Characterization of superparamagnetic particles with NMR relaxometry: good and bad news

Résumé

Superparamagnetic iron oxide particles find their main application as contrast agents for cellular and molecular Magnetic Resonance Imaging (1). The contrast they bring is due to the shortening of the relaxation times of water protons T1 and T2 (2). In order to understand their influence on proton relaxation, different theoretical relaxation models have been developed, each of them presenting a certain validity domain, which depends on the particle characteristics and proton dynamics (3). In this work, relaxation properties of suspensions of iron oxide particles in different solvents and at different temperatures, corresponding to different proton diffusion properties, were evaluated thanks to the measurement of nuclear magnetic relaxation dispersion (NMRD) profiles (4). These latter represent the evolution of the relaxation times with the magnetic field. The fitting of T1 NMRD profiles by the suited theory constitutes an interesting tool of characterization of the nanoparticles. The Roch theory, developed in the Motional Averaging Regime, was successfully used to fit T1 NMRD profiles, even completely outside the MAR validity domain, and provided a good estimate of the particle size. In order to refine the characterization of the particles, we tried to perform a simultaneous fitting of T1 and T2 NMRD data, which was unfortunately impossible. This occurrence constitutes a clear limitation of the Roch model. Finally, the theory was shown to fit satisfactorily the deuterium T1 NMRD profile of superparamagnetic particles suspensions in heavy water, usually dominated by quadrupolar interactions, providing good estimates of the size and magnetization of the particles.

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