



CHANGE OF STRUCTURE AND, ELECTRICAL BEHAVIOR BY DOPING OF ALUMINIUM AND COBALT IONS IN LITHIUM FERRITE

Suresh. S. Darokar

Science College, Congress Nagar. Nagpur-12, India.

Email: sureshdarokar@gmail.com

ABSTRACT:

A series of Lithium magnetoplumbite hexaferrites (M-type hexaferrites) with a composition of Aluminium and Cobalt substituted samples with the general chemical formula $\text{Li}_{0.5}\text{Fe}_{0.5-x}\text{Co}_x\text{Al}_{12-2x}\text{O}_{19}$ were synthesized using reacting oxide by high temperature solid state reaction technique. The structural characterization of compound has been carried out from X-Ray diffraction powder pattern. The compounds are in single hexagonal phase without traces of uncertainly ambiguous reflection. From XRD pattern lattice parameters has recorded with increasing doped aluminum element in the range from $a = 5.807 \text{ \AA}$ to 5.906 \AA and $c = 22.507 \text{ \AA}$ to 22.585 \AA pertaining the space group $P6_3/mmc$ (No.194) conformed from JCPDS data. The mass density of the ferrites were found linearly varies and depends upon the mass and volume of sample. The X-Ray density has depends upon the lattice constant and molecular weight of the compounds. The average particle size was also estimated. The compounds were studied magnetically by using Guoy's method in the temperature range 300 to 800 K, the result shows that the compounds are paramagnetic in nature. The Curie molar constant was worked out.

Keywords: Magnetoplumbite hexaferrites, Molar constant, Seebeck coefficient etc.

1. INTRODUCTION:

Lithium hardferrites with general chemical formula $\text{Li}_{0.5}\text{Fe}_{12.5}\text{O}_{19}$ has been of great technological interest in many electromagnetic devices for a long time. High electrical resistivity, low eddy current losses, low magnetic losses, and very good thermal and chemical stability make lithium ferrite of a material of great importance for microwave applications. In the family of hexagonal ferrites, the magnetoplumbite hexaferrites (M-Type) created much attention due to wide range of application in industries and created potential to interest in technological and scientific research due to their application importance such as high density magnetic recording, microwave device materials, hard disc in computer system. The application need particularly magnetic and electrical specification with the view, many attempts have been improved the properties of hexagonal ferrites using different tract of additives. The calcium hexferrites [1-6] have magnetic properties comparable to BaM and SrM. In Calcium ferrites many attempts has been made to replace Fe^{+3} ions with Al^{+3} , Cr^{+3} and Co^{+3} etc. A compound with the combination of bivalent-tetravalent cation was also used to replace Fe^{+3} ion such as Cu-Ti, Co-Ti, Co-Sn, Zn-Sn etc [7, 8] without any appreciable change in BaM structure. When Fe^{+3} ions are replaced by non magnetic ions like Ti^{+4} and Sn^{+4} etc. In the same way Lithium ferrites substituted with Al and Co has been studied structurally, electrically and magnetically [9]. In the present study a series of five sample with chemical formula $\text{Li}_{0.5}\text{Fe}_{0.5+x}\text{Al}_{12-2x}\text{Co}_x\text{O}_{19}$ ($x = 2, 3, 4, 5$ and 6) were prepared. Lithium ferrites have attracted considerable attention because of the squareness of hysteresis loop coupled with superior temperature performance the crystal structure of M-type like compound with a space group $P6_3/mmc$ (194) can be described as superposition of two structure block namely R-block with composition $\text{BaFe}_6\text{O}_{11}$ and S-block

with composition Fe_6O_8 [10] in the stoichiometric ratio.

2. EXPERIMENTAL:

Polycrystalline sample were synthesized in powder form by high temperature solid state reaction using A.R grade oxides with 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 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 diffractometry using Ni-filter copper radiation. The mean grain size of multicrystalline samples was in the range 150 - 200 \AA . All the samples show single phase formation with a space group $P6_3/mmc$ (194) confirmed from JCPDS data. X-ray pattern of the samples as shown in fig.1.1

The D.C electrical resistivity or electrical conductivity was measure by the methods using LCR meter [11]. 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:

In the present work, the Aluminium and Cobalt substituted Lithium hardferrites were introduced with general formula $\text{Li}_{0.5}\text{Fe}_{0.5+x}\text{Al}_{12-2x}\text{Co}_x\text{O}_{19}$ ($x = 2, 3, 4, 5$ and 6). The ions in Ba-M compounds can be replaced partly by Co^{+3} or completely Li^{+1} and combination of Fe^{+3} and Al^{+3}

ions without changing the crystal lattice symmetry [12]. In all the specimens substituted ions would be chosen to keep electrical neutrality and to have a similar ionic radii in these ferrites. Due to the resemblance of ionic radii of Fe⁺³ with Co⁺³ and Al⁺³ ions, the ferrites ions will replace by cobalt and aluminium. It is seen that former ions are very easily replaced at any substituted variation in all specimens. The hexagonal lattice parameters 'a' and 'c' decreases linearly with the substitution variation Co⁺³ and Fe⁺³ concentration in all specimens. Thus the doping ions cobalt and aluminium play an important role in the property variation of the compounds. XRD technique is used to confirm the formation of hexagonal M structure of compounds belonging to a space group P6₃/mmc (194) confirmed from JCPDS data in International Table, for X-ray diffraction photograph Homawalt 1956 [13-16]. The decrease in lattice parameter and cell volume agree with result for Ba/Sr ferrite [17,18]. The numerical values of compositional data such as lattice constant, cell volume and X-ray density are tabulated in table -1. The observed value of electrical conductivity, activation energy and curie molar constant for specimens are also tabulated in table.2.

The plot of electrical conductivity verses inversion of temperature i.e. ln σ verses (1/T) x 10⁻³ K for the entire sample was almost linear.

The electrical conductivity of these ferrites increases with increasing ferrite ion concentration. The electrical conductivity of sintered specimens varies from 2.193 x 10⁻¹² Ω⁻¹ cm to 5.78 x 10⁻⁶ Ω⁻¹ cm of these ferrites. The other workers have obtained a conductivity value of 2 x 10⁻² Ω⁻¹cm for Li-ferrite that obtained is 2.3 x 10⁻⁶ Ω⁻¹ cm [19]

In the present work the electrical conductivity value obtained for the compounds is 2.193 x 10⁻¹² to 5.78 x 10⁻⁶ Ω⁻¹cm. The value of the electrical conductivity may be partly attributed to the low evaporation of lithium from the sample, while the electrical conductivity values obtained by Venugopal Reddy et al 1984 is 2.3 x 10⁻⁶ (Ω⁻¹cm) and 2x10⁻² (Ω⁻¹cm) Rezlescu N. et al 1974 for lithium ferrite [20-22]. The variation of activation energy with the substitutional parameters x, it is explain on the basis of Verwey model [23], A small number of ferrous ions (Fe⁺²) are generally developed during sintering process which lead the conductivity in ferrites suggesting the hopping mechanism according (Fe⁺² = Fe⁺³+e⁻¹) [24]. However these transitions take place for a very small interval of time and are not detectable by the ordinary method. This valence exchange mechanism of Verwey may be considered for these ferrites as general and applicable to M-type ferrite.

Table 1 Structural data of lithium hexaferrites

Compounds	Lattice parameters		Cell Volume (Å) ³	Mol. Wt gm	X-Ray Density gm/cc
	a (Å)	c (Å)			
Li _{0.5} Fe _{2.5} Co ₂ Al ₈ O ₁₉	5.859	22.323	663.81	780.89	3.9065
Li _{0.5} Fe _{6.5} Co ₆ O ₁₉	5.695	21.262	597.22	1024.42	5.6963

Table 2 Electrical conductivity of compounds

Compounds	Electrical Resistivity at room temp. [Ω cm ¹]	Activation energy E in (eV)	Electrical Conductivity at room temp. Ω ⁻¹ cm ⁻¹
Li _{0.5} Fe _{2.5} Al ₈ Co ₂ O ₁₉	4.559x10 ¹¹	0.77	2.193 x10 ⁻¹²
Li _{0.5} Fe _{6.5} Co ₆ O ₁₉	1.72x10 ⁵	0.39	5.78 x10 ⁻⁶

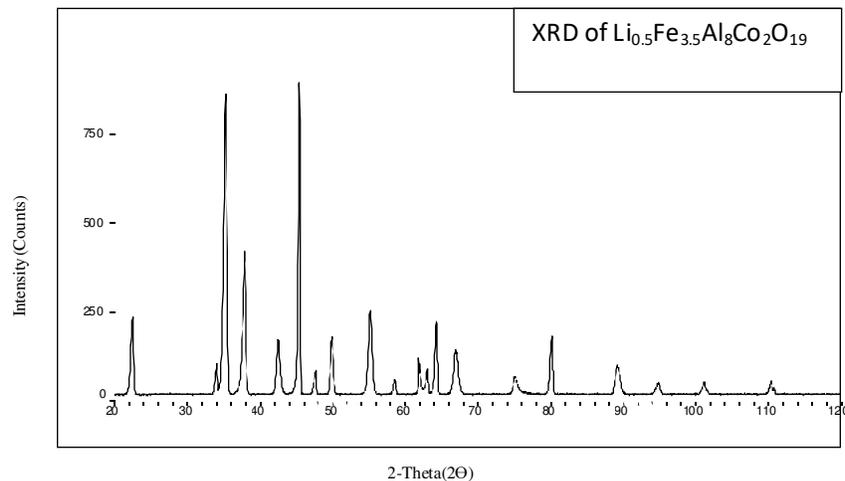


Figure 1.1

4. CONCLUSION:

In this present work of lithium hard ferrites is to check the formation of ferrite containing Al⁺³ and Co⁺³ ions along with Fe⁺³ ions. The values of lattice parameters *a* and *c* confirms the formation of hexagonal unit cell. 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 in the compound. In this series of Li_{0.5}Fe_{6.5}Co₆O₁₉ to Li_{0.5}Fe_{2.5}Co₂Al₈O₁₉ the electrical conductivity of these ferrites increases with increasing ferrite ion concentration. Also, by carried out the magnetic study, the Coercivity, Retentivity, Saturation magnetization, magnetic moment decreased with Al ions substitution. It is evident from the fact that Al ions is weak magnetic in nature. Lithium hard ferrites shows magnetic properties which are more useful in the field of information storage recording media.

REFERENCES:

1. J.Beretea and T.Brown. Austral. J.Chem.24(1971) 273
2. J.Lipka,A.Gruskova,O.Orlicky, J.Siteck, M.Miglierini,R.Grone, M.Hud and Toth Hyperfine Interaction 59(1990) 381.
3. G.Albanese, A Deriu, E.Luchini and G.Slokar.Appl Phys A 2(1981) 45
4. R.Muller, H.Pfeiffer and W.Schuppert, J.Mogn.Mogn Mater 18 (1991)101
5. D.K.Kulkarni and C.S.Prakash Bull Mater Sci.17(1994)
6. 35.G.Asti. M.Carbuccocchio. A Deriu, E.Lucchini and G.Slokar, J.Mogn mogn Mater 20(1980)44
7. J.G.Renson,J.A.Schullces and J.S.Van. Wlering,J.Phys Collog 32(1971)C1-924.
8. B.X.Gu,H.Y.Zang.H.R.Zhai,B.G.Slen, M.Lu,S.Y.Zhang &Y.Z.Maoi, Phys State Sol 133 (1992) K83
9. X.Obrador, A Isalgue,A Collomb, A Tejada, J.C.Joubert, J.,PhysC. 19(1986) 6605
10. D.B.Ghare, A.P.B.Sinha, J.Phys Chem Solid 29(1958) 885
11. K.Haneda, H.Kojima. Phys State Solid (A) 6(1971) 256
12. Kanke E, Takayama Muromachi Y.Uchida, Kato and S. Takikawa, J.Solid state Chem 95(1991) 43
13. Hanmawalt (1936) International Table for X-ray diffraction photograph.
14. L.G.Van Uitert, J. Appl. Phys 28.1 (1957)317
15. A. Isalgue, A Laberta, J.Tejada, X Obradir. Appl.Phys A39(1986) 221
16. S.S.Darokar, K.G.Rewatkar & D.K. Kulkarni;Mater Chem.Phys.56 (1998) 84-85
17. K. Haneda, M. Kojima, J. Appl. Phys 14.B(1973) 3760
18. V. Adelskod, Arkir Kemi Min Geo 12 A (1938)1
19. Albense G, Carbulichhio and Deril A J.Phys Solid State: A 23 (1974) 351
20. Venugopal Reddy et.al, J. Pure and Applied Physics 22,(1984)596,
21. N.Rezlescu, D.Condurachi, P.Petrarju and E.Lucca, J.A.M .Ceream Soc.57 (1974)40
22. S.S.Darokar, K.G.Rewatkar, M.S.Chowkase & D.K.Kulkarni, Indian J. Phys 74A(2) (2000) 155-157
23. E.J. Verway J.H, De-Bar.Pec.Trar.Chem Pay Bull 55 (1936)531
24. S.S. Darokar et.al, J. Adv. Appl. Sci. Research, 2013, 4(1): 173-177.