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ChemTech

International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN : 0974-4290
Vol.6, No.3, pp 2207-2209, May-June 2014

ICMCT-2014 [10th – 12th March 2014]
International Conference on Materials and Characterization Techniques

Synthesis of Zinc-Copper Nano-Ferrite and Characterization of their Structural, Electrical and Magnetic Behaviors

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Abstract: Nanoparticles of $Zn_{(1-x)}Cu_xFe_2O_4$ were synthesized at pH 10 for (x = 0.0, 0.25, 0.50, 0.75). The Nano-size structure and composition of Copper doped Zinc-Ferrite ceramics are analyzed by X-ray diffraction and further confirmed by Scanning Electron Microscope (SEM) micrographs. Electrical and magnetic properties have been determined with the help of inductance-capacitance and resistance (LCR) meter and Vibrational sample magnetometer (VSM) respectively. Superparamagnetic behavior of ferrites is observed from the materials.
Keywords: Copper-Zinc Ferrite, hydrothermal synthesis, super-paramagnetic.

1. Introduction& Experimental :

Nanosized ferrites are widely used important materials having applications such as medical diagnostics, ferrofluid technology, for drug delivery, high density information storage media, electronic devices, sensors technology, catalysts and high microwave applications. These materials possess excellent structural, electrical and magnetic properties [1-3].Their properties are greatly influenced by their synthesis method. The hydrothermal route is one of the most commonly used techniques owing to its economics and high degree of compositional control [4].This work deals to investigate the structural, electrical and magnetic properties of $Zn_{(1-x)}Cu_xFe_2O_4$ (x=0.0, 0.25, 0.50, 0.75) system by hydrothermal method. The starting materials were zinc-acetate, copper-nitrate, ferric-nitrate and sodium-hydroxide all of analytical grade. The pH value of 10 is to be maintained for the solutions by adding NaOH. Temperature of the autoclave was slowly raised to 180 °C and kept for 40 Hrs. Obtained precipitate was then washed off and dried in vacuum oven at 70 °C [5]. Structural characterization of the samples were performed by RIGAKU POWDER XRD using Cu-Kα radiation with wavelength (λ =1.5406 Å). Smart SEM, EVO 5.05 was used to show the surface morphology of ferrite material. For measuring dielectric properties inductance capacitance and resistance (LCR) meter (Waynekarr LCR 4300 series) is used in the frequency range of 20Hz to 100 KHz at room temperature. Magnetic properties of prepared powder were investigated with the help of Vibrational Sample Magnetometer.

2 Results and Discussion:

XRD patterns confirm single-phase spinel structure prepared by hydrothermal method as shown in **Fig 1.** Crystallite size was calculated and found to be of 7.74, 10.80, 11.58, 12 nmfor x= 0.00, 0.25, 0.50, 0.75

respectively. The SEM micrographs in **Fig.2** show that the grains of the Zn-Cu ferrite are in Nano-scale. **Fig.3(a)** and **Fig.3(b)** shows that value of real (Є) and imaginary (Є') dielectric constant decreasing with increasing frequency[6]. The variation of tan δ as shown in **Fig.3(c)** can be explained on the basis of Koop's phenomenological theory [7]. **Fig.3(d)** indicates that ac conductivity increases with increasing content of copper and frequency which is explained by electron hopping phenomenon [8].Increase in magnetic saturation with increasing copper content is shown in **Fig 4.** The dependence of saturation magnetization is explained in terms of spin-disorder and spin-canting Also with the increase in copper content unpaired electron are increasing which in result are responsible for increase in paramagnetic behavior [6].

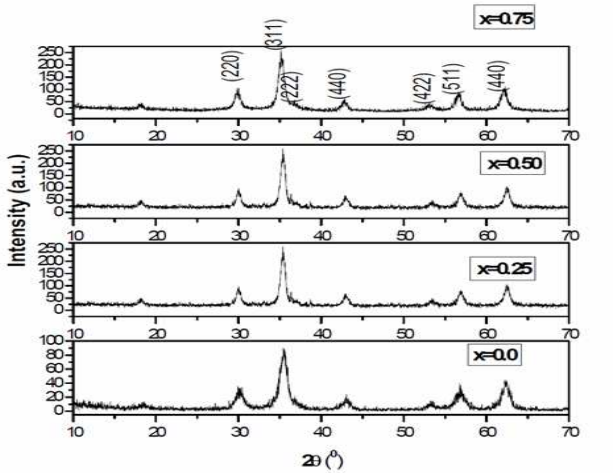

Fig.1 XRD pattern of $Zn_{(1-x)}$ $Cu_{(x)}$ Fe_2O_4x = (a) 0.00 (b) 0.25 (c) 0.50 (d) 0.75

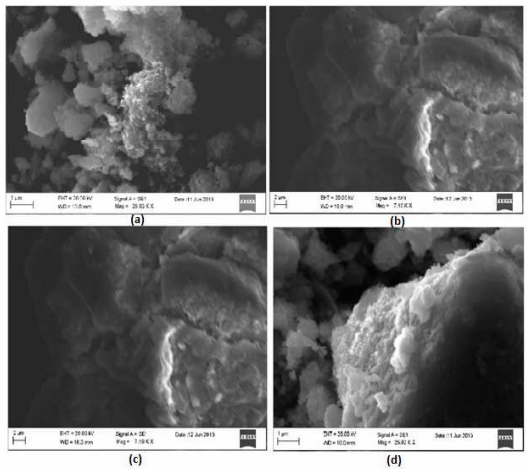

Fig. 2 SEM image of$Zn_{(1-x)}Cu_xFe_2O_4$ for x=(a)0.00(b)0.25(c)0.50(d)0.75

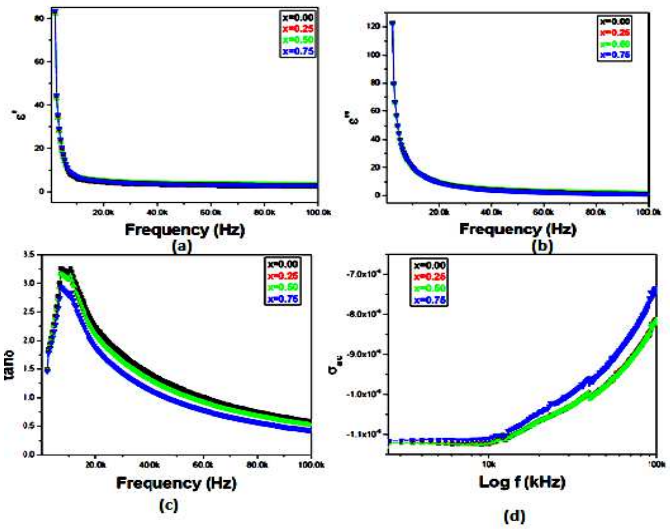

Fig.3 Variation of (a)real dielectric constant(b) imaginary dielectric constant
(c) tanδ(d)ac conductivity with frequency

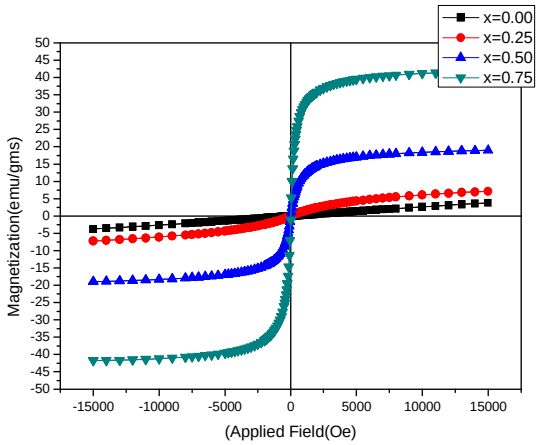

Fig.4 Magnetic hysteresis loops of samples synthesized at pH=10

In this work effect of copper substitution on structural, electrical and magnetic property of zinc-ferrite has been observed. Crystal size of materials is found to be of nanosize which is further confirmed by SEM images. Magnetization measurement indicated that synthesized ferrites are soft ferrites having superparamagnetic behavior. These nanoferrites are having number of application in various fields especially in the field of medical science, sensor technology and electronic industry.

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