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ORIGINAL ARTICLE

CRYSTAL STRUCTURE AND ELECTRICAL CHARACTERIZATION OF MIXED LITHIUM FERRITE CERAMICS.

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ABSTRACT:

A Cobalt and Aluminium substituted Lithium ferrite (M- type) samples with the general chemical formula $Li_{0.5}Fe_{0.5+x}Al_{12-2X}$ Co xO_{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 Å to 5.906 Å and c = 22.507 Å to 22.585 Å pertaining the space group $P6_3/mmc$ (No.194). 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.

KEYWORDS: Crystal Structure, Electrical, Mixed Lithium ferrite ceramics, Hexaferrites, Curie molar constant

INTRODUCTION:

A Lithium hexaferrites Li $_{0.5}$Fe $_{12.5}O_{19}$ mangnetoplumbite (M-Type) has been a great technological interest in many electromagnetic devices from a long time. High electrical resistivity, low eddy current losses, low magnetic losses, and very good thermal and chemical stability. Lithium ferrite material has a great importance for microwave applications. In the family of hexagonal ferrites, the Mangnetoplumbite 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 attempt 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 Sr M. In Calcium ferrites many attempt 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 replace 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 $Li_{0.5}Fe_{0.5+x}Al_{12-2X}Co_XO_{19}$ (x = 2, 3, 4, 5 and 6) were prepared. Lithium ferrites have attracted considerable attention because of the squareness of hysterisis 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 $BaFe_6O_{11}$ and S-block with composition Fe_6O_8 [10] in the stoichiomatricratio.

AllthepolycrystallinepowdersampleweresynthesizedbyhightemperaturesolidstatereactionusingA.R grade oxides with proper stoichiomatric 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 pallets slowly heated in the furnace at 600^0Cfor5-6hourstoremovebinder.Thenitwasfiredat1200^0Cfor120hourscontinuously,afterthatthe furnace were cooled at the rate of 20^0C per hours up to 1000 ^{0}C and then 50^0C per hours and then cooled in natural way the phase of final sample were verified by Philips X-ray diffrectometery using N-filter copper radiation. The mean grain size of multicrystalline samples was in the range 150 - 200 $A^{0.}$ All the samples show single phase formation with a space group $P6_3$/mmc (194). X-ray pattern of the samples as shown in fig.1.

The D.C electrical resistivity was measure by the methods using LCR meter /Q 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 550^0C.

RESULT AND DISCUSSION:

In the present work, the Cobalt and Aluminium substituted Lithium hexaferrites were introduced with general chemicalformula $Li_{0.5}$ Fe $_{0.5+x}Al_{12-2X}Co_XO_{19}$(X =2,3,4,5and6).Theions inBa-Mcompoundscanbe 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. The Cobalt and Aluminium play an important role in the property variation. XRD technique is used to confirms the formation of hexagonal M structure of compounds belonging to a space group $P6_3$ /mmc (194) Homawalt 1956. Due to the resemblance of ionic radii of Fe^{+3}withCo^{+3} and Al^{+3} ions [13, 14]. 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 [15]. The hexagonal lattice parameters '*a*' and 'c' decreases linearly with the substitutional variation co $^{+3}$ and Fe $^{+3}$ concentration in all specimens. The decrease in lattice parameters due to close packing of lattices in the materials [16-18]. The decrease in lattice parameter and cell volume agree with result for Ba / Sr ferrite [19-20]. 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.

From the plot of ln σ vs (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 to 2.193 x10^{12} Ω^{-1} cm to 5.78 x10^{-6} Ω^{-1} cm of these ferrites. The other workers have obtained a conductivity value of 2 x10^{-2} Ω^{-1}cm for Li-ferrite that obtained is 2.3 x 10^{-6} Ω^{-1} cm [21].

In the present work the electrical conductivity value obtained for the compounds are 2.193 x $10^{-12}\Omega^{-1}$cm to 5.78 x 10^{-6} Ω^{-1}cm. The value of the conductivity may be partly attributed to the low evaporation of lithium from the sample prepared different from these of Rozlescu etal 1974 and Venugopal Reddy 1981.The variation of activation energy with the substitutional variable parameters x -may be explain on the basis of Vewrway model [22-24], 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^{-}) [25,28]. However these transition 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 applicable to M-type ferrite.

Table 1: crystallographic structural data of lithium hexaferrites

Compounds	Lattice parameters		Cell Volume $(A^0)^3$	Mol. Wt gm	X-Ray Density gm/cc
	a (A^0)	c (A^0)			
$Li_{0.5}Fe_{2.5}Al_8Co_2O_{19}$	5.859	22.323	663.81	780.89	3.9065
$Li_{0.5}Fe_{6.5}Co_6O_{19}$	5.695	21.262	597.22	1024.42	5.6963

Table 2 Electrical conductivity parameters of compounds

Compounds	Electrical Resistivity at room temperature. $\Omega\ cm^{-1}$	Activation energy E in (eV)	Electrical Conductivity at room temperature. Ω^{-1} cm
$Li_{0.5}Fe_{2.5}Al_8Co_2O_{19}$	4.559×10^{11}	0.77	2.193×10^{-12}
$Li_{0.5}Fe_{6.5}Co_6O_{19}$	1.72×10^{5}	0.39	5.78×10^{-6}

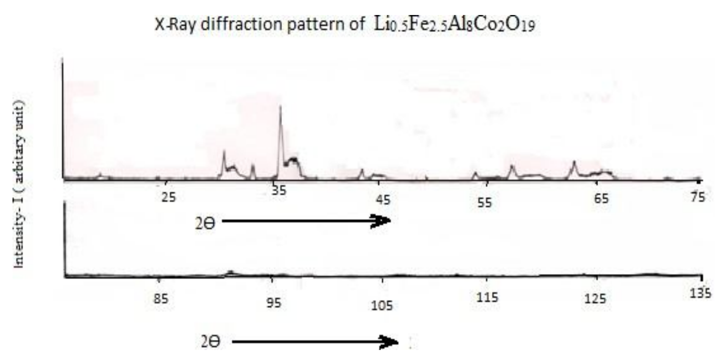

Fig. 1

A. ***Conclusion:***

In this present work, lithium hard ferrites are to check the formation of ferrite containing Al^{+3} and Co^{+3} ions along with Fe^{+3} ions. All these compounds have a magnetoplumbite structure (M-type) through the site distribution changes. No changes occur in the charge distribution but the site distribution is change due to strichiometric changes and the values of lattice parameters '*a*' and 'c'. The variation in electrical conductivity and activation energy may be due to chemical composition and a small number of ferrous ions Fe^{+2} ions are generally developed during the sintering process in the compounds.

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