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Physical and Magnetic Properties of Cd Doped Cu Ferrite

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Abstract: Spinel ferrites of copper ferrite with samples of Cu doped ferrite with Cd, general formula $Cu_{1-x}Cd_xFe_2O_4$ (x = 0.0 to 0.2) were prepared by using double sintering ceramic technique. The physical and magnetic properties of $Cu_{1-x}Cd_xFe_2O_4$ samples were studied by X-ray diffraction, high field hysteresis loop technique. Lattice constant 'a' is found to increase with increase in Cd content. X-ray density dx increases as increase in Cd content. The particle size of the samples is found to vary in the range of 177Å to 280Å. Magnetic moment n_B is found to increase as increase in Cd concentration.

Keywords: Ceramic, Lattice constant, magnetic properties.

I. Introduction

Ferrites with spinel have been the subject of large studies because of their magnetic properties resulting from a particular configuration. They can be used in several fields such as electronics, computer, telecommunication, radar, radio, television, videotape [1]. Ferrites are the most widely used magnetic materials due to their high performance and low cost [2]. The exchange interaction between the neighbouring atoms may be indirect and can take place through intermediate nonmagnetic atom such as oxygen or Sulphur [3]. One of the most important ferrites is a Copper ferrite $CuFe_2O_4$. Copper is supposed to be unique spinal ferrite because it contains Cu^{2+} ions which lead to Jahn Teller type distortion of the interstitial sites. The cation distribution of copper ferrite is variable and strongly dependent on temperature factor [4]. Copper ferrite shows tetragonal structure. Copper and substituted copper ferrite has been studied by several workers [5-7]. In present work Cd substituted copper ferrite is prepared in the bulk form by ceramic method. We have studied the structural and magnetic properties when Cadmium substituted in the copper ferrites.

II. Experimental:

Samples of the spinal system $Cu_{1-x}Cd_xFe_2O_4$ (x = 0.0 to 0.2) were prepared by double sintering ceramic technique using AR grade oxides CuO, CdO and Fe_2O_3.

The physical properties of the prepared samples were determined by X-ray powder diffraction technique. The X-ray diffraction (XRD) patterns were recorded of all the samples on a PW710 diffractometer using CuKα radiation in the range of $2\theta = 10^0$ to 90^0 and scanning rate of one degree per minute.

The magnetization measurements were carried out by using the high field hysteresis loop technique [8] at 300K.

III. Results and Discussion:

3.1 XRD Analysis:

Fig.1 show the XRD patterns of the samples of the present system for Cd content X=0.0 0.1and 0.2. These XRD patterns show sharp lines corresponding to single phase cubic spinel structure. The lattice constant value of 'a' were determined from XRD data and are listed in Table 1.

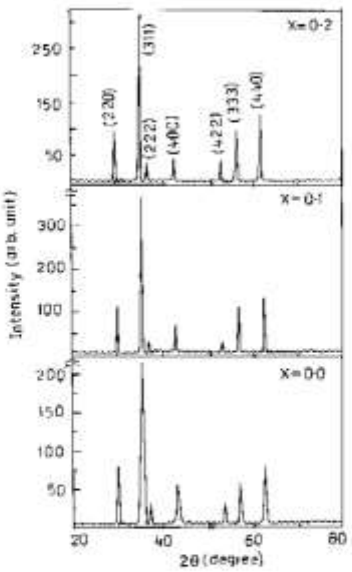

Fig. 1 X-ray diffraction pattern of Cu_{1-x} $Cd_xFe_2O_4$ for x=0.0-0.2.

It is evident that the lattice constant initially increases with Cd content increases. The variation of lattice with cadmium concentration can be explained by considering the difference in ionic radii of cadmium and copper. In the present series Cu_{1-x} $Cd_xFe_2O_4$ Cu^{2+} ions of smaller ionic radii (0.70Å) are replaced by larger ionic radii Cd^{2+} (0.99Å) ions. This causes the increase in lattice constant.
The x - ray density for each sample was calculated using the relation dx = ZM/NV
Where Z is number of molecules per unit cell (Z=8), M is molecular weight, N is Avogadro's number and V is volume of unit cell. The X-ray density values listed in Table 1 are found to increase with substitution of cadmium. This shows that the decrease in mass over takes the decrease in volume of unit cell in the present system.
The values of particle size t of all the samples estimated by using Scherre's formula [9] are listed in Table 1. It is evident that the particles size is found to vary in the range of 177Å to280Å.

Table 1: Lattice constant (a), X-ray density (dx) and particle size for $Cu1_{-x}$ $Cd_xFe_2O_4$

Composition x	Lattice constant a (A^0)	X-ray density dx (gm/cm^3)	Particle size t (Å)
0.0	a=8.39c=8.43	5.381	177
0.1	8.42	5.432	270
0.2	8.45	5.482	280

3.2 Magnetization:

The saturation magnetization value (M_s), coercivity (H_c), remanence magnetization (M_r) and magneton number n_B [9] (saturation magnetization per formula unit in Bohr magneton) at 300K for all the samples of the present system are represented in Table 2. It can be seen that the magnetion number increases with increase Cd content. The increase in saturation magnetization and hence magneton number may be attributed to the fact that though $Cd^{2+.}$
($0\mu_B$) ions occupy tetrahedral A-site, Cu^{2+} ions occupy octahedral B-site thereby increasing the magnetic moment of B-site. The occupancy of Cu^{2+} having magnetic moment $1\mu_B$ ions at octahedral B- site leads to increase in magnetic moment of B- site as compared to A-site magnetic moment.

Table 2: Saturation magnetization (M_s), coercivity (H_c), remanence magnetization (M_r) and Magnetron number (n_B) for $Cu_{1-x}Cd_xFe_2O_4$

Comp. (x)	Magnetization Parameter				Magneton number $n_B(\mu_B)$
	Remanent Magnetization M_r (emu/gm)	Saturation Magnetization M_s (emu/gm)	Coercive H_c (O_e)	Remnance R= M_r/M_s	
0.0	14.88	47.55	158.11	0.312	1.94
0.1	11.87	58.11	9.527	0.032	2.54
0.2	4.20	76.00	18.32	0.055	3.32

IV. Conclusions:

Lattice parameter increases. X-ray density increases with Cd content increases. Particle size is found to be in the range of 177 to 283Å. Variation of magneton number n_B indicates that magnetic structure is collinear

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