DNA Engineering with Pd and TiO2 nanoparticles

Engineering matter at the nanoscale is crucial for many fields ranging from photonics and photovoltaics to thermo-electricity, or plasmonic. The nanometer is the natural length scale for phenomena that are important for engineering, like heat transport, light propagation, or current conduction. Nanoparticles have emerged as a crucial building block to control light, heat, or electrons at the nanoscale. Nanoparticles are discrete, point-like, grains of matter that act as discrete “atoms”. In the same way that crystals of atoms (Silicon) have enabled the electronics industry, crystals of nanoparticles could enable new kinds of technological devices. However, crystallizing nanoparticles into defined geometries has proved challenging with conventional “dry” nanofabrication. But about ten years ago, an entirely new way of organizing nanoparticles was pioneered: DNA-directed crystallization of nanoparticles (Park et al., Nature, 2008) and (Nykypanchuk et al., Nature, 2008). By using DNA as a programmable glue between gold nanoparticles, a variety of crystalline geometry were accessed.

It is now possible to extend these early achievements to more complex systems that combine nanoobjects of a different nature to associate their unique properties. This PhD subject aims to synthesize in a controlled way the size and shape of Pd and TiO_2 nanoparticles to be able to structure them jointly using DNA to form the desired supra crystals for applications Hydrogen capture energies.

This research project will be carried out at the LMI in the "Low Dimensional Materials" team and in strong collaboration with LIMMS and the Fujii Laboratory of the University of Tokyo which have jointly developed a microfluidic droplet platform to massively screen the experimental conditions of a biomolecular system (e.g., a cocktail of enzymes amplifying DNA strands [3,4]). With further thermal engineering, the platform can now examine both the concentration and temperature of arbitrary chemical systems. This platform is now used at LIMMS to obtain a phase diagram of nanoparticle DNA systems, to reveal the assembly pathways and stability regions of these systems.

[1] Park et al., Nature, 2008
[2] Nykypanchuk et al., Nature, 2008
[3] Genot et al., Nature Chemistry, 2016
[4] Bacouche et al., Nature Protocols, 2017

Techniques

Synthesis Techniques: Reduction of metallic salts, Sol-gel, Inorganic synthesis
Characterization Techniques : Spectroscopies (IR, UV-vis, RAMAN), Electron Microscopies (MET)

Skills

The candidate must be graduated in Chemistry and be motivated by an interdisciplinary work ranging from material/precursor synthesis to chemical-physical characterizations. Strong background in chemistry, and possibly some knowledge in biochemistry as well as autonomy, organization in work and good English knowledge are sought after. We are looking for someone who is willing to work as a team and wants to develop their scientific curiosity.

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