


Internship proposal 2011-2012

Laboratory : Institute for NanoSciences in Paris (INSP) Address : 4, place Jussieu - Tour 22-12 - 4e étage - 75005 Paris, France Laboratory director : Bernard Perrin	 Institut des NanoSciences de Paris
Internship supervisor : Yves Borensztein Phone : 33 1 44 27 61 55 e-mail: borensztein@insp.jussieu.fr	

Physical and chemical properties of gold nanoparticles: application to heterogeneous catalysis

Gold is one of the first metals discovered by man. It was therefore thought for millenaries that its main properties were well known: no chemical reactivity, yellow colour in reflection. However, in the previous twenty years, it has been shown that gold, at the scale of a few nm, get unexpected properties.

In optics, the **plasmon resonance** phenomenon (collective oscillation of conduction electrons) provides a red or violet colour to the gold nanoparticles. This colour changes as a function of the size and of the shape of the particles. The plasmon resonance is also very sensitive to the immediate vicinity of the particles, and can strongly change when the gold nanoparticles interact with molecules or ions.

In catalysis, gold becomes extremely active when the size of the nanoparticles is smaller than 5 nm. For example, gold acts as a catalyst for the carbon monoxide oxidation, even at ambient temperature, while a temperature above 300 °C is required in catalytic exhausts. This effect is still poorly understood and is, nowadays, central in a number of researches in the world.

Our group, in collaboration with a laboratory of chemistry of our University (UPMC), the Laboratory of Surface Reactivity, world leader in this field, has been developing a multi-technique approach in order to understand this phenomenon of **catalytic activity of gold nanoparticles**. The used methods are: chemical elaboration of catalysts, catalytic reactivity, optical spectroscopy, transmission electron microscopy (TEM) and scanning tunnel microscopy.

The internship will be devoted to the physical properties and to the reactivity of nanoparticles made of gold, and in a second time made of gold-other metal alloys (Pd, Cu), for which synergy effects for catalysis and metallic segregation are expected. The optical properties of the nanoparticles in gas and during the chemical reaction (CO oxidation) will be investigated by means of a specially developed cell and of an **ultra-sensitive optical spectroscopy** developed in our laboratory, the differential diffuse reflectometry, which gave us the opportunity to get very promising results [1,2]. This experimental aspect will be completed by a **theoretical modelling** of the plasmon resonance in the gold nanoparticles in interaction with gas and molecules (effect of the particle shape, of charge transfer between nanoparticles and gas, substrate effect...). On the other hand, the student will be involved in an investigation by use of an **environmental scanning tunnel microscope** working in gaseous environment, which has been recently developed in our laboratory. It opens the way of in-situ studying, at the atomic scale, the structural, morphological and electronic properties of the nanoparticles, during their elaboration and in gas environment. The student will be also associated to TEM studies.

1. *Monitoring of the Plasmon Resonance of Gold Nanoparticles in Au/TiO₂ Catalyst under Oxidative and Reducing Atmospheres*, Y. Borensztein, L. Delannoy, A. Djedidi, R.G. Barrera et C. Louis, J. Phys. Chem. C 114, 9008 (2010)

2. *Kinetics of the plasmon optical response of Au nanoparticles/TiO₂ under O₂ and H₂ followed by differential diffuse reflectance spectroscopy*, Y. Borensztein, L. Delannoy, R.G. Barrera, C. Louis, Eur. Phys. J. D 63, 235 (2011)

Techniques in use : Optical spectroscopy, environmental scanning tunnel microscope, transmission electron microscope

Applicant skills :

Granted internship : yes (417 €/month)
C'nano IdF laboratory (France only) : yes
Possibility for a thesis : yes (type of grant : Master School grant)