Arc-Discharge Synthesis of Fe@C Nanoparticles for General Applications

S. Chaitoglou*, M. Reza Sanaee, N. Aguiló-Aguayo, E. Bertran
FEMAN Group, IN2UB, Department of Applied Physics and Optics, Universitat de Barcelona,
C/ Martí i Franquès, 1, 08028,
Barcelona, Spain.

The objective of the present work is to improve the protection against the oxidation, that usually appears in core@shell nanoparticles, through the control of the synthesis process. Oxidized iron nanoparticles involve a loss of the magnetic characteristics and also changes on the chemical properties. Our results indicate no loss of superparamagnetic characteristics. The reactor works in Arc-Discharge and spherical iron nanoparticles coated with a shell of carbon were obtained at near-atmospheric pressure conditions (5–8×10Pa). The current was always 40 A and the studied concentration range of the Fe into isooctane varies between 1% w/w and 4%w/w. Also the studied flow of the precursor gas varied from 30cm^3/min to 120cm^3/min. The resulting diameter of the iron core is between 5-9nm as we could measure by transmission electron microscopy (TEM). From the selected area electron diffraction (SAED), the nanoparticles appear to have a crystalline dense iron core. From the energy-dispersive X-ray analysis (STEM-EDX) we have verified the absence of oxygen in the core. The magnetic properties of the nanoparticles have been investigated up to 5K temperature using a superconducting quantum interference device (SQUID). The results reveal a superparamagnetic behaviour, narrow size distribution and an average diameter of 6 nm of the nanoparticles having a blocking temperature near 40 K.

References

[1] Margarethe Hofmann-Amtenbrink, Brigitte von Rechenberg and Heinrich Hofmann, Superparamagnetic nanoparticles for biomedical applications Nanostructured Materials for Biomedical Applications, 2009,121-122

[2] Mark T. Swihart,Vapor-phase synthesis of nanoparticles Current Opinion in Colloid and Interface Science 8 (2003) 127–133

[3] Nagarajan Sounderya1 and Yong Zhang, Use of Core/Shell Structured Nanoparticles for Biomedical Applications Recent Patents on Biomedical Engineering 2008, 1, 34-42

[4] http://www.wisegeek.com/what-is-a-carbon-anode.htm

[5] Yoshinori Ando and Xinluo Zhao Synthesis of carbon nanotubes by Arc-Discharge method.. New Diamond and Frontier Carbon Technology, Vol. 16, No.3 2006,127-128

[6] M. Vardelle, A. Vardelle, P. Fauchais, K.-I. Li, B. Dus-soubs and N. J. Themelis, “Controlling Particle Injection in Plasma Spraying,” Journal of Thermal Spray Technol-ogy, Vol. 10, No. 2, 2001, pp. 267-28

[7]http://www.jeol.com/products/electronoptics/transmissionelectronmicroscopestem/200kv/jem2100f/tabid/124/default.aspx

[8] Subrahmanyam K S, Panchakarla L S, Govindaraj A, Rao C N R Simple method of preparing graphene flakes by an arc-discharge method. J. Phys. Chem. C, 113, 11, (2009). 4257-4259, ISSN.

[9] Vladimir L. Kuznetsov, Anna N. Usoltseva, and Andrew L. Chuvilin Thermodynamic analysis of nucleation of carbon deposits on metal particles and its implicationsfor the growth of carbon nanotubes, , Physical Review Volume B 64, November 2001, 235401

10]Per Henk G. Merkus Particle Size Measurements: Fundamentals, Practice, Quality, Overview of Size Characterization Techniques ,2009,13

[11]http://serc.carleton.edu/research_education/geochemsheets/eds.html

[12] Daniele Gozzi,, Alessandro Latini , Gustavo Capannelli , Fabio Canepa Myrta Napoletano , Maria Roberta Cimberle d, Matteo Tropeano, Synthesis and magnetic characterization of Ni nanoparticles and Ni nanoparticles in multiwalled carbon nanotubes, Journal of Alloys and Compounds 419 (2006) 32–39

Figures

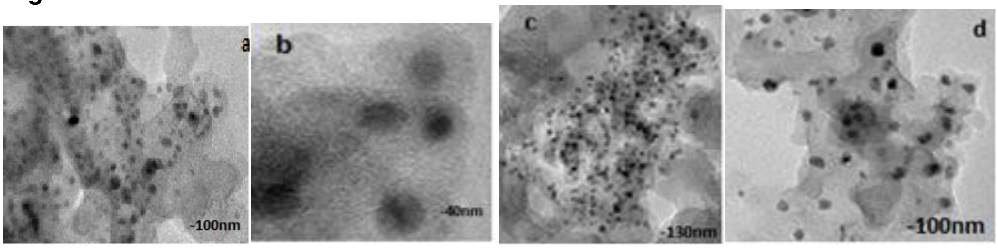


Figure 2: TEM images of Fe@C nanoparticles in different concentrations and flows. A) 30ml/min, in a concentration of 1% w/w, B) 30 ml/min, in precursor concentration of 2% w/w, C) 30 ml/min, in a concentration of 4% w/w D) 60 ml/min, in a concentration of 1% w/w

a/a	1%w/w /σ	2%w/w /σ	4%w/w/σ
30cm^3/min	8.18nm/1.22(Fig 3.c)	5.43nm/1.34(Figure 3.d)	5.34nm/ 1.33(Figure 3.f)
60cm^3/min	6.23nm/ 1.47 (Figure 3.a)	6.12nm/ 1.46(Figure 3.e)	5.22nm/ 1.22(Figure 3.g)
120cm^3/min	5.22nm/ 1.25(Figure 3.b)		

Table 2: The geometric mean and the geometric standard deviation of all our samples in relation with the set parameters.

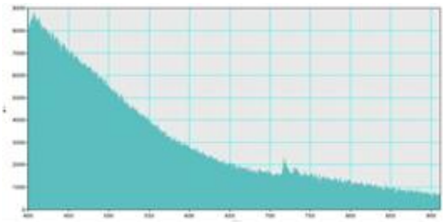
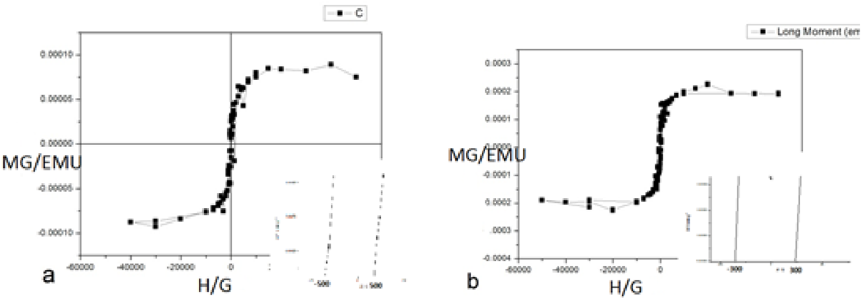


Figure 5: The energy-dispersive X-ray analysis in which we can see the pick that corresponds to the La excitation of iron and the absence of oxygen.



The hysteresis loops measured at 5K for samples with different precursor concentrations: a) 1% w/w and b) 2% w/w. Both were obtained at a precursor gas flow of 30 ml/min.

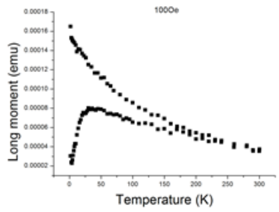


Figure 8: Zero fields cooled and the field cooled magnetization curves for 100 Oe field.