Polyethylene glycol iron oxide nanoparticles with fluorescent properties

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Iron oxide nanoparticles, due to their magnetic properties, can be used as magnetic resonance imaging agents in diagnostic, as heat mediators in hyperthermia treatments, and additionally as magnetic guidance in drug delivery applications. Magnetite (Fe_3O_4) or its oxidized form maghemite (γ-Fe_2O_3) are the most commonly employed in biomedical applications since their biocompatibility has been proven[1].

Fluorescent magnetic nanoparticles are formed by a magnetic core coated with an inorganic compound or organic polymer with a bound or embedded fluorophore. The preparation of fluorescent magnetic nanoparticles is, however, challenging. A specific difficulty in the preparation of fluorescent magnetic nanoparticles is the risk of quenching of the fluorophore on the particle surface by the magnetic core. This problem has been solved by coating the magnetic core with a stable isolating shell prior to the introduction of the fluorescent molecule or by attaching an appropriate spacer to the fluorophore.[2] The shell has to be biocompatible and non-immunogenic, preventing the agglomeration of the particles and at the same time minimizing non-specific interactions with proteins, cells and other components of biological media.

In this work, polymer coated iron oxide nanoparticles has been synthesized. The role of the polymer coating is twofold: on one hand it prevents the iron from oxidizing and on the other hand it allows the functionalization of the particles and minimizes the direct exposure of the iron nanoparticles surfaces to the biological environment. The polymer coated iron nanoparticles have been synthesized by a microemulsion method in two steps [3].

We have synthesized iron oxide nanoparticles coated by PEG [4,5]. The surface modified nanoparticles are expected to be more biocompatible: non-immunogenic, non antigenic and protein resistant, because PEG has uncharged hydrophilic residues and high surface mobility. The aim is to modify this coating in order to allow the subsequent functionalization of the nanoparticles (mPEG-NH_2) [6].

The most studied surface modification of the iron oxide nanoparticles has been their functionalization with different dyes so that the resulting nanoparticles can be detected by both magnetic and fluorescent techniques. Amine-reactive N-hydroxysuccinimidyl ester of Alexa Fluor 660 dye has been conjugated to the nanoparticle surface. This dye produces bright far red fluorescence emission with a peak at 690 nm.

In this study, preparation, modification and functionalization of PEG coated iron oxide nanoparticles is reported. We have been able to synthesize high susceptibility iron nanoparticles of sizes between 10-15 nm coated by a polymer.

References

[1] Qiao R.R, Yang C.H, Gao M.Y, J.Mater Chem **19** (2009) 6274.
[2] Corr S.A, Rakovich Y.P, Gun'Ko Y.K, Nanoscale Res Lett **3** (2008) 87.
[3] Zhou W.L, Carpenter E.E, Lin J, Kumbhar A, Sims J, O`Connor C.J, Eur. Phys. J. D **16** (2001) 289.
[4] Skumiel A, Józefczak A, Hornowski T, J. Phys. Conference Series **149** (2009) 01211.
[5] Yu W.W, Chang E, Falkner J.C, Zhang J, Al-Somali A.M, Sayes C.M, Johns J. Drezek R, Colvin V.L, J. Am. Chem. Soc. **129** (2007) 2871
[6] Harris J.M, Struck E.C, Case M.G, Paley M.S, Yalpani M, Van Alstine J.M, Brooks D.E, J. Polymer. Sci. Polymer Chem **22** (1984) 341

Figures

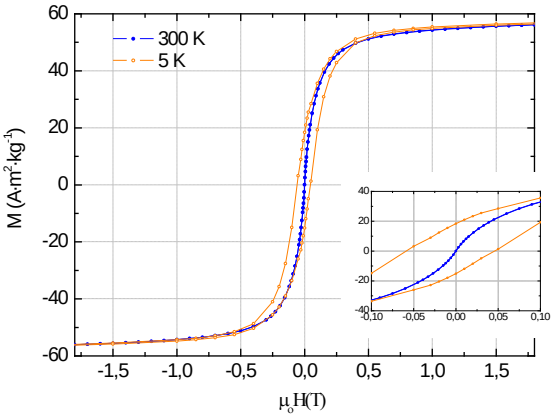

Figure 1. Hysteresis loops at 5 and 300 K.

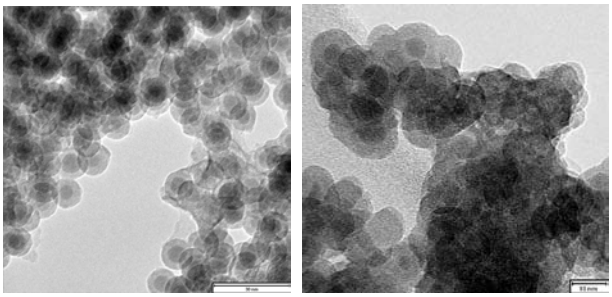

Figure 2. TEM micrograph of iron oxide PEG nanoparticles (left) and iron oxide PEG-NH_2 (right).

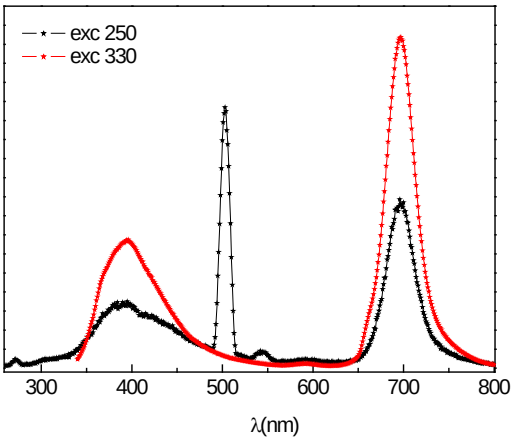

Figure 3. Fluorescence spectra of nanoparticles with dye.