Characterization of superparamagnetic iron oxide nanoparticles in biological environments

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We present a novel characterization technique for superparamagnetic iron oxide nanoparticles (SPIONs): the Superparamagnetic Quantifier (SPaQ). It was created to measure SPIONs in biological environments, such as blood, lymph nodes and tissue. The SPaQ can be used to improve sentinel node biopsies (SNB). The latter is a procedure to analyze if cancer cells have spread to lymph nodes, leading to personalized patient care. During SNB a tracer material is injected at multiple sites close to the tumor. Via mechanical transport the tracer will accumulate in the first nodes it encounters, namely the sentinel nodes. The sentinel node can then be found using a dedicated probe, and examined for metastases following surgical removal.

When SPIONs are used as a tracer in SNB, it is important to characterize them first. Therefore, we know what we are looking for in the human body. To characterize SPIONs, the magnetization curve is measured, which shows the response of the particles to an externally applied field. In the SPaQ this magnetization curve is measured by application of a constant AC magnetic field that has a low amplitude and a gradually increasing DC offset. The maximum field strength is 15 mT and the AC frequency can be chosen between 1 and 10 kHz. This leads to a scan through different external field strengths, which yields the derivative of the magnetization curve. The resulting curve is shown in Figure (a) for two types of SPIONs. Numerical integration yields the magnetization curve, which is shown in Figure (b).

The sample influences the susceptibility and saturation field strength, which is reflected in the magnetization curve. This allows us to quickly assess newly fabricated particles on their feasibility as a tracer material. In various biomedical applications, a measurement method like the SPaQ's allow for monitoring changes in physiological conditions of the system in a real time fashion. For example, a changing hydrodynamic particle diameter caused by protein corona formation in blood or binding of drugs in controlled drug delivery.

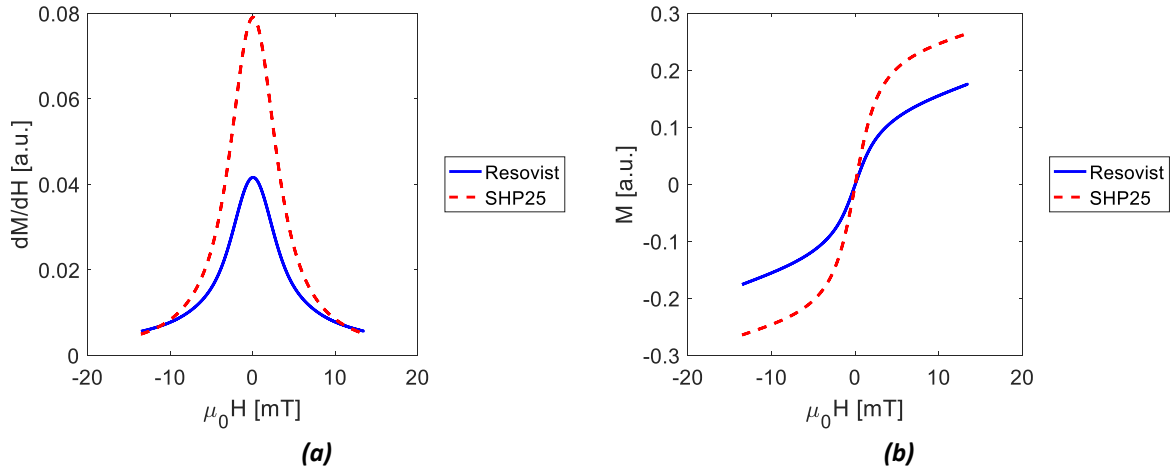

Figure – SPaQ results, measured on Resovist (Bayer Schering Pharma GmbH) and SHP-25 (Ocean Nanotech) samples containing 750 µg iron in a total volume of 150 µl, at a frequency of 2.5 kHz. ***(b)*** *is a numerical integration of* ***(a)****.*