CHAPTER – V

SUMMARY AND CONCLUSIONS

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The main purpose of the studies of magnetic oxide especially the ferrites has been to provide a suitable composition having useful properties for scientific and technological applications. The ferrites are also subjected to rigorous investigation using X-ray diffraction, neutron diffraction and Mossbouer spectroscopy.

The Magnesium ferrite $(MgFe_2O_4)$ and magnese ferrites $(MnFe_2O_4)$ were studied by many workers (1-6) from the point of view of understanding the magnetic and electrical properties.

It is wellknown that Mn^{2+} ions prefer A site where as Mg^{2+} prefers B site. As boths are being a partial inverse ferrites, studies to shed some light on role of ionic size difference, magnetic and nonmagnetic nature of divalent ion and variable valence of Mn in shaping the cation distribution are expecteed. Therefore the following studies on the Mg-Mn ferrite system were undertaken.

1)   Preparation of magnesium-magnese ferrites with the general formula $Mg_x Mn_{1-x} Fe_2O_4$ where $x = 0.0, 0.1, 0.3, 0.5, 0.7, 0.9$ and 1.0.

2)   X-ray diffraction studies to confirm single phase formation and to determine lattice constant I.R. absorption studies to obtain knowledge about the internal vibration and to find out positions of absorption bands

and to study the variation of force constant with bond length.

3) Magnetic studies were conducted to observe the variations in the magnetic moment, magnetization and hysteresis with composition at room temperature A.C. susceptibility studies were conducted to observe the domain structure.

4) Electrical resistivity, a.c. conductivity and thermo emf studies were carried out to understand the conduction phenomenon in these compounds.

The reports on these studies have been presented in this dissertation which comprises of Five Chapters. The First Chapter is introductory containing Historical development in ferrites, spinel structure, types of ferrites, applications of ferrites. The orientation of the present work is included at the end of chapter.

The Second Chapter is divided into three section for convenience of presentation. In Section A methods of preparation are reviewed and hot pressing technique is discussed to understand the possibility of obtaining high density ferrites. The details of actual sample preparation by using the standard ceramic method are given at the end of section. In Section B X-ray diffraction technique with necessary theory and analysis are given.

The analysis of X-ray diffraction patterns reveals the single phase spinel structure of samples. The calculated and observed 'd' values of the samples are in good agreement with each other. The lattice constant decreases with increasing Mg content. From X-ray data the bond lengths R_A and R_B are calculated. It is observed that both R_A and R_B with decreases with increase of Mg concentration.

Theory of ionocovalent bonding in ferrites was explained by Levine [7] on the basis of variation of bond length in the spinel structure. Thus it may be concluded that addition of Mg^{2+}ion has an effect of increasing the ionocovalent character of the ferrite.

In Section C necessary theoretical background for I.R. spectra is briefly discussed and the I.R. spectra of ferrite samples at the room temperature in the range of 300 cm^{-1} to 800 cm^{-1} with KBr pellet method are presented. Each sample shows the broadening of the absorption band Waldron [8] observed two absorption bands around 600 cm^{-1} and 400 cm^{-1} due to tetrahedral and octahedral complexes. For $MnFe_2O_4$ additional band around 345 cm^{-1} is observed. The fine structure is also observed. This can be explained by taking into consideration the multivalence state of Mn ion in the system. The absorption band around 345 cm^{-1} may be due to $Mn^{2+} O_6^{2-}$ octahedron. Force constant K_t K_o are found to increase linearly with R_A and R_B respectively. This behaviour is similar

to transition metal oxides.

The Third Chapter deals with the magnetic properties of samples of present system. It is divided into Four parts Section A is devoted to experimental details with necessary formulae to calculate magnetic parameters, variation of saturation magnetisation ($4 \pi M_s$) with composition shows increasing trend upto $x = 0.5$ Mg. then afterwards magnetisation decreases as content of Mg increases. The magnetic moment for Mn ferrite being rather low as compared to the reported [10,11] value. At present these results can not be explained on the basis of Neel's two sublattice model. Therefore, these results have been explained by assuming a triangular spin arrangement in these materials. The justification for which is at hand, in view of the possibility of Mn^{2+}, Fe^{2+}, Mn^{2+}, Fe^{2+} presenting a situation of comparable strength of A-B and B-B interactions. The reduction in magnetic moment is due to canting behaviour of Mn in the system.

In Section B the a.c. susceptibility study throws a light on the nature of magnetic particles in ferrites. With the help of these results one can distinguish between single domain (SD), Multidomain(MD), and Superparamagnetic (SP) nature of particles. The variation of normalized a.c. susceptibility as a function of temperature in the present case indicates all samples contain MD particles.

Section C deals with the initial permeability. It is observed that the variation of initial permeability as a function of temperature shows similar behaviour for all samples. The observed decrease in permeability with composition may be attributed to the decrease/ of Mg concentration. This also reflects on the density variations of the samples.

In Section D the experimental details of Curie temperature measurement is given. It is observed that the Curie temperature increases with content of Mg. This is attributed to the increase of A-B interaction on the addition of Mg in the system.

The Fourth Chapter is devoted to electrical properties of the present system, which comprises three sections. Section A contains D.C. conductivity studies .A· theoretical background related with the conduction mechanism in ferrites, hopping mechanism and polarons , along with experimental techniques is given. Ferrites being semiconductor their resistivity decreases with the increas / in temperature. The graphs of $\log \rho$ versus $10^3/T$ shows three regions with two transition temperature (T_1) and (T_2). The temperature T_2 nearly coinsides with Curie temperature of these samples. Similar behaviour is reported in literature [12] for different region of resistivity behaviour with temperature suggest the different conduction mechanisms[13]. The conduction in the first region is due to

impurity charge carriers (ΔE 0.2 eV). In the Second region is due to polaron hopping mechanism as the activation energy is (0.2< ΔE < 0.7 eV). In the third region $\Delta E > 0.7$ eV due to magnetic disordering.

The variation of thermo emf with temperature has been studied with a view to determine the type of conduction at different temperatures. It is seen that samples x = 0.0, 0.5, 0.7, 0.9 and 1.0 shows p-type conduction at room temperature and then change to n-type conduction. The transition temperature from p to n type is different for different composition and is less than 390 K where as samples x = 0.1 and x = 0.3 shows n-type conduction throughout the temperature range. The minima or cusp like minima is observed for all the samples this suggest that the simultaneous presence of acceptor and donor with relative predominance. The values of mobility (μ d) have been calculated using the values of thermo emf (α) and resistivity (ρ) for different temperature. The temperature variation of mobility is explained on the basis of polaron model the activation energy is calculated from log μ d versus 1/T which supports the hypothesis that the impurity conduction plays a dominant role of lower temperature.

Section C of this chapter deals with the a.c. conductivity studies. The dielectric measurement were carried out by using LCR meter in the range of 100 Hz to 10 MHz. The vaiation of resistivity and dielectric constant with

composition at fixed frequency is plotted which shows reverse nature each other.

The variation of ϵ' with frequency reveals dispersion due to Maxwell-Wagner interfacial polarization in agreement with Koops phenological theory [14]. The vartiation of loss tangent (tan δ) as function of frequency were studied which shows similar behaviour.

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