# Spatially-Resolved EELS Analysis of Antibody Distribution on Biofunctionalized Magnetic Nanoparticles

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## Abstract

In biomedical applications, core-shell magnetic nanoparticles are commonly used as supports for macromolecules of biological interest. The shell, either organic or inorganic, allows in principle the use of different functionalization protocols to link a large variety of biological moieties, depending on the final purpose.
The functionalization of nanoparticles with antibodies makes possible the use of the nanoparticles in applications based on immuno-recognition processes, in which the particles act, for example, as carriers for targeted drug delivery, as labels for immuno-assays [1] etc. An adequate immobilization strategy is critical in order to guarantee not only the stability of the antibody binding on the nanoparticle surface, but also its correct orientation [8-13] Therefore, detailed knowledge of the functionalized nanoparticle surface is crucial when working with nanoparticle-antibody conjugates. Some information can be obtained by means of biochemical techniques but there is still a need for characterization at microscopic level.
We have made use of Spatially Resolved Electron Energy Loss Spectroscopy (SR-EELS) using Scanning Transmission Electron Microscope (STEM) for the identification and determination of the spatial distribution of the components/elements of immuno-functionalized core-shell superparamagnetic magnetite nanoparticles [2] at subnanometer scale [3]. SR-EELS measurements have allowed the study and direct identification of the biological moieties (protein G and anti-Horse Radish Peroxidase antibody, which was used as a model system) on the nanoparticle. Our findings provide information on the spatial localization/distribution on the nanoparticle surface. We conclude that the data obtained in this study, together with those gathered by conventional biochemistry techniques, provide insight into the efficiency and potential applications of these nanoparticles in biomedicine and related fields.

## References

[1] D. Serrate, J.M. de Teresa, C. Marquina, J. Marzo, D. Saurel, F.A. Cardoso, S. Cardoso, P.P. Freitas, M.R. Ibarra, Biosens. Bioelectron. **35** (2012) 206.
[2] L. De Matteis, L. Custardoy, R. Fernandez-Pacheco, R, Magen, C.; de la Fuente, J. M.; Marquina, C.; Ibarra, M. R., Chem. Mater. **24** (2012) 451.
[3] R. Arenal, L. de Matteis, L. Custardoy, A. Mayoral, M. Tence, V. Grazú, J. M. de la Fuente, C. Marquina, M. R. Ibarra, ACS Nano **7** (2013) 4006.

## Figures