**Understanding the nanoscale correlation between morpho-chemical, mechanical and optical properties of plant cell walls toward biofuel applications**

*3 years fellowship for a PhD student supported by the Excellence Initiative of Aix Marseille University starting October 2018*

Fundamental studies of plant cell walls are important for a better understanding of the plant response to its environment as a result of induced force fields, chemical and radiation exposure, and thermal effects. The correlation between the molecular traits of the cell walls and its morphological, mechanical and optical characteristics is ultimately expressed in the plant response. As a result, how such molecular scale variations in the physical quantities of the cell walls translate into the bulk level and on to the whole organism level is not well understood.

In addition to result from the complex arrangement of polymers (mainly lignin, cellulose and hemi-cellulose), wood is a highly heterogeneous and anisotropic material with specific orientations highly dependent on the tree growth. Moreover specialized tissues, called **reaction wood**, are formed in reaction to physical stresses upon the stem or branch to bend during growth, causing variations in wood physical and chemical properties (ratios of wood polymers) along specific stress directions. For example, the mechanical properties are largely influenced by the wood orientations and irregularities of growth. In this project, **we will investigate the morphological, chemical, mechanical and optical properties of wood sheets constraint to abiotic stresses** directly acting on the tree/branch growth.
We will study the plant cell walls for their 1) molecular distribution and heterogeneity, 2) morphology, 3) mechanical properties, and 4) optical properties, with the goal of obtaining a correlation among these studies. Evolution of wood changes over growth stages while applying constant weight will be monitored.

Our specific goal is to understand what role each polymer plays in the nanoscale elasticity and plasticity of the cell walls. In our consortium, we showed that atomic force microscopy (AFM) and derived techniques can provide morpho-chemical and mechanical properties of the cell walls. Using these tools we propose among other mechanisms to study the role of lignin loss in cellular elasticity, plasticity, adhesion energy at the length scale relevant to cell wall domain transitions and molecular diversity.

According to the objectives different tasks will fall for the PhD student.

- Setting the green house for growth of poplar tree from the young sprout.
- Setting controlled abiotic stresses
- Study by AFM and QFM (quantitative force measurement) of normal and reaction wood over time growth
- Study by MS-AFM (Mode synthesized AFM) of the same sets of samples.
- Reflection and transmission optical measurements.
- SEM imaging of the samples.

**Expected profile of the candidate:** The candidate should have a background in physics and nanoscience and general interests in biomass, biofuels and plant morphogenesis. He or she should also combine a large interest for experimental techniques such as atomic force microscopy, optics, … and other techniques linked to nanoscience. The project involves trainings abroad implying flexibility and adaptability for the candidate. Finally, the candidate should be motivated and appreciate teamwork.

**Consortium:** Anne Charrier (CINaM) and Aude Lereu (Institut Fresnel) are co-advisors. Ali Passian and Brian Davidson (Oak Ridge National Lab, Tennessee) are partners. The candidate will spend some time within the group of A. Passian at ORNL.

**Related publications**


1. A. L. Lereu, A. Charrier, et al., To be submitted to Biomass and bioenergy (2018)
2. R. H. Farahi, A. L. Lereu, A. Charrier, et al., Submitted to Nature Communication (Mars 2018)
3. A. Charrier, A. L. Lereu, et al., Frontiers in Energy Research, section Bioenergy and Biofuels (2018)
4. R. H. Farahi, A. Charrier, A. Tolbert, A. L. Lereu, et al, . Sci. Report 7, 152 (2017)
5. L. Tetard, et al, A. Passian, Nat. Nanotech. 3, 501 (2008) & 5, 105 (2010) & 10, 870 (2015)
6. E. Lefèvre, et al, A. Charrier, Comp. Methods in Biomech. and Biomed. Eng. 16, 337 (2013)
7. L. Tetard, A. Passian, et al., A. L. Lereu, and T. Thundat, Nanotechnology 22, 465702 (2011)


**CONTACTS**


**Aude Lereu**, CNRS, Institut Fresnel, Marseille. aude.lereu@fresnel.fr

**Anne Charrier**, CNRS Centre interdisciplinaire de nanoscience de Marseille. charrier@cinam.univ-mrs.fr