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Preparation, Characterization and Magnetic Properties of Cd Substituted Li–Ni Nano Ferrites

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***Abstract*: The Nano sized Cd–Ni–Zn ferrites with general chemical formula Cd0.5 $Ni_{0.75-x/2}$ $Zn_{x/2}$ Fe_2O_4 (0<x<1) were synthesized from a simple polymer matrix-based precursor solution method. The solution was composed of metal nitrates, polymer (PVA) and disaccharide (sucrose). Thermolysis/flame pyrolysis of the precursor mass in an external temperature resulted in the oxide phase formation. X-ray diffraction studies (XRD) confirm the formation of single-phase ferrites. The micro structural studies were carried out by scanning electron microscopy (SEM). The average grain diameter was estimated by the Scherrer method and grain diameter is found to vary from 25 nm to 45 nm. The saturation magnetization was studied as a function of composition.**

***Keywords*: Nano Ferrites, SEM, Magnetic Properties.**

1. Introduction

The ferrites have long been considered as highly important electronics materials. They are mainly composed of iron oxide and other divalent metal oxides. The ferrites have high resistivity, low eddy current losses and have remarkable magnetic properties and applications in radio frequency region. The properties of spinel ferrites are enhanced when the size of particle reaches the nanometer range [1]. In recent years, fabrication and characterization of a nano phase and nanostructure materials have attracting a great deal of attention because of their potential applications in areas such as electronics, optics, catalysis, ceramics and magnetic storage. A central aspect of nano science is the development of nano materials below 100 nm range. Nano particles have large surface area and it has been shown that overall physical properties are determined by the surface environment and bonding of the surface cat ions. They increase saturation magnetization Ms and lower coercivity Hc at room temperature.

Lithium ferrite is a unique member of spinel class of ferrimagnets. These ferrite materials are dominating the field of microwave applications because of their rectangular and square hysteresis loop characteristics, high Curie temperature and large saturation magnetization. The synthesis of nano crystalline Ni–Zn ferrites has been investigated intensively in recent years due to their potential applications,

in non-resonant devices, radio frequency circuits, high-quality filters, rod antenna's, transformer cores, read/write heads for electronic devices etc., [3]. Now a day these materials are largely synthesized in nano metric scale for new improvised properties [4]. They exhibit interesting electrical and magnetic properties. Many researchers have studied Li–Ni–Zn, Li–Mg–Zn, Li–Ni ferrite systems prepared by conventional ceramic method [5], [6]. In this communication we report on the Preparation, characterization and magnetic properties of nanosized Zn substituted Li–Ni nano ferrites pre- pared by wet chemical method.

2. Experimental Details

The ferrites with the general chemical formula $Cd_{0.5}$–$Ni_{0.75-X/2}$ $Zn_{x/2}$ Fe_2O_4 (0 < X < 1) were prepared by the chemical route by using Metal nitrates, sucrose and PVA. The powders were presented at 600 ◦C for 6 hours in air medium. The powders were pressed into pellets by applying a pressure of about 5 tone/sq. inch for 5 minutes by putting a powder of about 1 gr in a die of 1 cm diameter. The pellets were subjected to final sintering at 800 ◦C for 8 hours and furnace cooled in air. The single phase formation of the samples was confirmed by X-ray diffraction studies using Philips PW-1710 X-ray diffractometer with CuKα radiation (h 1.5418 Å). The SEM micrographs of the samples were obtained using SEM Model JEOL-JSM. The average grain diameter for each composition was calculated using the Scherrer formula

3. RESULTS AND DISCUSSION

The single-phase spinel formation of the samples was confirmed by XRD patterns as shown in Figure 1.

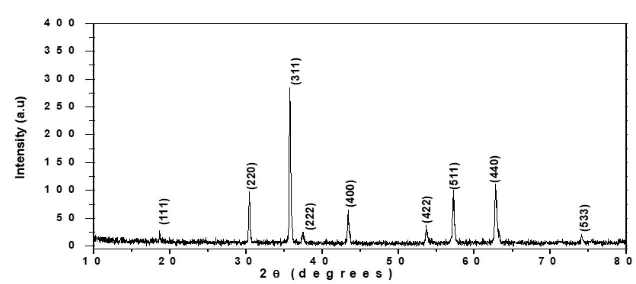

Fig. 1. XRD pattern

The variation of lattice parameter 'a' with Zn content is shown Table 1.

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Table 1
Data on lattice parameters, porosity and average grain size

Composition (x)	**Lattice parameters of the phases (Å)**	**Porosity (%)**	**Average grain size (nm)**
	Ferrite		
	a		
0.00	-	7.2	1.24
0.15	8.307	8.7	1.22
0.30	8.371	9.9	1.18
0.45	8.466	10.8	1.20
1.00	8.312	11.4	1.22

It can be seen that the lattice parameter increases linearly with Zinc content obeying Vegard's law. The Zn2+ ion have large ionic radius (0.74 Å) than Fe3+ (0.645 Å) Ni2+ (0.69 Å) and Li1+ (0.68 Å) ions. The Zn2+ ions successively replace the Fe3+ ions on A site. This results in increase of lattice parameter with content of zinc. A similar type of variation is also observed in Ni–Zn nano.

$$D = 0.9h/\beta \cos 8$$

Where h is wavelength of radiation, β is full width at half maximum (FWHM) and 8 is the angle of diffraction. The high field hysteresis Loop tracer was used to measure the magnetization of the samples. The single-phase spinel formation of the samples was confirmed by XRD patterns as shown in Figure 1. The variation of lattice parameter 'a' with Zn content is shown Table 1. It can be seen that the lattice parameter increases linearly with Zinc content obeying Vegard's law. The Zn2+ ion have large ionic radius (0.74 Å) than Fe3+ (0.645 Å) Ni2+ (0.69 Å) and Li1+ (0.68 Å) ions. The Zn2+ ions successively replace the Fe3+ ions on A site. This results in increase of lattice parameter with content of zinc. A similar type of variation is also observed in Ni–Zn nano ferrites. From the X-ray diffraction data the values of bond lengths RA and RB and ionic site radii rA and rB were calculated and are listed in Table 1. It can be seen that the bond lengths RA and RB increase linearly with the contents of Zn which can be attributed to the increase in lattice parameter with Zn content. Jadhav also observed similar results in Li–Cu–Zn ferrite [7]. It is also observed that site radii rA and rB increase linearly with Zn content. The SEM micrographs of the samples are shown in the Figure 2.

The micrographs reveals that all the samples show fine grains, segregation of impurity phases is not found and the porosity of the samples varies from sample to sample. The compositional variation of average grain diameter along with porosity is given in Table 1. The average grain diameter increases with Zn content upto 0.15 and then decreases beyond this limit. Similar variation hasbeen reported in the case of (Zn2+, Cd2+, Ti4+) substituted lithium ferrite [8]. An increase in grain diameter with Zn content can be attributed to the diffusion phenomenon involving Zn/oxygen vacancies and pores without its deposition on grain boundaries that hampers the grain growth. The increase in grain diameter with Zn content is attributed to the low solid solubility of nickel in the samples.

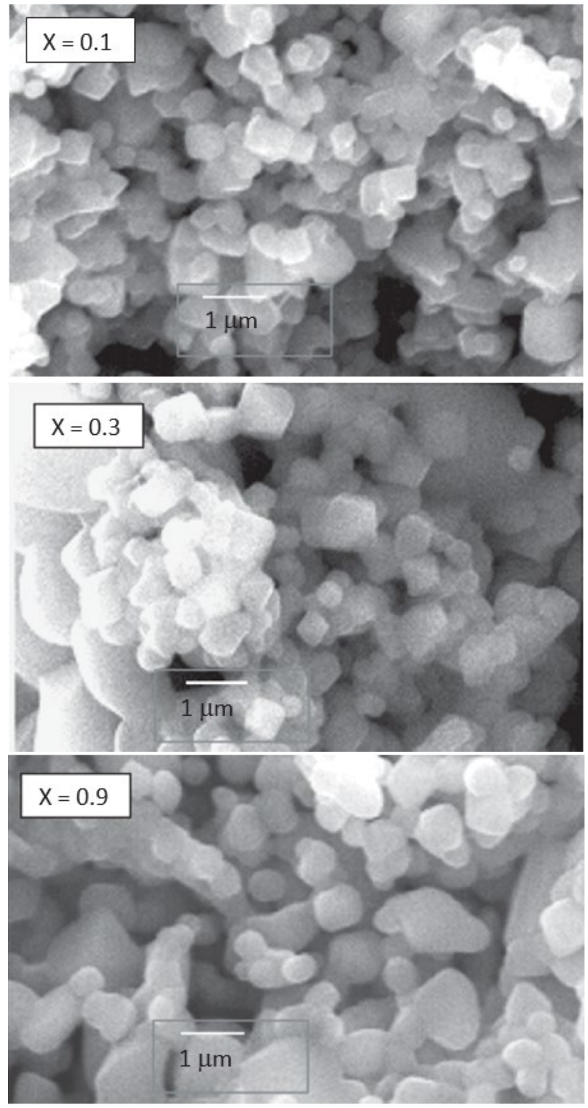

Fig. 2. SEM graphs

4. Conclusion

Ferrites with the general chemical formula $Cd_{0.5}$–Ni $_{0.75-X/2}$ $Zn_{X/2}$ Fe_2O_4 were prepared by chemical route. The single-phase spinel formation of the samples was confirmed by XRD patterns. From the SEM studies it is seen that all the samples show fine grains, segregation of impurity phases is not found and the porosity of the samples varies from sample to sample.

References

[1] Ding, J., Liu, X.Y., Wang, J. and Shi, Y., "Ultrafine ferrite particles prepared by coprecipitation/mechanical milling," Materials Letters, 44(1), pp.19-22, 2000.

[2] P. Poddar, H. Srikanth, S.A. Morrison, E.E. Carpenter, "Inter-particle interactions and magnetism in manganese–zinc ferrite nanoparticles," Journal of Magnetism and Magnetic Materials, vol. 288, pp. 443-451, 2005.
[3] Bid, S., and S. K. Pradhan. "Characterization of crystalline structure of ball-milled nano-Ni–Zn-ferrite by Rietveld method." Materials Chemistry and Physics 84.2-3 (2004): 291-301.
[4] Kim, Chul Sung, et al. "Growth of ultrafine Co–Mn ferrite and magnetic properties by a sol–gel method." Journal of applied physics 85.8 (1999): 5223-5225.
[5] R. G. Kharabe, R. S. Devan, C. M. Kanamadi, and B. K. Chougule, "Dielectric properties of mixed Li–Ni–Cd ferrites," Smart. Mater. Struct., vol. 15, no. 36, 2006.
[6] A. M. Shaikh, S. A. Jadhav, S. C. Watave, and B. K. Chougule, "Infrared spectral studies on Zn substituted Li-Mg ferrites," Mater. Lett. 44, 192, 2000.
[7] A. E. Verdin and K. O. Grady, J. Magn, Magn. Mater. 290, 868 (2005).
[8] Kanamadi, C. M., R. G. Kharabe, and R. B. Pujar. "Microstructure and initial permeability of Cd-substituted Li-Ni ferrites." Indian Journal of Physics 79 (2005): 257-260.
[9] Jadhav, S. A. "Magnetic properties of Zn-substituted Li–Cu ferrites." Journal of Magnetism and Magnetic Materials 224.2 (2001): 167-172.
[10] A. M. Shaikh, S. C. Watave, S. S. Bellad, S. A. Jadhav, and B. K. Chougule, "Microstructural and magnetic properties of Zn substituted Li-Mg ferrites," Mater. Chem. Phys. 65, 46 (2019).