Effects of inter- and intra-aggregate magnetic dipolar interactions on the magnetic heating efficiency of iron oxide nanoparticles

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Supporting information

Fig. S1. a) $[Fe]$ dependence of hysteresis loops, b) Normalized hysteresis loops of IONP dispersed in water at distinct $[Fe]$ and under given $H_{AC}$ conditions (100 kHz and 25 kA/m).
**Fig. S2**: Upper part: comparison of mass normalized AC (105 kHz) and DC magnetization cycles from IONP dispersed in water at room temperature and 2gFe/L. Lower part: Comparison of SAR values obtained by calorimetry (red) and magnetic (black) measurements obtained at 100 kHz and 25 kA/m.

**Figure S3**: Maghemite mass-normalized hysteresis loops obtained from IONP colloids in water (blue line) and glycerol 86% (cyan line) dispersions at 2 mgFe/mL under given $H_{AC}$ conditions (100 kHz).
**Fig. S4**: Field intensity dependence of SAR values from IONP dispersed in water at different [Fe] under given $H_{AC}$ frequency (105 kHz).

### Numerical simulations

Here, we described the methodology employed to run the simulations of hysteresis loops at given iron content (2 mg$_{Fe}$/mL) and different hydrodynamic sizes. As a consequence, we first considered $M_s$ and $K_{eff}$ as varying parameters in the simulations. In a first attempt, we fitted the hysteresis loop with the following hypothesis: i) with no size distribution and randomly oriented anisotropy axis. The results are shown in **Figure S5** and evidence that the distribution of coercive fields is a crucial parameter, ii) taking into account size distribution and with randomly oriented axis (see **Figure S6**). The shearing of the hysteresis loop, related to the distribution of $H_C$ is better reproduced, but the fact that $M_R$ is larger experimentally indicates a texturation of the anisotropy axis in the direction of the magnetic field, iii) with size distribution and oriented anisotropy axis (see **Figure S7**), where a perfect agreement with the experimental loop is achieved, using $M_s = 24.9$ Am$^2$/kg and $K_{eff} = 7200$ J/m$^3$. These parameters will then be kept constant, iv) with the same hypothesis as in iii) but including magnetic dipolar interactions. We have thus run a simulation with this value for $c$ and $N = 2000$ particles. **Figure S8** illustrates that, for such a low concentration, magnetic interactions are negligible, so the hysteresis loop is exactly the same as the one found in iii).
Fig. S5. Numerical simulations for IONP with $D_H=20$ nm. Magnetic interactions are neglected. IONP size distribution is not included. Anisotropy axis are randomly oriented.

Fig. S6. Numerical simulations for IONP with $D_H=20$ nm. Magnetic interactions are neglected. IONP size distribution is included. Anisotropy axis are randomly oriented.
Fig. S7. Numerical simulations for IONP with $D_{1b}=20$ nm. Magnetic interactions are neglected. IONP size distribution is included. Anisotropy axis are oriented in the direction of the field.

Fig. S8. Numerical simulations for IONP with $D_{1b}=20$ nm. Magnetic interactions are taken into account, with $N = 2000$ and $\phi_b = 0.038\%$. IONP size distribution is included. Anisotropy axis are oriented in the direction of the field.