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Enhanced Dielectric Properties of La Substituted CoFe2O4 Magnetic Nanoparticles

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Abstract : Spinel ferrite magnetic nanomaterials have received a great deal of attention in recent years due to their wide range of potential applications in various fields such as magnetic data storage and microwave device applications. Among the family of spinel ferrites, cobalt ferrite (CoFe2O4) has been widely used in the field of high-frequency applications because of its remarkable material qualities such as moderate saturation magnetization, high coercivity, large permeability at higher frequency and high electrical resistivity. For aforementioned applications, the materials should have an improved electrical property, especially enhancement in the dielectric properties. It is well known that the substitution of rare earth metal cations in Fe3+ site of CoFe2O4 nanoparticles leads to structural distortion and thus significantly influences the structural and morphological properties whereas greatly modifies the electrical and magnetic properties of a material. In the present investigation, we report on the influence of lanthanum (La3+) ion substitution on the structural, morphological, dielectric and magnetic properties of CoFe2O4 magnetic nanoparticles prepared by co-precipitation method. Powder X-ray diffraction patterns reveal the formation of inverse cubic spinel structure with the signature of LaFeO3 phase at higher La3+ ion concentrations. Raman and Fourier transform infrared spectral analysis also confirms the formation of inverse cubic spinel structure and Fe-O symmetrical stretching vibrations of CoFe2O4 nanoparticles, respectively. Transmission electron microscopy study reveals that the size of the particles gradually increases with increasing La3+ ion concentrations whereas the agglomeration gets slightly reduced for La3+ ion substituted CoFe2O4 nanoparticles than that of undoped CoFe2O4 nanoparticles. Dielectric properties such as dielectric constant and dielectric loss were recorded as a function of frequency and temperature which reveals that the dielectric constant gradually increases with increasing temperatures as well as La3+ ion concentrations. The increased dielectric constant might be the reason that the formation of LaFeO3 secondary phase at higher La3+ ion concentrations. Magnetic measurement demonstrates that the saturation magnetization gradually decreases from 61.45 to 25.13 emu/g with increasing La3+ ion concentrations which is due to the nonmagnetic nature of La3+ ions substitution.

Keywords : cobalt ferrite, co-precipitation, dielectric properties, saturation magnetization
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