Magnetic Studies of Nickel Ferrite Nanoparticles Prepared by Sol-gel Technique

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Abstract. Ni-ferrite nanoparticles were synthesized by sol–gel technique by varying the solvent concentration. X-ray diffraction studies confirmed the phase purity in the samples. The lattice constant and grain size were found to be in the range of 0.833-0.834 nm and 14-26 nm respectively. There was no systematic variation in magnetization value with the solvent concentration and grain size. The highest magnetization, remanence and coercivity values of 60 emu/g, 12 emu/g and 180 Oe respectively were observed at 300K in the present study for the sample prepared in 75ml of solvent. The observed magnetization value is 20% higher than the bulk value of 50 emu/g. The magnetization, coercivity and remanence values were enhanced at 60K compared to those at 300K. The observed high magnetization value in the nanoparticles can be explained on the basis of modified cation distribution in the lattice sites. The enhanced magnetic properties at 60K may be understood due to the reduced thermal fluctuation and increased anisotropy at low temperature.

INTRODUCTION

Ferrites are the most technologically important ferrimagnets which are widely used in many industrial applications. Spinel ferrites have the general molecular formula $A^{2+}B_2^{3+}O_4^{2-}$, where A^{2+} and B^{3+} are the divalent and trivalent cations respectively, occupying tetrahedral (A) and octahedral (B) interstitial sites of an fcc lattice formed by O^{2-} ions.[1] Ni-ferrite($NiFe_2O_4$) is an inverse spinel in which the A-sites are occupied by 8 Fe^{3+} and the rest 8 Fe^{3+} together with 8 Ni^{2+} ions occupy the B-sites in a unit cell.[1] Nanosized Ni-ferrite possesses attractive properties for the application as soft magnets, core materials in power transformers and low loss materials at high frequencies. They are also used for the gas and humidity sensing, electronic, electrical and catalytic applications. [2-5]

Physical properties of these nanoparticles are strongly dependent on the size of the nanoparticles and their distribution, microstructure, composition and cation distribution. The size of these nanoparticles may be controlled by synthesis method. Several synthesis methods like mechanical milling, evaporation condensation, micro emulsion technique, combustion method, spray pyrolysis, template-assisted electrochemical synthesis, inert gas condensation, hydrothermal reaction, ceramic method, sol–gel and co-precipitation techniques have been reported for the synthesis and control of crystallite/grain size of nickel ferrite nanoparticles. [2-9]Sol–gel method is one of the best methods to get very good stoichiometric control and the production of ultrafine particles with a narrow size distribution, in a relatively short processing time. [3, 9] In this study we report the effect of solvent concentration on the structural and magnetic properties of the Ni-ferrite nanoparticles synthesized by sol-gel technique.

EXPERIMENTAL DETAILS

In the synthesis, stoichiometric ratio of ferric nitrate nonahydrate [Fe $(NO_3)_3.9H_2O$] and nickel nitrate hexahydrate [Ni $(NO_3)_2.6H_2O$] (AR grade) were used as the starting salts and ethylene glycol was used as the solvent. The details of the synthesis procedure has been reported in our earlier work.[10] The as prepared powder collected at room temperature was ground well using an agate mortar pestle. By varying the solvent concentration

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