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STUDIES ON STRUCTURAL, OPTICAL AND MAGNETIC PROPERTIES OF ZINC FERRITE NANOPARTICLES

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Abstract - *Spinel zinc ferrite ($ZnFe_2O_4$) nanoparticles have rapt implausible and incredible properties such as structural, optical and magnetic properties. These properties are momentous in $ZnFe_2O_4$ which make it an apt entrant in the field of magnetic taping machine. Nano crystallite $ZnFe_2O_4$ as-synthesized nanoparticle was conveniently synthesized by a primordial co-precipitation route. From X-ray Diffraction (XRD) pattern depicts cubic spinel phase and the crystallite size was calculated using Scherrer formula. The average crystallite size was about 24.91 nm which corresponds to the most prominent peak (311). Fourier Transform Infrared (FT-IR) analysis confirms the spinel phase of zinc ferrite and the functional groups was found to be in the range of 4000-400 cm^{-1}. From UV- Visible Spectra, the optical bandgap (Eg) was calculated to be 2.88 eV. Magnetic property of zinc ferrite nanoparticles was studied using Vibrating Sample Magnetometer (VSM) and obtained rententivity for the as-synthesized is 3.7031×10^{-3}emu/g and the magnetic moment was found to be 0.00508.*

Key Words: zinc ferrite ($ZnFe_2O_4$); Coprecipitation; X-ray technique; Uv-visible.

1. INTRODUCTION

Ferrite nanoparticles have been enhancing notable properties in multifarious acreage [1-3], due to its appealing structural, optical and magnetic properties. As a imperative member of ferrite family, zinc ferrite ($ZnFe_2O_4$) nanoparticles shows elite properties such as large magneto-optical and the magneto - crystalline coefficient at ambient temperatures. Co-precipitation is one of the facile candid routes to prepare spinel phase ferrite nanoparticles at low temperature condition. It offers numerous rewards in superfluous than other synthesis routes such as high limpidness controlled crystallite size, no agglomeration of the particles and to alter the particle surface volume along with homogeneity [4, 5]. This work elucidates the synthesis of spinel zinc ferrite nanoparticles by chemical route and their properties were studied.

2. MATERIAL SYNTHESIS

The chemicals were used as purchased without any further purification, zinc chloride and ferric chloride was taken stoichiometric ratio of 1:2. The chemicals were dissolved in 50 ml of double distilled water with vigorously stirring for few minutes in order to have a homogeneous solution. . Then, 2 M of the NaOH aqueous solution was added as a mineralized in the above solution in order to attain pH 11 and then stirred at a ambient temperature for 3 hours to obtain brown precipitate, which then was washed several times using double distilled water and ethanol. The product was dried in an oven at 80 °C for 17 h under atmosphere. The annealed powder was well grounded by a mortar and sintered at the temperature 500 °C for 3 h in a muffle furnace and as the result nanocrystallite $ZnFe_2O_4$ particles was obtained.

3. RESULTS AND DISCUSSION

Single XRD analysis of the as-synthesized materials was performed on 3003 TT X-ray diffractometer with CuKα radiation (λ=1.540598 Å). The X-ray tube was operated at 40 kV in the 2θ range 20-70°. Figure 1 depicts X-ray diffraction patterns of the zinc ferrite nanoparticles as-synthesized with NaOH as a mineralizer shown in Fig. 1 All diffraction peaks can be indexed as the cubic spinel phase of $ZnFe_2O_4$ in the standard data (JCPDS card no 22-1012) with a lattice parameter of 8.354Å irrespectively for the as-synthesis route. The crystallite size was estimated from the Scherer's formula, $\Phi = k\lambda/\beta\cos\theta$, where Φ is the average grain size in nm, θ and β are the diffraction angle and full-width at half-maximum of observed peaks, k is a constant equal to 0.89 and λ is the X-ray wavelength respectively.

FTIR spectroscopy analysis for the as-synthesized nanoparticles was performed on a Perkin Elmer spectrometer at the range of 4000-400 cm^{-1}. The Fig.2 reveals the frequency bands which are very sensitive between cations and oxygen in octahedral and tetrahedral sites. The main characteristic absorption bands of $ZnFe_2O_4$ occur at 475 and 536 cm^{-1} corresponds to metal-oxygen

stretching vibrations located at octahedral and tetrahedral sites. The strong absorption peaks at 1536 cm^{-1} is attributed to water due to moisture. The absorption peak at 3507 cm^{-1} are corresponds to O-H groups which confirms the presence of moisture in the as-synthesized sample. The optical absorption spectrum of $ZnFe_2O_4$ nanoparticles and their comparison plot of photon energy (hν) versus $(\alpha h\nu)^2$ synthesized by co-precipitation method is shown in Fig.3a. The absorption coefficient (α) relates with the optical band gap (E_g) is given by, $\alpha h\nu = B(h\nu - E_g)^{1/2}$, where B is a constant for a direct transition and hν is the photon energy. By extrapolating the linear portion of the energy axis at zero absorption gives the direct band gap of $ZnFe_2O_4$. The sample as-synthesized by co-precipitation route have red shift of the absorption edge compared to the bulk bandgap counterpart. The red shift demonstrates the energy gap (E_g=3.02 eV) as shown in Fig. 3b.

Fig.4 depicts the magnetic hysteresis loops for the inverse spinel $ZnFe_2O_4$ nanoparticles at room temperature. The magnetic property was determined by Vibrating Sample Magnetometer (VSM). The observed hysteresis loops of the as-synthesized samples exhibits weak ferromagnetic. The hysteresis curve acknowledges the soft magnetic nature of the material which carries significance in magnetic memory devices. Obtained rententivity, Coercivity and magnetic moment value for the $ZnFe_2O_4$ nanoparticle is 3.7031×10^{-3}emu/g, 390.94 G and 0.00508 respectively.

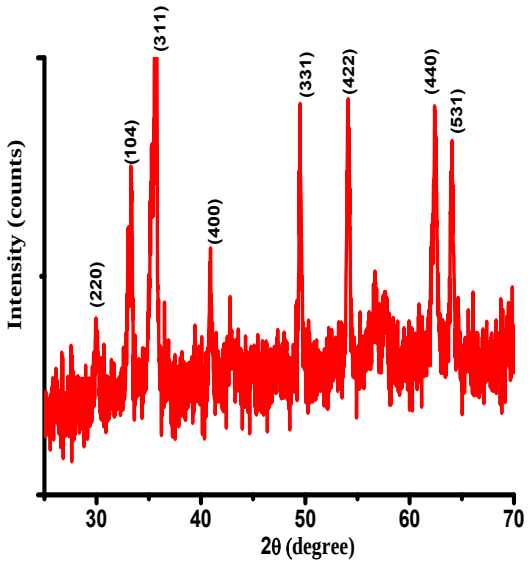

Fig.1 XRD diffraction pattern of $ZnFe_2O_4$

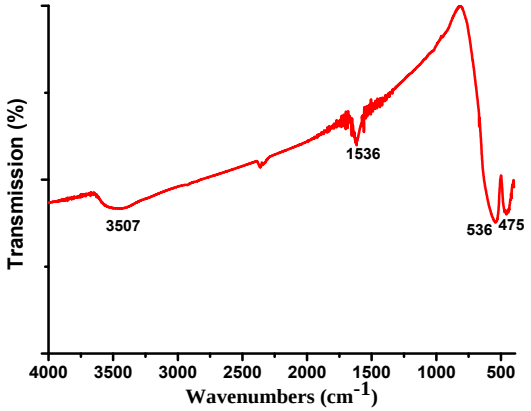

Fig. 2 FTIR spectrum of $ZnFe_2O_4$ nanoparticles

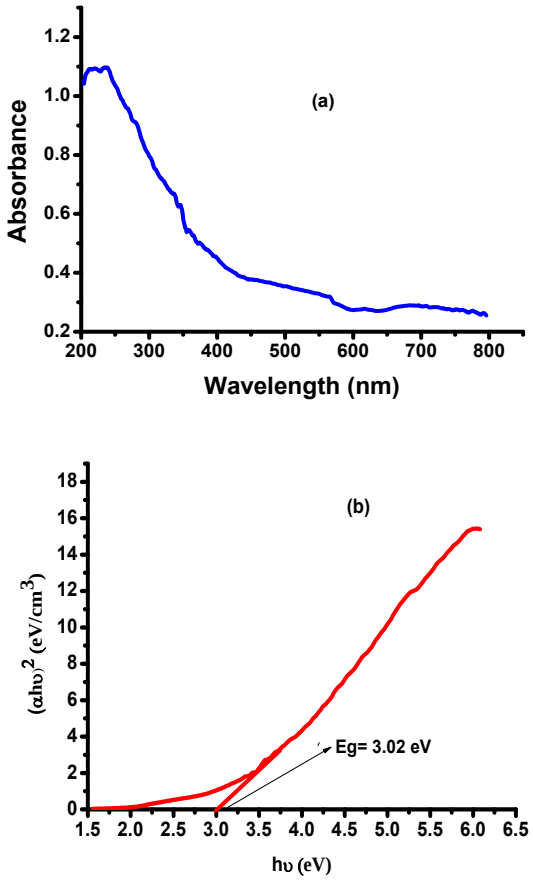

Fig. 3 a) Optical absorption spectra of $ZnFe_2O_4$ nanoparticles as-synthesized using co-precipitation and b) their comparison plot of $(\alpha h\nu)^2$ versus photon energy (hν).

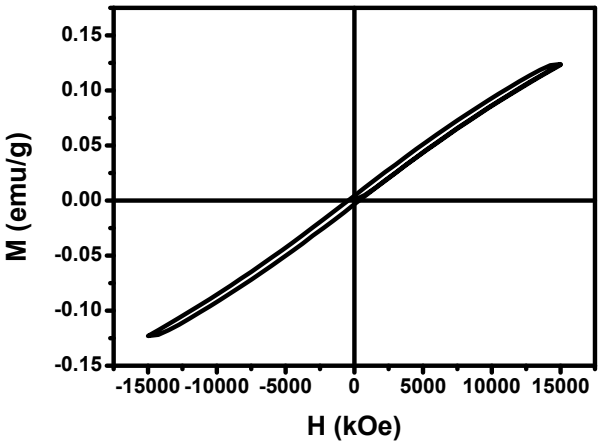

Fig.4 Hystersis loop for $ZnFe_2O_4$ nanoparticle

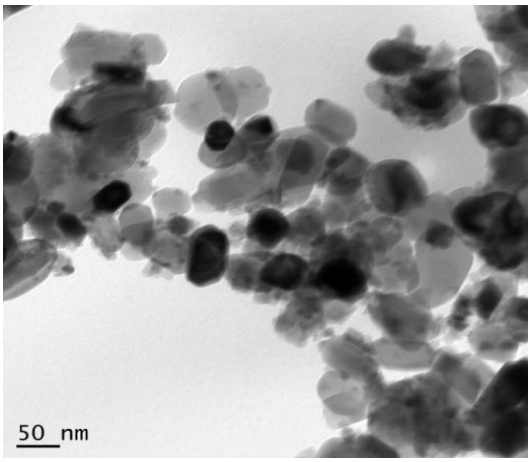

Fig.5 TEM for $ZnFe_2O_4$ nanoparticle

The arrangement of the particles allows in determining the size distribution generated in Fig. 5 which reflects the TEM micrograph of the $ZnFe_2O_4$ sample prepared by coprecipitation route. The pH had no obvious influence on the structure, but it affects the crystallite size, which demonstrates that the $ZnFe_2O_4$ nanoparticles is cubically spherical and monodisperse with average grain size was found to be 17 nm, which is smaller than Scherrer calculation.

4. CONCLUSION

In this investigation, spinel phase $ZnFe_2O_4$ nanoparticles were efficiently synthesized using co-precipitation route, ensuing favorable magnetic and optical properties. We may therefore well conclude that the magnetic and optical properties of $ZnFe_2O_4$ nanoparticles are considered as a incredible and imminent magnetic material for advance investigations and industrial applications.

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