Multifunctional Mesoporous and Nanostructured Catalysts: New Synthetic Methods and Applications

Tewodros Asefa,[1,2]

[1] Department of Chemistry and Chemical Biology, Rutgers, The State University of New Jersey, 610 Taylor Road, Piscataway, New Jersey 08854

[2] Department of Chemical and Biochemical Engineering, Rutgers, The State University of New Jersey, 98 Brett Road, Piscataway, New Jersey 08854

We have recently developed a series of synthetic methods to various multifunctional nanometer-sized porous metal oxide catalysts containing organic, organometallic or metallic nanoparticles. The materials are shown to serve as efficient recyclable catalysts for a wide range of reactions. Bifunctional mesoporous materials containing organoamine and transition metal complex are capable of efficient catalysis of multi-step in one-pot tandem reactions are also synthesized. By placing the organoamine grafted mesoporous material in fixed bed reactors, a continuous nitroaldol (Henry) reaction producing selectively either nitrostyrene, nitroaldol, or the Michael product is demonstrated. The rates of conversion and reaction selectivity are found to depend directly on the residence time of the reactants in the reactor, the types of reactants and on the reaction temperature. The continuous reactor and the catalysts are proven to catalyze the reactions efficiently, producing the respective exclusive products continuously for several days. Highly ordered mesoporous fluorosilicas (OMFs) and nanoporous and corrugated fluorosilica nanospheres which contain significant wt% F are synthesized from parent mesoporous silicas (MCM-41 and SBA-15) and silica nanospheres under ambient conditions using dilute non-aqueous solutions of triethyloxonium tetrafluoroborate (Et_3OBF_4). The fluorination synthetic procedure is also applied to sulphonic acid (-SO_3H) functionalized SBA-15. The resulting material shows an enhanced catalytic activity in the acid-catalyzed ring-opening reaction of styrene oxide by aniline to produce the corresponding β-aminoalcohol. Finally, novel controlled wet-etching synthetic methods to produce corrugated, nanoporous and hollow silica and core-shell silica nanospheres with diameters of 60 – 500 nm and their use for stabilization of enzymes and metallic nanoparticles for catalysis will be discussed.