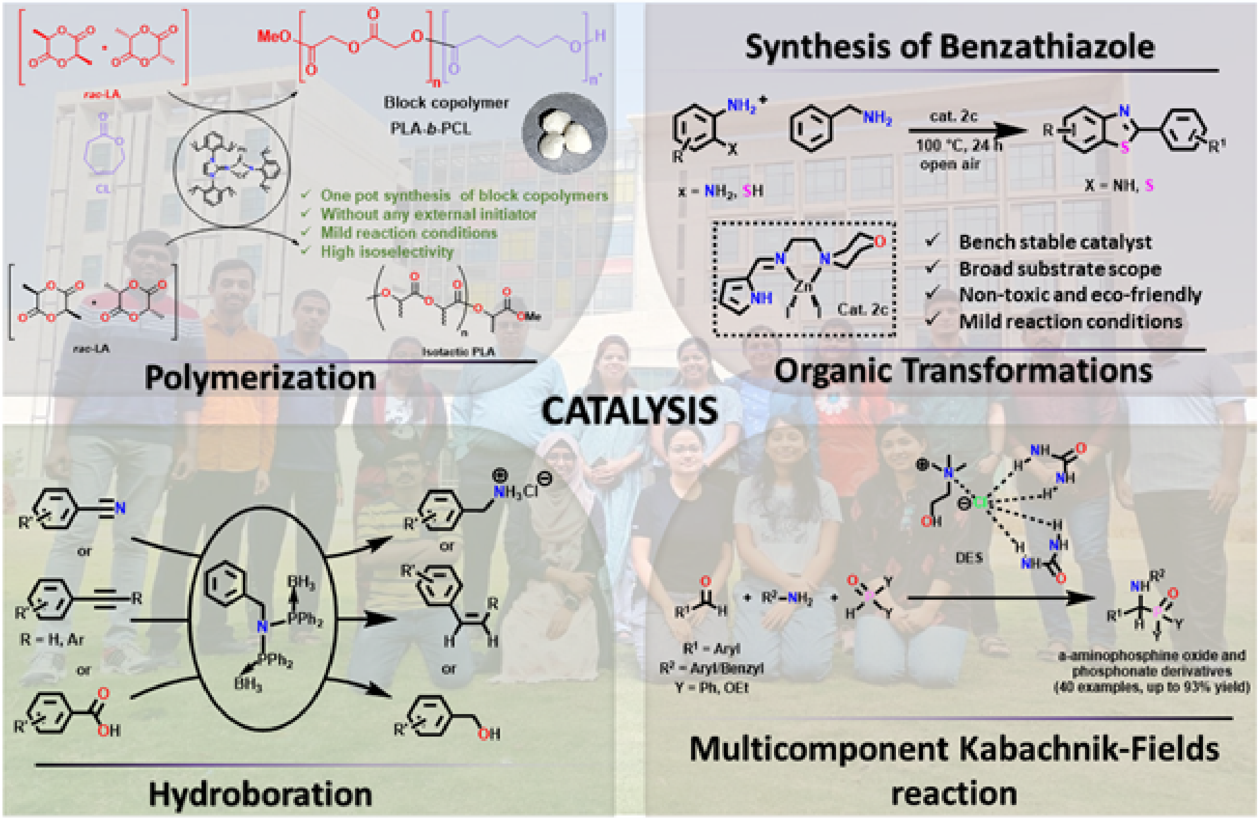
KID: 20230415

Motivation:

Our research group is working on innovative projects in organic and organometallic chemistry. We believe that great efficiency in all organic reactions is necessary to prevent the creation of hazardous contaminations, minimize waste and byproducts, and ensure the sustainability of chemical production in contemporary industrial processes. To accomplish this, well-defined organometallic complexes must be integral to homogeneous catalysis in methods that are safe for the environment. Catalysis plays a pivotal role in many areas of chemistry and has resulted in the creation of several sustainable and atom-efficient methodologies. Therefore, chemists play a specific role in this research area to find suitable alternatives to these non-renewable plastics and value-added products from renewable sources.

Problem Statement & Solution:

Transition metals, lanthanides, have received more extensive research which are relatively expensive, low abundance, toxic, and disposal of these metals can have negative impacts on ecosystems and humans. On the other hand, earth-abundant metal complexes based on alkali metals, alkaline earth metals, aluminium, and zinc shine as sustainable and affordable alternatives to precious metal catalysts, offering a crucial solution to our environment and resources, particularly in large-scale organic transformations and ring-opening polymerization reactions. The substitution of less expensive, safer, and ecologically friendly main-group metals for transition metals is widely desired due to the inherent disadvantages of transition metals. After considering all these drawbacks and issues, our group has been interested in exploring these earth-abundant metal complexes in the field of catalysis.



Scheme Diagram of Catalysis by Synthetic Organometallic Chemistry and Catalysis Lab (SOMCC Lab)

Differentiating factor:

In the field of organic transformations in catalysis, the predominance of nitrogen-containing heterocycles in natural products and drug molecules has led to the design of new drug derivatives in pharmaceutical chemistry. Also, organoboron compounds, which are produced by the hydroboration of unsaturated compounds, are very useful in various organic transformations. For example, borylamine, which is produced by the hydroboration of nitriles and amides, is essential to several industrial operations, including the synthesis of polyesters and dyes.

They also serve as building blocks for medicinal chemicals, resulting in the creation of artificially beneficial molecules. We also actively research for the development of new eco-friendly solvents which has become an important aspect of green catalysis. DESs are defined as the mixtures of two or three compounds that can be associated mainly via hydrogen bonds. DESs have various properties like biodegradability, low toxicity, and inexpensive nature, which make them better alternatives to ionic liquids (ILs).

These DESs have wide applications in electrochemical processes, polymer syntheses, catalysis, extraction of bioactive compounds from biomass, and many more. We have mainly focused on catalysis and therefore we have used DES as a dual role of solvent as well as catalyst in different organic reactions. In the field of polymerization, when compared to other metals, using earth-abundant metals as an ROP initiator has several benefits. Because of the incredibly low electron affinity of alkali metal ions, the ligand-electrons in these complexes are readily available for monomer activation.

Industry applications and social implications:

Catalysts based on alkali metals, alkaline earth metals, aluminium, and titanium can also be used for various catalytic processes. These metal catalysts have a long way to go before they are used commercially, but sustainability will always be the driving force.

Next phase of the work:

We are carrying out different projects as discussed earlier and developing different catalyst systems with diverse ligand backbones for various catalytic reactions such as hydroboration of nitriles, alkynes, and carboxylic acids; catalytic cyanosilylation of ketones; cross-dehydrocoupling of amines and silanes; synthesis of urea, biuret, isourea, isothiourea, phosphorylguanidine, and quinazolinones; catalytic addition reactions of amines, thiols, and diphenyl-phosphine oxides to heterocumulenes and copolymerization of various monomers. For biodegradable polymers, the produced PLA and block copolymers will be employed in drug delivery systems. The literature contains reports of drug administration methods that make use of biodegradable polymers such as polyglycolic acid (PGA) and polylactic acid (PLA). Therefore, it is appropriate to use biopolymers to deliver medications to cancer cells in a safe and controlled manner.

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