

CORK SCIENCE AND
APPLICATIONS 2025

Study of the compressive behaviour of natural cork under exposure to water and ethanol vapours during ageing

Massimiliano Gerometta, Xavier Gabrion, Aurélie Lagorce, François Villette, Sébastien Thibaud, Thomas Karbowiak

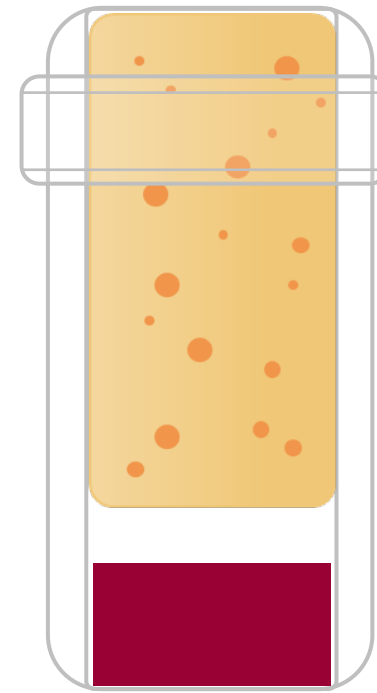
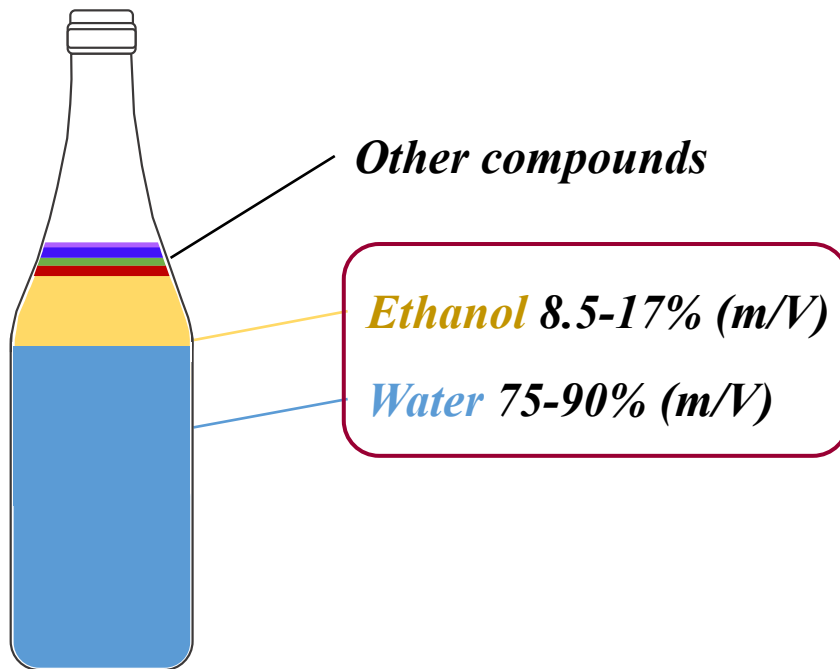
Cork in Science and Applications

13-14 October 2025

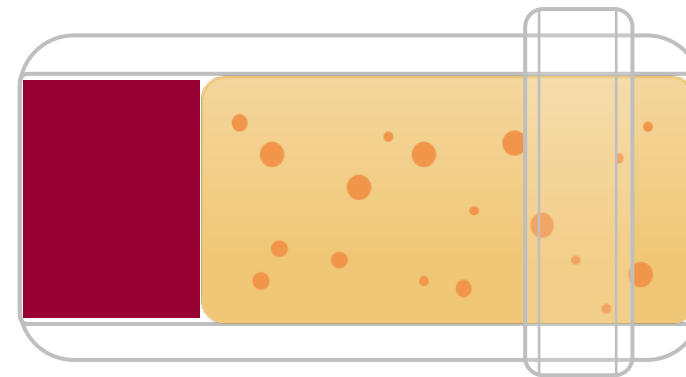


Why study water and ethanol ?

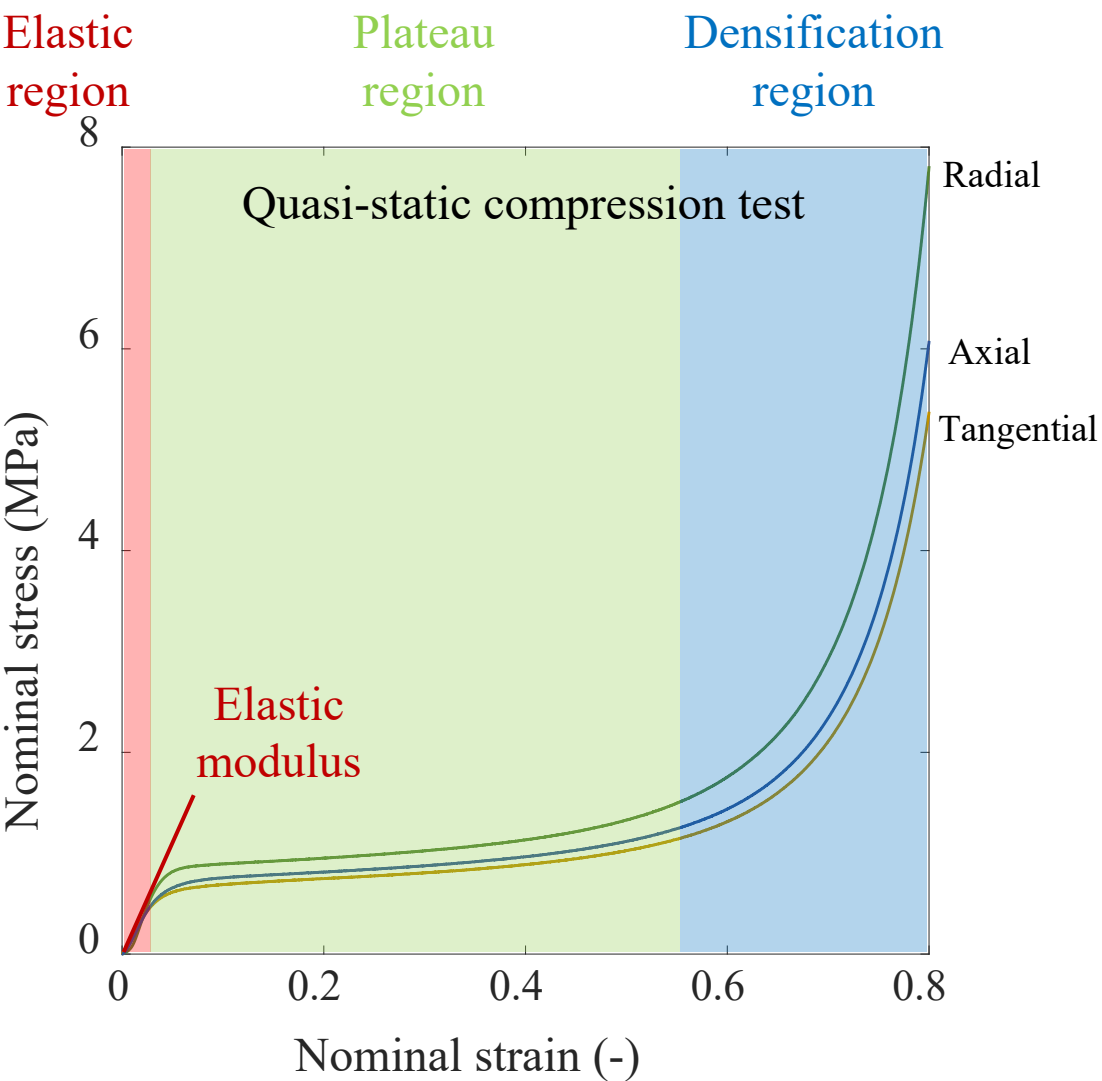
Wine is an hydroalcoholic solution of salified organic acids, colouring compounds and aromas.



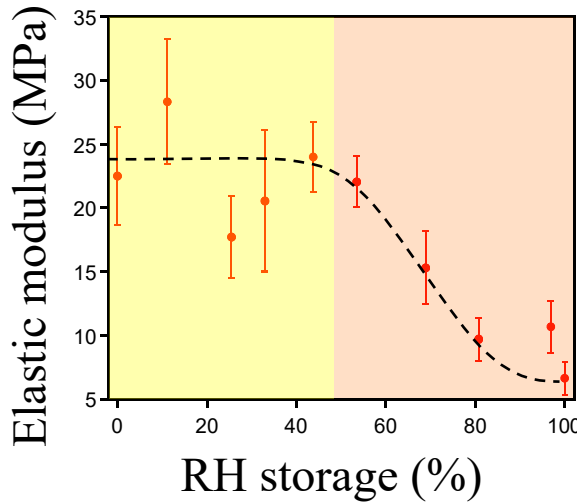
Vertical storage
Vapour phase contact



Horizontal storage
Liquid phase contact

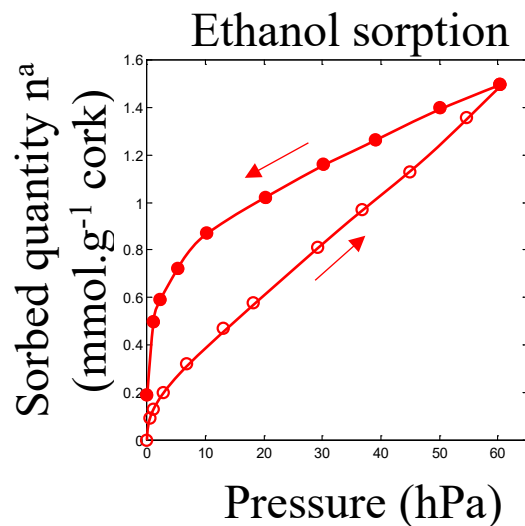


Factors: cork origin, growth rate, density, porosity, anisotropy, temperature, hydration state, ethanol, ageing

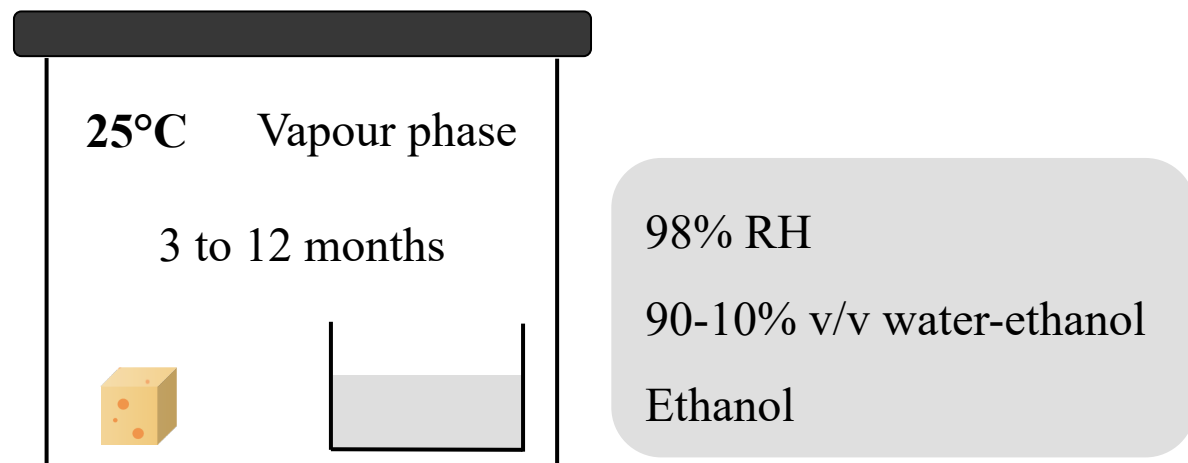


Lagorce-Tachon et al. Mechanical properties of cork: Effect of hydration, Materials & Design, 2015

Lequin et al. Sorption equilibria of ethanol on cork, Journal of Agriculture Food Chemistry, 2013



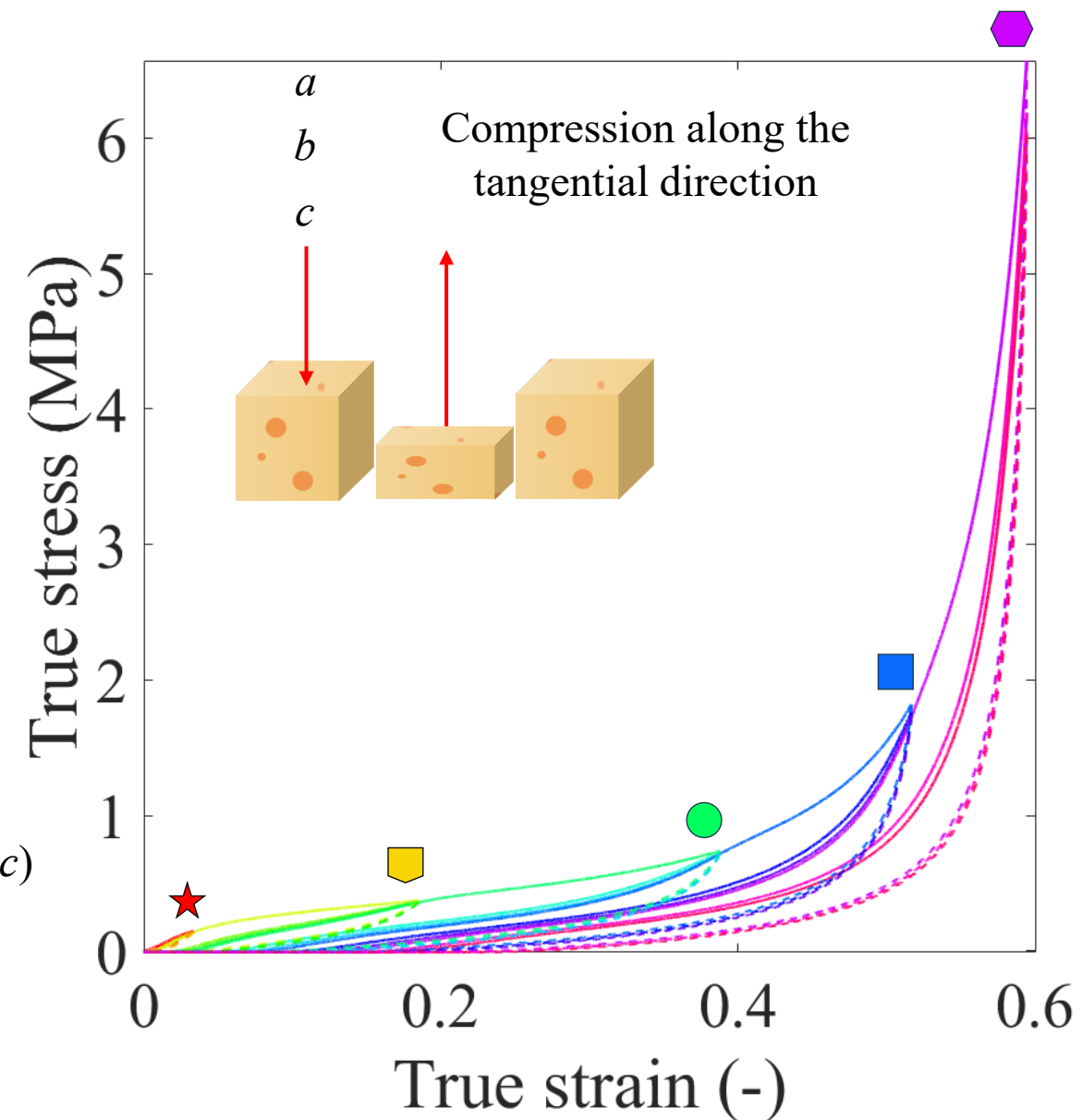
Mechanical ageing of cork stopper ?



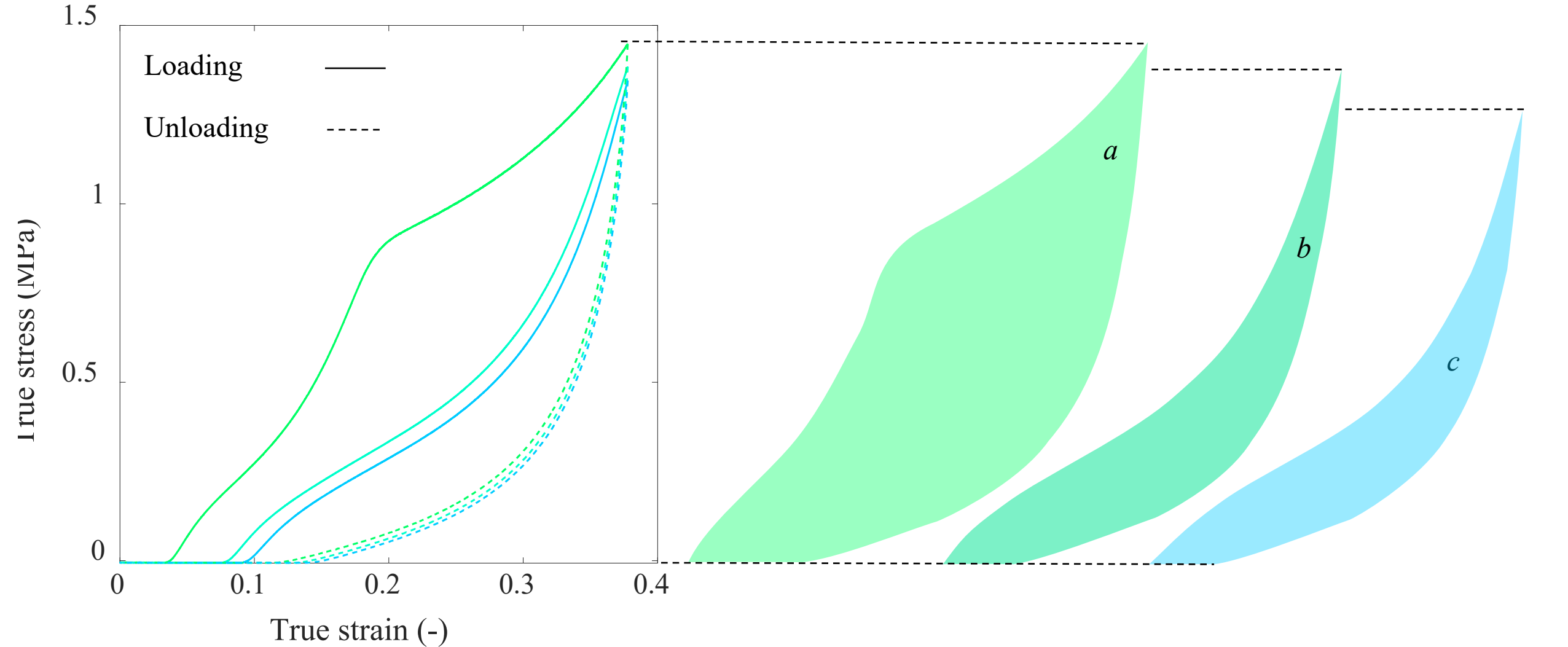
Methods

Quasi-static compression test (QS)

Progressive Repeated Loading test (PRL) with cycle repetitions (*a*, *b*, *c*)

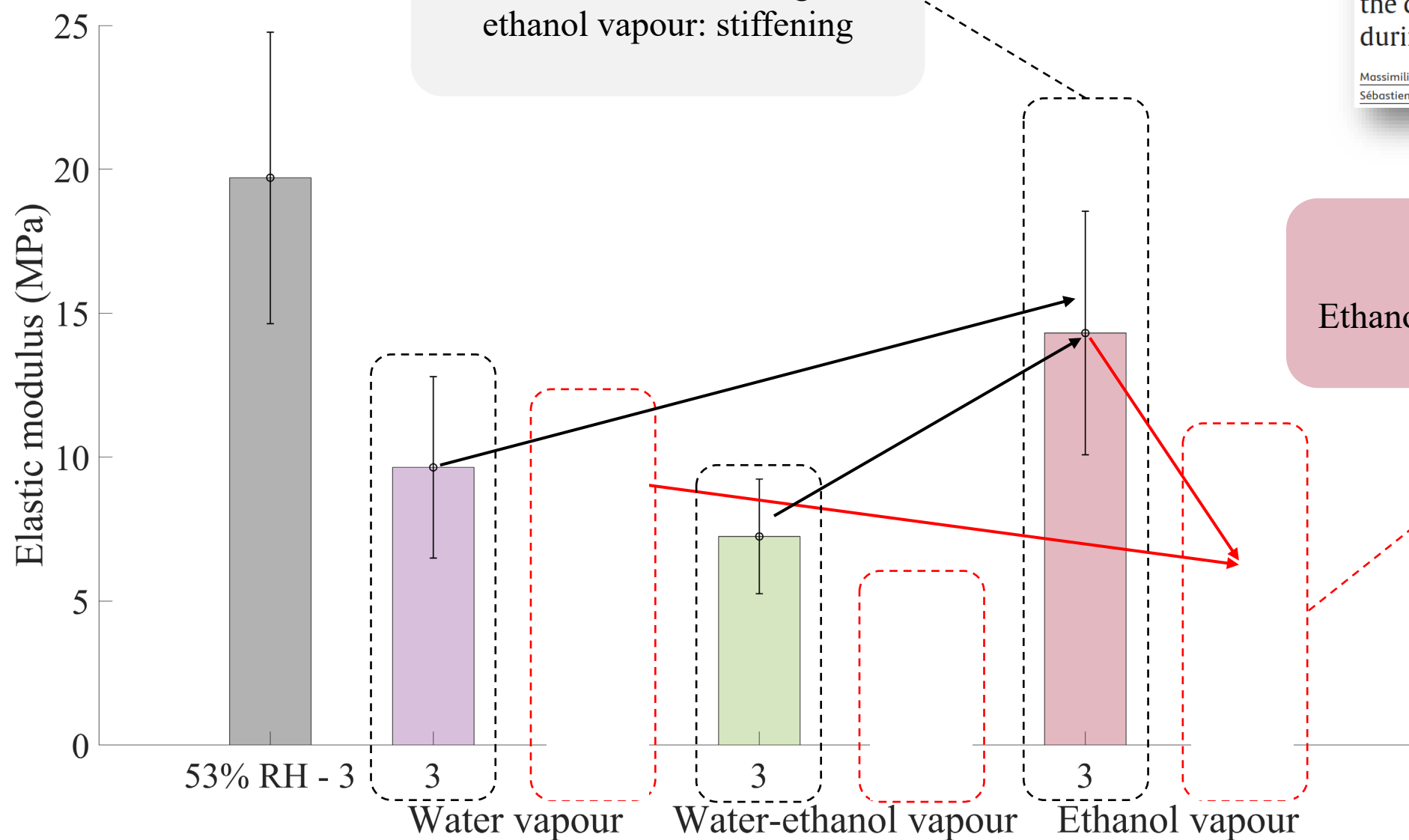


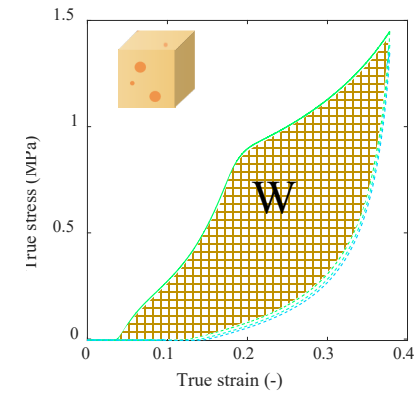
Stored energy (W): evolution of the cork mechanical response over time



Influence of water and ethanol vapours on the compressive behaviour of natural cork during ageing

Massimiliano Gerometta ^{a, b}, Xavier Gabrion ^b, Aurélie Lagorce ^a, François Villette ^b, Sébastien Thibaud ^b, Thomas Karbowiak ^a

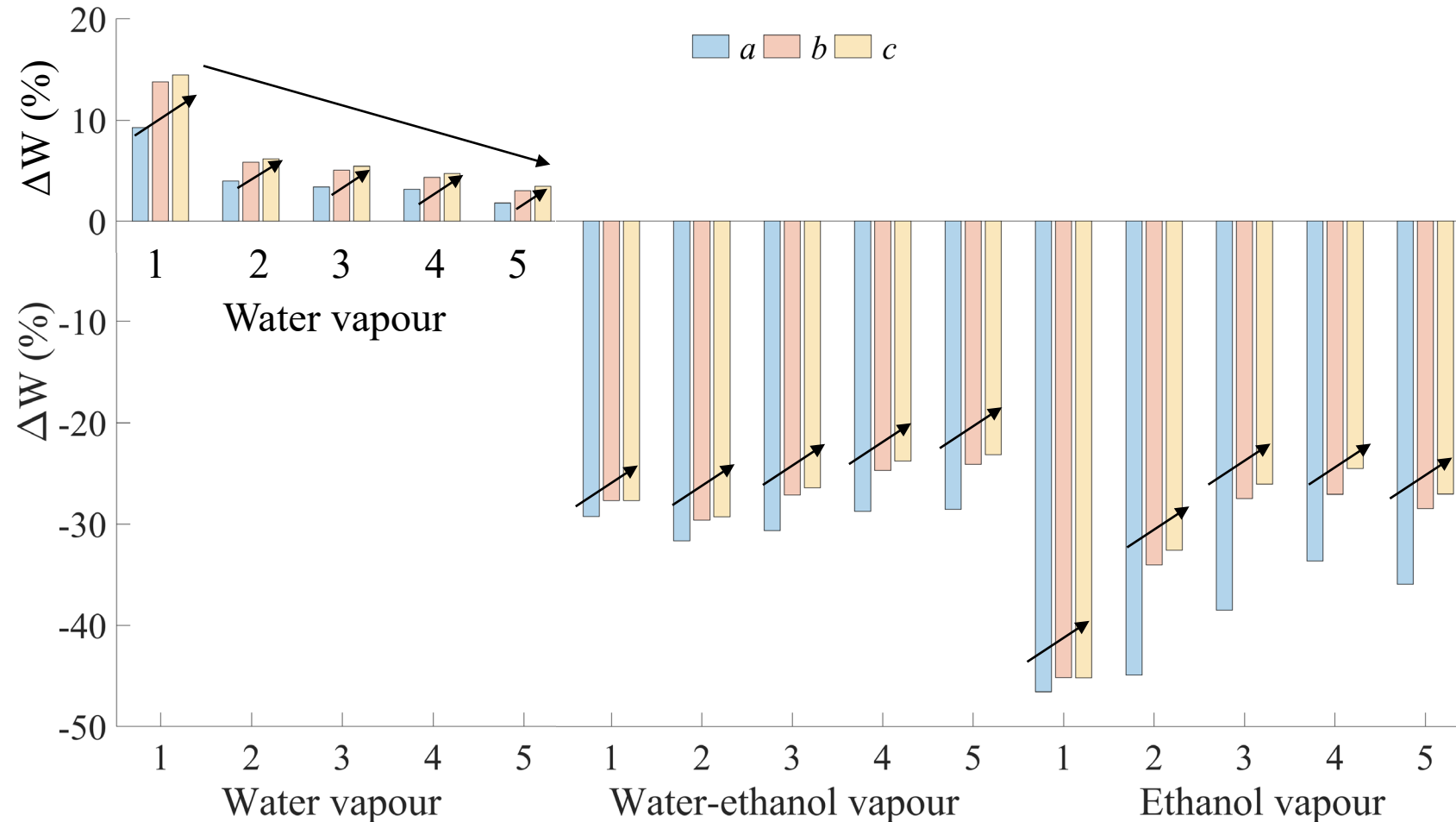




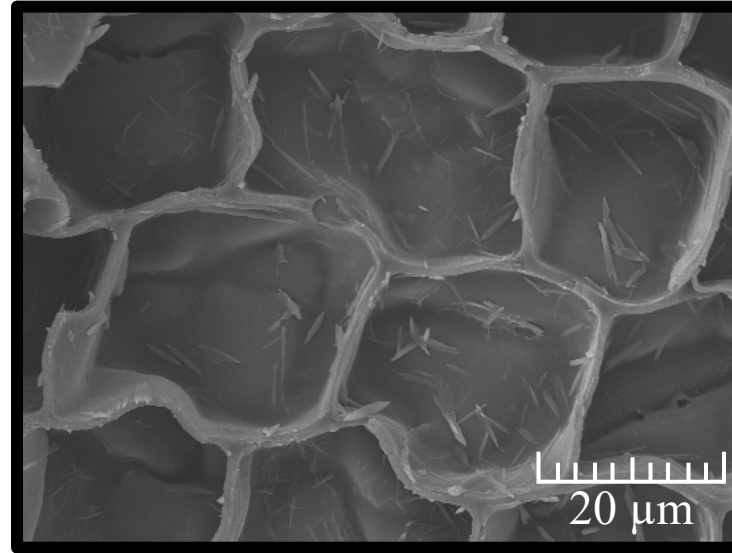
$$\Delta W_{time} = \frac{W_{12} - W_3}{W_3} \times 100$$

Comparison by each cycle repetition

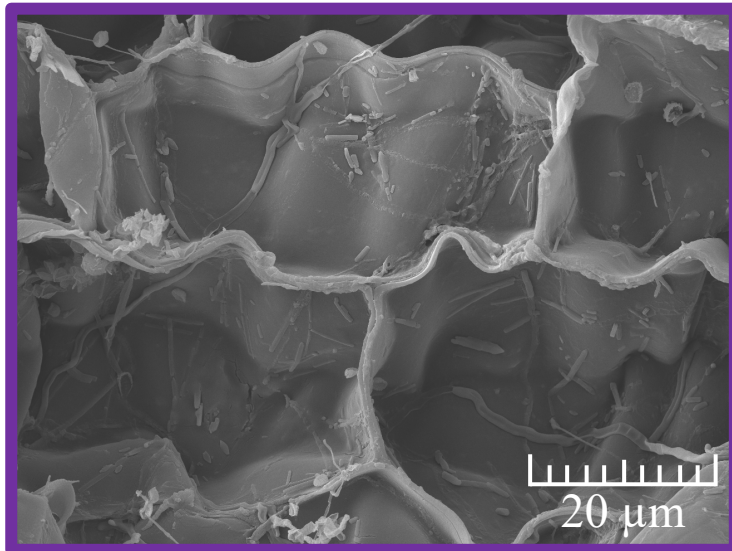
Structural modification of cork cell wall
Microscopic scale? → SEM
Molecular scale?



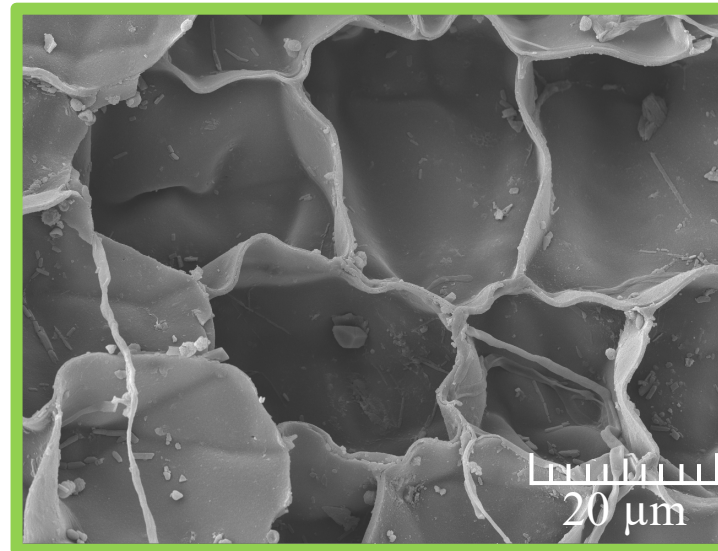
**Reference (25°C, 53% RH)
Not compressed**



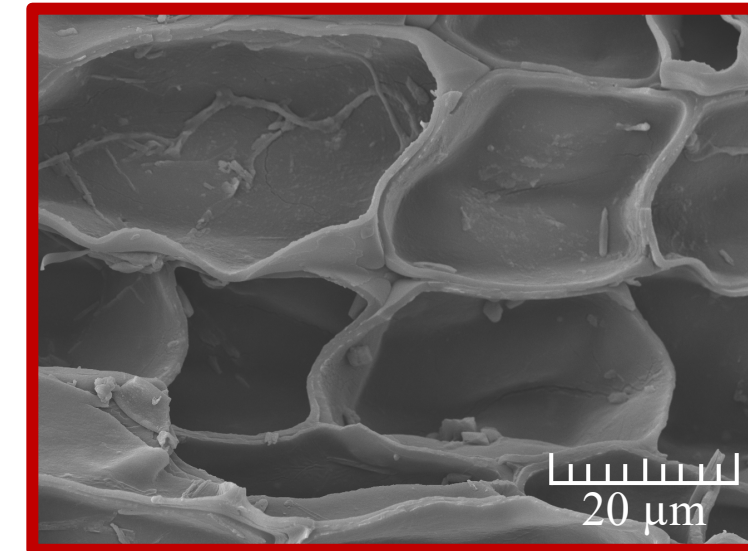
No difference between
reference and aged samples
after 12 months of storage



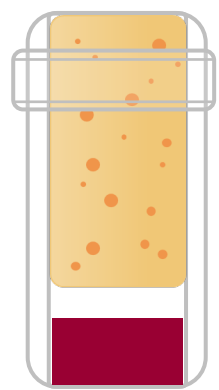
**Water vapour (25°C, 53% RH)
compressed**



**Water-ethanol vapour (25°C, 53% RH)
compressed**



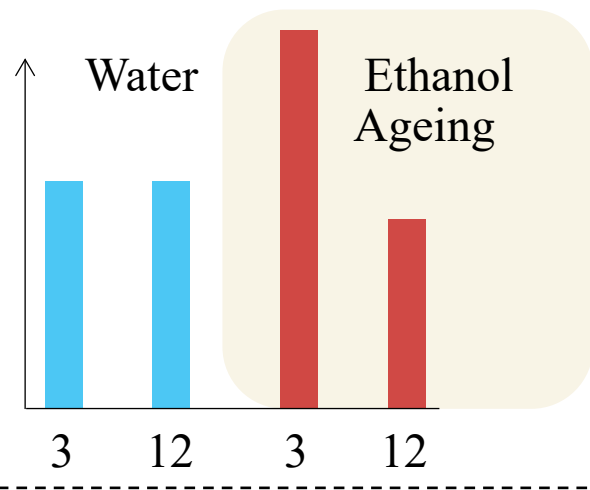
**Ethanol vapour (25°C)
compressed**



From Quasi-static
compression test

Elastic modulus

*(instantaneous
mechanical response)*

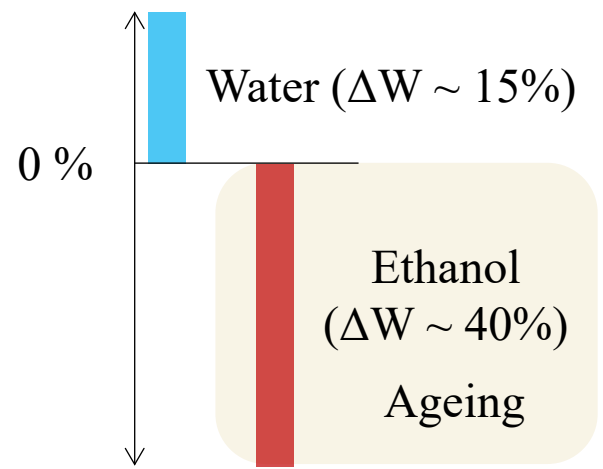


Ethanol accelerated the mechanical
ageing of cork compared to water in
the same period of storage

From Progressive
Repeated Loading test

Relative variation of
storage energy

*(mechanical response
over time)*



Hypothesis: influence on the long-term performance of the
cork–bottleneck system (mechanical and barrier properties)



Thanks for your attention