Magnetic Hyperthermia with Fe@SiO_2 Nanoparticles. Synthesis and Efficiency.

Arnaud Glaria, Wilfried Solo Ojo, Nicolas Hallali, Julian Carrey, Bruno Chaudret, Sébastien Lachaize, Fabien Delpech, Céline Nayral.

Laboratoire de Physique et Chimie des Nano-Objets (LPCNO) - UMR INSA/UPS/CNRS 5215
35 avenue de Rangueil, 31077 Toulouse CEDEX 04, France
glaria@insa-toulouse.fr, cnayral@insa-toulouse.fr, fdelpech@insa-toulouse.fr,
slachaiz@insa-toulouse.fr

Abstract

Magnetic hyperthermia is a powerful technique enabling an efficient NPs-mediated treatment of malignant cells either *in vitro* or *in vivo*. [1] Major breakthroughs have been reported over the past years but they mainly focused on iron oxide compounds. These materials possess many advantages and can be easily synthesized in aqueous or organic solvents with magnetic properties modulated depending on their size and shape. [2] However, even if these materials show great promises, using pure iron NPs would permit to obtain values of the Specific Absorption Rate (SAR) more than two times larger than the ones obtained with its classical oxide counterparts. [3] The use of these NPs in biological media needs water transfer where one great challenge is to avoid the oxidation of the metal and thus the loss of the magnetic properties. By using a chemical approach, where a non alcoholic media ensures the integrity of the iron NPs during the process, we are able to precisely control the growth of a silica shell as well as the number of iron NPs encapsulated (Figure 1a). [4] This new material already exhibits relatively high values of the SAR in between the ones reported for iron oxide and pure iron NPs respectively (Figure 1b). Moreover, we have developed a simple functionalization method that allows their rapid dispersion in PBS buffer. Finally, we will present how our global synthetic approach will be of great importance for future hyperthermia measurements performed *in vitro*.

References

[1] (a) E.-K. Lim, T. Kim, S. Paik, S. Haam, Y.-M. Huh, K. Lee, Chem. Rev., **115** (2015) 327 ; (b) L. H. Reddy, J. L. Arias, J. Nicolas, P. Couvreur, Chem. Rev., **112** (2012) 5818; (c) D. Yoo, J.-H. Lee, T.-H. Shin, J. Cheon, Acc. Chem. Res., **44** (2011) 863.
[2] (a) A. Walter, C. Billotey, A. Garofalo, C. Ulhaq-Bouillet, C. Lefèvre, J. Taleb, S. Laurent, L. Vander Elst, R. N. Muller, L. Lartigue, F. Gazeau, D. Felder-Flesch, S. Begin-Colin., Chem. Mater. **26** (2014) 5252 ; (b) C. Martinez-Boubeta, K. Simeonidis, A. Makridis, M. Angelakeris, O. Iglesias, P. Guardia, A. Cabot, L. Yedra, S. Estradé, F. Peiró, Z. Saghi, P. A. Midgley, I. Conde-Leborán, D. Serantes D. Baldomir, Scientific Reports **3** (2013) 1652
[3] B. Mehdaoui, A. Meffre, J. Carrey, S. Lachaize, L.-M. Lacroix, M. Gougeon, B. Chaudret, M. Respaud, Adv. Funct. Mater., **21** (2011), 4573.
[4] (a) N. El-Hawi, C. Nayral, F. Delpech, Y. Coppel, A. Cornejo, A. Castel, B. Chaudret, Langmuir, **25** (2009) 7540; (b) F. Delpech, C. Nayral, N. El-Hawi, patent WO 2009071794.

Figures

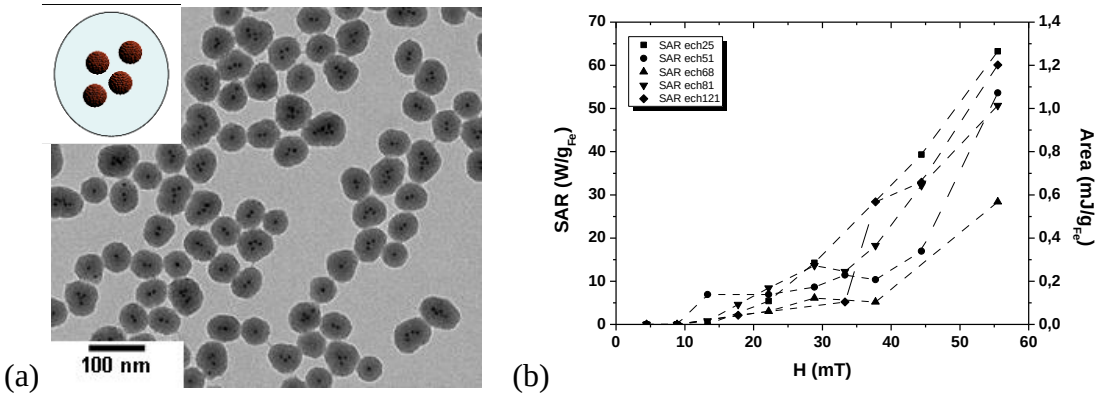

Fig.1: (a) TEM picture of silica coated iron NPs and (b) their associated hyperthermia measurements, $\mu 0H$ = 55 mT and f = 50 kHz.