Iron Oxide Nanoparticles: Preparation, Properties and Applications

ABSTRACT

of

THESIS

SUBMITTED TO

BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY
(A CENTRAL UNIVERSITY)
LUCKNOW

BABASAHEB
BHIMRAO
AMBEDKAR
UNIVERSITY

LUCKNOW

प्रज्ञा शील करुणा

ESTABLISHED 1996

FOR THE DEGREE OF

Doctor of Philosophy

IN

APPLIED CHEMISTRY

Submitted by

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ENROLMENT NUMBER. 858/12

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2018

ABSTRACT

Nanotechnology is the up-to-date advancement in the world of science stream. The word nanotechnology was first familiarized by Professor Norio Taniguchi of Tokyo Science University, in 1974 at the International Conference on Production Engineering in Tokyo. Inrecent years, nanotechnology has become one of the most imperative and exhilarating forefront fields in chemistry, physics, engineering and biology.A particle having one or more dimensions of the order of 100nm or less". In nanotechnology a particle is demarcated as a minor object that behaves as a complete unit in terms of its conveyance and properties.The properties that distinguish the nanoparticles from the bulk material characteristically progress at a critical length of under 100nm. Nanoparticles may or may not exhibition size related properties that fluctuate significantly from those observed in fine particles or bulk materials. Nanoparticles are found in different dimension like as 0-D, 1-D, 2-D, 3-D nanoparticles for various applications. The attention-grabbing and sometimes surprising properties of nanoparticles are therefore largely owing to the great surface area of the material, which dominates the contributions made by the minor bulk of the material. Nanoparticles exhibit important properties owing to quantum confinement, high surface to volume ratio. In case nanomaterials quantum confinement and surface to volume ratio is very important property. In first chapter also discuss the various synthetic technique for synthesis of nanomaterial.

Metal oxides constitute a miscellaneous and attention-grabbing class of materials whose properties cover the entire collection from metals to semiconductors and insulators. Their surface plays tremendous roles in an extremely comprehensive range of phenomena. These metal oxides nanoparticles plays very important role in

many fields of chemistry, physics and materials science for instance catalysts for an assortment of commercially significant reactions. Iron oxide nanoparticles have distinctive magnetic properties for instance superparamagnetism, high coercivity, low Curie temperature, high magnetic susceptibility, etc. In the last few decades, great efforts have been made on synthesis of iron oxide nanoparticles owing to their comprehensive range of applications like magnetic fluids, data storage, catalysis and bio-applications and structure and properties of various phase if iron oxide nanoparticles are discussed in 1st chapter. Application and literature review of iron oxide nanoparticles are explain in brief.

The whole thesis is divided in to 7 chapters. In 1st chapter, general introduction about nanotechnology and metal oxide, iron oxide nanoparticles and objective of research work has been presented. In the 2nd chapter discussion about characterization techniques of nanoparticles and typical applications of these techniques have been discussed. Morphological as well as structural investigation of nanoparticles is examined by XRD, SEM, FTIR, BET, UV-Vis, and PL. Basic principle and instrumentation of these techniques are explained in detail.

The 3erd chapter comprises synthesis of α-Fe_2O_3 nanostructures by chemical co-precipitation followed by annealing at 500 and 600°C for 3 h. Nanoparticle powders were characterized by X-ray diffraction (XRD), scanning electron microscope (SEM), energy dispersive X-ray spectroscopy (EDX), Fourier transform infra-red spectroscopy (FT-IR), particle size distribution, Brunauer Emmett Teller analysis (BET), photoluminescence and UV-Visible spectroscopy. XRD confirmed the formation of crystalline α-Fe_2O_3 nanoparticles while SEM confirmed the formation of rice grain and sphericalshapeα-Fe_2O_3nanostructures at 500 and 600 °C. From EDX and FTIR results formation of α-Fe_2O_3 is further established. BET analysis

confirmed the mesoporous behavior of nanoparticles. UV-Visible and photoluminescence spectra have been used to determine band gap and photo-oxidation behavior of dye methylene blue. Both Fe_2O_3-500 and Fe_2O_3-600 nanostructures exhibit exceptionally high photocatalytic activity however the same is higher for Fe_2O_3-500 than that of Fe_2O_3-600 for degradation of methylene blue (Meb).

The 4^{rth} chapter encompasses synthesis of poly vinyl pyrrolidone (PVP) coated magnetite nanoparticles by chemical co-precipitation method. The samples were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), Fourier transform infrared spectroscopy (FTIR) and Brunauer Emmett Teller (BET) methods. The surface area, pore volume and pore radius were calculated by the BET analysis. The EDX and FTIR analysis demonstrated the fabrication of PVP coated Fe_3O_4 NPs. The as synthesized Fe_3O_4/PVP has successfully been used as an adsorbent for elimination of Congo red dye in aqueous medium.

Cobalt ferrite has attracted considerable attention in recent years due to its unique physical Properties such as high Curie temperature, large magnetocrystalline anisotropy, moderate saturation magnetization, large magneto restrictive coefficient, excellent chemical stability and mechanical hardness. The 5thchapter presents preparation of cobalt ferrite magnetic nanoparticles by co-precipitation method using Fe(III) and Co(II) in the presence of NH_4OH, at 90˚C. The structure, morphology and magnetic properties of as-prepared were characterized via X-ray diffraction (XRD), High resolution Scanning electron microscope (HRSEM), Energy dispersive x-ray spectroscopy (EDX), Fourier transform Infrared (FTIR) and UV-Visible spectroscopy,. XRD revealed the crystallographic structure of the synthesized sample. HRSEM images have shown the nearly spherical shape and particle size and

morphology of cobalt ferrite nanoparticles. The EDS spectra have shown strong peaks of Fe, Co and O.

In 6thchapter Cd-Ni ferrite nanoparticles with a composition of $Ni_{0.6}Cd_{0.4}Fe_2O_4$ have been successfully prepared via simple co-precipitation technique using sodium hydroxide (NaOH) solution is used as a precipitating agent. The structural and optical properties of the samples were studied using Powder X-ray diffraction (PXRD), Scanning electron microscopy (SEM), Energy dispersive X-ray spectroscopy (EDX), Fourier transform Infrared Spectroscopy (FITR), UV-Visible spectroscopy (UV-Vis), and Fluorescence spectroscopy (FL) measurements. The PXRD analysis of all the samples shows the cubic phase without any impurity peaks. The average particle sizes were calculated by Scherrer's formula. The SEM image shows the agglomeration and flakes type nanoparticles with many void spaces due to exhaust of gases. EDX analysis is used for the elemental analysis of prepared samples (Cd, Ni, Fe, and O). FTIR spectra of the samples show the nature of the chemical bond between metal oxygen bonds (M-O). UV-Vis and PL spectra is used for the band gap calculation and its optical properties.

In 7th chapter complete conclusion of thesis is describe.