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► To cite this version:

Aurélie Lagorce-Tachon, Thomas Karbowiak, Dominique Champion, Régis D. Gougeon, Jean-Pierre Bellat. Mechanical Properties of Cork: Effect of Hydration. World Automation Congress (WAC 2014), Mar 2014, Beaune, France. 2014. hal-04255494

HAL Id: hal-04255494

<https://u-bourgogne.hal.science/hal-04255494>

Submitted on 24 Oct 2023

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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].

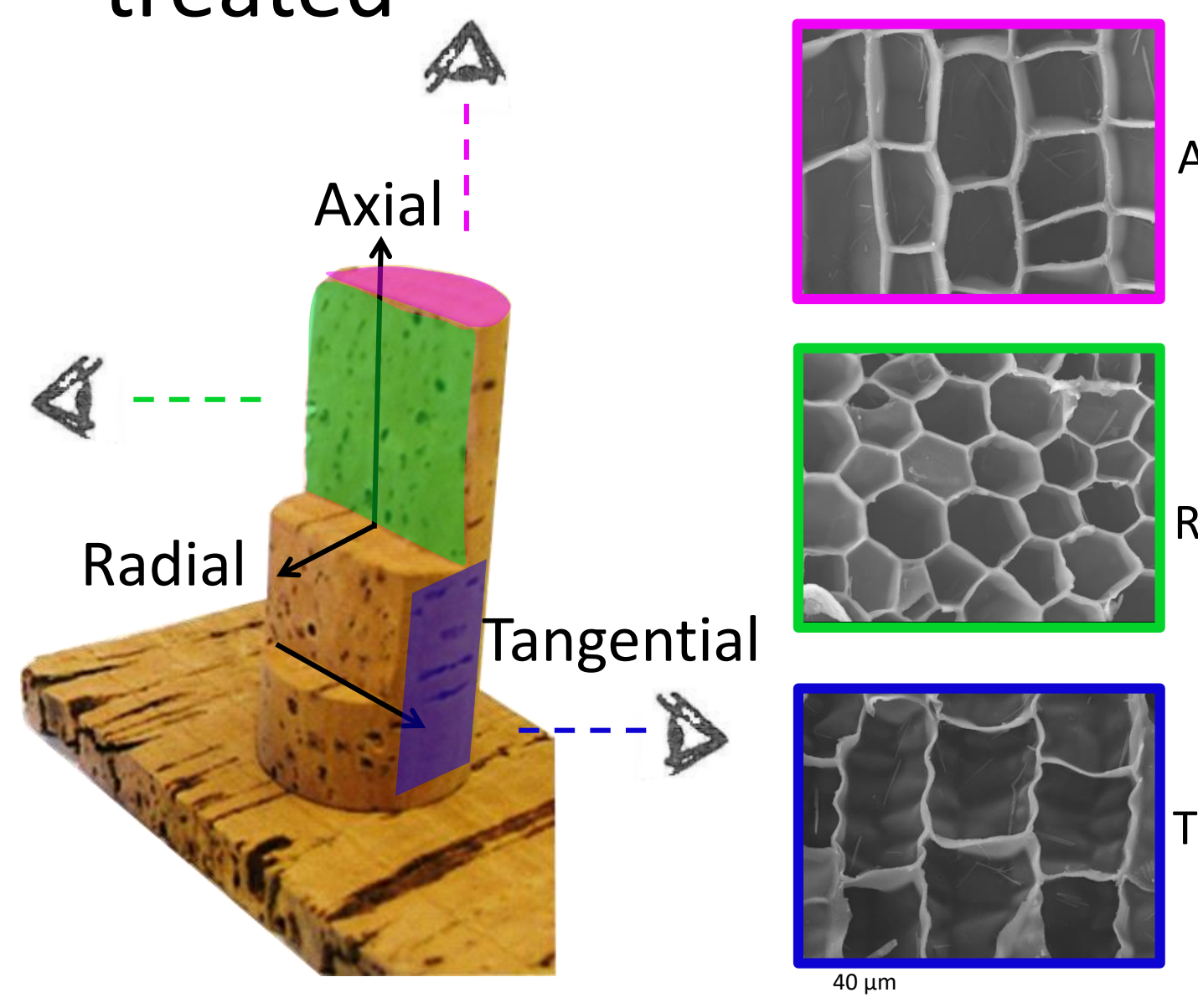
Objectives

- To determine 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

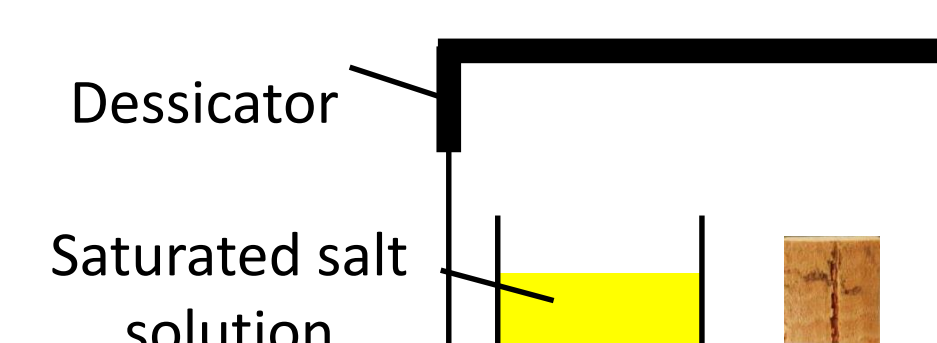
Materials & Methods

Cork

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



Sample preparation



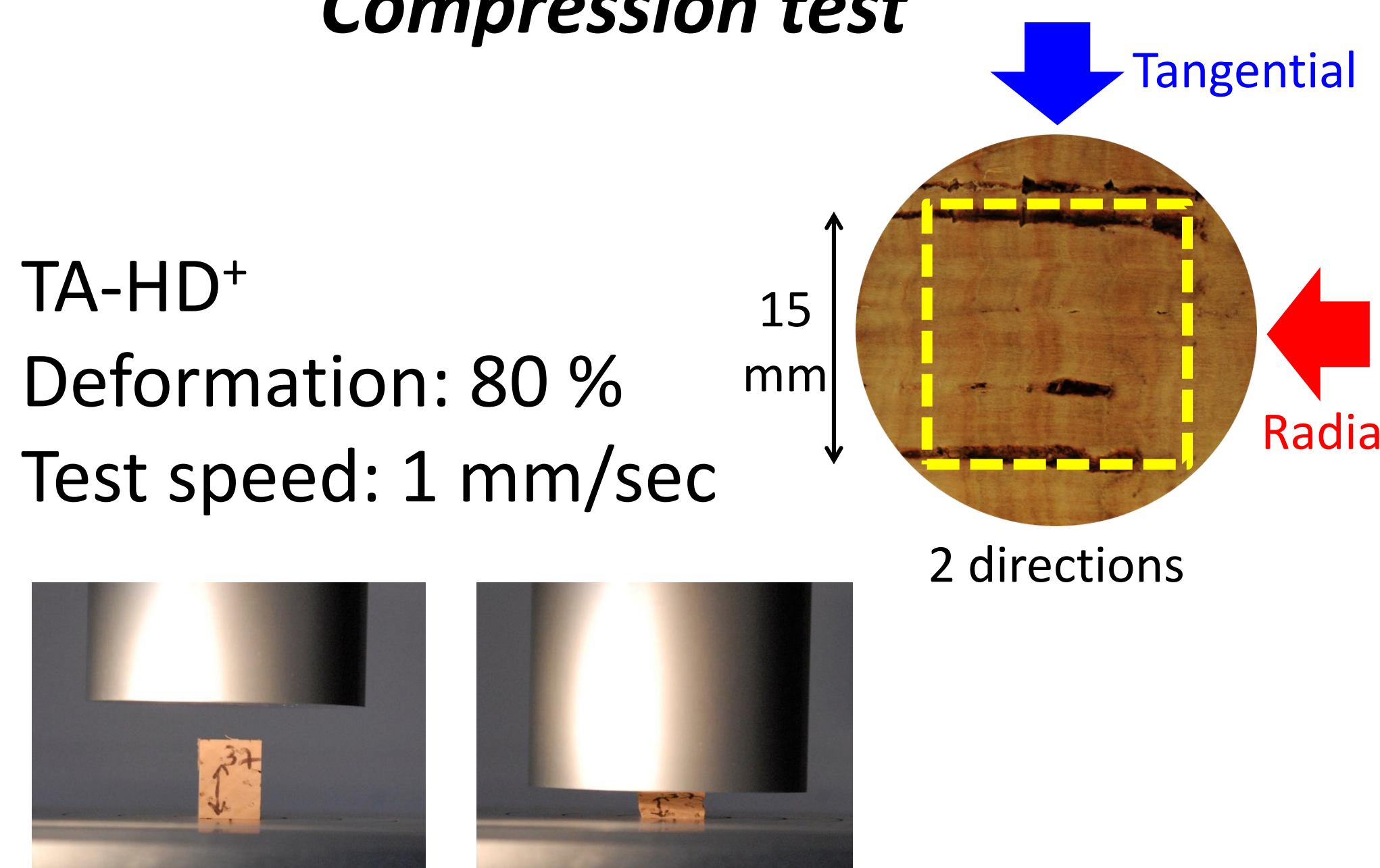
RH from 0 to 100 %
T = 25°C
Equilibration time ≈ 4 months

Compression test

TA-HD⁺

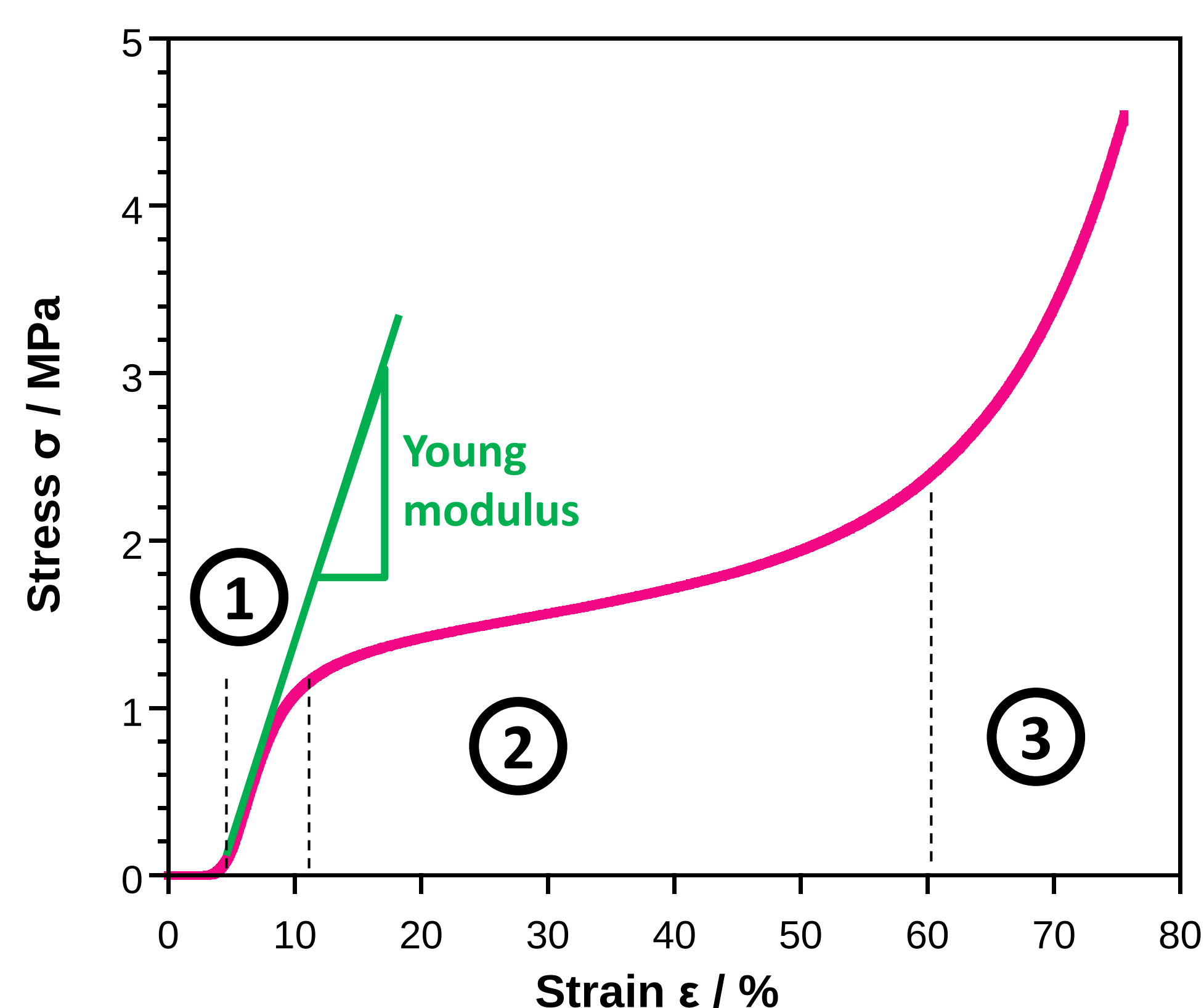
Deformation: 80 %

Test speed: 1 mm/sec



Results

Cork under compression



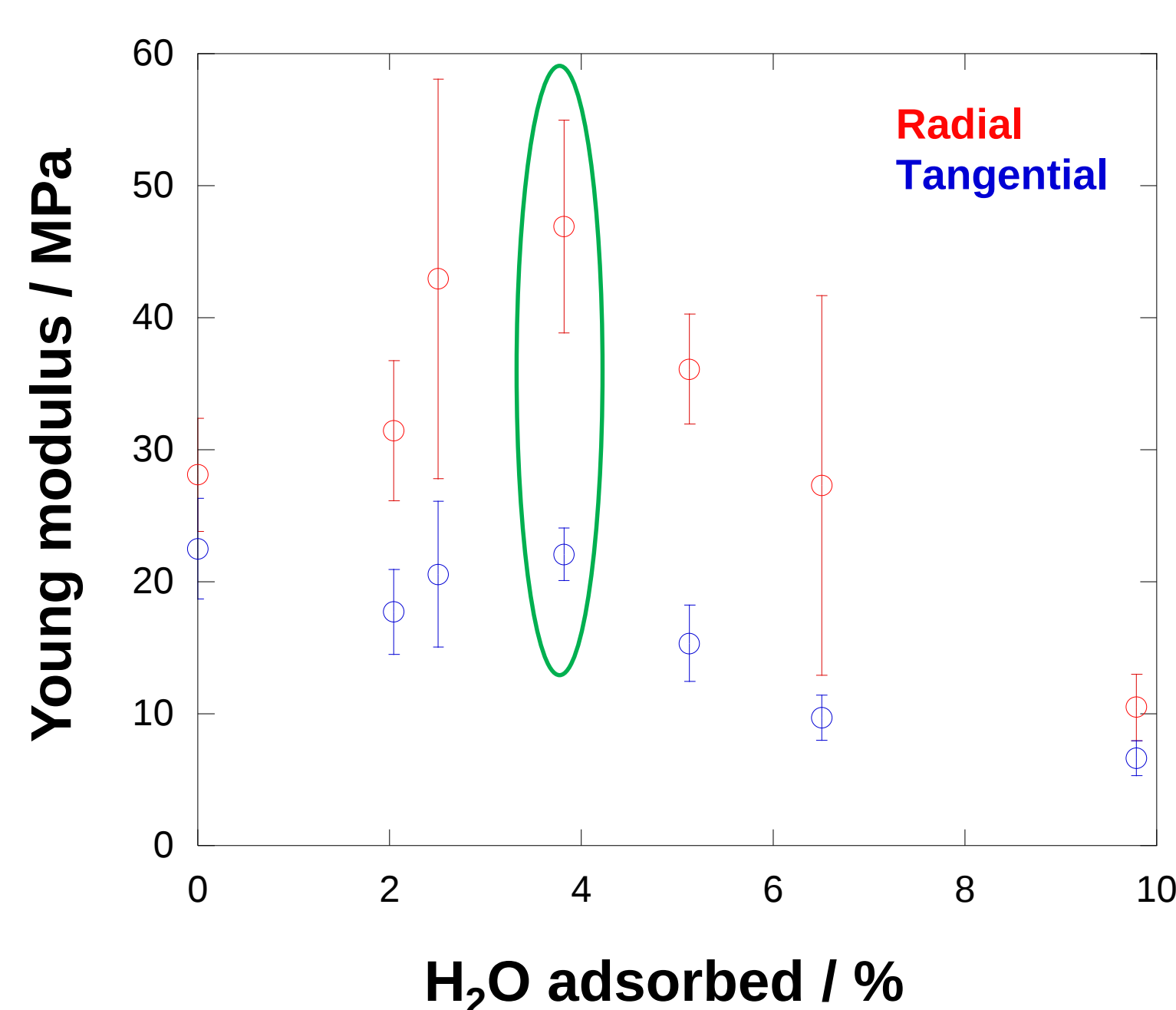
→ strain/stress curve:
3 regions

- 1 Elastic region
- 2 progressive buckling of cell walls
- 3 buckling of cell walls

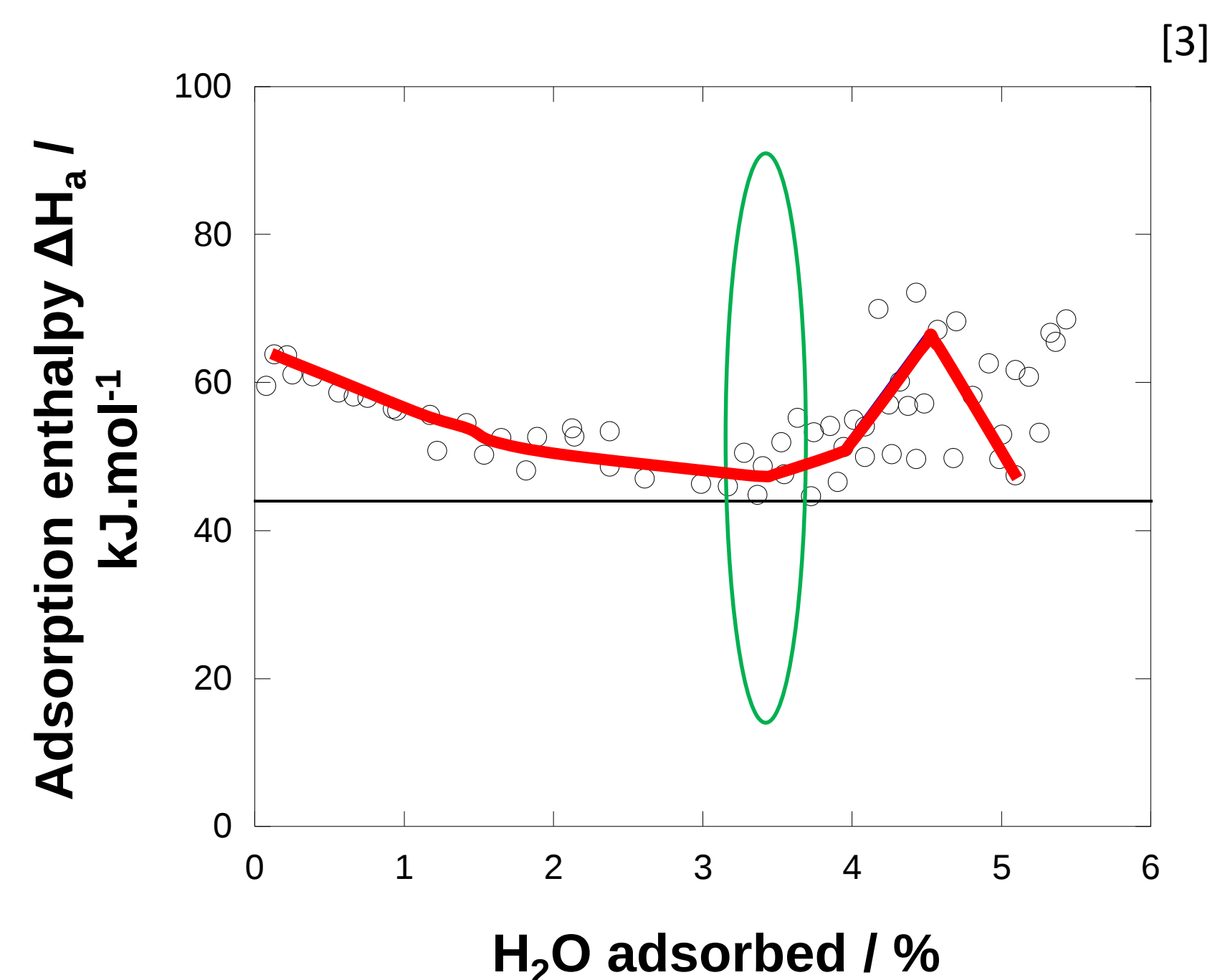
Young modulus calculation

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

Water effect on Young modulus

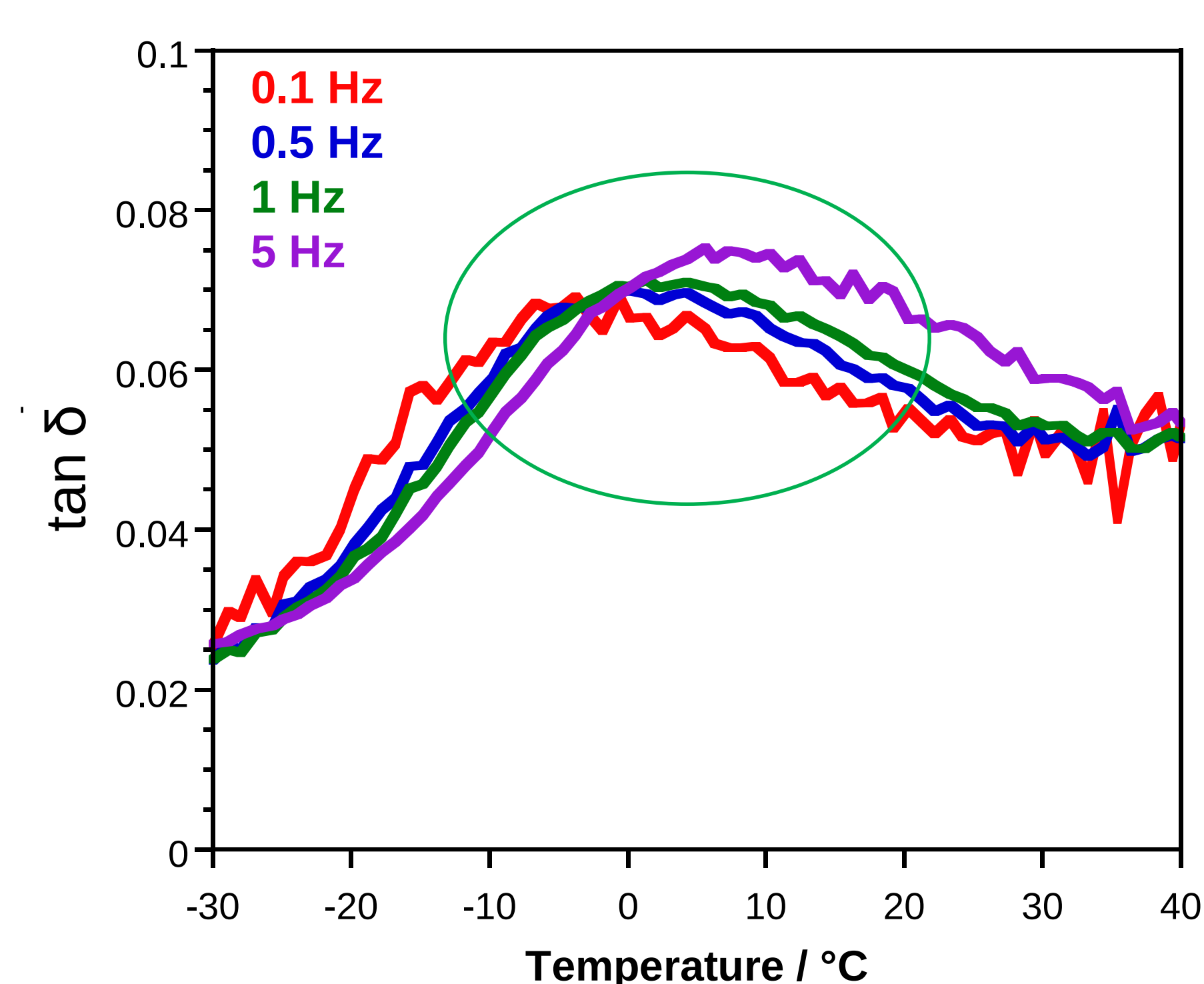


→ Rigidity: - radial > tangential
- maximum for HR ≈ 50%



→ Important role of water in cork structure

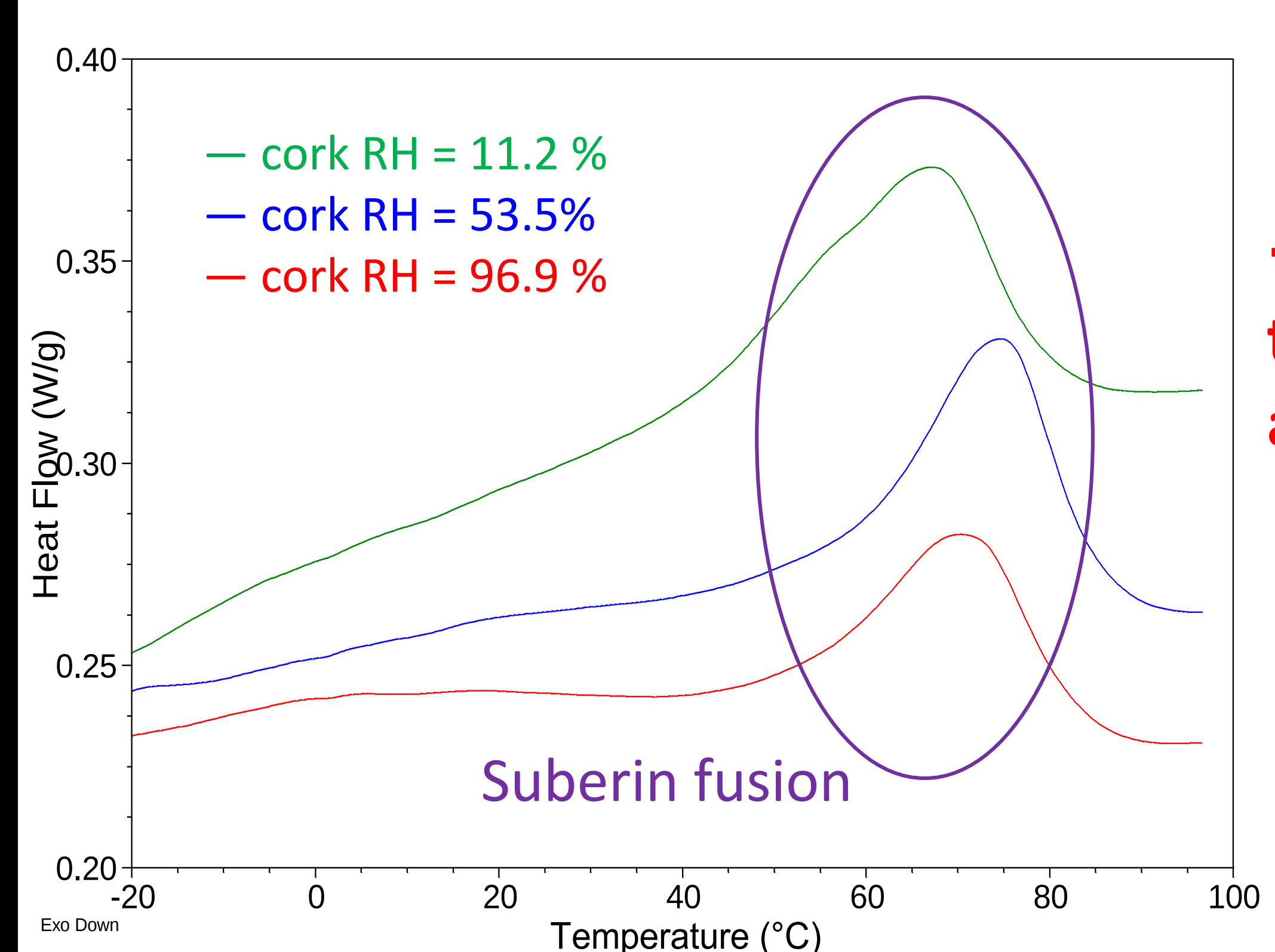
Dynamic mechanical analysis



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

→ Shift of tan δ for different frequencies: glass transition?

Differential scanning calorimetry



→ Difficult to identify a T_g

Conclusion

Mechanical properties of cork depend on relative humidity. Water plays an important role in cork structure with an antiplasticizing effect below 4 wt % water content, and then a plasticizing effect above this value. This can be explained by the existence of an amorphous fraction in cork which goes across its glass transition within this relative humidity range.

References

- [1] Mano, J.F. 2002. The viscoelastic properties of cork. *Journal of Membrane Science*, 37(2), 257-263.
- [2] Karbowiak, T., Gougeon, R.D., Alinc, J-B., Brachais, L., Debeaufort, F., Voilley, A., Chassagne, D., (2010). Wine oxidation and the role of cork. *Crit. Rev. Food. Sci.*, 50, 20-52
- [3] Lequin, S., Chassagne, D., Karbowiak, T., Gougeon, R. g., Brachais, L., & Bellat, J.-P. (2010). Adsorption Equilibria of Water Vapor on Cork. *Journal of Agricultural and Food Chemistry*, 58(6), 3438-3445.