# Polymer coated iron nanoparticles for biological applications

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Magnetic nanoparticles have numerous applications in biotechnology and biomedicine. Iron oxide nanoparticles such as magnetite ($Fe_3O_4$) or its oxidized form maghemite ($\gamma$-$Fe_2O_3$) are by far the most commonly employed in biomedical applications since their biocompatibility has been proven. They can be used as magnetic carrier for drugs, antibodies or cells, they can be heated up by alternating magnetic fields and potentially kill the cancerous cells by hyperthermia or be used as contrast agents for MRI [1]. This study aimed at the synthesis and surface modification of magnetic nanoparticles.

At present there is a big effort in synthesizing biocompatible magnetic nanoparticles with high susceptibility in order to improve the attraction and actuation of the particles by external magnetic fields. Magnetic nanoparticles are usually modified through the formation of few atomic layers of polymer/surfactant or inorganic metallic or oxide surfaces which are suitable for further functionalization by attachment of various biomolecules. It has synthesized iron nanoparticles coated in a polymer. 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 [2].

The water-in-oil microemulsion has been widely used to synthesize uniform size nanoparticles of various kinds, including magnetic materials, and has become a powerful tool. The water nanodroplets (nanoreactor) containing reagents undergo rapid coalescence that allows mixing, precipitation reaction, and aggregation processes for the synthesis of magnetic nanoparticles. The water-in-oil microemulsion has been prepared using nonionic surfactants.

The nonionic surfactant nonylphenol pentaethoxylate (NP5) forms reverse micelles in hydrocarbon oils, and has been successfully employed to synthesize iron nanoparticles [3]. The aim of this study is to introduce another surfactant, the poly (ethylene glycol) (PEG), that acts as a co-surfactant and investigate the influence of PEG surface active coating on the magnetic properties of the iron nanoparticles [4].

Furthermore, we have synthesized iron nanoparticles only coated by PEG with the same technique. The aim is to modify this coating in order to allow the subsequent functionalization of the nanoparticles.

The particles have been characterised by means of X-ray diffraction (XRD) and transmission electron microscopy (TEM). XRD shows a clear $Fe_{bcc}$ phase and no presence of Fe oxides can be detected. The average nanoparticle size of the core-shell structure is about 9-11 nm, with about 3-5 nm diameter core and 3 nm shell.The magnetic properties have been studied by means of the 300 K hysteresis loop performed in a high field vibrating sample magnetometer (VSM). $^{57}$Fe Mössbauer spectroscopy measurements were carried out at room temperature in transmission geometry using a conventional spectrometer with a $^{57}$Co-Rh source.

In conclusion, in this study it is reported the preparation of polymer coated iron nanoparticles by microemulsion technique. We have been able to synthesize high susceptibility Fe nanoparticles of sizes between 10-15 nm coated by a polymer.

## References


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[2] W.L. Zhou, E.E. Carpenter, J. Lin, A. Kumbhar, J. Sims, C.J. O'Connor, Eur. Phys. J. D. **16** (2001) 289.
[3] S. Santra, R. Tapec, N. Theodoropoulou, J. Dobson, A. Hebard, W. Tan, Langmuir **17** (2001) 2900.
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## Figures

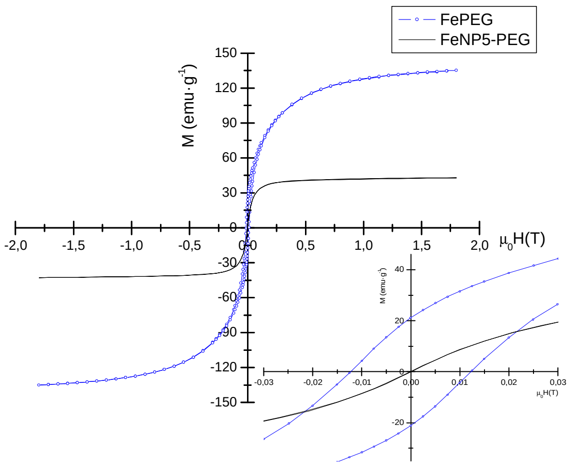


*Figure 1: Hysteresis loop at 300 K. The inset shows the region at low fields to highlight the presence of coercivity and remanence.*

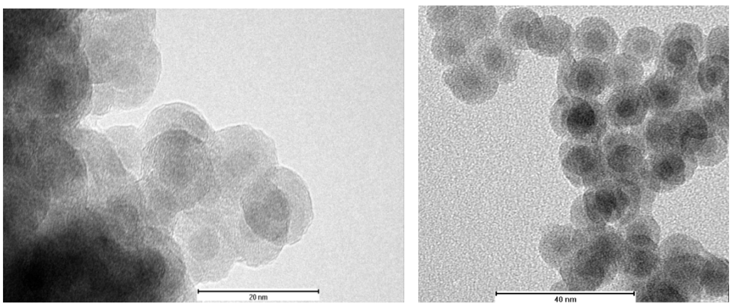

*Figure 2: TEM micrographs of iron coated nanoparticles.*

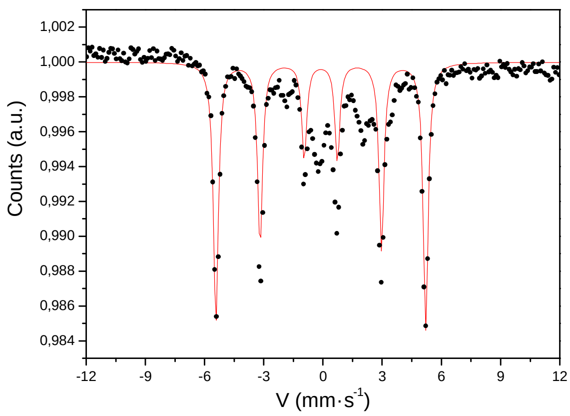


*Figure 3: Room temperature Mössbauer spectra.*