Master Thesis subjects 2015-2016 in Chemical and Materials Engineering

Engineering of Molecular NanoSystems Laboratory (EMNS) - ULB

1. Functionalization of gold nanoparticles using a unique calixarene-tetradiazoniums functionalization strategy

Summary: Gold nanoparticles find, or are expected to find, numerous applications in the fields of sensing and nanomedicine as environmental and biological optical sensors, Drug Delivery Systems, therapeutic agents,... . All these applications require the controlled functionalization of these materials by specific ligands which (i) ensure their stability in complex media and provide them with (ii) selectivity of interaction towards specific analytes or cellular receptors and/or (iii) new physico-chemical properties. Most of the functionalization strategies take advantage of the strong affinity of thiol groups for the gold surface. This strategy however presents several drawbacks as the sulphur-gold bond can be broken and the ligand released in the presence of other thiols and the surface density of the ligands is difficult to control. In collaboration with Prof. Ivan Jabin of the Faculty of Sciences, a unique functionalization strategy taking advantage of the covalent grafting of calixarene-tetradiazoniums and their subsequent modification with the ligand(s) of interest will be investigated. This strategy should allow overcoming the weaknesses of actual functionalization strategies and open many perspectives for the use of gold nanoparticles.

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2. Elaboration of structured nanomaterials using (bio)polymers coated nanoparticles

Summary: The explosion of both the academic and industrial interest in nanomaterials is due to the fact that the nanometric constituting elements present magnetic, electronic, optical and chemical properties that differ from those of the bulk material. When the nanometric building-blocks are assembled into 2D and 3D lattices, new collective properties can arise from the ordered periodic arrangement of the nanoparticles. In this framework, nanoparticles will be synthesized and functionalized with different (bio)polymers encoding for their auto-assembly into ordered nanostructures, and different strategies will be envisaged for the formation of the superlattices.

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3. Elaboration of molecular nanodevices for analyte recognition in water

Summary: One of our research axes, undertaken in the framework of a European Project, is the development of novel assays that can be used for the efficient detection of analytes in an aqueous environment. The approach pursued in the laboratory is rooted in supramolecular chemistry and consists in the encapsulation of molecular receptors into micelles in order to take advantage of the properties of these materials (cooperativity of many immobilized receptors, compatibility with the aqueous environment, change of a physical property during the binding event). The project will consist in the encapsulation of selective molecular receptors into micelles of different nature for the detection of pollutants in water. Studies will be undertaken by UV-Vis absorption and emission spectroscopy, microcalorimetry and NMR spectroscopy.

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4. Elaboration of micellar nanocatalysts for biomass conversion in water

Summary: One approach towards the development of environmental-friendly synthetic processes is the use of ecologic, healthy, and safe alternative reaction media to replace the commonly-used volatile organic solvents. Although water is a solvent with little environmental impact, its use has been limited in catalysis because the organic substrates are often poorly soluble in water. In this context, micellar systems represent one of the simplest methods to achieve organic transformation in an aqueous environment. We were interested in investigating, in collaboration with the University of Padova, the potential reactivity of vanadium supramolecular complexes in aqueous micellar media for the hydrolysis of model systems for lignin.

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