Master 2 training period in polymer science at Le Mans (France) – 4 to 7 months

Stabilization of emulsions using self-assembled polymeric Janus nanoparticles for application in catalysis

Context and objectives of the project

Cascade reactions offer an elegant route to improve atom economy and minimize waste generation, as they involve a sequence of spontaneous transformations in one pot, leading directly to the final product. Some of these reactions, such as those relevant to biomass valorization, require the coexistence of antagonistic catalysts that must be spatially separated to prevent mutual deactivation. A promising strategy to achieve this consists of performing catalysis within water/oil emulsions stabilized by bifunctional **Janus nanoparticles** – particles that possess two faces with distinct chemical properties. These particles can simultaneously stabilize emulsions by going to the interface and catalyze multi-step reactions, while maintaining the separation of catalytic sites on opposite sides of the particle, each side being in contact with a different liquid phase.

Within the *CASCADUS* project (ANR 2025–2029), our team aims to design **catalytically active Janus polymer nanocylinders (JNCs)** with diameters around 10 nm and lengths ranging from 100 nm to 1 µm. Their high specific surface area will enhance catalytic efficiency, while their anisotropy will promote emulsion stability (Fig. 1). These nanoparticles will be obtained by supramolecular self-assembly in solution.

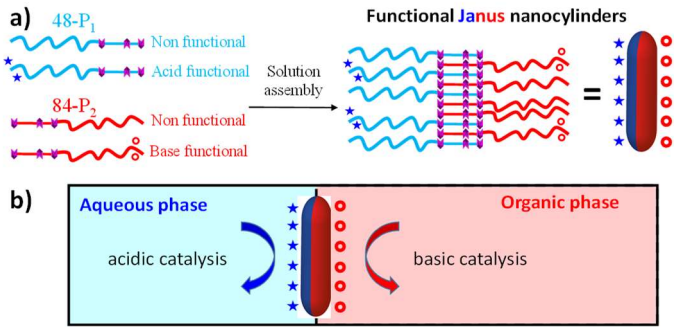

Figure 1. a) Preparation of Janus nanocylinders (JNC) by supramolecular self-assembly in solution; **b)** Use of JNC for stabilizing water/oil emulsions for catalytic applications.

Description of the M2 project

The objective of this Master 2 project is to prepare and characterize polymeric Janus nanocylinders (JNC) and to evaluate their performance in stabilizing water-in-oil emulsions.

Amphiphilic JNC will be synthesized via supramolecular assembly of functional polymeric building blocks using strong and cooperative hydrogen bonding, following established procedures. The synthesis of these polymers—already achieved by our collaborators in Paris (L. Bouteiller, S. Pensec, J. Rieger)— is not part of the present internship.

The nanocylinders will be characterized in aqueous and/or organic phases using **light and neutron scattering** and **transmission electron microscopy**. Their efficiency in stabilizing emulsions will be assessed through **macroscopic observation**, **turbidimetry** (under normal and accelerated gravity), and **confocal microscopy**.

The study will focus on understanding how various parameters — such as the oil phase composition, polymer structure, nanocylinder concentration, water/oil ratio, temperature, ionic strength, and emulsification method — influence droplet size distribution, emulsion stability, and coalescence behavior. Results will be interpreted in relation to the structure of the JNC, the affinity of the polymer arms towards each phase, as well as **measurements of interfacial tension** with and without JNC.

This internship will serve as a **gateway to a PhD thesis** continuing the *CASCADUS* project. A motivated and high-performing M2 student will have an excellent opportunity to be selected for the subsequent PhD position.

The ideal candidate will have a strong background in polymer science. Interest/background in nanostructured materials, supramolecular self-assembly and/or emulsion science is an asset but not mandatory. We are looking for a rigorous, curious, and team-oriented student eager to learn and collaborate across disciplines.

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Skills developped during the M2 project

Soft and General Skills

• Literature review and critical analysis

• Oral and written scientific communication

• Independent and collaborative work

• Rigorous scientific reasoning

Technical and Scientific Skills

• Characterization of polymers in solution and emulsion by static and dynamic light scattering, neutron scattering, confocal microscopy and LUMiSizer analysis.

• Experimental design and data interpretation in colloid and interface science

Location of the M2 training period : IMMM UMR CNRS 6283 - Institut des Molécules et Matériaux du Mans, Le Mans Université, Avenue Olivier Messiaen, 72085 LE MANS Cedex 09, France

https://immm.univ-lemans.fr/fr/index.html

Period: January-July 2026 (4 to 7 months, depending on availability).

Internship allowance : 550 €/month (gross)

Contacts :
Olivier COLOMBANI (olivier.colombani@univ-lemans.fr ; +33 2 43 83 33 15)
Erwan Nicol (erwan.nicol@univ-lemans.fr)
Frédéric Renou (frederic.renou@univ-lemans.fr)
Frédérick Niepceron (frederick.niepceron@univ-lemans.fr).

Application: Please send a CV, a cover letter describing your motivation and fit for this internship, your academic transcripts (M1 and M2 or equivalent), and at least one recommendation letter or reference contact.

Application deadline : January the 5th 2026