Abstract

Surface functionalization has emerged as one of the most important research areas in the field of advanced functional materials. Surfaces determine how objects interact with their environment and surface chemistry is a research domain of great interest, particularly in the study and design of nanostructures. Various techniques based on physical and chemical methods are available to functionalize the surface. The chemistry developed for surface functionalization mainly uses silanes on oxides, thiols on gold and electrostatic interactions for charged surfaces. Chemical covalent attachment of molecules on the surface offers great advantages over physical adsorption based strategies. Nanomaterials/particles to which functional molecules have been covalently attached through appropriate chemistries have wide spread applications in catalysis, separation, decontamination, drug delivery and sensor designing. In this thesis work, catalytic application of the functionalized nanoparticles has been discussed. Nanoparticles show higher catalytic activity because of their high surface area and colloidal nature. Because dispersions of these particles in appropriate solvents can be quite stable, they display the advantages of both homogeneous and heterogeneous catalytic systems. But the main problem in nanoparticle based catalysis lies in separating them from the reaction mixture without any aggregation and loss of catalytic activity. Thus there is a need to make macroscopic structure with the help of nanoparticles which will address the separation issue also. This will also help to develop continuous flow reactors for industrial application.

In the last decade, scientists have focused on the assembly schemes that allow building macroscopic structures from nanoscopic building blocks. In catalysis, hierarchical macroscopic structure is important because the macropore can favour mass transfer of the reactants where as the active site of the catalyst can be located in the mesopore or micropore. To make hierarchical materials different techniques has been pursued by the scientists. Mainly, surfactants and amphiphilic copolymers can be used as templates to synthesize ordered mesoporous and macroporous materials. Macropores have been fabricated in the system using latex spheres, nanoparticles, emulsions as templates.
In the content of this thesis work, silica and mesoporous silica nanoparticles were specially chosen since they are ideal candidates for functionalization due to their large surface area (~1000 m$^2$/g), large and tunable pore sizes (2-50 nm), hydrothermal stability and thicker walls that can be easily functionalized using simple silanol chemistry. Different functional organic groups such as amines, thiols, vinyls, carboxylic acids, sulphonic acids were installed on the surface of different siliceous materials. The functional groups installed by such modifications can be used to anchor various synthetic catalysts, bio-molecules and polymers to generate novel functional materials.

One more aim of the present work was to develop a complex hierarchical functional material which can display good catalytic activity. To achieve that aim, different level of complexity has been incorporated into the system starting from fabrication of very simple functionalized material. Various functionalized nanomaterials were synthesized, characterized and their catalytic activity was studied. We also demonstrated that these functional nanomaterials could be assembled and stitched together through covalent bonds and would yield functional 3-dimensional, porous materials.