

## How electrolytes vary the suspension structure of cellulose nanocrystals

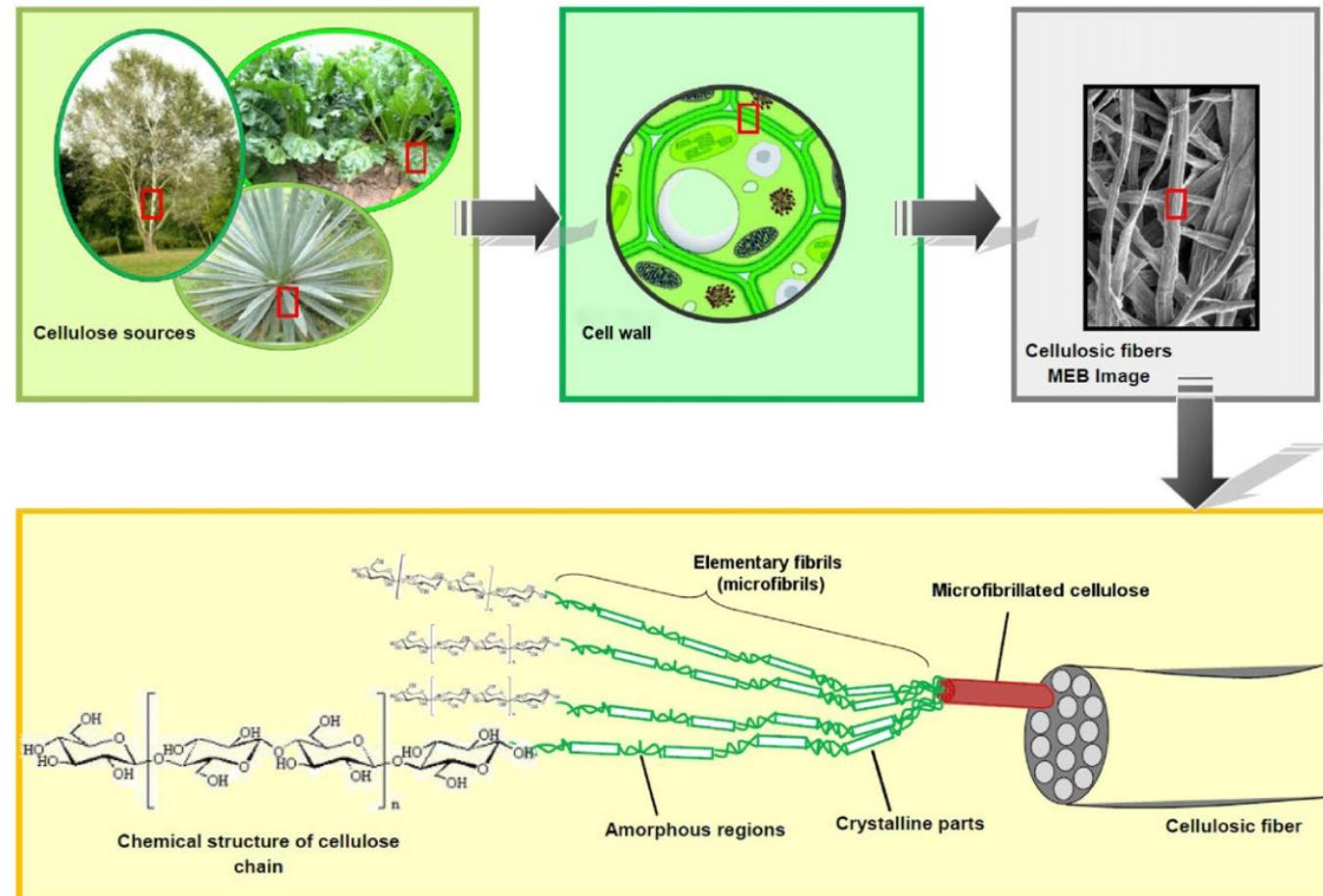
Christine Browne, Vikram Singh Raghuvanshi, Gil Garnier and Warren Batchelor

Bioresource Processing Research Institute of Australia (BioPRIA)  
Department of Chemical and Biological Engineering  
Monash University



# Cellulose

- Naturally abundant polymer
- Trees, crops, etc.
- Biodegradable
- Environmentally friendly
- Recyclable
- Fully renewable
- Green economy backbone



**Paper**



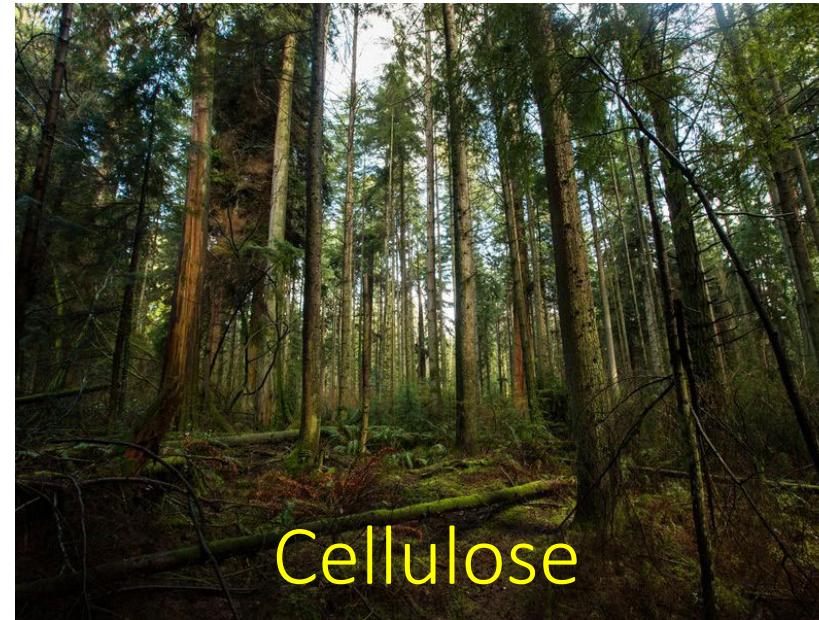
**Textile**



**Gels**



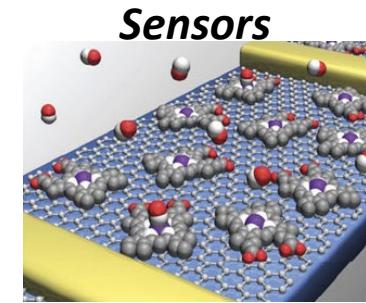
**Packaging**



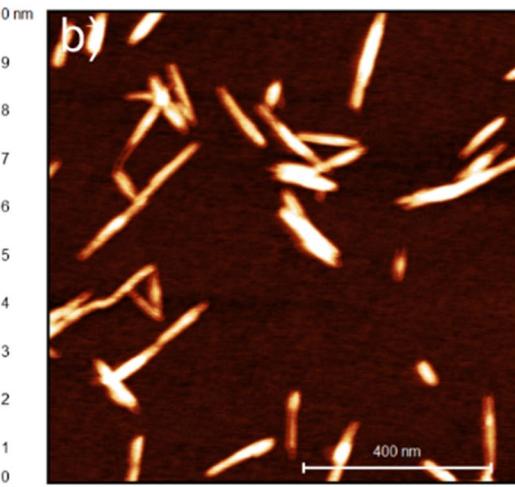
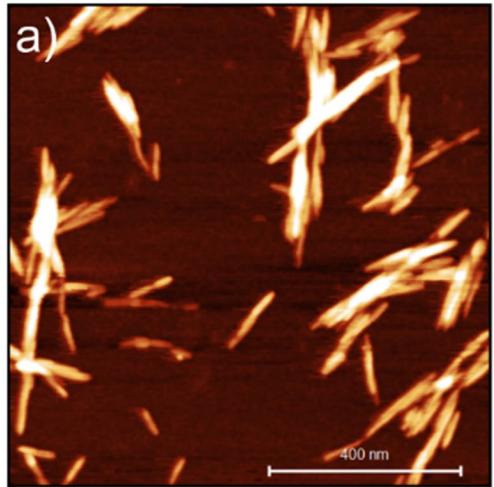
**Medical**



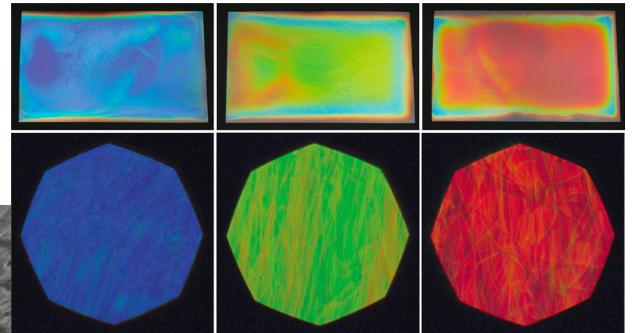
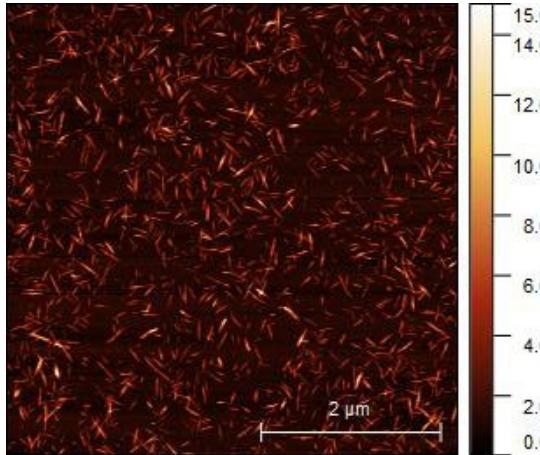
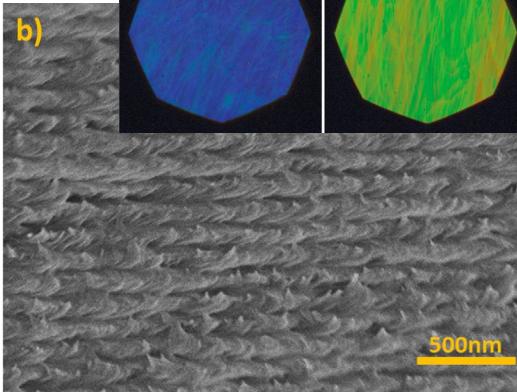
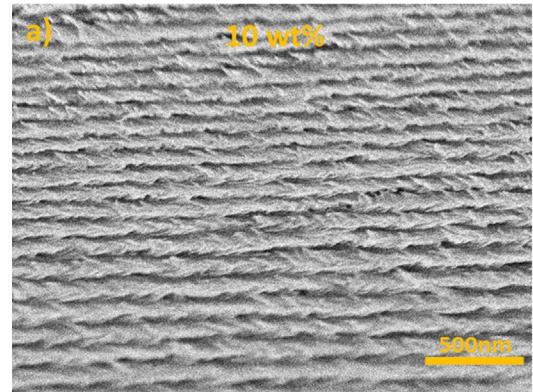
**Food**



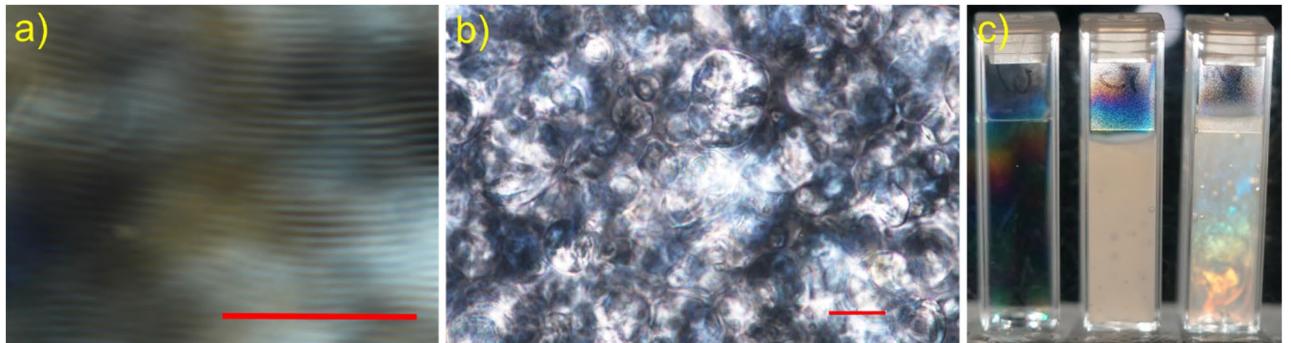
# Chiral nematic structures of CNC



Films



Suspension

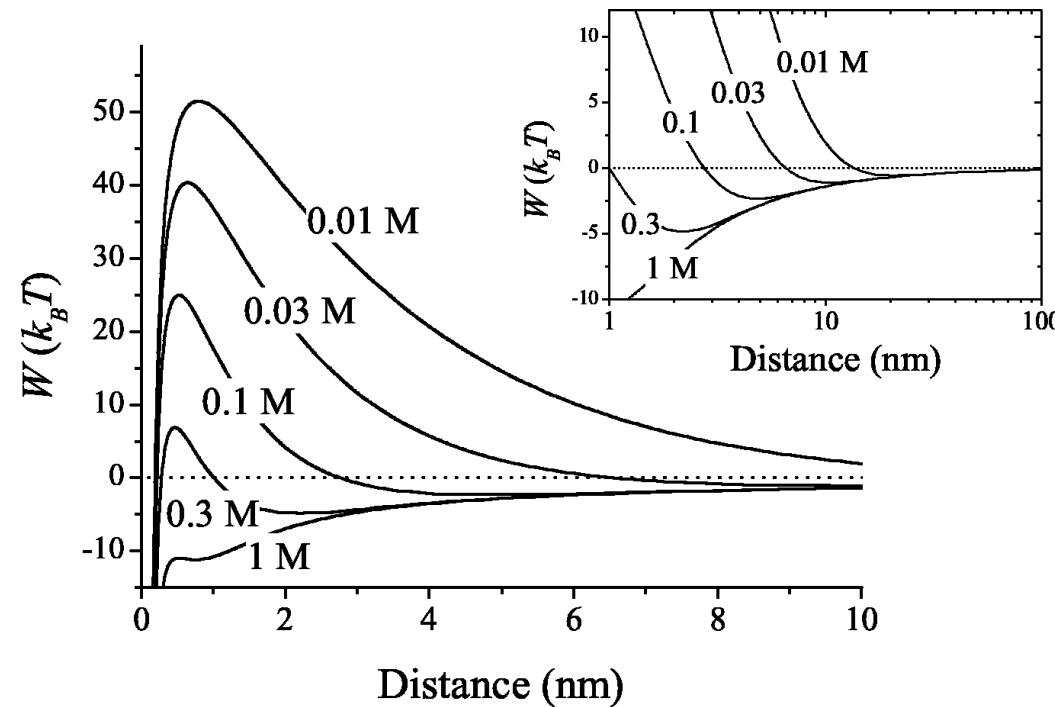
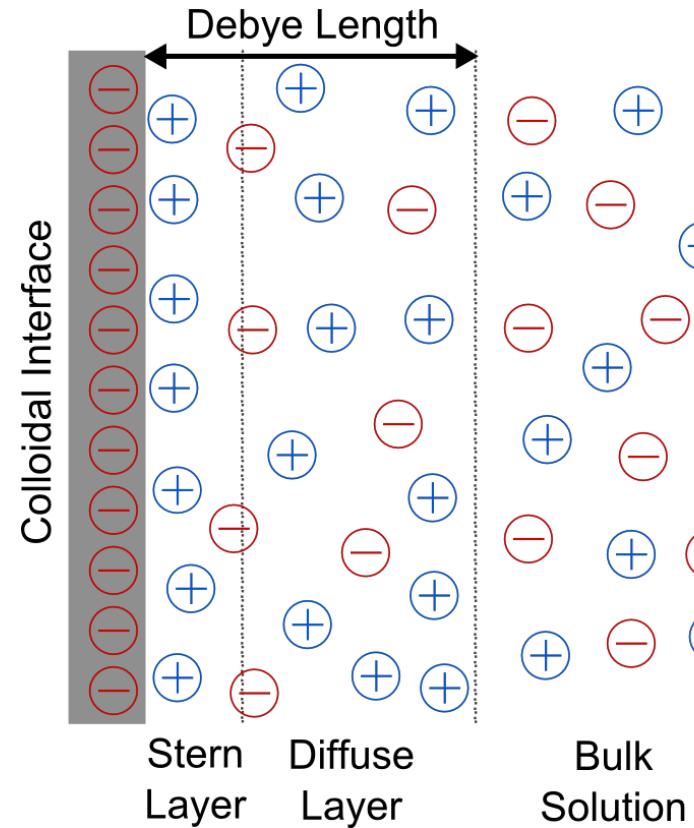


C. Browne, et al. Colloid Surf A, 2022, 651, 129532.

M. Lin, et al. JCIS, 2021, 584, 216-224.

B.E. Droguet, Nat. Mater., 2022, 21(3), 352-358

# Electrolyte addition



H.J. Butt, et al., Physics and Chemistry of Interfaces, 2006, Wiley-VCH.

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# Specific Ion Effects

## HOFMEISTER SERIES

### Cations

$\text{N}(\text{CH}_3)_4^+$     $\text{NH}_4^+$     $\text{Cs}^+$     $\text{Rb}^+$     $\text{K}^+$     $\text{Na}^+$     $\text{Li}^+$     $\text{Mg}^{2+}$     $\text{Ca}^{2+}$

$\text{SO}_4^{2-}$     $\text{HPO}_4^{2-}$     $\text{OAc}^-$     $\text{cit}^-$     $\text{OH}^-$     $\text{Cl}^-$     $\text{Br}^-$     $\text{NO}_3^-$     $\text{ClO}_3^-$     $\text{BF}_4^-$     $\text{I}^-$     $\text{ClO}_4^-$     $\text{SCN}^-$     $\text{PF}_6^-$

### Anions

kosmotropic  
 ↑ surface tension  
 harder to make cavity  
 ↓ solubility hydrocarbons  
 salt out (aggregate)  
 ↓ protein denaturation  
 ↑ protein stability  
 weakly hydrated soft cations of low charge density  
 strongly hydrated hard anions of high charge density

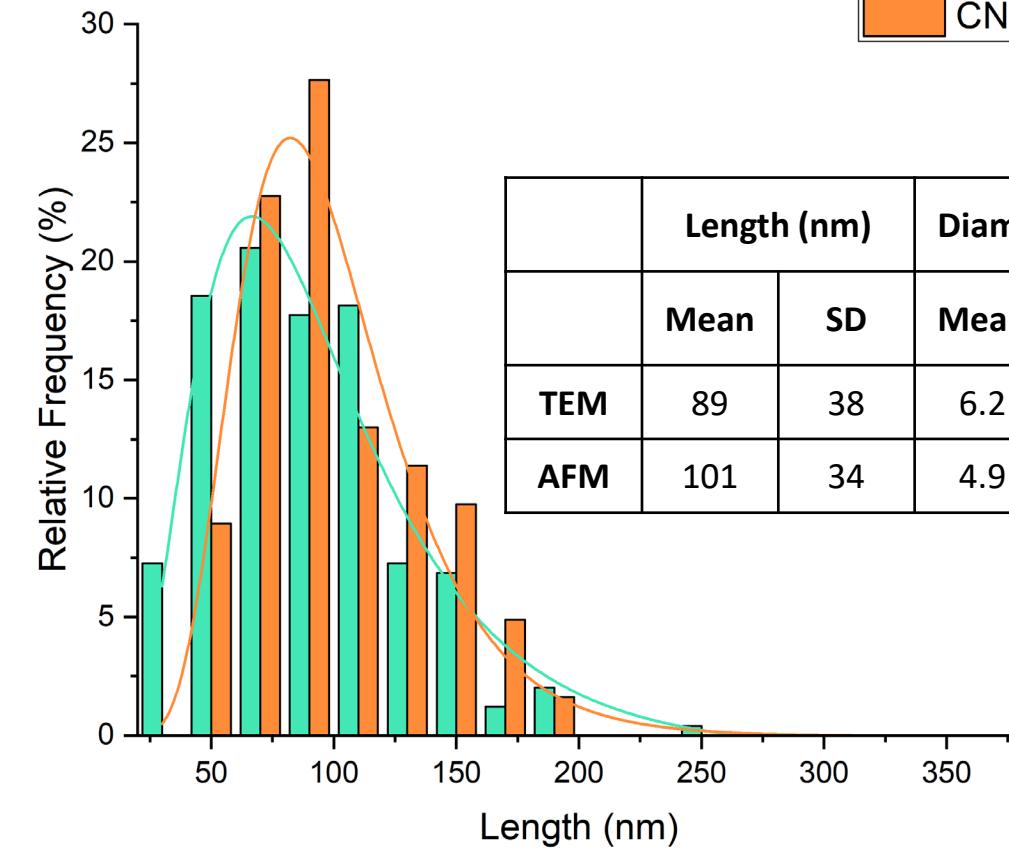
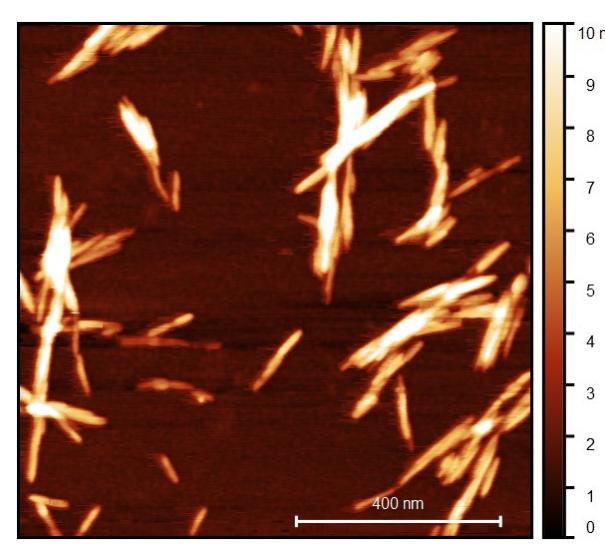


chaotropic  
 ↓ surface tension  
 easier to make cavity  
 ↑ solubility hydrocarbons  
 salt in (solubilize)  
 ↑ protein denaturation  
 ↓ protein stability  
 strongly hydrated hard cations of high charge density  
 weakly hydrated soft anions of low charge density

What role does electrolyte concentration, type and valency play on the suspension structure of CNC?

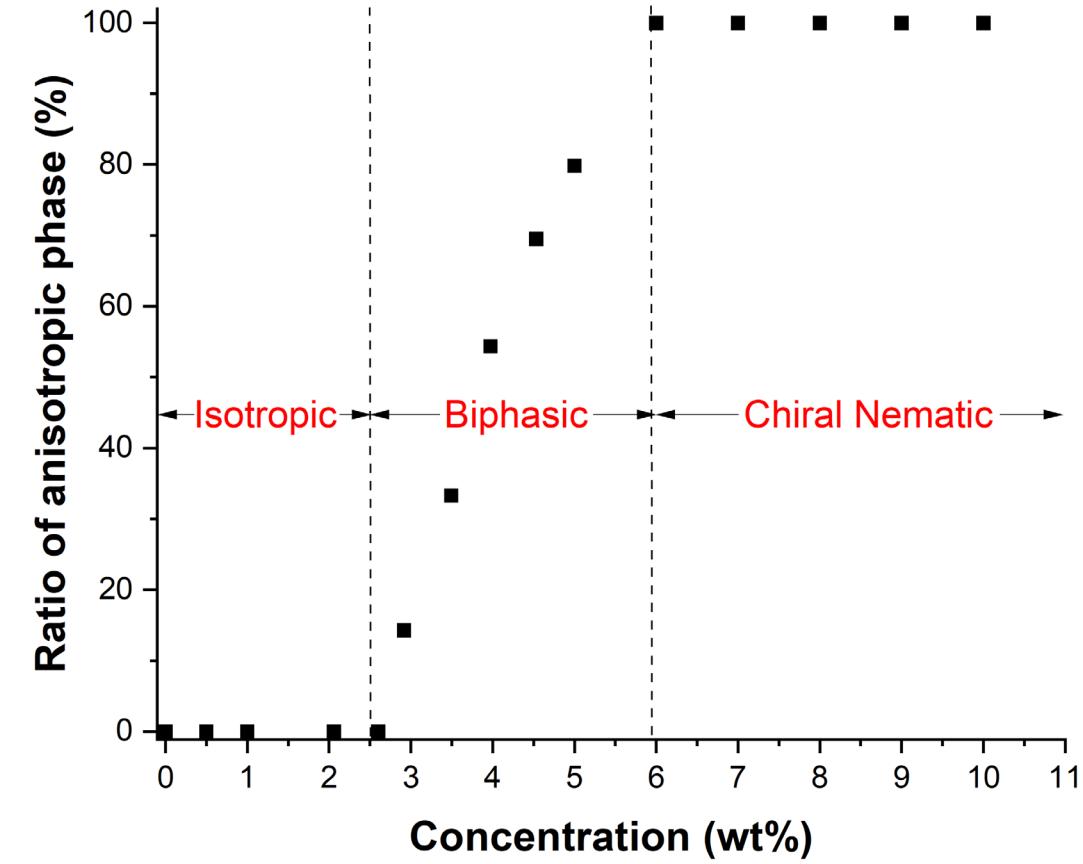
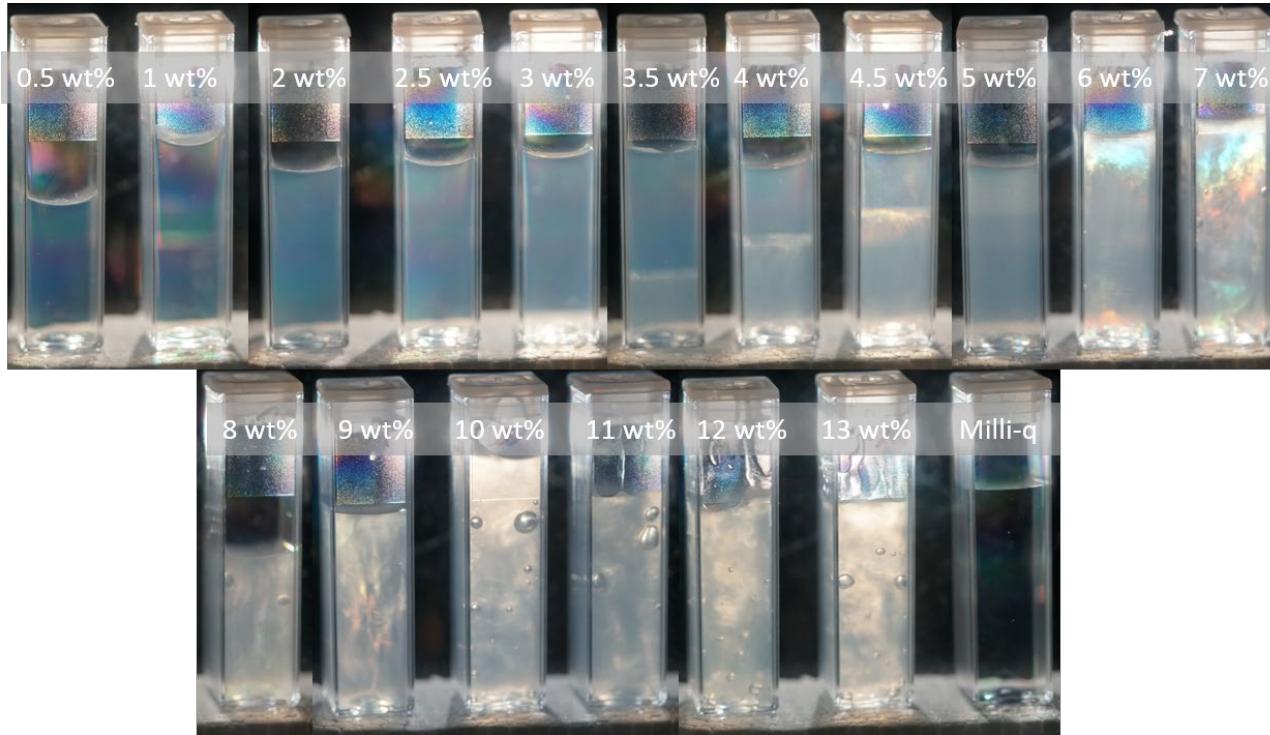
# CNC Properties

- Sulfur content –  $0.73 \pm 0.09$  wt%
- Zeta potential -  $-52 \pm 8$  mV



# Polarised Optical Photography (POP)

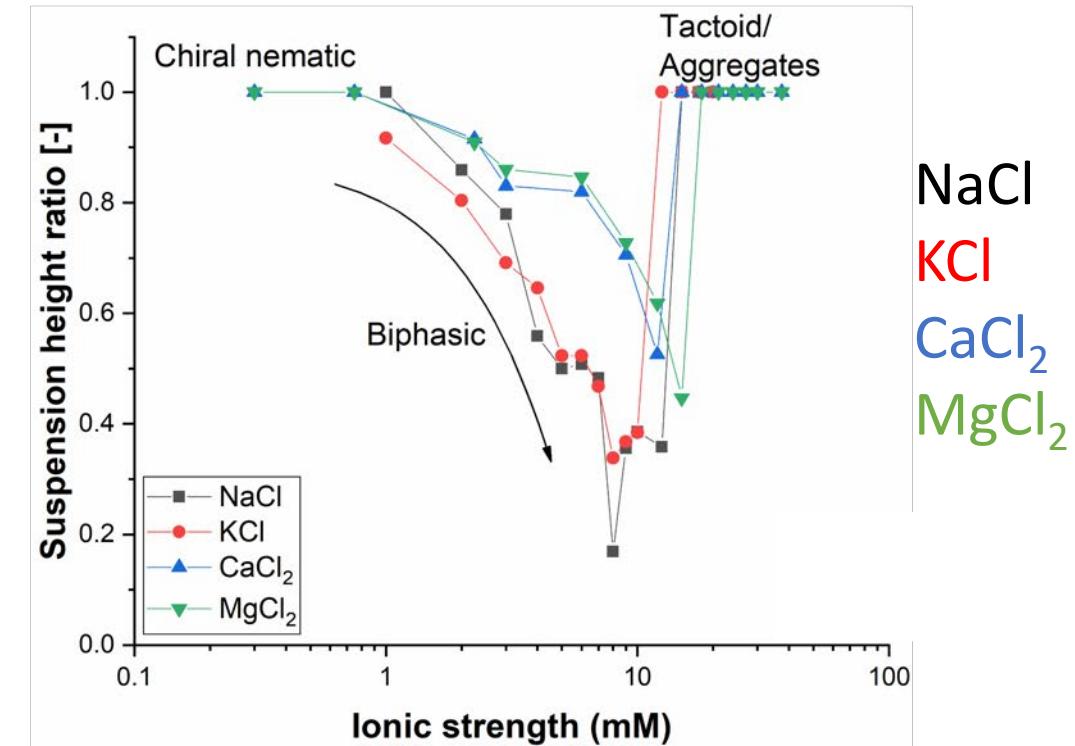
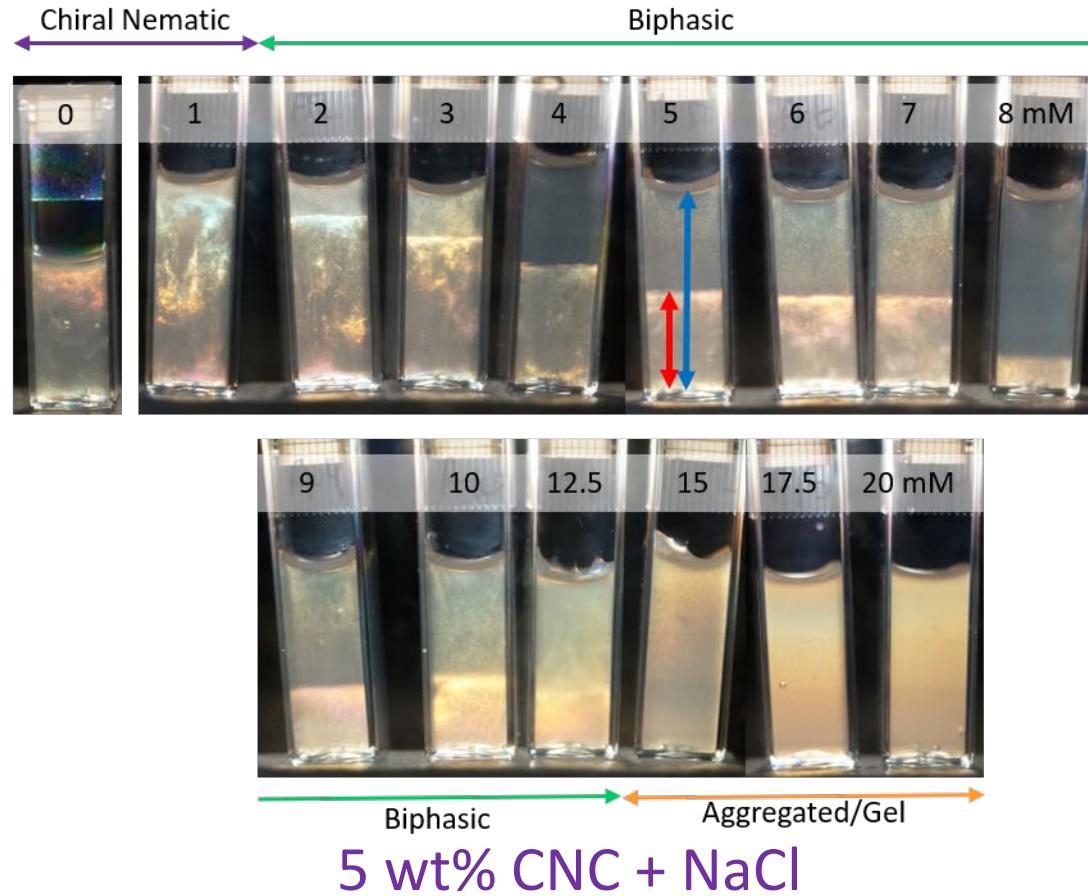
## CNC concentration



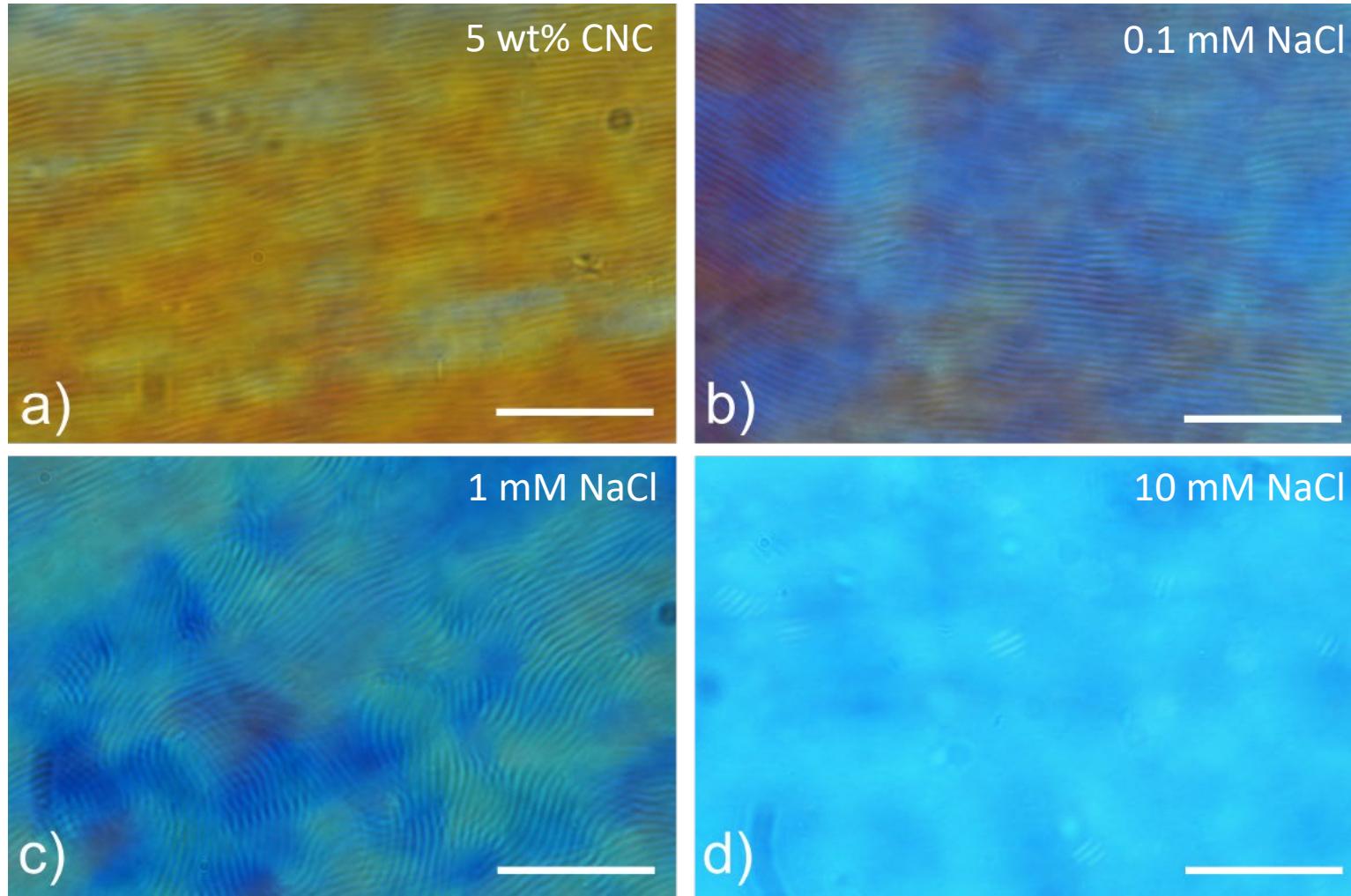
C. Browne, et al. Colloid Surf A, 2022, 651, 129532.

# Polarised Optical Photography

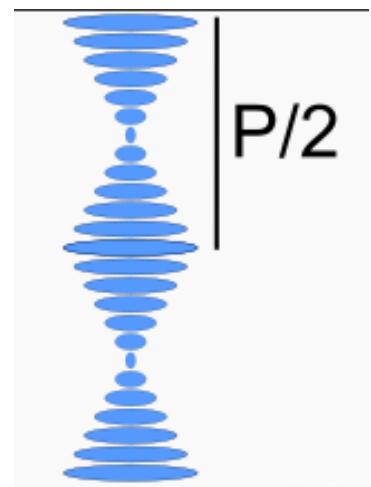
## NaCl concentration



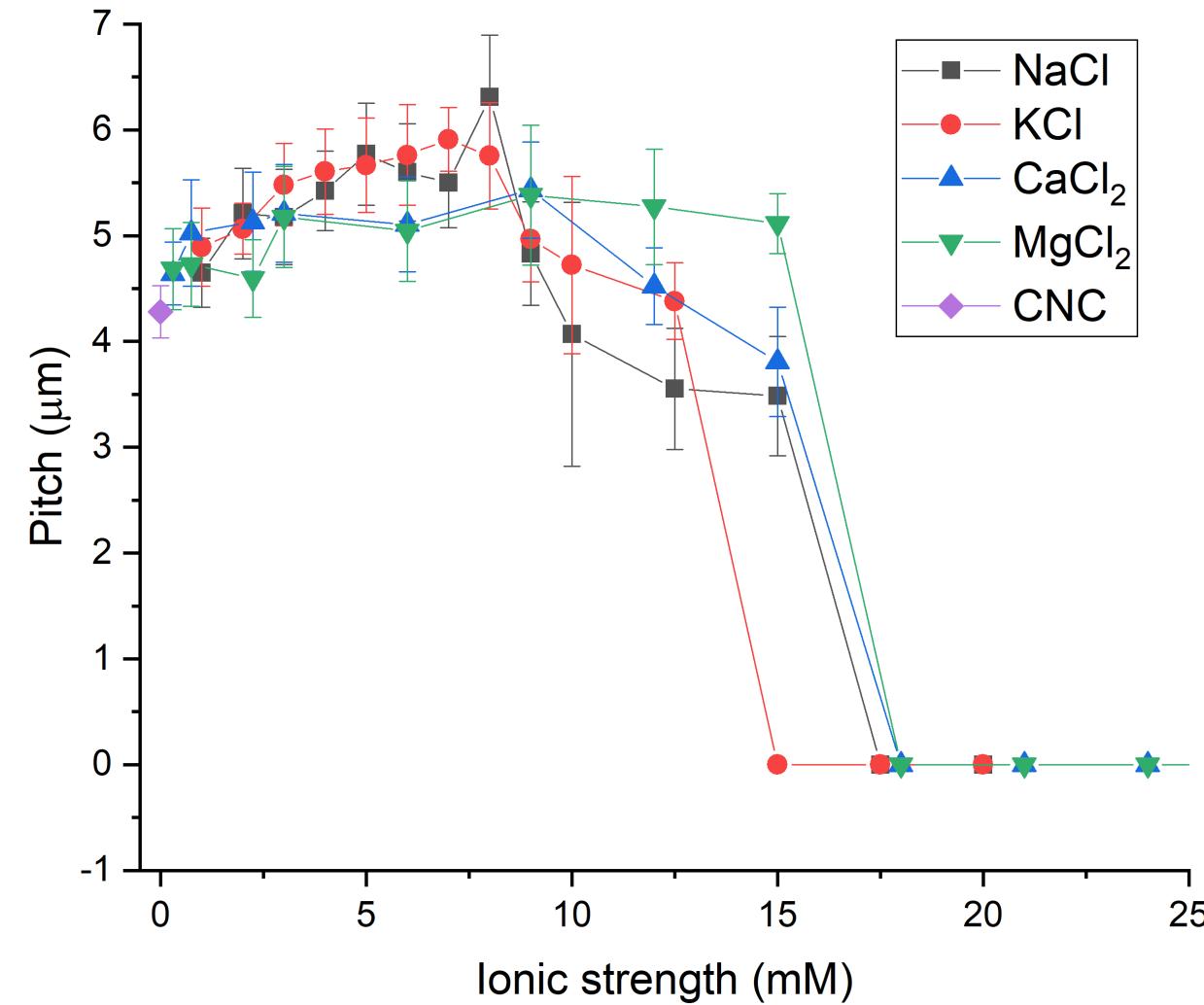
# Polarised Optical Microscopy



Scale bar – 40 μm

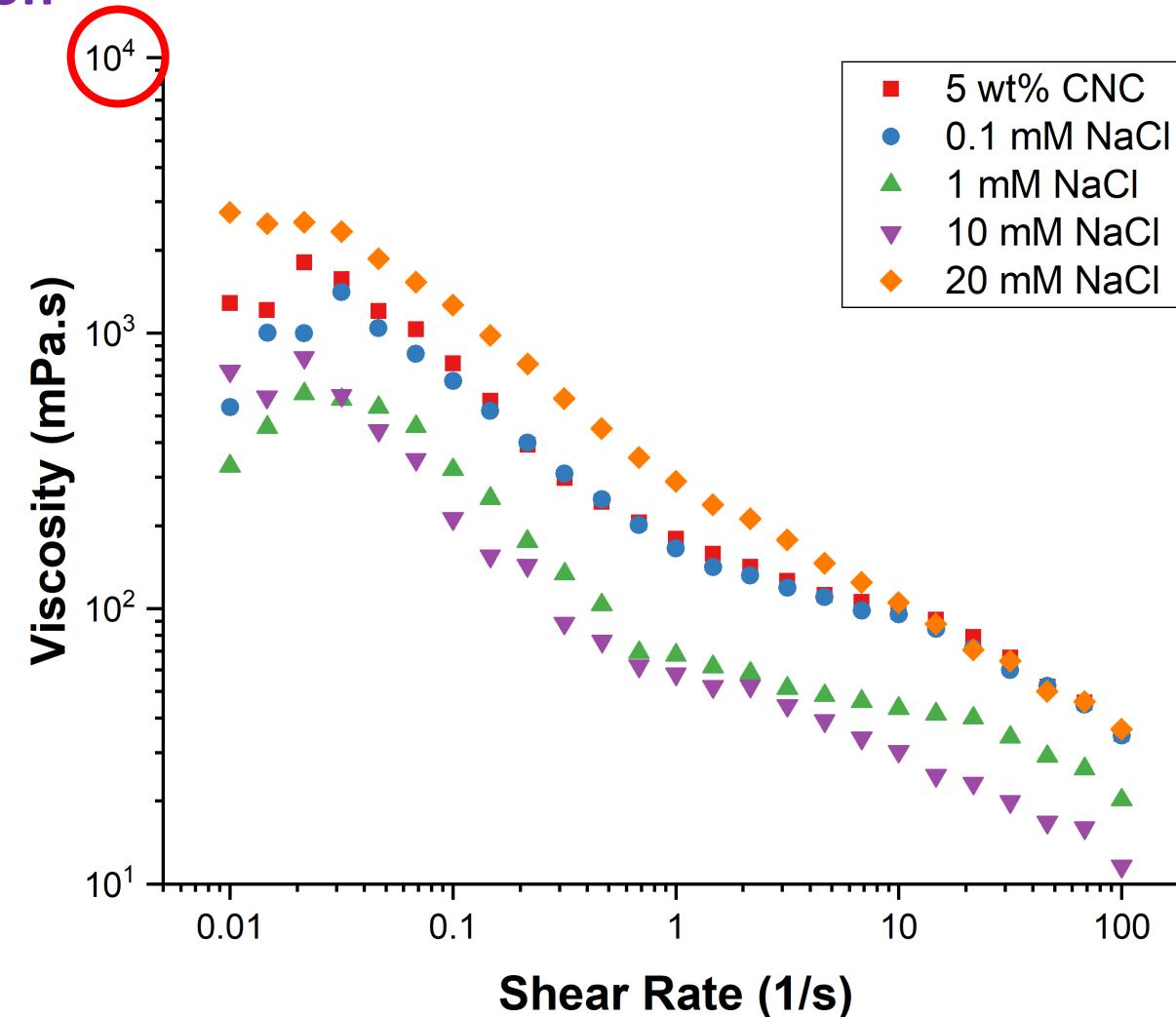


# Pitch verses ionic strength



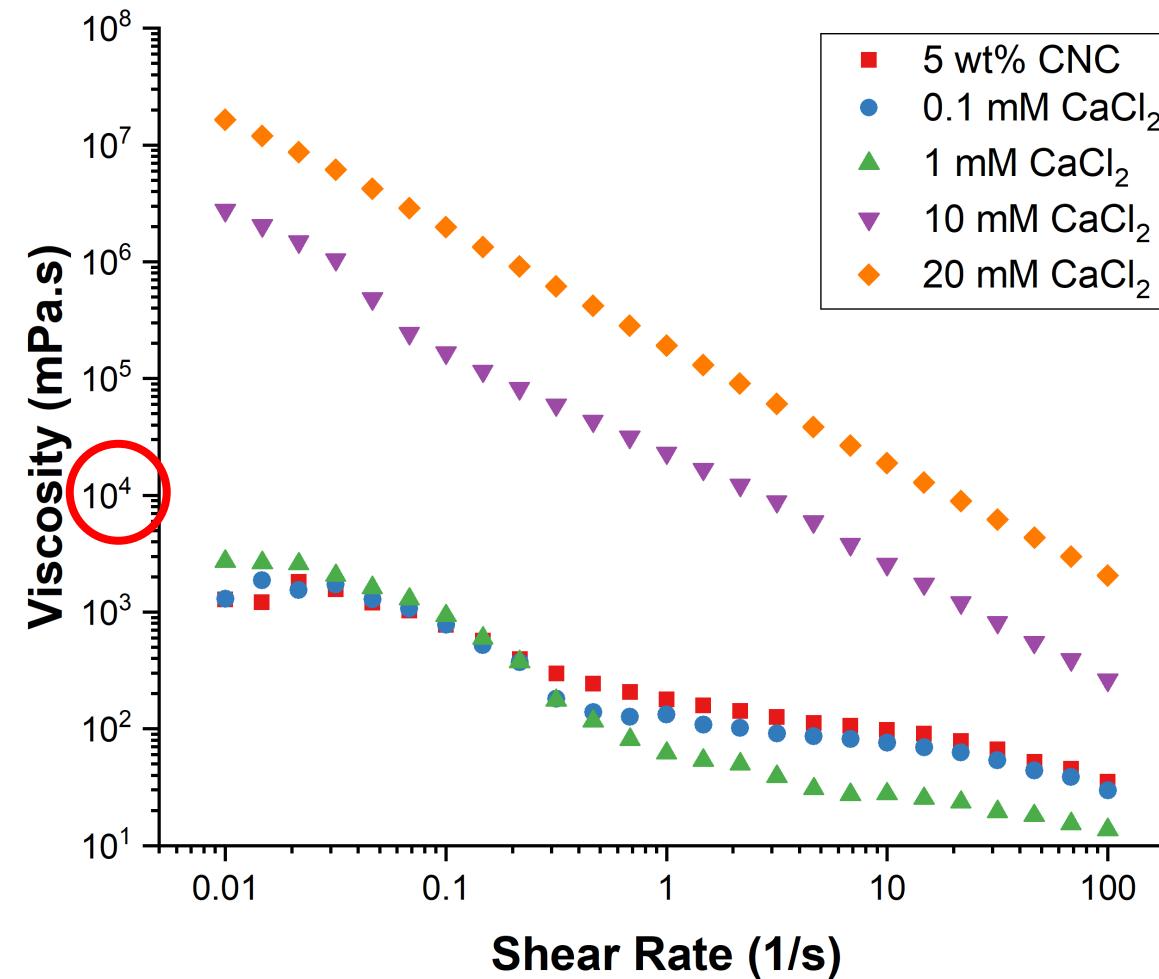
# Suspension rheology

NaCl concentration

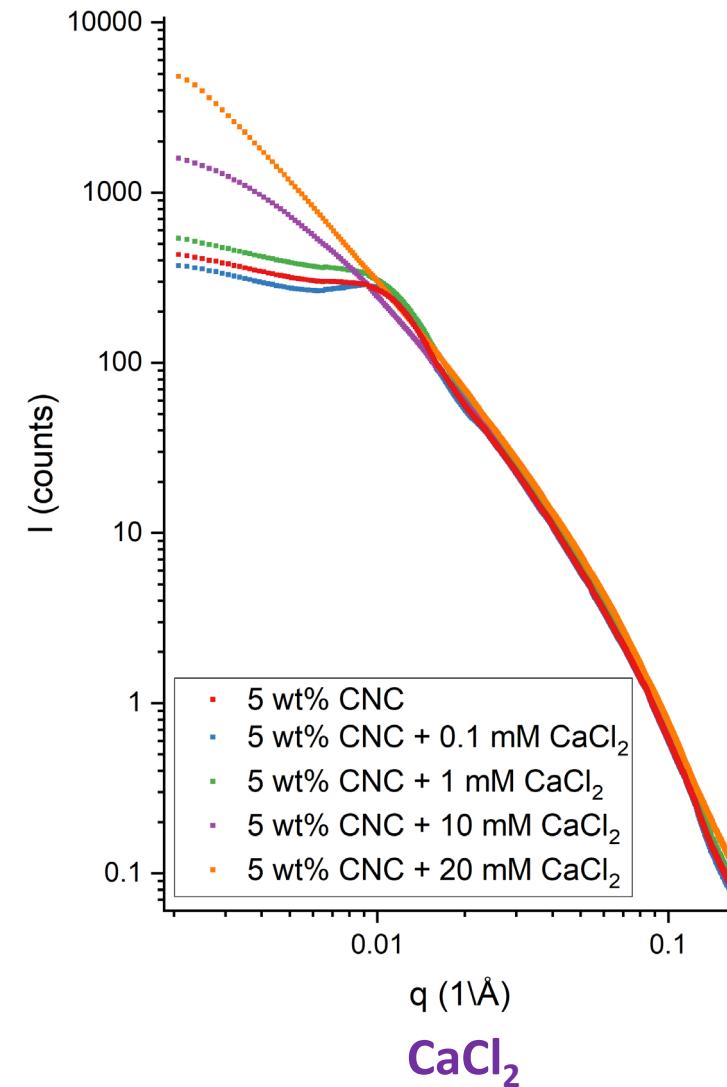
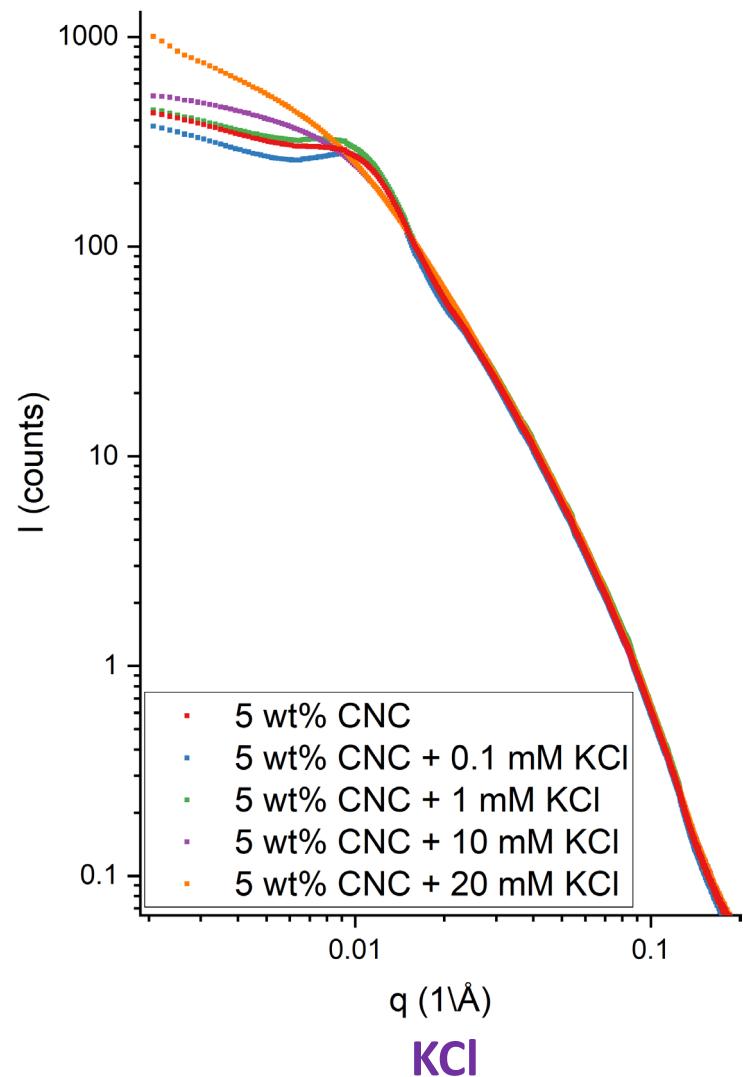


# Suspension rheology

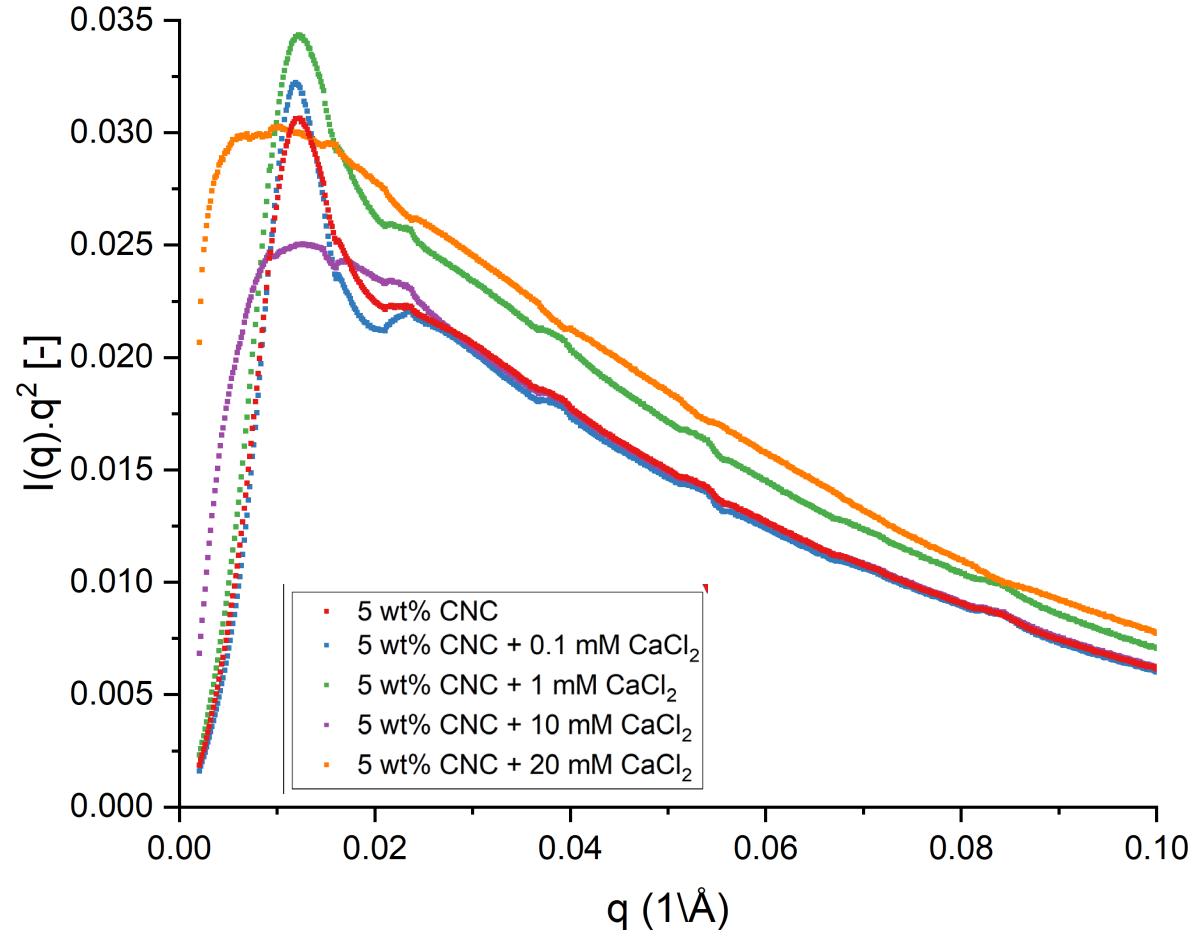
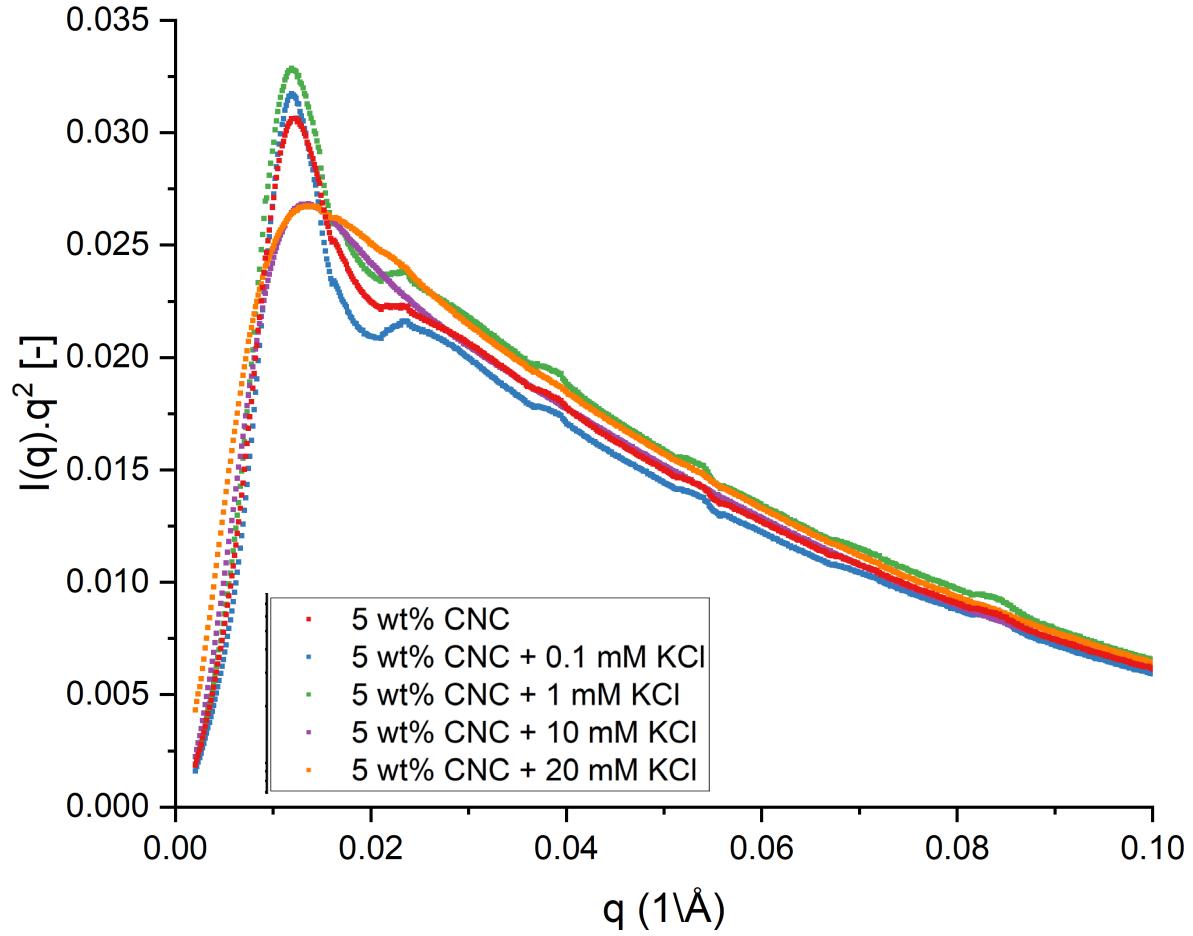
## $\text{CaCl}_2$ concentration



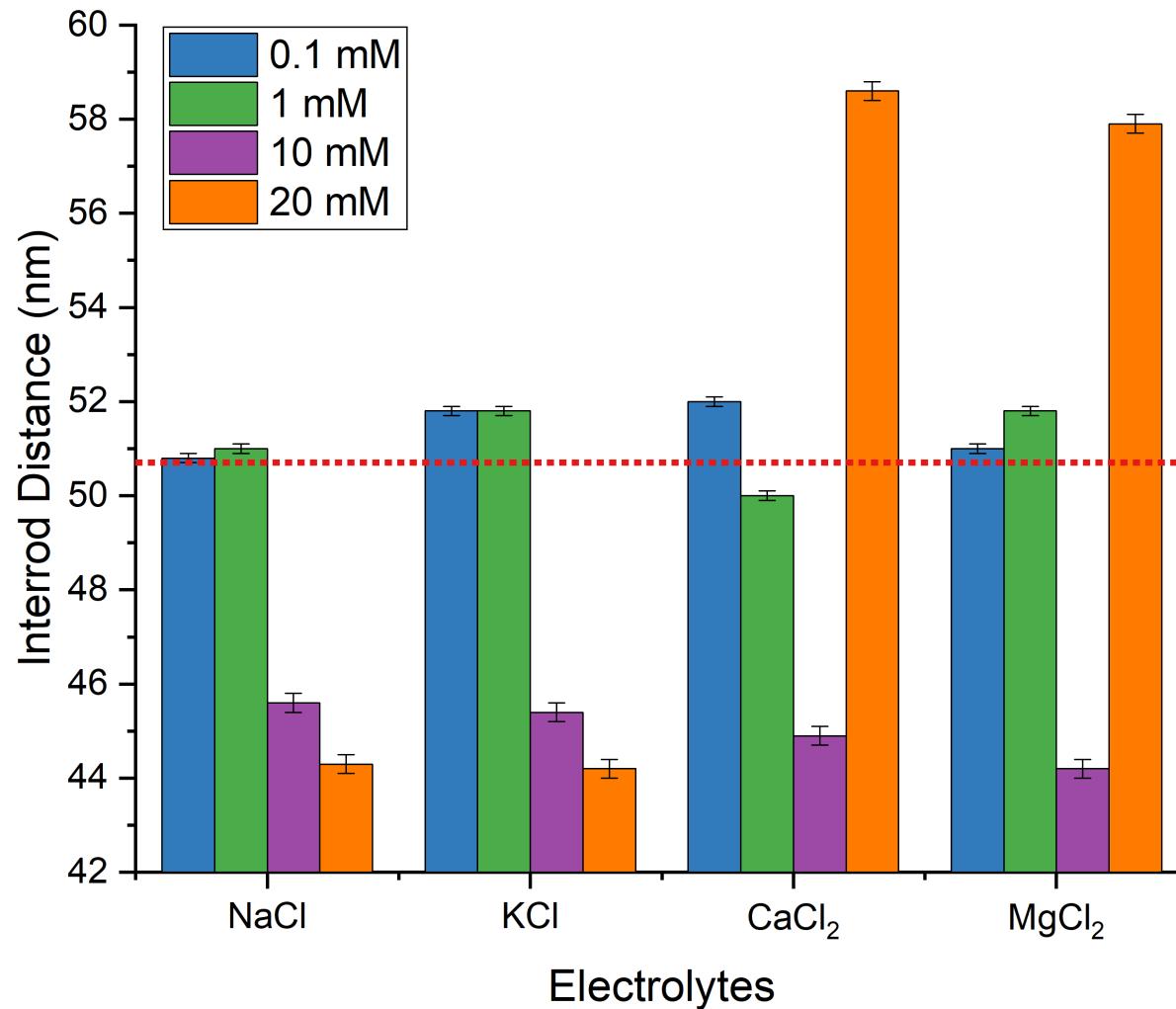
# SAXS data



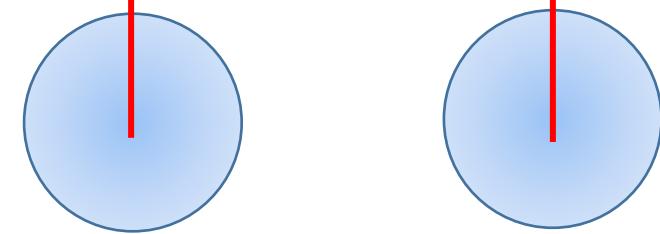
# Kratky Plots



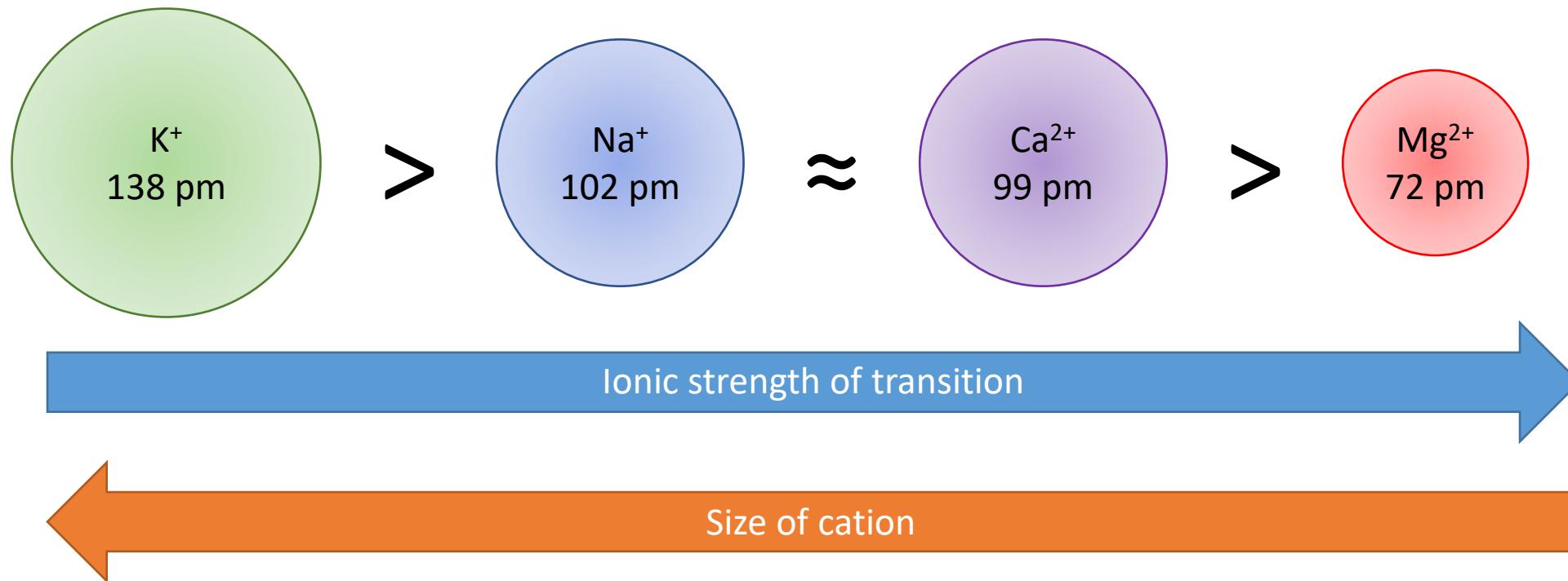
# Interrod distance

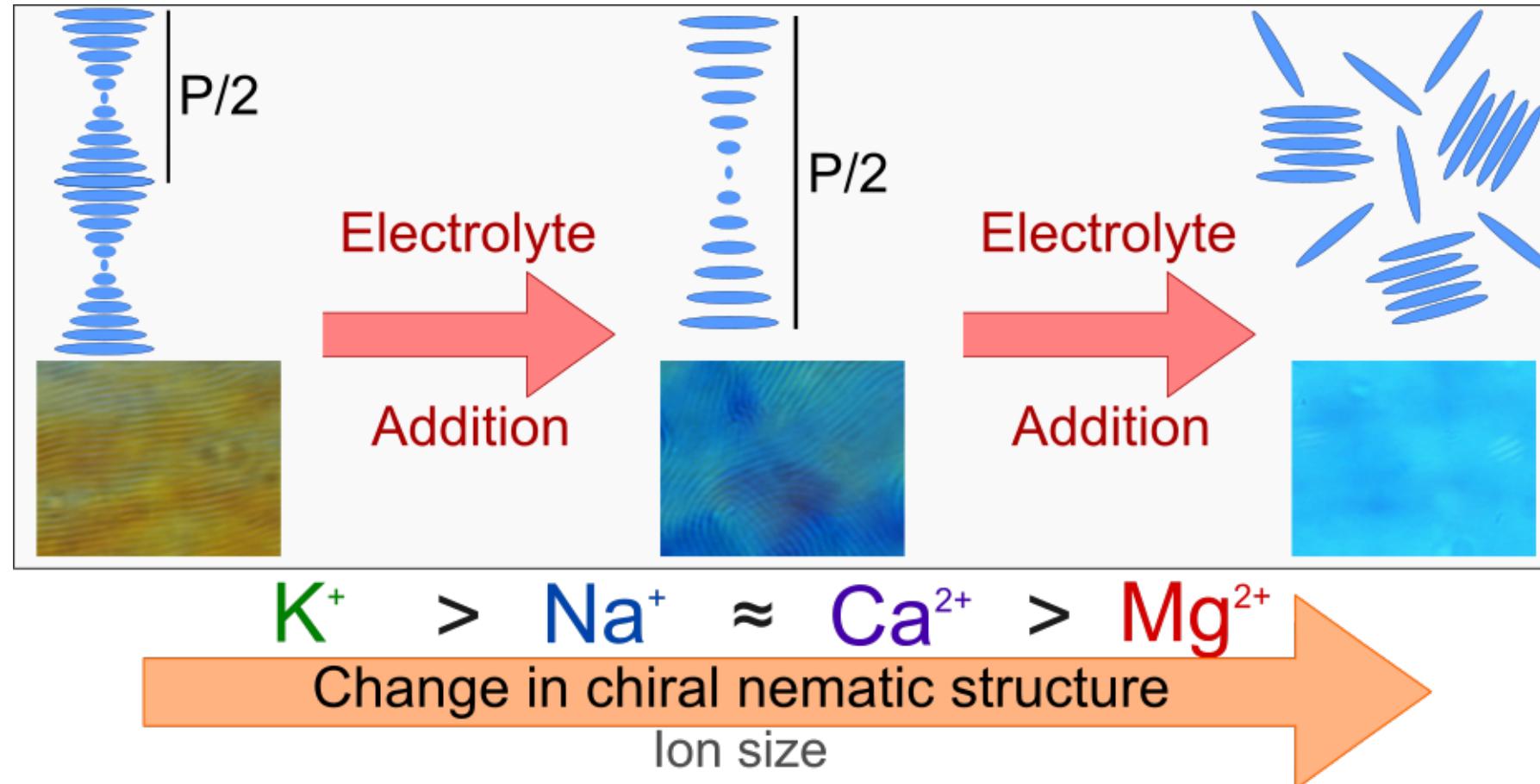


Interrod  
Distance



# Ion specificity





# Acknowledgements



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Australian Research Council