Preface

The term *nano*, which is derived from the Greek word *nanos,* which means dwarf, designates one billionth (10^{-9}) of a meter. Thus, the science of nanostructures and nanomaterials deals with objects in condensed matter physics on a size scale of 1 to 100 nm. The unique structure and properties of small atomic aggregations are of considerable scientific and technical interest, because they represent an intermediate state between the structure and properties of isolated atoms and bulk solids. In very small crystallites of the size of a few nanometers, new properties appear due to high surface-to-volume ratios, quantum size effects or scaling laws, which can be controlled by the size and shape of crystallites or particles. Nanoparticles tend to agglomerate due to their high surface energy. Hence, stability of nanoparticles is a great practical challenge to the science and technology. The past couple of decades has witnessed an exponential growth of activities in this field worldwide, driven both by the excitement of understanding new science and by the potential hope for applications and economic impacts. The largest activity in this field at this time has been in the synthesis of new nanoparticles of different sizes and new shapes. These offer many potential applications in the different interdisciplinary fields of chemistry, physics, material science and biology. A 'green chemistry' approach for the size controlled synthesis of mono- and bimetallic nanoparticles has been focused in this dissertation. The current development of nanoscience involves synthesis of bimetallic nanoparticles, composed of two different metals. We have also synthesized several core-shell and inverted core-shell type bimetallic nanoparticles by a 'green chemistry' approach. Moreover, metal clusters are extensively exploited as catalyst particles for a wide number of chemical reactions considering the progressive decrease in the reduction potential in the nanometer dimension. Again, the catalytic activities of the metallic nanoparticles get enhanced with the bimetallics compared to the monometallic counter parts. The synthesized mono- and bimetallic nanoparticles find catalytic and spectroscopic applications. Metal nanoparticles, stabilized in organic media are found to be advantageous for several spectroscopic and catalytic applications. We have ventured

into a new route for the synthesis of biomolecule functionalized copper nanoparticles in non-polar solvent, toluene. The physics of these particles and the application of computation methods to understand their behavior is being investigated. The synthesized particles show catalytic activity for the synthesis of octylphenyl ether. Self-assembly of the nanoparticles by different techniques is being pursued. Although many future applications will make use of the properties of the individual nanoparticles, there are other important applications that would require self-assembled nanoparticles. A wet chemical technique for the synthesis of self-assembled silver nanoparticles has been reported. The synthesized particles are found to be an elegant substrate for surface enhanced Raman scattering (SERS) studies. Using these aggregates we are able to reach almost to the single molecular level. We have developed a simple wet chemical route for the synthesis of copper nanorods. The rod shaped particles has been used as catalyst to study the oxidative phenol coupling reaction. Moreover immobilization of preformed metal nanoparticles onto the polystyrene beads becomes useful to study size-selective catalysis by metal nanoparticles. Finally, we have developed a synthetic strategy for the immobilization of pre-formed gold nanoparticles of different size onto the anion exchange resin beads to obtain the core-shell type metal nanocomposites. The composite material shows size selective catalytic properties for the reduction of a series of aromatic nitrocompounds. To make a general conclusion, gold particles of different sizes were also used as catalyst without any support.

Synopsis

Chapter I. This chapter describes a brief overview on nanoscience and nanotechnology. The unusual properties of the metal nanoparticles as a consequence of their reducing size has been discussed in the light of quantum confinement. Different techniques related to the synthesis of metal nanoparticles have been discussed. Finally some selected applications of such nanomaterials have been reported relevant to the following chapters of the thesis.

Chapter II. In this chapter, the general method for the synthesis of metal nanopartilcles using different sugar molecule has been described. The method was extended for the synthesis of core-shell and inverted core-shell type bimetallic nanoparticles also. The synthesized mono and bimetallic nanoparticles were then exploited as an effective catalyst for the reduction of 4-nitrophenol. Finally the particles were used as an elegant SERS substrate using crystal violet as a Raman probe.

Chapter III. This chapter demonstrates a new route for the synthesis of L-cysteine and or 1-dodecanethiol functionalized copper organosol in toluene using copper stearate as the copper precursor. The synthesized particles were then employed as an effective catalyst for the synthesis of octylphenyl ether.

Chapter IV. This chapter presents a wet chemical approach for the synthesis of self assembled of silver nanoparticles under alkaline condition using resorcinol as the reductant and stabilizer. The effect of vibrational energy and heat shock on the aggregate has been described. The synthesized aggregates were found to be an effective SERS substrate for different molecular probes. Using these aggregates detection of molecule almost to the single molecular level is possible.

Chapter V. This chapter reports the selective one-pot synthesis of copper nanorods and nanospheres under seedless and surfactantless condition using glucose under alkaline condition. The catalytic activity of the as synthesized copper nanorods has been substantiated from the oxidative phenol coupling reaction between 2-naphthol species.

Chapter VI. Here in we report the synthesis and size-selective catalysis by gold nanoparticles for the reduction of a series of aromatic nitrocompounds. The synthesized gold particles were immobilized onto the anion-exchange resin beads by the ready exchange of the anion of the anion exchange resin with the negatively charged gold nanoparticles. Gold particles were also used directly as a catalyst without any support. It was observed that smaller particles show higher activity for the reduction reaction.