PhD offer: Towards bio-inspired thermoplastic composites: nanostructuration and interfaces (BIONANINT)

October 2026 – sept 2029

UCCS UMR CNRS 8181, Université de Lille - Polymers, Composites and Hybrids unit, IMT Mines

Context:

In nature, materials such as wood, bone, and tendon exhibit remarkable mechanical performance thanks to hierarchically organized structures in which nanostructuration and interfaces play a critical role in transferring stress [1,2]. Inspired by these natural systems, nanocomposites offer a promising route to design sustainable materials with enhanced performances. Among nanoparticles, nanocelluloses (nanofibrils and nanocrystals) are biobased and biodegradable nanoparticles derived from cellulose microfibrils, and are promising reinforcing agents for polymers [3]. The current issues related to the use of nanocelluloses in thermoplastic polymers are a poor dispersion and the quality of the nanocellulose/matrix interface**.** By controlling the surface chemistry of nanocelluloses [4,5], and hence their dispersion and interfacial adhesion with thermoplastic matrices, it is possible to tailor the mechanical properties of the composites. Then, those materials could be used for various applications (transport, packaging, energy…). However, many questions remain: in particular, what are the respective roles of nanostructuration and interfacial adhesion? Understanding and characterizing the polymer/nanoparticle interfacial behavior is thus essential to optimize their performance and achieve the strength and tenacity of natural materials.

PhD project description:

The objective of this thesis is to tailor the interface in a nanocomposite based on functionalized nanocelluloses and a thermoplastic matrix, in order to elucidate the role of nanostructuration and interfacial phenomena on the resulting thermo-mechanical performances of the composites.

To this end, the PhD candidate will be in charge of the following tasks:

1. Functionalization of the CNC or CNF by ring opening polymerization strategies in collaboration with *Pr Philippe Zinck at UCCS UMR CNRS 8181, Université de Lille* [4,5].
2. Elaboration of nanocomposites using solvent casting and melt processing, characterization of interfacial interactions with multi-scale microscopy observations and rheological analysis, and characterization of the thermo-

mechanical properties (tensile, impact) in the *Polymers, Composites and Hybrids unit, IMT Mines Alès.*

Collaborations with researchers in X-ray scattering techniques, molecular dynamics, mechanical modelling, and plant structural biology are being considered, thereby encouraging interdisciplinary research and promoting progress in the design of bio-inspired and sustainable materials.

Expected profile of the candidate

The candidate must be highly motivated by experimental work and have a background in Physical-Chemistry or Polymer Science at Master II / Engineer (or equivalent) level. Prior experience in rheology and polymer processing techniques is an asset. Excellent communication skills are required.

Laboratories / supervisors

- Pr Philippe Zinck (UCCS UMR CNRS 8181, Université de Lille) : 25%
- Dr Aurélie Taguet and Dr Nicolas Le Moigne (Polymers, Composites and Hybrids unit, IMT Mines Alès : 75%

The candidate will have the opportunity to join a team of multidisciplinary and motivated doctoral students. He or she will be required to write publications in English and present his or her work at national and international conferences.

How to apply?

You must apply on the "PhD.imt" platform by following this link: https://phd.imt.fr/en/formation/advanced-materials-and-eco-materials/1766412289-21-towards-bio-inspired-thermoplastic and simultaneously send an email containing your CV, cover letter, academic transcripts and letters of recommendation (if possible) at aurelie.taguet@mines-ales.fr and nicolas.le-moigne@mines-ales.fr

DEADLINE to apply: 2026, February the 15th

[1] Doineau E., Cathala B., Benezet J. C., Bras J., & **Le Moigne N.** (2021). Development of bio-inspired hierarchical fibres to tailor the fibre/matrix interphase in (bio) composites. Polymers, 13(5), 804.

[2] Zimmermann E. A., Schaible E., Gludovatz B., Schmidt F. N., Riedel C., Krause M., ... & Busse, B. (2016). Intrinsic mechanical behavior of femoral cortical bone in young, osteoporotic and bisphosphonate-treated individuals in low-and high energy fracture conditions. Scientific reports, 6(1), 21072.

[3] Banvillet G., Bugaut M., Doineau E**., Taguet A., Le Moigne N.,** and Rojas O.J. (2023). Advances in the Production of Cellulose Nanomaterials and Their Use in Engineering (Bio)Plastics. Springer Nature ed., pp. 333–393

[4] Lalanne-Tisné M., Mees M.A., Eyley S., **Zinck P.,** Thielemans W. (2020). Organocatalyzed ring opening polymerization of lactide from the surface of cellulose nanofibrils. Carbohydrate Polymers, 250, 116974.

[5] Lalanne-Tisné M., Eyley S., De Winter J., Favrelle-Huret A., Thielemans W., **Zinck P.** (2022). Cellulose nanocrystals modification by grafting from ring opening polymerization of a cyclic carbonate. Carbohydrate Polymers, 295, 119840.