Magnetic particles functional characterization at the Bioinstrumentation Laboratory of the Centre for Biomedical Technology

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Nanoscience and nanotechnology are in the spotlight nowadays because researchers from these fields are now able to explain and control the phenomena observed at the nano and microscales. They are trying to create new medical applications like treatment and diagnosis using magnetic micro and nanoparticles by breaking down the frontiers between biology, chemistry and physics.

Researchers need to overcome several problems with these substances, such as toxicity issues or the understanding of the human body complexity, if magnetic micro and nanoparticles (MNs) are wanted to be used in medical applications. Besides, there’s a huge gap between in vivo and in vitro experimentation with MNPs that researchers are trying to remove. Following this idea, the Bioinstrumentation Laboratory is working on setting up a characterization platform of MNPs where researchers or fabricants send their samples and receive several data, such as the magnetic and mechanical response, relaxation time when are used as contrast agents in MRI, and movement behavior of the particles.

The magnetic and mechanical response is measured using the Alternating Gradient Field Magnetometer (AGFM) MicroMag Model 2900 AGM System®. Due to its high sensitivity, low noise floor and its capability to accommodate a large range of samples of very different properties, such as solid samples, ultra thin films, powders, liquids and even slurries, the AGFM can be used for characterizing the magnetic and mechanical properties of MNPs in biological samples. Some examples of actual research lines with the AGFM are the discrimination of the behavior of MNPs acquired by cells or situated on the extracellular matrix and the use of the AGFM as biosensor. The final goal is to use the AGFM combined with other techniques for the detection and identification of engineered MNs as contaminant in ex-vivo samples (see Figure 1) [1-4].

The SMARTTracer Relaxometer, in conjunction with a 2T Electromagnet, allows the acquisition of the T1 and T2 relaxation rates of water and biological solutions containing MNPs when are employed as Contrast Agents in MRI. The relation between relaxation rates and the morphological and physical properties of the particles can be obtained by adapting the information contained in the Nuclear Magnetic Relaxation Dispersion (NMRD) profiles (dependence of the relaxivity on magnetic field strength, Figure 2(a)) into a Theoretical Model. The main goal of this research line is to obtain the concentration of MNPs on the tissue directly from a MRI using the information of the NMRD profiles and the data from the Theoretical Model (see Figure 2 (a,b)) [5-7].

To achieve dynamic characterization, which means in this case movement of magnetic particles, it was made a set up that involves: magnets, auxiliary geometries for focalization, viscometer, analysis and simulation software as well as random laboratory material. With all these things together plus theoretical phenomena, it is possible the understanding of this kind of magnetic particles characteristics. The principal research lines are oriented to cellular filters fabrication, focusing of magnetic particles using magnetostatic fields, mathematical model optimization of magnetic phenomena, and human and animal models for in vitro experimentation (phantoms). The final goal is the use of these techniques to separate cells and its implementation for treatment and diagnosis (see Figure 3) [8-12].

References


Figure 1. Magnetic and mechanical response measured using an AGFM. The hysteresis loops can be seen, a) behavioral differences between solid and liquid samples with MNPs, and b) MNPs detection inside cells; a picture of the AGFM is shown on c).

Figure 2. MNPs Characterization as Contrast Agent in MRI: a) NMRD Profiles of a sample of MNPs. b) Differences between images with (left) and without (right) Contrast Agents. c) Fast Field Cycling Relaxometer.

Figure 3. Dynamic characterization of magnetic particles. On a) different equipment used for characterization, and on b) an image of magnetic particles dynamic characterization.
Contribution (Oral/Poster/Keynote) Magnetic particles functional characterization at the Bioinstrumentation Laboratory of the Centre for Biomedical Technology J.J. Serrano1,2, N. Félix1,2, V. Ferro1,2, R.A. García 1,2, A. Mina1,2, C. Sánchez1,2, P. Anaya1, L. Urbano1, A. Muñoz3, M. Manso3, D. Ruiz4, D. Losada4, F. Muñoz4, T. Fernández1,2,7, M. Ramos1,2,7, M. Maicas6, C. Aroca6, E. Alfayate5, J.A. Hernández-Tamames1,5, F. del Pozo1,2 1 Biomedical Engineering and Telemedicine Centre (GBT), Centre for Biomedical Technology (CTB), Technical University of Madrid (UPM), Campus de Montegancedo, Autopista M40, km 38, Pozuelo de Alarcón, 28223 Madrid, Spain. Request PDF | On Apr 11, 2011, Ana Lorena Urbano Bojorge and others published Magnetic Particles Characterization at the Bioinstrumentation Laboratory of the Centre for Biomedical Technology - Proceedings of the Nanospain 2011 Conference, Bilbao | Find, read and cite all the research you need on ResearchGate. Magnetic nanoparticles are a class of nanoparticle that can be manipulated using magnetic fields. Such particles commonly consist of two components, a magnetic material, often iron, nickel and cobalt, and a chemical component that has functionality. While nanoparticles are smaller than 1 micrometer in diameter (typically 1–100 nanometers), the larger microbeads are 0.5–500 micrometer in diameter. Magnetic nanoparticle clusters that are composed of a number of individual magnetic nanoparticles are... For articles published under an open access Creative Common CC BY license, any part of the article may be reused without permission provided that the original article is clearly cited. Feature Papers represent the most advanced research with significant potential for high impact in the field. Feature Papers are submitted upon individual invitation or recommendation by the scientific editors and undergo peer review prior to publication. Advances in the synthesis and characterization of magnetic particles, especially nanomagnetic particles, have also aided in the use of magnetic biomaterials [6â€“12]. The earliest known biomedical use of naturally occurring magnetic materials involves magnetite (Fe3O4) or lodestone which was used by the Indian surgeon Sucruta around 2,600 years ago. He wrote in the book Ayurveda that magnetite can be used to extract an iron arrow tip. Current areas in medicine to which magnetic biomaterials can be applied include molecular and cell biology, cardiology, neurosurgery, oncology and radiology. This eld attracts and retains the particles at the site of the disease (Fig. 17.5). The blood vessel will exhibit a paramagnetic response to the eld from entities such as the hemoglobin.