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Shape Control of Fe_3O_4 Nanoparticles

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Magnetic nanoparticles have been studied in several scientific fields, especially for applications in biomedicine [1]. Coated magnetic nanoparticles are studied as non-conventional cancer treatment methods [2]. The present work aims to establish the synthesis of the magnetic iron oxide nanoparticles with suitable chemical composition, morphology and magnetic properties. The samples were obtained by co-precipitation from the iron salts $FeSO_4$ and $FeCl_3$ in the ratio Fe(II)/Fe(III)=1/2 with NH_4OH solution addition. Solutions with different concentration of NH_4OH (0.15; 0.3; 0.50; 1 and 4 molar) were added into a solutions containing a mixture of $FeCl_3$ (0.45 M) and $FeSO_4$ (0.225 M). The structure of the obtained nanoparticles was studied by transmission electron microscopy (TEM), x-ray diffraction (XRD), and the magnetic behavior was studied by vibrating sample magnetometer (VSM) and by Mossbaüer spectroscopy. The produced iron oxide nanoparticles were observed by TEM. A Jeol 2010 instrument, operating at 200 kV under diffraction and phase contrast modes was used as main tool. Two different morphologies were observed: ferrimagnetic spheroidal nanoparticles and non-magnetic nanowires. The sample produced with low alkaline concentration (of NH_4OH) shows elongated shapes around 100 nm of length. The samples produced with high alkaline concentration, did not present elongated shapes, the particles have an average size in the order of 10 nm and display a spheroidal morphology. The population of elongated shapes seems to be reduced with the increase of alkaline concentrations, and eliminated when concentrations are above of certain range concentration (up to 0.5 M). The sample produced with 0.15 M of NH_4OH shows elongated shapes. Bright field TEM image, in the Fig. 1a, shows a goethite structures in order of 100 nm length and 10 nm width. Fig. 1b exhibits the corresponding selected area diffraction (SAED) and its dark field in the Fig. 1c. The samples produced with concentrations of 0.5 and 1 M of NH_4OH showed a homogeneous size distribution of magnetite spheroidal particles on the order of 10 nm diameter. The sample produced with 4 M of NH_4OH show a bimodal distribution of sizes: one of mean size around 8 and other of size around 40 nm approximately. Fig. 2a shows a TEM bright field image of the sample produced with 4 M of NH_4OH, Fig. 2b exhibit the corresponding indexed electron diffraction pattern (EDP), typical of the magnetite structure. Particles of two different mean size distributions are observed in the TEM bright field image of the Fig. 2c. The results of magnetic measurements show that the particles produced by using high alkali concentration, exhibit superparamagnetic behavior at room temperature

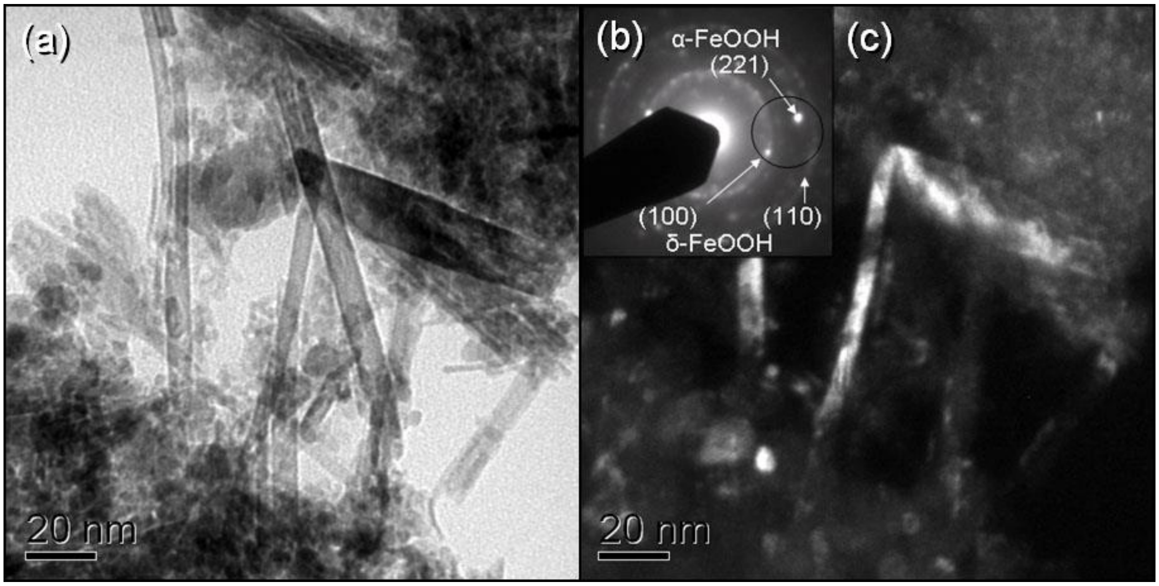

Figure 1. (a) Bright field TEM image of goethite structures of the sample produced with 0.15 M of NH4OH, (b) corresponding indexed selected area diffraction (SAED) and (c) dark field TEM image.

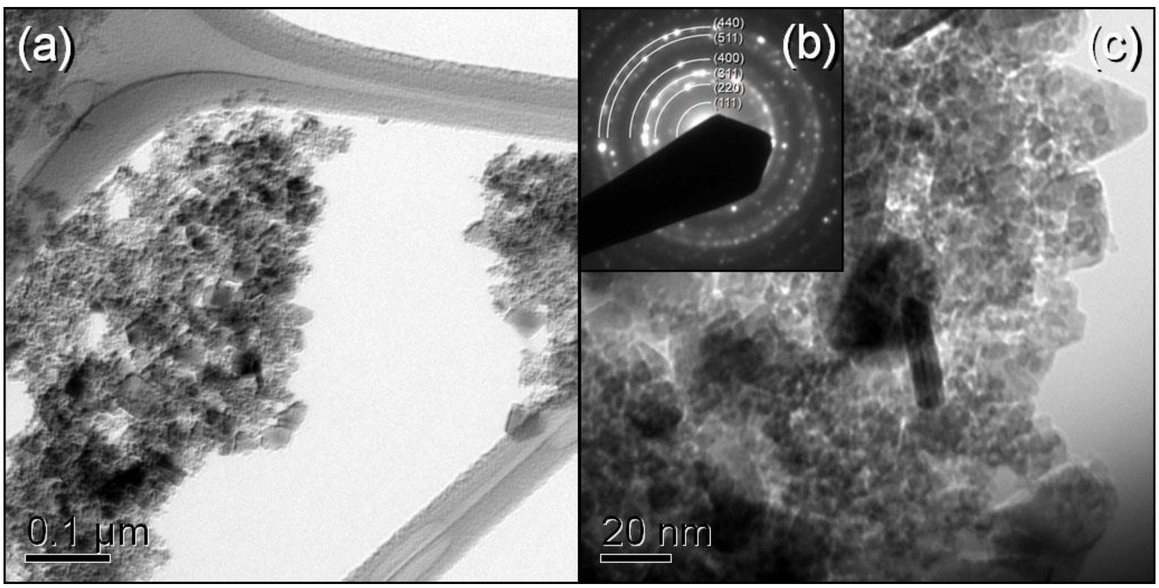

Figure 2. (a) shows a TEM bright field image of the sample produced with 4 M of NH4OH, (b) the corresponding indexed electron diffraction pattern (EDP), (c) TEM bright field image.

References
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