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Selecting Nanoparticles for Magnetic Fluid Hyperthermia Studies

Nanotherics is pleased to announce the launch of HyperMag™ - a superb colloidal suspension for the study of magnetic nanoparticle heating effects.

hyperMag™ provides excellent localised heating at various concentrations, with a high SAR value at low field strength - ***unlike other commercially available*** magnetic fluid hyperthermia particles.

Nanoparticle Requirements for Magnetic Fluid Hyperthermia

In studies of surface functionalized superparamagnetic nanoparticles in the past decade, the effect of particle size has been explored, as this parameter may aid with increasing SAR/SPA values, and tuning the particles for biomedical applications.

Currently, magnetic nanoparticles are extensively used as contrast agents in Magnetic Resonance Imaging (MRI) and as localized heating sources in clinical Magnetic Fluid Hyperthermia (MFH) applications.

In MFH, magnetic nanoparticles are introduced into the tumour, and localised heating is achieved through exposure to an alternating magnetic field. This aims to reduce the tumour size, or to intervene with growth/proliferation of the tumour tissue.

These magnetic nanoparticles are usually evaluated on their ability to produce heat, which is often represented as a measure of their specific absorption rate and specific power absorption.

It is widely believed that higher SAR/SPA values mean that the magnetic nanoparticles are better suited to MFH applications. However, this is not the case in reality – particularly if very large magnetic fields may be required to deliver high SAR/SLP values.

There is a requirement for commercial magnetic nanoparticles with high SAR/ SPA values at a tolerable field/frequency combination that are biocompatible, bio degradable, with a low poly dispersive index, high colloidal stability and capable of binding with various molecules.

Properties of hyperMag™ Nanoparticles

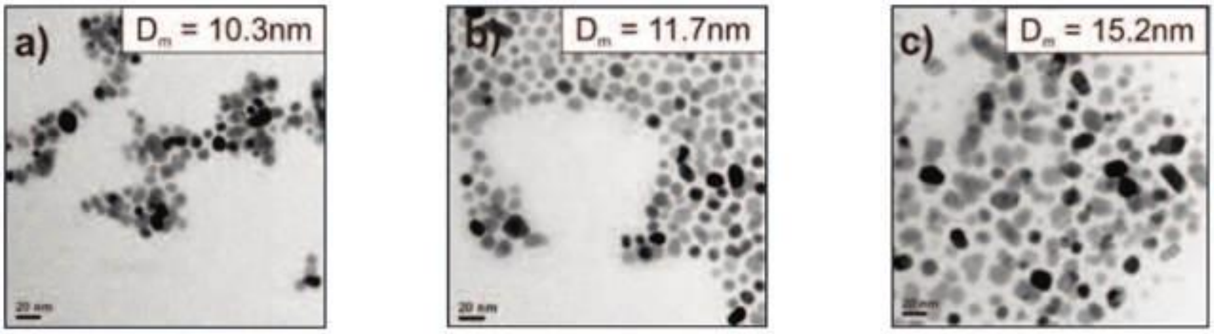

Figure 1. *Transmission electron microscope (TEM) images of the hyperMag™ A, B and C magnetic nanoparticles.*

Table 1. *Characterization of hyperMag™ particles.*

Product	Core size (nm)	Hydrodynamic diameter (nm)	Zeta potential (mV)	Iron concentration (mg/ml)	Dispersion medium
hyperMag™ A	10.3	100	-40	10	dH2O
hyperMag™ B	11.7	100	-40	10	dH2O
hyperMag™ C	15.2	100	-40	10	dH2O

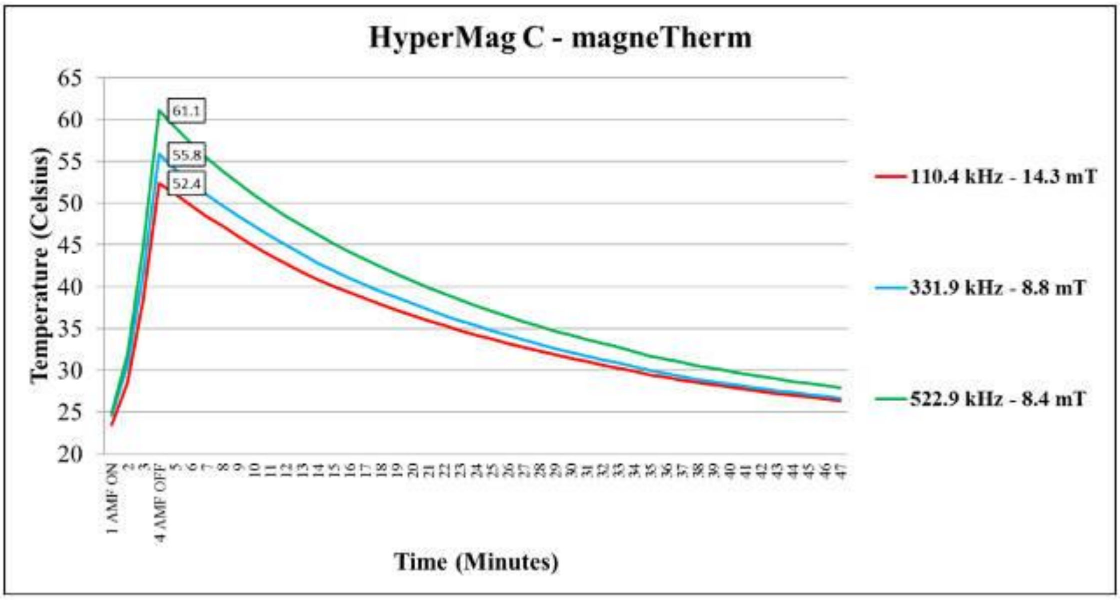

Figure 2. *Up to 36˚C change of temperature in 3 minutes by hyperMag™ when exposed to AMF in the magneTherm system*

Note: The field strengths required to achieve the very high ΔT are relatively small and the frequencies relatively low, (between 50 and 500 kHz). Too many SAR/SLP values are quoted at very large field strengths (or field and frequency combinations) for magnetic nanoparticles intended for magnetic fluidic hyperthermia applications – unless the H x f product is kept within acceptable limits then the particles would never be suitable for the proposed final application. ***This requirement should always be kept in mind when evaluating and testing particles for use in this area.***

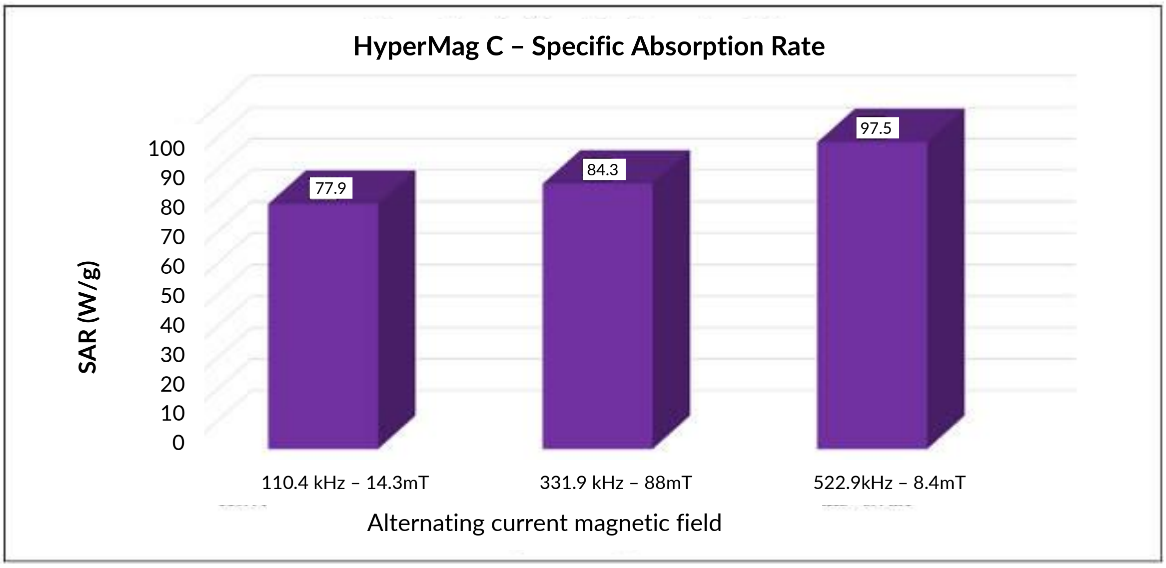

Figure 3. *Up to 97.5 W/g Specific Absorption Rate of hyperMag™ C - 522.9 kHz at 8.4 mT (6.7 kA/m; 84 Gauss) which is far better than most other commercially available particles.*

The important parameters involved here are the frequencies and the field strengths utilised to heat the magnetic nanoparticles. A limit for the product of H x f was discussed in the 80's based on patient discomfort:

$H \times f = 4.85 \times 10^{8}\ Am^{-1}s^{-1}$

(Atkinson WJ et al., 1984; Brezovich IA et al., 1984).

More recently, in the past decade another limit was proposed:

$H \times f = 5.10 \times 10^{9}\ Am^{-1}s^{-1}$

(Hergt, R. and Dutz, S. 2007)

These limits are widely taken into consideration for *in vitro*, *in vivo* and clinical studies. The magnetic nanoparticles which are specifically designed for such purposes should be able to provide localized heating within the tissue within these limits to restrict any off target effects.

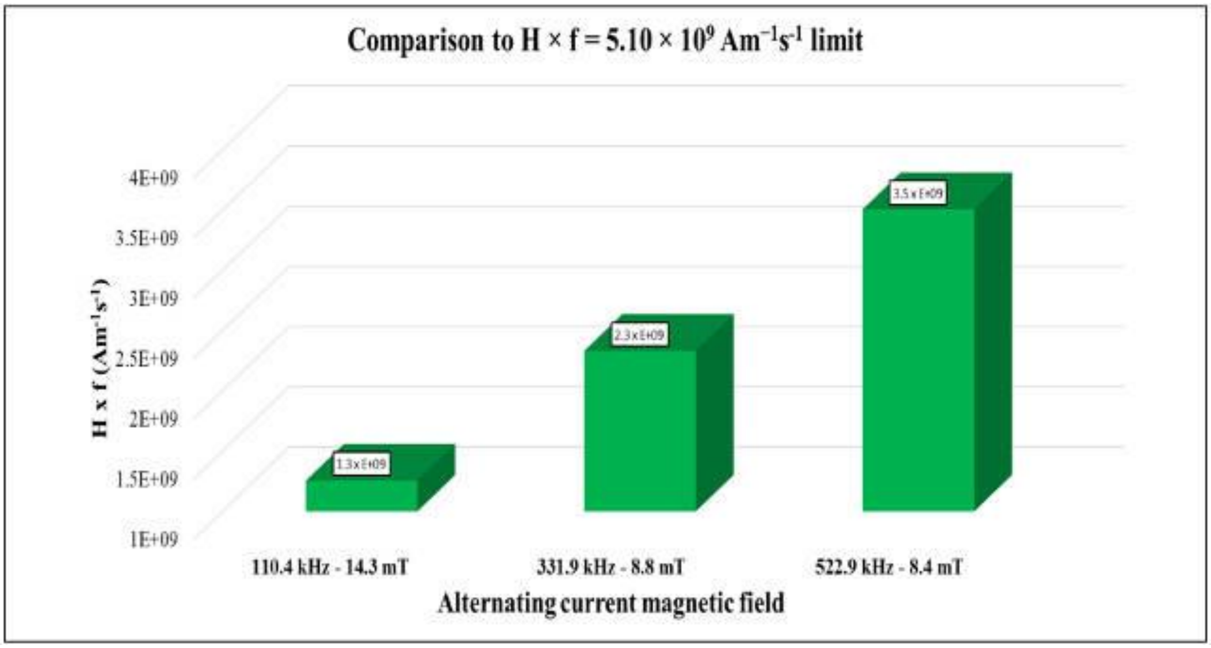

Figure 4. *The applied alternating magnetic field settings used for heating the magnetic nanoparticles shows that they are well within the range of the accepted limit i.e.* $H \times f = 5.10 \times 10^9\ Am^{-1}s^{-1}$

As observed from the results, HyperMag™ provides a very high SAR value even at low H × f values, well within the accepted MFH limits, thus ensuring its suitability for those applications.

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For more information or to request a quotation please visit www.nanotherics.com.