Constructing complex multilayer stacks from sustainable materials with anisotropic properties

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Summary:

Nature has developed composite materials (*e.g.* plant cell walls and Arthropod exoskeleton) with complex and hierarchical organization from the nano- to the macro-scale via molecular assembly. Such materials often possess remarkable optical and/or mechanical properties by simply assembling hard and soft elements. The outstanding properties of these materials have prompted the fabrication of bio-inspired composites.
Among all methods available for the preparation of multifunctional nanostructured composite materials, Layer-by-Layer (LbL) assembly,[1] is currently one of the most simple and versatile nanofabrication method.[2] Recently, we have assembled isotropic and anisotropic transparent wood-inspired nano-composite materials with mechanical properties challenging even medium quality steel (Figure 1, middle).[2][3] The combination of LbL assembly with grazing incidence spraying (GIS)[4-6] has permitted us to extend our approach toward the preparation of complex (e.g. helical) multilayer films (Figure 1, right) in which the composition and orientation of anisotropic nano-objects like nanocelluloses can be controlled independently in each layer (Figure 1, left).

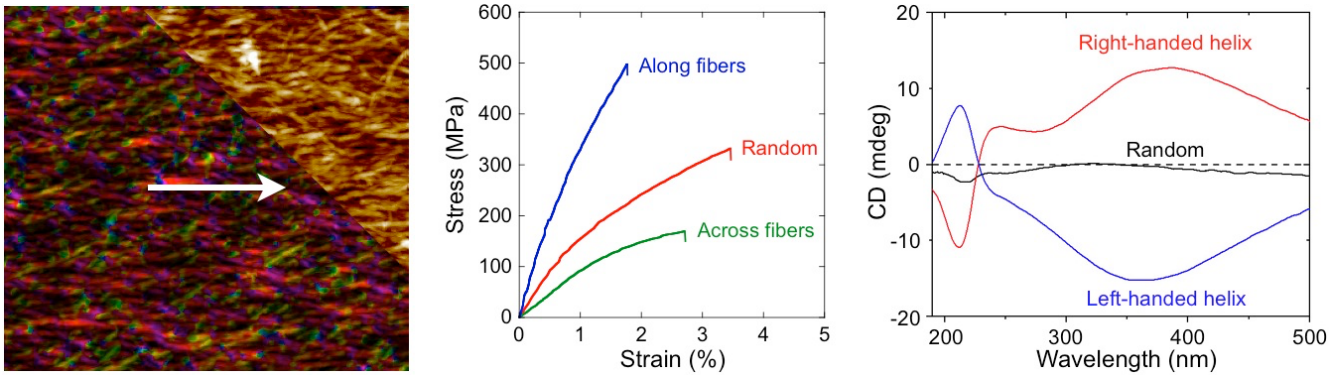

Figure. *(left) In-plane alignment of cellulose nanofibers deposited by GIS. (middle) Mechanical properties of random and oriented nanocomposite films. (right) CD spectra of random and helical films with opposite handedness.*

The goal of this internship is to study the preparation of nanocellulose-based composite materials using different deposition methods (dipping, spray-assisted, GIS, ...) and various surface analysis techniques (ellipsometry, UV-vis spectroscopy, …) and their optical and mechanical properties. The performance of these materials will be determined by advanced mechanical and optical characterization tools as a function of their composition and structure, the orientation of reinforcing agents, and the experimental conditions. This work will involve the PECMAT and MIM teams at Institut Charles Sadron (Strasbourg, France) and a collaboration with the CERMAV (Grenoble, France) and LCP-A2MC (Metz, France).

[1] G. Decher *Science* **1997**, *277,* 1232.
[2] R. Merindol, S. Diabang, O. Felix, T. Roland, C. Gauthier, G. Decher *ACS Nano* **2015**, *9*, 1127.
[3] R. Merindol *et al. ACS Nano* **2020**, *14*, 16525.
[4] R. Blell, X. Lin, T. Lindström, M. Ankerfors, M. Pauly, O. Felix, G. Decher, *ACS Nano* **2017**, 11, 84.
[5] R. Mujica *et al. Compos. Sci. Technol.* **2023**, *233*, 109889.
[6] R. Mujica *et al. Adv. Mater.* **2024**, *36*, 2401742.

Requirements & Application:

We are looking for a highly motivated master student having a formation in physical chemistry, chemical engineering or materials science and preferably with skills and/or interests in the following areas: materials, physical chemistry, thin layers, polymers and surfaces.
Please address your application (CV, motivation letter, copy of recent grades) to Olivier Félix (olivier.felix@ics-cnrs.unistra.fr).

This proposal can be sent to students abroad.