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Magnetic Characterization to Asses the Efficiency of In-vivo Settlement of Magnetic Nanoparticles in Rat Livers

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Magnetic nanoparticles (MNP) are used in a broad range of disciplines that include magnetic actuators, data storage, resonance imaging, as well as a range of applications in biomedicine. This study employs magnetic methods to assess the efficiency of delivering MNP into an isolated rat liver. MNP were injected into the portal vein in vivo, where they should be taken up from the blood by liver sinusoidal voids before procurement. Carbon-encapsulated, spherical cementite (Fe3C) MNP were synthesized via flame spray pyrolysis, and have an average diameter of 30 nm. The acquisition of isothermal remanent magnetization (IRM) was used to estimate the concentration of particles in the livers. Ten samples of pure cementite of varying concentration were prepared. Six were measured at 77 K and four at room temperature. These samples show a linear relationship between the saturation IRM and particle concentration. Three untreated liver samples, five blood samples and four empty holders were analyzed to establish the base magnetic signal. Subsequently IRM acquisition was measured on 18 liver samples that were treated with MNP. The IRM in fresh tissue was measured at 77 K to prevent chemical alteration within the tissue; the sample was subsequently freeze-dried and remeasured at 77 K and room temperature. No alteration of the remanent magnetic properties occurred during freeze-drying. Calculations of the MNP content in the tissue show that all MNP injected into the system settle directly inside the liver, distributing themselves very heterogeneously. The fact that all MNP remain in the liver indicates that once the particle-containing blood flows through the liver, the MNP settle into the tissue, so that the time in which the particles remain in the blood circulation is limited. The heterogeneous distribution of the MNP makes it difficult to calculate the total MNP content that settles in the liver. However, modification of the system by positioning a magnet near a specific part of the liver shows that the MNP distribution can be affected by the externally applied magnetic field. Improving this method could allow the MNP to be steered to a specific region within the liver. This study demonstrates the usefulness of magnetic methods in assessing the delivery of magnetic nanoparticles compared with elemental analysis techniques, which require chemical digestion and sample dilution due to matrix effects.