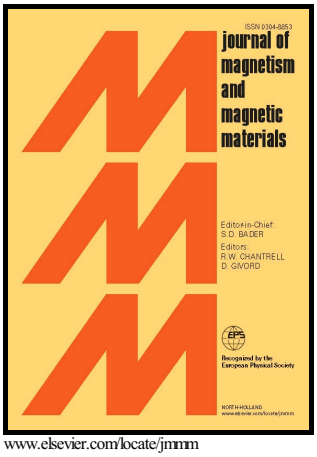

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Nonstoichiometry and Phase Stability of Al and Cr Substituted Mg Ferrite Nanoparticles Synthesized by Citrate Method

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Abstract

The spinel ferrite $Mg_{0.7}Cr_{0.3}Fe_2O_4$, and $Mg_{0.7}Al_{0.3}Fe_2O_4$ were prepared by the citrate technique. All samples were characterized by X-ray diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), High Resolution Transmission Electron Micrographs (HRTEM), Energy Dispersive X ray Spectroscopy (EDAX) and Atomic Force Microscope (AFM). XRD confirmed the formation of cubic spinel structure of the investigated samples. The average crystallite sizes were found to be between 24.7 and 27.5 nm for Al^{3+} and Mg^{2+} respectively. The substitution of Cr^{3+}/Al^{3+} in place of Mg^{2+} ion initiates a crystalline anisotropy due to large size mismatch between Cr /Al and Mg^{2+}, which creates strain inside the crystal volume. According to VSM results, by adding Al^{3+} or Cr^{3+} ions at the expense of Mg^{2+}, the saturation magnetization increased. The narrow hysteresis loop of the samples indicates that the amount of dissipated energy is small, which is desirable for soft magnetic applications. Magnetic dynamics of the samples were studied by measuring magnetic susceptibility versus temperature at different magnetic fields. The band gap energy, which was calculated from near infrared (NIR) and visible (VIS) reflectance spectra using the Kubelka-Munk function, decreases with increasing the particle size. Furthermore, the band gaps were quite narrow (1.5–1.7eV), hence the investigated samples could act as visible light driven photo catalysts. To sum up the addition of trivalent Al^{3+}, and Cr^{3+} ions enhanced the optical, magnetic and structure properties of the samples. $Mg_{0.7}$ $Cr_{0.3}Fe_2O_4$ sample will be a better candidate for the optical applications and will also be a guaranteeing hopeful for technological applications.

Keywords: Nano ferrite, Nonstoichiometric, optical properties, enthalpy, Magnetic properties.

1. Introduction

Nowadays, various kinds of spinel magnetic nanomaterials [1], their composites [2], doped ferrites [3] and materials with nanostructures [4] have been paid much attention concerning their advanced properties.

Two features of the component ions in crystalline materials influence the crystal structure the first is the magnitude of the electrical charge on each of the component ions. In general, the material must be electrically neutral. The chemical formula of a compound designates the proportion of cations to anions or the composition that attains this charge equalization. The second condition includes the ionic radii or sizes of the cations and anions r_C and r_A respectively [5]. Since the metallic elements give up electrons when ionized, cations are ordinarily smaller than anions and consequently the ratio r_C/r_A is less than unity. The Nano ferrites have an important characteristic of a narrow band gap, which lies in the visible region [6]. This feature allows ferrites to efficiently utilize the visible region of the solar spectrum in photo catalytic reactions [7] and