Selected scientific results
2016

O7. Hyperthermia tests with various Fe@FePt$_{L10}$@Pt nanoparticles, having different FePt$_{L10}$ intermediate shells, dispersed in water based solutions and gels;-continue

A7.1 Evaluation of hyperthermia tests for different Fe@FePt$_{L10}$@Pt nanoparticles systems in different solutions and gels;-continue

The characterization of the magneto-caloric properties of the synthesized nanoparticles was done by using an EasyHeat 0224 power supply (Ambrell, Scottsville, NY, USA), operating at frequencies between about 100-400 kHz and able to generate magnetic fields with strengths of up to 65 kA/m. The system is equipped with several coils made of copper tubes that circulate water for cooling. We used a 8 turns coil with an internal diameter of 2.5 mm and a total length of 40 mm (figure 1). The inductance of the coil was calculated from both its geometry and the resonance frequency of the circuit in which it was introduced and was determined as 10^{-6} H. The effective frequency and voltage values on the coil were monitored with a digital oscilloscope PeakTech 1170 operating up to 250 MHz.

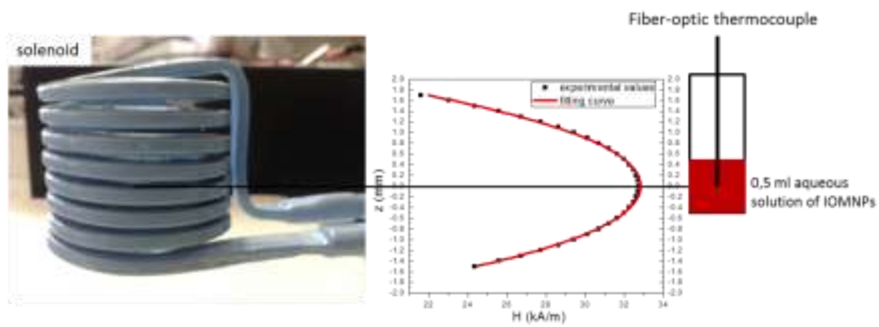


Fig. 1 Left-the solenoid used for hyperthermia measurements; Middle - experimental and theoretical values of the magnetic field strength along the z axis of the solenoid; Right – a sketch of the sample probe.

The magnetic parameters of the samples used in the hyperthermia tests are summarized in Tabelul 1.

Tabelul 1. Magnetic parameters of the samples.

Sample name	M_S (emu/g)	H_C (Oe)
Fe-FePt#1	92.1	107
Fe-FePt#2	37.5	650
Fe-FePt#3	77.3	8500
Fe-FePt#4	166	91

In the first stage the nanoparticles were dispersed in distilled water with a 30 mg/0.5 ml concentration. Sample Fe-FePt#1 and Fe-FePt#2 were used for this experiment.

Figure 2 shows the magnetic hysteresis corresponding to sample Fe-FePt#1. The saturation magnetization is 92 emu/g and the coercive field is 107 Oe. The hyperthermia test for various field amplitude ranging from 251.3 to 754 Oe are presented in figure3. As expected the temperature increase slope is directly proportional to the field amplitude. Also a linear temperature dependence is observed for higher field amplitudes.

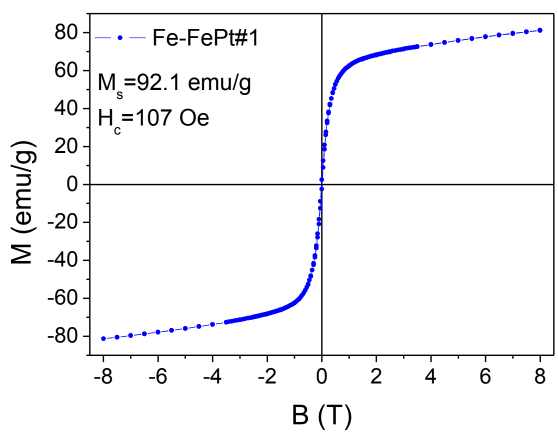


Fig. 2 Magnetization as a function of applied field for Fe-FePt#1 sample.

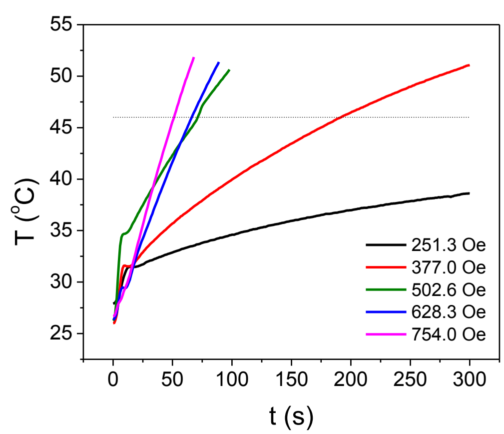


Fig. 3 Temperature vs. time for various AC fields corresponding to Fe-FePt#1 sample, dispersed in water.

In case of Fe-FePt#2 sample the magnetic hysteresis is presented in figure 4a. The saturation magnetization is 37.5 emu/g and the coercive field is 650 Oe. The minor hysteresis loop is presented in figure 4b. It is known that the area of the minor loop is proportional to the heat generated. The calculated area value is found 13.4 mJ/g. The hyperthermia tests results are presented in figure 5. One can see that only for high AC field values over 500 Oe the necessary 46^{o}C temperature for effective hyperthermia, is achieved.

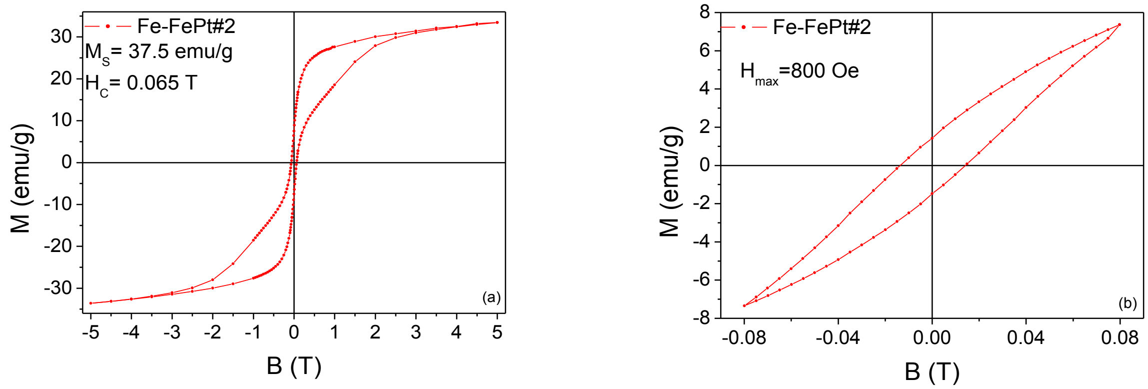


Fig. 4 Magnetization as a function of applied field for Fe-FePt#2 sample (a) high fields loop and (b) minor loop.

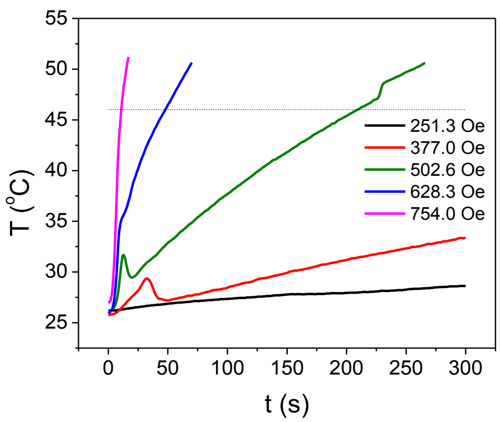


Fig. 5 Temperature vs. time for various AC fields corresponding to Fe-FePt#2 sample, dispersed in water.

In order to obtain a better dispersion the nanoparticles were dispersed in media with higher viscosity than water. In this way the heat generating mechanism is only by hysteresis loss. 4mg/ml concentration solutions of gel, SLS and oleic acid were used.

Figure 6 shows the magnetic hysteresis corresponding to sample Fe-FePt#3. The saturation magnetization is 77.3.5 emu/g and the coercive field is 8550 Oe. In this case the AC field amplitude is much smaller that the coercive field, hence the hyperthermia tests (figure 7) showed a small temperature increase.

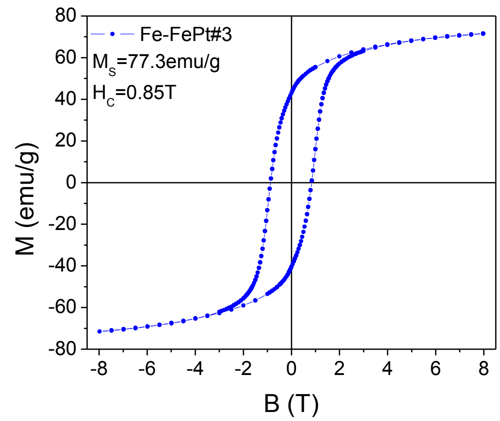


Fig. 6 Magnetization as a function of applied field for Fe-FePt#3 sample.

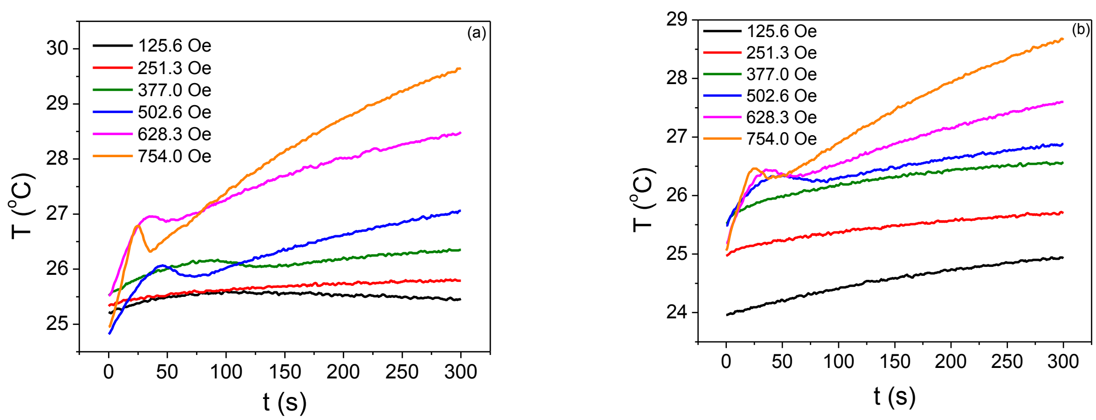


Fig. 7 Temperature vs. time for various AC fields corresponding to Fe-FePt#3 sample, dispersed in a) gel and (b) oleic acid.

In case of Fe-FePt#4 sample the magnetic hysteresis is presented in figure 8a. The saturation magnetization is 166 emu/g and the coercive field is 91 Oe. The minor hysteresis loop is presented in figure 8b. The calculated area value is found 20.4 mJ/g for H_{max}=300 Oe and 246.5 mJ/g for H_{max}=800 Oe. The hyperthermia tests (figure 9) show that the best temperature increase for small AC fields is obtained for the sample dispersed in oleic acid, followed by SLS and gel. The temperature slopes are presented in table 2. Regarding the best temperature control the best dispersion medium is the SLS followed by gel and oleic acid. The SAR values were calculated taking into account the specific heat of platinum. The SAR values are summarized in table 3.

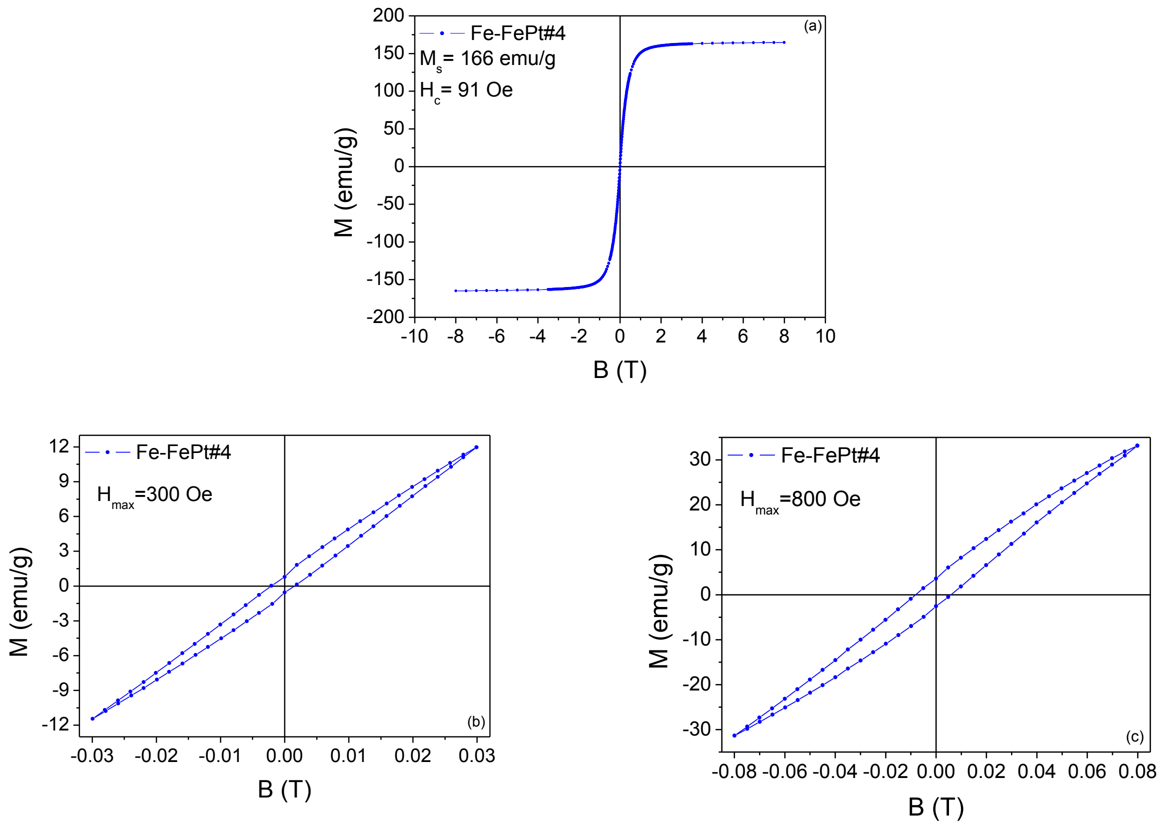
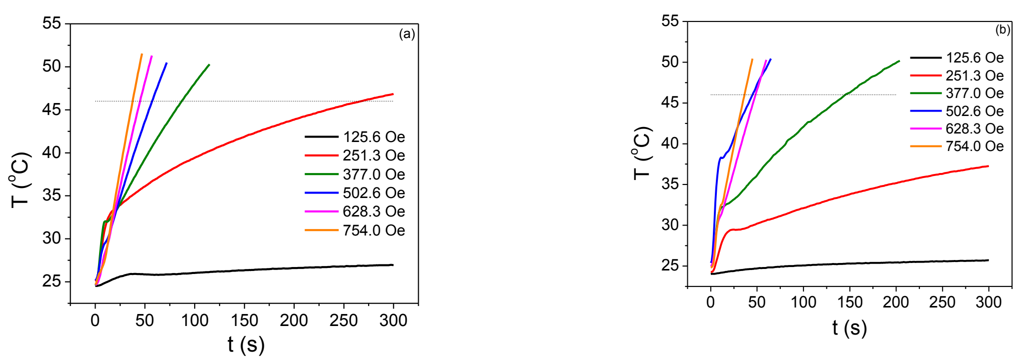


Fig. 8 Magnetization as a function of applied field for Fe-FePt#4 sample (a) high fields loop and (b-c) minor loop.



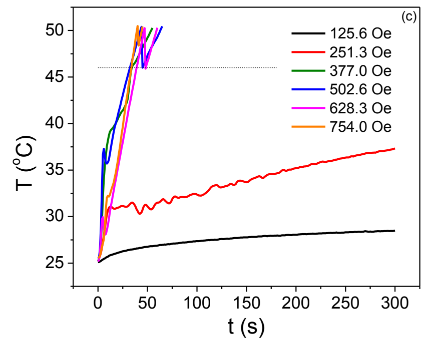


Fig. 9 Temperature vs. time for various AC fields corresponding to Fe-FePt#4 sample, dispersed in (a) SLS, (b) gel and (c) acid oleic.

Tabelul 2. Temperature slope for Fe-FePt#4 sample dispersed in SLS, gel and oleic acid.

ΔT/Δt [K/s]						
sample	H_{AC}= 125.6 Oe	H_{AC}= 251.3 Oe	H_{AC}= 377 Oe	H_{AC}= 502.6 Oe	H_{AC}= 628.3 Oe	H_{AC}= 754 Oe
Fe-FePt#4 - SLS	0.006	0.079	0.184	0.345	0.497	0.645
Fe-FePt#4 - gel	0.009	0.037	0.111	0.249	0.395	0.551
Fe-FePt#4 - oleic acid	0.012	0.022	0.186	0.412	0.573	0.719

Tabelul 3. SAR [W/g] corresponding to Fe-FePt#4 sample.

SAR [W/g]						
sample	H_{AC}= 125.6 Oe	H_{AC}= 251.3 Oe	H_{AC}= 377 Oe	H_{AC}= 502.6 Oe	H_{AC}= 628.3 Oe	H_{AC}= 754 Oe
Fe-FePt#4 - SLS	0.2002	2.6372	6.1424	11.5171	16.5913	21.5320
Fe-FePt#4 - gelatina	0.3004	1.2351	3.7055	8.3123	13.1862	18.3940
Fe-FePt#4 - acid oleic	0.4005	0.7344	6.2092	13.7537	19.1284	24.0023

Conclusions

The water dispersed nanoparticles showed best hyperthermia results for small coercive field values.

Hard magnetic nanocomposites are not suitable for hyperthermia.

The best temperature slope for small AC fields is obtained by using a dispersion medium of oleic acid, followed by SLS and gel.

The best temperature increase control is obtained in case of SLS dispersion medium.

O8. Functionalization of Fe@FePtL10@Pt, $FePt_{L10}$@PPy (P3HT) and $FePt_{L10}$@SiO_2 (TiO_2) nanoparticles in view of magnetically molecular separation and uptake tests from water based solutions.-continue

Fe@$FePt_{aTT}$@P3HT (FFP/P3HT) and Fe@$FePt_{aTT}$@SiO_2@NH_2 (FFP/SiO_2/NH_2) nanocomposites were obtained for magnetically molecular separation and uptake tests from water based solutions. The tests were done for aminoacid uptake from water based solutions and magnetically molecular separation.