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Title: **Synthesis, Characterization and Applications of Metal Oxide Nanoparticles**

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ABSTRACT

The hematite phase of iron oxide was synthesized by co-precipitation method and the as-synthesized nanoparticles were further modified with *Ocimum sanctum* leaf extract. Finally the antibacterial activity of IONPs was evaluated through disc diffusion assay and minimum inhibitory concentration (MIC) determination against gram-negative (E. coli) and gram-positive (S. aureus) bacteria. The modification with leaf extract resulted significant increase in antimicrobial propensity of IONPs. The result shows significant inhibition of S. aureus on treatment with modified IONPs.

Then α-Fe_2O_3 nanoparticles were synthesized by simple co-precipitation route using $FeCl_2.xH_2O$, NaOH and $(NH_4)_2C_2O_4$ as precursors. The surface modification was done by SDS and L-cysteine during the course of reaction. The crystalline nature of as-synthesised nanoparticles was found to be hexagonal as confirmed by X-ray diffraction (XRD) studies. The particles size, surface morphology, surface area and porosity were depicted by Transmission Electron Microscopy, Scanning Electron Microscopy and BET surface area analyser respectively. The BET studies clearly demonstrated the effect of surface modification, as the surface area of the modified nanoparticles was seven times higher than the unmodified nanoparticles.

The present study shows the peroxidase-like activity, electrochemical water splitting and supercapacitor applications of Fe_3O_4 nanocubes. The peroxidase-like activity of magnetic iron oxide nanoparticles (MIONPs) was checked by changing the concentration of H_2O_2, pH of the

buffer solution and the reaction temperature as compared with Horseradish peroxidase (HRP) enzyme and all the parameters were optimized. The electro-catalytic performances as dynamic and cost effective materials to the hydrogen evolution reaction (HER) and supercapacitor in alkaline medium versus Ag/AgCl were investigated at room temperature.

The delafossite $CuCrO_2$ were characterized by Powder X-Ray diffraction, TEM and BET surface area analyzer. The delafossite $CuCrO_2$ nanoparticles have shown the specific surface area of about 235 m^2g^{-1} which is 500 times higher than bulk $CuCrO_2$ (0.47 m^2g^{-1}) and 2-4 times higher than reported $CuCrO_2$ nanoparticles (50-100 m^2g^{-1}). The transmittance value of $CuCrO_2$ nanoparticles was found to be 77% in the visible range and direct band gap energy was determined to be 3.10 eV from the UV-Vis spectroscopy. $CuCrO_2$ nanoparticles were also shown remarkable enhancement in catalytic degradation of methylene blue in H_2O under the sunlight irradiation. The mass spectrometry was used to demonstrate the plausible fragmentation and the structural changes in the methylene blue molecule.

The facile, low cost and one pot approach was used to prepare ultra-small RuO_2 nanoparticles. The electro-catalytic performance as bifunctional activity in water for oxygen evolution reaction (OER) and oxygen reduction reaction (ORR) was determined in alkaline medium versus Ag/AgCl electrode in different atmospheres (i.e. air, N2 and O2). The RuO2 catalyst displays very low values of Tafel slope for OER and ORR.

In the present study WO_3 nanoparticles were synthesized by hydrothermal method. Tungsten oxide nanoparticles were used for catalytic degradation of methylene blue (MB) dye in sun irradiation. The as-synthesized nanoparticles could be used as photo as well as electro-catalyst in a number of reaction viz. degradation of organic pollutants such as dyes and other industrial effluents and electrolysis of water (HER and OER).