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Examination of the magnetic hyperthermia and other magnetic properties of $CoFe_2O_4$@$MgFe_2O_4$ nanoparticles using external field Mössbauer spectroscopy

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$CoFe_2O_4$@$MgFe_2O_4$ core/shell nanoparticles were synthesized by high temperature thermal decomposition with seed-mediated growth. The crystal structure and magnetic properties of the nanoparticles were investigated using X-ray diffractometry (XRD), vibrating sample magnetometry (VSM), and Mössbauer spectrometry. The magnetic hyperthermia properties were investigated using a MagneTherm device. Analysis of the XRD patterns showed that $CoFe_2O_4$@$MgFe_2O_4$ had a cubic spinel crystal structure with space group *Fd-3m* and a lattice constant (a_0) of 8.3686 Å. The size and morphology of the $CoFe_2O_4$@$MgFe_2O_4$ nanoparticles were confirmed by HR-TEM. The VSM measurements showed that the saturation magnetization (M_S) of $CoFe_2O_4$@$MgFe_2O_4$ was 77.9 emu/g. The self-heating temperature of $CoFe_2O_4$@$MgFe_2O_4$ was 37.8 °C at 112 kHz and 250 Oe. The $CoFe_2O_4$@$MgFe_2O_4$ core/shell nanoparticles showed the largest saturation magnetization value, while their magnetic hyperthermia properties were between those of the $CoFe_2O_4$ and $MgFe_2O_4$ nanoparticles. In order to investigate the hyperfine interactions of $CoFe_2O_4$, $MgFe_2O_4$, and $CoFe_2O_4$@$MgFe_2O_4$, we performed Mössbauer spectrometry at various temperatures. In addition, Mössbauer spectrometry of $CoFe_2O_4$@$MgFe_2O_4$ was performed at 4.2 K with applied fields of 0–4.5 T, and the results were analyzed with sextets for the tetrahedral A-site and sextets for the octahedral B-site.
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