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Mechanical properties of cork: effect of hydration

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Context

The use of cork as sealing for wine bottles is due to its low permeability to liquids and gases, imputrescibility and good mechanical properties, in particular its remarkable elasticity [1-2]. Although being used since centuries, its properties are not well characterized.

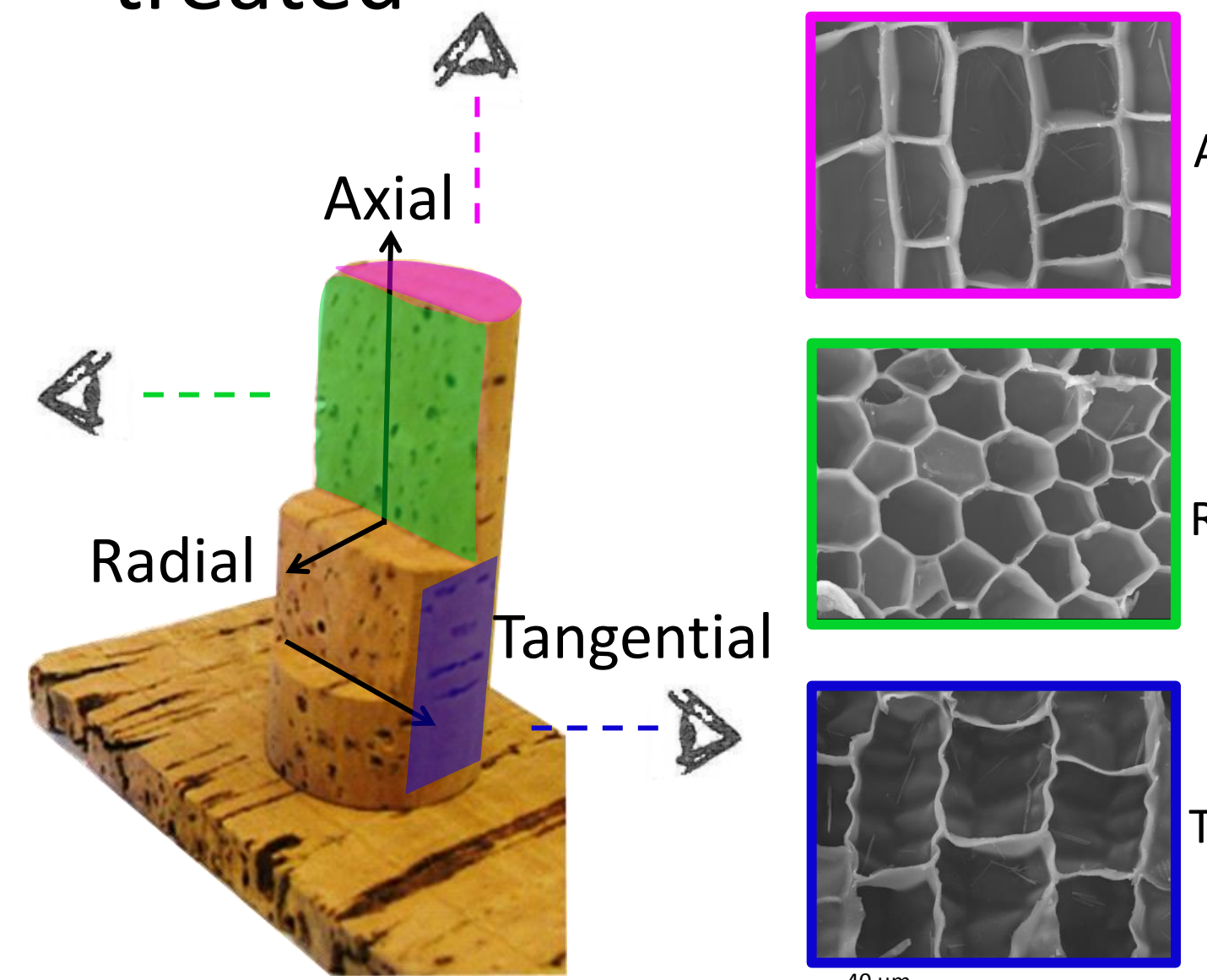
Objectives

- To determine the mechanical properties of cork along the radial and tangential directions (which corresponds to the compression in a bottleneck)
- To study the effect of hydration on mechanical properties of cork

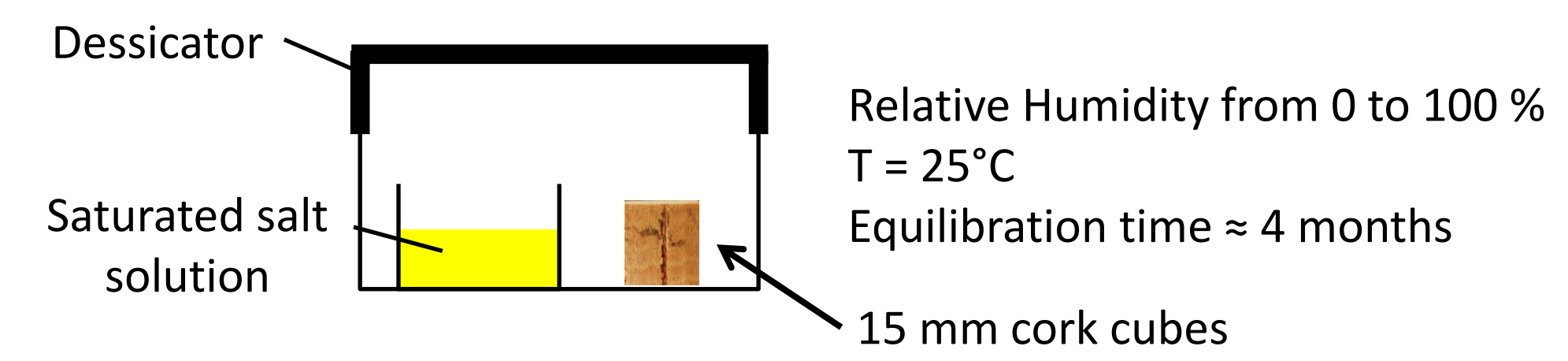
Materials & Methods

Cork

- Species: *Quercus suber* L.
- Origin: Portugal
- High quality (class 0)
- Neither washed nor surface treated



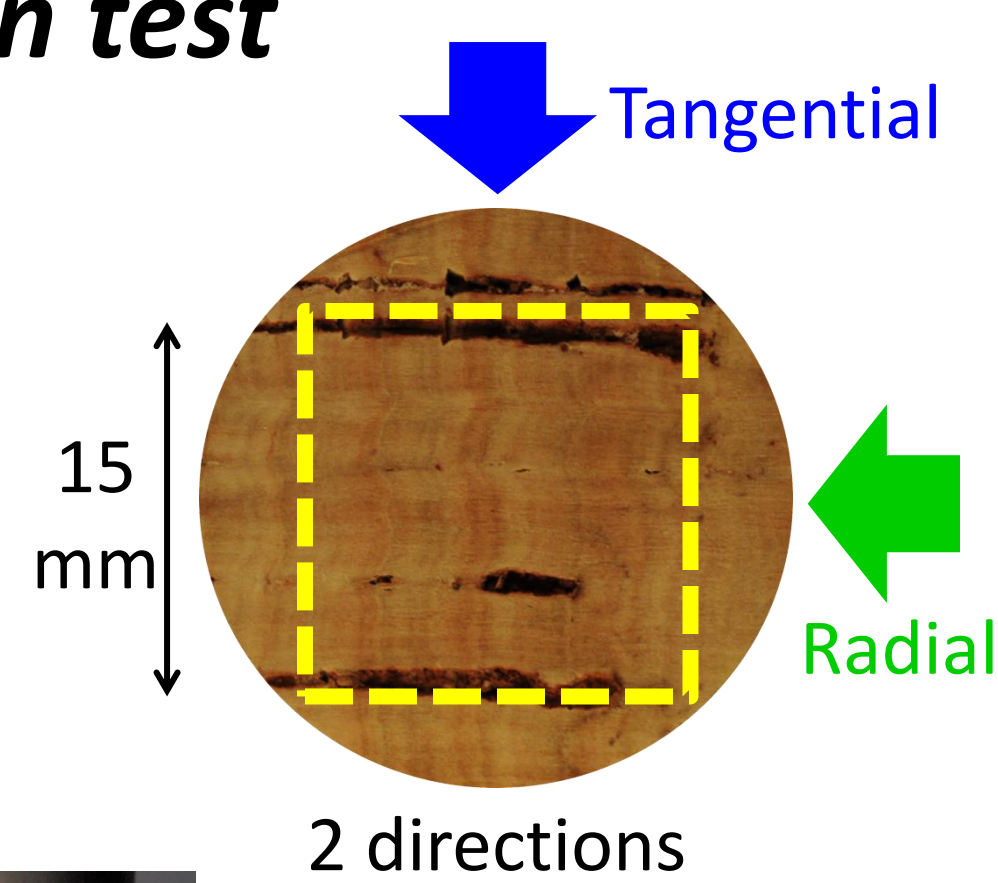
Sample preparation



Compression test

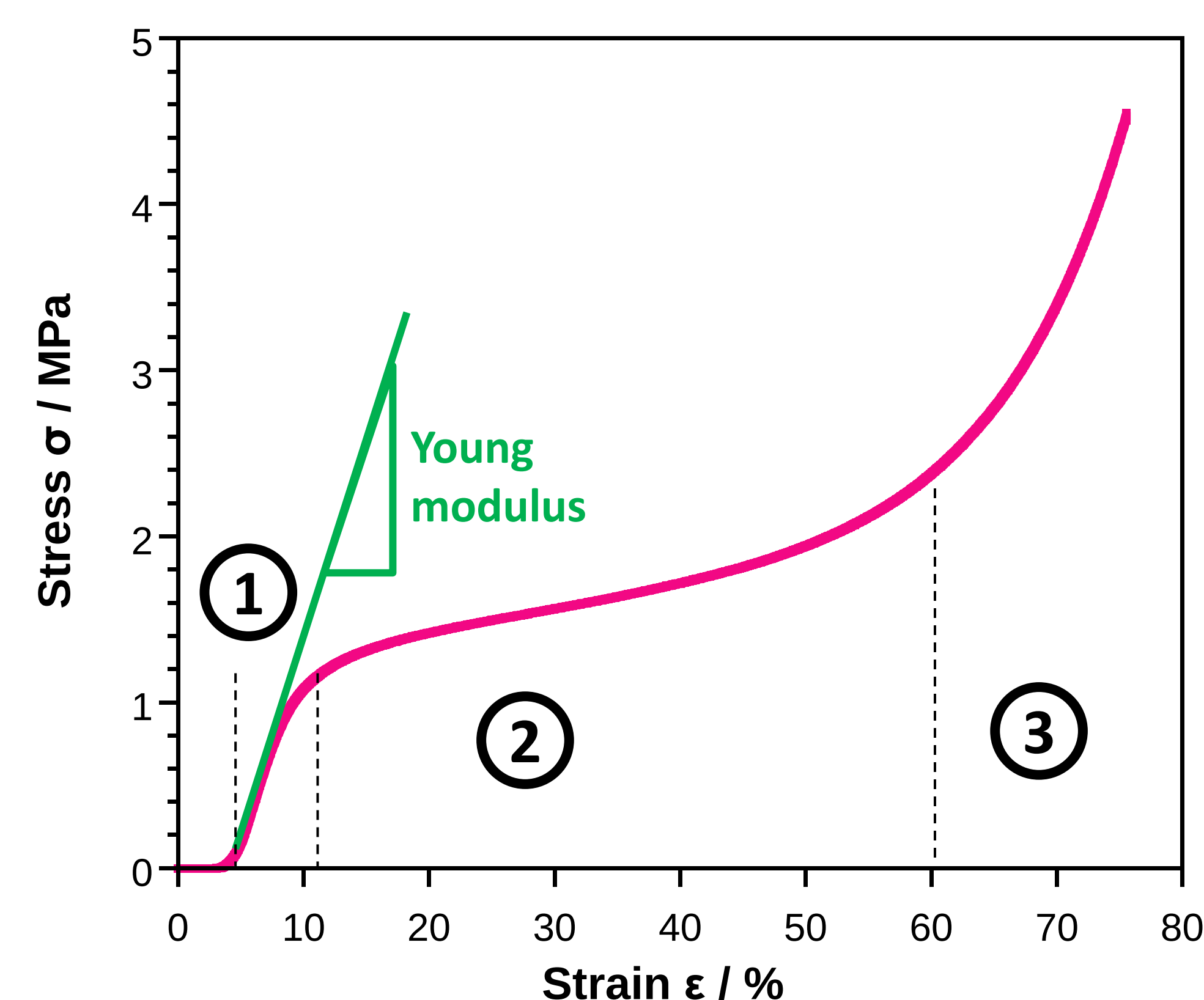
TA-HD⁺

Deformation: 80 %
Test speed: 1 mm.s⁻¹



Results

Cork under compression



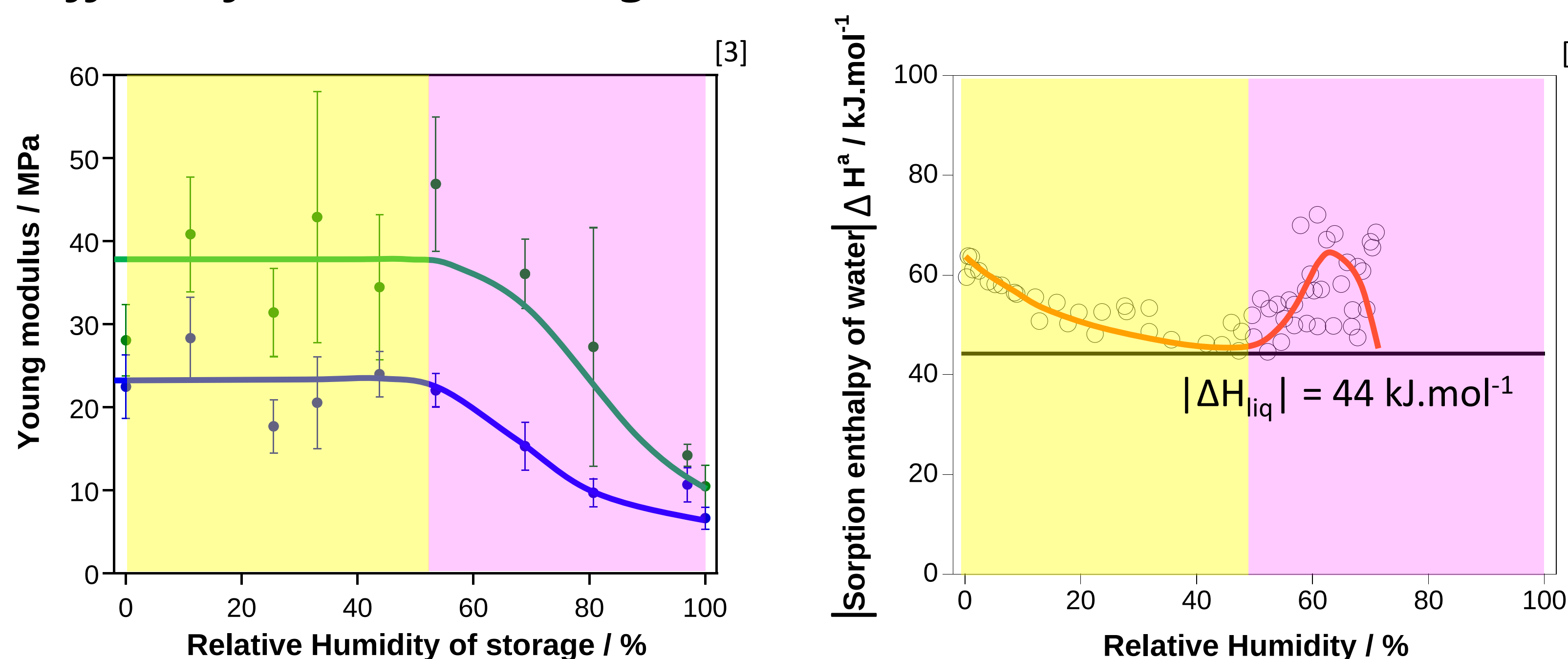
→ Typical strain/stress curve: 3 regions

- Elastic region
- Progressive buckling of cell walls
- Buckling of cell walls

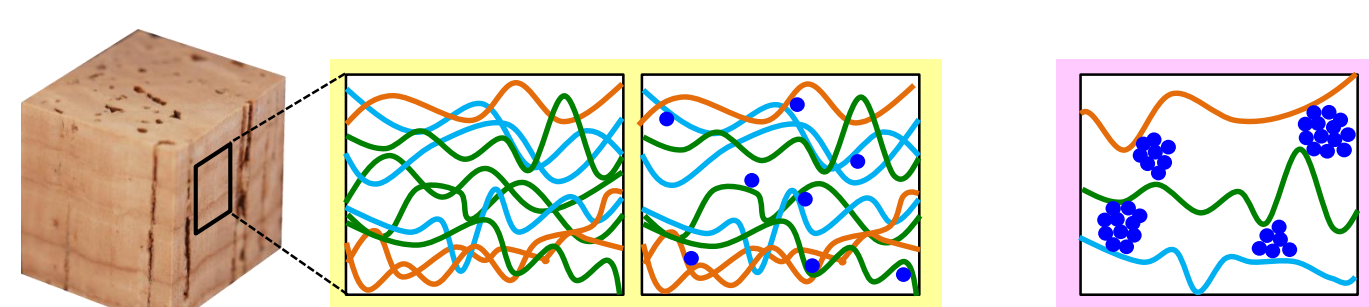
Young modulus calculation

$$E = \frac{\sigma}{\epsilon}$$

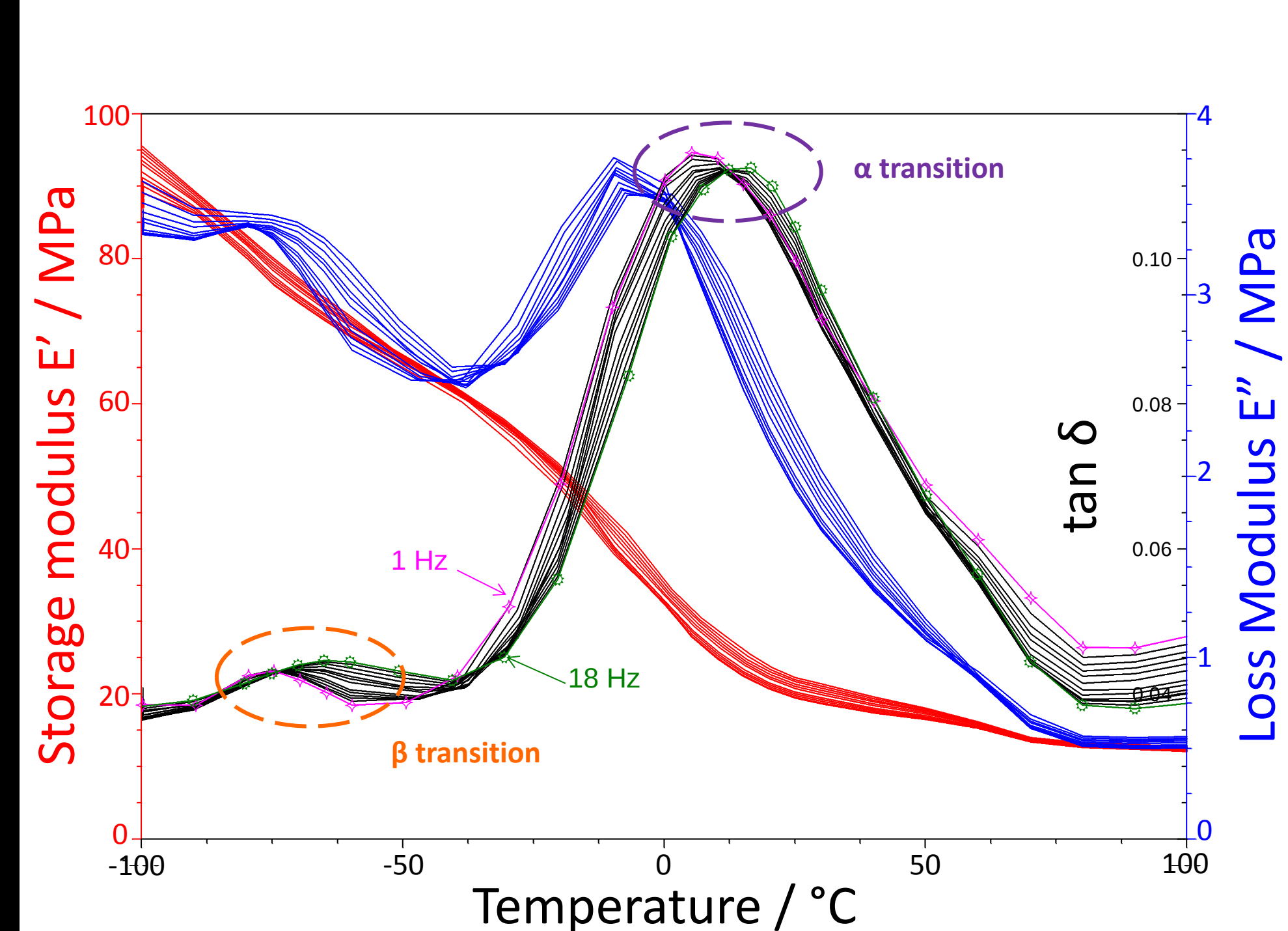
Effect of water on Young modulus



→ Rigidity: - radial > tangential
- < 50% RH: no change
- > 50% RH: decrease



Dynamic mechanical and thermal analysis

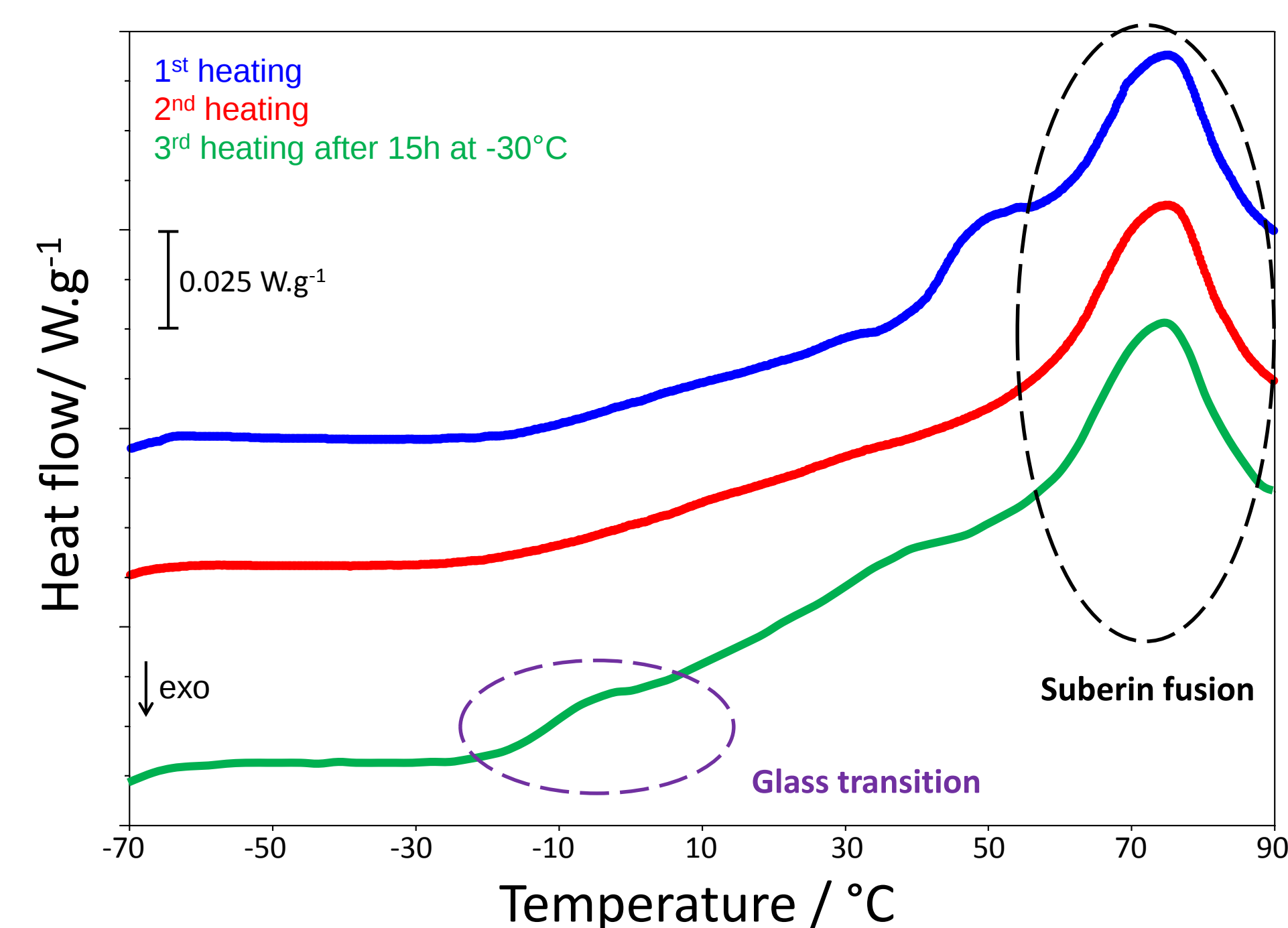


$$\tan \delta = \frac{E''}{E'}$$

→ Shift of $\tan \delta$ for different frequencies:

- α transition
 $0 < T < 20^\circ\text{C}$
- β transition
 $-80 < T < -60^\circ\text{C}$

Differential scanning calorimetry



→ Glass transition
 $T_g \approx -10^\circ\text{C}$
→ Suberin fusion
 $T_f \approx 80^\circ\text{C}$

Conclusion

Mechanical properties of cork are highly dependent on the hydration state of the material. While Young's modulus remained constant below 50% RH, a decrease was noticed for higher RH, due to clustering of water molecules. Altogether, our results showed for the first time that environmental parameters associated with the use of cork, can have significant impact on the mechanical properties of this wine sealer.

References

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