Available online at www.sciencedirect.com

ScienceDirect

Materials Today: Proceedings 4 (2017) 342–349

materialstoday: PROCEEDINGS

www.materialstoday.com/proceedings

5th International Conference of Materials Processing and Characterization (ICMPC 2016)

Current Development in Synthesis and Characterization of Nickel Ferrite Nanoparticle

Nitish Gupta[a], Pranat Jain[b], Ravindra Rana[c] and Sanjay Shrivastava[b]

[a] Department of Applied Chemistry, Shri G. S. Institute of Technology and Science, 23 Park Road, Indore 452003(MP) India
[b.] Department of Material Sci. & Metallurgical Eng. Maulana Adzd National Institute of Technology Bhopal (462003)India
[c.] Department of Mechanical Eng. Maulana Adzd National Institute of Technology Bhopal (462003)India

Abstract

This paper presents a comprehensive review on the synthesis and characterization techniques of ferrospinel nickel ferrite. AFe_2O_4 ferrospinels are a group of technologically important material due to their high electrical resistivity, sufficiently low dielectric loss over a wide range of frequency, high corrosion resistance, and thermodynamic stability. Among the ferrospinels, the inverse spinel is particularly interesting due to its high saturation magnetization and unique magnetic structure. Nickel ferrite with an inverse spinel structure shows ferromagnetism. This ferromagnetism originated from magnetic moment of anti parallel spins between Fe^{3+} ions at tetrahedral sides and Ni^{2+} ions at octahedral sides. Synthesis approaches of nickel ferrite include co-precipitation, combustion method, sol–gel process, spray pyrolysis, micro emulsion technique, pulsed wire discharge, soft mechanochemical route,chemical vapor deposition and hydrothermal process. Different techniques used to characterize nickel ferrite nanoparticles are, thermogrametric analysis (TGA), X ray diffraction(XRD), X-ray Photoelectron spectroscopy (XPS),Fourier transform infrared spectroscopy (FT-IR), scanning electron microscopy (SEM), and transmission electron microscopy (TEM),two-point probe electrical resistivity technique and vibrating sample magnetometer (VSM). Comprehensive understanding of these synthesis and characterization techniques are a vital component to obtain nanoparticles of desired properties and therefore, the aim of this paper is to review current developments in the synthesis and characterization techniques of nickel ferrite nanoparticles.

Keywords: Nickel Ferrite; Nanoparticle; Synthesis; Spinel; characterization

* Corresponding author Tel.: +91-731-258-8182; Fax:+91-731-243-2540.
E-mail address: nitish.nidhi75@gmail.com

1. Introduction

Spinel ferrite of general formula AFe_2O_4 ($NiFe_2O_4$, $CuFe_2O_4$, $CoFe_2O_4$, and $MnFe_2O_4$) are a large group of materials with many applications ranging from low wave-number to microwave and from low to high permeability including electronic devices, ferro fluids, magnetic drug delivery, microwave devices, antenna rod, recording head, loading coil, gas sensor, colour imaging, and high density information storage [1-4]. In a spinel structure there are 56 ions, 32 oxygen and 24 metal ions in a unit cell. Eight metal ions occupy tetrahedral sites and sixteen metal ions occupy octahedral sites. The general formula for the ferrite structure is given as $(M_{1-X}Fe_x)_A [M_XFe_{2-X}]_B O_4$, where A and B sites correspond to tetrahedral and octahedral sites, respectively [5]. This spinel ferrite belongs to space group Fd3m. These have high electrical resistivity and consequently low eddy currents and dielectric losses. Among the spinel ferrite, the inverse type is particularly interesting due to its high magneto-crystalline anisotropy, high saturation magnetization, and unique magnetic structure. $NiFe_2O_4$ is a cubic ferrimagnetic oxide which has an inverse spinel structure where Ni^{2+} ions occupy octahedral B-sites and Fe^{3+} ions occupy bothtetrahedral A-sites and octahedral B-sites [6]. The small particle size promotes a mixed spinel structure whereas the bulk form is an inverse spinel. Spin glass like behavior of these materials, can be considered as themost interesting property that leads to high field irreversibility, shift of the hysteresis loops, and anomalousrelaxation dynamics [7-8]. $NiFe_2O_4$ possesses p-type conductivity when the material contains cation vacancies and, consecutively, a corresponding amount of Ni^{3+} will be available at octahedral sites, apart from thecations Ni^{2+}, and Fe^{3+}, which are located at the octahedral sites. $NiFe_2O_4$ tend to attract oxygen during heating [9], and thus it isgenerally known as p-type semiconductor with cation vacancies [10]. It shows ferrimagnetism that originates from magnetic moment of anti parallel spins between Fe^{3+} ions at tetrahedral sites and Ni^{2+} ions at octahedralsites [11].The nickel ferrite in the ultra-fine form exhibit non collinear spin structure and magnetic moment at low temperature is appreciably lower than the value for the bulk material [12]. The magnetic character of thenanoparticles used in various industriesdepends crucially on the size, shape, purity and magneticstability (e.g. blocked unblocked state at particular operatingtemperature). These particles should be in single domain state, of pure phase, having high coercivity and moderate magnetization. From the application point ofview, the super paramagnetic blocking temperature ofthe nanoparticles used for recording devices should be well abovethe room temperature in order to have a stable data recording inthese devices. In medical applications the magnetic nanoparticles are used as drug carriers inside the body where conventional drug delivery systems may not work [13].

2. Material and Methods

The properties and application aspects of the synthesized ferrite depend strongly on the particle size, composition and morphology, which are sensitive to the preparation methodology used in their synthesis. Hence preparation of ferrite of desired size, morphology and composition has attracted more attention of researchers recent years. Number of physical and chemical methods have been attempted to prepare nanosize ferrite. Some of the main physical methods includes; mechanical milling [14], severe plastic deformation consolidation [15], and inert gas condensation [16]. While the chemical methods includes; sol gel [17,18], mechano-chemical, wet chemical, microwave assisted combustion method[38,39], solid state reaction[5,21], reverse micelle [37], citrate precursor method [39], combustion method[31,32], solvo-thermal [36], hydrothermal refluxing method[26,27,28], micro emulsion, spay drying, pulsed wire discharge[35]. Some of the main chemical methods used for the preparation are as follows:

2.1 Sol -Gel method

Sol gel process may be described as: formation of an oxide network through poly condensation reaction of a molecular precursor in a liquid form. Sol is a stable colloidal or a molecular suspension of solid particles of ions in a solvent. Gel is a three dimensional continuous network, which encloses a liquid phase. It forms when the solvent from the sol begins to evaporate and the particles or ions left behind begin to join together in a continuous network. This method hasthe advantages of simple preparation, cost-effective and gentle chemistry route resulting in ultra fine and homogeneous powder.Ebrahimi and Azadmanjiri reported sol gel auto combustion method using metal