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Cobalt ferrite nano particles by microemulsion route

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Abstract- Nanosized particles of Cobalt ferrite ($CoFe_2O_4$), has been synthesized from single water-in-oil microemulsion technique, consisting n-hexanol as an oil phase, surfactant CTAB and an aqueous solution of metal salts. The resulting $CoFe_2O_4$ was formed at temperature of around 600ºC, which is lower than that observed in the solid-state reaction. The synthesized particles were characterized by XRD and VSM. These studies reveal that the formation of cobalt ferrite by using microemulsion route resulted into the finer particle size and better magnetic properties than those of the conventional routes. Magnetic investigation indicates that the sample is soft-magnetic material with low coercivity.

INTRODUCTION

Metal oxides such as ferrites are of particular interest for therapeutic and diagnostic medical applications due to their relative inertness and properties that can be tailored by changing synthesis parameters. These ferrites have found application as contrast agents for magnetic resonance imaging (MRI), in ferrofluid technology for MRI monitoring in hypothermia, and in cancer tumor detection via SQUID magnetometry. Nanostructured materials exhibit unusual physical and chemical properties that differ significantly from those of conventional bulk materials because of their extremely small size or large specific surface area. The cobalt ferrites with good magnetic properties are used in a wide variety of technological applications [1], including satellite communications, memory devices, computer components, antenna rods and transformer cores. Various preparation methods have been used to produce Spinel ferrite nanoparticles. Among them, micro emulsion route is an alternative and promising technique for preparing soft ferrites, leading to highly pure, chemically homogeneous, and nanometric scale particles. A microemulsion system, which consists of an oil phase, a surfactant phase and an aqueous phase, is a thermodynamically stable isotropic dispersion of the aqueous phase in the continuous oil phase [2]. It exhibits a structure of nanosized droplets which are in the size range 5 to 20 nm, rendering the microemulsion optically transparent. Each of these droplets will be acting as a nanosized reactor for forming nanosized precipitate particles. In this work, we applied a microemulsion technique to prepare $CoFe_2O_4$ nanoparticles.

EXPERIMENTAL

All chemicals used in this work were analytic grade. To select a proper composition that would form reverse micelles, a phase diagram water/CTAB/n-hexanol [3] was used. The microemulsion system consists of n-hexanol as an oil phase, CTAB as a surfactant and an aqueous phase of metal salts. Aqueous solution was prepared by dissolving stoichiometric amount of Cobalt Nitrate and Ferrous Sulfate to deionized water. 6N NaOH was taken as a precipitating agent. The compositions were prepared by mixing of an appropriate amount of metal salts with proper amounts of CTAB and n-hexanol. During mixing, the solution was

heated between 50 to 60 ºC. Addition of NaOH gives rise to the pH value of the solution to 11 and an intermediate precipitate was formed. It has been oxidized by using H_2O_2. The resultants were then washed with water-methanol (1:1) to break up the micelles. The samples were further washed several times with ethanol and distilled water and dried at 70 ºC. The dried precursors were calcined at 600 ºC for 4 hours in muffle furnace. The synthesized Co-ferrite powders were examined by an X-ray diffractometer to identify the spinel phase. The particle size was determined from the (3 1 1) diffraction line broadening using Scherrer method. The magnetic properties of were measured using VSM.

RESULTS AND DISCUSSION

Figure 1 shows the XRD pattern recorded at room temperature from the precursor prepared using above composition and calcined at 600 ºC for 4 hrs in muffle furnace. The peaks are indexed to the cubic $CoFe_2O_4$ spinel phase. No other peaks or impurities are detected. The crystallite size was estimated 28 nm.

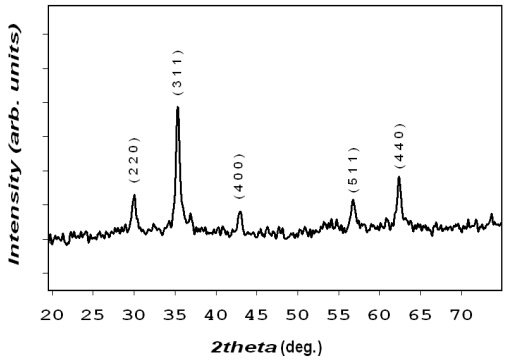

Fig. 1- XRD pattern of $CoFe_2O_4$ synthesized by microemulsion route calcined at 600 ºC for 4 hrs.

Magnetic measurements were done at room temperature on a VSM with a peak field of 15kOe. This yielded a saturation magnetization, M_s of 1.58 emu/g, a remanent magnetization, M_r of 0.612 emu/g and a coercivity of 1375 Oe. This coercivity value indicates that the particles formed are single domain with no nonmagnetic impurities.

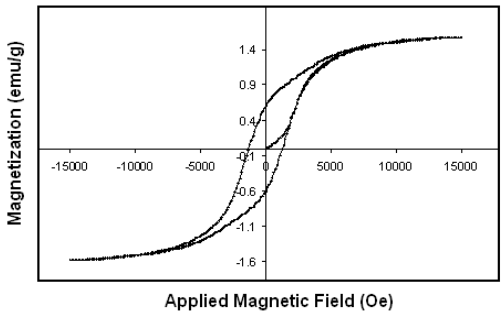

Fig. 2- Room temperature magnetization curve of $CoFe_2O_4$.

CONCLUSION

In this paper, we have presented a microemulsion method for the synthesis of nanoparticles of cobalt ferrite. In this technique, aqueous core of water/CTAB/n-hexanol microemulsions have been used for the precipitation of precursor hydroxides of Co^{2+} and Fe^{2+}. These hydroxides were then calcined to obtain the oxide. The formation of nanosized $CoFe_2O_4$ was confirmed by X-ray diffraction. The magnetic properties were measured using a VSM at room temperature.

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