VARIOUS FACTORS AFFECTING THE STRUCTURAL AND MAGNETIC PROPERTIES OF SOME FERRITE NANOSTRUCTURES

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Abstract

The properties of the ferrites depend upon the crystal structure, which plays a crucial role in their versatile applications and can be influenced by various factors. The present thesis focuses on changes in properties and morphology by varying synthesis parameters like surfactant, sintering temperature, time, synthesis temperature, pH, reducing agent, and doping of rare-earth ions in ferrite nanoparticles synthesized by sol–gel auto combustion method and hydrothermal method.

Cobalt ferrite (CFO) has been synthesized in the form of nanoparticles (NPs) through sol–gel auto combustion method. The prepared NPs of CFO were sintered for four hours at various temperatures from 300°C to 900°C. The average crystallite size of the NPs found to be increased from 28 nm to 59 nm with sintering temperature. The Magnetic behavior of CFO NPs has been tailored by varying the sintering temperature and strongly enhanced the range of application in spintronic and memory devices. The magnetic studies revealed that the saturation magnetization (M_S) increases 63 emu/gm to 88 emu/gm, while the coercivity (H_C) of nanoparticles decreases with the increase of sintering temperature. The wide range of coercivity of CFO NPs has been achieved from 934 Oe to 2237 Oe. Also, the high M_S value along with

high coercivity has been reported. The effect of the surfactant cetyltrimethylammonium bromide (CTAB) on cobalt ferrite ($CoFe_2O_4$) nanoparticles (NPs) using sol−gel auto−combustion method taking a different weight percent ratio of CTAB, i.e., 0%, 1%, 2%, 3%, and 4% with respect to metal nitrates also studied. Saturation magnetization and crystallite size were both found to be lowest in the case of a sample containing 2% CTAB.

Nickel ferrite nanoparticles (NFO) are synthesized by the hydrothermal method. The NFO nanoparticles have been synthesized using $NaBH_4$ as a reducing agent by the synthesis temperature vary like 80°C, 100°C, 120°C, 140°C, 160°C, 170°C, 200°C, 220°C, and 240°C, and the respective samples were named as N15, N1, N2, N3, N4, N5, N6, N7 and N8 (N-series). The study is further extended and we synthesized $NiFe_2O_4$ nanoparticles using 3M NaOH solution as a reducing agent and varying the reaction temperatures 140°C, 160°C, 180°C, 200°C and 220°C, these prepared samples named as T1, T2, T3, T4 and T5 (T-series) respectively. Magnetic properties were measured at room temperature using a physical property measurement system (PPMS). The crystallite size of the nanoparticles calculated using XRD data was found to be less in the case of the reducing agent $NaBH_4$ (12−22 nm) compared to the samples prepared using NaOH (35−40 nm), and in increasing order in size from 12 nm to 22 nm with an increase in synthesis temperature. A regular trend in crystallite size and coercivity was also observed for the samples prepared using $NaBH_4$ as a reducing agent with temperature. It was found that nanoparticle behavior tends to be superparamagnetic from ferromagnetic as we increase the synthesis temperature. But no regular magnetic behavior has been shown by the nanoparticles prepared using NaOH as a reducing agent. As different properties are achieved with temperature as above by using two different reducing agents, further synthesis of NFO nanoparticles is done by using both NaOH and $NaBH_4$ and studying the variation in structural properties with variation in time and pH of the solution in the hydrothermal method.

We further go to study the effect of doping on NFO behavior. And study the effect of Pr doping on structural, morphological and magnetic properties of NFO. Praseodymium rare-earth ion (Pr^{3+}) doped nickel ferrite ($NiFe_{2-x}Pr_xO_4$, $0 < x < 0.1$) nanocrystals (NFPO) were synthesized. The saturation magnetization (M_S) was found to be decreased and coercivity (H_C) increases by adding rare earth ions in nickel ferrite nanoparticles. All samples show the ferromagnetic behavior at room temperature. Further, in order to improve the solubility of rare-earth ions in NFO, we study the effect of reducing agents and pH variation on doping. We have achieved a solubility limit up to 0.025 using NaOH as a reducing agent. However, in this contribution, we have achieved a solubility limit of 0.15 for Pr ions using $NaBH_4$ as a reducing agent. Nevertheless, the solubility of Pr ions is found to be higher than Gd ions using $NaBH_4$ as a reducing agent in $NiFe_{2-x}RE_xO_4$. We have observed that not only do ionic radii of RE earth ions and the method of preparation of doped ferrite affect the solubility limit of RE ions in nickel ferrite, but other factors like reducing agents also play an important role in solubility. Then we further study the effect of pH on the solubility limit of Pr ions. The synthesis of the samples was done using a hydrothermal method. It is found that as we increase the pH, solubility has been decreasing for both the reducing agents.