PhD Research Proposal Form
China Scholarship Council (CSC) - ENS Group

FIELD: Physics & Engineering

Thesis subject title: **Shear-induced aggregation in colloid polymer suspensions**

Name of the French doctoral school: ED 52 PHAST, Physique et Astrophysique

Name of the Research team: Soft Matter team / Divoux Lab
Website: https://www.divouxlab.cnrs.fr/

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Lab Language: English & French

Research Proposal Abstract: Colloidal gels are ubiquitous in major industries with applications such as colloidal crystals, energy storage devices, advanced ceramic materials, and biomaterials. They consist of polymer and/or nanoparticles in attractive interactions that form a percolated space-spanning structure, which confers to the gel solid-like elastic properties [1]. However, harnessing the interplay between the building blocks' properties (shape, size, surface chemistry, etc.) and that of the resulting gel remains an outstanding challenge for manufacturing a vast range of applied materials.

In a seminal work, Otsubo et al. reported that shear applied to colloid polymer mixtures stable at rest leads to forming gels in which the flexible polymer coils bridge particles [2,3]. Such shear-induced flocculation is evidenced at the macroscopic scale by a substantial increase of the suspension viscosity. However, if the phenomenon is robust and well documented, it still raises crucial fundamental issues about the physics at play during flow-microstructure interactions.

The goal of this thesis is twofold (i) to investigate the local scenario associated with the shear-induced gelation and (ii) to determine the microstructural and viscoelastic properties of these suspensions flocculated by polymer bridging. We will investigate silica colloids dispersed in water that bridge into long necklaces by adsorbing polyacrylamide. The candidate will determine the impact of shear history on shear-induced gelation and rationalize the existence of a critical shear rate beyond which the gelation occurs. In addition, the candidate will measure the linear viscoelastic properties of the shear-induced gel through mechanical spectroscopy. The goal will be to link the gel terminal viscoelastic properties to the shear history (intensity, duration, etc.). Finally, rheometry coupled with local measurements, e.g., ultrasonic imaging [4], will be crucial to unravel the local scenario associated with forming such gels, whose microstructure will be studied by Dynamic Light Scattering.

References:

[1] Cao & Mezzenga, *Nature Food* **1**, 106 (2020); Johnson *et al.*, *J. Rheol.* **63**, 583 (2019)
[2] Otsubo, *Langmuir* **6**, 114 (1990); Otsubo, *Langmuir* **10**, 1018 (1994)
[3] Kamibayashi, Ogura & Otsubo, *J. Colloid Interface Sci.* **321**, 294 (2008)
[4] Gallot, Perge, Grenard, Fardin, Taberlet & Manneville, Rev. Sci. Instrum. **84**, 045107 (2013)

Type of PhD:

1.Full PhD

- Joint PhD/cotutelle (leading to a double diploma): NO
- Regular PhD (leading to a single French diploma): YES

2. Visiting PhD (for students enrolled at a Chinese institution who will be invited to a French institution to carry out a mobility period): NO