Surface chemistry of colloidal surfactant-free gold nanoparticles generated by laser ablation

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Synopsis: The stability of colloidal solutions of gold nanoparticles is investigated in free-standing conditions by photoelectron spectroscopy.

Matter at the nanoscale level is at the center of several scientific domains because of their promising potential applications in medical and technological fields [1, 2]. The nanoparticle (NP) surface state is of primary importance for the development of these fields due to their high sensitivity to the composition/structure of the NP surface. Among the various nanoscale materials, Au is mostly studied owing to its noble character and low toxicity. Au NPs used in biomedical-oriented studies are usually produced by wet chemical reduction [3], which requires stabilization agents in order to control their size and prevent their agglomeration. These ligands can be hardly removed and easily interfere to favor further functionalization. Another pronounced NP synthesis technique, based on laser ablation of solids in liquids [4], provides ligand-free NPs, suitable for these studies. However, NPs immersed in a solvent interact strongly with their environment leading to a modification of their surface properties. This environment-NP interaction plays a key-role in the colloidal stability, which is governed by the surface charge of the NPs. The present work aims to address this question in order to depict a clear picture of the origin of the colloidal stability.

In order to avoid any substrate or air contamination/influence, the NPs surface is analyzed in free standing conditions using an aerodynamic lens system [5], producing a NP beam further probed by synchrotron radiation. Photoelectron spectroscopy is accordingly used as surface-sensitive diagnostic technique for the NP surface characterization. This experiment has been performed at the PLEIADES beamline (SOLEIL facility, France) which delivers monochromatic XUV radiation in the range of 10-1000 eV. Au 4f (Fig. 1) and NP valence band have been probed for Au colloids in acetone. The corresponding results exhibit a partial oxidation of gold surface atoms. According to the literature [6], the latter, responsible for a negative surface charge, leads to electrostatic repulsion of NPs and consequently to colloidal stability. Beyond a proof-of-principle for free-standing gold NP beam generation, this experiment opens broad perspectives for the surface characterization of different Au colloids as a function of solvent nature, salinity, PH level [7].

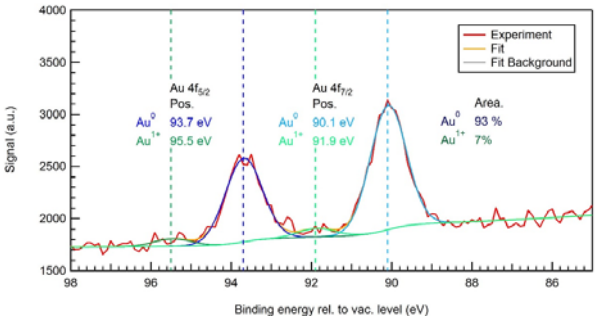

Figure 1. Au 4f probed at 200 eV. Au 4f levels exhibit two components associated to Au(0) and Au(I) oxidation degrees.

References

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