Relating Magnetic Properties and High Hyperthermia Performance of Iron Oxide Nanoflowers

We investigated in depth the interrelations among structure, magnetic properties, relaxation dynamics and magnetic hyperthermia performance of magnetic nanoflowers. The nanoflowers are about 39 nm in size, and consist of densely packed iron oxide cores. They display a remanent magnetization, which we explain by the exchange coupling between the cores, but we observe indications for internal spin disorder. By polarized small angle neutron scattering we unambiguously confirm that on average the nanoflowers are preferentially magnetized along one direction. The extracted discrete relaxation time distribution of the colloidally dispersed particles indicates the presence of three distinct relaxation contributions. We can explain the two slower processes by Brownian and classical Néel relaxation, respectively. The additionally observed very fast relaxation contributions are attributed by us to the relaxation of the disordered spins within the nanoflowers. Finally, we show that the intrinsic loss power (ILP, magnetic hyperthermia performance) of the nanoflowers measured in colloidal dispersion at high frequency is comparatively large and independent of the viscosity of the surrounding medium. This concurs with our assumption that the observed relaxation in the high frequency range is primarily a result of internal spin relaxation, and probably connected to the disordered spins within the individual nanoflowers.