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Characterization of superparamagnetic iron oxide nanoparticles synthesized in air atmosphere

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Quantum size effects, large surface area and superparamagnetic behavior of magnetic nanoparticles (NPs) offer a high potential of applications in many different areas such as, targeted drug delivery systems, cancer diagnosis and treatment, contrast agents in MRI, catalysis and also in magnetic recording [1]. Co-precipitation is one of the simplest and easiest techniques to synthesize NPs. In co-precipitation, iron oxide NPs are obtained by adding an alkaline to an aqueous solution of iron salts under vigorous stirring in the presence of inert gas atmosphere, mostly nitrogen. In this study, iron oxide NPs were synthesized in air atmosphere by adding ammonia solution to the ferrous aqueous solution prepared with the molar ratio of $[Fe^{+2}]/[Fe^{+3}]=2/3$. The influence of iron ion concentration on the saturation magnetization and particle sizes of NPs was studied.

The samples were characterized utilizing x-ray diffraction (XRD), fourier transform infrared spectroscopy (FTIR), vibrating sample magnetometer (VSM) and dynamic light scattering technique (DLS).

XRD results showed that the samples have a face centered cubic spinel structure having the characteristic peaks of magnetite, a typical example is shown in Figure 1a. In the XRD patterns, the crystallinity weakens and the particle size reduces while the iron ion concentration decreases. The mean particle sizes calculated from the most intense (311) peak of the patterns increase from 9 nm to 16 nm as the iron ion concentration increases. FTIR analysis also showed the Fe-O vibration band at around 570 cm^{-1} confirming the magnetite formation. To the VSM measurements, all samples are superparamagnetic showing zero remanence and coercivity, see Figure 1b. The magnetic particle sizes were calculated from VSM data according to the Langevin function. Saturation magnetization increases from 14 emu/g to 64 emu/g with the increase of iron ion concentration as the magnetic particle size increases from 8 nm to 13 nm. The hydrodynamic particle diameters obtained from DLS are consistent with the crystalline and magnetic particle sizes. It is shown that superparamagnetic iron oxide NPs can be synthesized in air atmosphere in a simple and economical way.

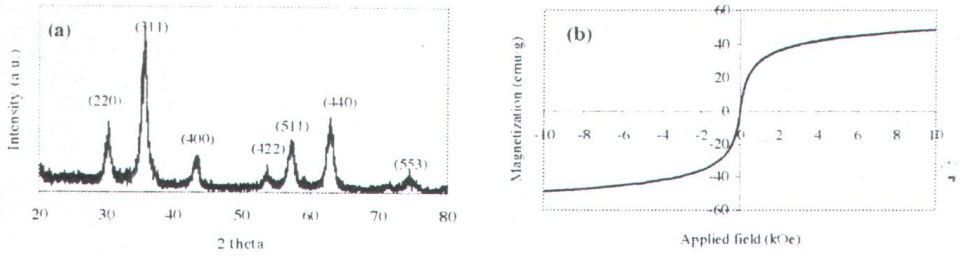

Figure 1: a) XRD pattern and b) Magnetization curve of superparamagnetic magnetite nanoparticles.

[1] S. Laurent, D. Forge, M. Port, A. Roch, C. Robic, L. V. Elst and R. N. Muller, Chem. Rev. **108** (2008), 2064-2110.

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