Preparation and Characterization of Magnetic Fe_3O_4 Nanoparticles Doped with Yttrium Ions with Potential Application in Biomedicine

P. Grzączkowska[1,2], J. Mikulski[1], P. Kowalik[1], T. Wojciechowski[1], K. Fronc[1], R. Rudniewski[1], R.Minikayev[1], M. Łapiński[3], A. Gardias[2], J. Rybusiński[2], D. Elbaum[1], B. Sikora[1], A. Twardowski[2] and J. Szczytko[2]

[1]Institute of Physics Polish Academy of Sciences, Al. Lotników 32/46,Warsaw, Poland
[2]Institute of Experimental Physics, Faculty of Physics, University of Warsaw, ul. Pasteura 5, Warsaw Poland
[3]Institute of Optoelectronics, Military University of Technology, ul. Kaliskiego 2, Warsaw, Poland

Cubic spinel-type structure Fe_3O_4 nanoparticles are a popular magnetic material of common use in the field of data storage or and high-density digital recording disks. Due to the strong magnetic properties their applications in biotechnology and medicine such as hyperthermia therapy have attracted significant attention.

Fe_3O_4 magnetic nanoparticles were synthesized in two chemical methods with various concentrations of Yttrium ions. The morphology and characterization of nanoparticles were measured with X-ray diffraction method, Scanning Electron Microscopy (SEM) and Superconducting Quantum Interference Device (SQUID) magnetometry. First synthesis of Fe_3O_4 is based on high temperature decomposition of the self-synthesized Fe(III)-oleate. Different concentration of Fe(III)-oleate and time of the reaction resulted in various size of each nanoparticles. In second synthesis the magnetic particles were obtained by chemical precipitation from ferric ($FeCl_3$) and ferrous salts ($FeSO_4$) in alkali with ammonia hydroxide medium.

The X-ray diffraction method confirmed a cubic single phase of Fe_3O_4 in both synthesis. SEM images showed sizes of nanoparticles ranging from 10 nm to 25 nm. Nanoparticles from Fe(III)-oleate reaction had size distribution around 2 nm and those obtained from precipitation around 6 nm. Measurements of relation between applied magnetic field (H) (Oe) and magnetization (M)(emu/g) varied from 9 to 84 (emu/g)(at 2000 Oe), where the maximum value was obtained by Fe_3O_4 nanoparticles doped with 1% Yttrium. In a 200 Oe precipitated nanoparticles reached higher magnetization values quicker than those from Fe(III)-oleate, which went in favor of these nanoparticles obtained in the second reaction.

Measuring the influence of a changing magnetic field on nanoparticles showed their ability to generate heat, which may be used in hyperthermia therapy.

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