Study of calorimetric effect in ferrogels subjected to the high-frequency rotating magnetic field

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This study investigates the calorimetric effect observed in ferrogels containing magnetic nanoparticles (MNPs) when subjected to a high-frequency rotating magnetic field (RMF). The primary heat generation mechanisms are magnetic relaxation (Néel and Brown) and magnetic hysteresis. These findings have potential applications in magnetic hyperthermia (MH) as adjuvant therapy in conjunction with chemotherapy and radiation therapy for cancer treatment.

In vitro experiments were performed at a frequency of 200 kHz, with magnetic field amplitudes up to 7.5 kA/m, using tissue-mimicking agar ferrogels with varying weight concentrations of MNPs (5-30%). The experimental setup employs a two-phase magnetic system enclosed by an external magnetic core, as shown in [1-3]. Two pairs of magnetizing coils and parallel-connected capacitors generate spatially and phase-shifted magnetic fluxes by 90 degrees, resulting in a RMF with constant amplitude during rotation. Although the design can achieve magnetic field amplitudes of up to 20 kA/m, such intensities are unsuitable for MH applications due to potential harm to the human body.

The study involved monitoring temperature over time for various magnetic field amplitudes and ferrogel samples, with the released power being proportional to the rate of temperature change ($\mathrm{d}T/\mathrm{d}t$). This approach enabled the determination of the contributions of both heat release mechanisms as a function of MNP concentration and magnetic field strength. The heating efficiency of RMF was approximately twice as effective as an alternating magnetic field (AMF) of the same intensity. As there is no existing data on the effects of RMF on ferrogels, the research provides novel results for the potential optimization of MH treatments using RMF rather than AMF.

References:

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