Switching of MRI Contrast Agents with Ultrasound

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Purpose

The utility of (super)paramagnetic agents to enhance contrast in MRI has been for some time demonstrated in human studies. The contrast provided by these agents arises from their ability to achieve reductions in T_1 and T_2^*. Another approach to designing contrast agents is to consider the use of ultrasound (US). We have developed a method involving the application of US in MRI in the presence of antibody coated magnetic nanoparticles to generate contrast. It is intersting to control their effect on MRI by additional parameters, which can be switched on and off externally, and depend on the properties of the surrounding tissue. Also, it suggests the use of low concentrations of the magnetic nanoparticles.

Method

While performing proton nuclear magnetic resonance (^{1}HNMR) spectroscopy, US is applied to an aqueous sample containing specially prepared magnetic nanoparticles. If the magnetic nanoparticles are coated with antibody from one side only as shown in Fig.1, then the center of mass is different from the center of geometry. When the asymmetric magnetic nanoparticles in the sample are subjected to an ultrasound wave, a torque is initiated along the vibrational motion and will cause the particle to tilt periodically. The asymmetric magnetic nanoparticles will act as an US driven radio frequency antenna, emitting photons of US frequency. This leads to an increase in the spectral density function at the US frequency. If the US frequency matches the Larmor frequency, protons in the near field region of the particle are stimulated to lose energy, and the T_1 of the aqueous solution decreases.

Results

Influence of resonant US on ^{1}HNMR using the asymmetric magnetic nanoparticles is examined. The relaxation rate is determined by an inversion recovery sequence where an US pulse is applied between 180° pulse and 90° pulse. Measurements are obtained for two different sizes of magnetic particles as shown in Fig.2. A significant increase of the relaxation rate is observed when using smaller sized particles.

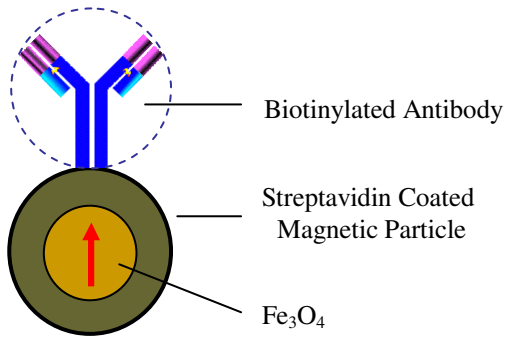

FIG.1. Attachment of antibody to the magnetic particle.

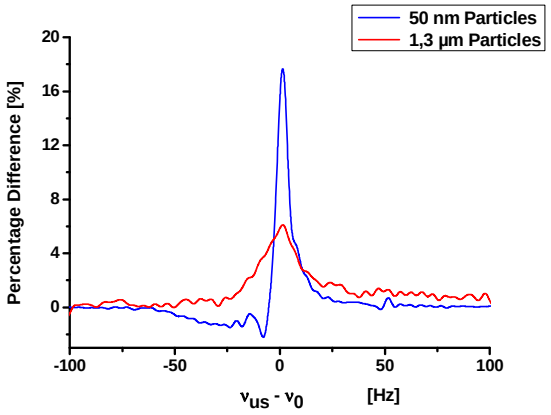

FIG.2. Comparison of the percentage difference in signal amplitude using two different sized particles.