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Cation distribution and magnetic properties of $Co_xMg_{1-x}Fe_2O_4$ nanoparticles

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Abstract

In this work, $Co_xMg_{1-x}Fe_2O_4$ (x = 0, 0.25, 0.5, 0.75, 1) nanoparticles were prepared by hydrothermal method. Basic characterization tools were used together with the synchrotron based technique to obtain correlation between structures and magnetic properties. The XRD and SEM results confirmed the spinel structure of all prepared samples with particle sizes between 61 and 145 nm and size distribution of less than 10 %. The cation valency and distributions were determined from the XAFS spectra measured at the Co and Fe K-edges. It has been shown from the result of this work that Fe and Co ions in $Co_xMg_{1-x}Fe_2O_4$ are predominantly trivalent and divalent, respectively, with no change as a function of compositions. The saturation magnetization of the x = 1 composition is much higher than those of other compositions. It was shown from the XAFS result that the added Co content in the mixture compositions could not increase the saturation magnetization substantially as the population of divalent ions in A sites are mostly Mg ions.

Keyword: nanoparticle, ferrite, spinel, hydrothermal, cation distribution, x-ray absorption

Introduction

In recent years, number of publications concerning ferrites, in particular, nanoparticle ferrites have increased substantially. In ScienceDirect, the search terms “nano ferrite” produces around 680, 796 and 1032 hits for the year 2013, 2014 and 2015, respectively, which are considerably greater than 38 hit in the year 2000. Ferrites were used extensively in magnetic components for several decades because they are stable compound and relatively inexpensive to synthesize [1]. Recent years, new synthesis methods to produce nanoparticles, such as sol-gel, precipitation, laser and hydrothermal, have been applied to ferrites [2]. Much attentions have been given to perovskite ferrites such as $BiFeO_3$ [3, 4] or rare-earth doped $BiFeO_3$ [5, 6] which are well