Fibre Technology perspectives

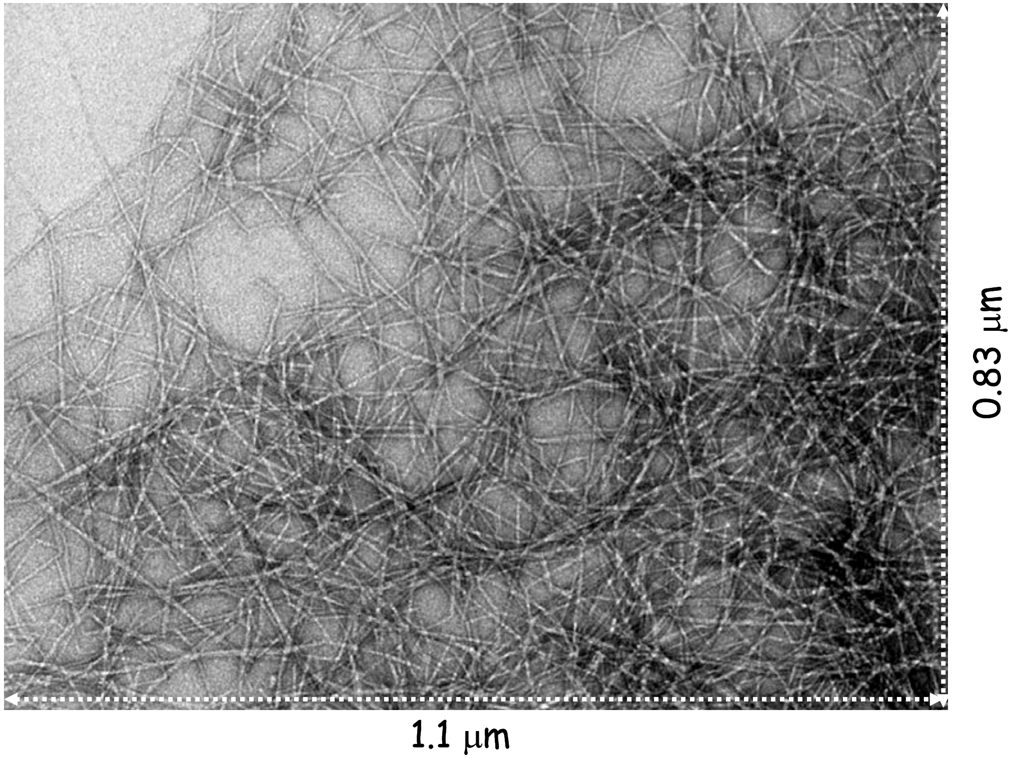
CNF-structures of dispersions, Gel structures, film and foam properties and carbohydrate solubility and their film-formation

Fibre Technology
Main interests

- How do cellulose fibrils reach their arrested/glassy state? What is the structure of the glassy state, how can we influence it and what is the influence on macroscopic structures and properties?
- Internal structure of cellulose beads and how it is changed with different processing conditions-Link to fibre wall organisation (Water/cellulose interactions).
- The structure of LbLs (Layer-by-Layer) and their macroscopic properties (Tailoring of mechanical properties)
- Solubility of carbohydrates, how it is changed with concentration and its influence on macroscopic properties??

Resulting material

1.9 g/l

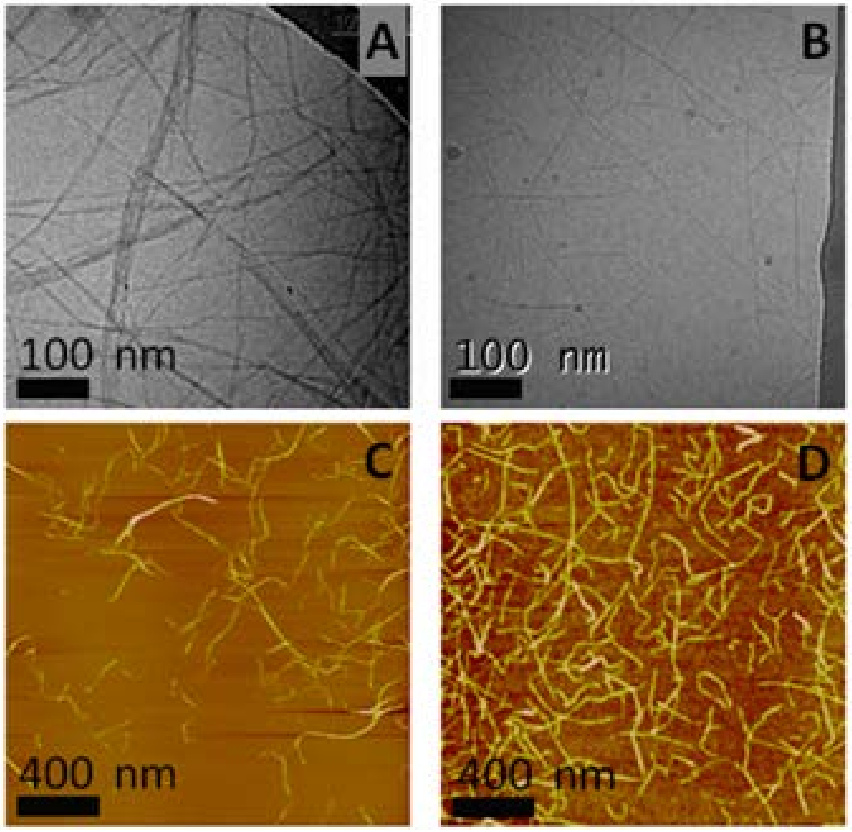


Material properties

Table 1. Charge, Gravimetric Yield, and Width of NFC Fibrils[a]

property	NFC600	NFC400	NFC120
pretreatment	CarbMe	CarbMe	enzyme
charge (μeq/g)			
pulp	589	327	44
dispersion	595	383	120
yield	97%	47%	36%
width (nm)			
AFM	3.5	2.3	4.6
cryo-TEM	5.0	4.3	5.5

[a] The charge of the pulp was measured with conductometric titration, and the charge of the dispersions was measured with polyelectrolyte titration. The gravimetric yield was measured after the centrifugation step.

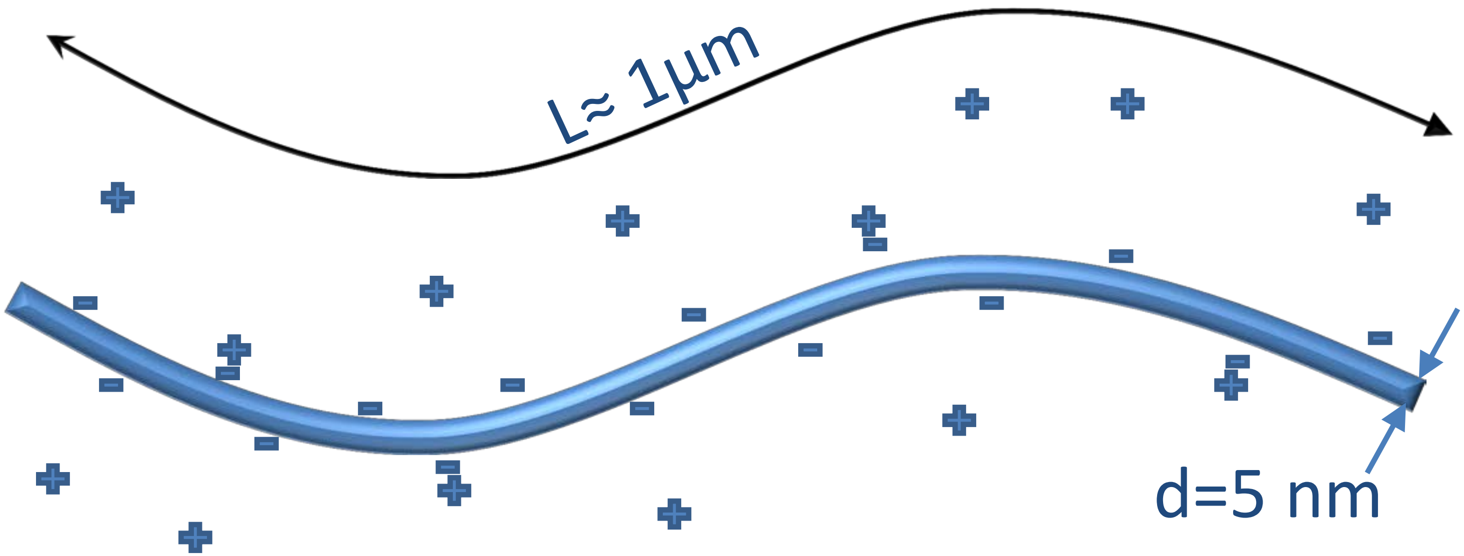


Fall et al, Langmuir 27 (2011)11332

WWSC WALLENBERG WOOD SCIENCE CENTER

KTH VETENSKAP OCH KONST

KTH Fibre and Polymer Technology



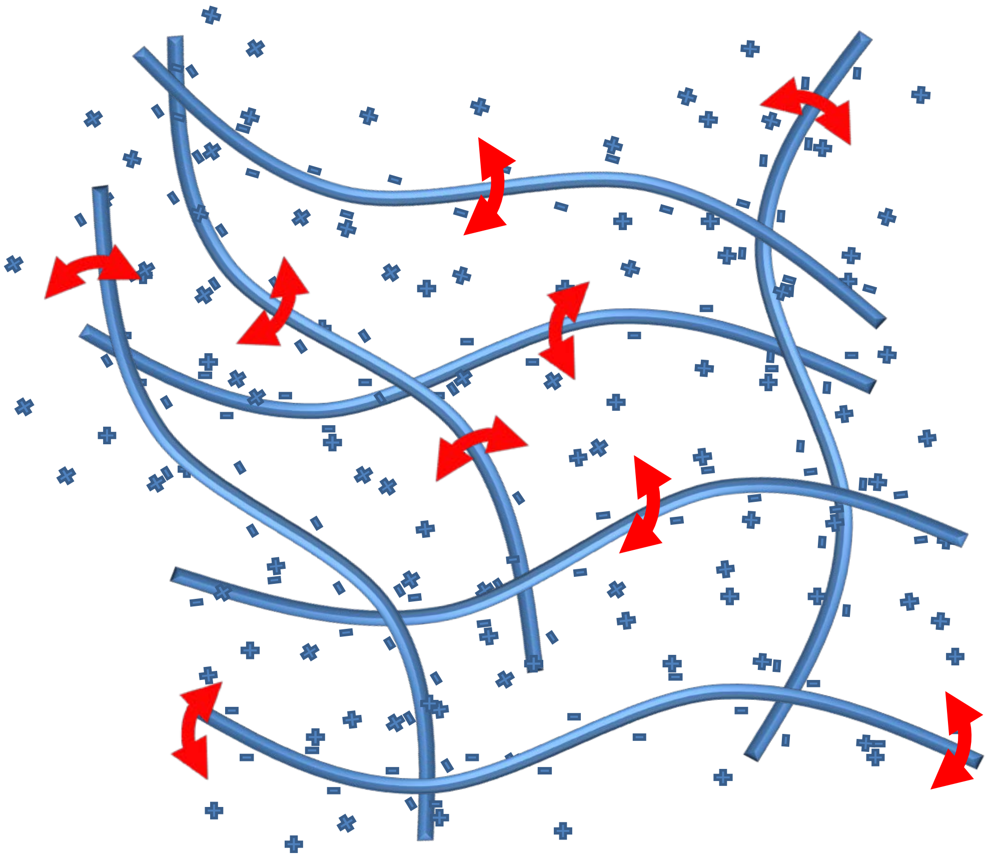
$\psi_{surface}$; 0-(-250) mV

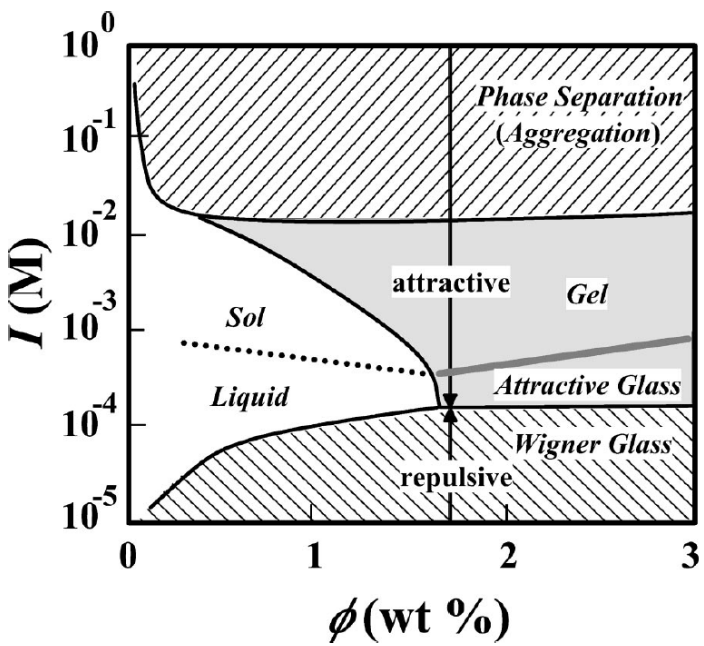
$$c_v = \frac{1.5}{r^2}$$

c_v = volumetric overlap concentration

r = length to diameter ratio(L/d)

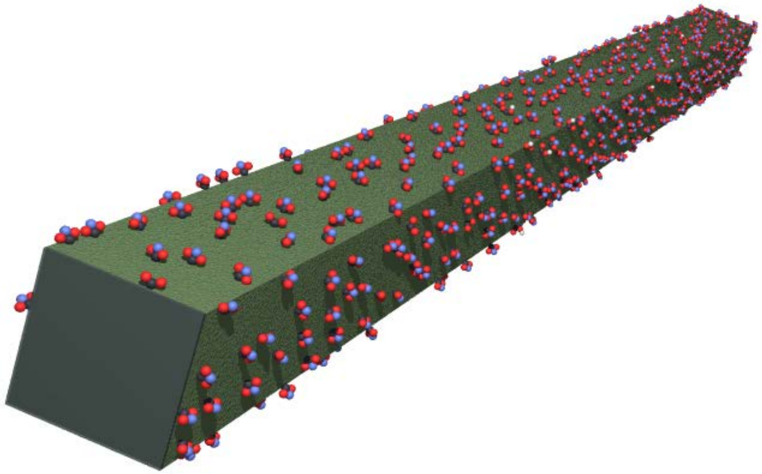
56 mg/l

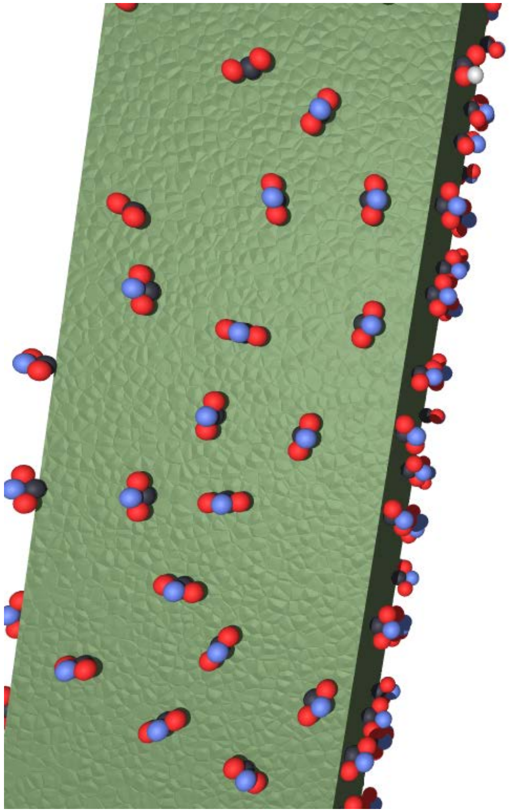




Bonn et al, Phys. Rev. E (2004) 69,031404

Availablility of charges on the cellulose fibrils- Specific adsorption





WWSC
WALLENBERG WOOD SCIENCE CENTER

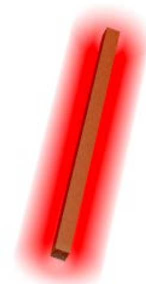
"Real" dimensions at different salt concentrations

KTH VETENSKAP OCH KONST
KTH Fibre and Polymer Technology

Only CNF

20 mM NaCl

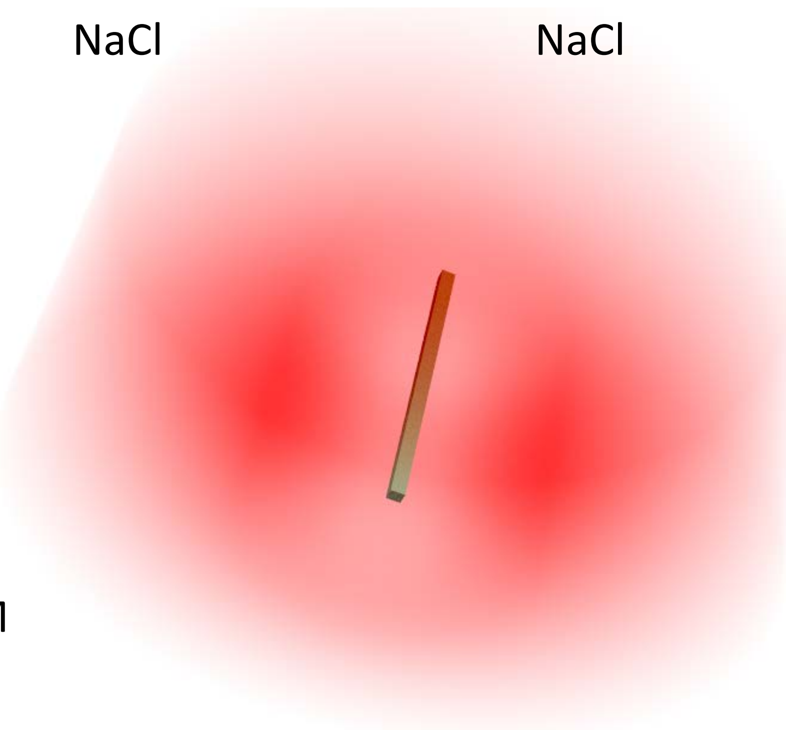
2 mM NaCl



1 mM NaCl

Influence of counterions on the interaction!

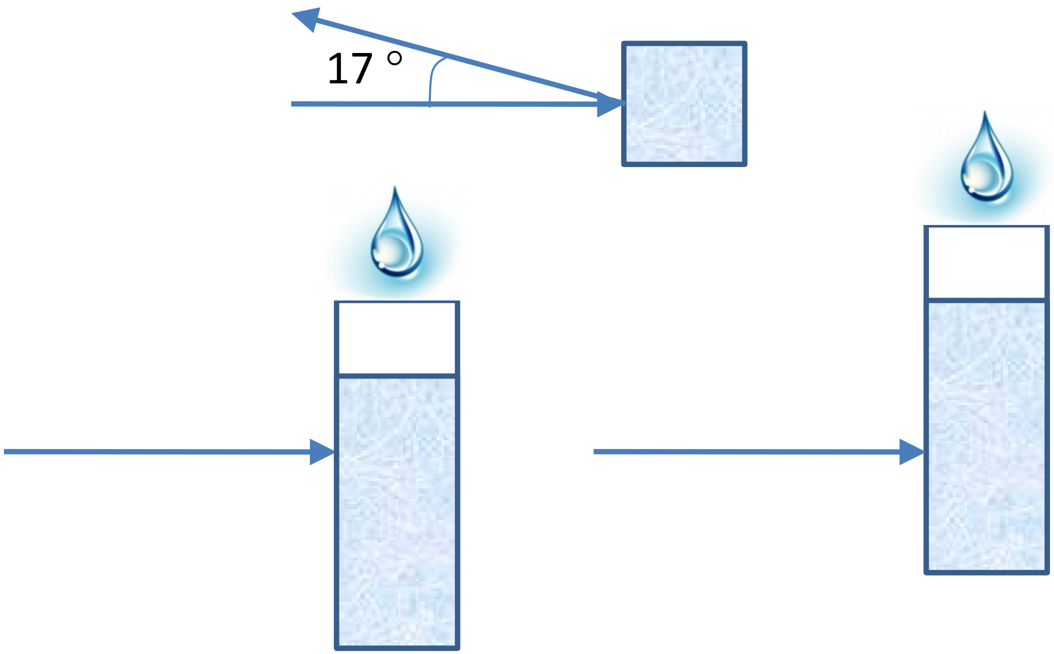
0.1 mM NaCl



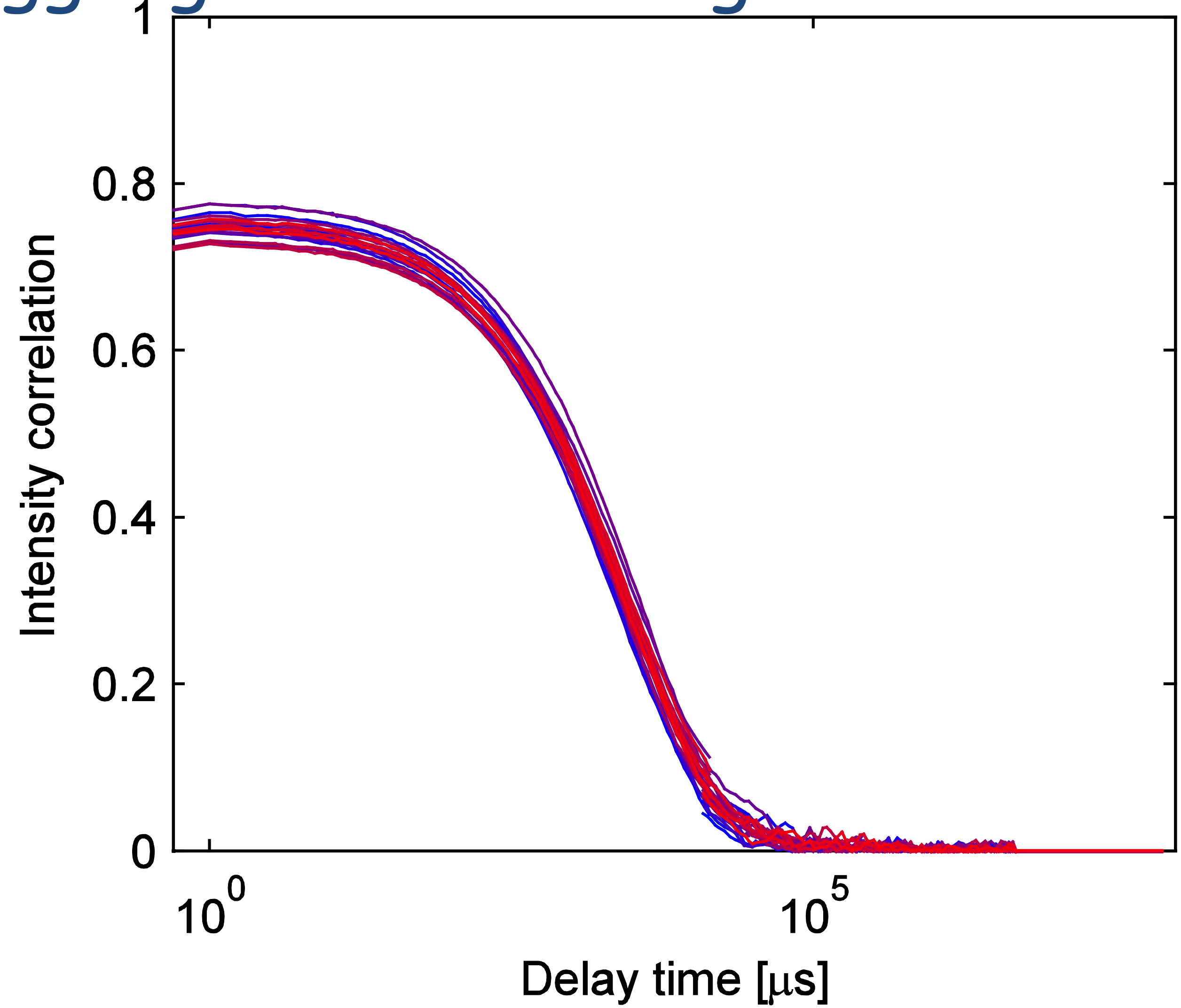
0.01 mM NaCl

Gelling in practice-DLS

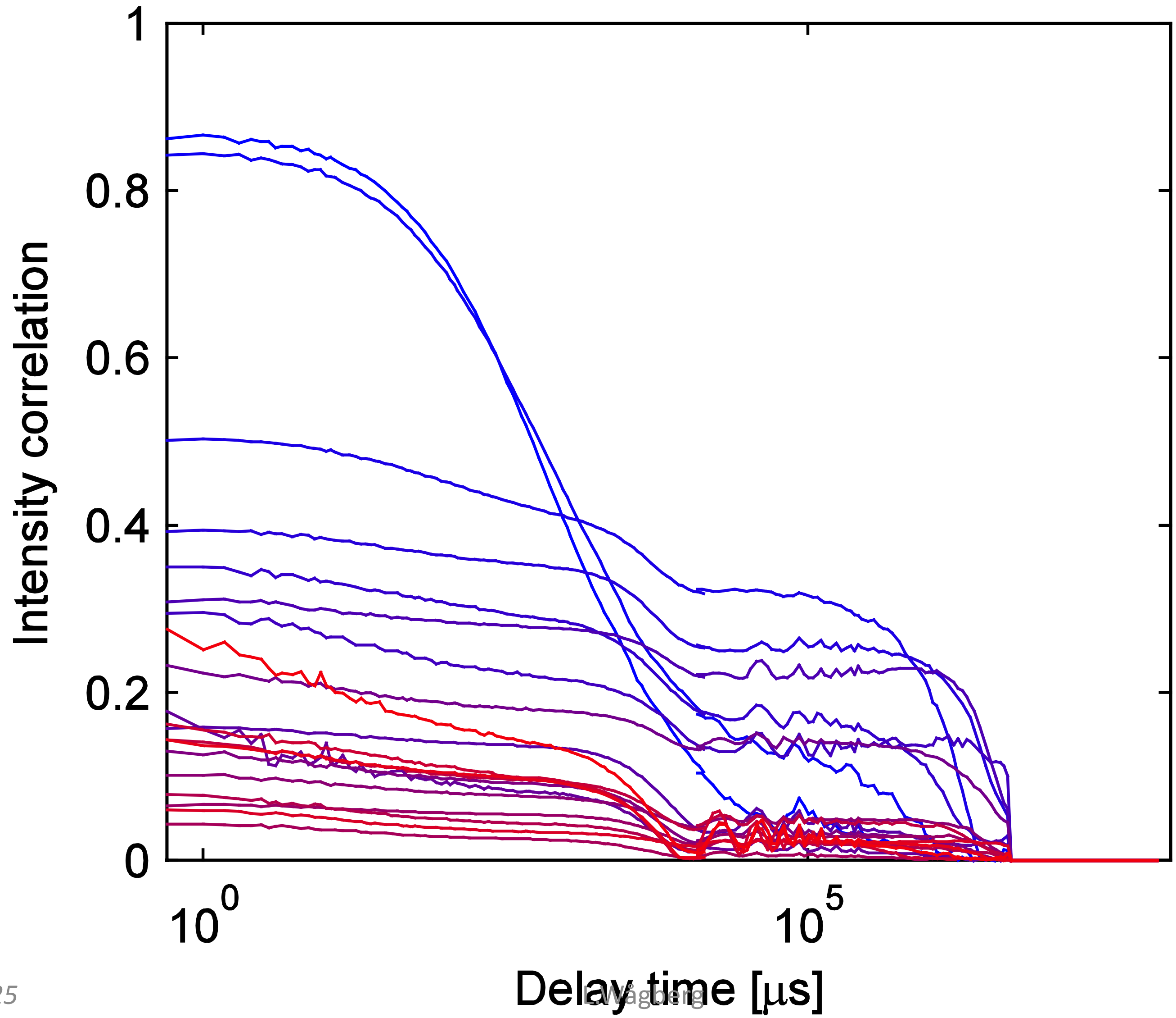
Dynamic Light scattering
Malvern Zetasizer, Nanoseries



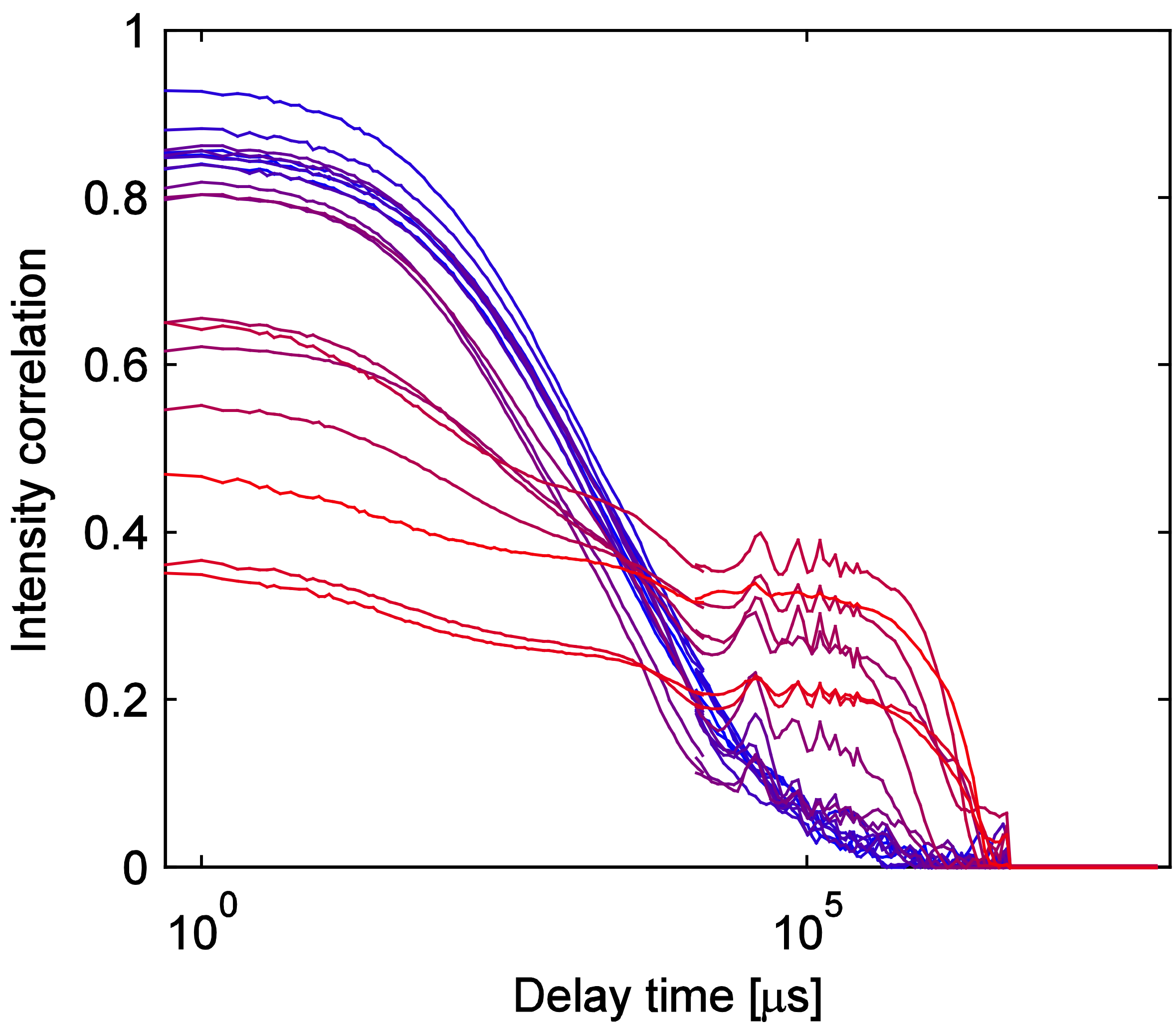
DLS-Dispersed NFC
Aggregation following salt addition



DLS-Upper part of measuring cell



DLS-Lower part of measuring cell

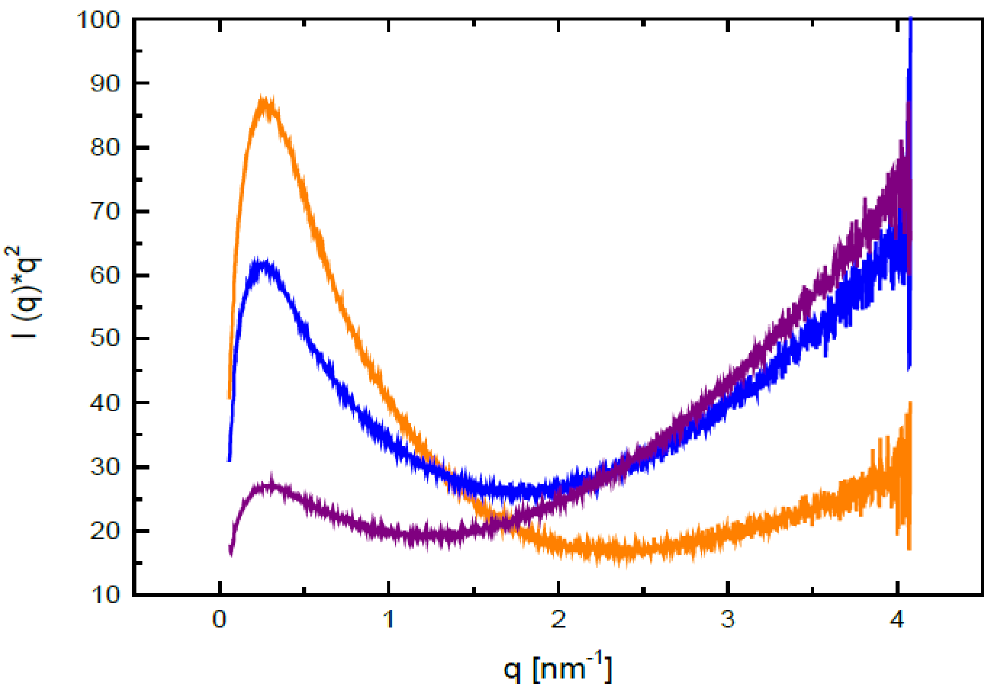


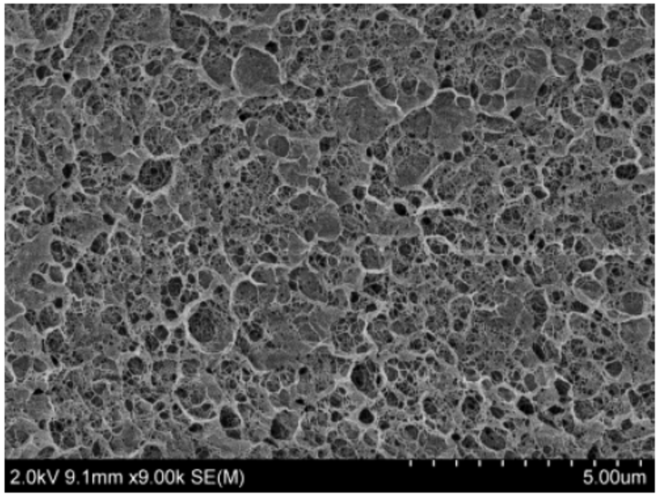
Gelling in practice- Methyl orange visualization

1 g/l

0.05 g/l

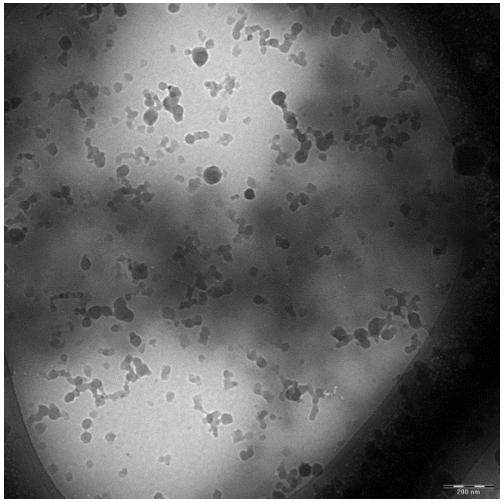
Cellulose beads as model gels

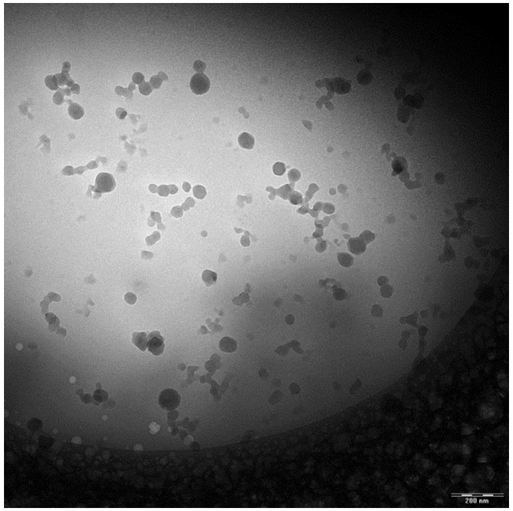


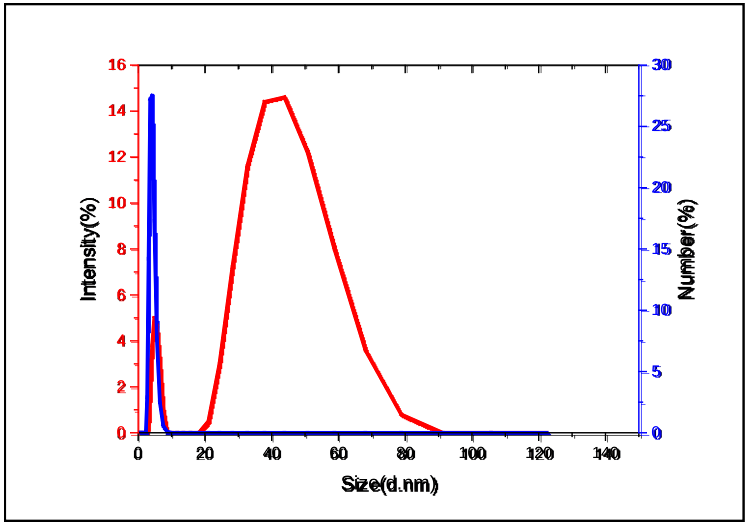


Link to fibre wall organisation needed

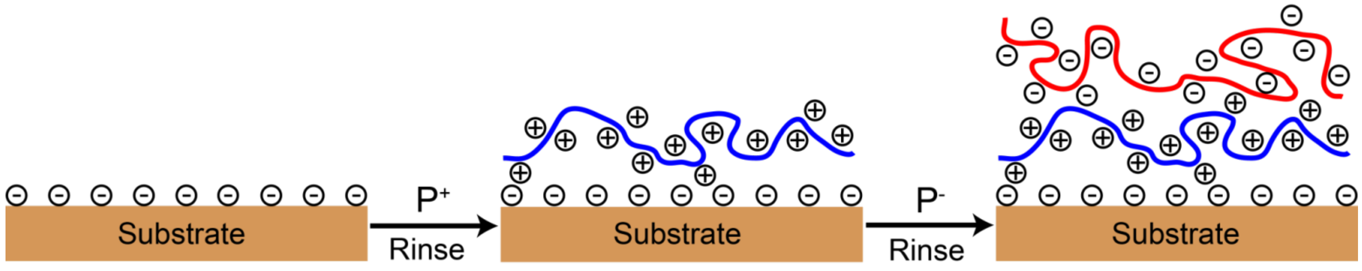
Solubility of hemicelluloses



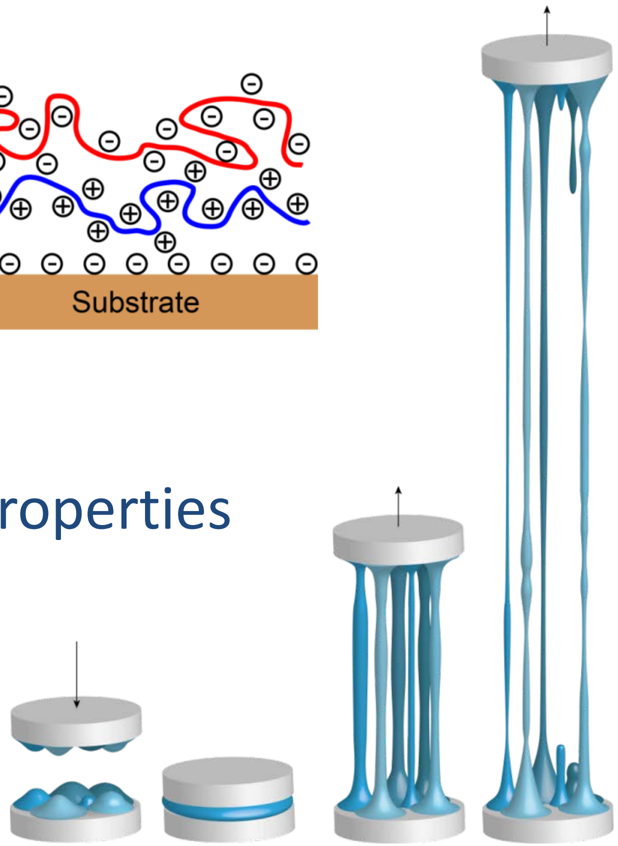




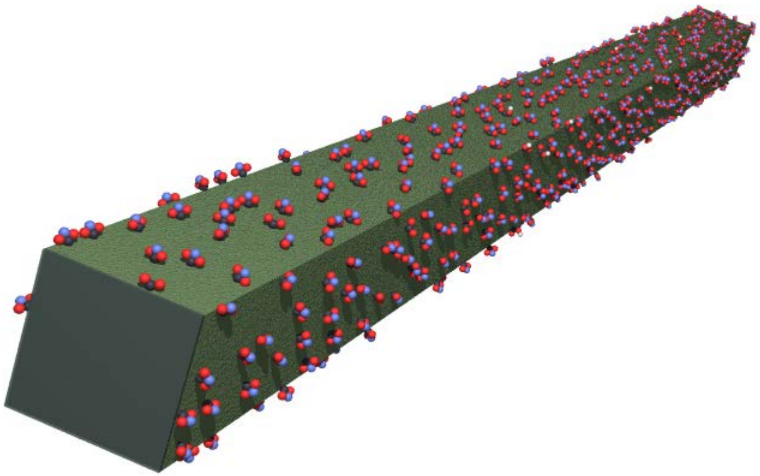
LbL Structure and properties

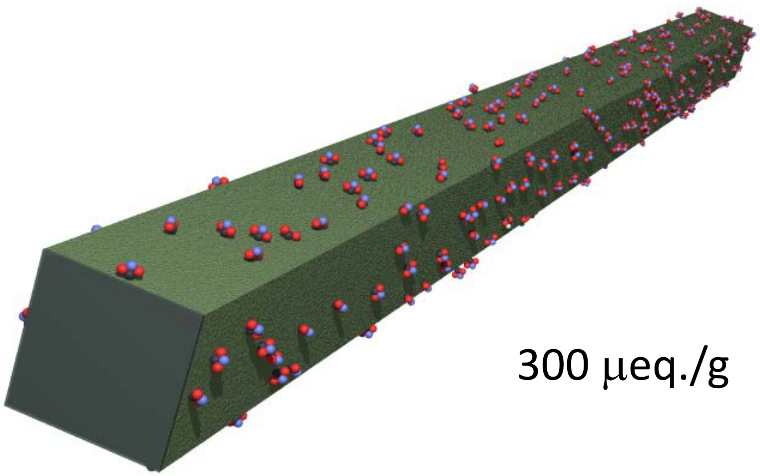


The relationsship between structure and properties



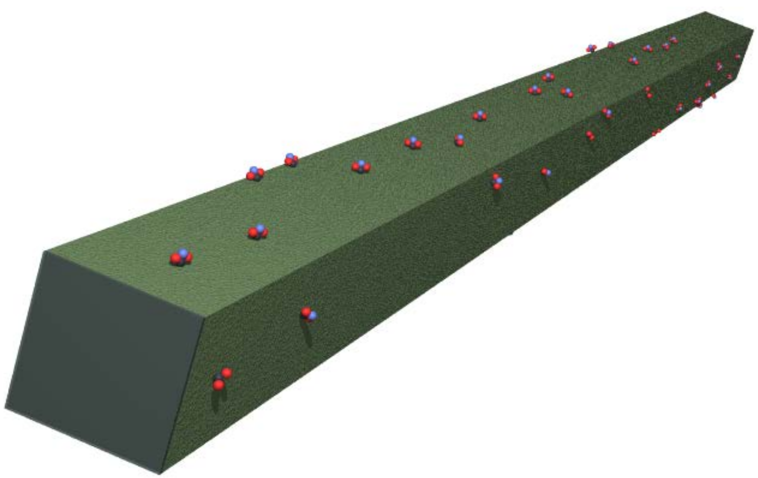
Comparison between different charges





300 μeq./g

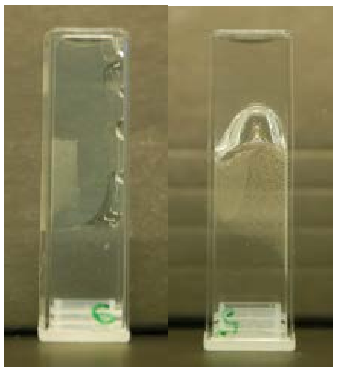
600 μeq./g



50 μeq./g

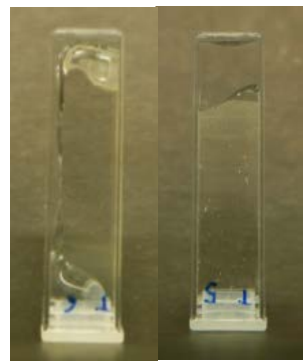
Gelling of nanocellulose dispersions Controlling factors- Charge and counterions

CarbMeth-CNF
(σ = 0.6 mmol/g)
3.2 3.4



C_{Col} = 2 mM

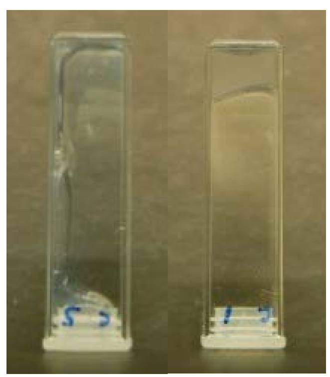
Tempo-CNF
(σ = 1 mmol/g)
7.0 8.0



C_{Col} = 8 mM

Far from aggregation caused by counterions

CarbMeth-CNC
(σ = 0.6 mmol/g)
31 33

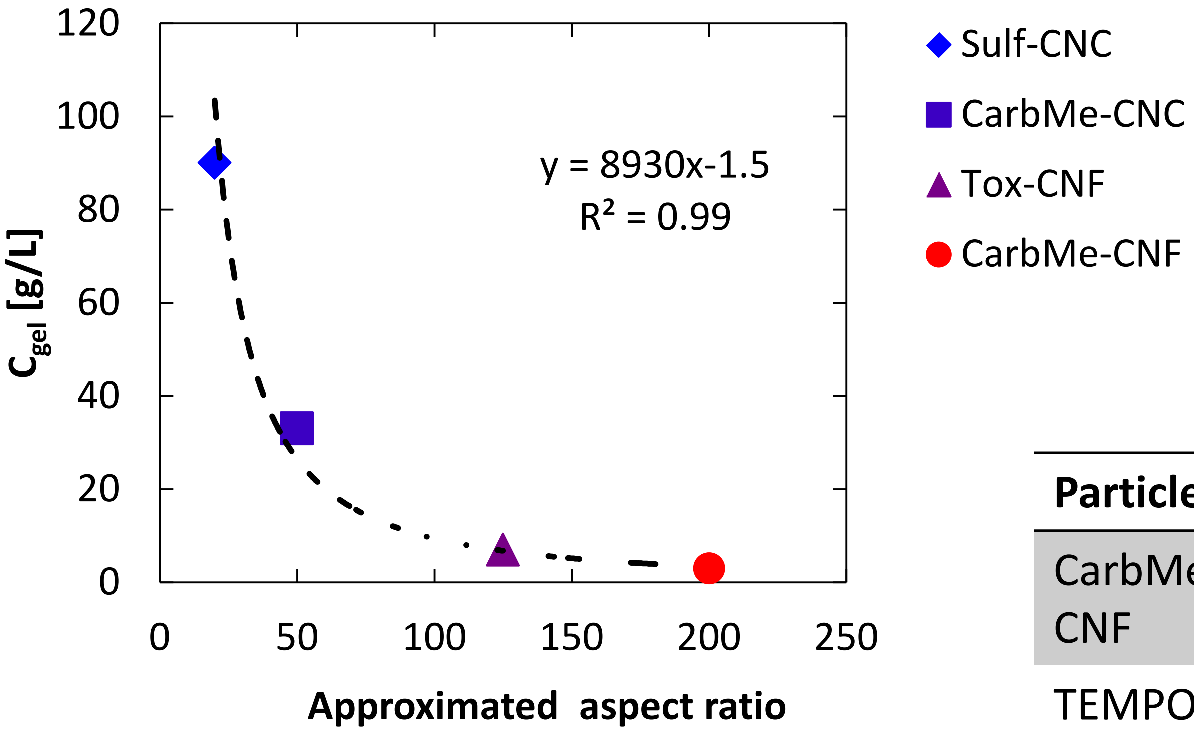


C_{Col} = 20 mM

Sulf-CNC
(σ = 0.2 mmol/g)
86 94

C_{Col} = 19 mM

Gelling of nano-cellulose dispersions Controlling factors- Aspect ratio

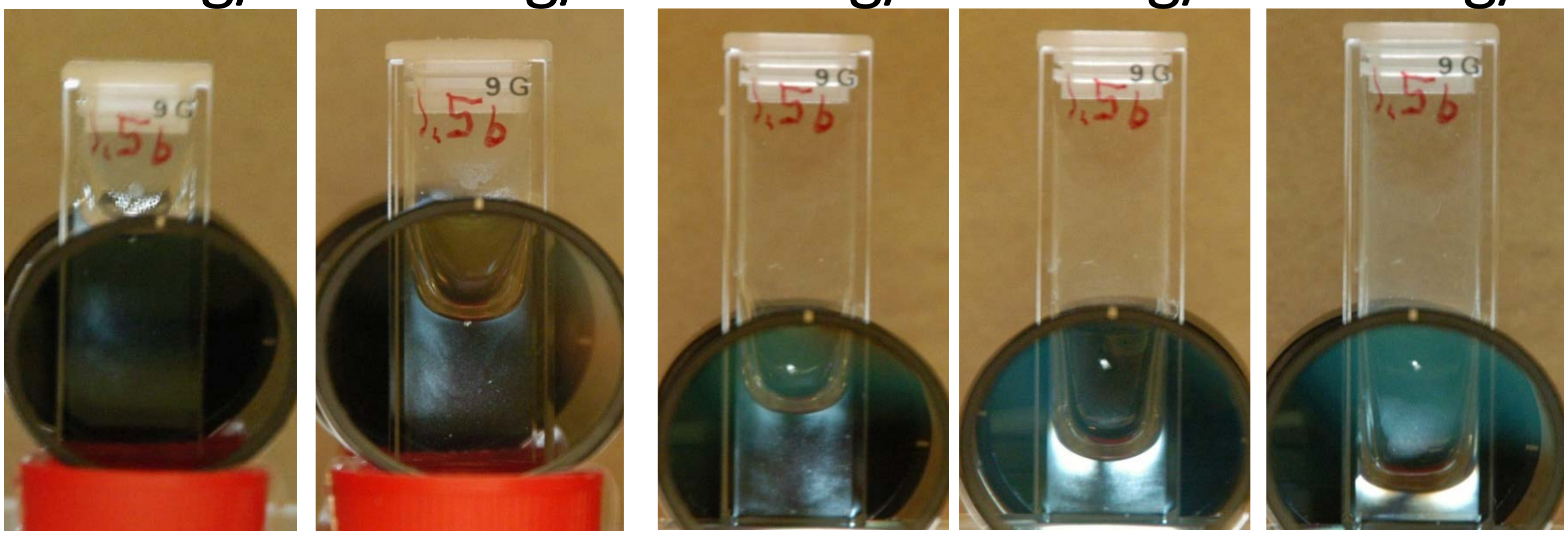


Particle	**Z_{avg} (DLS)**
CarbMeth.-CNF	558 nm
TEMPO-CNF	256 nm
CarbMeth.-CNC	143 nm
Sulf-CNC	94 nm

Entanglement of nanofibrils have a large effect on gel formation- Movement restriction

Orientation during gel formation Carboxymethylated CNF

1.8 g/L 2.3 g/L 4.4 g/L 7.0 g/L 12 g/L



Dispersions **Gels**

Indications of flow-induced alignment during water removal!!