Composition dependent Equation of State of Cellulose Based Plant Tissues

L. Bertinetti¹, A. Barbetta¹–², M. Harrington¹, N. Horbelt¹, T. Zemb²

¹Max Planck Institute of Colloids and Interfaces, Department of Biomaterials, Research Campus Golm, 14424 Potsdam
²Institut de Chimie Séparative de Marcoule, UMR5257, CEA/CNRS/UM/ENSCM, 30207 Bagnols–sur–Cèze (France)

*luca.bertinetti@mpikg.mpg.de

Wood consists of parallel cylindrical cells. Cell walls so-called "wood materials" are constituted by a complex, highly anisotropic and hierarchically organized nanocomposite, characterized by stiff crystalline cellulose nanofibers, parallel to each other, embedded in a softer and less anisotropic matrix of hemicelluloses and lignin. This matrix is hygroscopic, and it swells with increasing humidity. Consequently, wood cells undergo large dimensional changes.

We developed a minimal model of wood secondary cell walls to predict water absorption, in the form of an Equation of State (EOS) that represents water sorption isotherm in wood and osmotic pressure variations versus swelling. Starting from compositional and structural considerations, and including chemical and mechanical terms, modelization leads to a multi-scale force balance, in which molecular and macroscopic forces between wood building blocks that are responsible for the solvent uptake are independently considered and then balanced.

In the present communication, we will compare the expected experimental EOS (i.e pressure vs distance) in four different cases: 1) the standard compression wood, 2) the hemicellulose-rich example found in mistletoe berries from Viscum album, 3) the lignin-rich example composed by coir fibers, 4) with synthetic cellulose gel made of osmotically compressed cellulose crystals, separated by aqueous solution without lignin or hemimethylcellulose.

Figure 1 Swelling in terms of center-to-center distance of cellulose nanocrystals as a function of osmotic pressure (OP): experimental data of mistletoe (black dots) and calculated model of compression wood (black line)