Synthesis of Co-ferrite nanoparticles with narrow size distribution

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Nanoparticles having uniform size distributions are of great interest, due to their interesting physical properties. Among different magnetic materials, cobalt ferrite nanoparticles are of special attention because of their high magneto-crystalline anisotropy. Widespread of a research in the filed of nanoparticles synthesis has resulted in many different synthesis methods. Due to their simplicity, a co-precipitation from aqueous solutions is widely used synthesis procedure for preparation of the $CoFe_2O_4$ nanoparticles. The co-precipitation of Co(II) and Fe(II) hydroxides in the first stage is followed by the oxidation of Fe(II) hydroxide in the second stage, which results in the direct formation of the spinel ferrite phase. The main drawback of this co-precipitation method is relatively poor control of the particle size. In order to achieve better control over size and size distribution of prepared nanoparticles more advanced methods have been developed. One of such methods is co-precipitation in microemulsions, where formation of spinel ferrite is confined to small volume of water pools embedded with a surfactant and distributed within an oil phase. The size of these water pools, and consequently the size of the product, is thermodynamically determined, in particular by the water-to-surfactant ratio. In recent years, thermal decomposition of organo metallic complexes, such as oleates, in high-boiling-point organic solvents, have been intensively studied as another method allowing close control of the nanoparticle morphology. In such a method iron and cobalt oleates are prepared by reacting iron and cobalt acetylacetonates with oleic acid in a high boiling point organic solvent, such as benzyl ether. At lower temperatures oleates are formed which at higher temperatures decompose and ferrite nanoparticles are formed. The as-synthesized nanoparticles are coated by a mono-molecular layer of oleic acid. Such nanoparticles are hydrophobic and can be dispersed in non-polar organic solvents.

In this work, the structural and magnetic properties of the $CoFe_2O_4$ nanoparticles synthesized by three different methods: the co-precipitation in aqueous solutions, the microemulsion method, and the thermal decomposition of the oleates were compared. By controlling conditions during synthesis, three samples of the nanoparticles of the same average size (approximately 8 nm) were prepared. EXAFS experiments (performed at C beamline of HASYLAB, under EU Contract RII3-CT-2004-506008 (IA-SFS)) and magnetic-hysteresis measurements at room temperature and at 10K indicated considerable differences between nanoparticles synthesized by different methods in terms of different cation distribution inside the spinel lattice. Detailed comparison of synthesis methods and their impact on the control of cations distribution and consequently of the magnetic properties of the $CoFe_2O_4$ nanoparticles will be discussed.