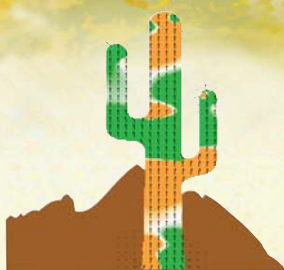


# 56<sup>TH</sup> ANNUAL CONFERENCE ON MAGNETISM AND MAGNETIC MATERIALS

30 October–3 November 2011  
Scottsdale, AZ



## ABSTRACTS

MMM 2011  
Scottsdale, Arizona

THURSDAY AFTERNOON, 3 NOVEMBER 2011

SAGUARO BALLROOM, 1:00 TO 5:00

**Session HT**  
**NANOPARTICLE CHARACTERIZATION II**  
**(POSTER SESSION)**

Natalie Huls, Chair

**CONTRIBUTED PAPERS**

**HT-01. Investigation of cation distribution in single crystalline  $\text{Fe}_{3-x}\text{Mn}_x\text{O}_4$  microspheres based on Mössbauer spectroscopy.** Y. Li<sup>1</sup>, T. Kouh<sup>1</sup>, I. Shim<sup>1</sup> and C. Kim<sup>1</sup>. *Department of Physics, Kookmin University, Seoul, Korea, Republic of*

Monodisperse  $\text{Fe}_{3-x}\text{Mn}_x\text{O}_4$  ( $x = 0, 0.25, 0.5, 0.75, 1.0$ ) microspheres were synthesized by a solvothermal reaction method. HR-TEM measurements showed that the size of the monodispersed particles was around 200 nm as well as diffraction patterns with single crystalline spots. From the detailed Rietveld refinement analysis, the crystal structure was determined to be cubic spinel with lattice constant  $a_0$ , linearly increasing from 8.395 to 8.509 Å with the Mn concentration. Also, with Mn concentration, saturation magnetization ( $M_s$ ) increased from 77.0 to 95.4 emu/g, while coercivity ( $H_c$ ) decreased from 66 to 36 Oe, at room temperature. We have analyzed the room-temperature Mössbauer spectra as 2 sets with six-lines of tetrahedral  $A$  site and octahedral  $B$  site. Hyperfine fields of  $A$  and  $B$  site were  $H_{\text{hf}}(A) = 489$  kOe,  $H_{\text{hf}}(B) = 456$  kOe for  $x = 0$ , and  $H_{\text{hf}}(A) = 481$  kOe,  $H_{\text{hf}}(B) = 446$  kOe for  $x = 1.0$ , respectively. The isomer shift values were 0.18–0.20 mm/s at the  $A$  site and 0.53–0.38 mm/s at the  $B$  site. The corresponding area ratio of  $A$  site increased by 40–49 % while that of  $B$  site decreased by 60–51 % as the Mn concentration changed from  $x = 0$  to 1.0. Here, the changes in the area ratios of  $A$  and  $B$  sites are due to the changes in the cation distributions at the  $A$  and  $B$  sites, originating from the randomly substituted Mn ions in  $\text{Fe}_{3-x}\text{Mn}_x\text{O}_4$  microspheres. We believe that there are two possible reasons for such changes. One is the hopping between  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$  ions depending on the amount of  $\text{Mn}^{2+}$  ion substituted in  $B$  site, and the other is the changes in the interaction between Fe ions between  $A$  and  $B$  sites due to the Mn substitution [1]. These result in the Mn-concentration dependent room-temperature Mössbauer parameters.

[1] J. A. Moyer, C. A. F. Vaz, E. Negusse, D. A. Arena, and V. E. Henrich, Phys. Rev. B **83**, 035121 (2011).

**HT-02. Bentonite/iron oxide composites studied by NMR and Mössbauer spectroscopy.** P. Kristan<sup>1</sup>, V. Chlan<sup>1</sup>, H. Stepankova<sup>1</sup>, K. Kouril<sup>1</sup>, R. Reznicek<sup>1</sup>, K. Polakova<sup>2,3</sup>, V. Prochazka<sup>2</sup>, J. Cuda<sup>2,3</sup> and I. Medrik<sup>2,3</sup>. *1. Faculty of Mathematics and Physics, Charles University in Prague, Prague 8, Czech Republic; 2. Centre for Nanomaterial Research, Faculty of Science, Palacky University, Olomouc, Czech Republic; 3. Regional Centre of Advanced Technologies and Materials, Departments of Physical Chemistry and Experimental Physics, Faculty of Science, Palacky University, Olomouc, Czech Republic*

Magnetic or superparamagnetic iron oxide particles of submicron/nanoscale dimensions are successfully applied in magnetic resonance imaging (MRI) as contrast agents for diagnostic purposes, location and tracking of labelled cell or drug delivery studies. Namely maghemite ( $\gamma\text{-Fe}_2\text{O}_3$ ) attached to the surface of the bentonite clay forms an efficient negative oral contrast agent for MRI diagnostics in gastroenterology [1]. In this contribution we report on a bentonite/iron oxide system prepared by isothermal calcination of powder composed of bentonite and precursor containing ferric acetate. This preparation technique enables us to get directly the composite material, i.e. maghemite embedded in a bentonite matrix, and prevent iron oxide particles from aggre-

gation. We characterized the prepared samples mainly by local methods based on hyperfine interactions:  $^{57}\text{Fe}$  nuclear magnetic resonance (NMR) and Mössbauer spectroscopy. In our NMR measurements we focused on spectral region corresponding to  $^{57}\text{Fe}$  resonance in maghemite and monitored its evolution with temperature of calcination  $T_{\text{calc}}$  from 320 to 520 °C. The spectra were recorded at 4.2 K in a zero external magnetic field using spin echo CPMG multipulse sequence. One of the main findings is that the spectral features characteristic for maghemite become more distinct with increasing  $T_{\text{calc}}$  up to 420 °C, which is most likely connected with higher degree of atomic/vacancy ordering in maghemite spinel structure. Evaluation of integral intensities in NMR spectra allowed us to determine the relative content of maghemite phase in particular samples of the series: the content rapidly grows for  $T_{\text{calc}}$  up to 420 °C. For higher  $T_{\text{calc}}$  a presence of hematite is detected while the amount of maghemite phase decreases, which is in accordance with results obtained by Mössbauer spectroscopy at room temperature.

[1] Katerina Kluchova, Radek Zboril, Jiri Tucek et al., Biomaterials **30** (2009) 2855–2863

**HT-03. Self consistent measurement and removal of the dipolar interaction field in magnetic particle assemblies and the determination of their intrinsic switching field distribution.** J.M. Martínez Huerta<sup>1</sup>, J. De La Torre Medina<sup>1</sup>, L. Piraux<sup>2</sup> and A. Encinas Oropesa<sup>1,3</sup>. *1. Instituto de Física, Universidad Autónoma de San Luis Potosí, San Luis Potosí, San Luis Potosí, Mexico; 2. Institute of Condensed Matter and Nanosciences, Université Catholique de Louvain, Louvain-la-Neuve, Belgium; 3. Division de Materiales Avanzados, Instituto Potosino de Investigacion Científica y Tecnológica A. C., San Luis Potosí, San Luis Potosí, Mexico*

Based on high remanence arrays of bistable magnetic nanowires a method to measure the dipolar interaction field based on remanence curve measurements is proposed and validated. While using mean field arguments this interaction has been removed from the as measured hysteresis loops and remanence curves, leading to the deshearing of the hysteresis loop and the determination of the intrinsic switching field distribution. The accuracy of the measured values of the interaction field as well as its correct removal from the as measured data have been verified by construction of the Henkel,  $\Delta H$  and  $\Delta M$  plots with the corrected data which yield results consistent with the Wohlfarth relation for an assembly of non interacting particles. Finally, general expressions for the effective demagnetizing field and the energy density for the assembly of interacting particles have been obtained.

E. P. Wohlfarth, J. Appl. Phys. **29**, 595 (1958). E. Della Torre, Magnetic Hysteresis, IEEE Press, New York (1999). pp. 77 J. De La Torre Medina, L. Piraux, J. M. Olais Govea, and A. Encinas, Phys. Rev. B. **81**, 144411 (2010). R. J. Veitch, IEEE Trans. Magn. **26**, 1876 (1990). U. Netzelmann, J. Appl. Phys. **68**, 1800 (1990). H. J. Richter, Jour. Phys. D: Appl. Phys. **40**, R149 (2007). R. J. M. van de Veerdonk, X. Wu, and D. Weller, IEEE Trans. Magn.