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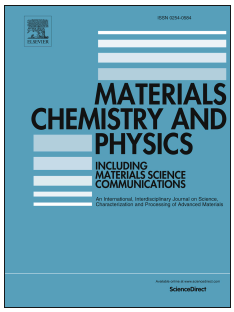

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Microstructure and magnetic properties of cobalt ferrite nano powder prepared by solution combustion synthesis

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Abstract

In this study, cobalt ferrite nanoparticles ($CoFe_2O_4$ NPs) were prepared by solution combustion synthesis using urea and glycine as fuels. The magnetic properties of the $CoFe_2O_4$ powders were modified by using various amounts of extra fuel (above the stoichiometric value). Thermodynamic calculations indicates that as the extra fuel increases, the amount of gases produced and the adiabatic flame temperature (T_{ad}) rise. To investigate effect of urea, glycine and amount of extra fuel on the structural and magnetic properties of $CoFe_2O_4$ powders, the produced samples were studied by using X-ray diffraction (XRD), vibrating sample magnetometer (VSM), field emission scanning electron microscopy (FESEM), thermo gravimetric analysis and differential scanning calorimetry (TGA-DSC), and Brunauer-Emmett-Teller (BET) technique. XRD results of the produced sample indicated that the single phase $CoFe_2O_4$ with an average crystallite size between 17 and 33 nm was synthesized. By using two different type of fuel, the specific surface area of the produced powders were increased from 1.6 (glycine fuel) to 56.2 m^2/g (urea fuel). By changing the type of fuel and the amount of extra fuel, the $CoFe_2O_4$ coercivity (H_c) ranges between 870 and 1667.8 O_e and the saturation magnetization (M_s) varies between 31.6 and 83.7 emu/g. The solution combustion synthesized $CoFe_2O_4$ powders exhibit a hard ferrimagnetic behavior. Based on the results, Urea is the proper fuel for producing cobalt ferrite nanoparticles (with a particle size less than 100 nm) and in case of using glycine, the minimum amount of this fuel should be 2 times the stoichiometric amount.

Keywords: Cobalt ferrite nanoparticles, Solution combustion synthesis, Magnetic properties.

1. Introduction

Cobalt ferrite is well known to have significant magnetic anisotropy, moderate saturation magnetization and remarkable chemical stability [1]. These properties make $CoFe_2O_4$ particles a good candidate for the technological applications such as magnetic recording devices, gas sensors, catalysis, ferrofluids and medical applications such as hyperthermia, drug delivery, and contrast enhancers in magnetic resonance imaging [2-8]. The cationic distribution for nanophase cobalt ferrite is different from its bulk counterpart. Bulk state is purely inverse spinel with general formula of $(Fe^{3+})_T(Co^{2+}Fe^{3+})_O$ (T indicating tetrahedral and O indicating octahedral sites) [9]. For cobalt ferrite nanoparticles the cationic states and distribution are complicated. $CoFe_2O_4$ nanoparticles as mixed spinel which can be represented as $(Co^{2+}{}_{\delta}\,Fe^{3+}{}_{1-\delta})_T(Co^{2+}{}_{1-\delta}\,Fe^{3+}{}_{1+\delta})_O$ where δ is the degree of inversion [1,9]. The magnetic properties of $CoFe_2O_4$ particles are mainly dominated by particle size, specific surface area, morphology and cationic distribution in the two interstitial sites (tetrahedral and octahedral) [3]. Cobalt ferrite nanoparticles were produced so far by various

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