

An Approach for Enhancement of Saturation Magnetization in Cobalt Ferrite Nanoparticles by Incorporation of Terbium Cation

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Cobalt ferrite nanoparticles were synthesized by a reverse micelle process. The optimum processing conditions required to fabricate nanocrystalline cobalt ferrite using a reverse micelle technique, especially the effect of water-to-surfactant molar ratios including $w = 8, 10, 12$, and 14 , pH values in the range of 8 to 11 , and annealing temperatures in the range of 400°C to 800°C , were evaluated. x-Ray diffraction (XRD), field-emission scanning electron microscopy (FE-SEM), vibrating-sample magnetometry, and superconducting quantum interference device analysis were employed to evaluate the structural and magnetic properties of synthesized nanoparticles. XRD analysis confirms that the nanoparticles have a single-phase cubic spinel structure. The average particle size increases with increasing pH value and annealing temperature. Magnetization study reveals that the cobalt ferrite nanoparticles exhibit a superparamagnetic trend. The zero-field-cooled magnetization curves of cobalt ferrite nanoparticles indicated that, with an increase in pH value, the blocking temperature increases. Based on the obtained optimum parameters, terbium-substituted cobalt ferrite nanoparticles with composition $\text{CoFe}_{2-x}\text{Tb}_x\text{O}_4$ ($x = 0.1$ to 0.5) were prepared by a reverse micelle process. XRD and field-emission scanning electron microscopy evaluation demonstrated that single-phase spinel ferrites with narrow size distribution were obtained. Mössbauer spectroscopy was used to determine the site preference of terbium cation. The results confirm that terbium cations were distributed at tetrahedral and octahedral sites, but with a preference for the former. It was observed that, with an increase in terbium content, the saturation magnetization increases.

Key words: Cobalt ferrite, terbium cations, magnetic properties, reverse micelle

INTRODUCTION

Cobalt ferrite is a well-known hard-magnetic material with relatively high coercivity, fairly large magnetocrystalline anisotropy, and moderate saturation magnetization.¹ CoFe_2O_4 has the inverse spinel structure where Fe^{3+} ions are filled in the tetrahedral and octahedral sites, while Co^{2+} ions are

filled in the octahedral sites only. The interesting magnetic properties of ferrimagnetic spinels with general formula AB_2O_4 originate mainly from the magnetic interactions between cations with magnetic moments situated in the tetrahedral and octahedral sites.² Extensive studies have recently been performed on the fabrication and magnetic characteristics of cobalt ferrite nanoparticles substituted with cations such as Zn^{2+} , Cr^{3+} , La^{3+} , Gd^{3+} , and Nd^{3+} .^{3–10} Lee et al.⁶ demonstrated that

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