NANOSYSTEMS: PHYSICS, CHEMISTRY, MATHEMATICS, 2016, 7 (3), P. 558–560

The study on ultrasonic velocities of $Co_xFe_{3-x}O_4$ nanoferrofluid prepared by co-precipitation method

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PACS 47.65.C, 75.50.Mm **DOI 10.17586/2220-8054-2016-7-3-558-560**

Nanoferrofluids of $Co_xFe_{3-x}O_4$ were prepared by the chemical co-precipitation method by varying the value of x (0.2, 0.6 and 1.0 M). The structural and surface morphological investigations were done by X-ray diffraction (XRD) and SEM techniques respectively. The particle size calculated from the data of XRD, (3 1 1) plane revealed that the particle size increases with higher cobalt content and are in the range of 5 – 16 nm. The ultrasonic velocity of the aqueous carrier fluid and Cobalt ferrofluids was measured by varying the temperature from 30 – 70 °C. The ultrasonic velocities of magnetic nanoferrofluids decrease with concentration in the absence of magnetic field. The higher value for the nanoferrofluid's velocity compared to that of the carrier liquid in the absence of a magnetic field shows the influence of dispersed particles on the velocity of ultrasonic propagation.

Keywords: nanoferrofluid, co-precipitation, ultrasonic velocity.

Received: 5 February 2016

Revised: 4 April 2016

1. Introduction

Ferrofluids are stable colloidal dispersions of nanosized particles of ferro- or ferrimagnetic particles in a carrier liquid [1]. Among spinel ferrites, cobalt ferrite has attracted considerable attention in recent years due to its unique physical properties, such as high Curie temperature, large magnetocrystalline anisotropy, high coercivity, moderate saturation magnetization, large magnetostrictive coefficient, excellent chemical stability and mechanical hardness [2]. The physical and chemical properties of spinel nanoparticles are greatly affected by their synthetic route. For this reason, various methods have been reported in the literature for the preparation of these nanoscale spinel particles, e.g. the ceramic method, sol–gel, co-precipitation, solvent evaporation, hydrothermal, combustion, micro emulsion and citrate methods [3–7]. The magnetic properties of ferrites are directly related to the distribution of the cations over tetrahedral and octahedral lattice sites. Since the magnetic moments of the ions are ordered parallel within each sublattice and antiparallel between both sublattices, the difference in the magnetic moments between both sublattices gives magnetic moment to the ferrite crystal [8]. In the present work, attempts are made to investigate the change in the acoustic properties of magnetic fluids by increasing the concentration of cobalt in the spinel ferrite.

2. Experimental

Nanoferrofluids of $Co_xFe_{3-x}O_4$ were prepared by the chemical co-precipitation method by varying the value of x (0.2, 0.6 and 1.0). Aqueous solutions of $FeCl_3$, $CoCl_3$ and NaOH were prepared separately in the respective stoichiometric ratios. The NaOH solution was then added dropwise to $FeCl_3$ and $CoCl_3$ solutions separately and both were mixed with constant stirring using magnetic stirrer at 80 °C for 1 hr. The precipitate thus formed was isolated by centrifugation and washed several times with deionized water. The magnetic nanoferrofluids thus obtained were stabilized by the addition of surfactant and stirred at 80 °C for 1 hr. The resulting product was washed several times with deionized water to remove impurities and free radicals. The samples prepared at different values of x were characterized by XRD and SEM. Then, aqueous nanoferrofluids were prepared and ultrasonic velocity studies were carried out.

3. Results and Discussion

Figure 1 shows the XRD pattern of the samples. Series of characteristic peaks in the spectrum agree with standard $CoFe_3O_4$ XRD spectrum. The average crystalline size D of the particles from Scherer formula is in the range of 5 to 16 nm. The peaks at 30 °(110), 45.4 °(311) reveal that the presence of Fe_3O_4 [9]. The intensity of the peak increases with increased cobalt concentration. The characteristic peak at 40.25 ° appears due the presence of cobalt [10]. The SEM images of the samples are shown in Fig. 2.

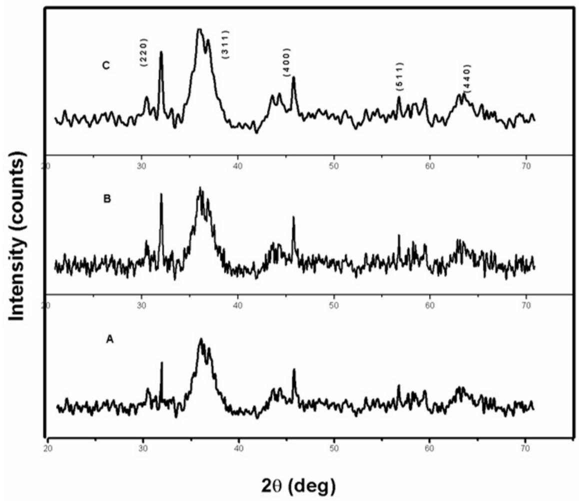

FIG. 1. The XRD pattern of $Co_xFe_{3-x}O_4$ for (A) x = 0.2 M; (B) x = 0.6 M; (C) x = 1.0 M

The ultrasonic velocities of the nanoferrofluids for various values of x were measured by varying the temperature from 30 to 70 °C. The variation of velocity with temperature of the nanoferrofluids is shown in Fig. 3. The ultrasonic velocity decreases with increased temperature for all values of x in the absence of magnetic field. The higher values of velocity for nanoferrofluids than that of the carrier liquid in the absence of magnetic field shows the influence of dispersed particles on the velocity of ultrasonic propagation. This indicates that the fluids of higher concentration are less compressible than those of lower concentration [11].

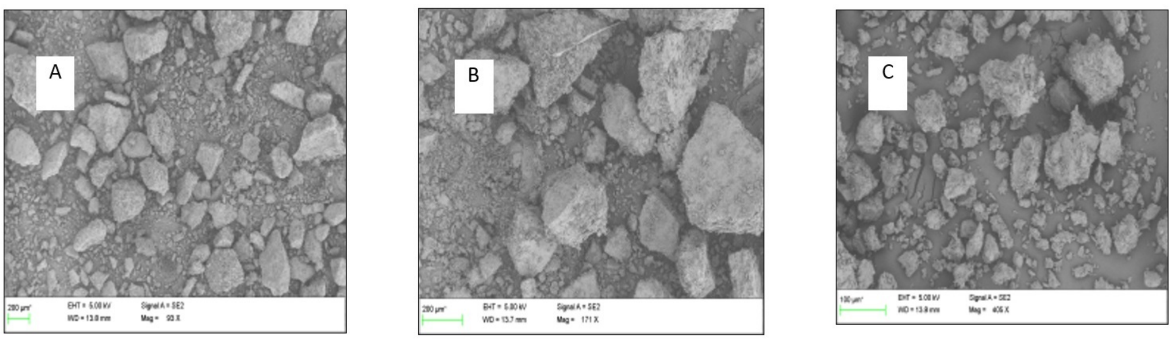

FIG. 2. The SEM images of $Co_xFe_{3-x}O_4$ for (A) $x = 0.2$ M; (B) $x = 0.6$ M; (C) $x = 1.0$ M

4. Conclusion

Cobalt ferrite nanoferrofluids were prepared by the chemical co-precipitation method. The XRD pattern of the composite confirms the presence of cobalt containing magnetic phases without any additional phases. The SEM data shows that the formation of nanoparticles. The increase of ultrasonic velocity with cobalt is attributed to the increased compactness of the medium or reduction in free space between the components.

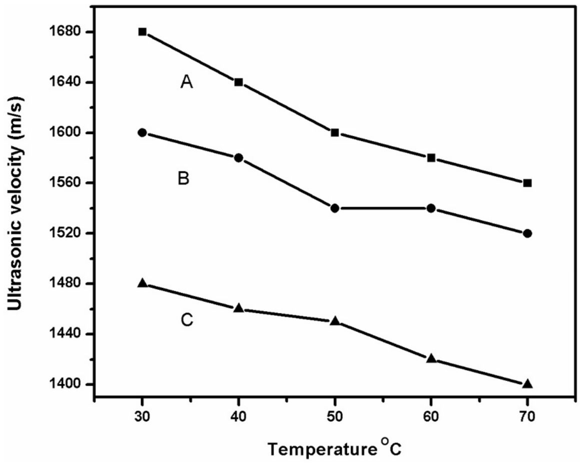

FIG. 3. The variation of ultrasonic velocity with temperature of $Co_xFe_{3-x}O_4$ for (A) $x = 0.2$ M; (B) $x = 0.6$ M; (C) $x = 1.0$ M

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