Effect of Ni^{2+} substitution on structural, magnetic and electrical properties of nano-size Zn-ferrites

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Abstract

Nanocrystalline $Ni_xZn_{1-x}Fe_2O_4$ (x = 0.2, 0.4, 0.6 and 1.0) materials were prepared by chemical co-precipitation method at constant pH value of 8. X-ray diffraction studies confirmed formation of single phase spinel ferrites. Magnetic measurements revealed the super-paramagnetic nature of developed ferrites as well as the compositional variation of magnetic properties. The effect of composition, temperature and frequency on dc/ac conductivity ($\sigma_{dc/ac}$), dielectric constant (ε') and dielectric loss ($\tan\delta$) were studied and possible mechanisms were explained. FTIR studies were carried out for absorption bands of ferrites and to study the effect of Ni^{2+} ion substitution on tetrahedral and octahedral vibration frequencies.

Keywords: Co-precipitation; Spinel ferrites; super-paramagnetic, magnetometer; FTIR; dielectric.

1. Introduction

Spinel ferrites have been vastly studied for their physical and fundamental properties because of their great demand in devices like inductors, magnetic heads, magnetic resonance imaging, sensors, magnetic refrigeration etc. [1-3]. Nano-size of these types of materials strongly affects their properties due to large surface to volume ratio and enhanced reactivity. Spinel ferrites at nano-scale have attracted a great interest of present researchers from technological and application point of view [4-11]. Ni-Zn ferrites have been used widely as high frequency ferrites because of their high electrical resistivity and high permeability in radio frequency region [12]. Microstructure of nano-size ferrites strongly depends on the preparation techniques viz. mechanical alloying, chemical co-precipitation, sol-gel, sono-chemical reactions and hydrothermal synthesis [13-16]. Out of various synthesis techniques, chemical co-precipitation method is simple method with high yield for the synthesis of nano-size ferrite particles. Particle size homogeneity is also maintained in this method.

In the present research work, $Ni_xZn_{1-x}Fe_2O_4$ (x = 0.2, 0.4, 0.6 and 1.0) nano-particles were synthesized by chemical co-precipitation method. Developed particles were studied for crystalline, magnetic, electric/dielectric and chemical properties by powder x-ray diffractometer (XRD), vibrating sample magnetometer (VSM), impedance analyzer and Fourier transform infra red (FTIR) respectively. Dc/ac conductivity ($\sigma_{dc/ac}$), dielectric constant (ε') and dielectric loss ($\tan\delta$) of different compositions of synthesized $Ni_xZn_{1-x}Fe_2O_4$ (x = 0.2, 0.4, 0.6 and 1.0) nano-particles for temperature and frequency dependence.

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