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A systematic investigation of structural, optical and magnetic properties of pristine $BaFe_2O_4$, Mg and Mg, Cs co-doped in $BaFe_{2-x}Mg_xO_4$ and $Ba_{1-x}Cs_xFe_{2-y}Mg_yO_4$ spinel nanoferrites

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The oxygen annealed barium nanoferrites have been synthesized by the chemical co-precipitation technique integrated with microwave treatment. The effects of doping on structural, optical and magnetic properties have been studied in detail. Powder XRD of the Mg doped and Mg, Cs co-doped $BaFe_2O_4$ shows large variation in the crystallite size especially due to the impact of alkali (Mg) and alkali earth metal (Cs) doping in octahedral and tetrahedral sites of the orthorhombic spinel structure. The appropriate atomic compositions and functional groups have been confirmed by the EDX and FTIR spectrums. The structural transformation of substantial nanoparticles to marginal nanorods explicit in the SEM micrograph and the evolution of high band gap have been obtained from the UV-Vis spectra. The magnetic hysteresis in the field range of ±1.5 T at room temperature has revealed the hard ferromagnetic characteristics with large coercivity and remanence for Mg, Cs co-doped $BaFe_2O_4$ than other spinel systems.

Keywords: Magnetic materials, Chemical synthesis, X-ray diffraction, Magnetic properties, Optical properties

1 Introduction

Magnetic nanoparticles holds a solid ground in diverse fields of applications particularly in permanent magnets, magnetic recording media components, high frequency applications, coherent spin FET, ceramic pigments, microwave absorbers, photocatalysts and magnetic sensors[1-8]. These materials in the nanoscale with remarkable finite size effect and exotic surface effect can be synthesized by various frequent techniques such as chemical co-precipitation, thermal decomposition, micro emulsion, hydrothermal synthesis, sol-gel method and sonochemical synthesis[9-11]. According to Lu *et al.*[9], chemical co-precipitation method surpasses the others by being the simplest experimental procedure under ambient conditions with low reaction temperature, short time period, narrow particle size distribution and high yield of desired size of crystallites and particles. It has also been evidenced that it is the most preferred method of synthesis especially for the magnetic nanomaterials derived from an iron and metallic oxide precursors[10]. Among the big sort of magnetic materials in nanometer range, ferrites particularly would contribute a larger portion under the active applications due to its high coercivity than Alnico magnets, differential response to temperature variation, low cost and good chemical stability[2].

The barium ferrites ($BaFe_2O_4$) are one of the very interesting and promising spinel materials (AB_2O_4) in comparison to other ferrites (Co, Ni, Sr, Cu, Zn, Mn, Al and Mg) because it has high Curie temperature, strong magnetic anisotropy field effect and large energy efficiency, which is mostly used for fast magnetic memory storage devices[2]. These ferrites are more sensitive when a small change induced by an inclusion of foreign atom, heat treatment or external stabilizing by capping agent induces a remarkable change in the magnetic domain alignment, crystalline phase and both optical and electrical band gap[5,12]. For a speedy and complete evaporation of solvent using the microwave treatment with a better surface stabilizing agent such as PEG gives a good crystallinity with lower amount of secondary elements than other heating methods[13]. Further, the barium ferrite nanoparticles were annealed in oxygen atmosphere at 700 °C for 6 h to improve the mechanical strength and get defect free crystallites of barium nanoferrites. We have fabricated the pristine

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