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ESRF	**Experiment title:** Colloidal magnetic nanoparticles for personalized theranostics in oncology: advanced in-situ x-ray spectroscopic research	**Experiment number**: MA-3315
Beamline: ID26	**Date of experiment**: from:28 September 2016 to: 01 October 2016	**Date of report**:
Shifts: 9	**Local contact(s)**: Sara Lafuerza bielsa (email: sara.lafuerza@esrf.fr)	*Received at ESRF:*

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Report:

[1] Low toxic maghemite nanoparticles for theranostic applications // Kuchma EA, Zolotukhin PV, Belanova AA, Soldatov MA, Lastovina TA, Kubrin SP, Nikolsky AV, Mirmikova LI, Soldatov AV International Journal of Nanomedicine 2017, 12:6365-6371

Background: Iron oxide nanoparticles have numerous and versatile biological properties, ranging from direct and immediate biochemical effects to prolonged influences on tissues. Most applications have strict requirements with respect to the chemical and physical properties of such agents. Therefore, developing rational design methods of synthesis of iron oxide nanoparticles remains of vital importance in nanobiomedicine.

Methods: Low toxic superparamagnetic iron oxide nanoparticles (SPIONs) for theranostic applications in oncology having spherical shape and maghemite structure were produced using the fast microwave synthesis technique and were fully characterized by several complementary methods (transmission electron microscopy [TEM], X-ray diffraction [XRD], dynamic light scattering [DLS], X-ray photoelectron spectroscopy [XPS], X-ray absorption near edge structure [XANES], Mossbauer spectroscopy, and HeLa cells toxicity testing).

Results: TEM showed that the majority of the obtained nanoparticles were almost spherical and did not exceed 20 nm in diameter. The averaged DLS hydrodynamic size was found to be ~33 nm, while that of nanocrystallites estimated by XRD was ~16 nm. Both XRD and XPS studies evidenced the maghemite (γ-Fe2O3) atomic and electronic structure of the synthesized nanoparticles. The XANES data analysis demonstrated the structure of the nanoparticles being similar to that of macroscopic maghemite. The Mossbauer spectroscopy revealed the γ-Fe2O3 phase of the nanoparticles and vibration magnetometry study showed that reactive oxygen species in HeLa cells are generated both in the cytoplasm and the nucleus.

Conclusion: Quasispherical Fe3+ SPIONs having the maghemite structure with the average size of 16 nm obtained by using the fast microwave synthesis technique are expected to be of great value for theranostic applications in oncology and multimodal anticancer therapy.

Not published data:

During the beatime a number of HERFD XANES reference Fe_3O_4 specra were measured taking care of radiation damage and self-absorption effects. Particularly we found that sigma aldrich Fe_3O_4 nanoparticles Fe K-edge HERFD XANES showed a redshift compared to bulk (1 wt. % magnetite in cellulose) suggesting even higher Fe reduction in Iron Oxide Nanoparticles (IONPs) (Figure 1 left).

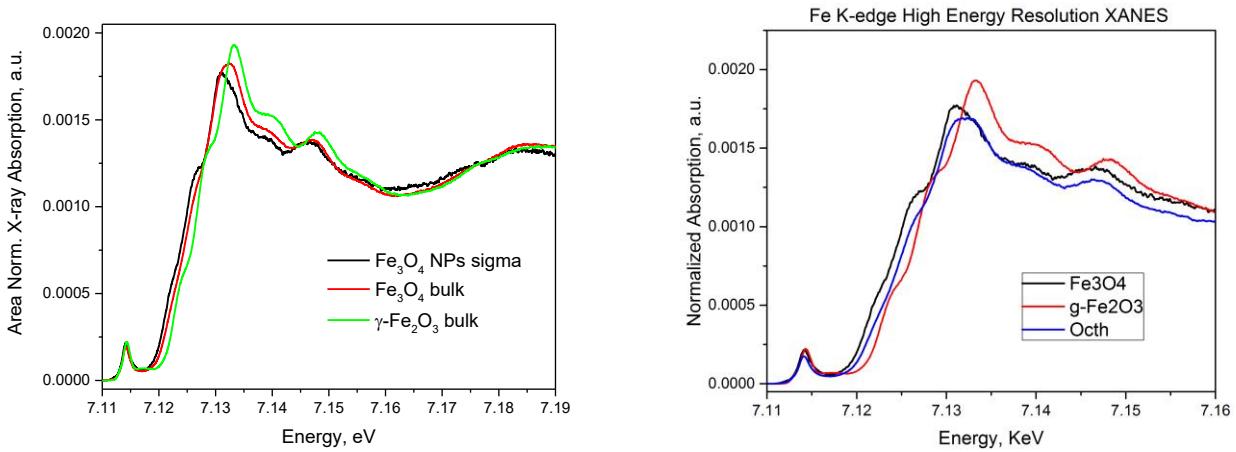

Figure 1 Left Fe K-edge HERFD XANES spectra of reference inverse spinel iron oxides

HERFD XANES spectra were measured for a number of IONPs synthesised by means of various methods. An example for one the sample is shown on the right panel of figure 1. A linier combination fit of reference compounds gave an info of iron oxidation state for each synthesis method. The later compared to TEM data give a hint for synthesis of oxidation stable Fe_3O_4 IONPs.

On the other hand the data is compared to theoretical simulations that give additional info on the IONPs peculiar properties (Figure 2).

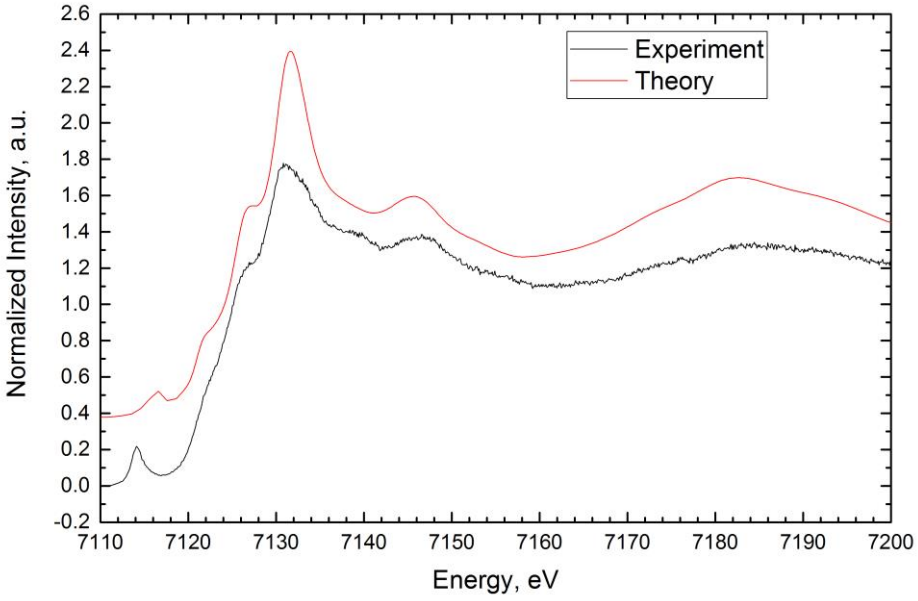

Figure 2 Fe K-edge HERFD XANES spectra of synthesised IONPs compared to theory.