Impact of nanocelluloses on the mechanics and microstructure of pectin hydrogels

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TAPPI

RISE Competence Platform on nanocellulose/hybrid materials

- Internal competence platform : RISE Bioeconomy , Bioscience and Materials , PFI, Processum
- To gather nanocellulose knowledge and expertise across RISE
- Long term goal to benefit industry and society with novel uses/products for nanocelluloses
- Different areas of research:
  - WP 1: Inorganic nanoparticles/nanocellulose
  - WP 2. Graphene/nanocellulose
  - WP 3: Nanocellulose based films
  - WP 4: Nanocellulose and polysaccharide interactions

Background I

- Advances is nanocellulose production at large scale are driving the need for a better understanding of the interactions of these materials with other **plant polysaccharides** used in food, pharma ad biotechnology.

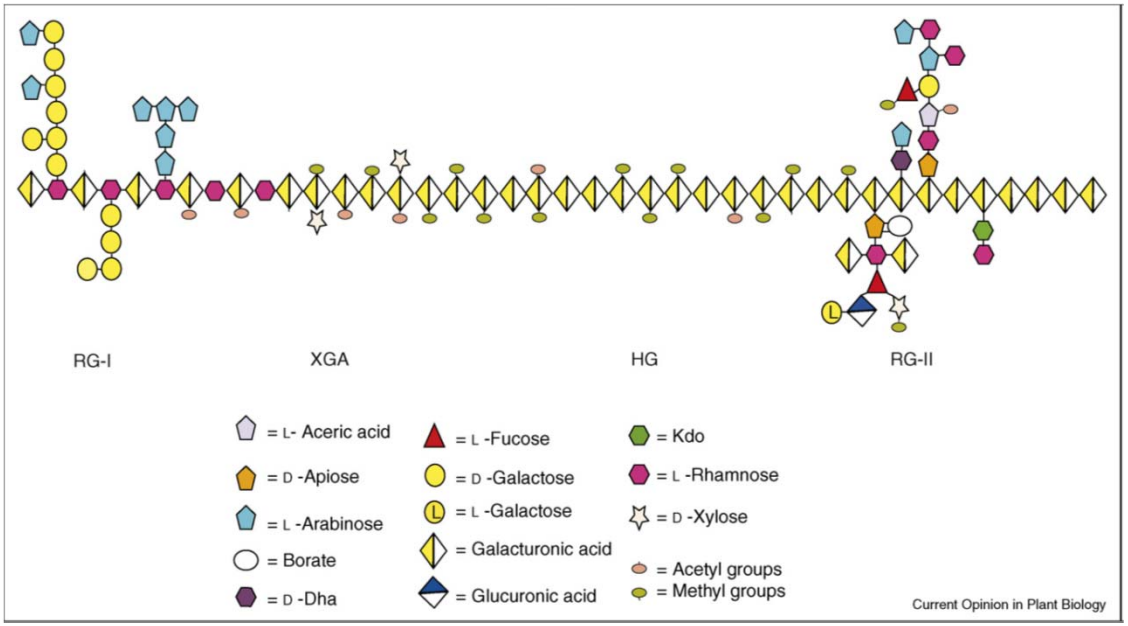
- Polysaccharide **hydrogels** have applications in:
  - Food (texturisers, control release, dietary fibres, satiety)
  - Personal care and cosmetics (viscosifiers, water holding)
  - Biomedicine and pharma (wound healing, drug release)
  - Agriculture (water retention, control release)

- Potential benefits of addition of **CNC, CNF and BNC** are due to mechanical properties, high water holding capacity, biocompatibility, biodegradability , etc

Aim

- Investigate the impact of addition of CNC on the mechanical properties and the microstructure of pectin ionotropic calcium gels.

Pectin structure



Current Opinion in Plant Biology 2008, 11:266–277

Ionotropic calcium gelation of low DE pectin

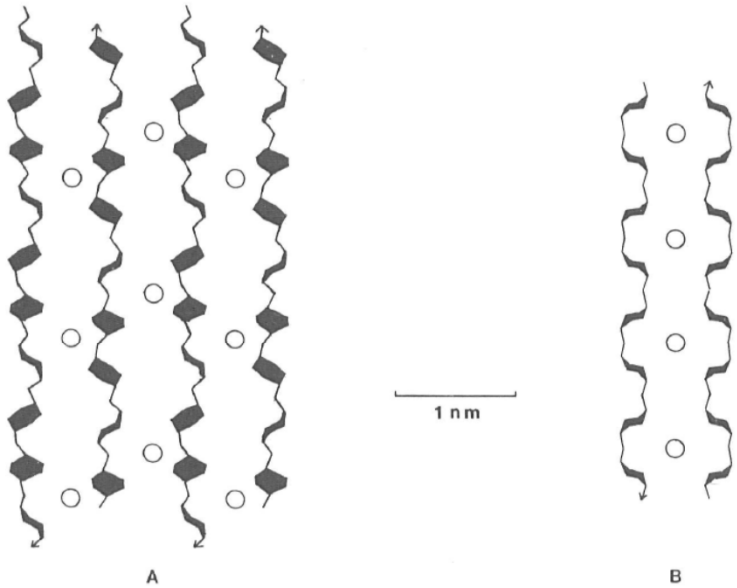
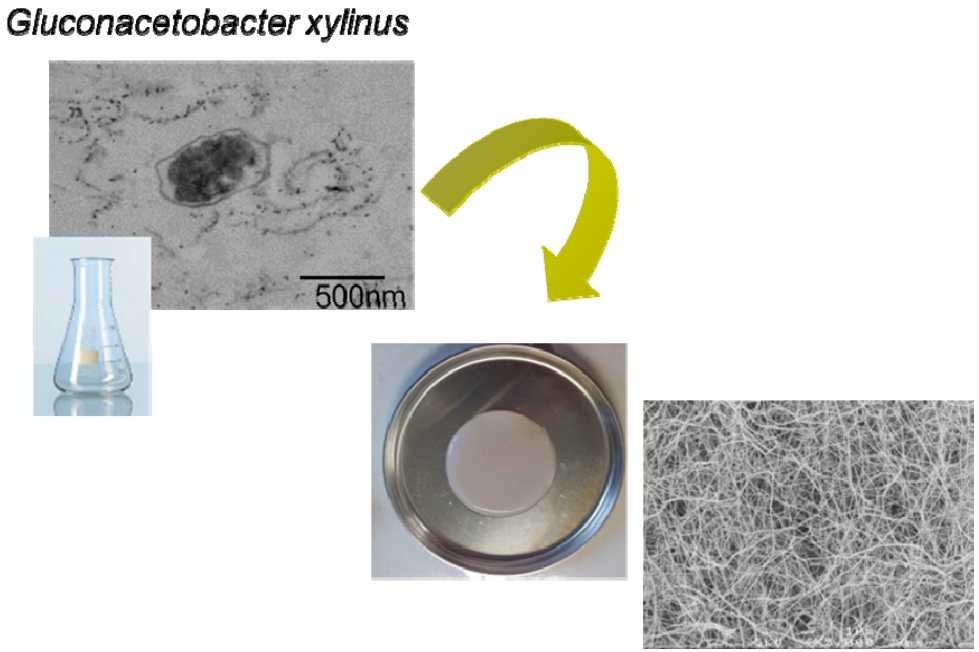


Figure 3. Structures proposed for primary units of calcium pectate junction zones. (A) Tetramer of 3_1 helical chains (Walkinshaw & Arnott, 1981b). (B) Dimer of 2_1 helical chains (Morris *et al.*, 1982). Open circles represent co-ordinated calcium ions.

Plant Cell and Environment (1984) 7, 153-164

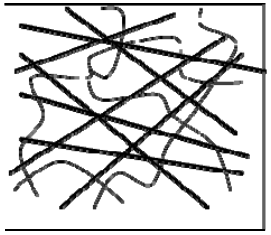
Pectin/ BC hydrogels



Chanliaud,E., Burrows, K.M., Jeronimidis,G., & Gidley, M.J. *(2002). Planta, 215, 989-996.*
Chanliaud,E., De Silva,J., Strongitharm,B., Jeronimidis,G., & Gidley, M.J. *(2004).The Plant Journal, 38, 27-37*

Types of pectin interactions with BC

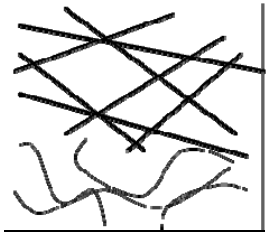
Inter-penetrating networks



Pectins with DE 30-85 and Ca^{2+}

Lopez-Sanchez *et al*. Carbohydrate Polymers (2017) 15,71-81

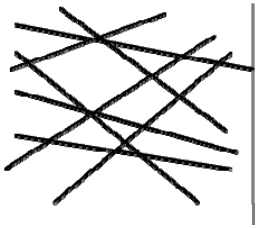
Phase-separated networks



Pectins DE<30 with Ca^{2+}

Chanliaud *et al*. The plant journal (1999) 20, 25-35

Surface adsorption (removed by washing)



Galactan and Arabinan

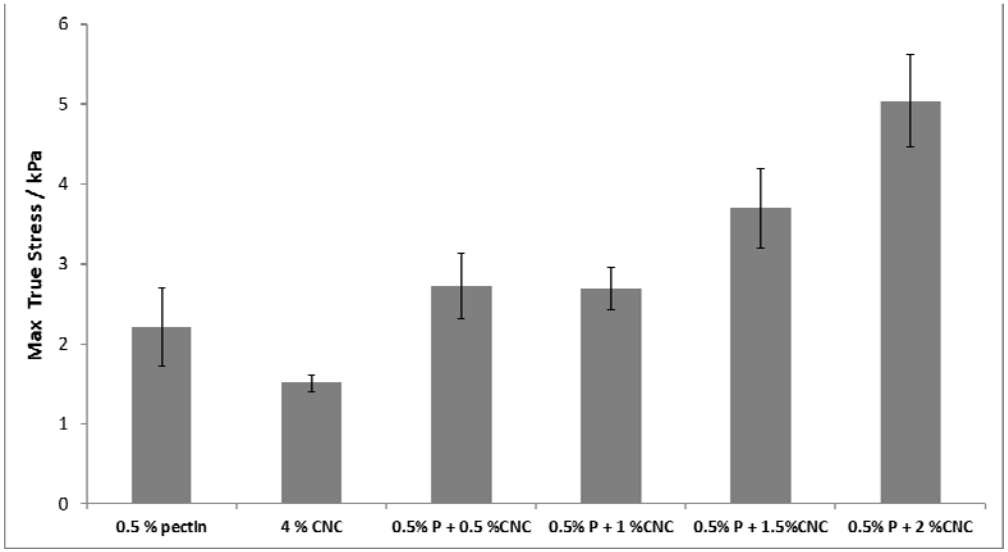
D. Lin *et al*, Carbohydrate Polymers (2015) 126, 108-121

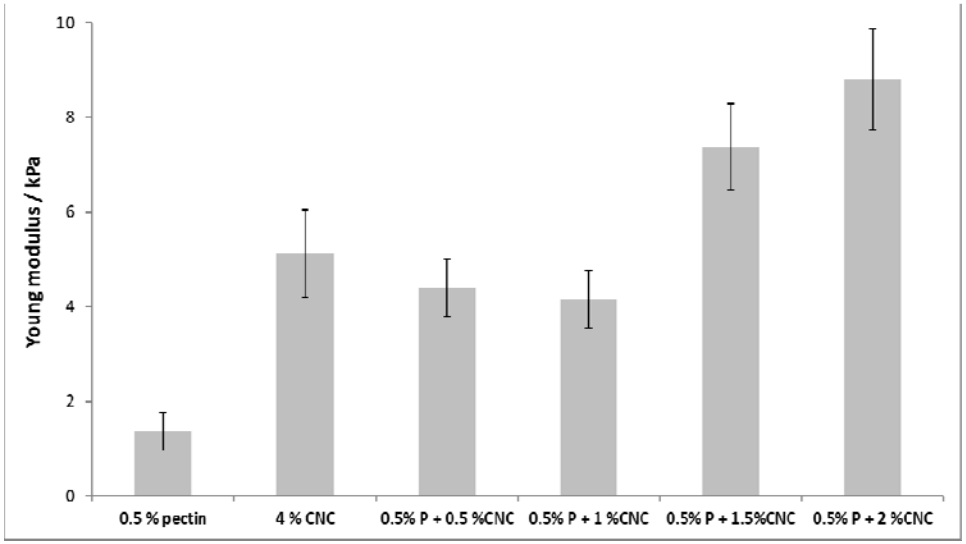
Pectins without Ca^{+2}

D. Lin *et al*, Food Hydrocolloids (2015) 52, 57-68

Mechanical properties

Pectin DE 37

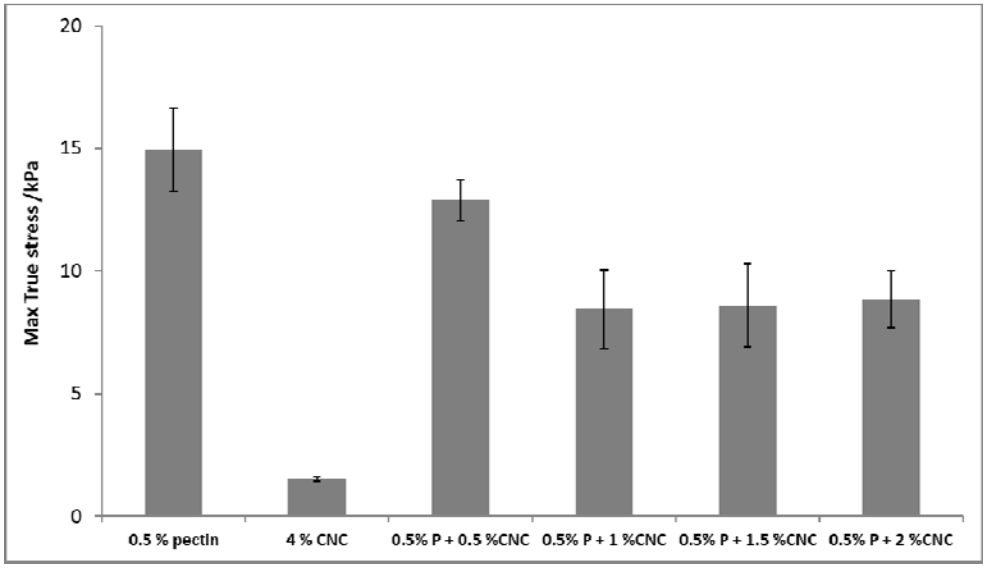


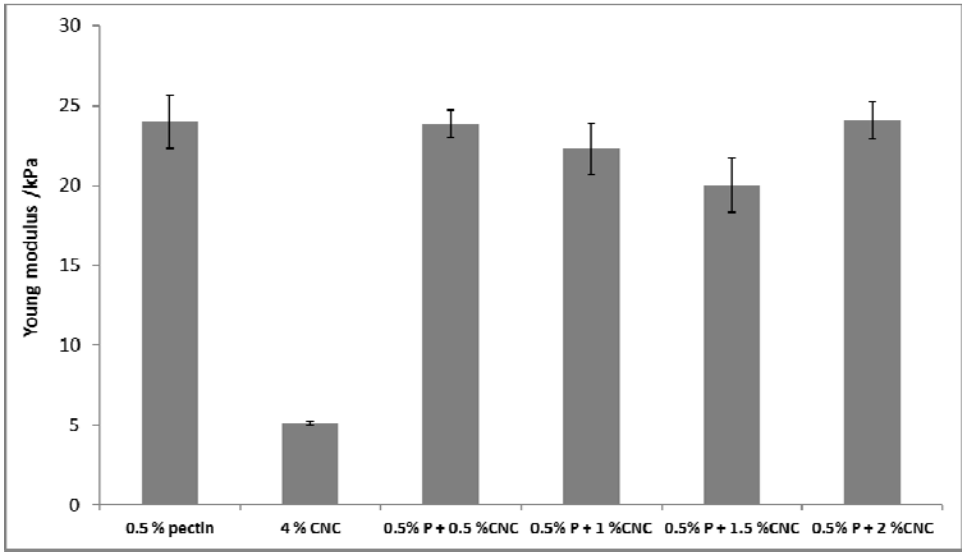


- Gels: 0.5% wt. pectin DE 37/ $CaCO_3$/ GDL
- Gel strength and Young modulus increase with CNC content .

Mechanical properties

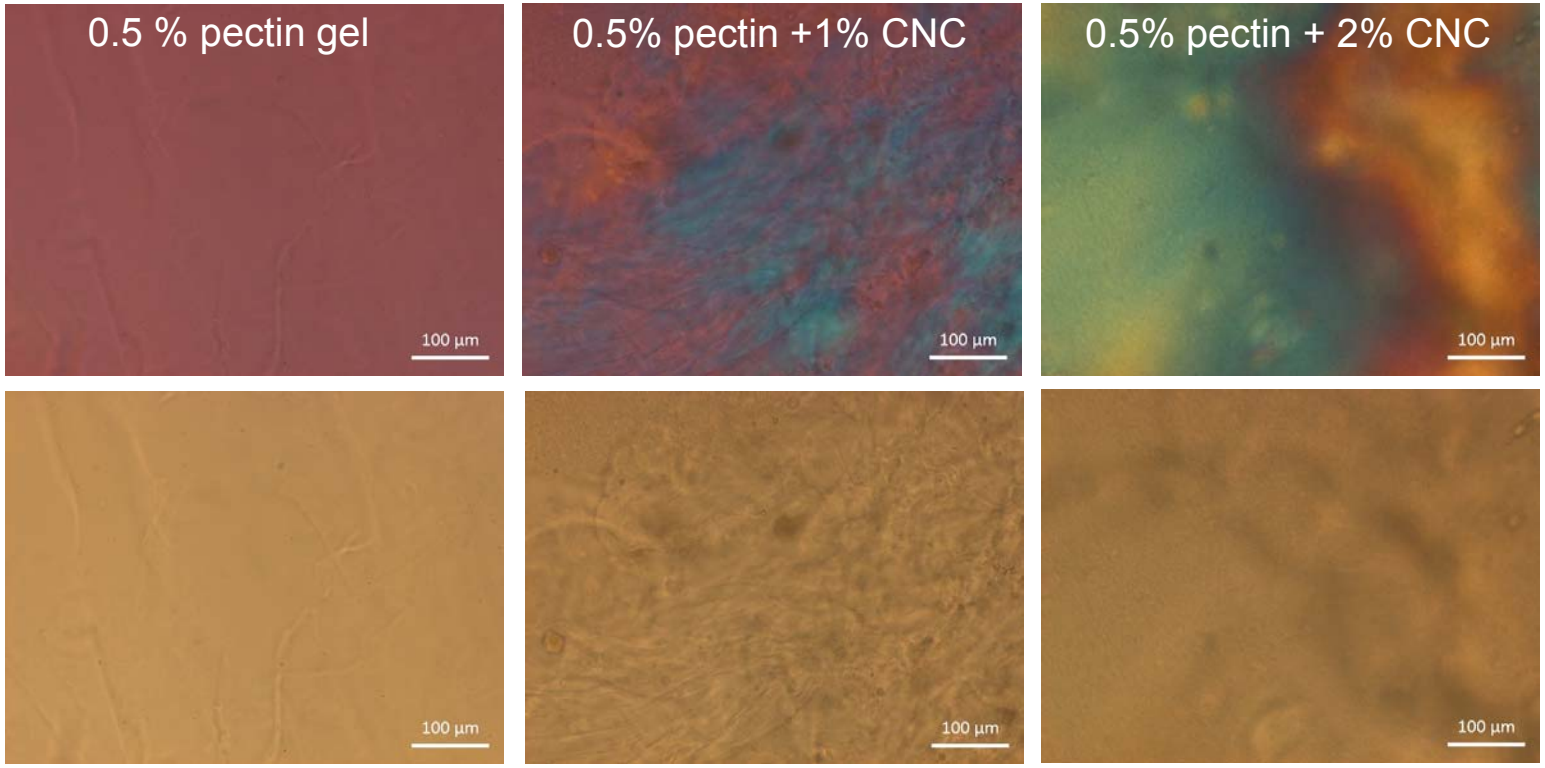
Pectin DE 2.1





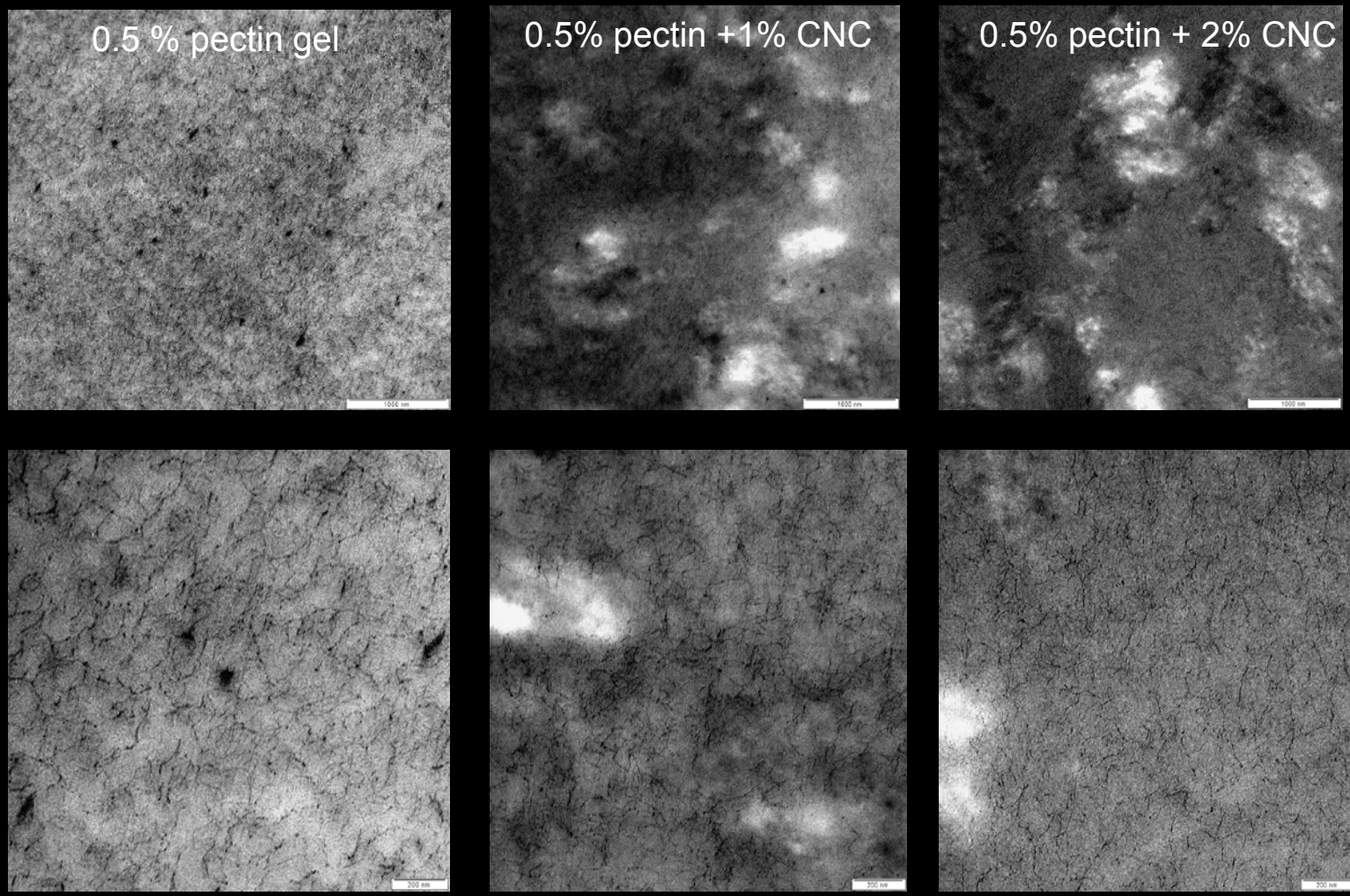
- Gels: 0.5% wt. pectin DE 2.1/ $CaCO_3$/ GDL (Ca^{+2} in excess of stochiometric amount)
- Gel strength decreases with CNC content
- Similar young modulus to pectin gel.

Polarised optical microscopy

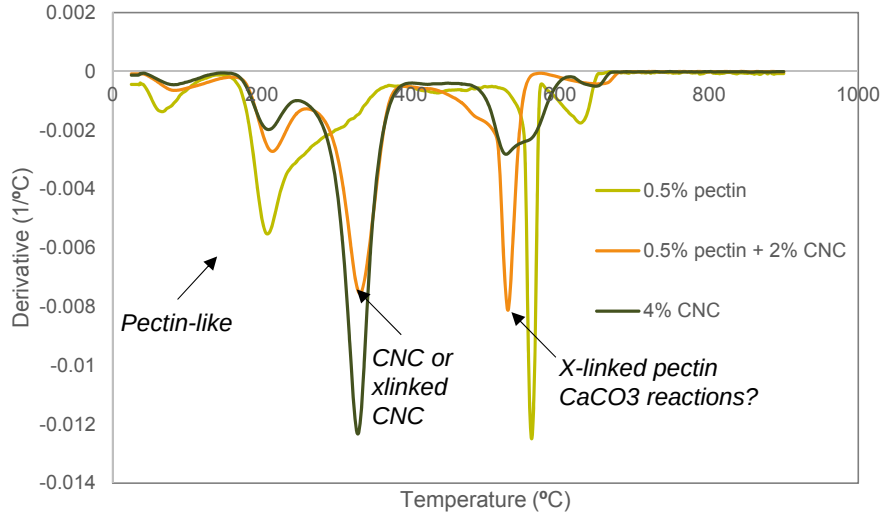


- The increase in CNC concentration could be observed by POM
- Ongoing Transmission Electron microscopy (TEM) to investigate the nanostructure of the hydrogels

TEM

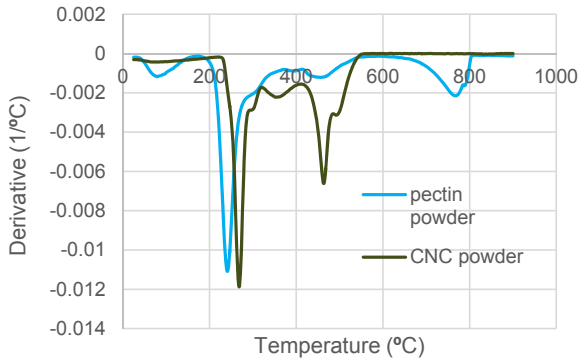


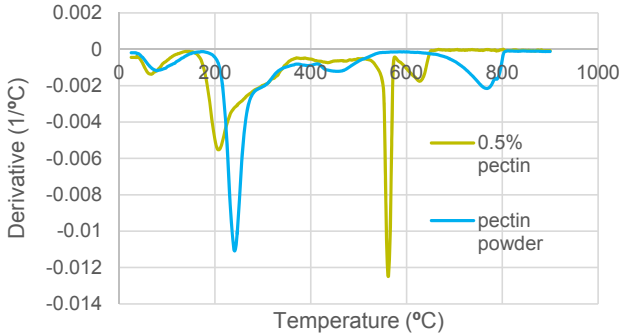
DTG of freeze-dried gels

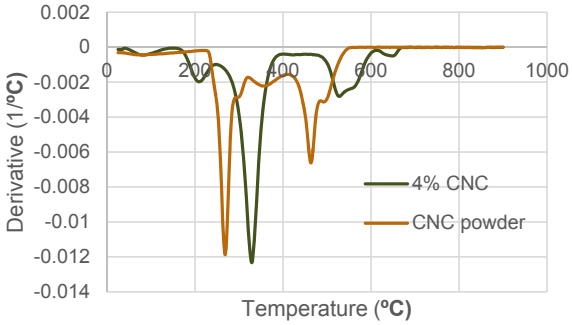


Aerogels:

- Pectin and CNC are quite similar – CNC more thermally stable
- Pectin peaks seem shifted to lower T's with crosslinking
- CNC peaks seem shifted to higher T's with crosslinking







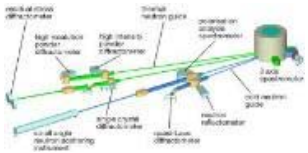
Ongoing : Molecular interactions/structure/ function studies

Pectin hydrogels / CNC
Pectin hydrogels /CNF
CNF/hemicelluloses hydrogels

Micromechanics & rheology

Swelling and Mass transport

Microstructure (TEM, SAXS,WAXS)



Acknowledgements

- Annika Altskär
- Chan Huy Dam

Thank you

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