

MRI Relaxation Properties and Hyperthermia Performance of Poly-L-lysine Functionalized Iron Oxide Nanoflowers

I. Khmara,¹ M. Kubovcikova,¹ J. Vojtova,² O. Strbak,² I. Smolkova,³ V. Zavisova,¹ M. Koneracka,¹ and J. Vilcakova^{3,4}

¹*Institute of Experimental Physics SAS, 04001 Kosice, Slovakia.*

²*Biomedical Centre Martin, Jessenius Faculty of Medicine in Martin, Comenius University in Bratislava, Mala Hora 4, 03601 Martin, Slovakia*

³*Centre of Polymer Systems, University Institute, Tomas Bata University in Zlin, Zlin, Czech Republic*

⁴*Faculty of Technology, Tomas Bata University in Zlin, 760 01 Zlin, Czech Republic.*

Multicore iron oxide nanoflowers (IONFs) exhibit enhanced collective magnetic behaviour arising from strong inter-core exchange and dipolar coupling, making them highly relevant for magnetism-based medical applications. Magnetite nanoflowers were synthesized via a polyol method and functionalized with poly-L-lysine (PLL) to improve colloidal stability while preserving intrinsic magnetic properties. Transmission electron microscopy confirmed highly crystalline multicore structures with preserved architecture after polymer functionalization. Magnetization measurements demonstrated superparamagnetic behaviour at room temperature with high saturation magnetization (≈ 74 emu/g for IONFs and ≈ 73 emu/g after PLL coating), indicating negligible impact of the polymer shell on collective magnetism. MRI relaxometry at 7 T revealed dominant transverse relaxation effects, with strong T_2 and T_2^* shortening and high r_2 and r_2^* relaxivities, confirming efficient local magnetic field perturbations generated by the nanoflowers. For IONFs, we obtained $r_1 = 3.23 \pm 0.78$ mM⁻¹s⁻¹, $r_2 = 513.10 \pm 123.14$ mM⁻¹s⁻¹, $r_2^* = 626.50 \pm 150.36$ mM⁻¹s⁻¹, $r_2/r_1 = 158.85$, $r_2^*/r_1 = 193.96$. For PLL-IONFs, we obtained $r_1 = 3.44 \pm 0.82$ mM⁻¹s⁻¹, $r_2 = 651.80 \pm 156.43$ mM⁻¹s⁻¹, $r_2^* = 742.60 \pm 178.23$ mM⁻¹s⁻¹, $r_2/r_1 = 189.48$, $r_2^*/r_1 = 215.87$.

Magnetic hyperthermia measurements performed at 1.05 MHz and 5.9 kA/m yielded specific absorption rate (SAR) values up to ~ 170 W/g for bare IONFs and ~ 76 W/g for PLL-functionalized IONFs in water. And SAR values of ~ 37 W/g and ~ 32 W/g in agar gel for bare and PLL-functionalized IONFs respectively. These results demonstrate that PLL-functionalized IONFs retain strong collective magnetic dynamics relevant for imaging and magnetically induced heating in medical applications.

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