# Review Of Research

## MAGNETIZATION STUDY OF CERIUM DOPED COBALT-CHROMIUM FERRITE PREPARED BY SOL GEL AUTO COMBUSTION TECHNIQUE

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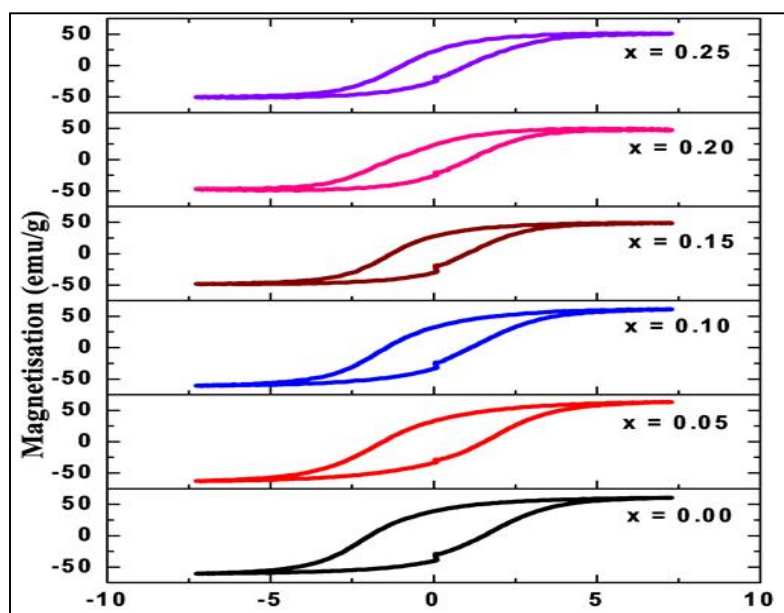
**ABSTRACT:**
The magnetic properties of Ce substituted Cobalt ferrites having general formula $CoCr_{0.5}Ce_xFe_{1.5-x}O_4$ ($x$ = 0.0, 0.025, 0.05, 0.075, 0.01) were synthesized by the Sol Gel Method were investigated. The samples were annealed at $600^0$C for 4 h and were studied by means of magnetization measurements. The saturation magnetization $\sigma_s$ and magneton number $n_B$ measured at 300 K using high field hysteresis loop technique decreases with increasing $x$, suggesting decrease in ferrimagnetic behavior.

**KEYWORDS:** *Ferrite, Sol Gel method, magnetic material.*

## INTRODUCTION:

An investigation of literature showed that, in the last decades magnetic nanoparticles have considerably attracted the attention of material scientists for their unique physical and chemical properties that differ significantly from those of the bulk material, due to their extremely small size and large specific surface [1-2].

The sol–gel method is a simple process with excellent control of the stoichiometry, and a homogeneous film with small grain size of ferrite can be formed over a large area via the sol-gel method at a relatively low processing temperature, which is required for high-density magnetic recording media [3].

There is an ever increasing interest in cobalt ferrite in the nanometer range because of its extensive application in high-density magnetic recording [4]. Cobalt ferrite with high coercivity is a promising material for various magnetic applications such as magneto-optical devices and magnetic recording [5-7]. In the recent years several researchers have studied the physical and chemical properties of Co-Cr ferrite system for possible applications in modern industries [8-10].

This paper deals with the

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structural and magnetic properties of Ce substituted Co-Cr ferrite nanoparticles synthesized using the sol-gel auto-combustion method.

## EXPERIMENTAL:

We prepared our samples by the sol–gel auto-combustion technique, in which nitrates were used as precursors. According to stoichiometric composition $CoCr_{0.5}Ce_xFe_{1.5-x}O_4$ ($x$ = 0.0, 0.025, 0.05, 0.075, 0.01) specified molar amount of A.R. grade citric acid ($C_6H_8O_7 \cdot H_2O$), Cobalt nitrate $Co(NO_3)_2 \cdot 6H_2O$, Chromium nitrate, Cerium nitrate [$Ce(NO_3)_3 \cdot 9H_2O$] and ferric nitrate $Fe(NO_3)_3 \cdot 9H_2O$ were used as starting materials. Reaction procedure was carried out in air atmosphere without protection of inert gases. The molar ratio of metal nitrates to citric acid was taken as 1:3. The metal nitrates were dissolved together in a minimum amount of double distilled water to get a clear solution. An aqueous solution of citric acid was mixed with metal nitrates solution, then ammonia solution was slowly added to adjust the pH at 7. The mixed solution was kept on to a hot plate with continuous stirring at 90 $^0$C. During evaporation, the solution became viscous and finally formed a very viscous brown gel. When finally all water molecules were removed from the mixture, the viscous gel began frothing. After few minutes, the gel automatically ignited and burnt with glowing flints. The decomposition reaction would not stop before the whole citrate complex was consumed. The auto-combustion was completed within a minute, yielding the brown-colored ashes termed as a precursor. Prepared powder was then annealed at 600 $^0$C for 4 h.

Magnetic measurements were performed at room temperature using a hysteresis loop tracer at room temperature with maximum applied magnetic fields up to 8.5 kOe.

## RESULTS AND DISCUSSION:

The magnetic hysteresis loops of $Ce^{3+}$ substituted $CoCr_{0.5}Fe_{1.5}O_4$ nanocrystalline ferrite material was recorded at room temperature. The variation of magnetic properties with applied field is shown in Fig. 2. The sample shows saturation magnetic decreases with increase in $Ce^{3+}$ substitution (Fig. 1).
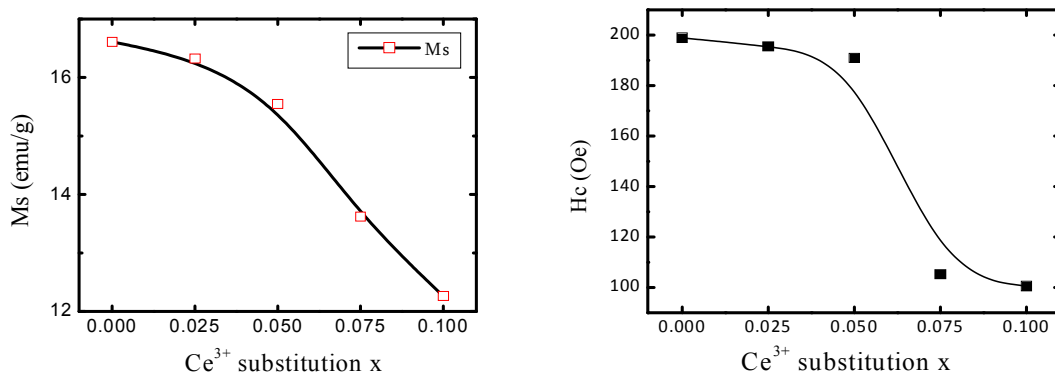


**Fig. 1: Variation of magnetization at 8.5 kOe (M)  and coercivity (Hc) with $Ce^{3+}$ composition x for $CoCe_xCr_{0.5}Fe_{1.5-x}O_4$**

The decrease in saturation magnetization is due to surface spin effects arising due to smaller particle sizes. This decrease in saturation magnetization can also explained by substitution of $Fe^{3+}$ by $Ce^{3+}$ ions. The variation of coercivity with composition x is depicted in Fig. 1. The coercivity decreases with particle size and becomes very small for the average particle sizes of 50 nm and below, because of the presence of a considerable volume fraction of superparamagnetic particles.
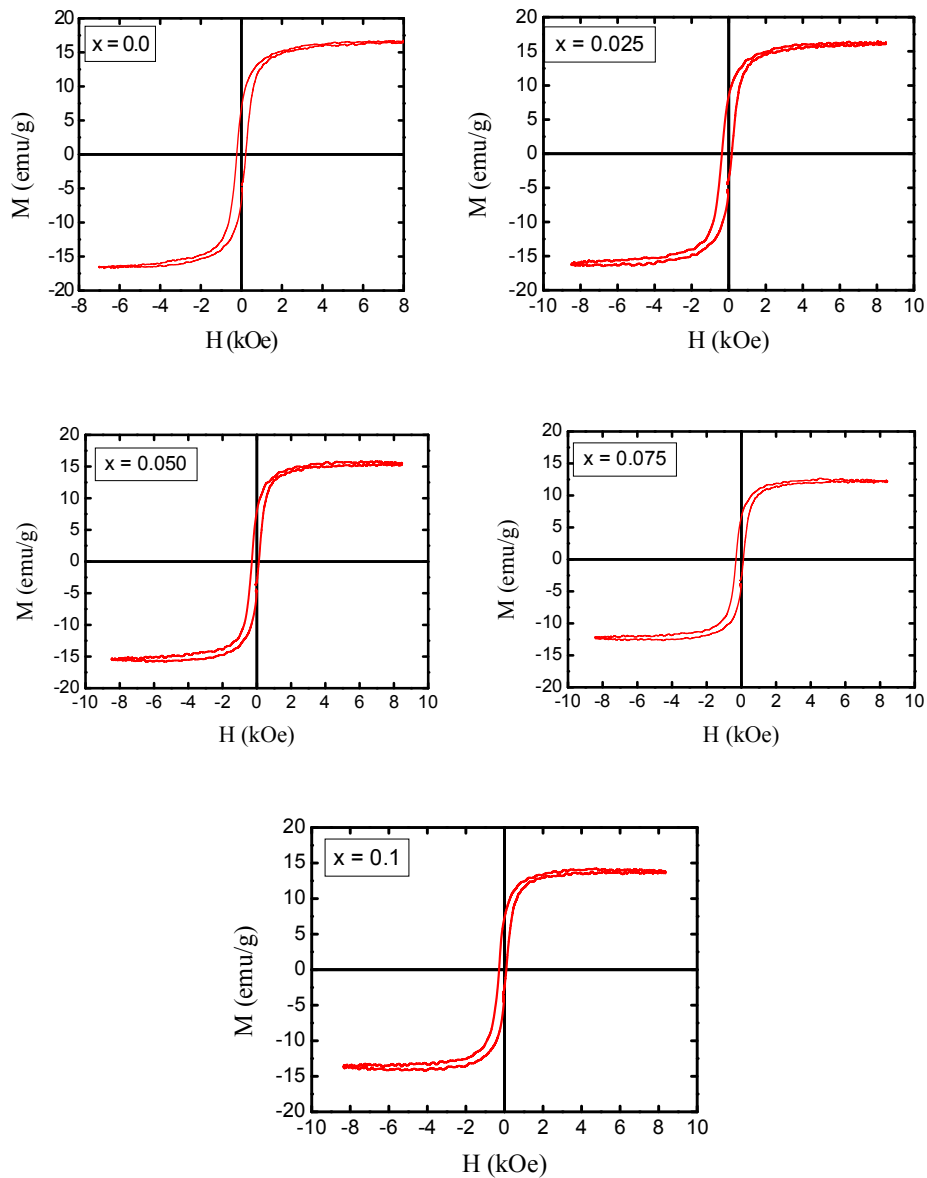
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**Fig. 2: Variation of magnetization (M) with applied field (H) for $CoCe_xCr_{0.5}Fe_{1.5-x}O_4$ (x=0.0, 0.025, 0.050, 0.075, 0.1)**

The observed behavior of the saturation magnetization with the $Ce^{3+}$ concentration could be explained on the basis of cation distribution between the A and B-sites. Cation distributions of the present samples show that all the atoms (Co and Fe) are present on both A and B-sites. In the cubic system of ferromagnetic spinels, the magnetic interaction could be explained by the superexchange interaction mechanism between the cations in the A and B sites.

According to Neel's two sublattice model of collinear ferrimagnetism, the magnetic moment per formula unit is expressed as $M = M_B - M_A$ where $M_B$ and $M_A$ are the magnetic moment at the B-site and A-site respectively. All the parameters determined from the hysteresis loops are shown in Table 1. For $Ce^{3+}$ substituted Co-Cr ferrite, $Ce^{3+}$ substitution for $Fe^{3+}$ ions at B site, leading to decrease in the B-site sublattice

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magnetization and magnetic moment (Fig. 3). The variation in magnetization and magnetic moment can be explained on the basis of known magnetic moments for $Ce^{3+}$ ($0\mu_B$), $Co^{2+}$ ($3\mu_B$), $Cr^{3+}$ ($3\mu_B$) and $Fe^{3+}$ ($5\mu_B$).

The observed magnetic moment ($n_B$ Obs.) per formula unit in Bohr magneton ($\mu_B$) was calculated by using the relation [11]:

$$n_B = \frac{M_W \times M_S}{5585} \qquad\qquad (1)$$

where, $M_W$ is the molecular weight of the sample, $n_B$ is the magnetic moment of the samples expressed in Bohr magneton, Ms is the saturation magnetization. The variation of observed magnetic moment with $Ce^{3+}$ content x is displayed in the Fig.3 and Table 1.
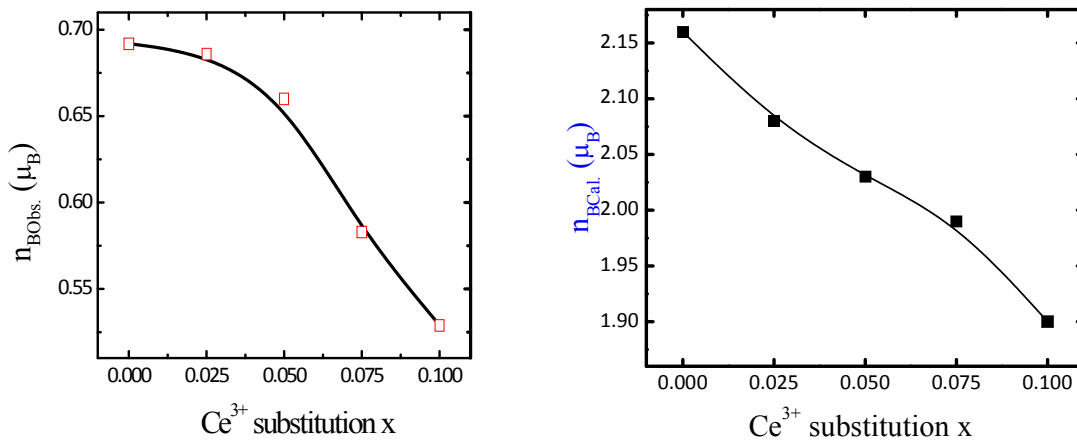


**Fig. 3: Variation of observed ($n_B$ Obs.) and calculated ($n_B$ Cal.) magneton number with $Ce^{3+}$ composition x for $CoCe_xCr_{0.5}Fe_{1.5-x}O_4$**

**Table 1: Saturation magnetization ($M_s$), Magneton number ($\eta_B$) and Coercivity ($H_C$) of $CoCe_xCr_{0.5}Fe_{1.5-x}O_4$ (x = 0.0, 0.025, 0.050, 0.075, 0.1)**

| Comp. x | $M_s$ (emu/g) | $\eta_B$ ($\mu_B$) | | $H_C$ (Oe) |
| --- | --- | --- | --- | --- |
| | | Cal. | Obs. | |
| 0.0 | 16.61 | 2.16 | 0.692 | 198.9 |
| 0.025 | 16.32 | 2.08 | 0.686 | 195.6 |
| 0.050 | 15.55 | 2.03 | 0.660 | 190.9 |
| 0.075 | 13.62 | 1.99 | 0.583 | 105.2 |
| 0.1 | 12.26 | 1.90 | 0.529 | 100.5 |

## CONCLUSIONS

The magnetic properties of the samples are strongly affected by cation distribution. The saturation magnetization depends upon the Co concentration on octahedral B-site. The saturation magnetization decreases as $Ce^{3+}$ substitution increases. The calculated magnetic moment and observed magnetic moment value calculated by considering the cation distribution and ionic magnetic moments of individual ions.

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