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

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Supporting information

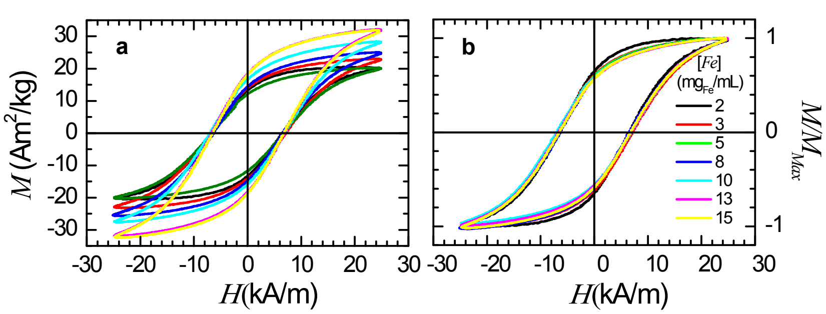

Fig. S1. a) *[Fe]* dependence of hysteresis loops, b) Normalized hysteresis loops of IONP dispersed in water at distinct [*Fe*] and under given H_{AC} conditions (100 kHz and 25 kA/m).

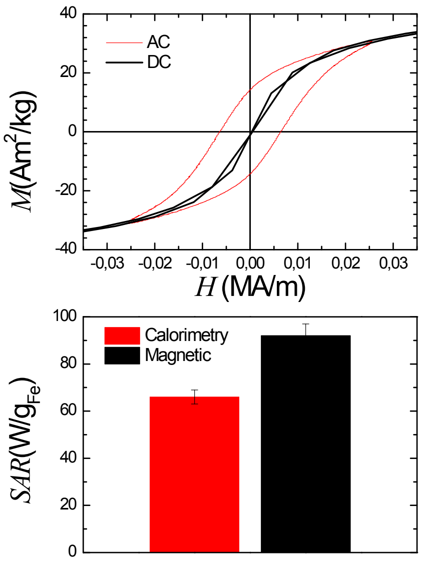

Fig. S2: Upper part: comparison of mass normalized AC (105 kHz) and DC magnetization cycles from IONP dispersed in water at room temperature and $2g_{Fe}/L$. Lower part: Comparison of *SAR* values obtained by calorimetry (red) and magnetic (black) measurements obtained at 100 kHz and 25 kA/m.

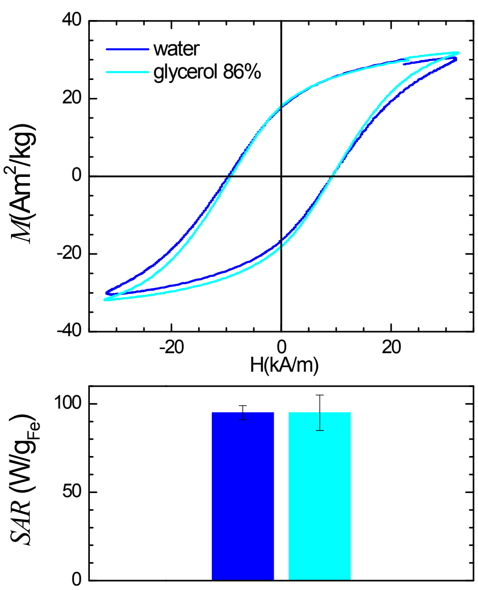

Figure S3: Maghemite mass-normalized hysteresis loops obtained from IONP colloids in water (blue line) and glycerol 86% (cyan line) dispersions at 2 mg_{Fe}/mL under given H_{AC} conditions (100 kHz).

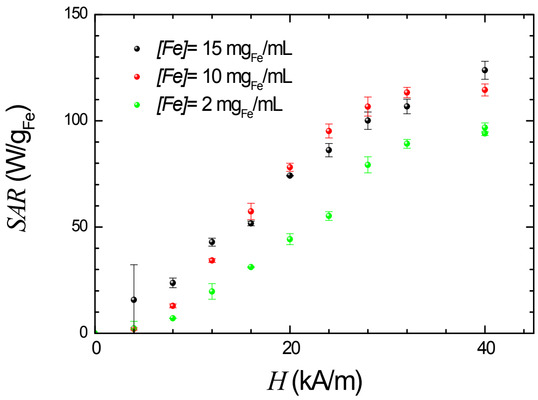

Fig. S4: Field intensity dependence of *SAR* values from IONP dispersed in water at different *[Fe]* under given H_{AC} frequency (105 kHz).

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 coervice 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).

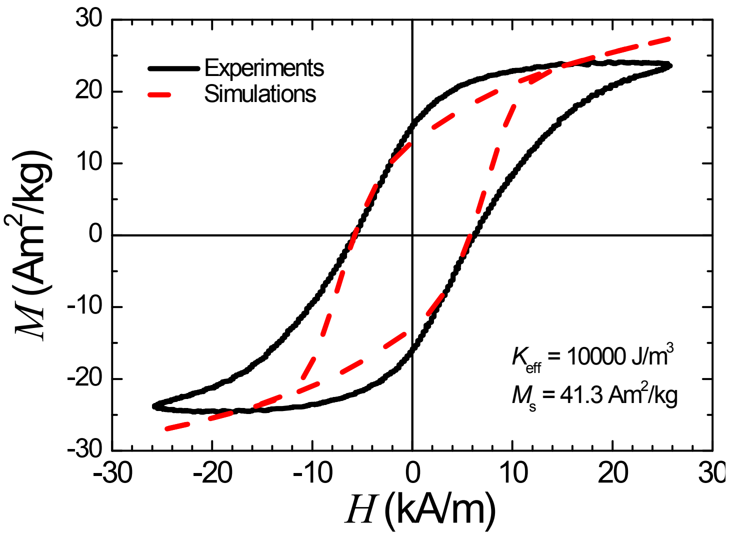

Fig. S5. Numerical simulations for IONP with D_H=20 nm. Magnetic interactions are neglected. IONP size distribution is not included. Anisotropy axis are randomly oriented.

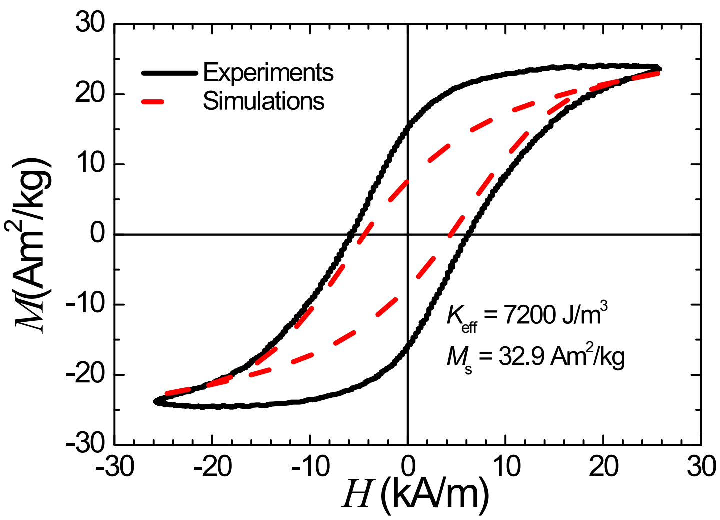

Fig. S6. Numerical simulations for IONP with D_H=20 nm. Magnetic interactions are neglected. IONP size distribution is included. Anisotropy axis are randomly oriented.

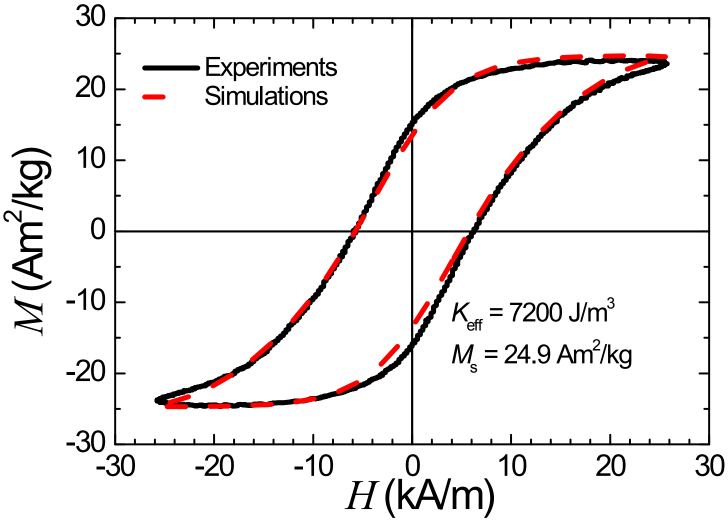

Fig. S7. Numerical simulations for IONP with D_H=20 nm. Magnetic interactions are neglected. IONP size distribution is included. Anisotropy axis are oriented in the direction of the field.

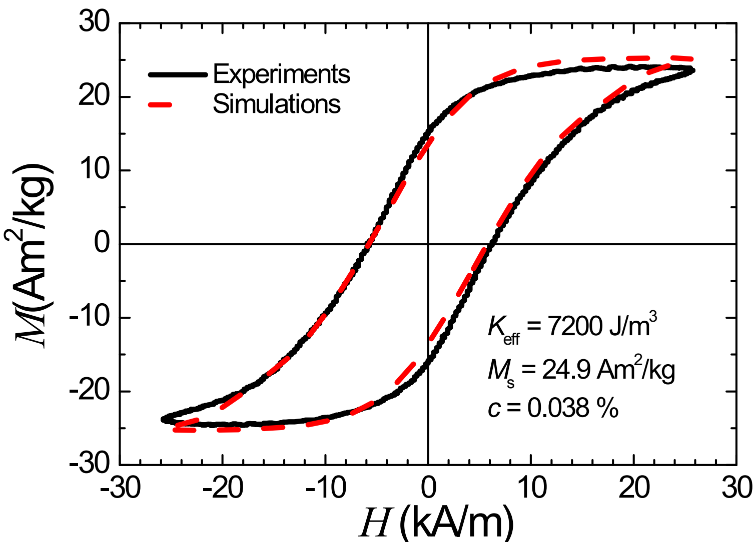

Fig. S8. Numerical simulations for IONP with D_H=20 nm. Magnetic interactions are taken into account, with N = 2000 and ϕ_d = 0.038%. IONP size distribution is included. Anisotropy axis are oriented in the direction of the field.