Carbon Nanotubes as Directional probes for Magnetic Resonance Imaging

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Magnetic Resonance Imaging (MRI) has become one of the most powerful tools in modern medical diagnosis because of its non-invasive character, high inherent spatial resolution and the possibility to enhance locally and specifically image intensity using appropriate paramagnetic or superparamagnetic contrast agents (CAs). Most of the MRI CAs currently available are chelates of paramagnetic metals of the rare earth series or superparamagnetic iron oxide nanoparticles, the Gd(III) chelates being the most widely used [1]. In all these cases, the induced relaxation of the water molecules surrounding the probe is isotropic precluding the encoding of directionality in many fundamental biological processes already detectable by molecular imaging [2, 3]. On these grounds, it would entail considerable relevance to develop CAs in which the predominant molecular orientation of the probe with respect to the external magnetic field can be inferred from the non-invasive MRI measurement.

In this lecture we shall describe the use of Single-Wall and Multi-Wall Carbon Nanotubes as directional probes for MRI. SWCNT suspensions are excellent candidates for this purpose, since they orient parallel to the external magnetic field B_o and are able to induce anisotropic relaxivity [4] and anisotropic diffusion [5] of water molecules in a way in which the orientation of the nanotube can be predicted from the MRI measurement. We shall discuss the production, shortening and characterization of these arrangements using Atomic Force Microscopy, Transmission Electron Microscopy (+Energy Dispersive Spectroscopy), SQUID, VSM and MRI. Our measurements provide for the first time to our knowledge a sound basis for the magnetic properties of these preparations and allow their decoration with customized reporter molecules for improved imaging or therapeutic performance.

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