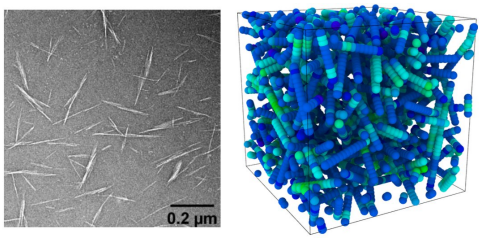
PhD Position : Modeling the rheology of cellulose nanocrystal hydrogels

Location : **3SR Lab**, CoMHet team, Grenoble, France

Mehdi Bouzid, Antoine Naillon and Laurent Orgéas

Project

Cellulose nanocrystals (CNC) are captivating nanoparticles extracted from plant biomass. These naturally bio-sourced derived nanocrystals are akin to slender rod-like bio-polymers of about 10 nm in diameter and 100 nm in length with tunable surface chemistry. When dispersed in a fluid such as water, they can self-assemble into micro and meso-structures that percolate to form a rigid network called hydrogel, with nanoscale pores that restrain water. These environmentally friendly new soft materials have numerous potential applications in the fields of civil engineering, health, foodstuff, electronics and robotics. In addition, CNC hydrogels are the parent materials to produce other interesting biosourced nanomaterials such as nanopapers with interesting barrier and optical properties, nanocomposites as well as architected materials such as ice-templated or 3D printed cellular structures with relevant specific mechanical properties for structural applications. In order to be properly used in the aforementioned applications, much effort has to be provided to better understand the complex rheology of CNC hydrogels. To address this challenge, in this PhD project, we will combine simulation, theory and rheometry to provide quantitative statistical insights into the elementary nanofibre scale mechanisms governing CNC networks formation and their rheological properties under shear and compression.



Left. SEM image showing the geometry of cellulose nanocrystals extracted from wood pulp. Right. Snapshot of simulation of rod-like colloidal particles.

Location and practical aspects

The successful candidate will benefit from the international outreach of the University of Grenoble Alpes and CNRS. The core of the thesis will be on computational and theoretical modeling at **laboratory Soils, Solids, Structures, Risks** (3SR Lab, https://3sr.univ-grenoble-alpes.fr/fr) in the "CoMHet" team gathering experts in the physics and mechanics of soft architectured and bio-mimetic materials.
In parallel, the PhD student will contribute to experiments. Starting date: November 2024 for a period of 3 years.

Profile and required skills

Candidates with academic backgrounds in statistical physics, soft matter, and materials science (mechanics of materials) are expected. Specific skills in numerical modeling will be strongly appreciated. Additional knowledge in polymer physics and colloidal materials will be interestingly examined. Interested candidates should send their **CV**, a **cover letter** and **official transcripts of the last two years** before **2024, May the 23rd** to M. Bouzid mehdi.bouzid@3sr-grenoble.fr, A. Naillon antoine.naillon@3sr-grenoble.fr and L. Orégas laurent.orgeas@3sr-grenoble.fr
Review of applications will start immediately.

References

[1] Bantawa, M., Keshavarz, B., Geri, M., Bouzid, M., Divoux, T., McKinley, G. H., & Del Gado, E. (2023). The hidden hierarchical nature of soft particulate gels. Nature Physics, 1-7.
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[3] Orgéas, L., Dumont, P. J., Martoïa, F., Marulier, C., Le Corre, S., & Caillerie, D. (2021). On the role of fibre bonds on the elasticity of low-density papers: a micro-mechanical approach. Cellulose, 28(15), 9919-9941.
[4] Martoïa, F., Dumont, P. J. J., Orgéas, L., Belgacem, M. N., & Putaux, J. L. (2016). Micro-mechanics of electrostatically stabilized suspensions of cellulose nanofibrils under steady state shear flow. Soft matter, 12(6), 1721-1735
[5] Orgéas, L., Gupta, S., Martoïa, F., & Dumont, P. J. (2022). Ice-templating hydrogels with high concentrations of cellulose nanofibers to produce architected cellular materials for structural applications. Materials & Design, 223, 111201.