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REMARKABLE INFLUENCE OF TERBIUM CATIONS ON THE MAGNETIC PROPERTIES OF COBALT FERRITE NANOPARTICLES

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Abstract. Terbium substituted cobalt ferrite with composition of $CoFe_{2-x}Tb_xO_4$ nanoparticles (x = 0-0.5) were prepared employing a reverse micelle process. The effect of Tb^{3+} cations substitution on structural and magnetic properties of cobalt ferrite nanoparticles was investigated. X-ray diffraction and field-emission scanning electron microscopy evaluations demonstrated that single phase spinel ferrites with narrow size distribution were obtained. The particle size was beyond the range of superparamagnetic range. Vibrating sample magnetometer was employed to probe the magnetic properties of the samples. It was found that with an increase in terbium content, the coercive field decreases while the saturation of magnetization increases. The Mössbauer spectroscopy was used to determine the site preference of constitutive elements. It is interesting to find that adding terbium cations could enhanced saturation magnetization of cobalt ferrite and make it as a suitable candidate for recording head.

1. Introduction

Cobalt ferrite is a well-known hard magnetic material with a relatively high coercivity, strong magnetocrystalline anisotropy, and moderate saturation of magnetization. Synthesis of nanocrystalline cobalt ferrite has been investigated intensively in recent years for its potential applications in high-density magnetic recording media, microwave devices, and magnetic fluids [1-3]. It has been observed that the magnetic properties of nanocrystalline cobalt ferrite are entirely different from its bulk counterpart, which is not only strongly dependent on particle size, distribution and morphology of crystallites, but also on changes in the cation distribution between the two tetrahedral and octahedral sites [4]. $CoFe_2O_4$ 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 of the general formula AB_2O_4 originate mainly from the magnetic interactions between cations with magnetic moments that are situated in the tetrahedral and octahedral sites. Certainly, the magnetic interactions will vary with the change of cations in chemical composition and with different cation distribution between the tetrahedral and octahedral sites [5].

Recently, we have focused our studies on the preparation and magnetic characteristics of ferrite nanoparticles [6-10]. Although 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+} [11-18], to the best of our knowledge no

The size distribution obtained for cobalt ferrite nanoparticles by the reverse micelle technique is significantly narrower than that obtained by ball milling, co-precipitation technique, and sol gel process [19-21].

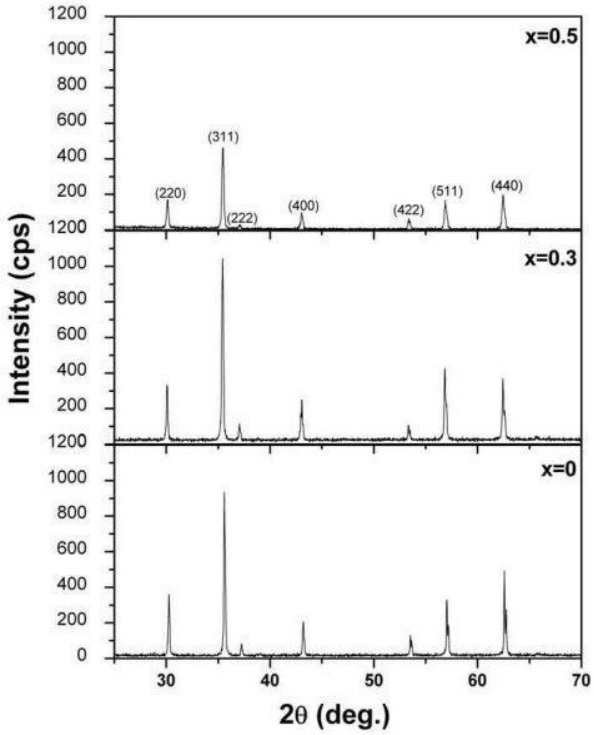

Fig. 1. XRD patterns of $CoFe_{2-x}Tb_xO_4$ ferrite nanoparticles with composition of x = 0, 0.3, and 0.5.

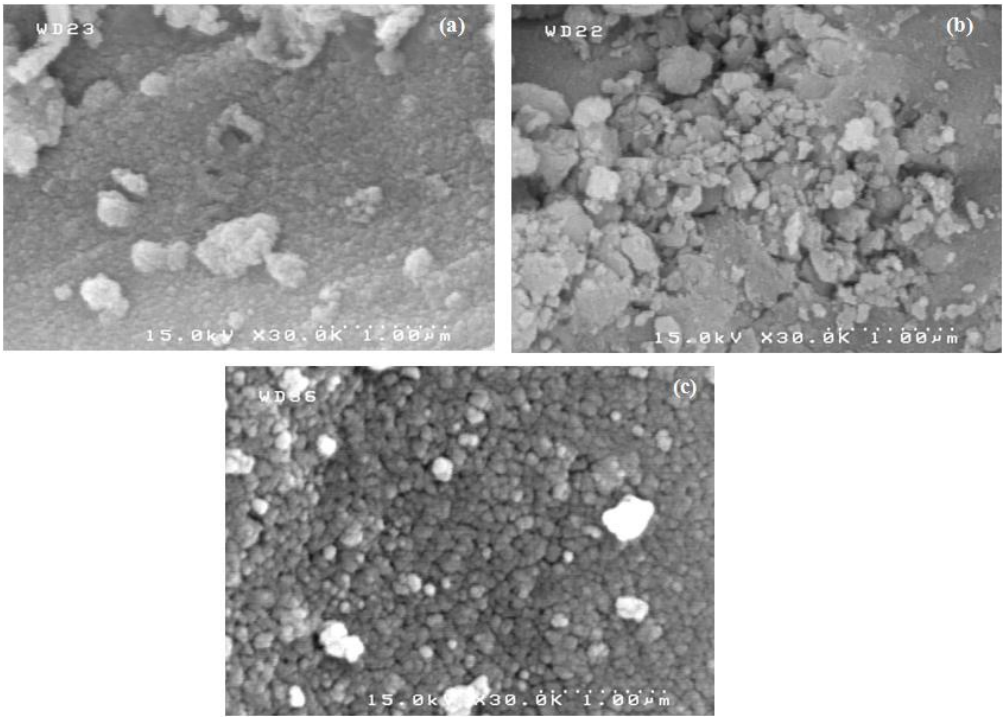

Fig. 2. FE-SEM micrographs of $CoFe_{2-x}Tb_xO_4$ ferrite nanoparticles with composition of (a) x = 0, (b) x= 0.3, and (c) x= 0.5.

Traditionally recording head were made of cubic ferrites, which are soft, and therefore easily magnetized. However, the saturation magnetizations are not large, so strong magnetic fields cannot be generated. The higher saturation flux density facilitates writing in higher-coercivity media, and allows for narrower track widths and in turn a higher storage density. It is interesting to find that adding terbium cations could enhance saturation magnetization of cobalt ferrite and make it as a suitable candidate for recording head.

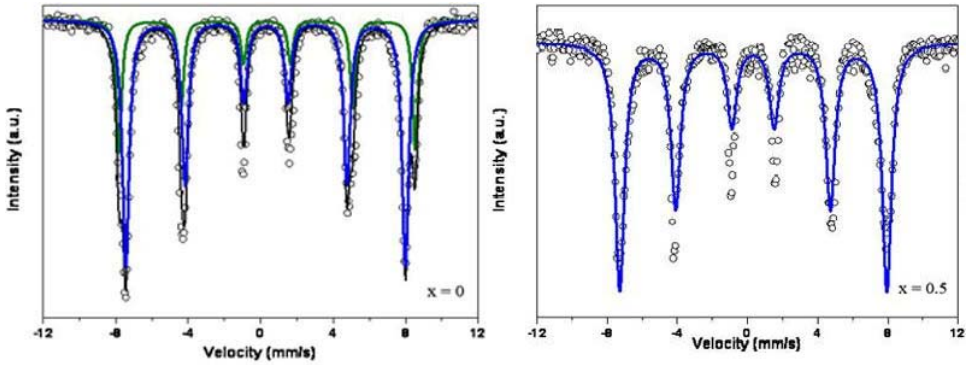

Fig. 4. Mössbauer spectra of $CoFe_{2-x}Tb_xO_4$ ferrite nanoparticles.

4. Conclusions

Fine particles single phase of $CoFe_{2-x}Tb_xO_4$ (x=0-0.5) were prepared by a reverse micelle method. The average particle size increased with an increase in terbium content. It was found that with an increase in terbium amount, the coercive field decreases while the saturation of magnetization increases. The higher saturation of magnetization observed in nanoparticles is attributed to the change in the cation distribution. In addition, the results revealed that terbium cation could reduced magnetocrystalline anisotropy of cobalt ferrite and consequently altered the hard magnetic phase to a soft one.

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