PhD offer 2024-2027

Optimizing fiber-fiber bonds in cellulose fiber mats: Towards new lightweight, stretchable and resistant papers to replace plastic and reduce natural resource consumption.

Thesis description. To address environmental challenges, it is imperative to drastically reduce the use of petroleum-derived polymers, particularly in the packaging sector. In this context, **paper** (Fig. 1) **represents an intriguing alternative, being bio-sourced, recyclable, and biodegradable**, provided it exhibits sufficient barrier properties, sealability, and/or **3D formability**. However, the 3D formability is significantly **constrained by the lack of paper ductility**. The mechanical strength of **fiber bonds** often limits the mechanical performance of papers. During the paper formation at the wet state, low-energy interactions (van der Waals, Coulomb, hydrogen bonds) develop between fibers when fibrous surfaces come into contact due to pressing and capillary forces generated by water films at fiber intersections (Fig. 2). Enhancing the mechanical strength of these bonding zones can be achieved **by increasing the fiber-fiber contact area** and promoting the development of Coulomb interactions and/or covalent bonds.

Fig. 1. Structure 3D du réseau fibreux d'un papier obtenue par microtomographie à rayons X.

The objective of the thesis is **to study and quantify the contributions of fiber properties** (morphology, chemical composition, surface charge density, flexibility modified by refining or surface chemical treatments) and process parameters (wet pressing, free/constrained drying) **to the increase in fiber-fiber contact area and drying shrinkage phenomena,** at all scales, **leveraging advanced experimental techniques** (mechanical tests and/or drying tests coupled with measurements of kinematic fields using digital image correlation, in-situ testing through X-ray microtomography and/or atomic force microscopy (AFM)).

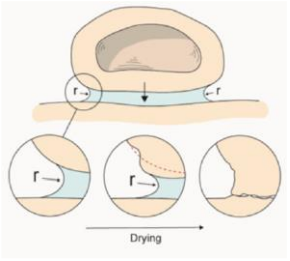

Fig. 2. Mécanismes de mise en contact des fibres sous l'effet des forces capillaires

Supervision and location. During their thesis, the candidate will work under the supervision of Pierre DUMONT and Florian MARTOIA at the Laboratory of Contact Mechanics and Structures (LaMCoS, INSA Lyon) located on the campus of INSA Lyon in Oyonnax (01), as well as with Jérémie VIGUIÉ at the Laboratory of Process Engineering for Biorefinery, Bio-based Materials, and Functional Printing (LGP2) located on the University Campus in Grenoble (38). The recruited individual will also collaborate with researchers from the Soils Solid Structures-Risks Laboratory (3SR Lab), the Research Center on Plant Macromolecules (CERMAV), and the Technical Center of Paper (CTP). The doctoral candidate will be primarily based on the Oyonnax campus, with travel or a several-month stay in Grenoble expected.

Qualifications of the candidate. The recruited candidate should hold a Master's degree (or equivalent) and possess skills in materials science, with a specialization in physics and/or mechanics. Knowledge of lignocellulosic fibrous materials would be advantageous.

Salary. ANR scholarship, approximately €2100 gross per month.
To apply. Please send your CV and cover letter via email to pierre.dumont@insa-lyon.fr, florian.martoia@insa-lyon.fr, and jeremie.viguie@lgp2.grenoble-inp.fr. Deadline: **May 15, 2024**.

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