Telescoping Sustainable Catalysis: Technologies Impactful to Organic Synthesis in Industry

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Chemistry Seminar on *Sustainable catalysis*

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Abstract: Organometallic catalysis requires both the catalyst and solvent, with the catalyst consisting of two components: the metal and the ligand. Recycling the metal is easier than the ligand, which is expensive and slowly breaks down during catalysis, leading to the catalyst's death. Therefore, ligand-free catalysis is highly desirable. However, the challenge with ligand-free catalysis is that it results in the agglomeration of metal and the lack of optimal steric and electronic properties at the metal center, which can lead to easier oxidation of the lower oxidation state of metal. To address this issue, we developed a ligand-free nano-heterogeneous catalysis that is both stereoretentive and stereoselective. We achieved this through secondary interactions arising from the in-situ formation of supramolecular structures, which arise from substrate-solvent-metal nanoparticle interactions. This approach allowed for sustainable catalytic processes that are both economical and resource-efficient and have the potential to achieve ligand-like structures.

The use of solvents in organic processes costs the environment heavily, with over 80% of the waste generated coming from their usage. Using water as a solvent has the potential to save the environment as it is safe, stable, inexpensive, and naturally abundant. However, water is mostly used in syntheses for reaction work-up rather than as the reaction medium. Despite that, water has many remarkable features that make it effective and environmentally cleaner for chemistry. For example, it enhances catalysis and controls reaction selectivity via metal-micelle cooperativity or the shielding effect of the micelle. Therefore, using water in synthesis enables powerful catalysis that avoids expensive ligands and toxic organic solvents, increases worker and environmental safety, and adds tremendous economic value. In addition to these benefits, some current limitations of chemistry in water will also be discussed.

About the speaker: Prof. Sachin Handa is a tenured associate professor in the Chemistry Department at the University of Missouri, Columbia. He completed his Ph.D. in less than four years in 2013 and continued his research work as a postdoc fellow with Prof. Bruce Lipshutz from 2013-2016. He started his independent career in 2016. His research primarily revolves around green chemistry, energy, nanocatalysis, and photochemistry. He has recently been honored with the NSF CAREER award, the Ralph E. Powe Junior Faculty Enhancement Award in Physical Sciences by Oak Ridge Associated Universities, and the ACS Peter J. Dunn Award for Green Chemistry and Engineering Impact in the Pharmaceutical Industry. Besides fundamental research, his work also focuses on synthetic problems associated with the pharmaceutical industry and, therefore, is funded by several top pharmaceutical industries. Aside from academic work, he serves on editorial boards of various journals such as *ACS Sustainable Chemistry and Engineering*, *Green Chemistry Letters & Reviews*, and *Molecules*. He is a member of the ACS Green Chemistry and Engineering advisory board.