

Catalyst accelerator: metallo-nanocatalysis for a self-sustaining tomorrow

Editorial

If we consider modern organic synthesis is the main body of organic chemistry then, catalysis should be the heart of that as an accelerator for chemical transformations. Almost all the commercially available chemicals are produced by the methods those involve at least one catalytic step. So there is a growing demand of catalysis in industrial application. The growing needs of industry to synthesize a chemical by more economic way as well as the environmental concern makes synthetic chemist to take the challenge of “ideal synthesis” that means synthesis with almost 100% yield and selectivity with cost-effective, energy-saving, environmentally benign, and sustainable way. At this point the story of catalysis begins with as it is the “Midas touch” for the synthetic organic chemist to fulfill their goal towards “ideal synthesis”.

Recently scientists categorized catalysis mainly in three fields, Homogeneous, Heterogeneous and Biocatalysis. Homogeneous catalysis mainly has two subfields one is metallocatalysis and another is organocatalysis. But the last category is not the focus of this Editorial. In homogeneous catalysis transition metal catalysts are the most intensely studied one. In the presence of d-orbital's they can easily activate substrates and accelerate the reactions by means of coordination, ligand exchange and other mechanism leading to the formation or cleavage of carbon-hydrogen, hydrogen-hydrogen and carbon-carbon bonds. The activity and selectivity of these catalysts can be tuned very easily through tuning and modifying their coordinating partners.

There are numerous outstanding example of transition metal catalyst in different fields. A few of them are as follows, asymmetric hydrogenation (Rh, Ru, Ir etc.), asymmetric epoxidation and dihydroxylation (Ti, Os and other complexes), olefin metathesis (Ru, Mo etc.), and Pd-catalyzed cross coupling reactions. Transition metal catalysts for hydrogenation and cross-coupling reactions have been shown to exhibit extremely high reactivity and enantioselectivity, which are comparable to the enzymatic systems. However, despite of their numerous advantages and large use in chemical industries, they also have some drawbacks; mainly they are very difficult to recover from the product or post-reaction mixture. This can be overcome by supporting the active catalytic moiety on the solid support materials and approaching to heterogeneous catalysis.

Heterogeneous catalysis often possesses numerous advantages such as handling simplicity, efficient recovery, ease separation, high stability and outstanding turn over. There are many examples of transition metal-based heterogeneous catalyses such as C-C bond formation and carbon-heteroatom coupling. A few listed name reaction of this type are as follows, Heck, Shonogashira, Suzuki-Miyaura, Kumada-Corriu, Negishi, Stille, Hiyama and Fukuyama coupling reaction, which found most broadly industrial application. The wideness and applicability of C-C bond formation reaction can be evidenced by the Nobel Prize for chemistry (2010) has been attributed to Heck, Negishi and Suzuki. In spite of this vast applicability heterogeneous catalysis still has disadvantages; the major one lies with their low interaction probability due to phase separation, low

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reactive surface area and less catalytic power.

Despite these achievements, most of the known transition-metal guided homogeneous and heterogeneous catalyses do not meet the requirements for modern industrial manufacturing processes. Their main limitation is low efficiency and catalytic turn over. To overcome the limitations of the aforementioned two catalytic systems, a new catalytic system is needed that can have the advantages over homogeneous and heterogeneous system, allow all the catalytic active sites to be accessible and effective, and make catalyst separation simple. Recent advances on nanocatalysis reveal that they can pave a new way towards new catalytic system having all the desired qualities to be the futuristic catalysts for “ideal synthesis”. Nanoparticles can substitute conventional materials and serve as active and stable heterogeneous catalyst due to their small size, low coordination number, active surface, enhanced contact with the reactants, akin to those of homogeneous catalyst; thus they are the “balanced catalyst”, organic chemist are looking for. Now-a-days nanoparticle based catalyst are the hot field in catalysis chemistry. Thus application of nanocatalysis is an emerging research field for all organic transformations.

Now in case of future application the main development is expected, in the field of direct C-H bond functionalization reaction. These reactions offer new routes for synthesizing useful compounds without the need for tedious functional-group transformations and have markedly increased synthetic efficiency. Other recent hottest topic in this fields are hydrogenation of CO₂ a mimicking reaction of photosynthesis, biomass conversion and selective oxidation of simple aromatic molecules. With growing environmental concern, the need of replacement of expensive and/or toxic transition metals with nonprecious and biocompatible metals, especially iron, manganese, has drawn considerable interest among synthetic chemists in academia and industries. The unique reactivity of nonprecious metals can be expected to offer new opportunities for futuristic catalytic systems. Although many obstacles to balancing catalyst compatibility remain, the need to develop highly efficient catalysts and related catalytic reactions is a never-ending challenge in synthetic organic chemistry.

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Conflict of interest

There is no Conflict of interest.