Structural and magnetic properties of magnesium ferrite nanoparticles prepared via EDTA-based sol-gel reaction

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Abstract

Magnesium ferrite (MgFe2O4) nanoparticles have been prepared, for the first time, by ethylene diamine tetraacetic acid (EDTA)-based sot-get combustion method. The prepared ferrite system is calcined at 400, 500 and 600 degrees C. Thermo-gravimetric and differential thermal analysis (TGA-DTA), X-ray diffraction (XRD), Fourier transform infrared (FTIR) spectroscopy, high resolution transmission electron microscopy (HRTEM) and vibrating sample magnetometry (VSM) were applied for elucidating the structural and magnetic properties of the prepared system. XRD patterns revealed that the prepared system have two spinet MgFe2O4 structures, namely cubic and tetragonal phases that are dependent on calcination temperature (T-c). The crystallite sizes varied from 8.933 to 41.583 nm, and from 1.379 to 292.565 nm for the cubic and tetragonal phases respectively depending on T-c. The deduced lattice parameters for the cubic and (tetragonal) systems are a=8.368, 8.365 and 8.377 and (a=7011. 5.922, 5.908 and c=6.622, 8.456, 8.364) angstrom at T-c=400, 500 and 600 degrees C respectively. While the cation distribution of the cubic phase is found to be mixed spinel and T-c-dependent, it is an inverse spinel in the tetragonal phase where the Fe3+ ions occupy both the tetrahedral A- and octahedral B-sites in almost equal amount; the Mg2+ ions are found to occupy only the B-sites. The HRTEM and selected-area electron diffraction (SAED) revealed the detailed morphology of the nanoparticles, and confirmed their crystalline spinel structure. VSM indicated the existence of an appreciable fraction of superparamagnetic particles at room temperature, with pure superparamagnetic behavior observed for samples calcined at 400 degrees C. Besides, the magnetic properties are found to change by thermal treatment as a result of the varied phase concentration, cation distribution and lattice parameters. Thus, the new synthesis route used in this study by applying EDTA as an organic precursor for preparing MgFe2O4 nanoparticles at rather low temperatures proved to be efficient in obtaining nanoparticles with favorable structural and magnetic properties. Such properties would qualify them for several potential applications including e.g. in hyperthermia treatment, as contrast agents in magnetic resonance imaging (MRI), and in ferroelastomers technology. (C) 2014 Elsevier B.V. All rights reserved.

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