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# A STRUCTURAL AND MAGNETIC CHARACTERIZATION HOLMIUM SUBSTITUTED COBALT FERRITES

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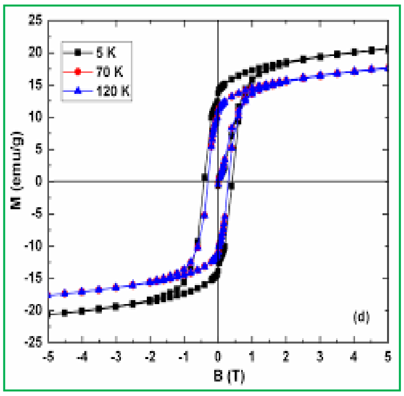
**ABSTRACT:**

*Holonium substituted cobalt ferrites having molecular formula $Ho_xCoFe_{2-x}0_4$ where x=0.0 and x=0.025 have been synthesized using sol-gel auto combustion method, spectral characterized by X-ray diffraction method , proved the samples have single phase cubic spinel structure, the lattice parameter 'a' increases with increase in concentration of $Ho3^+$ ions is attributed to different range of ionic radii. The average practical size was determined from F.W.H.M. of XRD peaks is in 15-22 nm. The I.R spectra scans are in the range of 200-800 cm-$^1$ show two frequency bands, high frequency band $v_1$ is assigned as tetrahedral A site and law frequency bond $v_2$ octahedral B site .scanning electron micros - copy ( SEM) photographs shows that ferrite crystal growth is uniform The magnetic properties were studied as $HO^{3+}$ ion content.*



**KEYWORDS:** *Spinel ferrites, Sol- gel Auto combustion Method. X-ray diffraction, magnetization.*

## INTRODUCTION:

Spinel Ferrites with general formula $MFe_2O_4$ are class of chemically and thermally stable compounds, which attract the attention of researchers ,because of their interesting application in various field [1].The spinel ferrites used in magnetic recording media and storage of retrieval information, magnetically guided drug delivery, sensors etc. The spinel ferrites prepared by many methods, The traditional ceramic method [2] and recently developed Co-precipitation method [3] Sol-gel auto combustion method [4] to produce ultrafine to nano Ferro-spinel compounds. The structural magnetic and electrical properties of spinel ferrites also depends upon the nature of dopants and its concentration [5] The present work deals to study the effect of holmium dopants on the investigate the structural and magnetic properties of the cobalt ferrites, synthesized by sol-gel auto combustion method.

## EXPERIMENTAL:

The ultrafine particle of $HO_xCoFe_{2-x}0_4$ where x=0.0 and x=0.025 were synthesized by sol-gel auto combustion method[6] using A.R. grade Holmium Nitrate (Ho.$(NO_3)_3.6H_2O$) Cobalt Nitrate ($Co(NO_3)_2.6H_2O$ ) and Ferric Nitrate Fe(NO3)$_3$.9H2O ,as starting materials. The stichoiometric mixture of metal nitrate were dissolved in distilled water and ammonia solution added till $_P$H =7 and citric ($C_8H_8O_7.H_2O$ ) in 1;2 ratio of metal nitrate was add as a fuel for auto combustion process. The solution was allowed for gel formation an magnetic stirrer at 60 $^oC$ with constant stirring ,the reaction mixture converted into brownish gel and it burn in a self propagating combustion manner until the whole gel was completely burnt out to form a loose powder. , The formed powder was annealed at 600$^0$ for six hours to remove organic material present in powder then powder finely grinded .To determine structure and crystal size X-ray diffraction taken at room temperature on Philip X-ray diffractometer (Model PW3710). The unit cell dimension and particle size were calculated using the program Powder-X. The magnetization was measured using high field hysteresis loop tracer.

## RESULT AND DISCUSSIONS:

The x-ray diffraction patterns for the studied samples $Ho_xCoFe_{2-x}0_4$ where x=0.0 and x=0.025 are shown by Fig.1. The main reflection from plane (220), (311), (440), and (333) are strongly observed. The reflection of any other plane (221), (422), and (533) can be observed but width weak intensities. The analysis of XRD pattern indicate that the studied ferrite samples have spinel cubic structure with a single phase. The lattice constant "a" is calculated with an accuracy of ±0.002 Å, using Bragg's Law [6] and program Powder – X both values are listed in Table 1. The values of lattice constant are good agreement with JCPDS values for x=0. $COFe_2O_4$ cubic, a =8.391 A Space group Fd3mz=8. JCPDS file No.22-1086 The values of lattice constant "a" increase for sample x=0.25 due to addition of dopants $Ho^{3+}$ ion concentration, the variation of lattice can be explained on the basis of difference in ionic radii of $Fe^{3+}$ ion (0.64Å) replace by larger $HO^{3+(}$0.89Å)

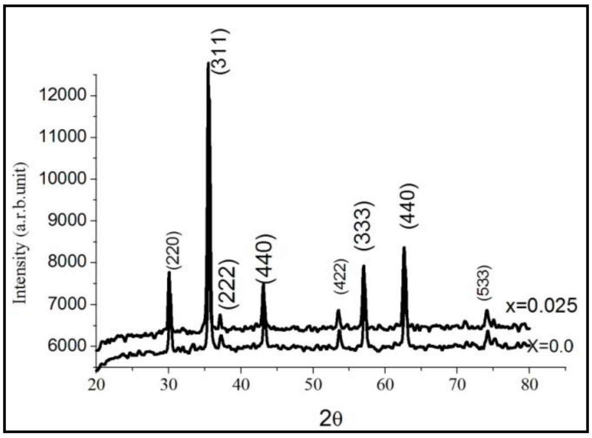


*Fig. 1. X-ray Diffraction patterns of $Ho_xCoFe_{2-x}O_4$ ferrite system.*

The X--ray density ($d_x$) of both sample calculated by using relation

$$d_x = \frac{8M}{Na^3} \quad gm/cm^3 \tag{1}$$

where, M is molecular weight, N is Avogadro's number and 'a' is lattice parameter.

**Table 1: Values of lattice parameter, X-ray density, band positions and magnetic field.**

| 'x' | Lattice Constant 'a' (Å) | X-ray density | band positions | | Magnetic Field | | |
|---|---|---|---|---|---|---|---|
| | | 'd$_x$' gm/cm$^3$ | '$\nu_1$ ($cm^{-1}$) | '$\nu_2$' ($cm^{-1}$) | 'Hc' Oe | 'Mr' emu/gm | 'Ms'emu/gm |
| 0.0 | 8.38162 | 5.301 | 421.17 | 748.28 | 1538.0 | 28.5444 | 62.6462 |
| 0.25 | 8.38287 | 5.398 | 432.47 | 752.86 | 1828.4 | 34.5677 | 69.0317 |

The values of X-ray density are listed in table in Table 1. With lattice constant X-ray density also increases is attributed in relative atomic mass of Holonium (164.93 gram) then $Fe^{3+}$ (55.8450) which overtakes the increase in volume of unit cell.

The average crystalline size of both the composition were calculated from full width at half maximum ( FWHM)) of plane (311) of X-ray diffraction using Scherrer relation [7]

$$t = \frac{0.9\lambda}{B\cos\theta_B}, \qquad (2)$$

where, t is diameter of crystal particle, $\lambda$ is wavelength of the X-ray radiation, $\theta_B$ is Bragg's angle. The calculated crystalline size are in few nanometers.

In order to confirm the formation of spinel phase the I.R. Spectra of synthesized sample were recorded shown by Fig. 2. Illustrating absorption bands of IR spectra for the ferrite system $Ho_xCoFe_{2-x}0_4$ x=0.0 and x=0.025 which is found to be in expected ranges [8,9]. The band positions and intensities are given in Table 1 The high frequency band $\nu_1$ which is in the range of 480-510 $cm^{-1}$ is assigned to vibrations of tetrahedral group, whereas the lower frequency band which is in the range of 700-750 $cm^{-1}$ is assigned to intrinsic vibrations of octahedral cations. The difference in $\nu_1$ and $\nu_2$ is expected because of the difference in $Fe^{3+}$ and $Co^{2+}$ octahedral and tetrahedral complexes. The change of the values of $\nu_1$ and $\nu_2$ from one composition to another is due to change in distance between $Fe^{3+}$ and $Co^{2+}$ with $Ho^{3+}$ addition

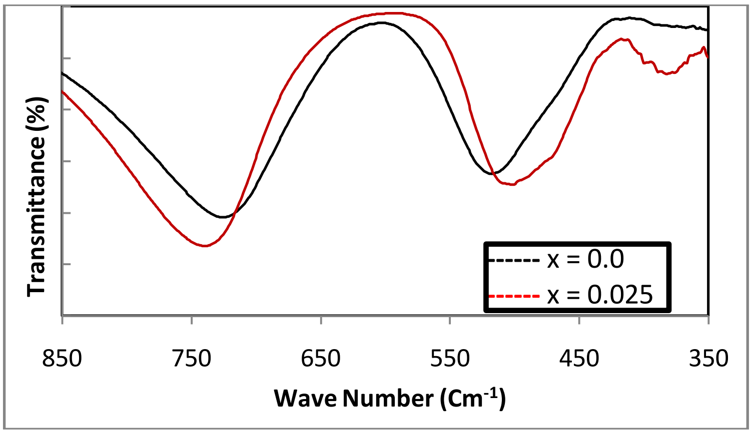


*Fig. 2. IR spectra of $Ho_xCoFe_{2-x}O_4$ system.*

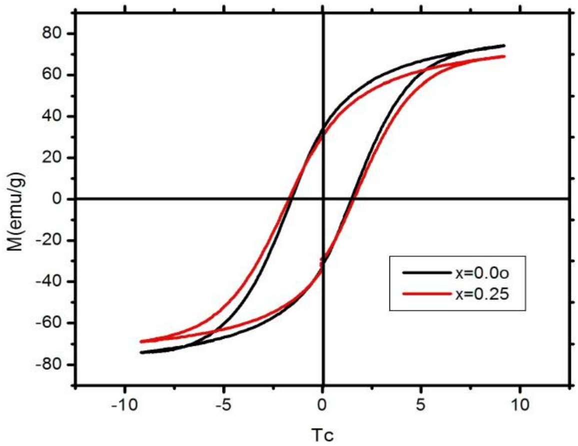


*Fig. 3: I-H curves of $Ho_xCoFe_{2-x}O_4$ ferrite system.*

In a cubic system of ferromagnetic spinels, the magnetic order is mainly due to a super exchange interaction mechanism occurring between the metal ion in the A and B sub-lattices. Therefore, it is possible to vary magnetic properties of the samples by varying the cations. The magnetization curves of the calcined samples of Ho-substituted Co-ferrites obtained from room temperature pulse field magnetization measurement are shown in Fig. 3. Addition of $Ho^{3+}$ ions into Co- ferrite greatly affects its magnetic properties. These curves are typical for a soft magnetic material and indicate hysteresis ferromagnetism in the field ranges upto 1.0 T. The values of saturation magnetization (Ms), coercivity (Hc) and magneton number obtained from magnetization plots are given in Table 1. It is observed from Figs table 1, that magnetization and coercivity increases with the increase in $Ho^{3+}$ substitution. It was well known that the magnetic properties of ferrites with $AB_2O_4$ spinel crystal structure depended on the composition of cation in tetrahedral A-site and octahedral B site. A increase in magnetization is expected when holmium is added to the ferrite lattice since paramagnetic $Ho^{3+}$ is known to occupy tetrahedral sites and increase the density of magnetic ions in sublattice B, thus reducing not only the magnetic moment of the sublattice but also the exchange interaction. According to Neel's molecular-field model [10], the A-B super exchange interaction predominate the intrasublattice A- A and B-B interactions. Therefore, the net magnetic moment is given by the sum of the magnetic moments of the A and B sublattices.

## CONCLUSIONS:

Nanocrystalline $Ho_xCoFe_{2-x}O_4$ ferrites have been prepared by sol-gel auto combustion method at a sintering temperature of 600 ºC for 6 h. The prepared samples show the formation of single phase cubic spinel structure without any impurity peaks. Lattice constant and X-ray density found to increase due to the difference in ionic radii of $Ho^{3+}$ to that of $Fe^{3+}$ ions. The IR spectra shows the two peaks. The saturation magnetization increase with increasing $Ho^{3+}$ substitution. This behavior is ascribed to the fact that the increasing concentration of magnetic ions strengthens the inter-site exchange interaction, increasing the value of saturation magnetization. The calculated and observed values of the magneton number are in good agreement, suggesting that the structure is collinear.

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