Poster

Challenges on the Characterization of Superparamagnetic Particles as Contrast Agents in MRI

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Contrast Agents (CA) in MRI enhances the differences between tissues with similar properties by locally modifying the nuclear relaxation rates of water protons. The efficiency of a CA is determined by its longitudinal and transversal relaxivities, defined as the relaxation rate per mol of colloid (r_1, r_2 *respectively)*. This data can be expressed as a function of the magnetic field strength in the NMRD profiles (figures 1-3). One of the most important steps in the characterization of a new CA is the study of the NMRD profiles from which it is possible to determine the best application for the CA in a specific field strength, either to enhance images weighed on T1 or on T2, depending on the ratio r_1/r_2.CA based on superparamagnetic particles significantly reduces the transverse relaxation rate due to the local field created by its large magnetic moment. Those structures consist of an iron oxide core coated with macromolecular materials.

Some theories have been formulated to describe physical phenomena associated with the proton relaxation by superparamagnetic particles. These theories are important not only for the understanding of these phenomena but also to relate the information contained in the NMRD profiles to the morphological and physical properties of the particles like: average radius, specific magnetization or Néel relaxation time. All these parameters are important for the design and fabrication of the CA, along with their ability to predict the behavior and the final target of certain types of particles prior to their manufacture. In this work we present the challenges on the characterization of superparamagnetic particles as CA in MRI.

One of the challenges is the lack of consistence between experimental data and the theoretical model. In our last work we found some discrepancies when evaluated some experimental data against a theoretical model (figures 1-3). Some of these inconsistencies were explained by a low field dispersion caused by the anisotropy of the crystal, or by the aggregation of the particles in solution. It has been shown that the more sensitive parameter in the theoretical model is the particle´s radius, so the aggregation can cause that a group of agglomerated particles can be seen as only one particle of bigger size. It is also observed that the experimental measurement of this parameter is very sparse (table 1); this may be due to the aggregation of the particles or lack of consistence in measurement, which also leads to another challenge in the characterization.

Our first measurements of relaxivities in new contrast agents have shown that the lack of an experimental protocol results in a lack of repeatability and consistency in the data, because the parameters involved in making the measurements are too many and depend largely on the equipment used, so that measurements can be not objective enough and depending on the laboratory that performed them. To ensure the reliability of the measurements a protocol is needed. It must specify in detail the equipment, the pulse sequence and the parameters of the sequence used.

Finally, it is necessary to develop or to modify an existing theoretical model in order to understand the relaxation mechanism in biological environments. The last challenge in the research of nanoparticles as CA is the determination of concentrations directly from the MRI data. This is important because for therapy and for diagnosis it is necessary to know if you have the needed amount of drug or of marker for a particular disease or condition.

References:

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[4] Muller RN, Roch A, Gillis P, et al. Relaxation by Metal-Containing Nanosystems. Advances in Inorganic Chemistry: Academic Press; 2005. p. 239-292.

Figures:

Dextran Coated SPIO AMI-25 ENDOREM®	
Reference	**Particle Diameter (nm)**
[3]	58
[4]	120-180 <d>p*
[6]	23(22%) 130(78%)
[7]	4.8-5.6 (core), 80-150 <d>p*
[8]	72 <d>p*
Theoretical Model [9]	**12.8**

Table 1. *Experimental values of the measurement of particle diameter of the compound ENDOREM. At the bottom, the value used for the NMRD profiles of the theoretical mode is shown. * <d> p: Hydrodynamic diameter derived from the technique of dynamic light scattering, which calculates the average of the particles in solution by monitoring the characteristics of diffusion.*

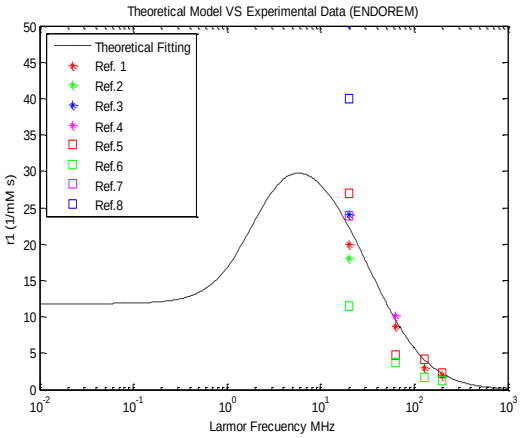

Figure 1. *T1 NMRD profiles for ENDOREM. The graphic shows the experimental data and the fit with de theoretical model for a diameter of 12.8nm*

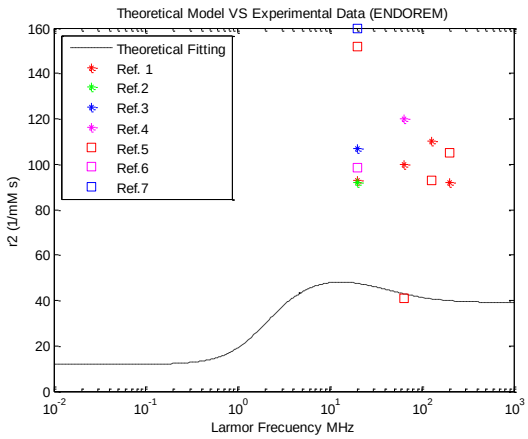

Figure 2. *T2 NMRD profiles for ENDOREM. The graphic shows the experimental data and the fit with de theoretical model for a diameter of 12.8nm*

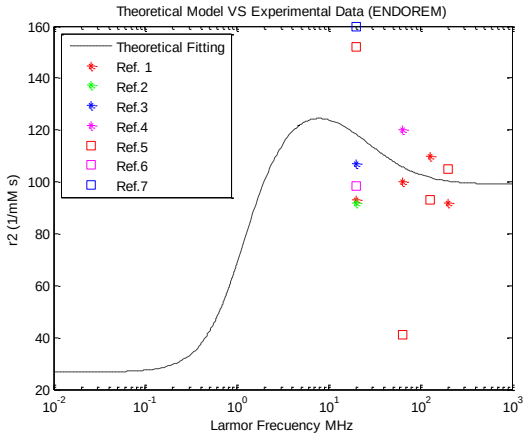

Figure 3. *T2 NMRD profiles for ENDOREM. The graphic shows the experimental data and the fit with the theoretical model when the diameter is modified from 12.8nm to 16nm.*