First studies with a new wide frequency range device for the induction of hyperthermia in magnetic fluids, for magnetic fluids experimentation in biomedical applications

A.Mina Rosales[1,2,3], *J.J. Serrano Olmedo,*[1,2,3] , *C. Maestú Unturbe*[1,2,3], *R. García Mendoza*[1,2,3], *F. del Pozo Guerrero*[1,2,3].

[1] *Bioengineering and Telemedicine Group (GBT), Biomedical Technology Center (CTB), Polytechnic University of Madrid (UPM), Avenida Complutense 30, "Ciudad Universitaria". 28040 – Madrid, Spain.*

[2] *Bioengineering, Biomaterials and Nanomedicine Network for Biomedical Research, Madrid, Spain.*

[3] *Biosciences Program MADR.IB-CM Comunidad de Madrid*

amina@gbt.tfo.upm.es, jjserran@etsit.upm.es

Hyperthermia (Greek word for "overheating") is defined as the phenomenon that occurs when a body is exposed to an energy generating source that can produce a temperature change inside, 42-45^{0}C range [1-2] along a given time. The excitation should be retained for a minimum period of 30 minutes, to produce cell dead by thermal destruction in the treatment area. Generation of magnetic hyperthermia is performed through changes of the magnetic induction in magnetic nanoparticles (MNPs) that are embedded in viscous medium. The MNPs have the capacity to absorb energy from an alternating magnetic field to generate heat. The main applications of this technique are identified in cancer therapy and delivery of drugs into specific sites.

In this work we present a new device for hyperthermia induction in magnetic fluids. The device was completely designed and built by our research-group and presents advantages as compared to commercial devices. One of them, and the most important one, is the ability to achieve a wide range of working frequencies from 9 KHz to 2MHz, whilst the commercial equipment generally can handle only one frequency or very short frequency range. Another advantage is the possibility to use different signals like sinusoidal, square, pulse sequences configurations, etc.; our purpose is to study the phenomena of the heat generation by changing the excitation signal. This could be the way to optimize the magnetic hyperthermia induction parameters.

The hyperthermia device basically consists of a signal generator, an amplifier, a cooper coil, a cooling system, an optical temperature sensor, control software, multimeter and the probe (Figure 1). The amplifier has a wideband frequency range (9KHz-2MHz) and a linear output up to 1000W. The selected signal passes through the amplifier and feeds the cooper coil, where is produced the magnetic field. The cooling system serves to keep controlled and fixed the environmental temperature, so isolating the sample from the thermal external influence. In order to know the temperature inside the sample it is used an optical temperature sensor with a range of 0 to 120^{0}C and 0.02^{0}C resolution. We have control software to avoid undesired changes in the magnetic field due to spurious fluctuations in the delivered power. The probe is an adiabatic chamber made of borosilicate. As well as we had made this device, we are making a theoretical approximation on the thermal system response to be able to obtain the specific absorption rate (SAR) and the other interesting parameters.

To show the functionality of our device, we present results about the behavior of some MNPs [3]. The methodology consists in the application of a magnetic field 2.8 kA/m intensity and 1.8MHz frequency for 45 minutes. We continue to record the temperature for 15 minutes without excitation to observe the heat dissipation. The description of the samples used for the study is in Table 1. The time-dependent temperature curves are shown in figure 2. The highest observed temperature change correspond to the smallest diameter (15 nm) MNPs, as expected.

Sample	**Coating**	**Diameter MNPs (nm)**	**Amount of simple (μliters)**	**Concentration**
Magnetita	Dextran	20	200	10mg/ml
Magnetita	Dextran	50	200	10mg/ml
Endorem	Varios	15	200	-

Table1. Description of the samples used for the study.

References:

[1] Pankhurst QA, Conolly J, Jones S K, Dobson J. Applications of magnetic nanoparticles in biomedicine. *Journal of physics. D, applied physics 36(13)*, (2003), pp. R167.

[2] Lee SW, Bae S, Takemura Y, Yamashita E, Kunisaki J, Zurn S, Kim CS, Magnetic Properties, Self-Temperature Rising Characteristics, and Biocompatibility of $NiFe_2O_4$ Nanoparticles for Hyperthermia Applications, *Magnetics, IEEE Transactions on*, vol. 42, (2006) pp. 2833-2835.

[3] Mina Rosales A., Ma. A. Peramo Serrano, J.J. Serrano Olmedo, F. del Pozo Guerrero, Generación de hipertermia mediante campos magnéticos alternos, aplicada en muestras con nanopartículas magnéticas: fenómenos físicos y primeros resultados, Congreso Anual de la Sociedad Española de Ingeniería Biomédica, (2010), pp 166.

Figures:

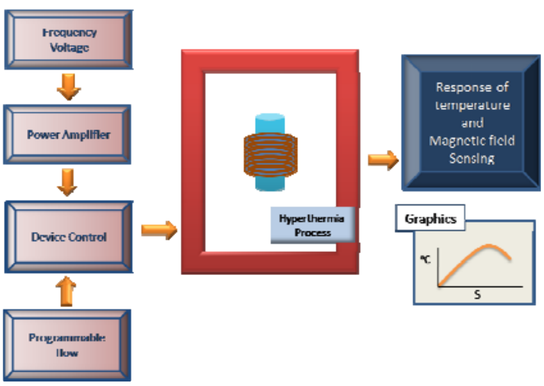

Figure1. Scheme of hyperthermia device

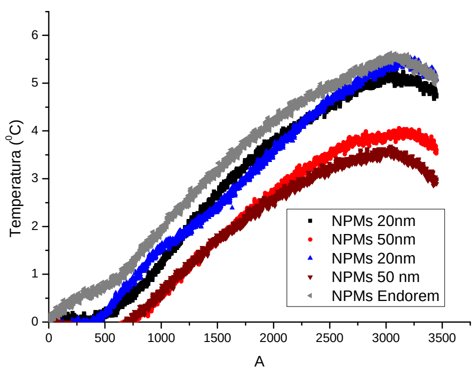

Figure2. Time-dependent temperature curves of the samples in 1.8 MHz and 2.6 kA/m.