International Journal of Latest Research in Engineering and Technology (IJLRET)
ISSN: 2454-5031
www.ijlret.com ǁ PP.50-53

STUDIES ON COBALT FERRITE NANOPARTICLES

P. Annie Vinosha[1], L. Ansel Mely[1], N. Esther Catherene[2], S. Jerome Das[1*]
[1,]Department of Physics, Loyola College, Chennai, India 600 034.*
[2]PG Department of Physics, Women's Christian College, Chennai, India - 600 006
Corresponding author email:annieakash@gmail.com; jeromedas.s@gmail.com

Abstract*:* Spinel cobalt ferrite ($CoFe_2O_4$) nanoparticles have awestruck incredible and remarkable combinations of properties, principally its optical properties and magnetic. These properties are catered in $CoFe_2O_4$ which make it a fitting candidate in the field of electronics. Nanocrystalline $CoFe_2O_4$ powders were expediently synthesized by a primitive co-precipitation technique. The X-ray Diffraction (XRD) pattern shows that all diffraction peaks were indexed as the cubic spinel structure and the particle sizes has been calculated using Scherrer equation. The estimated average grain sizes were about 10.58 nm corresponding to the most prominent plane (311). The Fourier transform infrared (FT-IR) characterization of the synthesized sample confirmed the inverse spinel structure of cobalt ferrite. By analysing the UV- Visible Absorption Spectra, their optical band gaps (Eg) were calculated. Magnetic property of cobalt ferrite nanoparticles were studied using Vibrating Sample Magnetometer (VSM). Obtained rententivity values for the sample synthesized is 8.7338×10^{-3}emu/g. Further the Coercivity value is found out to be 427.03 G.

Keywords: Cobalt Ferrite ($CoFe_2O_4$); Nanomaterials; Coprecipitation synthesis; X-ray technique.

1. Introduction

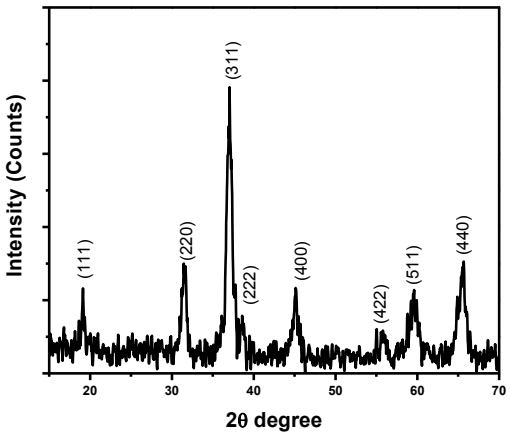
Magnetic nanoparticles have been remunerating human intellects by drawing notable attention due to their biological and technological applications in multifarious acreage [1-3], due to its appealing structural, magnetic and electrical properties. As an vital member of ferrite family, cobalt ferrite ($CoFe_2O_4$) nanoparticles show exclusive properties such as large magneto-optical coefficient and the magneto - crystalline coefficient at ambient temperature. Co-precipitation is one of the candid techniques to prepare spinel structured ferrite nanoparticles at low temperatures. It offers the reward in surplus than other techniques such as controlled crystallite size, high limpidness, no agglomeration of the particles and to alter the particle surface along with homogeneity [4, 5]. This manuscript elucidates the preparation of uniform sized cobalt ferrite nanoparticles by co-precipitation technique and their properties were investigated.

2. Experimental details

The indispensable quantity of cobalt nitrate (Co $(NO_3)_2$) and ferric nitrate (Fe $(NO_3)_3$) was weighted in a stoichiometric ratio of 1:2. The opaque solution was then vigorously stirred for a few minutes in order to have a lucid and homogeneous solution. . Then, 2 M of the NaOH aqueous solution was added dropwise as a mineralized in the admixing solution in order to maintain pH 8. Ensuing, it was kept at an ambient temperature for 3 hours to obtain brown precipitate, which then magnetically alienated and washed several times using ethanol and double distilled water alternately. The byproduct was dried in an oven at 80 °C for 24 h under air atmosphere. The dried powder was ground well by ceramic mortar and sintered at the temperature 500 °C for 5 h in a furnace and as an upshot; the self-ignited nanocrystalline $CoFe_2O_4$ particles were obtained.

3. Results and Discussion

XRD analysis of the synthesized materials were performed on a GE Inspection technology 3003 TT X-ray diffractometer with CuKα radiation (λ=1.540598 Å). The X-ray tube was operated at 40 kV and 30 mA in the 2θ range 10-70°. Figure 1 presents powder X-ray diffraction patterns of the cobalt oxide nanoparticles synthesized with NaOH depicted in Fig. 1 All diffraction peaks can be indexed as the cubic phase of $CoFe_2O_4$ inverse spinel in the standard data (JCPDS card no 22-1086) with a lattice parameter of 8.085Å irrespectively of the synthesis route. The average crystallite size, estimated from the Scherer's equation is given $\Phi = k\lambda/\beta\cos\theta$, where Φ is the average grain size in nm, k is a constant equal to 0.89, λ is the X-ray wavelength and β and θ are the diffraction angle and full-width at half-maximum of observed peaks, respectively.



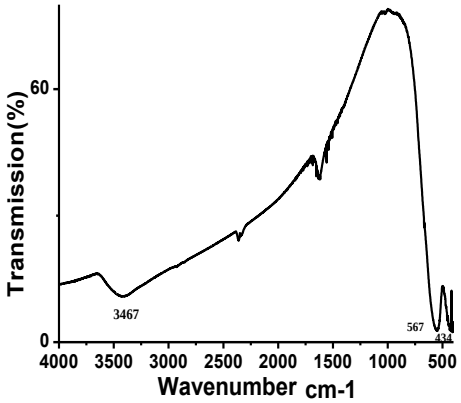


Fig.1 *XRD diffraction pattern of* $CoFe_2O_4$ ***Fig. 2*** *FTIR spectrum of* $CoFe_2O_4$ *nanoparticles*

FTIR spectroscopy analysis of the synthesized materials was performed on a Perkin Elmer spectrometer using KBr pellet technique at the range of 400-4000 cm^{-1}. The Fig.2 reveals the high frequency bands which are very sensitive to the changes in the interaction between cations and oxygen in tetrahedral and octahedral positions. The main characteristic absorption bands of $CoFe_2O_4$ occur at 434 and 567 cm^{-1} correspond to metal-oxygen stretching vibrations located at tetrahedral and octahedral positions. The strong absorption peaks at 1630 cm^{-1} is attributed to the adsorbed stretching mode of water due to moisture. The absorption peak at 3467 cm^{-1} are corresponding to stretching vibrations O-H groups which confirms the presence of water in the sample. The optical absorption spectra of $CoFe_2O_4$ nanoparticles and their comparison plot of $(\alpha h\nu)^2$ versus photon energy ($h\nu$) synthesized by co-precipitation method is shown in Fig.3a. In the direct transition, 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 $h\nu$ is the photon energy and B is a constant for a direct transition. The energy gap E_g can then be estimated from the intercept of $h\nu$ vs for direct transitions. By extrapolating the linear portion of the energy axis at zero absorption gives the direct band gap of these materials. The sample synthesized by co-precipitation method a red shift of the absorption edge compared to the bulk bandgap. The red shift demonstrates the energy gap (E_g=3.24 eV) as shown in Fig. 3b. The increase in band gap can be attributed to quantum confinement.Fig.4 depicts the magnetic hysteresis loops for the inverse spinel $CoFe_2O_4$ nanoparticles at room temperature. The magnetic properties were investigated by Vibrating Sample Magnetometer (VSM). The observed hysteresis loops of the synthesized samples exhibit weak ferromagnetic.

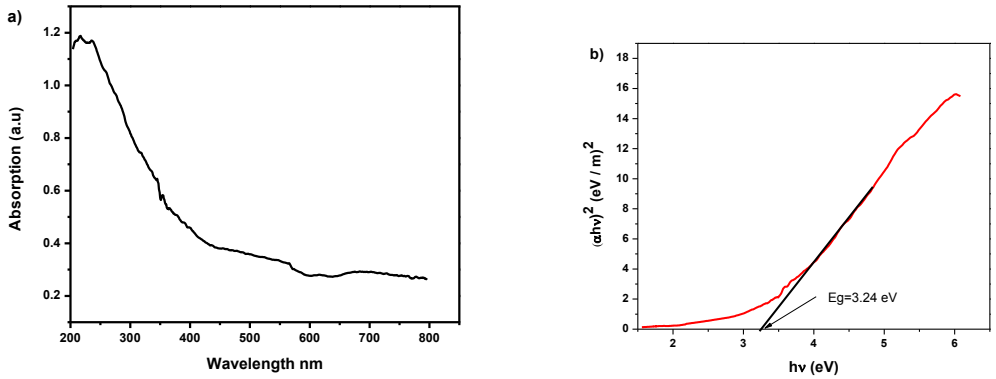


Fig. 3 *a) Optical absorption spectra of $CoFe_2O_4$ nanoparticles synthesized using co-precipitation and b) their comparison plot of $(\alpha h\nu)^2$ versus photon energy (hν).*

Low area hysteresis curve shows that the nanomaterials is a soft magnetic material which carries much importance in magnetic memory purposes. Obtained rententivity and Coercivity value for the $CoFe_2O_4$ nanoparticle is 8.7338×10^{-3}emu/g and 427.03 G respectively.

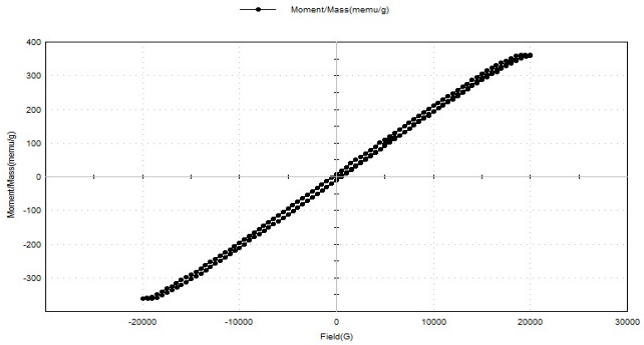


Fig.4 *Hystersis loop for $CoFe_2O_4$ nanoparticle*

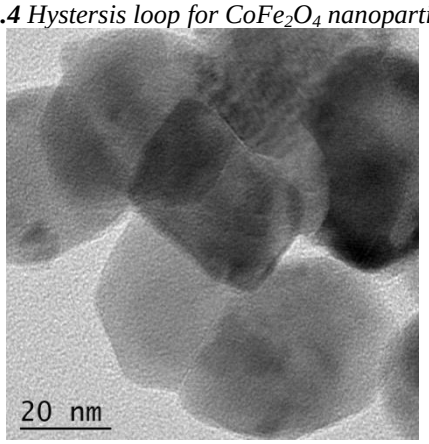


Fig.5 *TEM for $CoFe_2O_4$ nanoparticle*

The orientation of particles allows for the measure of the size distribution to be generated. Fig. 5 reflects the typical TEM micrograph of the $CoFe_2O_4$ sample prepared by coprecipitation method. The pH had no obvious influence on the morphology, but it affects the crystalline size, which demonstrates that the $CoFe_2O_4$ nanoparticles were monodisperse and cubically spherical shape with average distributed grain size was found to be 19 nm, which is smaller than Scherrer calculation.

4. Conclusion

In précis, single phase inverse spinel $CoFe_2O_4$ nanoparticles were effectively synthesized using co-precipitation method, ensuing into small particle size and favorable magnetic properties. We may therefore well conclude that the magnetic properties of $CoFe_2O_4$ nanoparticles are varied with a decrease in crystallite size and

considered as a remarkable and impending ternary magnetic material for advance investigations and valuable applications.

Acknowledgments

The authors are thankful to the management of Loyola College, Chennai – 34 for the award of LC – Times of India Major Research project (3LCTOI14PHY002)

Reference

[1]. S.Chang, Q.Haoxue, IEEE Transactions of magnetics **108,** 1 (2009).
[2]. JR Anusha, Hee Je kim,Albin T.Fleming, S Jerome Das, Kook-Hyun Yu, Sensor Actuat B. **202,** 827 (2014).
[3]. J Emima Jeronsia, L Allwin Joseph, M Mary Jaculin, P Annie Vinosha, S Jerome Das, JTUSCI Doi:10.1016/j.jtusci.2015.12.003**.**
[4]. G Fan ,Z Gu , L Yang , F Li, J Chem Eng **155**, 534 (2009).
[5]. CN Chinnasamy, A Narayanasamy, N Ponpandian, K Chattopadhyay, Mater. Sci. Eng *A,* **304**, 983 **(**2001).