Structural, Transport and Magnetic Properties of Li-Mg Ferrites

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Abstract - Mixed ferrosplins with a general formula \(\text{Li}_x\text{M}_y\text{Mg}_{1-2x}\text{Fe}_2\text{O}_4\) (for \(x=0.25\) and \(0.5\) are prepared by ceramic technique. Formation is checked by XRD and all compounds are cubic spinels even in presence of J-T ions with lattice dimensions ranging from 8.30 to 8.37\text{"A}. Charge and site distribution is obtained from diffraction data supported by electrical and magnetic parameters. The compounds are semiconducting with energy of activation ranging from 0.25 to 0.63\text{eV}. The observed magnetic results (Guoy and n-d) are explained by Neel's model or by Yafet-Kittel model.

1. INTRODUCTION

Ferrosplins have attracted the attention of scientists and technologists due to their interesting and controllable physical properties, which depend upon method of preparation [1] site [2] and valence distribution [3] etc.

With this view of examining the chemical and magnetic structure, transport and magnetic properties; mixed Li-Mg ferrites with general formula \(\text{Li}_x\text{M}_y\text{Mg}_{1-2x}\text{Fe}_2\text{O}_4\) (for \(M=\text{Cr}, \text{Mn, Fe, Co}\) for \(x=0,0.25\) and \(0.5\) are studied in this work.

2. EXPERIMENTAL

Nine compounds mentioned in table 1 are prepared by standard ceramic technique [4] using analar grade oxides. For each compound the reactants were mixed and ground in a proper molar ratio. Using an agate mortar under acetone. The mixtures in the form of pellets were sintered at 1100\text{\degree}C for 100 hrs and were slowly cooled to room temperature in about 10 hrs.

The formation of the compounds was checked by powder method using filtered copper radiation. The diffraction pattern of these compounds do not show the presence of reactant oxides or other binary oxides but were only due to a single phase.

2.1 Electrical Resistivity

Pellets of 12mm dia. and 3mm thickness were prepared for resistivity measurements. Dimensionally identical pellets were chosen to avoid the differences in specific resistance to the possible extent due to stray capacitance and porosity etc. Silver paste was used as a gold contact material. The measurements were carried out in the temperature range of 300\text{\degree}K to 1000\text{\degree}K in the steps of 10\text{\degree}K by applying a constant voltage(6V) across the pellet using LCR (Radar) bridge.

2.2 Magnetic Susceptibility and Neutron Diffraction

Paramagnetic susceptibility of the compounds was determined by Guoy method. Measurements were compared with the standard data obtained for \(\text{Er}_2\text{O}_3\) in order to minimize some of the systematic errors due to packing etc.

Few samples were studied for their magnetic structural studies using neutron diffraction. Thermal neutron flux of 6\times10^3 \text{cm}^{-2}\text{sec}^{-1} at an operating power of 40 MW were used for the purpose. Aluminium single crystal in the form of slab with (111) face has been used as monochromator. The wavelength used was 1.215\text{\AA}. An unpolarised neutron spectrometer with angular speed of 6 degree/hr in steps of \(1^\circ\), \(1/2^\circ\), \(1/3^\circ\), \(1/4^\circ\) and \(1/12^\circ\) was used. The automatic recording of data is accomplished by using simple control circuit. Magnetic and nuclear contribution are discriminated by either scanning the samples below and above the Curie temperature or by applying saturation magnetic field along the scattering vector of the reflecting plane.

3. RESULTS

All the compounds studied here are found to crystallize in cubic symmetry with lattice parameter varying between \(8.30\text{\AA}\) to 8.37\text{\AA}. Charge and site distribution of cations is obtained mainly by X-ray intensity evaluations supported by other studies, such as neutron-scattering data and resistivity parameters. Magnetic susceptibility findings predict, in general linear ferrimagnetic structure of the compounds. Resistivity plots shows the semi-conducting behaviour of the materials with change in slope generally occurring in the region of Curie temperature. Findings of various studies for the compounds obtained in the work are given in Table I.

4. DISCUSSION

All the nine compounds studied here crystallize in cubic...
symmetry. The lattice parameter of the compounds is found compatible with atomic number of metallic ion ‘M’ except for manganese. This may be due to the distortive nature of Mn$^{4+}$ ion [5]. However, the distortion could not alter the symmetry of the system. The chemical and magnetic lattice dimensions are same for all the compounds. Charge and site distribution of ion evaluated by using X-ray and neutron data confirms either the already reported finding or established model [7] with minor variations.

Electrical resistivity studies show the semiconducting behaviour of the compounds and conduction is due to hopping of charge carriers. Change in slope observed in most of the compounds in the vicinity of Curie temperature may be due to the transfer anomalies [8,9,10] caused by the influence of magnetic ordering of charge carriers.

Magnetic susceptibility findings for these nine compounds show sufficient closeness to the theoretical spin only values. Thus, the observed results mostly agree well with the Neel’s model. However, in few cases observed values are slightly different from the theoretical values which may be due to the slight non-collinear spin alignments. Such findings are also supported by neutron diffraction studies. And therefore, existence of canting or sub canting like Yafet-Kittel [11] can not be ruled out in few cases where the deviation is observed.

### REFERENCES