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Experimental characterization of hydrogel swelling under plant cell wall environment

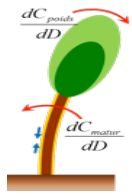
C. Assor[a], T. Alméras[b], F. Quignard[c], O. Arnould[b]

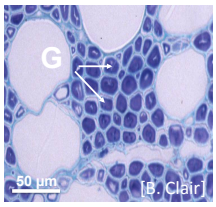
Context

Characterization of molecular mechanisms responsible of wood maturation growth stress

Biomechanic functions of tension wood: weight increase balance and plant orientation control

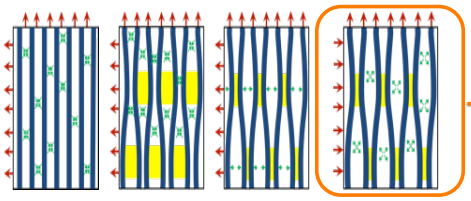
Wood tension





Cell wall structure: specific gelatinous G-layer

Discrimination of molecular mechanisms producing tissue stress:

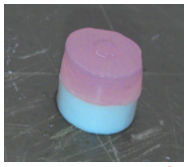


consistent with experimental observations: cellulose longitudinal tension and transverse compression

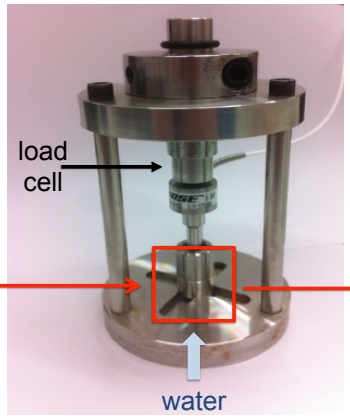
Crystalline cellulose

Amorphous matrix swelling

Materiel and methods



10 mm



-Vertical displacement is locked

-Force due to the "swelling" of the gel is measured continuously

confined chamber

-6 mL of water-dissolved alginates (1, 2 or 3%, dw) are enclosed in a 15 mm diameter dialysis membrane and immersed in 35 mL of 0.1 M $CaCl_2$

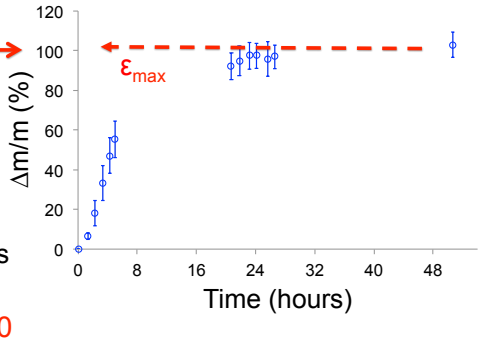
-After 24h, hydrogels are cleaned 3x with distilled water and 10 mm disks are sampled from them

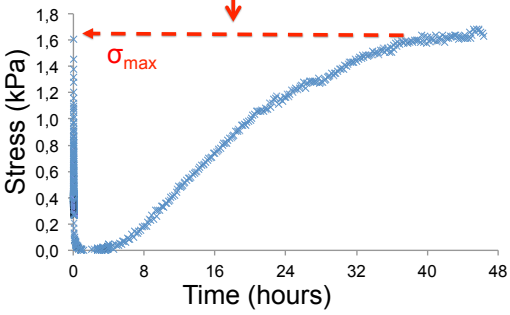
Results

In parallel, free swelling of hydrogels in water is characterised:

-linear correlation between volume and mass variations of samples

swelling = $(\Delta m/m_0)x100$





Effect of alginate content on hygromechanical properties: free swelling strain and confined swelling stress; elastic shear modulus (rheometer, 0.02-0.1 Hz)

Alginate (%, dw)	ε_{max} (%)	σ_{max} (kPa)	G' (kPa)
1	129	0.71	10
2	103	1.60	41
3	51	1.75	86

Conclusions and perspectives

-The confined swelling stress could more correspond to an osmotic pressure. Additional tests will be established with different alginates structures to characterize the origin of the stress developed.

-The 0.2% deformation of crystalline cellulose estimated within the G-layer require a lateral compressive stress from the matrix closed to 1 MPa, that could not be reached by the osmotic pressure. From these experimental results, it appears that the confined chamber is too stiff as the matrix needs to be less confined to produce a sufficient swelling stress.

-Nano hydrogels could allow to raise a polymer ratio around 20% that would be a more realistic G-layer analog and would allow to study cellulose/matrice interactions.

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