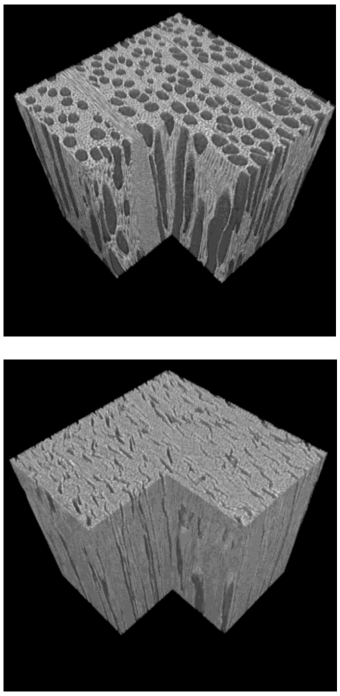
Postdoc Position

Delignified & Densified Wood:
Towards a novel architected bio-based material with high specific mechanical properties

Project summary

Designing sustainable, renewable, biodegradable and lightweight materials with high specific mechanical properties is of major importance, *e.g.*, for the aircraft, automotive and sports industries. Many research efforts are being developed purposely, in particular by looking for novel processing routes with fibrous materials extracted from the vegetal biomass. Among them, wood is a well-known relevant cellular material made of cellulose nanofibers, *i.e.*, slender crystalline building blocks with high mechanical properties (longitudinal elastic modulus and strength close 150 GPa and 2 TPa, respectively). Despite the low density of wood, the wood specific mechanical properties are not enough elevated for the aforementioned applications. Recently, some interesting studies proved that when properly combining a soft chemical treatment (to extract lignin from wood cell walls and to soften their hemicellulose) with a compaction (to close the lumen cells and wood vessels, see figure), it was possible to obtain densified wood samples with very high specific mechanical properties, *i.e.*, as high as some superalloys or structural fiber-reinforced polymer composites used for aircraft, automotive and sport applications. Up to date, however, only standard compression molding has been investigated and the resulting wood architectures exhibit chaotic cell wall ordering (see figure).



3D images (X-ray tomography) showing a typical cellular architecture of a beech wood sample before (upper micrograph) and after (lower micrograph) standard compression molding.

The main objective of the postdoc project is to explore novel densification routes to optimize the architectures of compressed wood cell and vessel walls towards higher specific mechanical properties of resulting densified woods. For that purpose, various experimental analyses will be carried out:

- ➯ Chemically treated wood samples will be subjected to various densification routes combining shear and compression loadings, by using a specific apparatus developed for geomaterials (BCR3D) under controlled environment (temperature, relative humidity).
- ➯ The densified microstructures will be analyzed using SEM and laboratory X-ray microtomography.
- ➯ The mechanical properties of densified woods will be investigated under tension, shear and bending loadings
- ➯ 3D imaging using synchrotron X-ray micro tomography (ESRF) will also be carried out for 3D *in situ* and real time observations of densification phenomena for the most relevant shear-compression loadings to finely analyze densification micro-mechanisms.

Work context and practical aspects

- ➯ **Context:** The proposed offer is part of a CNRS research project which includes two academic partners from CNRS and Univ. Grenoble Alpes, *i.e.*, 3SR lab and CERMAV. The recruited person will work within a research group of four senior researchers (C. Dano, Y. Nishiyama, L. Orgéas, S. Rolland du Roscoat) from these labs and one PhD student, experts in the fields of mechanics of materials, 3D imaging and glycoscience.
- ➯ **Location:** the postdoc project will be mainly located at 3SR Lab, a solids mechanics research lab of the CNRS and the Univ. Grenoble Alpes (Grenoble, France, https://3sr.univ-grenoble-alpes.fr/), with strong interactions with CERMAV. Some of the experiments will be carried out at the European Synchrotron Research Facilities (ESRF, Grenoble), *i.e.*, for mechanical tests with 3D *in situ* imaging using the X-ray tomographs of the BM18/BM05 beamlines.
- ➯ **Duration and starting date**: 12 months, October/November 2024
- ➯ **Salary**: around 2800€/month

Skills & Applications

- ➯ **Requested degree**: PhD in mechanics of materials or materials science
- ➯ **Keywords**: Bio-based materials, experimental mechanics, 2D/3D imaging for heterogeneous and/or fibrous and/or cellular materials
- ➯ **Contact**: laurent.orgeas@3sr-grenoble.fr