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Electrical properties of $Li_{0.5}Fe_{0.5+x}Al_{12-x}O_{19}$ ferrites

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Abstract : Five compounds with general chemical formula $Li_{0.5}Fe_{0.5+x}Al_{12-x}O_{19}$ ($2<x<6$) were synthesised by standard ceramic technique using stoichiometric proportions. The dc conductivity measurements were carried out over the temperature range 27-850°C. The specimens were found to be *n*-type semiconductors as their seebeck coefficient were negative. The electrical conductivity of ferrites increases with Fe^{+3} ion concentration. Electrical conductions in the ferrites were explained on the basis of Veryway model.

Keywords : Ferrites, electrical conductivity, semi-conductor.

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1. Introduction

Conduction mechanism in mixed ferrites with a view to study electrical properties like electrical conductivity, dielectric constant, thermoelectric power as a function of composition and temperature have been studied by us. {Cu – Ti by Rewatkar *et al* [1], Al–Cr by Kulkarni and Prakash [2], Li–Co by Darokar *et al* [3]}. In continuation of this work, it was thought desirable to undertake for the first time a study of the dependence of the electrical conductivity of the mixed lithium ferrites on the composition and temperature, with magnetic susceptibility measurement carried out from room temperature to 723°K, and results of these studies are presented in this paper. In addition, the substitutional effect on composition and structure have been reported for reviewing the crystal symmetry.

2. Experimental

The samples with chemical composition $Li_{0.5}Fe_{0.5+x}Al_{12-x}O_{19}$ (X = 2, 3, 4, 5, 6) were synthesised by standard ceramic technique. The preparational procedure was similar to that reported earlier [3]. X-ray studies have been undertaken to confirm single-phase *M*-type mixed ferrites. The values of seebeck coefficient were determined for the various specimens to confirm the type of conductivity. Magnetic susceptibility measurements were carried out using a Gouy's balance in the temperature range 300 to 500K. All the samples studied showed paramagnetic behaviour. The Curie molar constant C_M was worked out. The electrical conductivity of polycrystalline Li-Al ferrites having different compositions have been measured over temperature range 300 to 800 K using a two probe method [1].

3. Results and discussion

In the present work lithium-aluminium substituted hexaferrites were introduced with a general chemical formula $Li_{0.5}Fe_{0.5+x}Al_{12-x}O_{19}$ ($2<x<6$). The ions in BaM-compounds, can be replaced partially by Al^{3+} or completely by Li^{+1} and a combination of Fe^{+3} and Al^{+3} ions without changing crystal lattice symmetry. In all the specimens, substituted ions would be chosen to keep electrical neutrality and to have similar ionic radii. In these ferrites the aluminium plays a major role in the property variations. XRD technique is used to confirm the formation of hexagonal *M*-structure of the compound belonging to space group : $P6_3/mmc$ (No. 194). Due to the resemblance of ionic radii of Fe^{+3} and Al^{+3} ions, the ferrite ions were replaced by aluminium. It is seen that the former ions are very easily replaced at any substitutional ratio without changing the crystal structure. The lattice parameters *a* and *c* decrease linearly with substitutional variation in all the specimens. The decrease in lattice constants may occur due to close packing of lattice in the materials. The numerical values of compositional data, such as, lattice constants cell

Table 1. Consolidated data for lattice parameters of $Li_{0.5}Fe_{0.5+x}Al_{12-x}O_{19}$ ferrites.

S.No.	X	a(Å)	c(Å)	V(Å^3)	X-ray density (gm/cc)
1	2	5.906	22.585	682.23	3.489
2	3	5.852	22.452	665.92	3.719
3	4	5.827	22.208	653.03	3.939
4	5	5.811	22.081	645.86	4.131
5	6	5.807	22.507	644.26	4.290