Interface Engineering of Cellulose Nanocrystals for Multifunctional Materials

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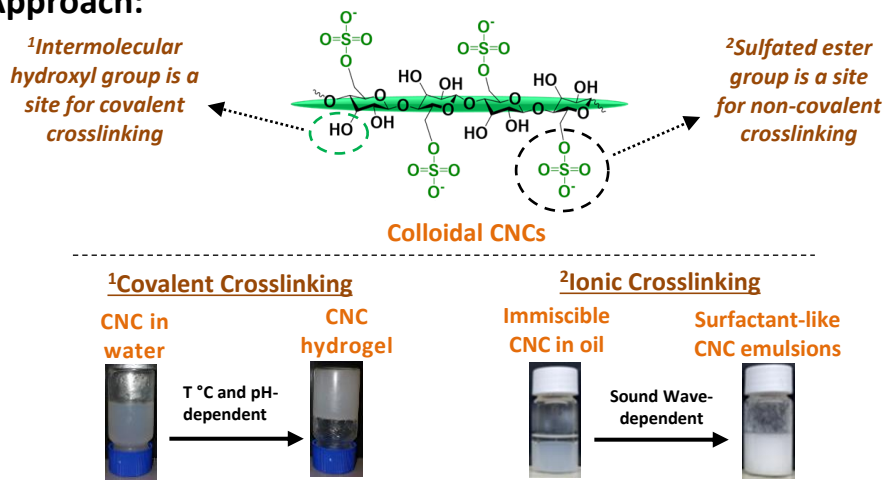
Background/Relevance

- Cellulose nanocrystals (CNCs), rod-like biomaterials, are known for their unique physicochemical and mechanical properties
- CNCs have been used as fillers for petroleum-based polymers due to their surface chemistry activities along the hydrophobic (2 0 0), and hydrophilic (1 1 0) and (1 $\bar{1}$ 0) plane directions
- However, the H bonding between CNCs, used alone, leads to structural instability of the molecular crystal–based network

Innovation

- To control the intermolecular H-bond, and develop advanced materials with CNCs as building blocks for their practical uses in dry and wet environment

Approach:



Key Results

Covalent Crosslinking

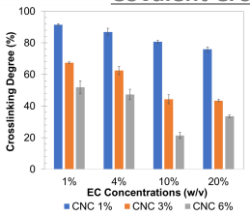


Fig. 1. Degree of crosslinking at varied reaction conditions.

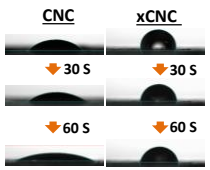


Fig. 2. Water contact angle of colloidal CNC and xCNC from 0 s to 60 s.

Ionic Crosslinking

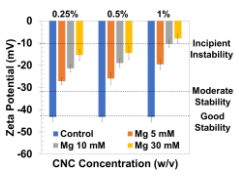


Fig 4. Zeta potential of CNC emulsion at varied reaction conditions.

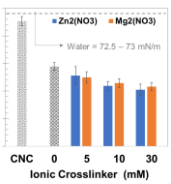
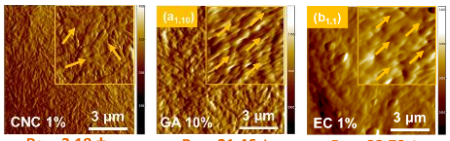
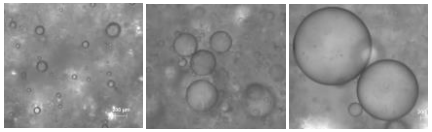


Fig 5. Interfacial tension of CNC in oil emulsion.



Rq = 3.18 ± 0.41 nm Rq = 31.46 ± 1.08 nm Rq = 23.79 ± 0.14 nm

Fig. 3. AFM images with surface roughness (RMS), showing the effect of crosslinking on crystal organization.



0.25% 0.50% 1.00%

Fig 6. CNC emulsion with tunable droplet size made without the use of petroleum-based surfactants.

Conclusions

- Crosslinking CNCs led to control of intermolecular H-bond with formation of stable hydrogels and surfactant-like emulsions
- Oscillatory frequency tests showed that structural deformations can be modulated by varying degrees of crosslinking
- Micrographs showed self-alignment of crystals with varied surface roughness, confirming the relationship between crystal alignment and wetting properties of the engineered materials

Future Work

- Achieve CNC-based nano/microstructures and implement their uses in pharmaceutical, coating, and agriculture industries

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The Center For Advanced Surface Engineering