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Editorial

Porous Solids: A Catalytic and Green Chemistry Viewpoint

Anand C* and Vinu A

Australian Institute for Bioengineering and Nanotechnology (AIBN), The University of Queensland, Australia

Corresponding author

Chokkalingam Anand, Australian Institute for Bioengineering and Nanotechnology, The University of Queensland, Brisbane 4072, QLD, Australia, Tel: +61-7-334-64168; Email: c.anad@uq.edu.au

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INTRODUCTION

The phenomenon of reducing the energy requirement of a chemical process by changing the rate of attainment of equilibrium through lowering of activation energy is termed catalysis and the material as catalyst. However, catalysts do not alter the equilibrium position of a reaction which are controlled thermodynamically and require high pressures. Recent estimations revealed that ca. 90% of chemicals ranging from bulk chemicals to consumer products come into contact with a catalyst at one stage or another of their manufacturing process. Depending upon their relative reaction medium catalysts can be classified into two basic types, heterogeneous and homogeneous. The world wide effort to replace homogeneous acid catalysts by heterogeneous catalysts in industries is to control pollution and waste. In homogeneous type, the catalysts are in the same phase as the substrate and are uniformly distributed. As the catalyst gets dissolved in the reaction medium almost all the reactions under homogenous type takes place within the liquid phase whereas in most cases of heterogeneous system the catalyst used is a porous solid and the reaction takes place either on its external surface or surface within the pores of the solid. Heterogeneous catalytic systems, in which fluid reactants are reacted over solid acid catalysts, are the most widely preferred catalytic processes in the manufacturing industries at present. When compared to their homogeneous counterparts following are the advantages of heterogeneous systems:

- Minimal pollution, less corrosion and wastes
- High activity, selectivity and suppression of side products
- Shape-selectivity
- Easy separation of product and catalysts from the reaction mixture
- Use of renewable starting materials
- Easy separation of end products

The concept of green chemistry has gained momentum among researchers both in academic and industries as a tool for achieving sustainability by promoting innovative chemical technologies that reduce or eliminate the use or generation of hazardous substances in the design, manufacture and application of chemical products. Strong legislative enactments towards controlling discharge of waste products from industries into the environment and their restrictions in the manufacture, transport, storage and use of certain hazardous chemicals has sparked the introduction of cleaner technologies. Realizing the unsustainable consequences of exceeding the Earth's natural capacity in dealing with the waste and pollution which industries generate, Anastas and Warner coined a set of twelve principles as green chemistry. Heterogeneous catalysis is an omnipotent tool to realize all the twelve principles of green chemistry. Heterogeneous system is more convincing in controlling environmental pollution. Two significant factors of heterogeneous catalysts that influence the environmental impact of cleaner chemical processes are (1) E-factor, i.e. the mass ratio of waste to product formation and (2) atom efficiency, which is the ratio of the molecular weight of the desired product to the sum of the molecular weight of all other products formed. Heterogeneous catalysts are considered to be viable system contributing green and sustainable chemistry in a superior way than the homogeneous catalysts and also as the key to achieve the E-factor and atom efficiency. Porous solids as heterogeneous catalytic systems have the advantages of ease of recovery and recycling and are readily amenable to continuous processing.

Porous materials have widespread applications such as catalysts, catalyst supports, adsorbents sensors, data storage, electrical and biomedical devices due to their high thermal, hydrothermal, mechanical and chemical stabilities as well as high specific surface area, large specific pore volume and pore diameter (Figure 1). The IUPAC has recommended specific nomenclature for classification of porous materials into three groups based on their predominant pore size: microporous

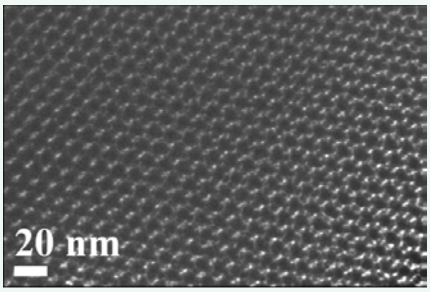

Figure 1 HRTEM image exhibiting well-ordered structure and uniform array of pores in SBA-15 sample, one of the highly explored materials of porous solids.

(pore diameter < 2 nm), mesoporous (2 nm < pore diameter < 50 nm) and macroporous (pore diameter > 50 nm). Zeolites, zeotype materials and activated carbons are examples of microporous materials. M41S family, mesoporous AlPOs, aero-gels and most recent SBA-1, SBA-15 and KIT-5 are few examples of mesoporous materials. Examples of macroporous materials include silica-gel, activated charcoal and CPG (controlled porous glass). Porous materials offer advantages such as easy handling, catalyst regeneration, environmentally safe disposal, high activity, selectivity and negligible level of reactor plant corrosion. Recently, research and applications of porous solids have undergone astounding progress owing to the aforementioned multiple functionalities [1-3].

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