Search for a candidate (Master 2) to apply to a PhD grant at the Defense Innovation Agency

Description:

The project **Cataplasm** aims to propose a solution to the problem of water contamination by opioids that are not removed/degraded by traditional water treatment. The abuse of synthetic opioids has reached epidemic proportions on a worldwide scale. Developed as a sedative for pain relief, synthetic opioids cause the depression of the respiratory system and psychomotor impairment. Acute administrations of opioids can result in overdose and death. Besides, when opioids are ingested, they break down into metabolites—often other opioids—that end up in wastewater. Plasmonic material such as plasmonic NPs (silver or gold especially) are highly relevant materials because they have very interesting plasmonic properties when the light is interacting with those materials. Indeed, the localized surface plasmon (LSP) is a collective oscillation of the electrons confined inside metallic nanoparticles (NPs) or nanostructures and induced by the interaction with light. The LSP generation can have several effects on the local environment as the electrons are highly excited. It can induce local increase of the electromagnetic field (enhanced field) and of the temperature (thermoplasmonic effect) or generate the creation of hot electrons. As some catalytic reactions need a high temperature or an electron transfer to be initiated, both effects can be exploited to induce a LSP mediated catalytic reaction. As such, localized surface plasmon resonance (LSPR) mediated catalytic reactions can complement other alternative and non-traditional methods for accelerating catalytic reactions such as microwave heating, micellar catalysis. Thus, the overall aim of the **Cataplasm** project is to prepare new nanocatalysts from plasmonic NPs and nanosurfaces to initiate and accelerate the reaction kinetics of N-dealkylation of opioids that will lead to the biological inactivation of the latter. Thus, to reach the objectives, the project will be conducted as follows:

First, (i) the student will work with hybrid materials that consist of colloidal Au NPs onto which metal porphyrins are grafted. The catalytic properties of these nano-catalysts during their activation by plasmonic excitation will be evaluated through the N-dealkylation of model amines (such as tributylamine).

Second, (ii) he/she will prepare lithographied nanosurfaces functionalized by porphyrins. He/she will integrate those lithographied substrates into a microfluidic cell. Thus, He/she will study the irradiation of the solution to perform the N-dealkylation reaction and the reaction will be monitored directly inside the cell using Surface Enhanced Raman Spectroscopy (SERS) to detect, at very low concentration, the transformation of the N-alkylated amines around the nanosurfaces and the potential modification of the metal porphyrins. In other words, with such a tool, it will be possible to degrade molecules, under irradiation and through catalysis, while examining the catalytic mechanism involved *in situ*. At the end, the collected solution will be analyzed by GC-MS to be able to identify degraded aminated compounds and correlate those results with the SERS analysis. Finally, both colloidal and lithographied nanomaterials will benefit from the 3 plasmonic effects: thermal effect and maybe hot electrons for the N-dealkylation reaction and the field enhancement for the SERS detection. The influence of optical and plasmonic properties of nanocatalysts on the catalytic reaction will be determined (yield, kinetics, excitation wavelength).

Skills: The PhD student will perform synthetic organic reactions and coordination chemistry. Therefore, skills in fine organic chemistry are necessary (synthesis and characterizations). The coordinator will fully train the recruited student in required aspects of physical chemistry and nanoparticle synthesis. However, some knowledge of those fields would be appreciated.

Context:
The project is part of an interdisciplinary collaboration between two teams: one in Ceisam laboratory at Nantes University and one with IMMM laboratory at the Mans University. The recruited person will be located at the Ceisam laboratory and will have to travel to the IMMM laboratory. The research will be supervised by Clémence Queffélec and Yann Pellegrin (Ceisam) and Marc Lamy de la Chapelle (IMMM). Our US collaborator (Pr. A. Knight, Florida Institute of Technology) will actively participate to the project and internships in his laboratory will be encouraged.

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- The recruited person may realize experiments at the IMMM lab.
- The recruited person may have to move to different sites for meetings / congresses. This will be financed by an IEA project coordinated by C. Queffélec.

Starting date: 01/09/2022 or 01/10/2022