On The Experimental Method for Specific Absorption Rate Measurement of RF Heated Magnetic Nanoparticles

by

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ABSTRACT

Experimental determination of heat generation of magnetic nanoparticles in alternative magnetic field is critical for optimization of these materials for cancer hyperthermia and other applications employing remote heating. Accurate measurement of nanoparticles' specific absorption rate (SAR) is a key step in enabling comparison with theoretical models, which is required to assess the effect on the heat generation rate of various factors including nanoparticle coating and functionalization, nanoparticle clustering and nanoparticle immobilization.

Current SAR measurement setups usually comprise of a homemade coil directly wound around the container that holds the magnetic nanoparticle solution. The temperature of the sample is recorded as function of time once the magnetic field is turned on. SAR is then determined from the initial slope of the temperature, which is typically obtained by dividing the temperature rise by time interval or fitting the temperature curve with a polynomial and taking its derivative at time=0. However this approach may have several shortcomings which are overlooked in current literature. The first one is related to the coil/sample volume aspect ratio. If the coil size is comparable to the sample volume the magnetic field across the sample is non-uniform, producing non-uniform heat generation rates, which may affect the temperature measurement. Secondly, heat losses may become important when the sample size is small and volumetric heat generation rate is comparable with surface heat losses to the adjacent media. In addition, the container heat capacity may also have a significant effect on the initial slope of the temperature if the thermal size of the sample is much smaller than that of the container. Furthermore, due to heat losses through the container walls and ferrofluid surfaces the temperature distribution across the sample is not uniform during the induced heating. Therefore the sensor probe position is another aspect that is related to the erroneous results. Finally, to obtain an accurate SAR measurement fitting temperature with appropriate curvature is required. In general, the initial slope acquired by higher order polynomial fitting is more accurate than other methods. To illustrate these effects, theoretical and experimental investigation is carried out.