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ORIGINAL ARTICLE

Effect of Zn, Ni, and Mn doping ions on magnetic properties of MFe_2O_4 (M = Mn, Zn, and Ni) nanoparticles synthesized via sol–gel autocombustion using PVA/sago starch blend as a chelating agent

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Abstract

In this study, MFe_2O_4 nanoparticle materials (M = Mn, Ni, Zn) were synthesized by sol–gel combustion using polyvinyl alcohol blend sago starch as the chelating agent. To achieve the highest percentage yield, the concentration of PVA and of sago starch solution for coating the synthesized materials is 1.0 g and 30 mL (35% sago starch solution). The samples were characterized by X-ray diffraction and transmission electron microscopy techniques: the crystallite size was observed to be 8–27 nm. The magnetic properties of all three samples were studied, and the measurements were carried out using a vibrating sample magnetometer; the samples exhibit ferromagnetic properties. $NiFe_2O_4$ nanoparticle gave the highest saturation magnetization value of 109.32 emu/g and the lowest coercivity value of 83.20 O_e. Moreover, the samples showed no difference in thermal properties. The synthesized MFe_2O_4 nanoparticle can be applied as a density magnetic recording media material.

Keywords MFe_2O_4 nanoparticles · Sol–gel · Sago starch

1 Introduction

Nanoferrites have attracted considerable interest for use in technological applications in several industries because of their magnetic, electrical, dielectric, and catalytic properties [1]. The magnetic characteristics of nanoferrite particles used for recording media depend on their size, shape, and purity [2]. The magnetic performance of ferrites can be improved by substituting a metal ion (e.g., Zn^{2+}, Mg^{2+}, Mn^{2+}, Ni^{2+}, Co^{2+}, and Fe^{2+}) [3]. Nickel ferrite ($NiFe_2O_4$) nanoparticles are one of the most important magnetic nanoferrites, due to their suitability for use in storage devices, microwave devices, gas sensors, ferrofluids, and catalysts [4, 5]. In addition, $MnFe_2O_4$ has excellent properties such as higher saturation magnetization, higher initial permeability, higher resistivity, and lower losses than other ferrites, and $MnFe_2O_4$ is used in ultrasensitive MR imaging probes, electrode materials in biosensors for the detection of biomaterials and for various biomedical applications [6, 7]. Furthermore, substitution with Zn in nanoferrites was studied for application in solar thermochemical fuel production [8]. Nanoparticles of ferrites with metal ion doping were obtained through various techniques such as sol–gel, combustion, microwave, and hydrothermal methods [9–11]. Generally, the sol–gel and combustion methods are found to be cost-effective and rapid. These methods are known to produce identical and narrow-size-distribution nanoparticles. The thermal energy supplied from an external source to the solution in the sol–gel combustion method leads to the internal combustion of chelating substances. These processes are rapid and may involve the direct transformation of the molecular constituents of a substrate to the final oxide product. The formation of the crystal phases may or may not require inter-crystallite diffusion between crystals for the

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