Graduate Course on **Nanochemistry**

(By Vivek Polshettiwar, TIFR, Mumbai)

1. Basic Concepts of Nanochemistry

1.1. Introduction to nanoscience and nanotechnology.

1.2. Discussion on various phenomenon at nano-scale, such as size, shape, surface, surface energy, surface stabilization, characteristic length, self-assembly, defects, size quantization, surface plasmon, conductivity, tunneling, magnetism, etc.

2. Synthesis of Nanomaterials

2.1. Basics of nanofabrication method:, top-down, bottom-up approaches, gas phase, liquid phase, solid phase synthesis, self-assembly, templated synthesis, sol-gel, electrodepostion.

2.2. Fundamentals of nanoparticle formation: thermodynamic approach, supersaturation-nucleation-growth, homo vs hetero nucleation.

2.3. Synthesis of nanoparticles: metallic, semiconducting, quantum dots, oxides, hybrids. Micelles and microemulsion as templates for synthesis.

2.4. 0, 1 and 2D nanoparticles. Core-shell nanoparticles. Shaped nanoparticles.

3. Characterization Techniques

3.1. Discussion on various techniques available for characterizing the nanomaterials to analyze their size, shape, morphology, crystalline phase, oxidation states, textural properties (surface area, pore volume, pore size), thermal stability, light absorption, and band gap.

3.2. Scanning electron microscope (SEM) & Transmission electron microscopy (TEM).

3.3. X-ray powder diffraction (XRD) & X-ray photoelectron spectroscopy (XPS).

3.4. Scanning tunneling microscopes (STM) and atomic force microscopes (AFM).

3.5. Thermal analysis.

3.6. N_2 sorption techniques for textural properties of the material.

3.7. Solid state NMR for characterizing functionalized materials.

4. Applications of Nanomaterials

4.1. Nanocatalysis: fundamentals, homogeneous vs heterogeneous catalysis, effect of surface area, effect of particle size, shape and morphology. Effect of composition, bimetallic system etc.

4.2. Nanomaterials for photo-catalysis [dye degradation, water splitting, organic transformations, plasmon assisted photo-catalysis, band gap tuning, etc].

4.3. Nanomaterials for CO_2 capture and conversion [Synthesis of sorbents, characterization, their evaluation for CO_2 capture using gravimetric and volumetric techniques, stability, chemical conversion of CO_2 to fine chemicals, photocatalytic conversion of CO_2 to fuel, artificial trees].

Course evaluation will be based on one midterm exam and one final exam.