

PhD position

REFOAM: Cellulosic foam insulation panels from paper and board recycling fibrous waste

Context and work environment

Context: Buildings use about 40% of Europe's total energy, with more than half dedicated to heating and cooling. Insulation is key to reducing energy demand, but most current materials, such as glass wool, rock wool, and polymer foams, are derived from non-renewable sources and are hard to recycle. Bio-based alternatives made from plant, animal, or mineral fibers represent only about 10% of the European market. Among them, cellulose wadding from recycled paper is efficient but cannot form rigid panels. Since paper fibers degrade after several recycling cycles, around 350,000 tons of cellulose-rich waste are discarded annually. The PhD project seeks **to transform this waste into 100% bio-based insulation panels using a liquid foam forming process**. This technique creates ultra-porous structures without synthetic binders, relying instead on natural fiber bonding during drying. The PhD will focus on optimizing several technical aspects. First, the foaming process will be refined by adjusting surfactant type, concentration, and mixing parameters to produce stable foams. Next, drainage and drying conditions will be optimized to maintain high porosity and ensure strong fiber bonding with minimal shrinkage. The PhD will also explore alternative, energy-efficient drying methods such as infrared or vacuum drying to cut energy use and processing time.

Work environment. The PhD will be carried out in two Tec21 labs located on the Grenoble Campus:

- [Laboratory of Process Engineering for Biorefinery, Bio-based Materials and Functional Printing](#) (LGP2), which is internationally recognized for its expertise in lignocellulosic fibers, nanocellulose, and the development of sustainable processes for converting plant biomass into industrial materials. The laboratory has extensive experience in liquid foam forming techniques for producing highly porous materials and their physical properties. It also demonstrates strong expertise in advanced multi-scale characterization of materials, including physico-chemical, structural, and mechanical analyses. LGP2 also has in-depth knowledge of recycled fiber properties and the valorization of papermaking residues.
- [Soils, Solids, Structures, Risks Laboratory](#) (3SR), which specializes in the experimental and numerical modeling of porous media across multiple scales. Its core expertise in mechanical behavior, imaging (e.g. microtomography), and advanced simulation tools makes it an ideal partner for understanding the relationships between foam structure, processing conditions, and macroscopic material properties.

Team description: The PhD will be carried out under the supervision of Dr. Jérémie Viguié (LGP2, Grenoble INP), an expert in design and characterization of lignocellulosic materials and Pr. Sabine Rolland du Roscoat (3SR, CNRS), an expert in multiphysics modelling and structural analysis using X-ray tomography. The research team will also include three other researchers: Dr. Cécile Sillard, Dr. Quentin Charlier and Pr. Julien Bras (LGP2, Grenoble INP), experts in cellulose-based and lignocellulosic materials, innovative bio-based and functional materials for sustainable applications.

This recruitment is part of the PhD@Tec21 Programme, co-funded by the Marie Skłodowska-Curie COFUND actions under grant agreement No. 101217261. The recruitment process follows a specific selection and evaluation procedure with particular eligibility criteria, all of which are detailed in the applicant guide available on [PhD@Tec21 Website](#).

Mission and main activities

Cellulosic foam insulation panels from paper and board recycling fibrous waste

Description of the project:

The project aims to valorize fibrous waste generated during the paper and board recycling process by converting it into 100% bio-based insulation panels using a liquid foam forming process. The targeted materials must exhibit thermal, mechanical, permeability and dimensional stability properties that are at least equivalent to those of commercially available plant fiber panels, whose fiber mat cohesion typically relies on a percentage of synthetic fibers or polymer-based binders. Additionally, the production costs must remain competitive with existing commercial insulation products. To meet these targets, the PhD will focus on several key technical and technological objectives. While all tasks are essential, the candidate will have the opportunity to place greater emphasis on specific aspects according to their interests or expertise.

Optimization of liquid foaming parameters: Identify and optimize key parameters in the liquid foaming process (such as the type and concentration of surfactant, mixing speed and duration, turbine geometry, and the use of thixotropic agents) to produce foams with high air content (60–80%), good stability, and optimal spatial and size distribution of air bubbles. This stage aims to better understand the interactions between process conditions and the formation behavior of liquid foams in suspensions of cellulosic fibrous waste.

Optimization of drainage & drying conditions: Determine the most effective drainage and drying strategies (e.g. filtration setup, drying temperature, energy input) to preserve the foam's high porosity while minimizing shrinkage and ensuring consolidation through the development of fiber-fiber bonding. The goal is to produce a homogeneous, ultra-porous solid foam (>95% porosity) with the required thermal insulation and mechanical performance, while maintaining energy-efficient processing.

Alternative drying strategies: Investigate innovative and energy-efficient alternatives to conventional drying methods. These may include infrared drying, vacuum drying, or accelerated airflows, with the aim of reducing processing time, energy consumption, and equipment costs, while preserving foam structure.

Environmental assessment: Conduct a preliminary life cycle assessment (LCA) to quantify the potential environmental benefits of replacing conventional insulation materials with panels, including reduced landfill burdens, renewable content and energy savings in production and use phases.

The PhD student will benefit from the extensive technical infrastructure already available at LGP2 and 3SR laboratories:

- **Foam generation & analysis:** High-shear mixers, foam analyzer, bubble size measurement tool.
- **Fiber & morphology characterization:** Morphological analyzer, tensiometer, rheometers, optical and electron microscopes (SEM).
- **Drying & mechanical testing:** Controlled drying chambers (oven, hot-air tunnel, infrared), mechanical presses, conductivity meters, climatic chambers.
- **Advanced imaging & modeling:** Access to X-ray microtomography for structural analysis, and computational resources for 3D modeling and simulation.

Research axes:

Two complementary research axes may be explored. The PhD candidate will have the opportunity to prioritize one of them based on their skills and interests:

1. A research axis could focus on establishing multiscale relationships between the characteristics of the fibrous feedstock (morphology, size distribution, chemical composition, presence of mineral fillers or residual additives), the properties of the liquid foam (air content, bubble size, rheological stability), and the performance of the final material (density, thermal conductivity, mechanical strength, and dimensional stability). The role of natural structuring or stabilizing agents, such as cellulose nanofibrils (CNF), lignin, or starch, will be studied in detail, particularly for their ability to enhance foam stability and favor consolidation.

2. A second research axis could focus on developing numerical modeling and simulation tools to relate pore structure (open vs. closed cells, tortuosity, porosity distribution) to thermal and moisture transport properties. These models will

offer predictive insights into how such ultra-porous bio-based materials behave under real-world conditions, helping guide future material design and process optimization.

Supervisors: Pr. Sabine Rolland du Roscoat, Dr. Jérémie Viguié

Research fields: Lignocellulosic fibers, Bio-based insulation materials, Liquid foam forming, Fibrous waste valorization, Porous structure characterization and modeling

Possible secondments (industrial or academic partners): Centre Technique du Papier or DS Smith

Doctoral school: [I-MEP2](#): Engineering - Materials, mechanics, environment, energy, processes, production

Desired profile and expected skills

Education, diplomas: Master's degree (or equivalent, MSc/Engineer) in one of the following fields:

- Materials science and engineering
- Paper science and bio-based materials
- Process engineering / chemical engineering
- Mechanical engineering (with knowledge of materials characterization)
- Physical chemistry or colloid science

Background in bio-based materials, cellulosic fibers or polymeric foams would be an asset.

Disciplinary skills, experience: Solid understanding of materials formulation and processing, especially involving fibrous or porous materials. Knowledge of foam formation (liquid foams, surfactants, rheology) or pulp/fiber suspension processing. Experience in one or more of the following areas:

- Drying, filtration, or consolidation processes
- Characterization of porous materials (e.g. density, porosity, mechanical or thermal properties)
- Microscopy or image analysis of fibrous structures
- Life Cycle Assessment (LCA) or environmental evaluation of materials (optional but valued)
- For the modeling-oriented research axis: familiarity with numerical modeling, simulation of transport phenomena, or structure–property relationships would be appreciated.

Personal skills

- Strong motivation for experimental research and interest in sustainable, bio-based materials.
- Scientific curiosity and analytical thinking, with the ability to link physical phenomena across different scales.
- Autonomy, rigor, and good organizational skills for experimental design and data analysis.
- Team spirit and good communication skills — ability to work in a multidisciplinary environment (materials, process, environmental sciences).

Employment benefits and conditions

Université Grenoble Alpes (UGA) is offering a 36-month full-time work contract. In line with the European Commission rules for Marie Skłodowska-Curie grant holders, the remuneration will consist of a gross monthly salary of 2,669 EUR. The estimated net salary to be perceived by the PhD fellow will be between 2,050 and 2,152 EUR¹. Benefits include:

- Access to a high-quality work environment, including a personal computer, scientific equipment and access to library and shared lab facilities
- Full social security benefits and participation to health insurance
- Access to high-level scientific and inter-sectoral training through 120 hours of doctoral courses and workshops

¹ As an average over the 3 years, depending on French tax regulations. Fellows might benefit from an additional allowance depending on their family situation (74 EUR monthly net allowance)

- Opportunity for 2-month secondments at an academic institution or industrial partner during the 2nd year of the PhD
- A vast choice of networking events and activities within the PhD@Tec21 Programme and through the international network of MSCA fellows
- Access to the UGA International Student Office, to assist the PhD fellows in searching for accommodation in Grenoble and support with administrative issues including visas, health, bank accounts, etc.
- Visa fees and registration to the UGA Doctoral School are covered by PhD@Tec21
- Sick leave, parental leave, 45 days of paid holidays
- Parental leave

General information

Contact for the questions related to the position:

PhD@Tec21 Management Board: guillaume.chambon@inrae.fr / amelie.bataille@univ-grenoble-alpes.fr