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Co-Precipitation Synthesis and Structural Properties of Magnetic Nano Ferrites Used for Hyperthermia

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Absract: The magnetic nano ferrites ($Zn_{0.54}Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$) were successfully synthesized by a low-cost and time-saving Co-precipitation method. The purity of phase was checked by X-ray powder diffraction technique (XRD) and the average crystalline size of the sample was calculated from the Debye Scherrer equation and it is found to be 207 nm. The morphology and crystalline information of nano ferrites was investigated using Scanning Electron Microscopy (SEM), and it is confirming the nano cube morphology with a size range of nearly 200 nm. FTIR shows identification of chemical composition of synthesized particle. These results confirm the appearance of $Zn_{0.54}$ $Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$ synthesized by co-precipitation method. The Curie Temperature (Tc) was analysed using experimental setup and it was found to be nearly 55ºC which may be suitable for magnetic induction hyperthermia.

Index Terms: **Magnetic hyperthermia, Nano particles, Co-precipitation method, Curie temperature**

1. INTRODUCTION:

The study of ferrite based nano particles confirmation of major progress in the previous decade due to interesting technique and developments to achieve the nano-meter size of magnetic particles. At the nanoscale, there is a new behaviour and properties which is different from bulk structure [1-3]. Exclusively in ferrite which is materials with high chemical steadiness and small production cost now used for various applications field [4]. Ferrite based magnetic nanoparticles recently used in application such as optical materials [5], semiconductors [6], nanofluids [7-9], superconducting stage used for data storage [10,11], magnetic imaging, and biomedical applications such as magnetic hyperthermia [12]. Magnetic induction hyperthermia is a novel cancer therapy technique, which can kill cancer cells without damaging healthy cells by heating the tumour tissues to certain temperature range, in general, 42- 46 °C [13].

In this research work, we successfully synthesized the magnetic nano ferrites ($Zn_{0.54}Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$) by Co-precipitation method. The crystalline structure and phase purity was successfully checked by X-ray powder diffraction technique (XRD). Calculated the average crystalline size of the sample by using the Debye Scherrer formula and it is found to be 207 nm. The surface morphology and crystalline information of nano ferrites was examined using Scanning Electron Microscopy (SEM), and it is confirming the nano cube morphology with a size range of nearly 200 nm. The Fourier Transform Infrared Spectroscopy (FTIR) shows identification of chemical composition of synthesized particle. These results confirm the appearance of $Zn_{0.54}$ $Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$ synthesized by co-precipitation method. The Curie Temperature (Tc) was analysed using experimental setup and it was found to be nearly 55ºC which may be suitable for magnetic induction hyperthermia.

2. EXPERIMENTAL PROCEDURE:

To magnetic nano ferrite $Zn_{0.54}$ $Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$, were synthesis by using co-precipitation method. $ZnCl_2$ (8.91 mmol), $CoCl_2 \cdot 6H_2O$ (7.59 mmol), $CrCl_3 \cdot 6H_2O$ (9.9 mmol) and $FeCl_3 \cdot 6H_2O$ (23.1 mmol) were dissolved in 80 mL deionized water under stirring to form a transparent metal salts solution. Then under magnetic stirring at room temperature, the precipitant agent, NaOH solution (4 mol·L−1, 150 mL), was added dropwise into the previous metal salt solution to form the precursor. Washed the precursor with ethanol and deionized water and filtered it. The filtered precursor was taken in a crucible and heated on the hot plate at 90ºC for 2 hours. The black powdered suspension is formed. Now, to obtained fine powdered we allowed to heat the black suspension at 950ºC for 3 hours in muffle furnace to obtained magnetic nano ferrite $Zn_{0.54}$ $Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$. Fig.1 shows the flowchart of the synthesised materials.

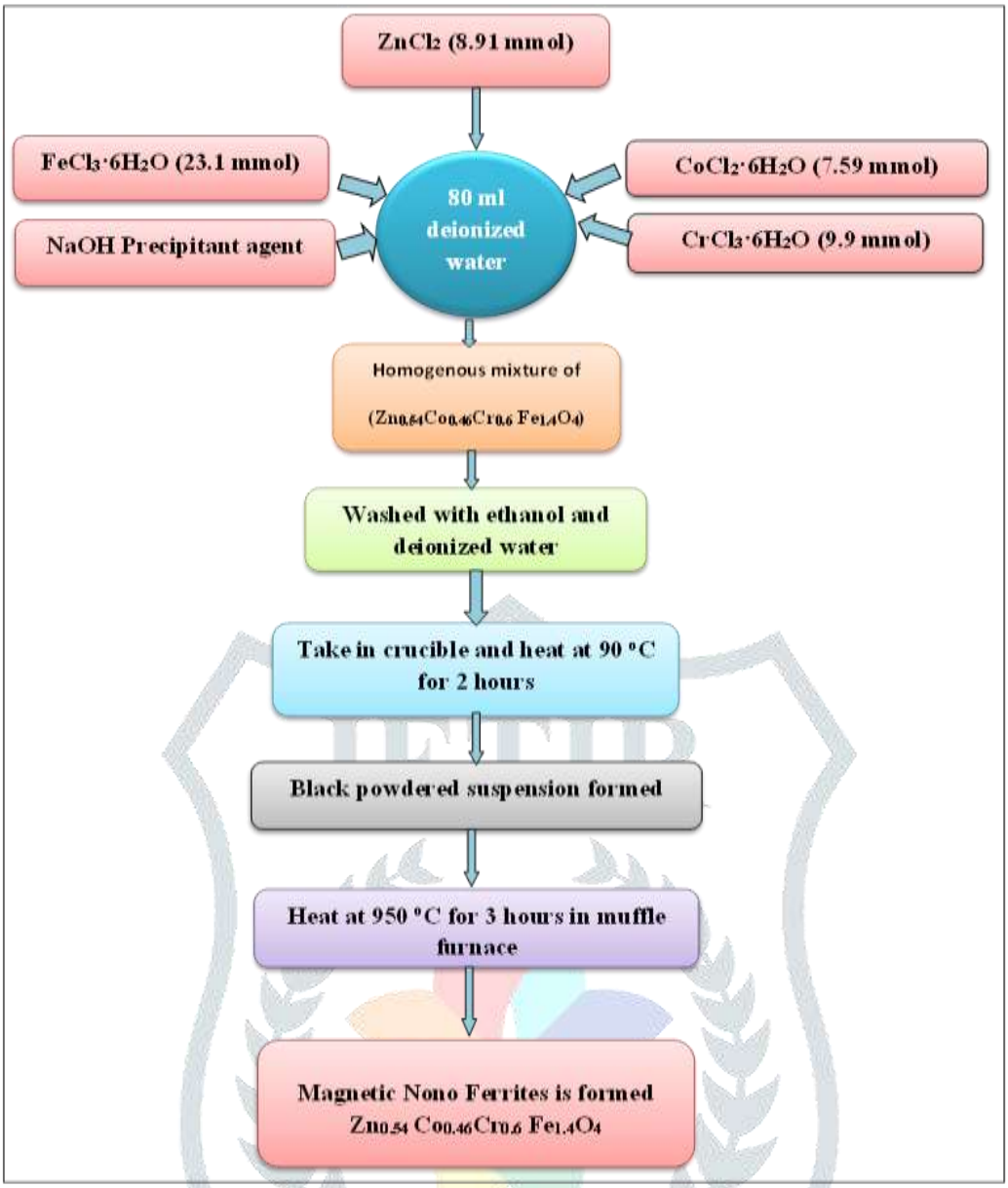

Fig. 1: Flowchart of Magnetic Nano Ferrite Synthesised by Co-precipitation Method

3. RESULTS AND DISCUSSION:

3.1 X-Ray Diffraction (XRD) Analysis:

The formation of magnetic nano size ferrite $Zn_{0.54}$ $Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$ sample in the crystalline phase synthesised by co-precipitation method was confirm by XRD pattern as shown in Fig.2. The XRD pattern for $Zn_{0.54}$ $Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$ sample well agreed with the $CoFe_2O_4$ phase standard data from PDF card no. 1533163. Also, XRD pattern show that the synthesised nano ferrite possesses cubic structure with space group F d -3 m: 2 (227) with lattice parameter a = b = c = 8.3806 $A°$ and interfacial angle α = β = γ = 90◦. In XRD spectra the typical peak at an angle 30.14, 35.50, 43.14, 57.06, 62.66 corresponding to the plane (2 2 0), (3 1 1), (4 0 0), (5 1 1), (4 4 0) that implies size of nanoparticle is small. The size of nanoparticle was calculated using Debye's Scherrer formula [14] using peak having h k l values (3 1 1) and the size of nanoparticle was found to be 207 nm.

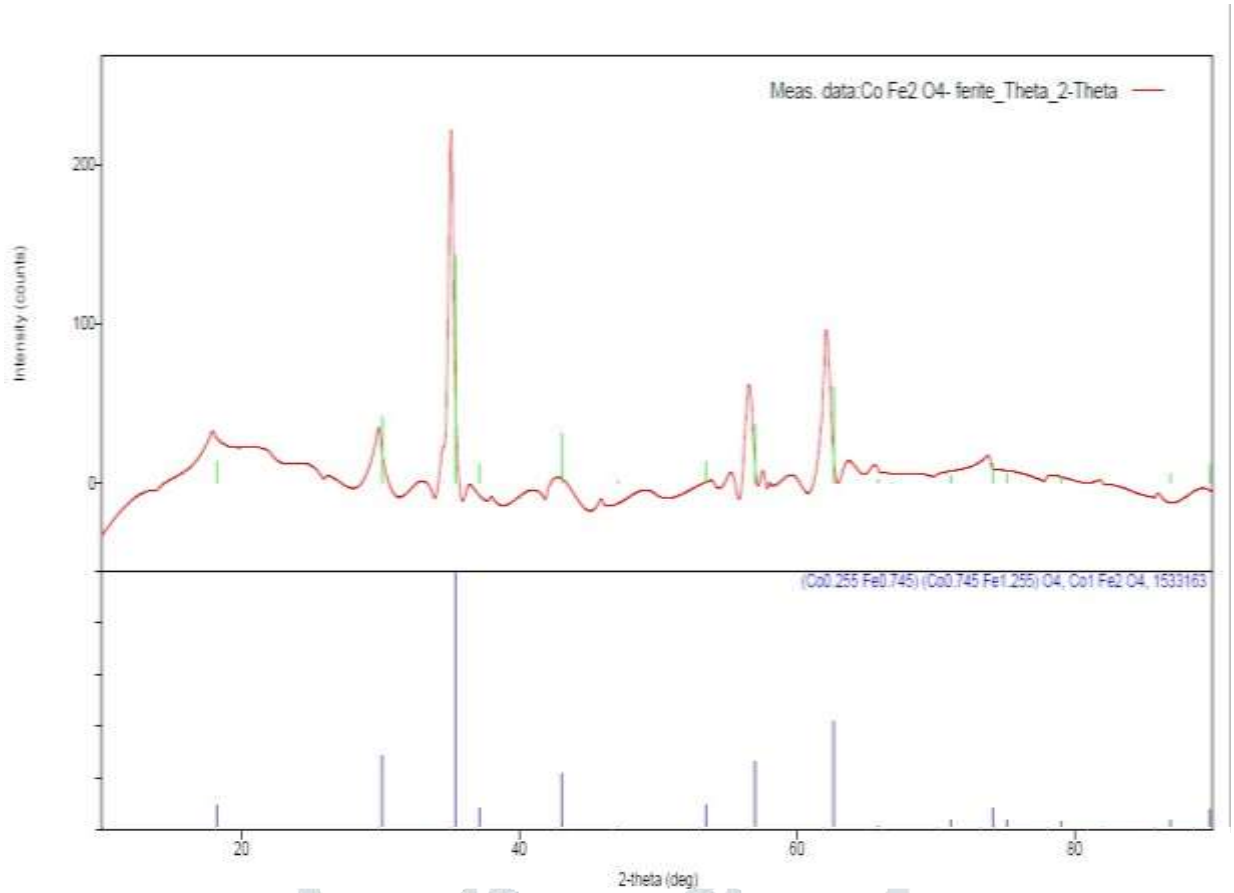

Fig.2: XRD Pattern of magnetic nano ferrite $Zn_{0.54}$ $Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$ synthesised by co-precipitation method

3.2 SEM Analysis:

The scanning electron microscopy (SEM) was carried out to obtain the surface morphology and the shape of synthesized magnetic nano ferrite $Zn_{0.54}Co_{0.46}Cr_{0.6}Fe_{1.4}O_4$. The images as shown in Fig. 3 confirms the nano cube morphology of the magnetic nano ferrite with a size range of nearly 200 nm.

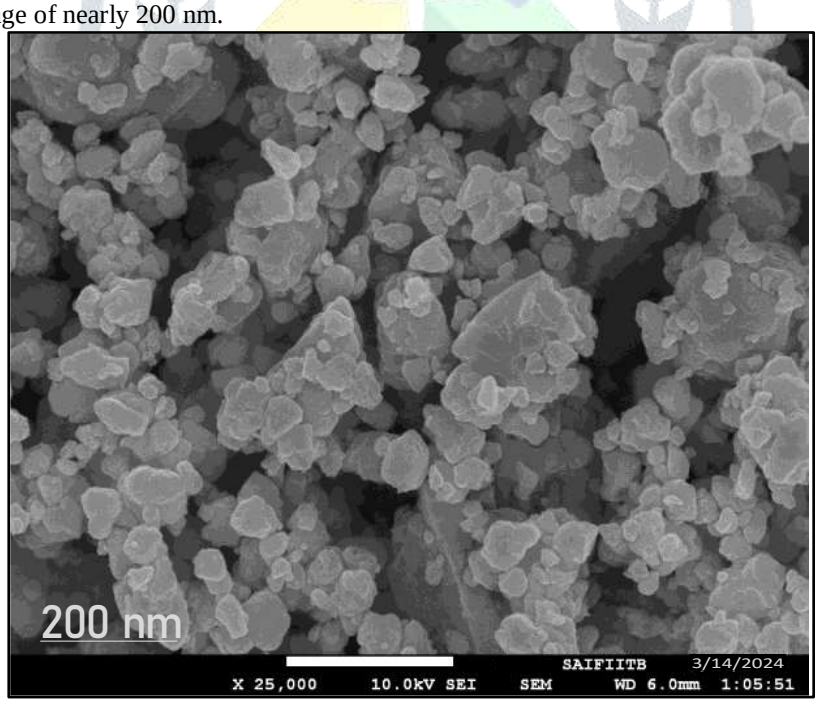

Fig. 3: SEM micrograph of magnetic nano ferrite $Zn_{0.54}$ $Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$ synthesized by co-precipitation method

3.3 The Fourier Transform Infrared Spectroscopy (FTIR) Analysis:

Fig. 4 shows FTIR spectra of $Zn_{0.54}$ $Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$ nanoparticles. The absorption band around 3400 cm^{-1} and 1600 cm^{-1} are ascribed to the stretching mode of O-H and H-O-H bending vibration, respectively. The absorption band are attributed to the stretching vibration of tetrahedral group complexes [15]. FTIR shows identification of chemical composition of synthesized particle. These results confirm the appearance of $Zn_{0.54}$ $Co_{0.46}Cr_{0.6}$ $Fe_{1.4}O_4$ synthesized by co-precipitation method.

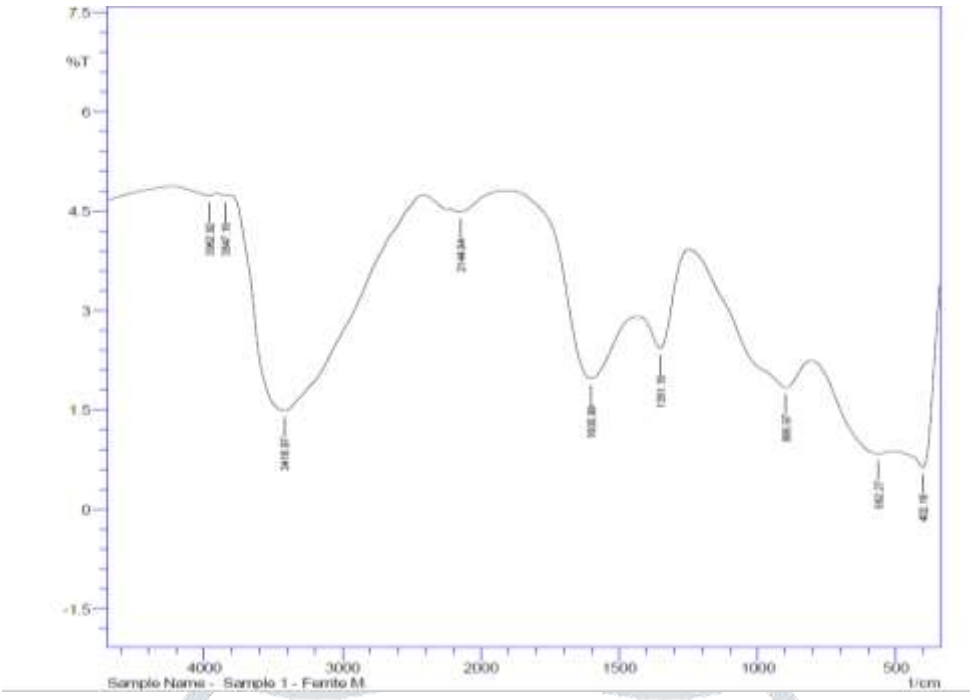

Fig. 4 shows FTIR spectra of $Zn_{0.54}Co_{0.46}Cr_{0.6}Fe_{1.4}O_4$ nanoparticles synthesized by co-precipitation method

3.4 Determination of Cuire Temperature (Tc):

In order to measure the Curie temperature, the curve is obtained by using experimental data. We performed the experiment with the help of following tools: Solenoid, LCR Meter, Temperature indicator, Glass tube, Probes, Sample of Magnetic nano ferrite, etc. First, we put the obtained magnetic nano ferrite in sealed glass tube. Now, heat the glass tube at about 120ºC. Put the heated glass tube with sample in the solenoid. Measure the temperature of powder sample sealed in a glass tube in decreasing order using temperature prob. Simultaneously measure the corresponding inductance of a coil (Solenoid) using LCR Meter. Plot the graph between temperature on x-axis and inductance on y-axis.

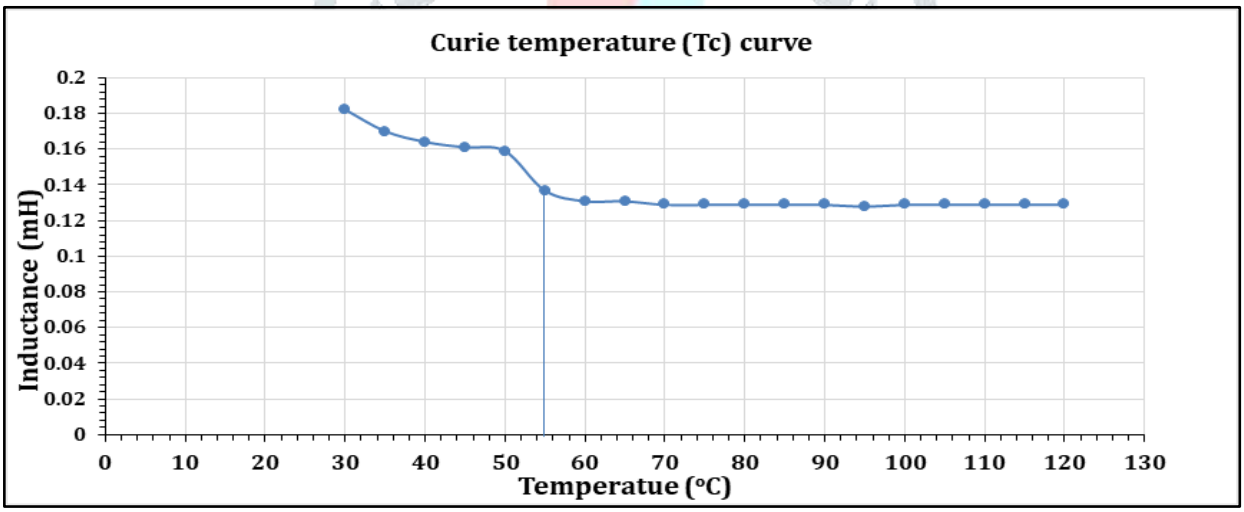

Fig. 5: Shows the Cuire Temperature (Tc) Curve having Tc obtained at 55ºC

The Curie temperature (Tc) is obtained at 55ºC as shown in Fig.5. Tc is critical temperature, below which ferromagnetic materials will hold a spontaneous magnetization resulted of the ordered magnetic moments and above which the ordered magnetic moments change and become disordered.

In these nano ferrites the magnetic order is mainly due to the super exchange interaction between ions sites [16], and Tc is positively correlated with the overall strength of the exchange interaction between the magnetic ion's sites. Therefore, the Curie temperature (Tc) is nearly 55ºC which may be suitable for magnetic induction hyperthermia.

4. CONCUSSION:

The magnetic nano ferrites ($Zn_{0.54}Co_{0.46}Cr_{0.6}Fe_{1.4}O_4$) were successfully synthesized by a Co-precipitation method. The phase purity was checked by X-ray powder diffraction technique (XRD) and the average crystalline size of the sample was calculated from the Debye Scherrer equation and it is found to be 207 nm. The morphology and crystalline information of nano ferrites was investigated using Scanning Electron Microscopy (SEM), and it is confirming the nano cube morphology with a size range of nearly 200 nm. FTIR shows identification of chemical composition of synthesized particle. These results confirm the appearance of $Zn_{0.54}Co_{0.46}Cr_{0.6}Fe_{1.4}O_4$ synthesized by co-precipitation method. The Curie Temperature (Tc) was analysed using experimental setup and it was found to be nearly 55ºC which may be suitable for magnetic induction hyperthermia.

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