Proceedings of the 10th World Congress on Recent Advances in Nanotechnology (RAN 2025)
Barcelona, Spain - April, 2025
Paper No. ICNNFC 120
DOI: 10.11159/icnnfc25.120

Magnetic Nanoparticles with Three Different Coatings for Hyperthermia Applications

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Extended Abstract

In this work the magnetic, structural and morphological properties of iron oxide magnetic nanoparticles (IOMNP) are presented. The IOMNP are synthesized by thermal decomposition method, subsequently samples are separated in three batch, first (M1) is coated with oleic acid, second (M2) is bare magnetite and third (M3) is coated with carbon. TEM images for all the samples are presented, in this it is possible to see that IOMNP are spheroidal with a mean size of 30 nm. The electron diffraction of samples can be indexed using Fe_3O_4 diffraction planes.

Magnetic properties were measured using a VSM at room temperature. Results shown that magnetic saturation is higher for sample coated with carbon and lower for sample coated with oleic acid in comparison to sample M2 (no coated), indicating that oleic acid could increase the magnetic dead layer around the nanoparticle[1]. Result also show a higher magnetic remanence in sample M2, indicating a possible aggregation of nanoparticles [2].

The size distribution, morphology and aggregation state were analyzed using SAXS. The SAXS patterns were analyzed using the Porod law [3]. It was observed that only the Porod law is needed to fit all data for sample M2. For sample M3 it is observed a knee around $q = 0.159$ nm^{-1}, it is related with the mean particle size. For q-values over the knee the Porod law is satisfied. For q-values below this knee, particle size distribution and structuring are responsible of scattering. For the higher q-values scattering is governed by the background.

Another important structural parameter obtained from saxs curves are the correlation length (l), the correlation surface (S) and the correlation volume (V). These parameters were calculated using SASFit software. Results shown that l, S and V are higher for sample M2, indicating higher particle size.

For fitting the overall curve for sample M3, the analytical expression for the scattering of polydisperse spherical particles and a mass fractal structure factor ($S(q)$) was used [4]. Results shown that mean particle size for M3 sample is 11.44 nm

Finally, to apply this IOMNP in magnetic hyperthermia, specific absorption rates (SAR) experiments were performed measuring the heating curve (T vs t) at different field amplitudes and f = 260 kHz. Results shown that sample M3 (carbon coated) exhibits a higher SAR in comparison with M2 sample (bare magnetite). The last is in accordance with magnetic results, where magnetic saturation of sample M3 is higher that sample M2.

References

[1] [Diego Fernando Coral, P. Mendoza Zélis , ME de Sousa , D. Muraca , V. Lassalle , P. Nicolás , ML Ferreira y MB Fernández van Raap, "Quasi-static magnetic measurements to predict specific absorption rates in magnetic fluid hyperthermia experiments," *J. Appl. Phys.*, vol. 115, no. 4, p. 043907, Jan. 2014, doi: 10.1063/1.4862647.

[2] M. B. Fernández van Raap, Diego Fernando Coral, S. Yu, G. A. Muñoz, F. H. Sánchez, and A. Roig, "Anticipating hyperthermic efficiency of magnetic colloids using a semi-empirical model: a tool to help medical decisions," *Phys. Chem. Chem. Phys.*, vol. 19, no. 10, pp. 7176–7187, 2017, doi: 10.1039/C6CP08059F.

[3] O. Glatter and O. Kratky, *Small angle x-ray scattering*. Academic Press, 1982.

[4] Diego Fernando Coral and J. A. Mera-Córdoba, "Applying SAXS to study the structuring of Fe3O4 magnetic nanoparticles in colloidal suspensions," *DYNA*, vol. 86, no. 209, 2019, doi: 10.15446/dyna.v86n209.73450.

[5] Diego Fernando Coral, Paula Andrea Soto, Viviana Blank, Alejandro Veiga, Enrique Spinelli, Sergio González, Gustavo Pablo Saracco, Marisa Alejandra Bab, Diego Muraca, Patricia C Setton-Avruj, Anna Roig, L Roguin, MB Fernández Van Raap, "Nanoclusters of crystallographically aligned nanoparticles for magnetic thermotherapy: aqueous ferrofluid, agarose phantoms and ex vivo melanoma tumour assessment," *Nanoscale*, vol. 10, no. 45, pp. 21262–21274, Nov. 2018, doi: 10.1039/C8NR07453D.