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Magnetic Properties and Hyperthermia of Zn-doped Fe_3O_4 Nanoparticles with Plasma Treatment

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Magnetic $Fe_{3-x}Zn_xO_4$ ($x = 0.01, 0.025, 0.050, 0.075, 0.1$) nanoparticles are prepared by the high temperature thermal decomposition method. The samples are characterized by using X-ray diffractometer (XRD), vibrating sample magnetometer (VSM), magneTherm device and Mössbauer spectroscopy techniques. From the result of XRD measurement, the crystal structure of Zn-doped Fe_3O_4 samples are determined to be cubic spinel with space group Fd3m. With increasing Zn contents, x up to 0.050, magnetization and coercivity values at 295 K increase followed by decrement above $x = 0.050$. Plasma treatment was performed on sample with $x = 0.050$, showing the highest magnetization values. The magnetization and coercivity values of plasma-treated sample increase to 79.7 emu/g and 5 Oe, respectively. The self-heating temperature of the sample increases up to 70 °C after the plasma treatment. We have analyzed the Mössbauer spectra as three six-line of tetrahedral A-site, octahedral B_1, B_2-sites and doublet of B_3-site at 295 K and four six-line of A, B_1, B_2, and B_3-sites at 4.2 K. From the isomer shift values at 4.2 and 295 K, the valence states at the B_2-site is determined to be ferrous and the others are at ferric state. With increasing Zn content, the area ratio of A-site decreases, while the area ratio of B-sites including B_1, B_2, B_3-site increase. It can be seen that the amount of Zn ions substituted at the A- and B- sites affects the super-exchange interaction.

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