

SIZE AND QUALITY CONTROL OF COBALT FERRITE NANOCRYSTAL SYNTHESIS USING A MAGNETO-OPTICAL PROBE

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Controlling the structure and composition of ternary compounds is a formidable task. In particular obtaining the correct phase of the same materials in the form of colloidal nanocrystal dispersion is even more difficult since the temperatures that can be applied in the synthesis of colloidal oxide nanoparticles are limited by solvent boiling/decomposition temperatures, which are usually much lower than the proper annealing temperatures required for achieving equilibrium structures in the bulk materials. At the elevated temperatures used in bulk materials synthesis the colloidal particles would agglomerate and sinter to larger crystals. Ferrites have a spinel-type crystal structure, where the lattice is constructed of a fcc structure of the oxygen ions, and two types of metal cation interstitial sites, the tetrahedrally coordinated 'A' site, and the octahedrally coordinated 'B' site. Cobalt ferrite has a partially inverse spinel structure, where the Co^{2+} ions occupy both the A and B sites and so does the Fe^{3+} .

The present study focused on developing a colloidal CoFe_2O_4 (cobalt ferrite) nanocrystal synthesis using magneto-optical (MO) spectroscopy as a probe of the insertion of the Co^{2+} ions into the ferrite lattice. We have developed a new cobalt ferrite synthesis using mixed types of organometallic precursors and compared to cobalt ferrite nanocrystals produced according to previously reported synthesis techniques. The standard characterization techniques (e.g., EDS, SQUID magnetometry, provided similar results for the nanocrystals prepared by the different syntheses (roughly Co/Fe ratio of 0.5), while MO spectroscopy yielded very different results for the various syntheses¹. MO spectroscopy is a site-specific probe, since it probes localized electronic transitions at distinct crystal interstices and thus used to probe the concentration of the Co^{2+} ions in the ferrite lattice. The newly developed synthesis produced nanocrystals with a significantly higher inclusion of cobalt ions in the crystal lattice compared with other synthesis schemes published in recent years, which probably have most of the Co out of the lattice or as Co^{3+} . The second part of the study examined the influence of the addition of co-surfactant polyol type molecules on the synthesized cobalt ferrite nanocrystals. The addition of the co-surfactant was found to increase the size of the synthesized nanocrystals, while the MO spectra revealed that the size

increase was accompanied by a decrease in the concentration of the Co^{2+} ions incorporated into the ferrite lattice.

The achievement of control over cation distribution in the ferrite particles is less important in the case of tuning the magnetic properties of the nanocrystals and more important in the case of using the nanocrystals for magneto-optical applications. Moreover, this study is a significant milestone in the development of general preparation schemes of stoichiometrically and size controlled multi-cation oxide nanocrystals and in the application of suitable characterization probes.