chapter V

Summary & Conclusions

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SUMMARY AND CONCLUSIONS

Ferrites are important ferrimagnetic materials which find wide application in the field of electronics and communication instruments. Extensive work has been done on ferrites by many research workers to upgrade the properties. Ferrites are semiconductor by nature and they possess high electrical resistivity, low power losses due to eddy current, high permeability and small coercive force. Hence these are widely used in industrial electronic, microwave and computer industries. They are useful for transformer chokes, transformer cores, induction tuners, antenna rods, magnetic pole pieces of high frequency induction heaters. They are also used in T.V. receivers, telephone circuits, loudspeakers, and in the field of memory and switching devices.

In spinel ferrites electric and magnetic properties are structure sensitive and can be influenced by substituting and heat treatment. The mixed Cu-Co ferrite system has been studied by many workers (1,2,3,4,5) from the point of view of crystal structure, d.c. electrical and magnetic properties etc. However data on Aluminium substituted Cu-Co ferrite is scares in literature. Hence it will be interesting to study and compare the d.c.

electrical and magnetic properties of the Cu-Co mixed ferrites with those which are substituted with Aluminium. Both the ferrites i.e. $CuFe_2O_4$ and $CoFe_2O_4$ are inverse spinels. Both possess high electrical resistivity. Thus in Cu-Co ferrite both electrical and magnetic properties are expected to change. Therefore in order to understand the role of Aluminium in Cu-Co ferrite system the following studies have been carried out.

1. Preparation of Aluminium substituted Cu-Co ferrite system Cux Co1-x Fe1.5 O4 by standard ceramic method with x = 0, 0.2, 0.4, 0.6, 0.8 and 1.
2. XRD studies to confirm the solid state reaction, determination of crystal structure and calculation of lattice parameter.
3. IR studies to detect the internal variation due to tetrahedral and octahedral metal ion complexes and evaluate force constant.
4. Measurement of d.c. electrical conductivity to compute activation energy and to propose conduction mechanism.
5. Hysteresis study at room temperature to observe the variation of saturation magnetization and magnetic moment with composition.
6. A.C. susceptibility measurements to decide the nature of magnetic particles.

7. Curie temperature measurement by a.c. susceptibility and d.c conductivity.

The reports of these studies have been presented in this dissertation.

This dissertation comprises five chapters. The first chapter deals with the introduction of ferrites in which historical development, crystal structure of spinel ferrites along with classification are discussed. The theories of ferrimagnetism, electrical and magnetic properties have been discussed briefly. Application of ferrites are mentioned and the orientation of work is given at the end of the chapter.

The second chapter is divided into three parts viz. preparation, XRD studies and IR studies. In the preparation part, various methods of preparation of ferrites are given along with the stages of preparation are reviewed. The ceramic method is discussed in somewhat details. A brief discussion of sintering and pressing is given along with a short introduction to hot pressing technique (6). A detailed procedure used for the sample preparation and flowchart of ceramic method of the preparation is presented.

The XRD studies deals with the idea of X-ray diffraction and Bragg's law (7). The methods of X-ray diffraction are discussed briefly (8). The XRD pattern of

all the ferrite samples are obtained to confirm the single phase formation of ferrites. The lattice parameter 'a' and the interplanar distance 'd' are calculated. The observed 'd' values are found to match with the calculated d-values. There is no much variation in lattice parameter for all samples since the ionic radii of Cu is 0.70 A^o and Co is 0.78 A_o are very nearly same. In the present system Cobalt is replaced by copper. Therefore there is no much variation in the lattice parameter because of their nearly equal ionic radii. The XRD pattern of all the six samples are also presented. The bond length R_A and R_B are calculated and tabulated for all the samples. It has also been found that there is no much variation in bond lengths because of above reason. Also porosity decreases with increasing Cu content.

The IR studies are carried out at room temperature in the frequency range of 200 cm^{-1} to 800 cm^{-1} in KBr medium. The high frequency band v_1 is observed at 590 to 610 cm^{-1} and low frequency band v_2 is observed at 400cm^{-1} to 430cm^{-1} (9, 10). From the band frequencies v_1 and v_2 the force constants K_1 and K_2 are determined. It has been observed that the force constant decreases with increasing Cu content. This is due to the decrease in

covalence with increase in Cu content. That is Co is more covalent than Cu.

The third chapter is divided into two sections (III A) magnetization studies and (III B) a.c. susceptibility. In the magnetization studies (11) domain theory, hysteresis and coercivity are discussed briefly. The experimental technique and formulae for magnetization calculation are given. It is observed that magnetic moment and saturation magnetization decreases with increase of copper content. The values of nB, Ms are presented.

The a.c. susceptibility studies includes the theory of a.c. susceptibility and experimental technique. The variation of normalized susceptibility with temperature indicates that for lowest and highest concentration of copper content MD particle behaviour is observed. For intermediate concentration of copper content SD + MD behaviour is observed. From a.c. susceptibility the curie temperature also shows a decreasing trend with increase in content of copper. The values of curie temperature obtained form this method are found in good agreement with those obtained by d.c. conductivity method (12).

The forth chapter deals with the electrical properties which as d.c. conductivity. The conduction mechanism is discussed briefly with hopping mechanism

(13, 14). The experimental technique used for d.c. electrical resistivity is given. The d.c. conductivity study shows that the variation of resistivity with temperature obeys the Arrhenius equation.

$$\rho = \rho_o \text{ Exp } (E/KT).$$

Three distinct regions of conductivity were observed in the conductivity plots. The activation energy in the paramegnetic and ferrimagnetic region is calculated and it has been found that the activation energy in ferri region is more than in para-region. Also it was observed that curie temperature decreases with increase in copper content. The d.c. resistivity is measured in the temperature range 300 to 700° K. The resistivity obeys the relation given by Arrehenius. Three regions in logρ Vs 1/T are observed at two transition temperatures. The higher transition temperature (T_2) are found to be coinciding with nearly curie temperature. These regions suggest the different conduction mechanism. The conduction in the first region is due to impurities and in the second region polaron hopping and in the third region is due to magnetic disordering (15).

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