

Wettability and swelling of acetylated and furfurylated wood analyzed by a multicycle Wilhelmy plate method

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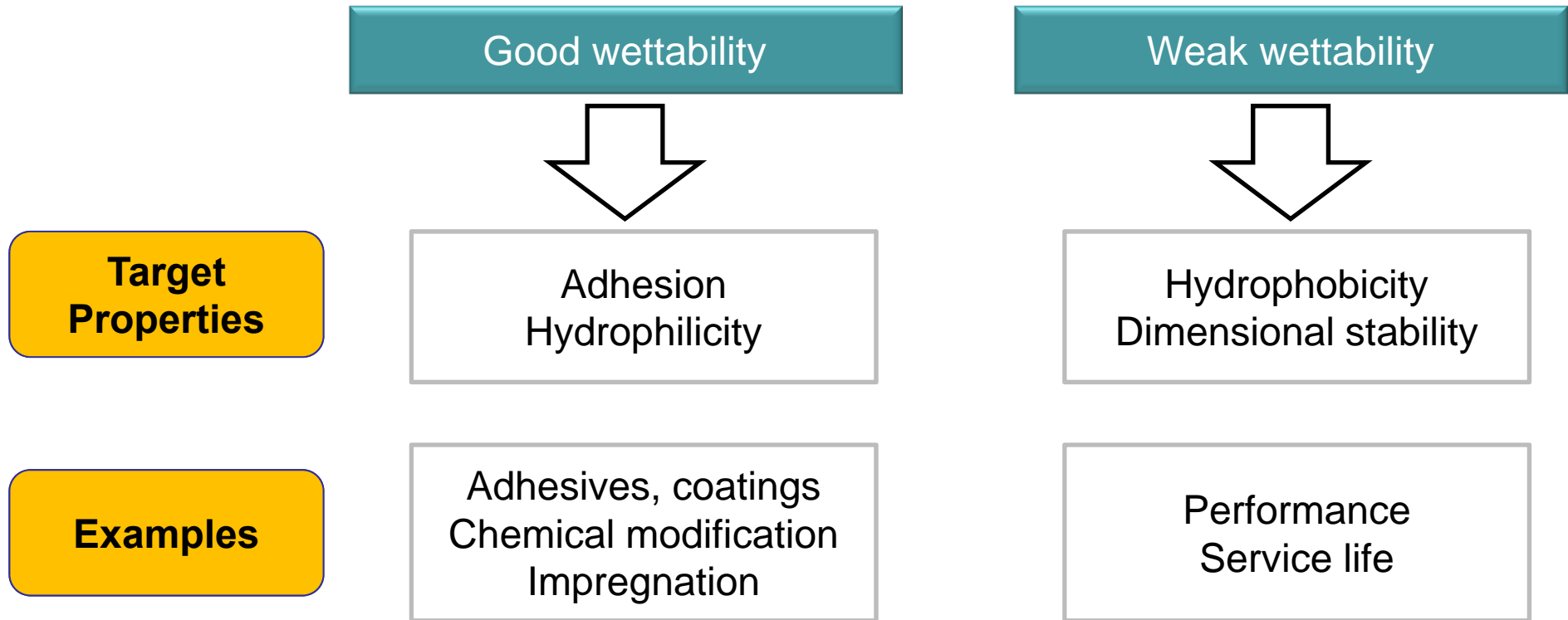
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BACKGROUND

Why wettability study?



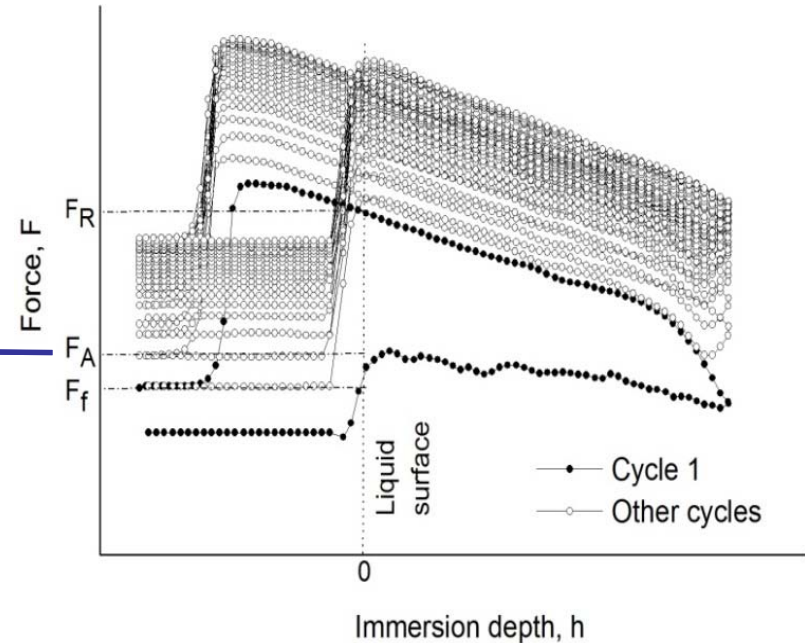
BACKGROUND

multi-cycle Wilhelmy plate method

$$F(h) = P\gamma\cos\theta - \rho Ahg + Fw(t)$$

$$F_A = P\gamma\cos\theta_A$$

- Contact angle
- Dynamic sorption
- Dimensional stability
- Extractives dissolution



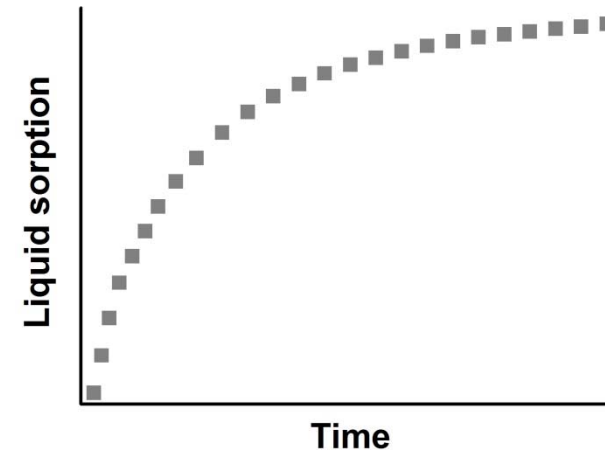
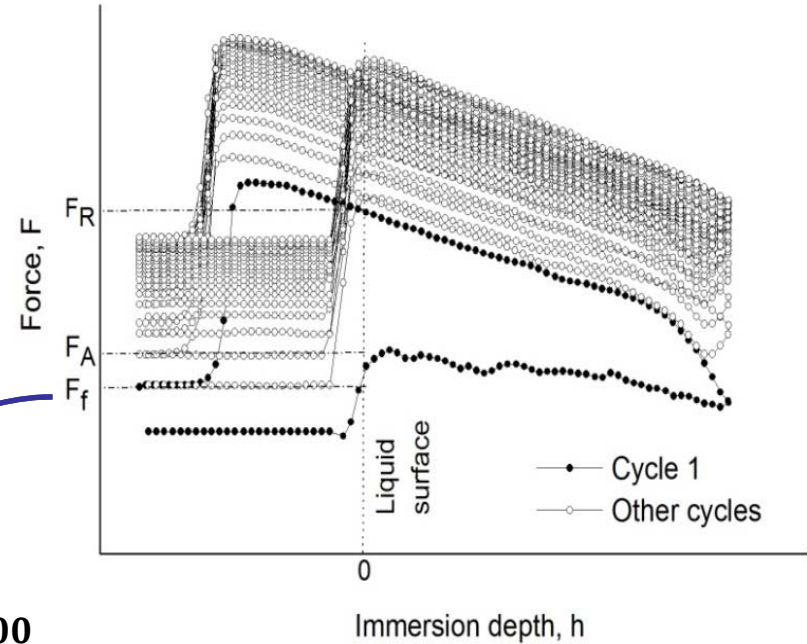
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$$\text{liquid mass (\%)} = \frac{F_{f,n}}{W_o} \times 100$$



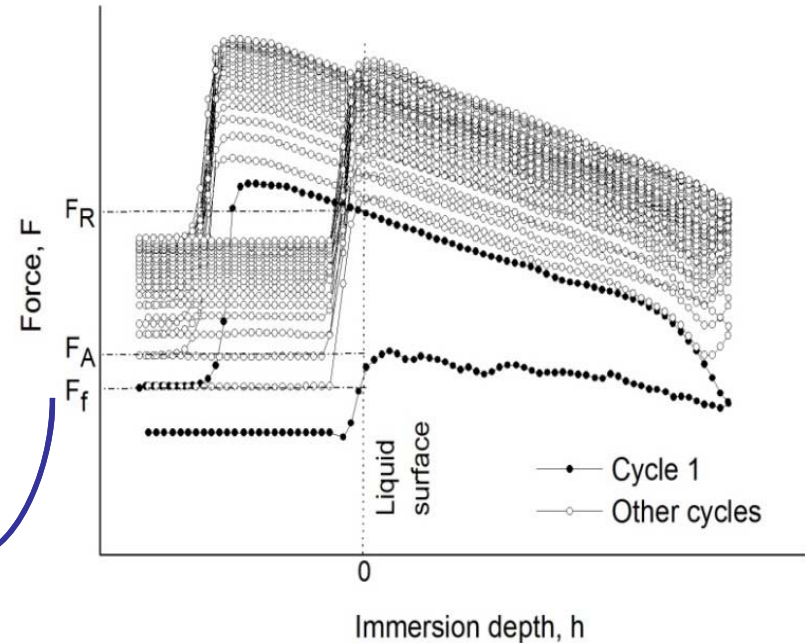
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BACKGROUND

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$$P_n = P_{n-1} + (F_{f,n} - F_{f,n-1}) \frac{\Delta P}{\Delta F_f}$$

- Sedighi et al., *Langmuir* (2013), **29**(39): 12145-12153.

P_n & P_{n-1} : veneer parameters after cycle n and $(n-1)$

$F_{f,n}$ & $F_{f,n-1}$: final forces for cycle n and $(n-1)$

$\Delta P = P_f - P_0$

ΔF_f : total changes in final force



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BACKGROUND

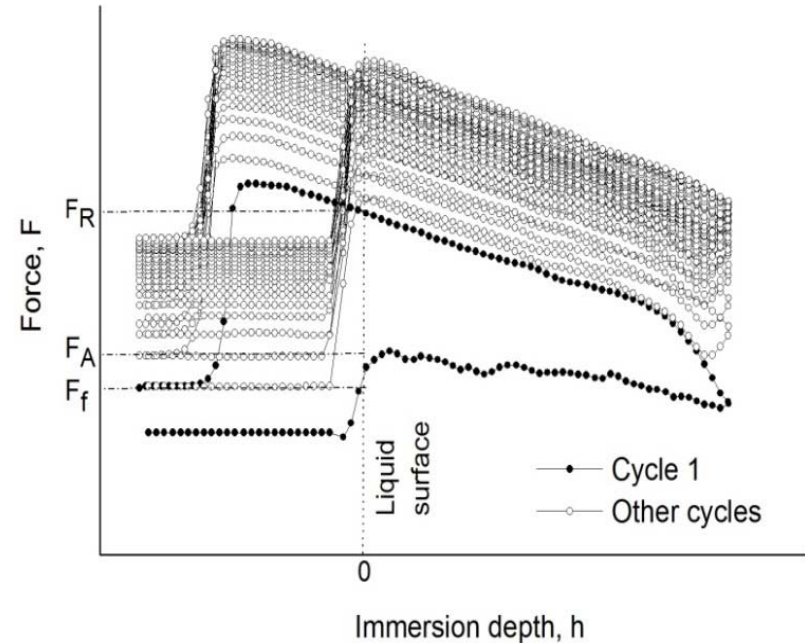
multi-cycle Wilhelmy plate method

$$F(h) = P\gamma\cos\theta - \rho Ahg + Fw(t)$$

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□ Measuring surface tension of water before and after a multicyle test

$$\Delta\gamma = \gamma - \gamma_f$$



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OBJECTIVES

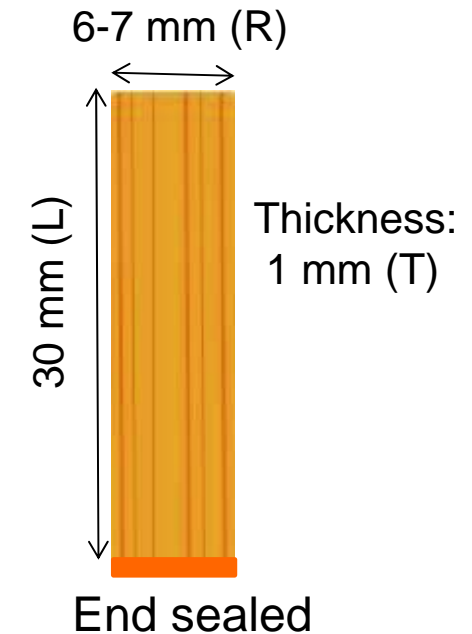
- Applying multi-cycle Wilhelmy plate method on modified wood in order to study dynamic wetting and swelling, as well as dimensional stability
- Evaluating the effect of level and type of modification on **capillary uptake** and **swelling rate** of modified wood samples



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MATERIALS AND METHODS

Sample name	Sample type
AS22.2	Acetylated SYP with 22.2% acetyl content
US22.2	Unmodified SYP matched to AS22.2
AS15.9	Acetylated SYP with 15.9% acetyl content
US15.9	Unmodified SYP matched to AS15.9 Control sample fo furfurylated samples
FS28	Furfurylated SYP with WPG of 28%
FS45	Furfurylated SYP with WPG of 45%
FS54	Furfurylated SYP with WPG of 54%



SYP: Southern Yellow Pine



- Thermally treated veneers at 104 °C for 1 h (MC=0%)
- Freshly cut veneers



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MATERIALS AND METHODS

- Liquids

- Water swelling liquid
- Octane non-swelling liquid

- Multi-cycle Wilhelmy plate method

- 20C for water and 10C for octane

- Perimeter determination by doing an octane immersion

- Dimensional stability – using the perimeter model



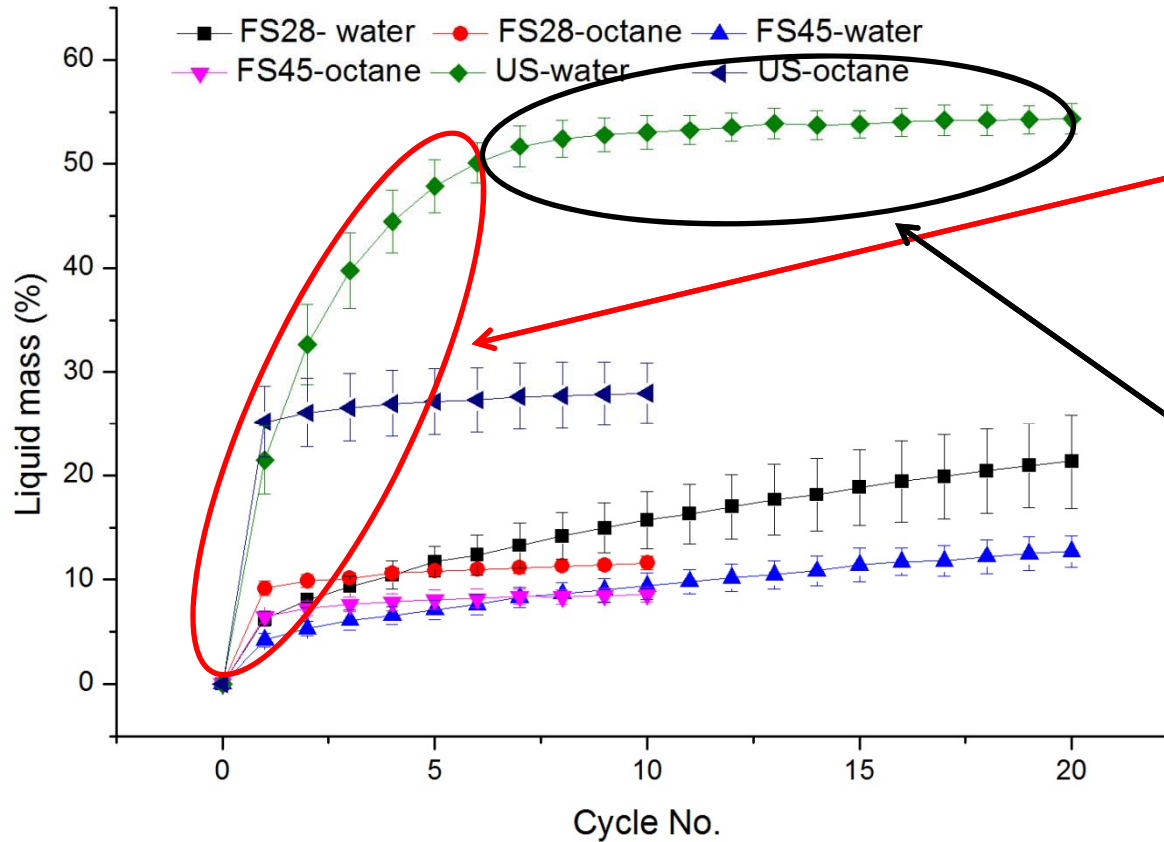
RESULTS and DISCUSSION

Contact angle

Sample name	CA _{app} (°) thermally treated sample	CA _{app} (°) fresh sample
AS15.9	81±5	72±1
US15.9	81±3	55±9
AS22.2	73±5	76±1
US22.2	63±5	58±3
FS28	63±5	54±7
FS45	87±4	70±3
FS54	65±7	58±3

RESULTS and DISCUSSION

Sorption- Furfurylated samples



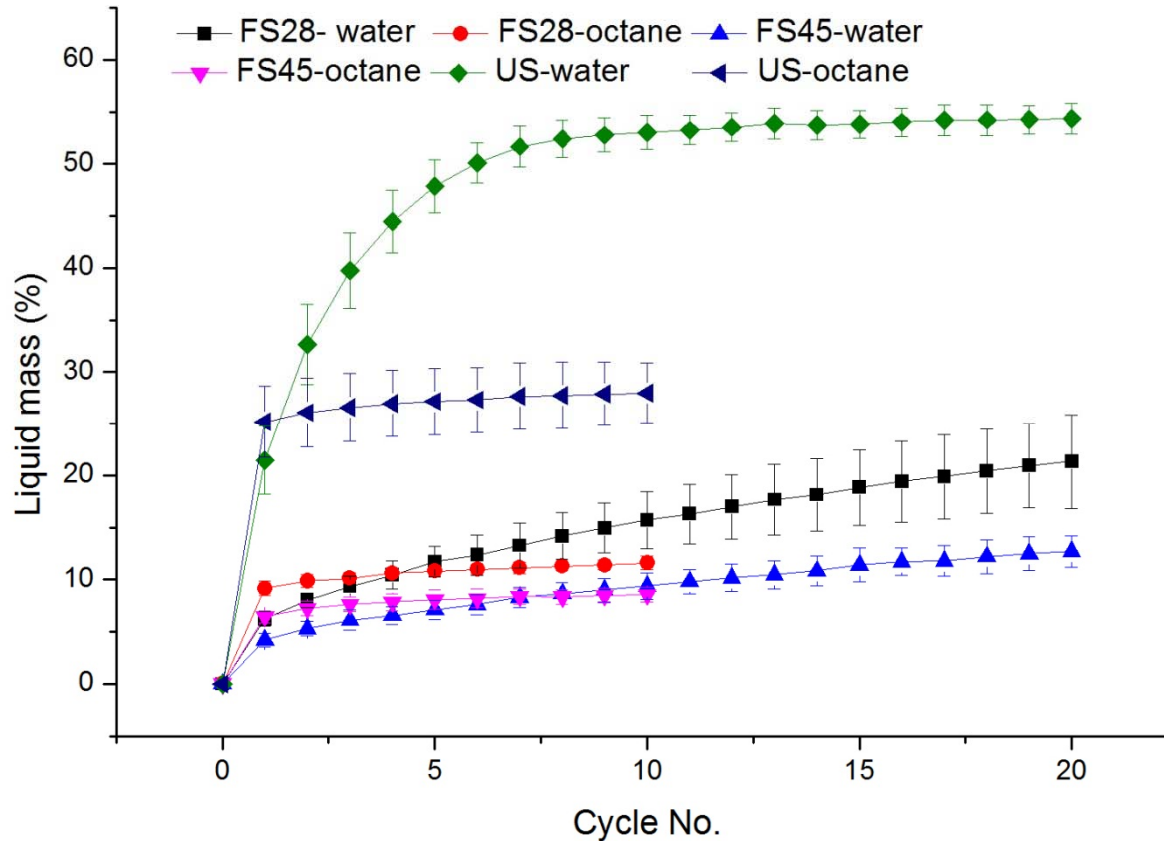
- A fast regime with filling the voids and capillary action

- A slower regime with liquid up-take by diffusion/swelling



RESULTS and DISCUSSION

Sorption- Furfurylated samples

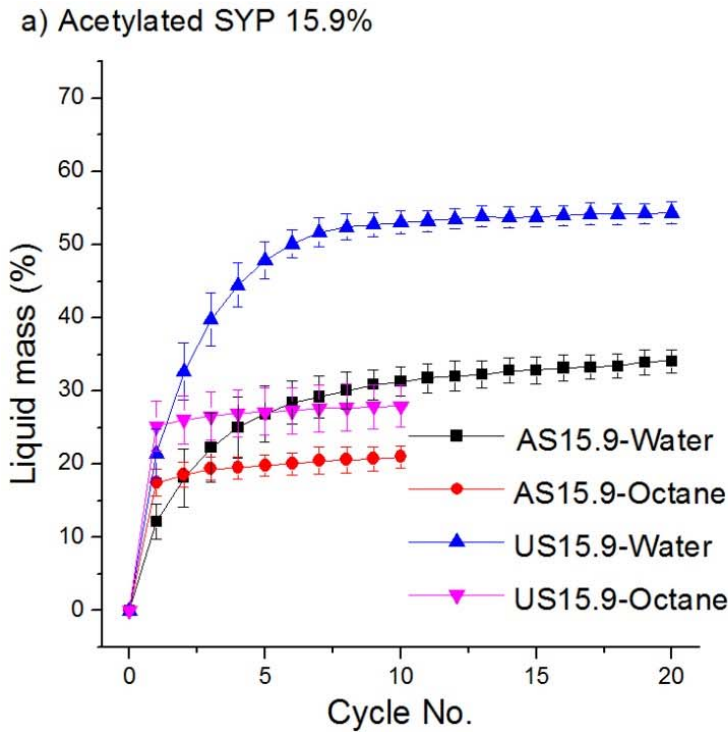


- Furfurylation decreases both the porosity and the degree of swelling
- Higher liquid repellency with higher level of modification

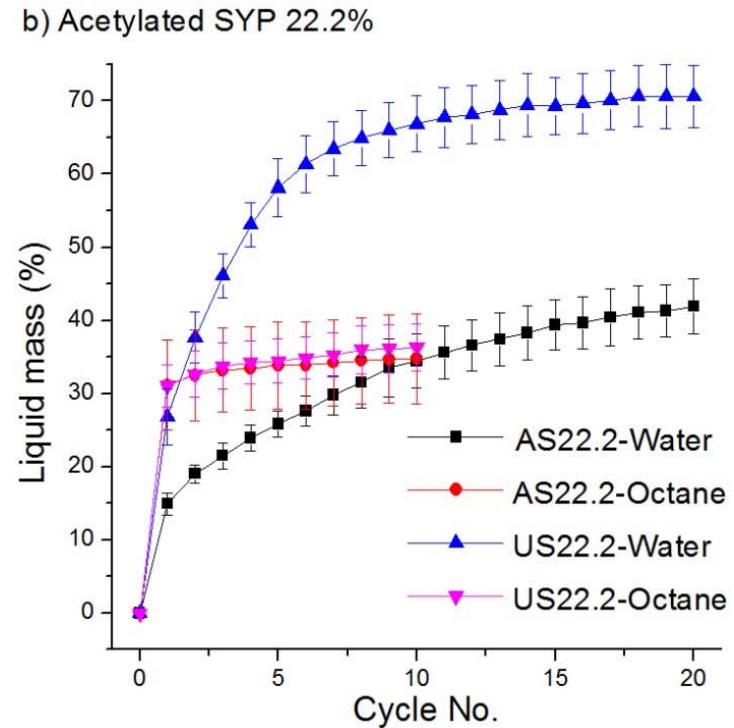


RESULTS and DISCUSSION

Sorption- Acetylated samples

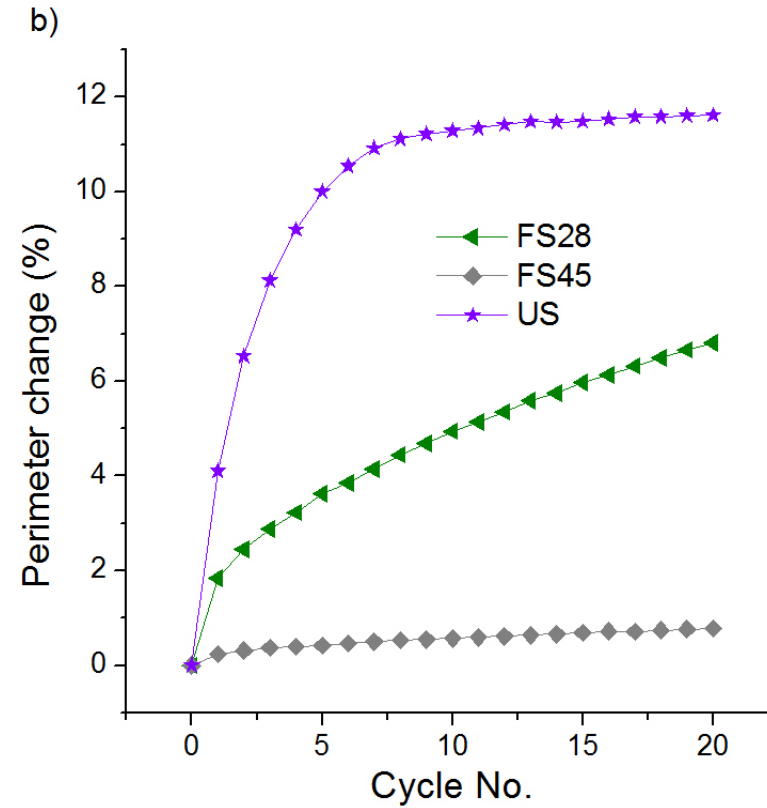
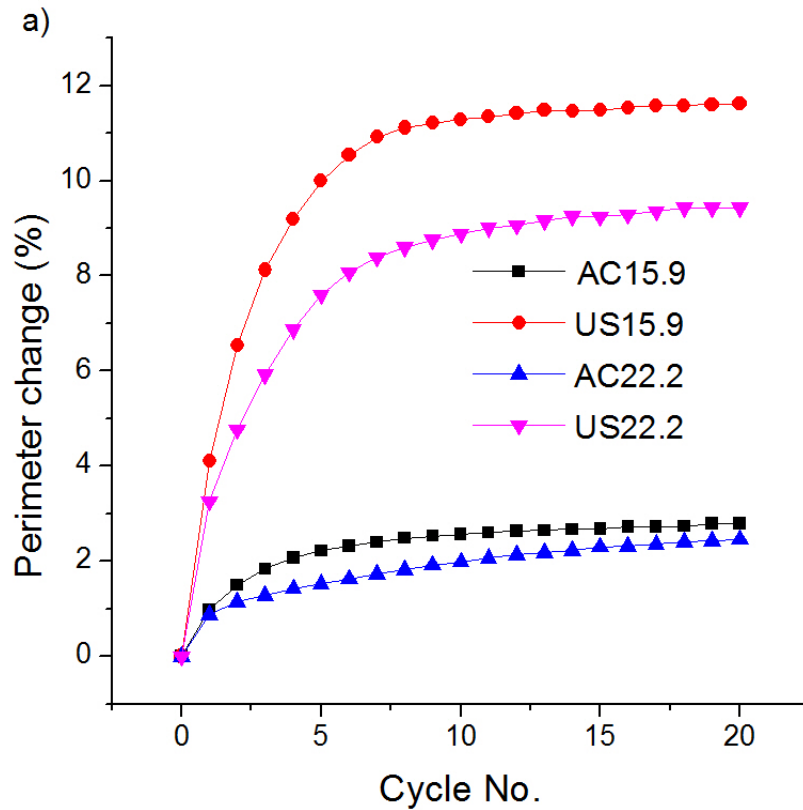


- Lower rate and level of swelling for acetylated samples



- Lower liquid uptake for the sample having more latewood

Results and discussion- dimensional stability



RESULTS and DISCUSSION

Acetylation vs. Furfurylation

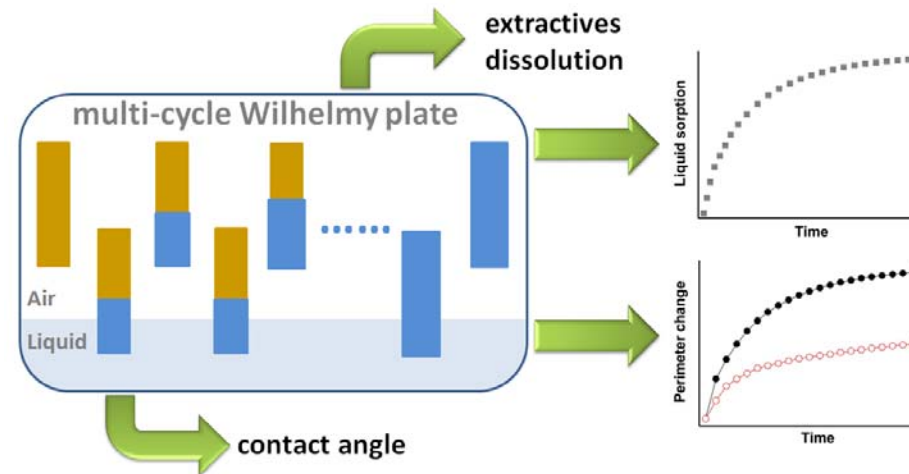
Sample name	Water up-take (F_{f20}) (%)	Octane up-take (F_{f10}) (%)	ΔP_{20} (%)
AS15.9	34.1±1.6	21.0±1.5	3.7±0.5
US15.9	54.3±1.5	28.0±2.9	12.2±5.6
AS22.2	41.9±3.7	34.8±6.2	2.5±0.3
US22.2	70.6±4.2	36.3±3.2	9.9±1.2
FS28	21.3±4.5	11.8±0.6	7.0±4.1
FS45	12.7±1.5	8.5±0.7	0.8±0.7
FS54	18.1±4.9	12.6±3.0	1.8±0.3

- Swelled cell wall due to chemical bonds for both type of modification
- Highly branched and cross-linked polymer in furfurylated samples



CONCLUSION

- Multicycle Wilhelmy plate method is a suitable technique for studying the dynamic wetting, swelling and liquid sorption behaviour of modified wood



- Lower contact angle for freshly cut veneers than thermally treated ones
- Acetylation makes the wood surface more hydrophobic

CONCLUSION

- Lower liquid (water and octane) uptake, lower swelling and higher dimensional stability for furfurylated samples than acetylated ones
- Earlywood SYP shows higher liquid uptake/swelling than the latewood region
- By multicycle Wilhelmy in a swelling liquid (water) and non-swelling liquid (octane), it is possible to study the capillary uptake and swelling rate
- Acetylation mainly affects the swelling part of water uptake, while furfurylation decreases both capillary uptake and swelling level



ACKNOWLEDGEMENTS

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Thanks for your attention!



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