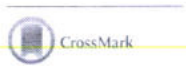
Materials Research Express



PAPER

RECEIVED
16 August 2019

REVISED
29 October 2019

ACCEPTED FOR PUBLICATION
18 November 2019

PUBLISHED
27 November 2019

Magnetic properties of Zn-ferrite nanoparticles prepared by sol-gel and coprecipitation methods

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Keywords: zinc ferrite nanoparticles, sol-gel, coprecipitation, annealing, magnetic properties

Abstract

Zn-ferrite nanoparticles were synthesized by sol-gel and coprecipitation methods and were annealed at different temperatures in air for 2 h. Grain size of the as-prepared samples was 6 and 13 nm for the samples prepared by coprecipitation and sol-gel methods respectively. It was increased with the increase in annealing temperature in both the cases. The as-prepared sample prepared by coprecipitation method showed superparamagnetic behavior whereas the sample prepared by sol-gel method showed ferrimagnetic behavior. The magnetization values of 5 and 11 emu g^{-1} were observed at 300 K for the as-prepared samples synthesized by coprecipitation and sol-gel methods respectively. The magnetization and coercivity decreased with the increase in annealing temperature. The magnetization values were enhanced at 60 K compared to those at 300 K. The highest magnetization of 37 emu g^{-1} was observed at 60 K for the sample annealed at 350 °C prepared by coprecipitation method. In the temperature dependent magnetization curves, the blocking temperature (T_B), Neel temperature (T_N) and irreversible temperature (T_{irr}) decreased with the increase in the applied fields. The observed magnetic properties can be understood on the basis of grain size and their distribution, and cation distribution in these nanomaterials with the increase in annealing temperature.

1. Introducion

Spinel ferrites attracted much attention in various technological applications like magnetic data storage, sensors, magnetic refrigeration, MRI contrast agent, magneto-optical devices, and bio-medical fields due to their unique physical properties [1–8]. Spinel ferrites have cubic spinel structure with formula, MFe_2O_4, in which oxygen ions form a FCC lattice and the cations, M^{2+} and Fe^{3+} occupy the tetrahedral (A) or octahedral (B) sites. The magnetic properties of the spinel ferrites strongly depend on the occupancy of these cations in the lattice sites, grain size and morphology of the nanoparticles. $ZnFe_2O_4$ (Zn-ferrite) is an interesting material among spinel ferrites due to its interesting magnetic, catalytic and electrical properties. In bulk it has normal spinel structure with all the Zn^{2+} in the A–site and all the Fe^{3+} in the B–site. Zn^{2+} is non-magnetic with no unpaired electron and Fe^{3+} is the magnetic ion with magnetic moment of 5 μ_B. The superexchange interaction between the magnetic moments of Fe^{3+} distributed over the B–sites leads to an antiferromangetic ordering below Néel temperature (T_N) of 10 K in Zn-ferrite [9]. However, Zn-ferrite nanoparticles and thin films showed ferrimagnetic or superparamagnetic behavior depending on the grain size and their distribution in the material [10–12].

Grain size dependent cation distribution in Zn-ferrite nanoparticles can be achieved by varying synthesis techniques and annealing. So, various synthesis methods like sol-gel, coprecipitation, thermal decomposition, hydrothermal, high energy ball milling, polyol and micro-emulsion methods have been reported for the synthesis of Zn-ferrite nanoparticles [10, 12–16]. In the present study, we prepared Zn-ferrite nanoparticles by

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