

Structural Investigation of Composite Biomaterials for Hyperthermia

V. Simon¹, H. Mocuta^{1,2}, D. Eniu³, D. Trandafir^{1,2}, S. Simon^{1,2}

¹ Babes-Bolyai University, Faculty of Physics, Cluj-Napoca, Romania. ² Institute for Interdisciplinary Experimental Research of Babes-Bolyai University, Cluj-Napoca, Romania.

³ University of Medicine and Pharmacy, Faculty of Pharmacy, Cluj-Napoca, Romania.

INTRODUCTION: Localized hyperthermia is a therapeutic procedure used to raise the temperature of a region of the body affected by cancer. The treatment is based on a direct cell-killing effect at temperatures above 43°C. Our studies are focused on iron containing aluminosilicate composite materials able to develop nanocrystalline magnetic phases as heating media for cancer treatment.

In nanostructured composite materials, beside composition the knowledge of the structure is a key requirement for understanding materials properties. Since the X-ray wavelengths are in the same order as the sizes of nanostructures, we used X-ray diffraction to investigate the composite architecture.

METHODS: Samples belonging to $x\text{Fe}_2\text{O}_3(80-x)\text{SiO}_2 \cdot 20\text{Al}_2\text{O}_3$ system ($5 \leq x \leq 20$ mol %) were prepared by the sol-gel method starting from silicic acid as source of silica, iron and alumina nitrates. The sludges were stirred at room temperature for 3 hours and the precipitates were filtered. Reddish coloured solid sample were obtained after drying at 110°C. The dried samples were subjected to heat treatments carried out at 500°C for 1 hr and at 1200°C for 24 hrs.

The structure of the thermal treated samples was investigated by XRD with a Shimadzu diffractometer using $\text{CuK}\alpha$ radiation. The average crystallite size was estimated by using the Scherrer equation:

$$D = \frac{k\lambda}{\beta \cos \theta}$$

where D is the crystallite size, λ is the X-ray wavelength, k is the shape factor equal to 0.9, θ is the diffraction angle of selected line and $\beta = \sqrt{B^2 - b^2}$, where B is the full width at half maximum intensity and b the resolution parameter of the diffractometer.

Electron paramagnetic resonance (EPR) measurements were carried out in these samples on ADANI PS 8400 system EPR spectrometer, in the magnetic field range of 700-4700 Gauss, in the X-band, at room temperature.

RESULTS & DISCUSSION: The heat treatment applied at 500°C does not lead to crystalline phase development, but that applied at 1200°C (Fig. 1)

mainly determines the grows of hematite nanocrystals. Selection of a reducing atmosphere will be able to produce a finely dispersed magnetite the samples [1].

The size of hematite crystals determined using Scherrer formula is about 8.7 nm. DRX data also evidence aluminosilicate crystals of mullite ($\text{Al}_6\text{Si}_2\text{O}_{13}$) type [2] that confer to samples a high structural stability.

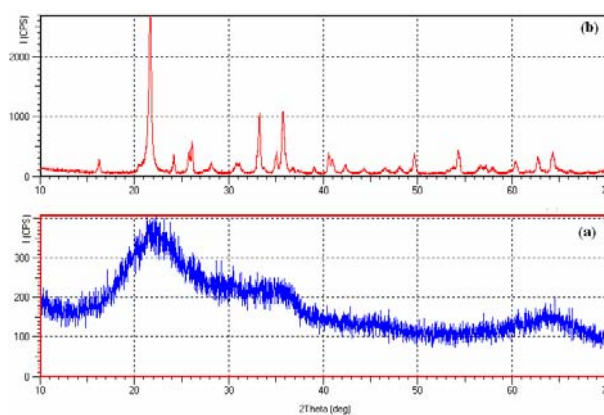


Fig. 1: XRD patterns of samples with 20 mol% Fe_2O_3 heat treated at 500°C (a) and 1200°C (b).

The EPR results obtained for as prepared samples are specific to disordered oxide systems with high Fe_2O_3 content. The resonance line at $g \approx 2.0$ is shifted to lower values of the magnetic field when the iron oxide content increases. The spectra of the heat treated samples contain an additional narrow line at $g \approx 4.3$ arising from Fe^{3+} ions disposed in the crystalline phases well developed during the applied heat treatment.

CONCLUSIONS: The non-crystalline state of iron containing aluminosilicate samples obtained by sol-gel route is transformed by heat treatment applied at 1200°C in a structural stable composite material with hematite nanocrystals and $\text{Al}_6\text{Si}_2\text{O}_{13}$ crystals.

REFERENCES: ¹ K.A. Gross, R. Jackson, J.D. Cashion, et al (2002) *Eur Cell Mater* 3 Suppl.2:114-17. ² P. Hou, S.N. Basu, V.K. Sarin (1999) *J Mater Res*, 14:2952-58.

ACKNOWLEDGEMENTS: The present work was supported by the scientific research project CEEEX 100/2006 (MATNANTECH) of the Romanian Excellence Research Program.