



4TH National Conference of Iran Chemistry, Chemical Engineering And Nano

Preparation and characterization of nickel ferrite magnetic nanoparticles by sol-gel method

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Abstract: In the study, nanoparticles nickel ferrite (NiFe_2O_4) powder was successfully prepared from an aqueous solution containing ferric nitrate and nickel nitrate salts by a sol-gel route. The as-prepared samples were characterized by scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FT-IR). SEM indicated that the size of NiFe_2O_4 nanoparticles were spherical and showed that the average size of the nickel ferrite nanoparticles is smaller than ~ 40 nm. FTIR spectra showed the stretching and bending vibrations of Ni–O and Fe–O bonds nickel ferrite.

Keywords: Nanoparticles, Nickel ferrite, sol-gel.

1. INTRODUCTION

Nanocrystalline spinel ferrites with the general formula MFe_2O_4 ($\text{M} = \text{Ni, Zn, Mn, Co and Mg, ...etc}$) are the most important magnetic materials [1]. Nickel ferrite (NiFe_2O_4) is one of the most important materials in the inverse spinel family exhibiting ferromagnetic properties with high saturation magnetization, excellent chemical stability and mechanical hardness, electrical resistivity and low eddy current loss in alternating current applications [2–5]. Nano ferrites are potential candidates for various applications which include their usage in microwave control components such as circulators, isolators, and phase shifters [6]. Also they are applicable for gas and humidity sensing, drug-delivery technology, high density magnetic storage media, MRI contrast agents, color imaging, ferro-fluids, high frequency ($\sim \text{GHz}$) devices electric and electronic applications, water treatment, biomedical and biotechnology fields, magnetic refrigerators and catalysts applications [5–10]. Nickel ferrite is an inverse spinel ferrite in which the tetrahedral (A) sites are occupied by ferric ions and the octahedral (B) sites by ferric ions and nickel ions. Thus NiFe_2O_4 can be represented as $(\text{Fe}^{3+})_{\text{A}} [\text{Ni}^{2+}\text{Fe}^{3+}]_{\text{B}} \text{O}_4^{2-}$. [11].

Nickel ferrite nano particles have been prepared by several methods such as hydrothermal [12], co-precipitation [13], micro emulsion [14], ball milling [15], sol-gel [16] and sol-gel auto combustion [17]. It should be mentioned that the preparation method influences the composition and microstructural characteristics of the synthesized powders [3,18].

Sol-gel auto-combustion method is a unique combination of the ignition and the chemical gelation processes. This method has the advantages of simple preparation, cost-effectiveness and gentle chemistry route resulting in ultra-fine and homogeneous powder [10].

In the present study the sol- gel method was carried out to prepare NiFe_2O_4 particles using aqueous solution of ferric nitrate, nickel nitrate and citric acid.