# Nanomaterials for Biomedical Applications: Magnetic Hyperthermia and Magnetofection

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Recent results obtained in collaboration on materials with magnetic hyperthermia potential applications, aimed to determine NP moment relaxation mechanisms, quantify the NPs specific absorption rate (SAR) and correlate SAR with other NPs properties, are presented. A linear dependence of SAR on ferrofluid concentration and on squared-RF field amplitude was observed up to moderate concentrations and amplitudes for uncoated Zn doped magnetite ferrofluids. Relaxation times obtained from SAR experiments were found to be in good agreement with those calculated for Néel or Brown mechanisms and with those retrieved from Mössbauer measurements. Relaxation occured via the Néel mechanism for sizes below 18 nm and via the Brown one for larger sizes, and SAR values of up to 370 W/g were attained at 41 kA/m and 260 kHz for selected compositions and NP sizes (e.g. $Zn_{0.1}Fe_{2.9}O_4$, 16 nm NPs). Mössbauer, XRD, XAS and magnetization experiments confirmed that Zn enters selectively at the spinel tetrahedral site, enhancing NP magnetic moment for small Zn additions. Coating induced phenomena are presented for ferrofluids of magnetite NPs functionalized with citric acid. Effects on heat dissipation ability due to variation of synthesis parameters were studied by TEM, PALS, magnetization and SAR. Coating enlarged NP hydrodynamic size, increasing Brown relaxation time and induced steric repulsion reducing dipolar interactions amongst NPs affecting the Néel relaxation mechanism. Finally, effects on saturation magnetization and SAR, are presented.

Preliminary in vitro magnetofection (magnetically assisted gene transfer) experiments performed in collaboration with Dr. R. Goya (INIBIOLP) are presented. Magnetic field applicators were built and fully characterized and the recombinant adenoviral vector termed RAd-GFP was complexed with polymer coated magnetite NPs. Then the complex was incubated with B-92 glial cell cultures under a magnetic field. An empirical correlation between transfection efficiency and the magnetic force on the NP/virus complexes was deduced.