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Structural, Magnetic, Dielectric and Electrical Properties of Gd3+ Doped Cobalt Ferrite Nanoparticles

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Abstract : In this work, $CoFe_{2-x}Gd_xO_4$ (x=0.00, 0.05, 0.10, 0.15, 0.20) spinel ferrite nanoparticles are synthesized by sonochemical method. The structural properties and cation distribution are investigated using X-ray Diffraction (XRD), Raman Spectroscopy, Fourier Transform Infrared Spectroscopy and X-ray photoelectron spectroscopy. The morphology and elemental analysis are screened using field emission scanning electron microscopy (FE-SEM) and energy dispersive X-ray spectroscopy, respectively. The particle size measured by FE-SEM and XRD analysis confirm the formation of nanoparticles in the range of 7-10 nm. The electrical properties show that the Gd^{3+} doped cobalt ferrite ($CoFe_{2-x}Gd_xO_4$; x= 0.20) exhibit enhanced dielectric constant (277 at 100 Hz) and ac conductivity (20.17 x 10^{-9} S/cm at 100 Hz). The complex impedance measurement study reveals that as Gd^{3+} doping concentration increases, the impedance Z' and Z' ' decreases. The influence of Gd^{3+} doping in cobalt ferrite nanoparticles on the magnetic property is examined by using vibrating sample magnetometer. Magnetic property measurement reveal that the coercivity decreases with Gd^{3+} substitution from 234.32 Oe (x=0.00) to 12.60 Oe (x=0.05) and further increases from 12.60 Oe (x=0.05) to 68.62 Oe (x=0.20). The saturation magnetization decreases with Gd^{3+} substitution from 40.19 emu/g (x=0.00) to 21.58 emu/g (x=0.20). This decrease follows the three-sublattice model suggested by Yafet-Kittel (Y-K). The Y-K angle increases with the increase of Gd^{3+} doping in cobalt ferrite nanoparticles.

Keywords : sonochemical method, nanoparticles, magnetic property, dielectric property, electrical property
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