INTRODUCTION

Spinel ferrites with general chemical formula \( \text{MF}_{2}\text{O}_4 \) (M = Fe, Co, Ni, Mn etc) are very promising magnetic materials because of their high performance in applications of high density magnetic recording, microwave devices, drug delivery, Ferro fluid, magneto-optic, magnetic resonance imaging, transformer core, antenna rod, memory chips etc [1,2]. The particle size can be broad to a small value [nano meter dimension] by using the Novel chemical methods. Magnetic particles have become a subject of considerable interest in last decades and many physical studies have been devoted on them. The ability to produce the particles of nano size dimension has opened new application for magnetic materials like ferrite. Recent interest in the study of several spinel type ferrites is in terms of the synthesis of their nanoparticles relatively at low temperatures by different techniques, in view of their potential applications in several fields. The structural, electrical and magnetic properties of the nano sized ferrite materials are entirely different from those of their bulk counter parts [3]. The nano size ferrites with uniform particle size and narrow size distribution are preferable for a variety of applications like magnetic data storage, magnetic drug delivery etc.

A present study on this ferrite system is focused on the production of the nano size material at very low temperatures by wet chemical co-precipitation technique. It is assumed that the substitution of chromium ions in manganese ferrite may alter their Structural and dielectric properties and therefore, \( \text{MnFe}_2\text{x}_{\text{Cr}_x}\text{O}_4 \) spinel ferrite system has been studied in the present paper because less work has been found on this system.

EXPERIMENTAL DETAILS

In this work, the spinel ferrite system having the generic formula \( \text{MnFe}_2\text{x}_{\text{Cr}_x}\text{O}_4 \) (with \( x = 0.0, 0.2, 0.4, 0.6, 0.8 \) and 1.0) has been prepared by wet chemical co-precipitation method. A.R. grade manganese sulphate (\( \text{MnSO}_4 \cdot 7\text{H}_2\text{O} \)), ferrous sulphate (\( \text{FeSO}_4 \cdot 7\text{H}_2\text{O} \)) and chromium sulphate \( \text{Cr}_2\text{(SO}_4)_3 \cdot 6\text{H}_2\text{O} \) were used as a raw material for the synthesis of \( \text{MnFe}_2\text{x}_{\text{Cr}_x}\text{O}_4 \) spinel ferrite system. The as prepared powder of \( \text{MnFe}_2\text{x}_{\text{Cr}_x}\text{O}_4 \) was annealed at 960° C for 12 hours. The dielectric measurement carried out with an LCR-Q meter (HIOKI 3532-50) at room temperature in the frequency range between 100 Hz to 5 MHz.

RESULTS AND DISCUSSION

The lattice constant \( a \) calculated from the XRD data for the entire samples .The lattice constant \( a \) decreases as chromium percentage increases is shown in fig.1. The decrease in lattice constant is attributed to the difference in ionic radii of the constituent ions. In the present spinel ferrite system \( \text{Fe}^{3+} \) ions of ionic radii 0.67 Å were replaced by chromium ions of ionic radii 0.63 Å and hence lattice constant of the present system decreases. Similar observations of lattice constant were observed in the literature [4].

![Figure 1: Variation of Lattice Constant with X of \( \text{MnFe}_2\text{x}_{\text{Cr}_x}\text{O}_4 \)](image)

Dielectric Analysis:

The variation of the dielectric constant \( \varepsilon \) as a function of frequency for all the samples measured at room temperature is shown in Fig.2. It can be observed that all the samples show strong frequency dependent as well as composition dependents. The dielectrics constant decreases exponentially with increase in frequency. At higher frequency the dielectric constant reaches constant values may be due to the fact that beyond a certain frequency of external A.C. field, the electron exchange between \( \text{Fe}^{3+} \) and \( \text{Fe}^{2+} \) cannot follow the alternating field.

![Figure 2: Variation of dielectric loss with log F Of \( \text{MnFe}_2\text{x}_{\text{Cr}_x}\text{O}_4 \) (0.0 ≤ x ≤1.0)](image)
The variation of dielectric loss as a function of frequency is shown in Fig.3. It can be seen from Fig.3 that all the samples exhibit similar behavior. The dielectric loss decreases as frequency increases. The decrease in dielectric loss rapid at lower frequency and becomes less sensitive at higher frequency. The decrease in dielectric loss constant is similar to that of dielectric constant.

Fig.3 Variation of dielectric loss (ε") with log F of MnFe\(_{2-x}\)Cr\(_x\)O\(_4\) (0.0 ≤ x ≤ 1.0)

Fig.4 shows the variation of dielectric loss tangent (tanδ) as a function of frequency. It can be seen from Fig.4 that the dielectric loss tangent decreases with frequency.

Fig.4 Variation of dielectric loss tangent with Log F of Fe\(_{2-x}\)Cr\(_x\)O\(_4\) (0.0 ≤ x ≤ 1.0)

According to the Iwauchi [5] there is a strong correlation between the conduction mechanism and the dielectric behavior of ferrites. A maximum value in tanδ can be observed when the hopping frequencies are approximately equal to that externally applied electric field [6]. The dielectric behavior of the present spinel ferrite system MnFe\(_{2-x}\)Cr\(_x\)O\(_4\) is similar to that reported for Mn-Zn nano ferrites [7, 8].

CONCLUSIONS

The MnFe\(_{2-x}\)Cr\(_x\)O\(_4\) spinel ferrite systems have been prepared using wet chemical co-precipitation method. Nano size particles have been obtained using wet chemical co-precipitation method. The dielectric constant, dielectric loss and dielectric loss tangent all decreases with frequency. Thus, the wet chemical co-precipitation technique is found to be one of the easiest, simplest and effective chemical routes for the preparation of nano sizes particles.

REFERENCES:

4. V. T. Thanki, N. N. Jani, Urvi Chhaya, H. H. Joshi & R. G. Kulkarni,