Magnetic nanoparticle arrays: Effect on magnetic hyperthermia

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Magnetic particle hyperthermia is a synergistic cancer treatment technique that takes advantage of heat released by magnetic nanoparticles (MNPs) when are exposed in an alternating magnetic field and may lead cancer cells either to a severe shock or even to apoptotic death. The thermal response of MNPs solution depends on a large number of parameters, such as the intrinsic properties of nanoparticle (e.g. size, magnetization), the medium parameters (e.g. viscosity, stability) of the solution and the field features (amplitude, frequency). In this work, we investigate how MNPs arrays (comprised of magnetite nanoparticles arranged in lines) may affect thermal response in comparison to the individual randomly dispersed MNPs (control samples). For this reason MNPs arrays where prepared, using as solvent a mix of agarose gel (agar) and water in magnetite nanoparticle solutions prepared by aqueous coprecipitation (shown in Fig.1a), by varying agar solution concentration (0.05-10 mg/mL) under two configurations of static magnetic field (100-400 G) parallel ($\theta=0^o$) and perpendicular ($\theta=90^o$) with respect to hyperthermia field direction (Figs. 1b-1d). Scanning Electron Microscopy (SEM) results reveal the successful formation of MNPs arrays (Fig. 1e). Moreover, hyperthermia measurements in two experimental setups (frequencies: 210, 765kHz, amplitudes: 250-300 Oe), revealed the enhanced thermal response of samples subjected parallel in magnetic field with respect to perpendicular and control samples (Fig. 2) for both concentrations as quantified by Specific Loss Power (SLP), a heating efficiency index. The effect of solution viscosity tuned by the agar concentration to the formation of the chains, and subsequently to SLP values is discussed together with the dipolar interactions governing array formations and their stability.

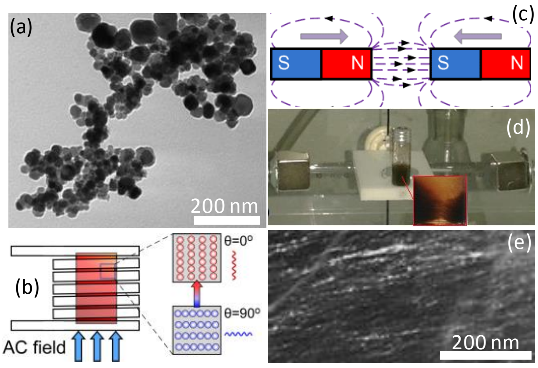

Figure 1: (a) TEM imaging of magnetite nanoparticles, (b) experimental setup of magnetic hyperthermia setup at two configurations: $\theta=0^o$ (parallel) and $\theta=90^o$ (perpendicular). 1(c) schematic magnetic field representation, 1(d) MNPs array formation under static magnetic field, 1(e) SEM imaging of MNPs arrays.

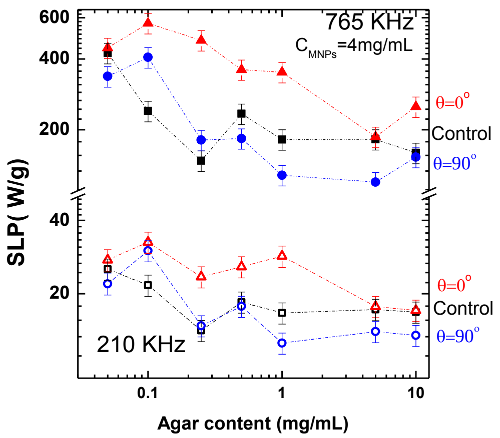

Figure 2: SLP values for varying agar content, under two different field frequencies (210 and 765kHz) and amplitude (300Oe).

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