NIR-fueled Mechano-Photochemistry

Project context: *Photochemistry* and *Mechanochemistry*, both well-established components of the arsenal of the Green Chemistry, known respectively for selectivity issues, and for the reduced amounts of additives (solvents), have been now combined into the burgeoning field of *Mechano-Photochemistry*. However, most of the studies are based on conventional excitation with energetic light (UV or visible (blue)) therefore complying with the standard limitations of Photochemistry (i.e. Beer-Lambert law). [1] Irradiation with the poorly absorbed low-energy Near-InfraRed (NIR) circumvents this issue thanks to the "upconversion" phenomenon. New sensitizers, transforming NIR into higher energy one, have been made popular, such as the lanthanide-based upconverting nanoparticles (Ln-UCNP). Emissions spanning from 800 nm down to UV (310nm) can be easily achieved. Furthermore, Ln-UCNPs' photophysics depends on other physical parameters allowing the development of innovative optical nanosensors, such as the temperature[2] and the pressure[3]. Eventually UCNPs have
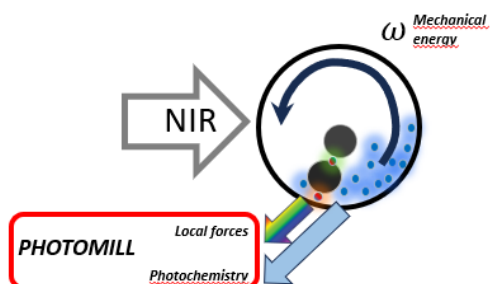
been used to trigger photocatalytic reactions.[4] Therefore the **Photomill project** funded by the french **Research Funding Agency (ANR)** aims *inter alia* at:

1. using up-converting nano-particles (UCNPs) as nano-lamps in solid-state mechanochemistry,
2. using UCNPs as local reporters for physicochemical parameters such as temperature and pressure

PhD-Project and objectives

The project of the PhD is to take benefit of the above-mentioned remarkable properties of Ln-UCNPs to reach the goals of mechano-photochemistry. Since the Softmat team is used to prepare and characterize Ln-UCNPs for various uses (from bioimaging to local photochemistry),[4] we have identified two main tasks to be addressed:

- The preparation of UV to blue light-producing UCNPs, based on thulium emitters and suitable to excite UV responsive photosensitizers, more specifically the photocatalysts explored in the Photomill project.
- The understanding and calibration of mechanosensitive UCNPs to analyze the energetics of the photochemical transformations.

Part of the work in particular the mechanochemical experiments will be done in tight partnership with IBMM and will require the PhD student to move to Montpellier for short term missions.

References

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https://pubs.acs.org/doi/10.1021/acscentsci.9b00300

Scientific environment

The **PhotoMill** project gathers 4 complementary partners, including **IBMM** (Pr. X. Bantreil Institut des Biomolécules Max Mousseron, Montpellier), **GBCM-CNAM** (Dr. Z Amarias, Department of Genomics, Bioinformatics and Molecular Chemistry, Conservatoire National des Arts et Métiers, St Denis), **Softmat** (Dr C . Coudret, Laboratoire Chimie des colloïdes, polymères & assemblages complexes, Toulouse) and **LNE-CNAM** (Dr L. Gevaux, Laboratoire Commun de Métrologie, Conservatoire National des Arts et Métiers, St Denis). This PhD will take place between the Softmat and IBMM laboratories

The laboratory of **Softmat** lab (Chemistry of colloids, polymers & complex assemblies) is dedicated to research into the **chemistry of soft matter**. It focuses on the design of organized systems made up of surfactants, polymers, bio-molecules or nanoparticles. Our skills in analytical chemistry, physical chemistry and photochemistry also enables us to accurately assess the structure/properties relationship of these responsive objects. This research is the subject of frequent collaborations with academic or industrial partners, and thus helps to meet the scientific and societal challenges of our time. The lab is based in the south of France, in the city of Toulouse. Have a look to our website: https://softmat.fr/en/

The **Institut des Biomolécules Max Mousseron** (IBMM) IBMM is nationally and internationally recognised for its work in the different classes of essential biomolecules: lipids, sugars, nucleosides and oligonucleotides, peptides and proteins, prebiotic molecules and biopolymers. IBMM displays its skills for integrated research, with the aim of understanding the mechanisms of life by designing molecules and systems useful for biology, medicine, and agriculture while developing green chemistry processes. In the IBMM, the Green Chemistry and Enabling Technologies team (www.greenchem.cnrs.fr) is located in the new Balard building on the CNRS Montpellier campus. The team has expertise in mechanochemistry (ball-milling and reactive extrusion), and access to the physical measurements laboratory (LMP) of UAR2041 PAC Balard.

Candidate profile, training and development
Complimentary expertise of the Softmat and IBMM laboratories will provide the candidate with a large panel of know-hows, from organic to inorganic colloids chemistry, from Nanosciences to Green Chemistry. Candidates should have a Master's degree in Chemistry. The skills required lie in the field of soft matter (inorganic and organic colloids) and organic chemistry. Scientific curiosity and social skills will be appreciated.

Application
Supervision: Christophe Coudret (Softmat) and Xavier Bantreil (IBMM)
Apply through the CNRS Job Offer portal: https://emploi.cnrs.fr/Offres.aspx
Expected start: October 2025.