Journal of Magnetism and Magnetic Materials 379 (2015) 50–57

Contents lists available at ScienceDirect

Journal of Magnetism and Magnetic Materials

journal homepage: www.elsevier.com/locate/jmmm

Synthesis, characterization and magnetic properties of monodisperse Ni, Zn-ferrite nanocrystals

Sanjeev Kumar [a,*], Pankaj Kumar [a], Vaishali Singh [b], Uttam Kumar Mandal [c], Ravinder Kumar Kotnala [d]

[a] University of Petroleum and Energy Studies, Dehradun, Uttarakhand, India
[b] University School of Basic and Applied Science, India
[c] University of Chemical Technology, GGS Indraprastha University, Sector 16, Dwarka, Delhi 110403, India
[d] National Physical laboratory, New Delhi 110012, India

ARTICLE INFO

Article history:
Received 6 August 2014
Received in revised form
5 December 2014
Accepted 8 December 2014
Available online 9 December 2014

Keywords:
Nickel–zinc ferrite
Nanocrystals
Inverse microemulsion
Magnetic measurements
Superparamagnetic

ABSTRACT

Synthesization of monodisperse Ni, Zn-ferrite ($Ni_{1-x}Zn_xFe_2O_4$, $x=1$, 0.8, 0.6, 0.5, 0.4, 0.2, 0.0) nanocrystals has been achieved by the inverse microemulsion method using CTAB as surfactant and kerosene as an oil phase. The detailed characterization of the synthesized nanocrystals and measurement of the magnetic properties has been done by techniques like X-ray diffraction (XRD), field emission transmission electron microscopy (FETEM), Fourier transform infrared spectroscopy (FITR) and Vibrating Sample Magnetometer (VSM) respectively. The relationship between the structure and composition of the nanocrystals with magnetic properties has been investigated. The nanocrystals size is found to be in the range 1–5 nm. The effect of Zn substitution on size and magnetic properties has been studied. It has been observed that magnetism changed from ferromagnetic at $X=0$ to super paramagnetic to paramagnetic at $X=1$ as Zn concentration increased. The Curie temperature is found to decrease with an increase in Zn concentration.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Ni–Zn ferrite is one of the most versatile soft magnetic materials with spinel configuration known for many years. It has been used in high power device and high frequency cases, such as transformers and telecommunication applications due to its high electrical resistivity, chemical stability and good electromagnetic properties. Ni–Zn ferrite crystallizes into a cubic close packed structure of the type $(Zn_xFe_{1-x})_A[Ni_{1-x}Fe_{1+x}]_BO_4$. The properties like magnetic coercivity, permeability, electrical resistivity and eddy currents loss are highly sensitive to the compositions, structure, shape, size and heat treatment. The magnetic properties of these nanocrystals are sensitive to synthesis conditions, particle size, shape, and composition, so a large amount of experimental data has been collected with a large variance in the observed magnetic behavior [1,2]. However, the unusual physiochemical properties of magnetic nanocrystals continue to evoke interest, and new experimental recipes for the controlled synthesis of nanomaterials continually come forth. Most reports of monodisperse magnetic nanocrystals have focused on monodisperse metals, metal alloys, and binary and ternary metal oxides, but there are few investigations on monodisperse compounds with more than three components [2,3]. Systemic and profound understanding, especially of the magnetic properties of the nanocrystals with nearly same size and morphology but different compositions remains challenging. In our previous study we concluded that reverse microemulsion technique generates high quality superparamagnetic $Ni_{0.5}Zn_{0.5}Fe_2O_4$ ferrite nanocrystals. Therefore, it would be meaningful to carry out a study of compositional variation using a selective revere microemulsion synthesis strategy to enrich and better understand the magnetism of these nanocrystals.

The present study aims at thorough learning of compositional variation of Ni, Zn-ferrite system to understand and control superparamagnetic properties at the atomic level through chemical manipulations. Highly monodisperse Ni, Zn-ferrite ($Ni_{1-x}Zn_xFe_2O_4$, $x=1$, 0.8, 0.6, 0.5, 0.4, 0.2, 0.0) nanocrystals with multiple components have been prepared by inverse microemulsion method. The character of the Ni, Zn-ferrite nanocrystals such as composition, crystal structure morphology and size distribution can be regulated by adjusting the route of synthesis and the molar ration of inorganic salts in the initial mixture. Extensive characterization of the synthesized nanocrystals has been done, the detailed investigation of which has been mentioned below.

* Corresponding author. Fax: +91 135 2776090.
E-mail address: sanjeevkumar.dubey2@gmail.com (S. Kumar).

http://dx.doi.org/10.1016/j.jmmm.2014.12.006
0304-8853/© 2014 Elsevier B.V. All rights reserved.

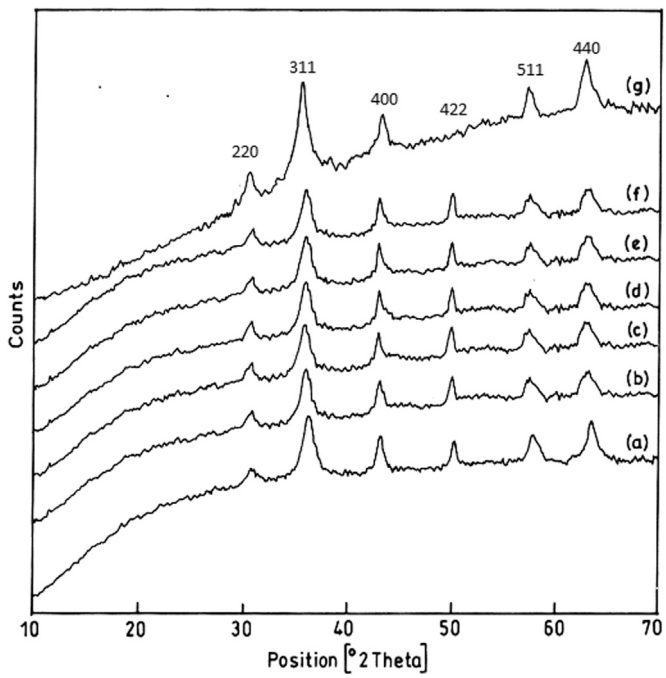

Fig. 1. XRD patterns of (a) NZ_1, (b) NZ_2, (c) NZ_3, (d) NZ_4, (e) NZ_5, (f) NZ_6 and (g) NZ_7 ferrite nanocrystals attained from inverse microemulsion.

2. Experimental section

2.1. Materials

The chemicals such as (i) $FeCl_3$ (sd fine chemicals, India), (ii) $NiCl_2 \cdot 6H_2O$ (sd fine chemicals, India), (iii) $ZnCl_2$ (sd fine chemicals, India), (iv) Isoamyl alcohol (SRL, India), (v) Cetyl trimethyl ammonium bromide (Spectrochem, India) used in this experiment were of analytical grade and (vi) Kerosene (specific gravity 0.76) was procured from local market and used after double distillation.

2.2. Preparation of Ni, Zn-ferrite nanocrystals by inverse microemulsion

Again a quaternary reverse microemulsion system consisting of cetyl trimethyl ammonium bromide (CTAB)/water/kerosene/isoamyl alcohol was selected for this study. Stoichiometric amounts of 0.5 M $FeCl_3$, x M $NiCl_2$ and y M $ZnCl_2$ were mixed to prepare an aqueous solution of $Ni_{1-x}Zn_xFe_2O_4$. The solution was then heated at 60 °C for 1 h to make the precursors becomes completely miscible. 15.78 wt% of CTAB was added to 42 wt% of Kerosene to prepare first inverse microemulsion ME_1. This step was followed by addition of 31 wt% of aqueous solution (containing the precursor salts) to the mixture of kerosene and CTAB obtaining a murky emulsion. Finally 10.52 wt% of isoamyl alcohol was added under continuous stirring for 1 h which yielded a transparent

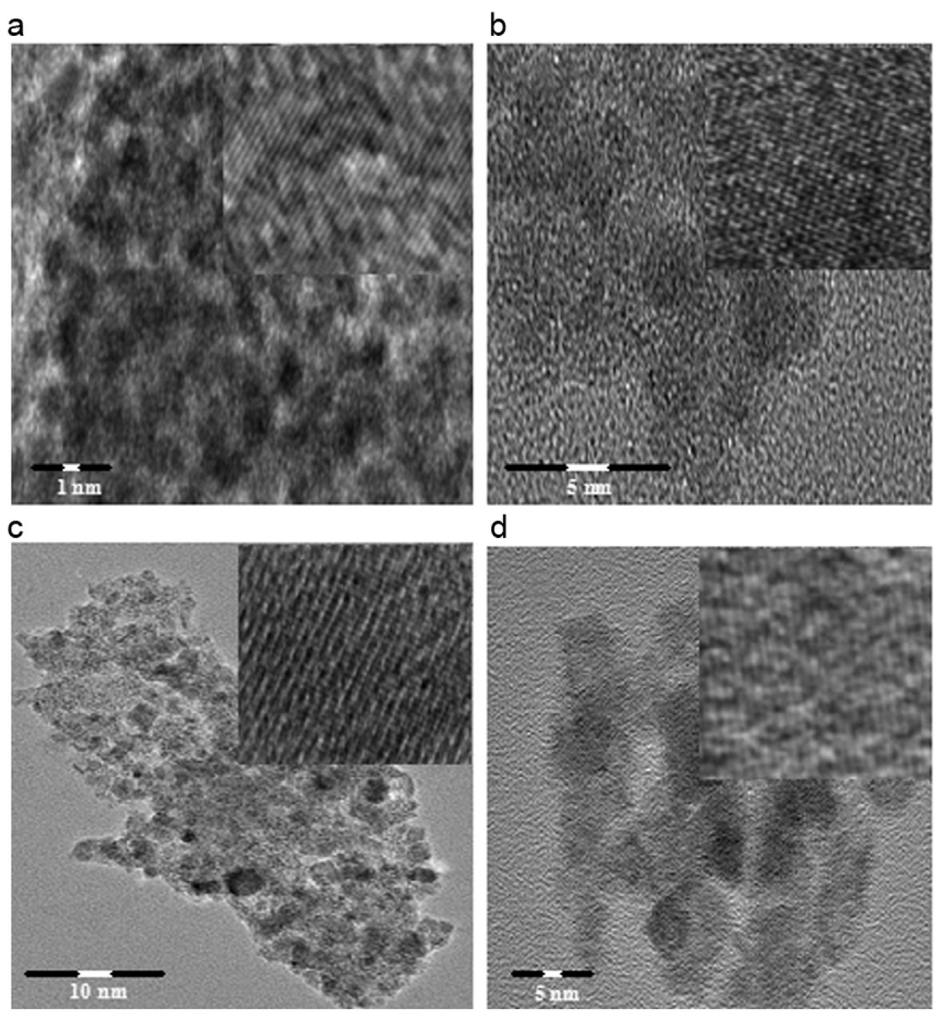

Fig. 2. FETEM image of (a) NZ_1; (b) NZ_2; (c) NZ_3 and (d) NZ_4 ferrite nanocrystals attained from inverse microemulsion.

Download English Version:

https://daneshyari.com/en/article/1799368

Download Persian Version:

https://daneshyari.com/article/1799368

Daneshyari.com