ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title Optical probes for the measurement of viscosity in complex coacervates

Internship supervisor

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Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Mehdi Vahdati

Student profile looked for

Master program (*more than one box can be ticked*)	☒ Material science and engineering ☐ Chemistry ☒ Physics
Other indications if necessary	An open-minded, curious, and interactive student ready to work as part of a multidisciplinary research team. Interest in polymer physical chemistry, microscopy, and or rheology is a plus. Fluent communication in English is a requirement. No previous experience in confocal microscopy, rheology, or chemical synthesis is required.

Internship description

Context

Biomolecular condensates are micrometer-sized droplets that form in the cytosol due to the interactions between different biomolecules, in a process called liquid-liquid phase separation (LLPS). They are involved in a broad range of cellular processes, from RNA transcription to the formation of amyloid plaques during the development of neurological diseases [1]. It has been hypothesized that their mechanical properties (such as their viscosity) are connected to their function. However, condensates are normally not mechanically characterized – since not many techniques can measure the mechanical properties of liquids at such a small scale [2].

Fluorescent probes show great promise to study the mechanical properties of small volumes of liquid. For example, the viscosity of a medium can be calculated from the speed at which fluorescent molecules diffuse through it, or by the speed at which part of a fluorescent rotor can spin around a single bond [3]. Optical techniques such as these can be performed non-invasively in a confocal microscope, on very small amounts of sample, and in their native environment. However, calculating viscosity values from them requires several assumptions and simplifications. To continue using these techniques to characterize biomolecular condensates, they must be verified and calibrated against standard, bulk methods.

Objectives

In this project, the intern will work with complex coacervates as models for biomolecular condensates. Complex coacervates are droplets formed via LLPS due to the interactions between charged polyelectrolytes [4]. Unlike biomolecular condensates, complex coacervates can be easily prepared at a large scale and studied with standard techniques for materials. The intern will first prepare a series of complex coacervates, and characterize their mechanical properties using bulk techniques such as oscillatory and rotational rheology. Once that the mechanical properties of the different coacervates are well known, the intern will use fluorescent probes to calculate the viscosity of the same systems from confocal microscopy measurements. Comparing the outcome of both types of techniques will determine if the optical methods can be validated for this purpose, or if other factors also need to be taken into consideration.

References

[1] Banani, et. al. *Nature Reviews Molecular Cell Biology* 2017, 18 (5), 285–298; **[2]** Jawerth, et. al. *Physical Review Letters* 2018, 121 (25), 258101; **[3]** Paez-Perez, Kuimova, *Angewandte Chemie Int Ed* 2023, e202311233; **[4]** Vahdati, et. al. *Progress in Polymer Science* 2023, 139, 101649.