Cellulose nanofibril (CNF) enabled non-conventional food serving products

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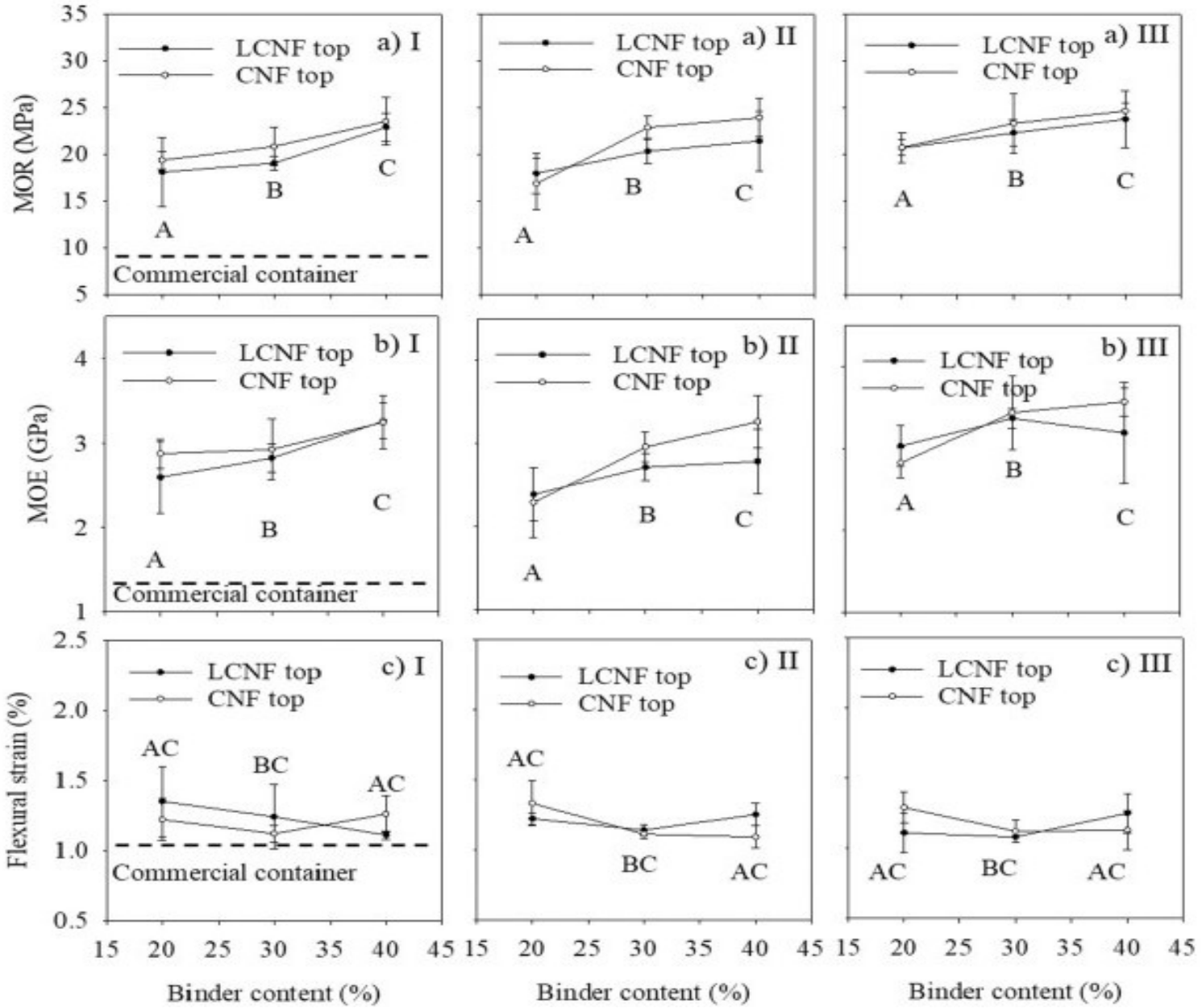
Motivation

- Provide economical option for paper industry to get rid of PFAS
- Introduce non-conventional fibers and lignocellulosic particles to molded fiber industry
- Sustainable approach

CNF as a binder

WF-CNF plate

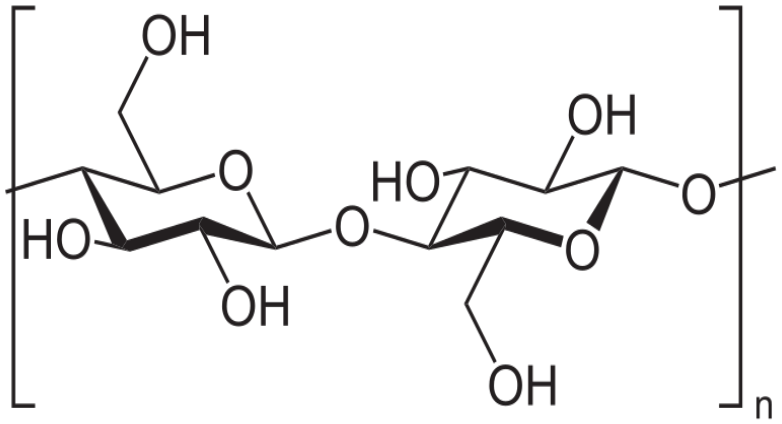
Flexural test



Hossain, R., Tajvidi, M., Bousfield, D., & Gardner, D. J. (2022). Recyclable grease-proof cellulose nanocomposites with enhanced water resistance for food serving applications. *Cellulose*, 1-21.

Approach

- Use natural lignocellulosic fibers to develop molded products for food serving containers
- Screen formulations in terms of functionality, biodegradability, and sustainability
- Laminate the plates with CNF to make them grease resistant



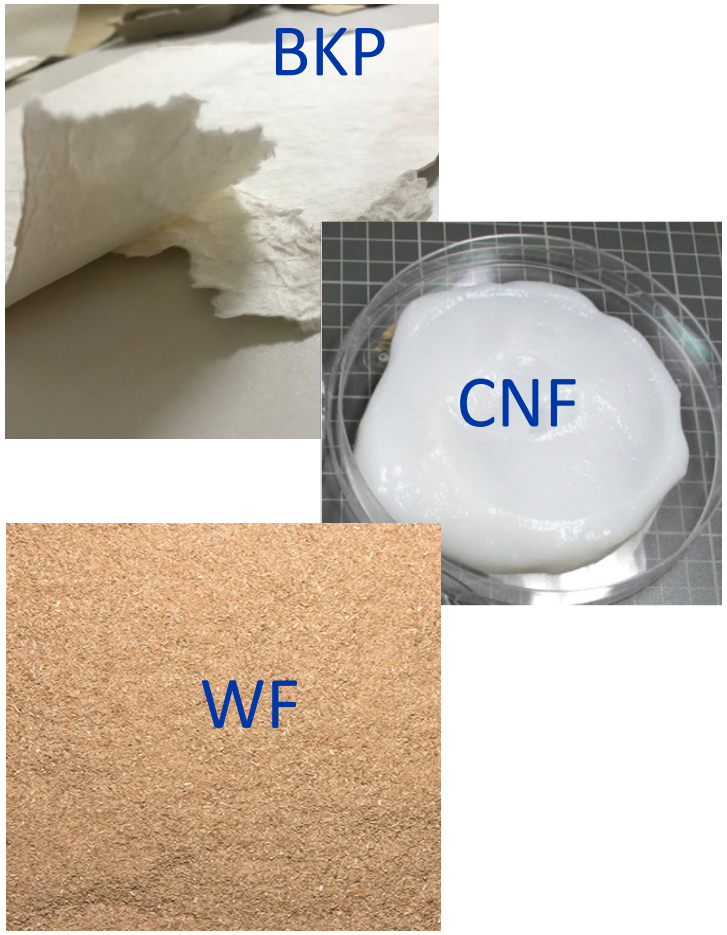
Chemical structure of Cellulose

Wood flour (WF) plate with CNF as a binder

Laminated plate with CNF on top

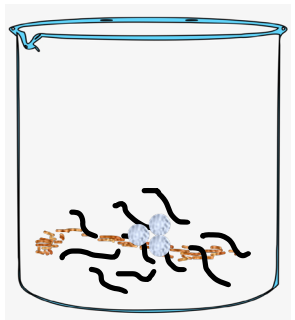
Lignocellulosic composite system

- Bleached Kraft Pulp (BKP) + Wood flour (WF) + Cellulose Nanofibers (CNF) as a binder



Formulations
BKP 100%
BKP 45% WF 45% CNF 10%
BKP 55% WF 35% CNF 10%
BKP 65% WF 25% CNF 10%
BKP 58.75 % WF 38.75 % CNF 2.5%

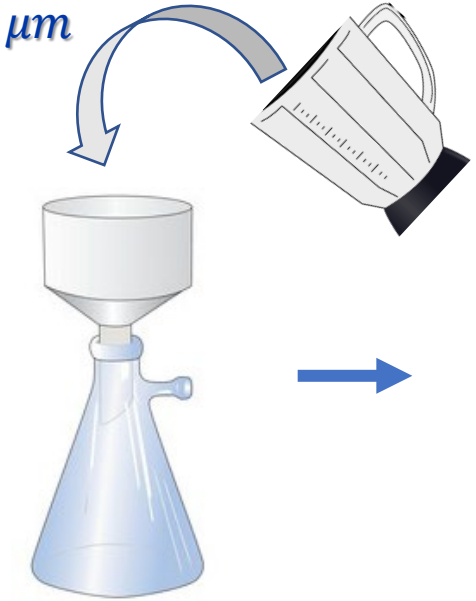
Forming process



Adding Raw Material

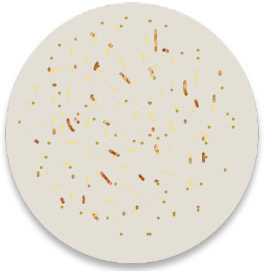
Mixing
Time: 30 s

Transfer contents on a Plastic filter paper
Pore size 70 µm



Vacuum Filtration

Blow air



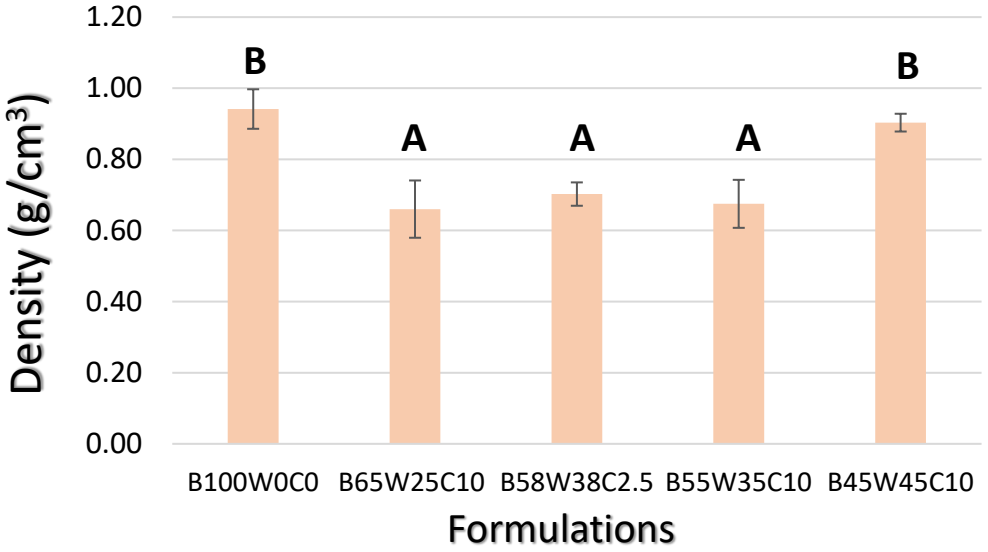
Wet sheet

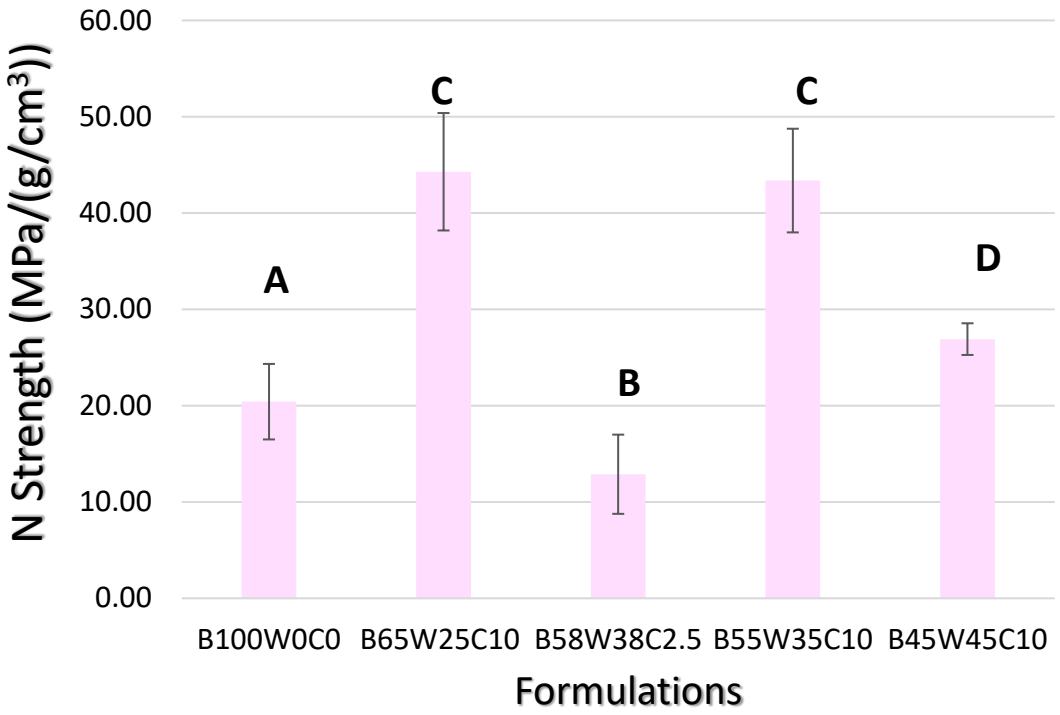
Hot press between steel plates
Temp: 150 ^{0}C
Time: 3 min

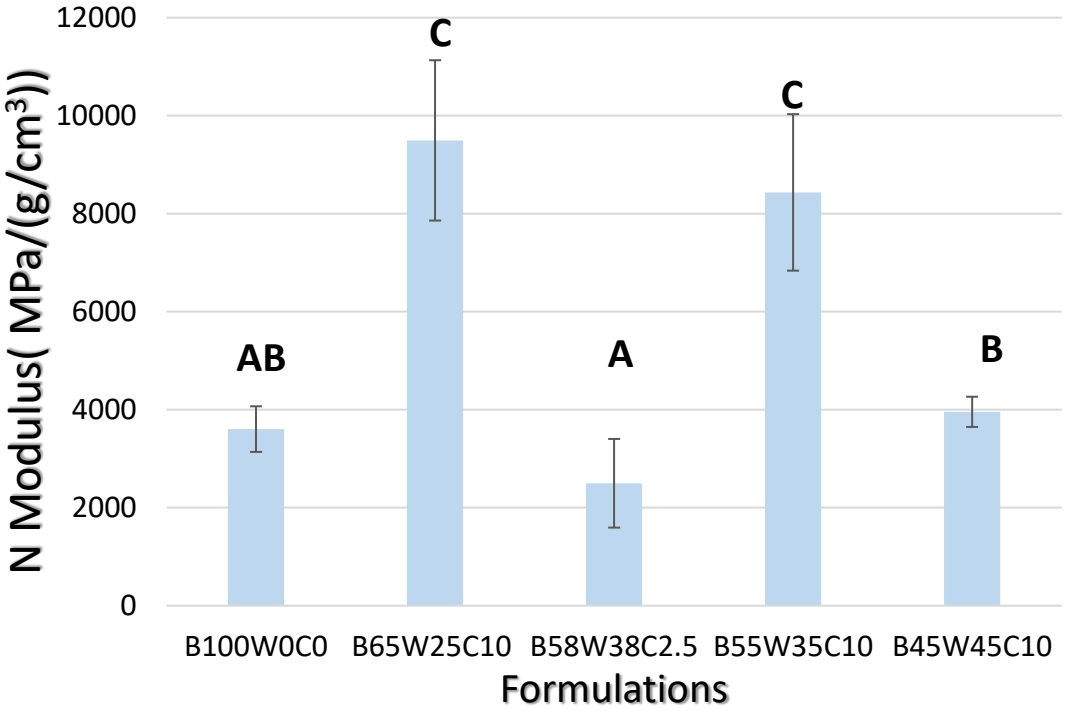
Hot pressed sheet
Grammage 600 g/m^2

Flexural Test

(Normalized properties based on density)

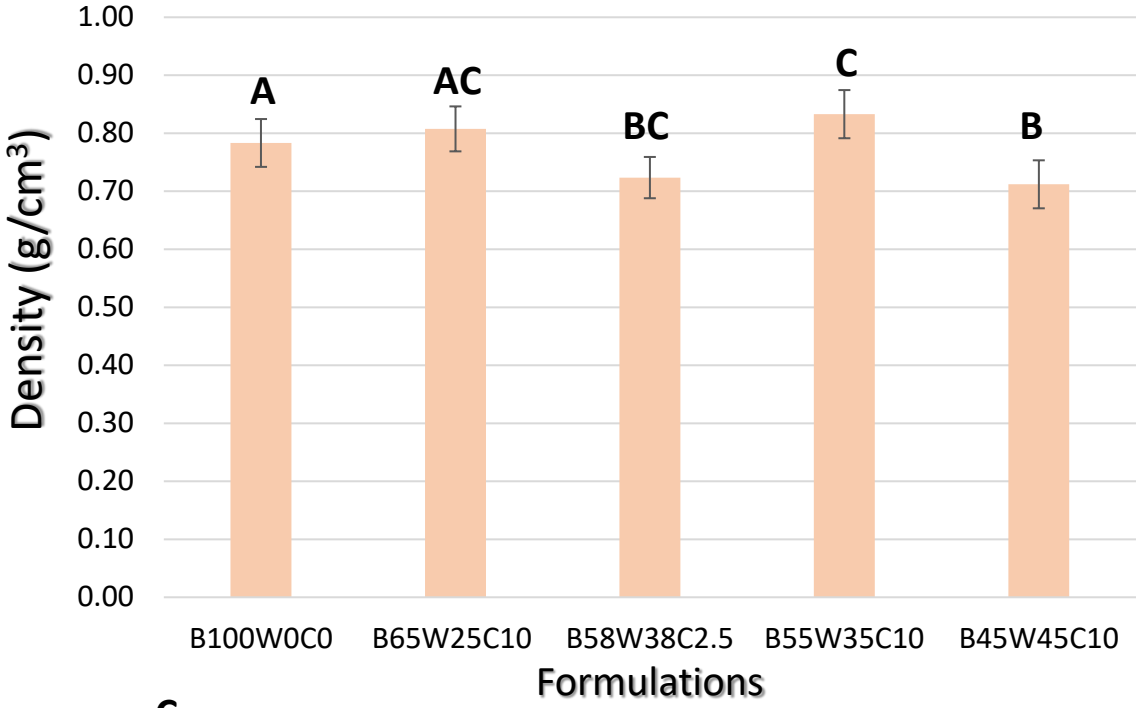


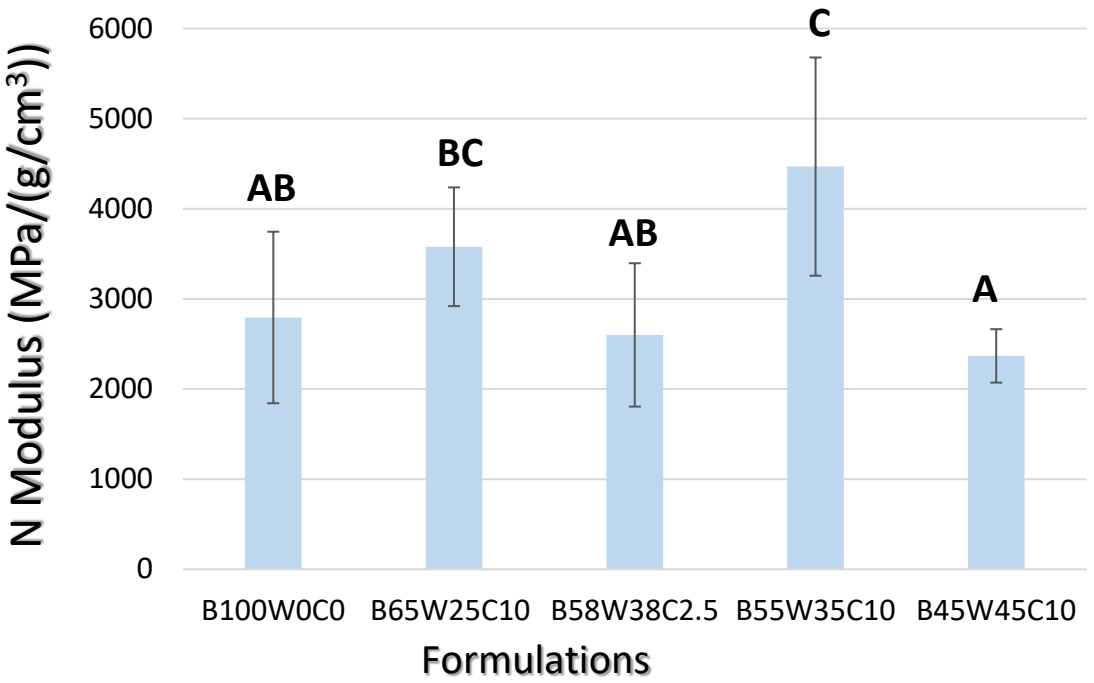


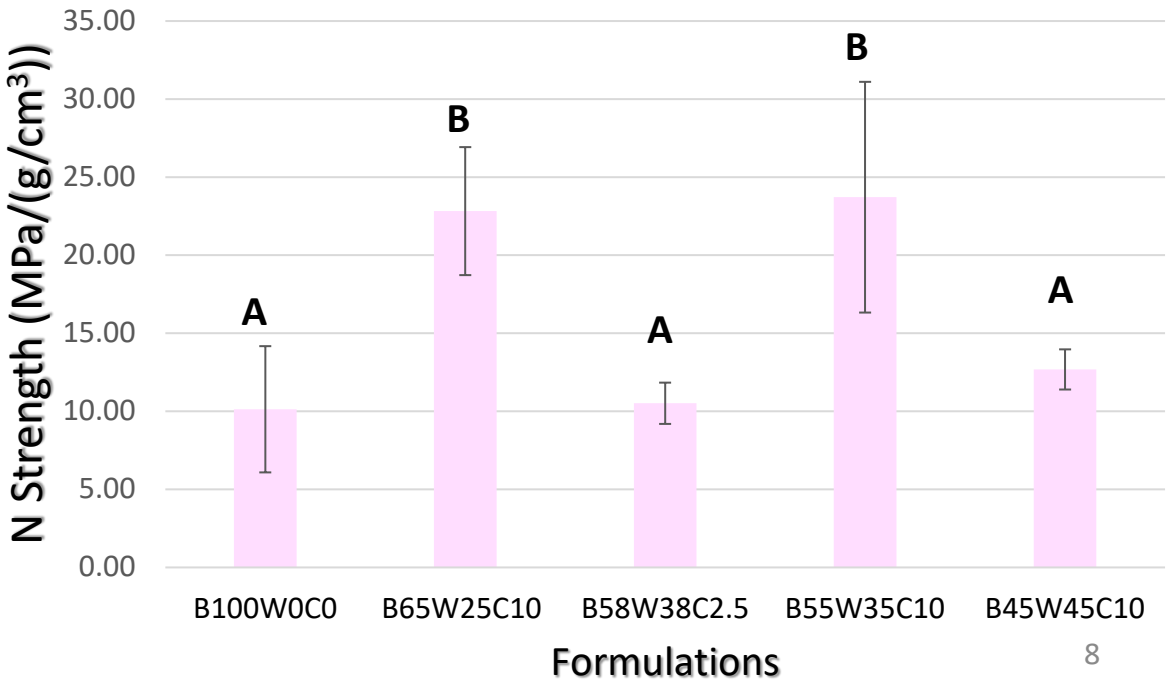


Tensile Test

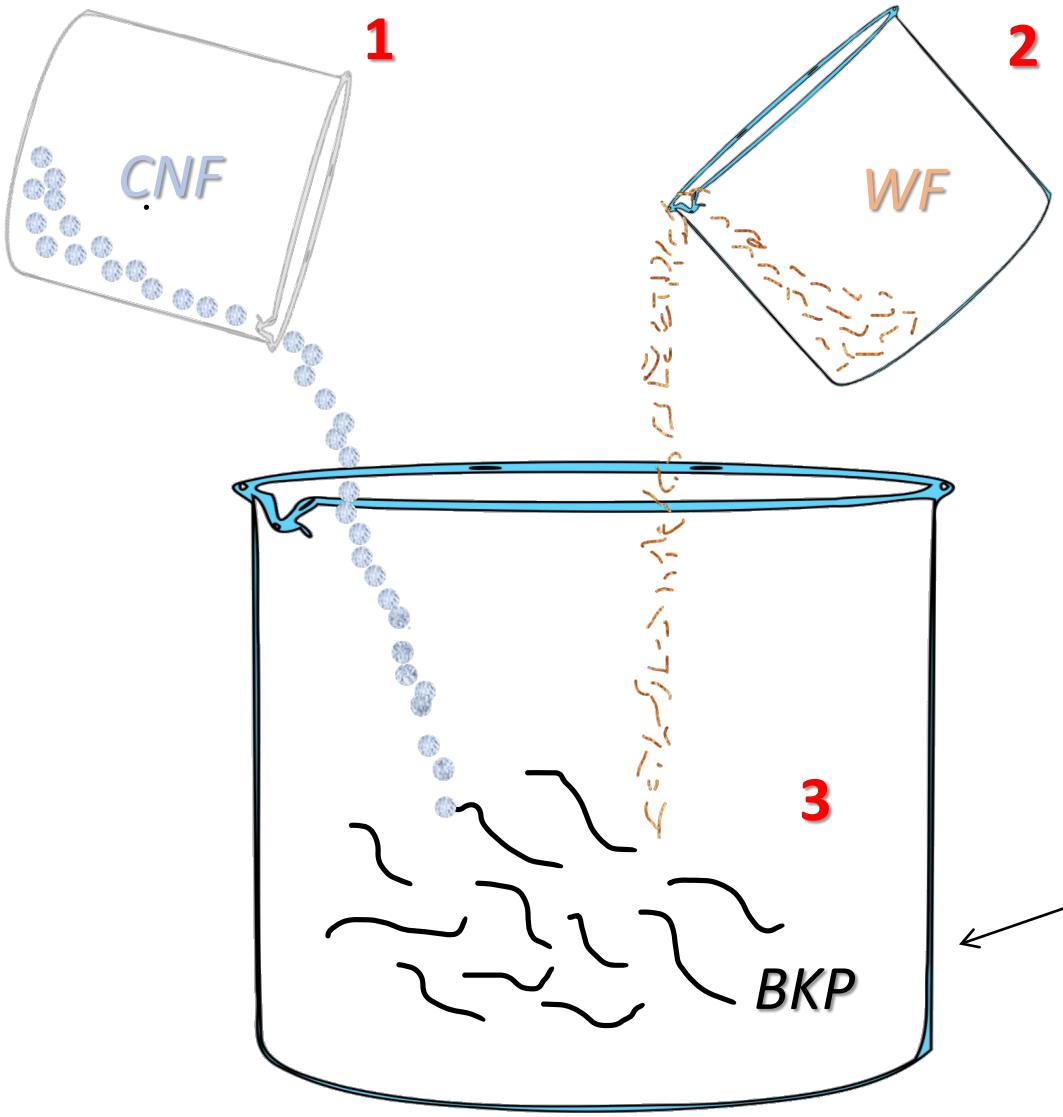
(Normalized properties based on density)



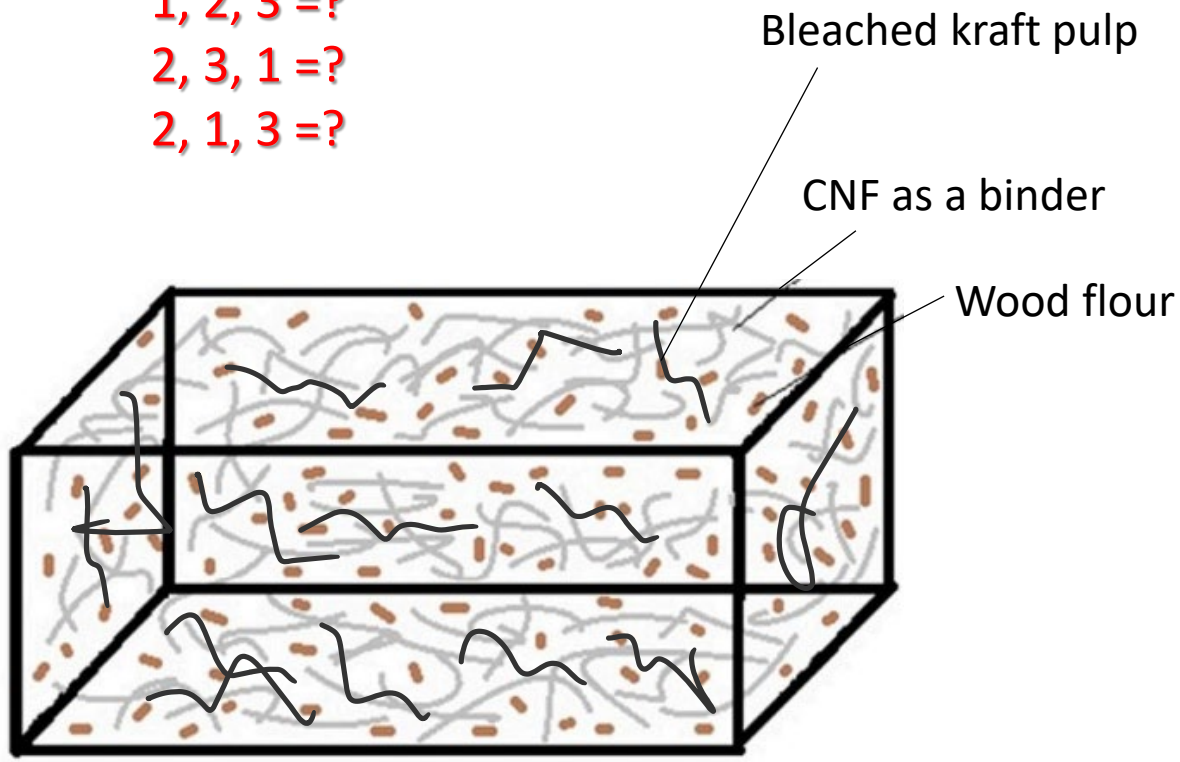




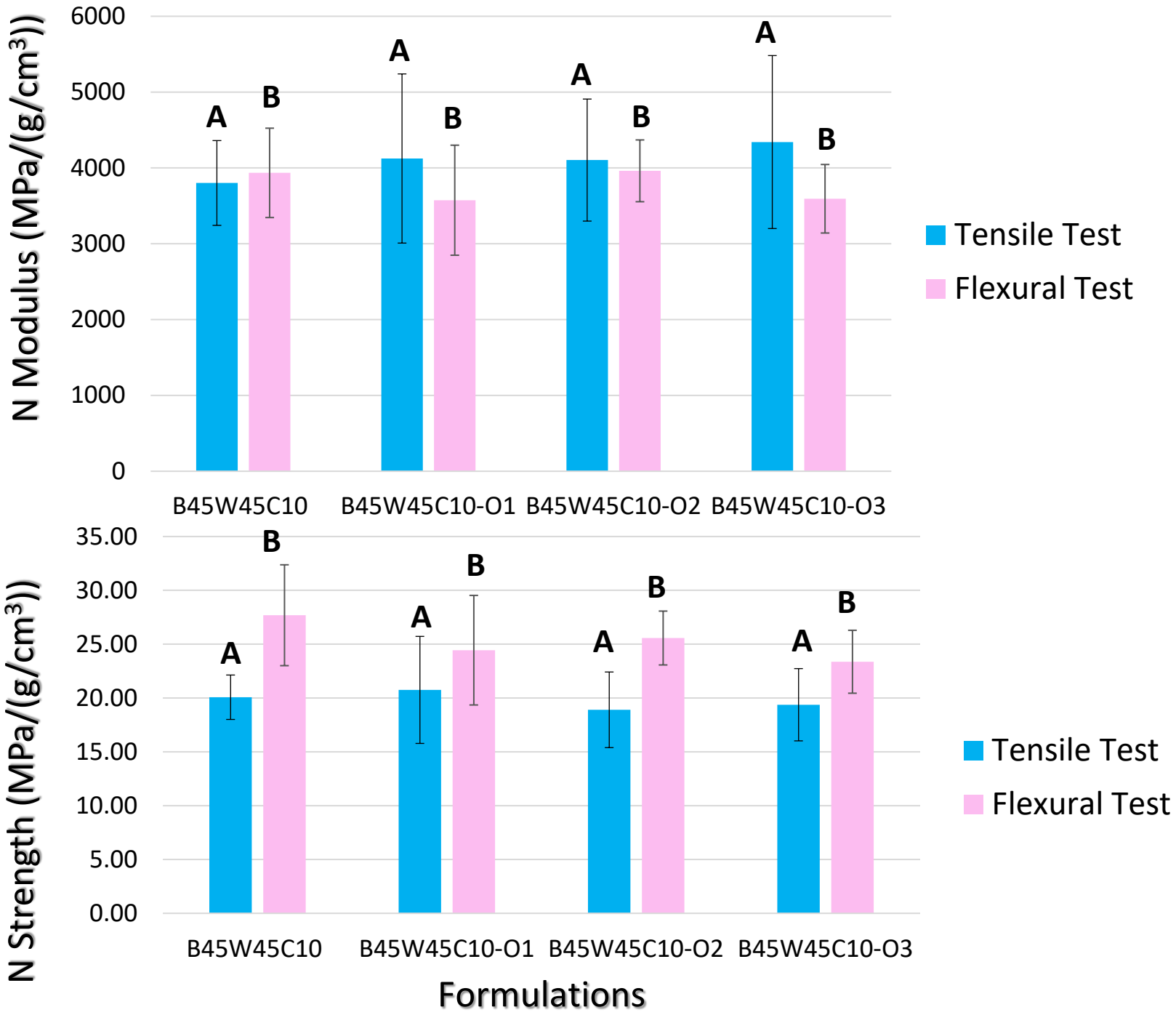
Does Order of addition matter?



1, 2, 3 =?
2, 3, 1 =?
2, 1, 3 =?

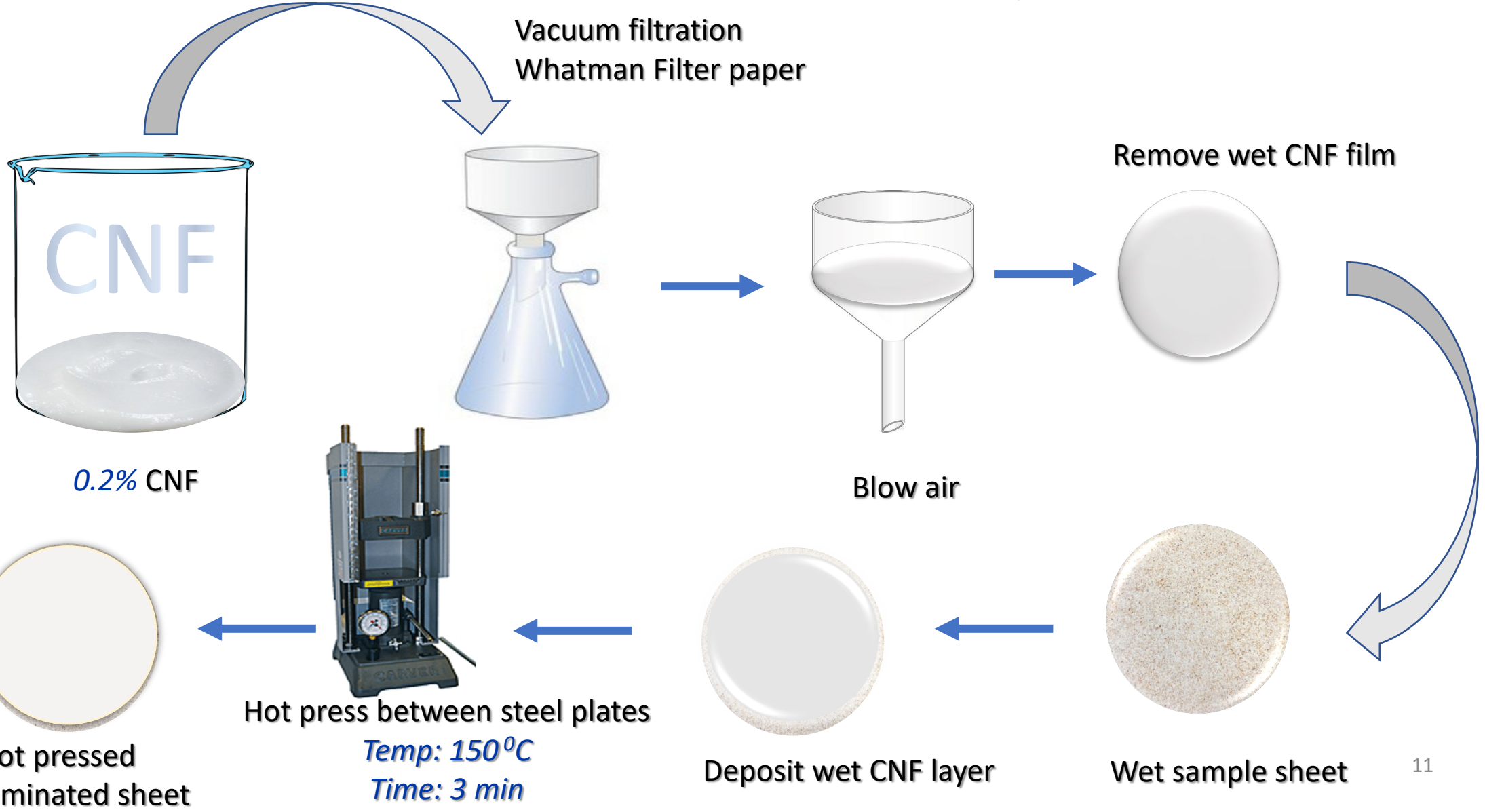


Comparing mechanical strength for different orders of addition

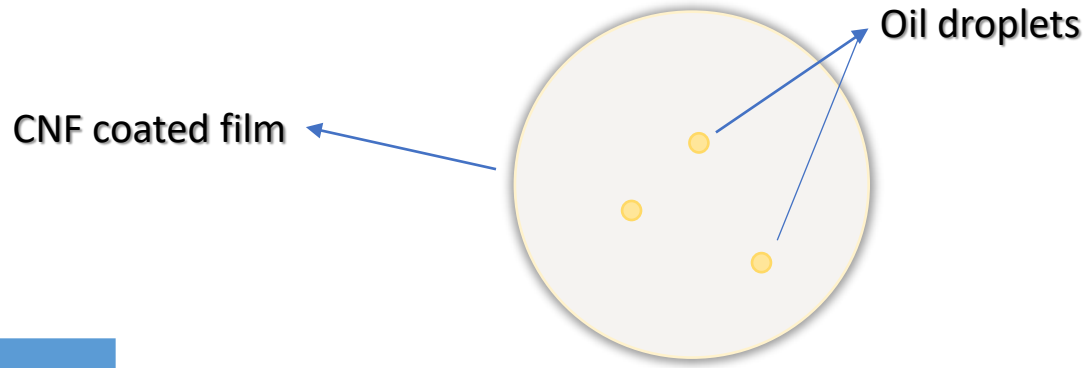


The mechanical strength of the sheets is not affected by changing the order of addition

Lamination of sheets with CNF layer



Oil and Grease test



Formulation: BKP 55% WF 35% CNF 10%

CNF Top layer (g/m²)	Tappi Kit no.
60	12
50	12
40	12
20	12
10	7
5	3

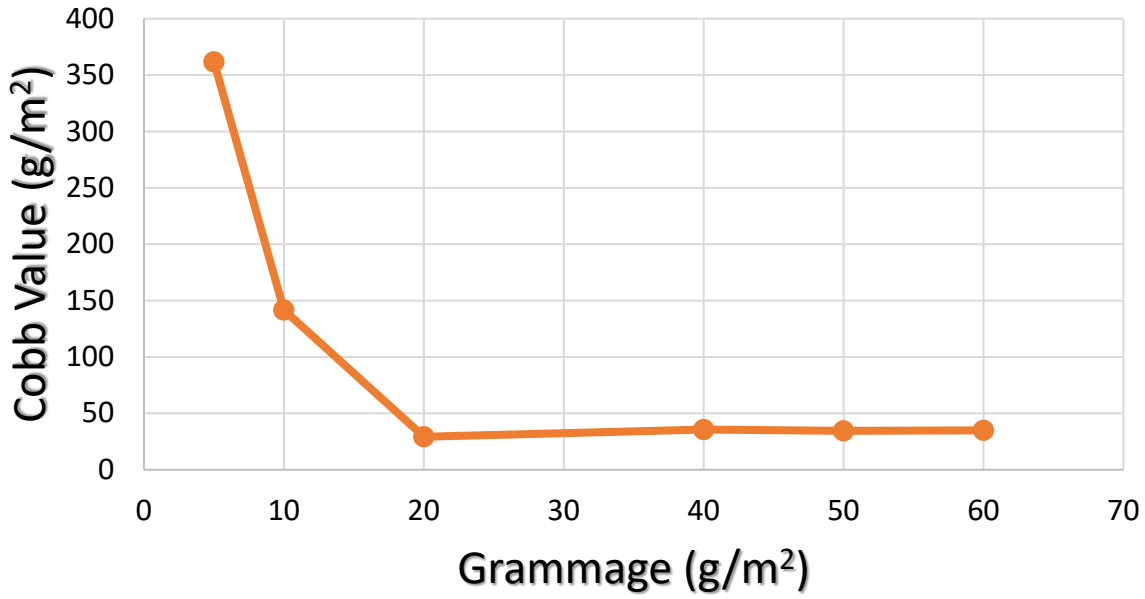
All the CNF coated samples up to 20 g/m² exhibited excellent oil and grease resistance and passed kit value 12 (the maximum possible).

The CNF Film with 10 g/m² and 5 g/m² showed less Kit values of 7 and 3 respectively.

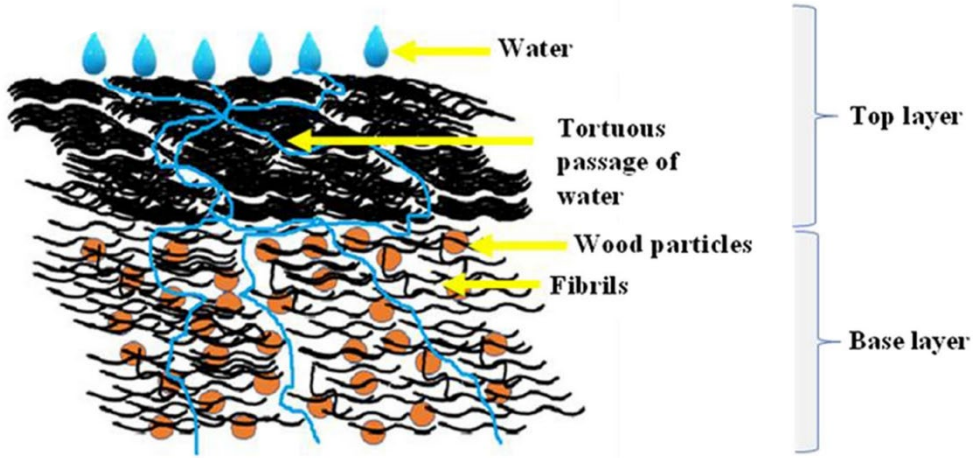
Water Resistance

- ***Cobb test*** ***(Time 120 s)***

$$\text{Cobb value}\left(\frac{g}{m^2}\right) = \frac{\text{Weight of the 'wet' sample (g)} - \text{Weight of the conditioned sample (g)}}{\text{Area of the test surface } (m^2)}$$



Water needs to travel through a tortuous path formed by the layered arrangement of the CNF coating layer to reach the base layer.



Water absorption values are high with low grammage CNF film and Cobb values plateaus at 10 g/m^2. This shows that at high grammage of CNF films can act as a water barrier for the given time.

Picture from Hossain, R., Tajvidi, M., Bousfield, D., & Gardner, D. J. (2022). Recyclable grease-proof cellulose nanocomposites with enhanced water resistance for food serving applications. *Cellulose*, 1-21.

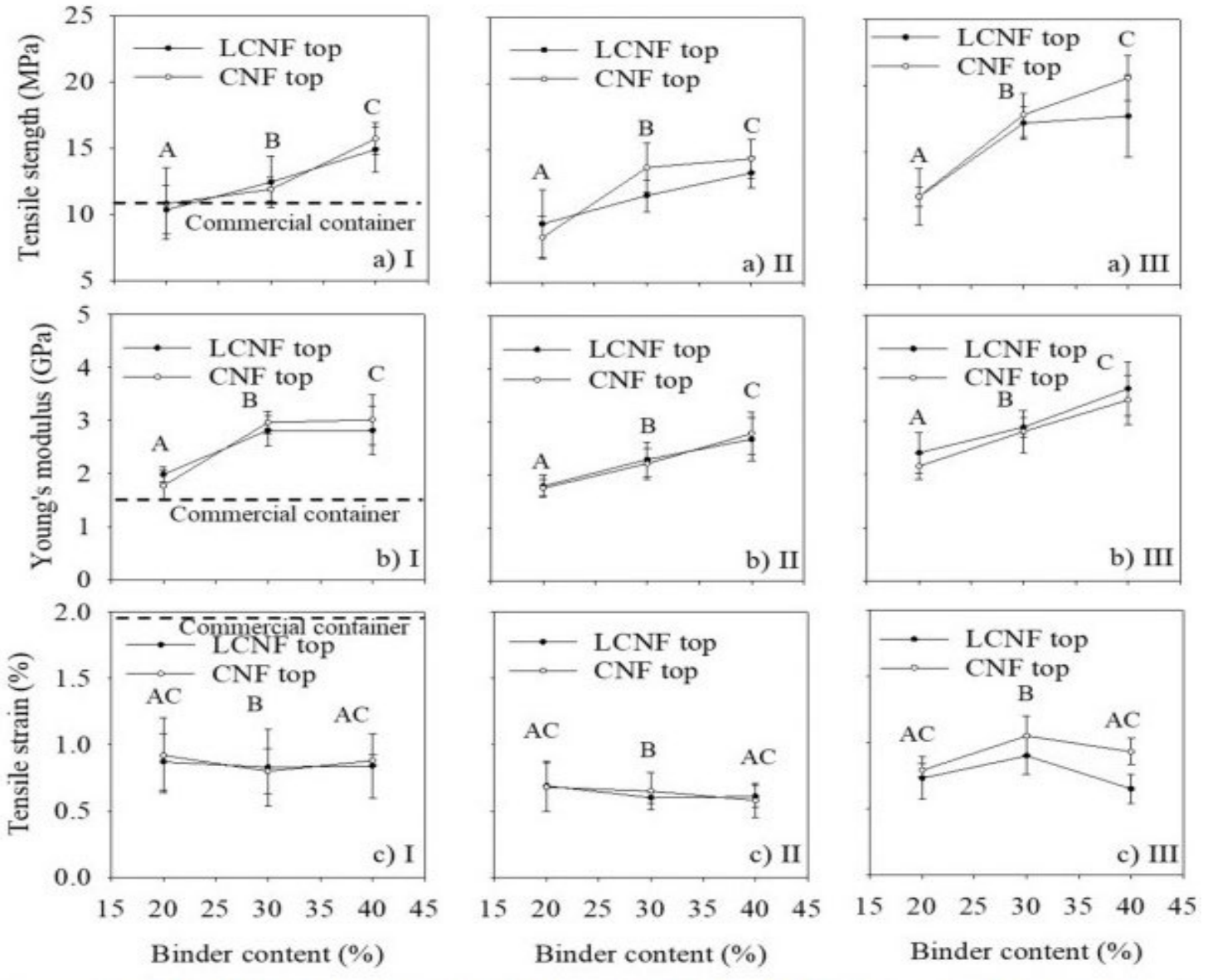
Future Work

- Compare sheet forming with direct thermoforming and design a double-dipping process for the thermoforming to coat a layer of CNF on the base layer to be thermoformed

- Investigate post- surface treatment methods on formed sheets to augment grease and water resistance

Thank you!
Questions?

Previous work



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