Hierarchical nanocomposite materials with anisotropic properties

Directeur de these : Olivier FELIX
Institut Charles Sadron, 23, rue du Loess, 67034 Strasbourg
Tel : 03 88 41 40 67 ; e-mail : olivier.felix@ics-cnrs.unistra.fr

The remarkable properties of natural composite materials (e.g. plant cell wall, animal exoskeleton) have attracted a wealth of research to understand their structure-properties relations at all length scales and to design novel materials with superior performance. However, while nature masters the organization of anisotropic nano-objects like nanocelluloses into complex superstructures, the development of synthetic nanocomposite materials with complex and precisely controlled architectures (e.g. helical) has proven to be difficult due to the lack of suitable approaches for their preparation.
With respect to the preparation of multimaterial thin films with a high level of control over the spatial positioning of their constituents, Layer-by-Layer (LbL) assembly [1,2] has gained its merits as a simple and highly versatile nanofabrication method. While the sequence of components in layered multimaterial films can be very well controlled by LbL-assembly, tuning of the in-plane anisotropy has not yet been achieved. Recently, we have introduced a method called “Grazing Incidence Spraying” for the in-plane alignment of anisotropic nanoparticles (cellulose nanofibrils, metallic nanowires, …) on large areas [3,4]. Its combination with the LbL-approach permits to extend it toward the preparation of complex (e.g. helical) multilayer films in which the composition and orientation can be controlled independently in each layer.

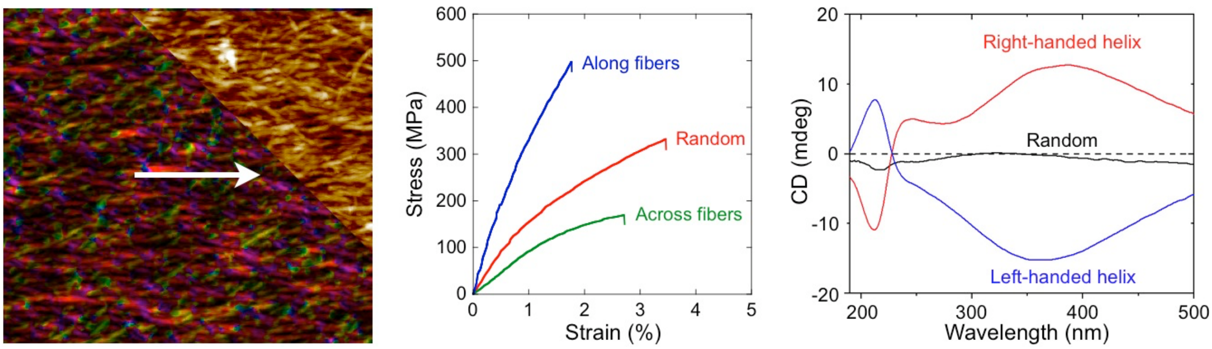

Figure 1 : (left) In-plane alignment of cellulose nanofibrils by GIS. (center) Tensile properties of random and oriented nano-composites. (right) CD spectra of random and helically oriented films.

The PhD thesis will focus on (i) the fabrication and physico-chemical characterization of complex anisotropic nano-hybrid thin films combining nanocelluloses with soft polymer building blocks and (ii) the investigation of their optical (transparency, birefringence and dichroism) and mechanical properties. It will be interesting to study (i) how the nature, the aspect-ratio, the orientation and the properties of the nano-objets will influence the macroscopic optical and mechanical properties of the assembled nanocomposite materials, and (ii) how the film architecture (e.g. crisscross, helical) will modify their physical properties.

[1] G. Decher, Science **277**, 1232 (1997).
[2] R. Merindol, S. Diabang, O. Felix, T. Roland, C. Gauthier, G. Decher, ACS Nano **9**, 1127 (2015).
[3] R. Blell, X. Lin, T. Lindström, M. Ankerfors, M. Pauly, O. Felix, G. Decher, ACS Nano **11**, 84 (2017).
[4] H. Hu, M. Pauly, O. Felix, G. Decher, Nanoscale, **9**, 1307 (2017).
[5] Merindol, R.; Diabang, S.; Mujica, R.; Le Houerou, V.; Roland, T.; Gauthier, C.; Decher, G.; Felix, O. *ACS Nano*, ***14***, 16525 (2020).