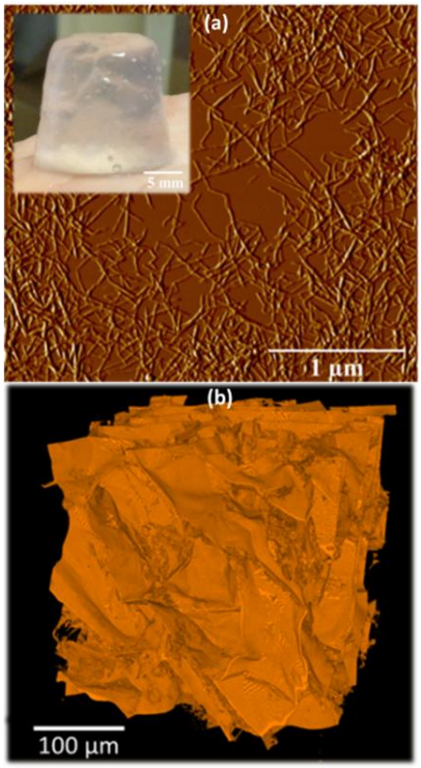
PhD Position

« Ice templating of gels of nanofibrils of cellulose (NFC) for the design of NFC cellular materials »

Project summary

Cellular materials such as foams (Fig b) or aerogels of nanofibrils of cellulose (NFC, Fig a) constitute novel low density bio-based materials with high mechanical and insulation properties and thus have a great potential in several engineering fields. They can be used in the automotive industry as heat/sound insulation systems, cores of structural sandwich composite panels, or for biomedical applications such as filters, scaffolds for tissues... NFC cellular materials can be obtained by ice templating, *i.e.*, by freezing colloidal and concentrated NFC aqueous suspensions (or gels, Fig a) and sublimation of the formed ice crystals (freeze-drying). The ice templating process has received considerable attention in recent years owing to its simplicity and to the wide variety of porous materials that this technique can provide. **However, in the case of NFC gels, growth mechanisms of ice crystals formed during the freezing phase, *i.e.*, when they squeeze and consolidate the remaining NFC gels up to very high NFC concentrations, are complex and still poorly understood**. This severely hinders the optimization of the microstructure of NFC cellular materials. **The main objective of the PhD Project is to better understand them**. For that purpose, various experimental analyses will be carried out to better understand (i) the rheology of concentrated NFC gels and (ii) the growth of ice crystals in the presence of these gels:



(a) AFM micrograph showing some NFCs. The inset illustates a typical NFC gel. (b) 3D micrograph of a NFC foam (X-ray microtomography, ESRF).

1. **Rheology of NFC gels** – NFC gels will be fabricated with various NFC types and concentrations (from the concentrated to the hyper-concentrated regimes). Their shear and compression rheology will be investigated to assess their elastoviscoplastic behavior (LaMCoS). Some rheometry experiments will be carried out with 3D *in situ* imaging of the mesoscale gel flow using X-ray microtomography (ESRF) and 3D digital image correlation (3SR Lab).
2. **Solidification of NFC gels –** Freezing experiments will be carried out with the aforementioned gels using well-chosen freezing conditions (3SR Lab / IGE / CNRM). The orientation and the morphology of ice-templated crystals will be analyzed using, respectively, cryo-EBSD (IGE in collaboration with Institut of Géosciences at Montpellier) and X-ray microtomography (ESRF) and dedicated image analysis procedure (CNRM, 3SR Lab). In addition novel freezing experiments will also be carried out with 3D *in situ* imaging (ESRF) to observe and analyze the ice crystal growth within NFC gels.

This PhD project will be part of a collaborative work between scientists from Univ. Grenoble Alpes and Univ. Lyon (France): Edward Ando, Christian Geindreau, Laurent Orgéas (supervisor), Sabine Rolland du Roscoat, (Laboratoire Sols, Solides, Structures, Risques / 3SR Lab, https://www.3sr-grenoble.fr/), Frédéric Flin (Centre National de Recherche Météorologique / CNRM, http://www.umr-cnrm.fr/), Maurine Montagnat and Armelle Philip (Institut des Géosciense et de l'Environnement / IGE, http://www.ige-grenoble.fr/), P. Dumont (co-supervisor) and F. Martoïa (Laboratoire de Mécanique des Structures et des Contacts / LaMCoS, http://lamcos.insa-lyon.fr/). The proposed research team gathers experts from (i) the rheology of NFC gels, (ii) the physics and the mechanics of ice crystals. This constitutes a valuable asset for the success of the project.

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Location and practical aspects

The successful applicant will be hosted:

- For approximately half the duration, by 3SR Lab in the “CoMHet” research group.
- For the rest of time, by the LaMCos (Oyonnax site).

The PhD fellowship offer is available from September 2017 for a duration of 3 years.

Qualifications of the applicant

Applicants must have a Master 2/ Master Thesis or an equivalent degree, when starting the PhD. We are looking for a candidate with good expertise in materials science and mechanics of materials, with a good experience with experimental methods. Expertise in the rheology of soft-glassy materials and/or bio-based materials will be a “plus”.

Applications

Interested applicants should send electronic applications to Laurent.Orgeas@3sr-grenoble.fr . The application documents should include a cover letter describing interests and qualifications for the position, a complete curriculum vitae including a details list of courses followed and marks obtained for the last 2 years and the names and e-mail addresses of two referees.