



Structural and Magnetic Properties of Cobalt Substituted Lithium Hexaferrites

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Abstract: A series of M-type hexaferrites with a composition of compounds in chemical formula $\text{Li}_{0.5}\text{Fe}_{0.5+x}\text{Co}_x\text{Al}_{12-2x}\text{O}_{19}$ for different five compositions (x ranging between 2 and 6) are synthesized with the substitution of Co^{+3} in the laboratory by standard ceramic technique. The result show the magnetic intensity enhances with high Curie temperature. The high intensity of magnetization is explained on the basis of superexchange interactions in the magnetic sublattices.

Keywords:- M-type Lithium hexaferrite, Magnetic moment, Curie temperature etc

1. Introduction:

Lithium ferrites have attracted considerable attention because of the squareness of the of the hysteresis loop coupled with a superior temperature performance. The crystal structure of the magnetoplumbite (M) like compounds have a space group SG: $P6_3/mmc$ (194) can be described as superposition of two structural blocks namely R-block with composition $\text{BaFe}_6\text{O}_{11}$ and the S-block with composition $(\text{Fe}_6\text{O}_8)^2$ [1] in 1:1 ratio. The cations are distributed within five different crystallographic sites viz. 2a, 2b, 4f1, 4f2 and 12K [2]. The magnetic behavior of the compound has been explained mainly due to the interaction amongst the ions occupying these crystallographic sites. Various comparative magnetic interactions are occurring in the lattice due to several possible site distributions which in turn decided the net magnetic behavior. All the samples prepared in the series with chemical formula $\text{Li}_{0.5}\text{Fe}_{0.5+x}\text{Co}_x\text{Al}_{12-2x}\text{O}_{19}$ (x ranging between 2 and 6) have been synthesized with a view to study the substitutional effect on the magnetic properties of these ferrites.

2. Experimental:-

All the multicrystalline powder sample were synthesized by high temperature solid state reaction using A.R grade oxides of stoichiometric ratio Li_2O , Fe_2O_3 , Al_2O_3 and Co_2O_3 mixture. Li_2O oxide was carefully dehydrated before the mixing procedure, after grinding the mixture under acetone acid for six hours. During the preparation of pellets of thoroughly grounded mixture in the proper molar ratio with 5% of PVA as a binder are prepared by applying 10 tone pressure per square inch. These pellets slowly heated in the furnace at 600°C for 5-6 hours to remove binder. Then it was fired at 1200°C for 120 hours continuously, after that the furnace were cooled at the rate of 20°C per hours up to 1000°C and then 50°C per hours and then cooled in natural way the phase of final sample were verified by Philips X-ray diffractometer





using N-filter copper K α radiation. The mean grain size of multicrystalline samples was in the range 150 - 200 Å. All the samples show single phase formation with a space group P6 $_3$ /mmc (194). The electrical conductivity [3] Ghare D.B. et.al was measure by the methods using LCR meter. The end faces of pellets were coated with thin layer of conducting silver paste and measurement were made from room temperature to 800 K Thermoelectric power measurement were carried out after sandwiching the thick pellet between two copper rod from room temperature to 550°C

3. Result and discussion:

All the samples were synthesized in polycrystalline form using stoichiometric mixture of oxides with standard ceramic technique. The mixture was ground in acetone acid and sintered at 1000°C for 120 hours. Phase unicity of the final samples was verified from long exposures X-ray diffraction pattern (XRD). The lattice parameters of hexagonal cell for the compounds were deduced from XRD pattern. XRD pattern of one of the compound of Lithium ferrite Li $_{0.5}$ Fe $_{2.5}$ Co $_2$ Al $_8$ O $_{19}$ as shown in figure-1. X axis represent the angle of diffraction and Y axis represent intensity in arbitrary units. The Experimental setup used for magnetic susceptibility measurement was the same as reported earlier [4]. The intensity of magnetization of the samples was measured for all the samples at room temperature are enumerated in Table-1.

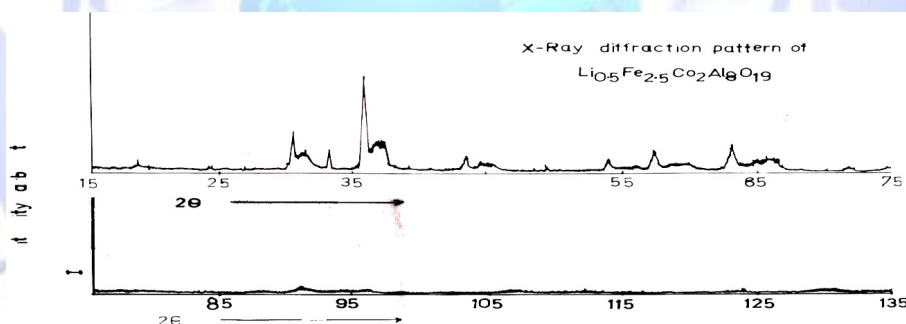


Fig. -1 XRD Pattern of one compound of Lithium ferrite Li $_{0.5}$ Fe $_{2.5}$ Co $_2$ Al $_8$ O $_{19}$

Table-1 Result of Li $_{0.5}$ Fe $_{0.5+x}$ Co $_x$ Al $_{12-2x}$ O $_{19}$

x	a (Å)	c (Å)	M (emu)	x (emu)
2	5.8598	22.3234	12x10 $^{-3}$	1091x10 $^{-6}$
3	5.8185	21.8798	16x10 $^{-3}$	2547x10 $^{-6}$
4	5.8074	21.8410	30x10 $^{-3}$	3821x10 $^{-6}$
5	5.7939	21.8075	60x10 $^{-3}$	5015x10 $^{-6}$
6	5.6952	21.2620	94x10 $^{-3}$	5703x10 $^{-6}$

All the samples had shown no transition in magnetic moment up to 1000°C. However the intensity of magnetization per unit volume at room temperature of the sample was found to be increases with increase in Co $^{3+}$ ion concentration.





In BaM, there are four main super-exchange interactions between magnetic sites viz. 12K-4f₁, 12K-4f₂, 2a-12k and 2a-4f₁, the Fe⁺³ ions favour these sites are responsible for the large value of magnetic moment [5]. The neutron diffraction and NMR studies have shown that Co⁺³ ions occupy mainly 4f₁ and 12K sites [6-7]. The strong increase in Curie temperature T_c value indicates that same inter sub lattice exchange interactions are dominant. The 2a-12K, 4f-12K and 2a- 4f₁ interaction contribute to the enhance magnetic moment ion hexaferrite. From the results it seems that these sites are occupied by Co⁺³ ions, which leads that magnetic interaction increase with an increase in T_c value resulting the increase in intensity of magnetization. Particularly, the interactions 12K-4f₁ is important and determine the magnetic behaviors of the compound. A mean field analysis of the exchange interaction in M-type hexaferrite has been carried out by Isalouge et.al [8-9]. The result shows that the Fe in 12K sub lattice making the link among R and S blocks is subjected to very strong competitive exchange interaction. So, when the Fe⁺³ions in the 12K sublattice are replaced by Co⁺³ions, strengthening of the super exchange interaction between magnetic ions results in increase of magnetic moment.

4. Conclusion:

In the present work of lithium ferrites, is to check the formation of ferrite containing Al⁺³ and Co⁺³ ions along with Fe⁺³ ions. All these compounds have M-structure through the site distribution changes. No changes occur in the charge distribution but the site distribution is change due to strichiometric changes.

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