Sustainable Nano-Materials What is happening at the cellular level?

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Advanced Materials: Cellular Level

mm

100 μm

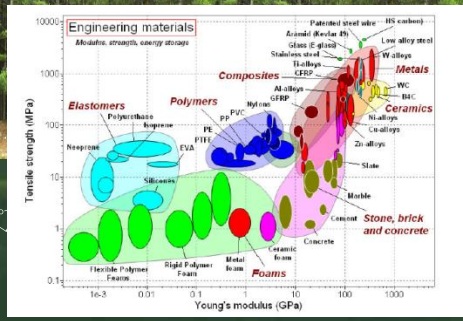
1 μm

10 μm

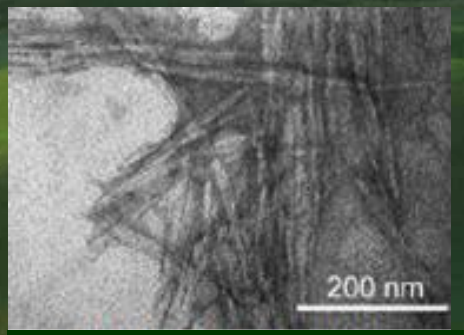
10 nm

nm

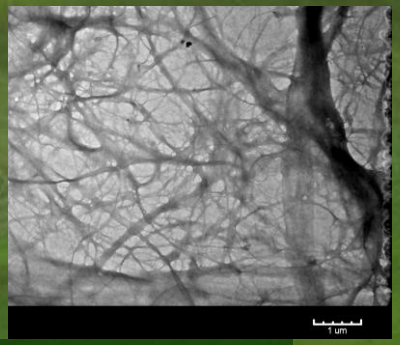
1 cm



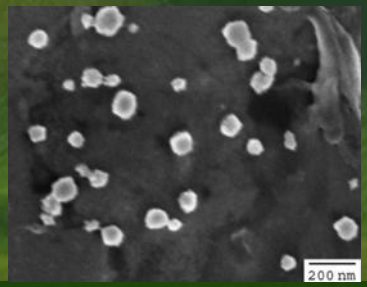
Chemicals
Enzymes
Mechanical



Cellulose Whiskers



Micro Fibrillated Cellulose



NanoCellulose Balls

Composite Whisker Films

Water Based polymer + Whiskers>> Easy Dispersions

Matrix = hydrosoluble polymers

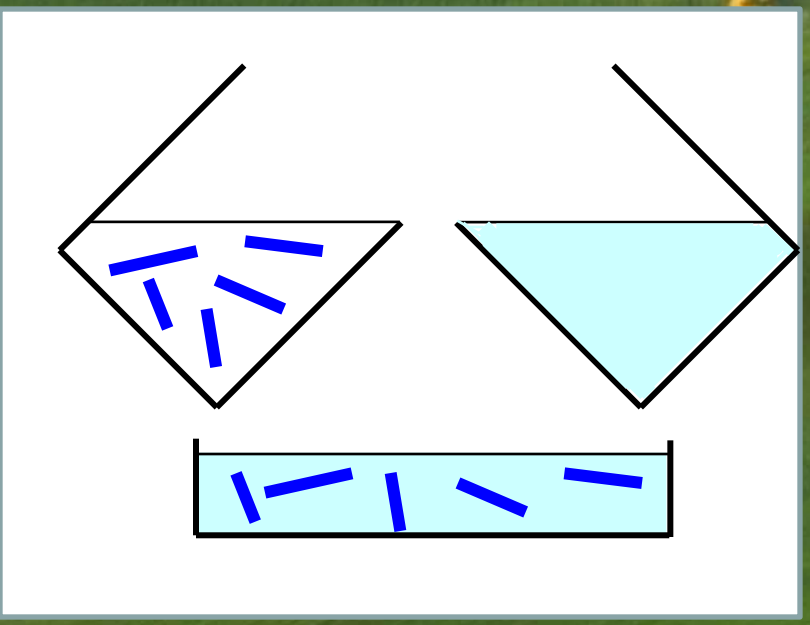
Poly(oxyethylene)

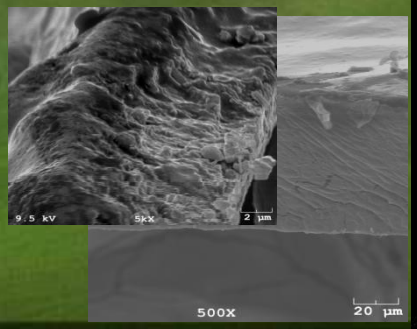
Xylans; Hemis

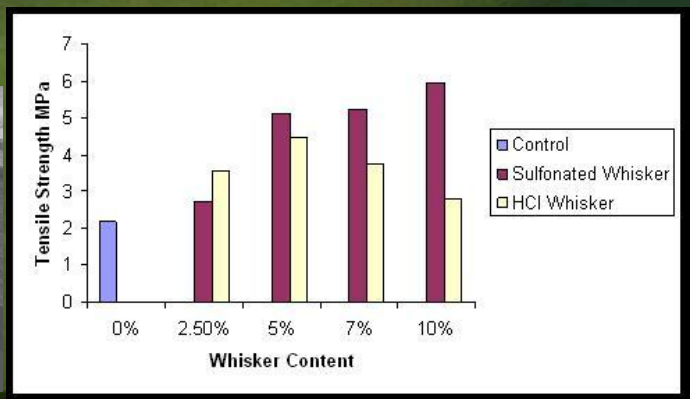
Thermoplastic *starch*

Xylan, CMC

Water evaporation → nanocomposite film

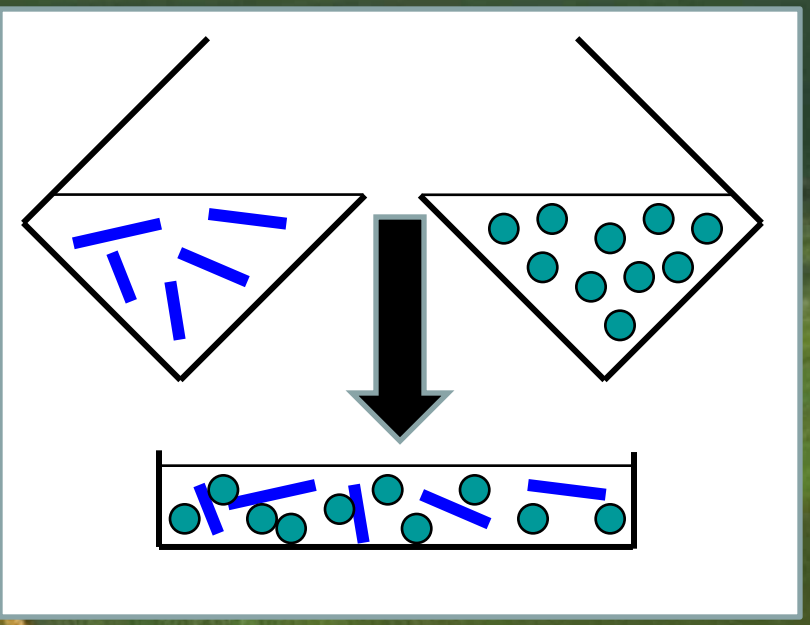






Composite Whisker Films

Alternative = use of an aqueous dispersed polymer (latex)



Poly(S-co-BuA)

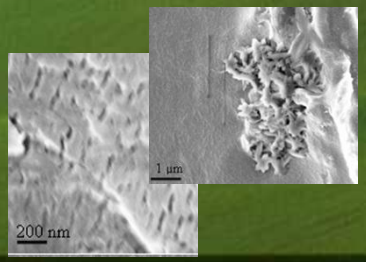
Poly(hydroxyoctanoate)

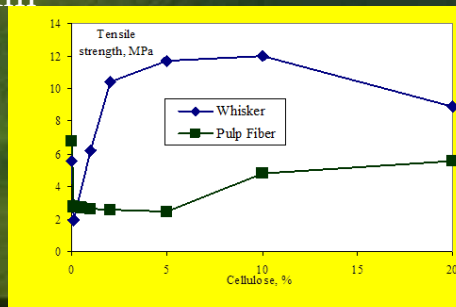
Poly(caprolactone)

Natural rubber

Poly(vinyl acetate)

water evaporation → particle coalescence → nanocomposite film

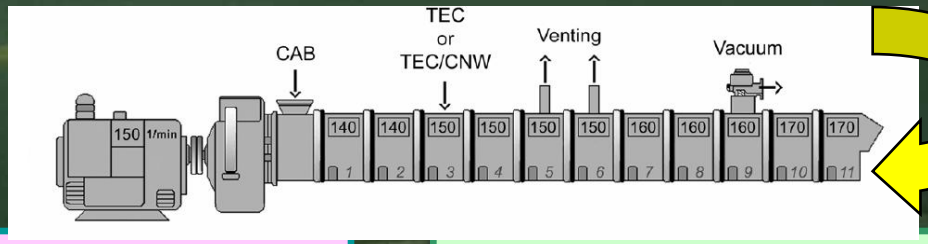




Composite Whisker Films

Hydrophobic Polymers

Dispersion of polysaccharide nanocrystals in an organic medium

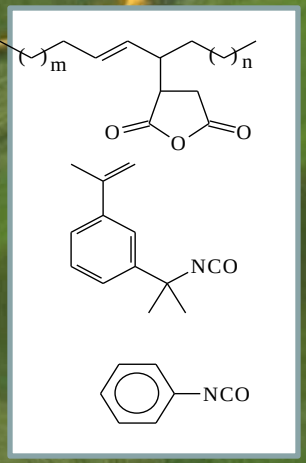


Coating of nanoparticles surface with a surfactant

Chemical modification of nanoparticles surface

Use of an adequate solvent

High specific area : high amount of surfactant



alkenyl succinic anhydride (ASA) centered around C18 (Mn=300)

isopropenyl-α,α'-dimethylbenzyl isocyanate

phenyl isocyanate

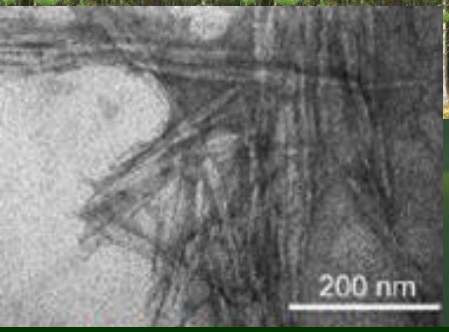
Dispersion of whisker in Select Organic Solvents: DMF, DMSO

Without any additive or surface modification

	TEA*, J/m^2
Polystyrene	8.9
Polystyrene/ NC whisker	+70%

Practical extrusion/mixing remains challenging need better understanding of intermolecular forces of association polymer – whisker forces

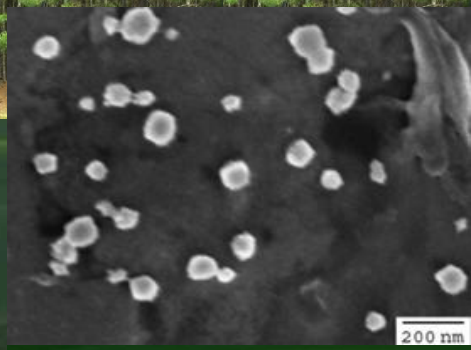
Advanced Materials: Cellular Level



Cellulose Whiskers

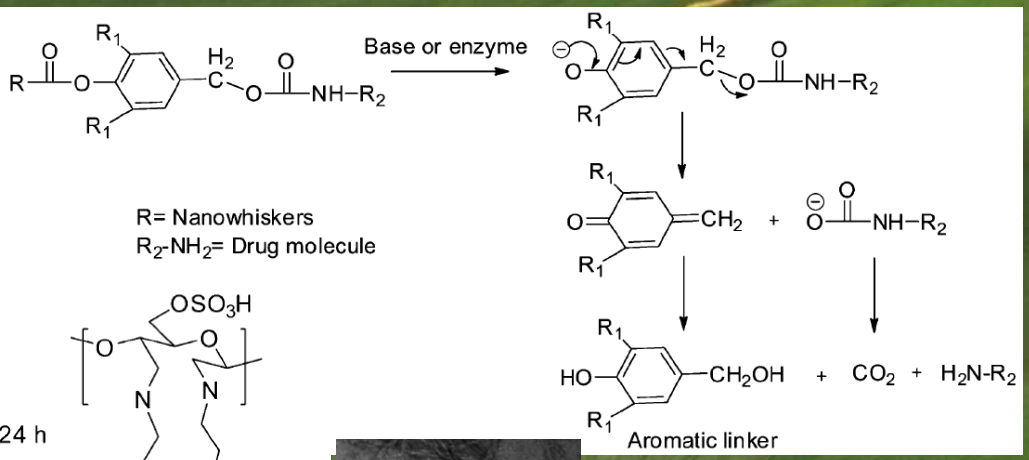
Cellulosics
Artificial Skin/Blood Vessels

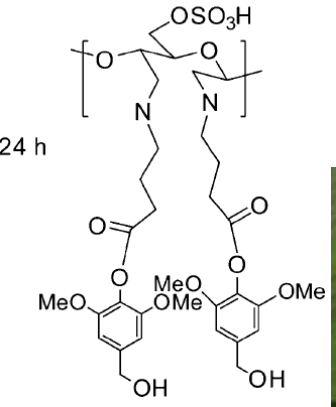
High surface area, Hydrophilicity, Biocompatibility, and Biodegradability

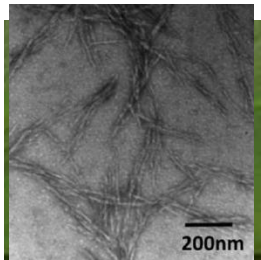


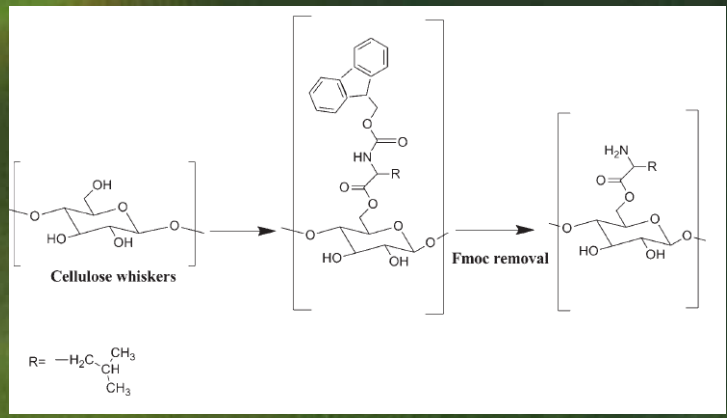
NanoCellulose Balls

Nanocellulosics – Human Health



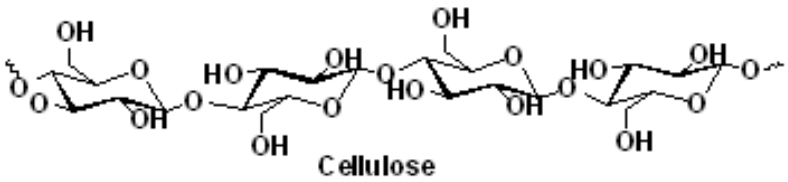


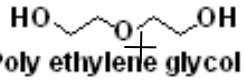


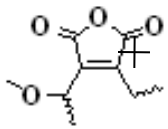


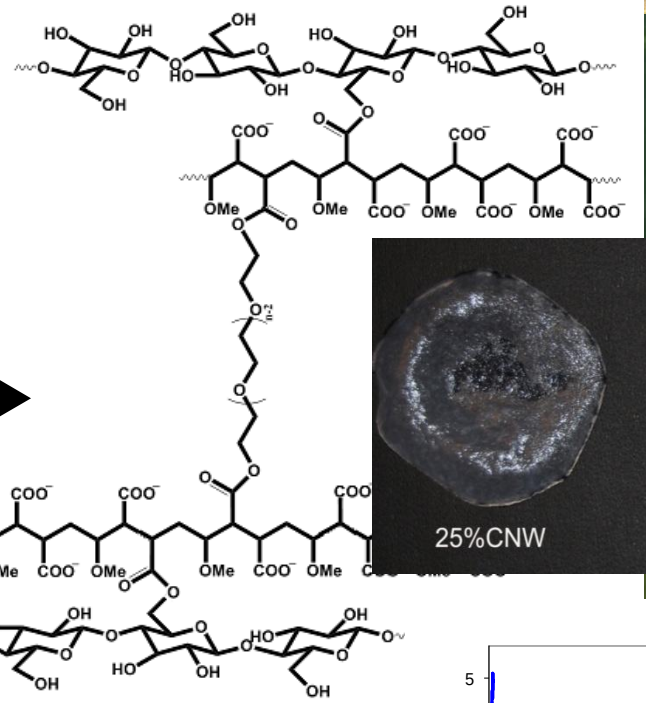
Drug delivery, Coupling NC with Protein Chemistry
Organ printing

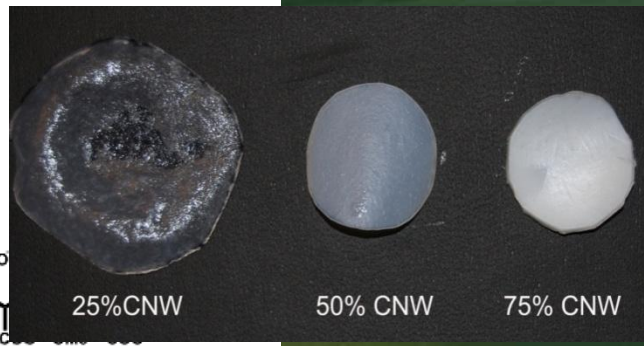
Advanced Materials: Cellular Level Cross Linking Whiskers







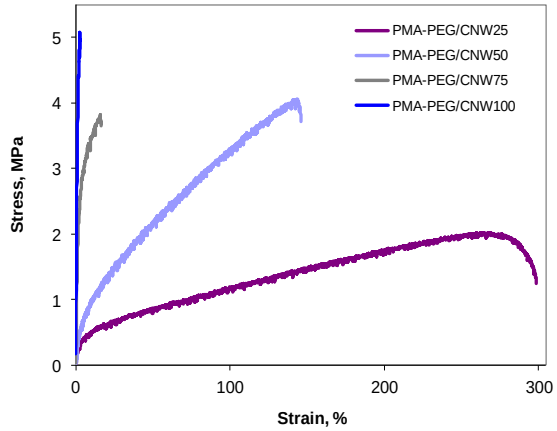




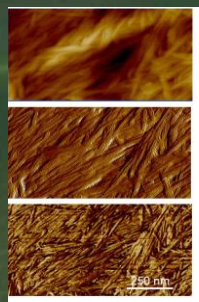
- Crosslinked pulp fibers → dry, then wetted...

- Crosslinked whisker films → dry, then wetted...

Properties:
Nature linking arm
Crosslinking density
Application:
Hygiene, Drug Delivery
Electrodes

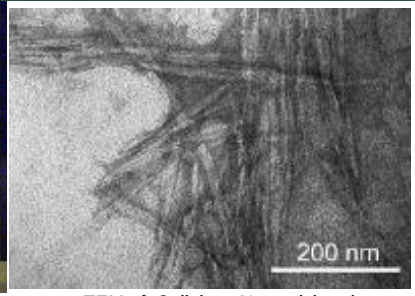


Advanced Materials: Cellular Level Cross Linking Whiskers



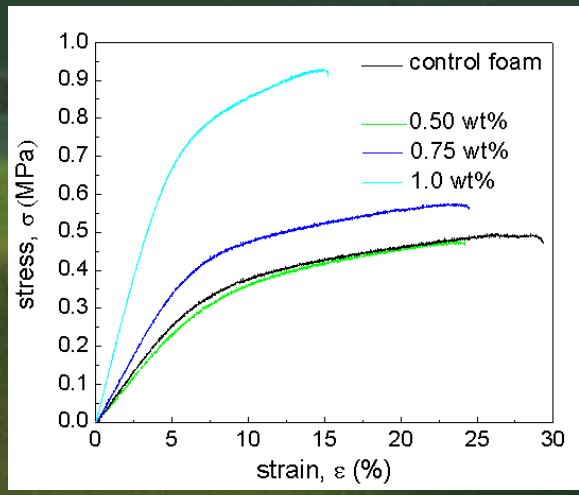
AFM of Cellulose Nanowiskers

Birefringence of Cellulose Nanowiskers

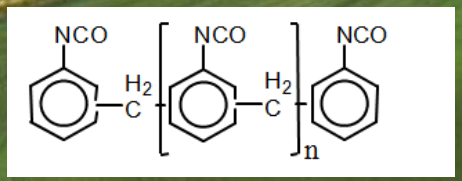


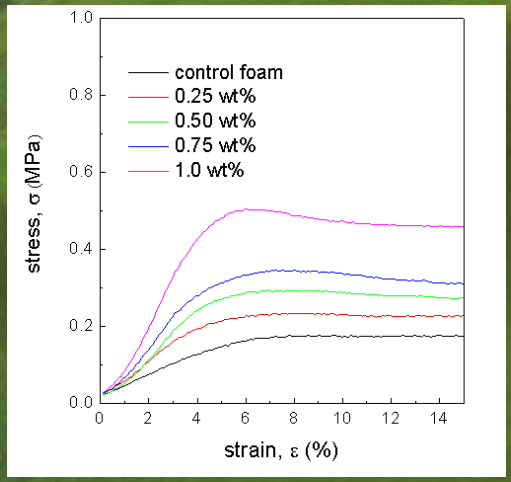
TEM of Cellulose Nanowiskers[1]

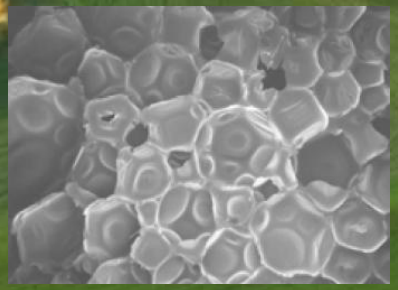
Preparation of sulphonated cellulose whiskers from ECF SW Kraft Pulps



Foams





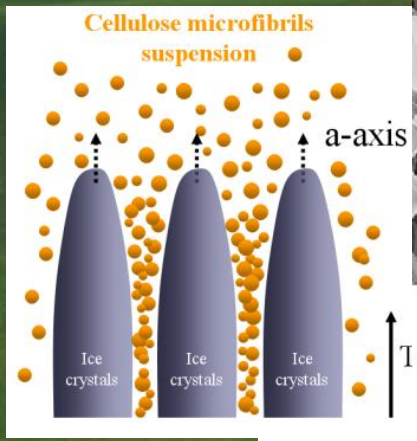


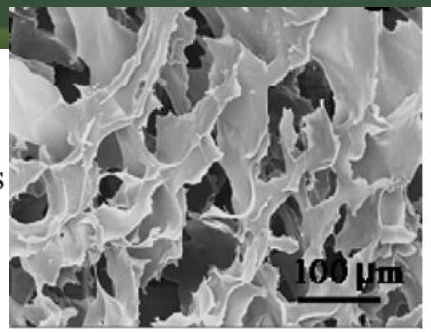
Application:

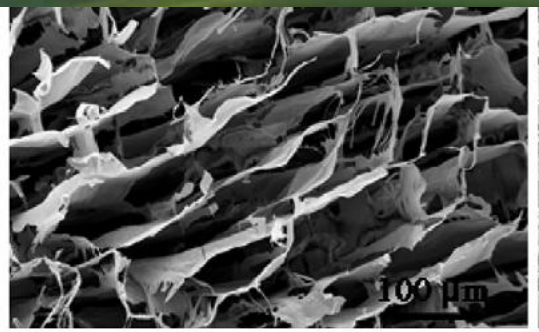
Transportation

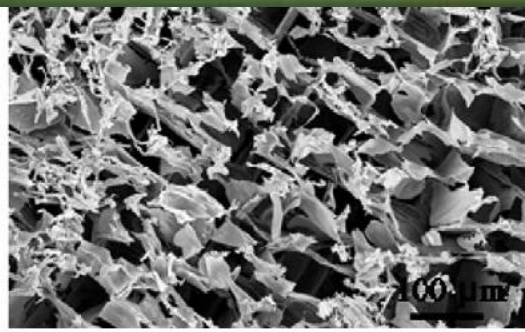
Construction

Advanced Materials: Cellular Level Ice-Templated Organization

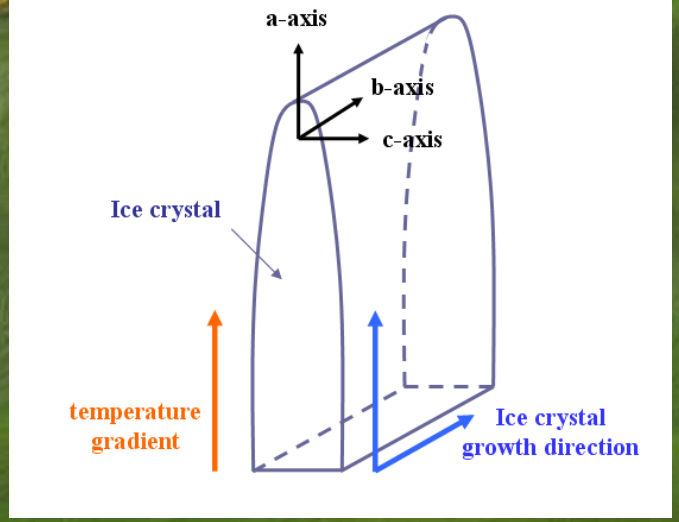


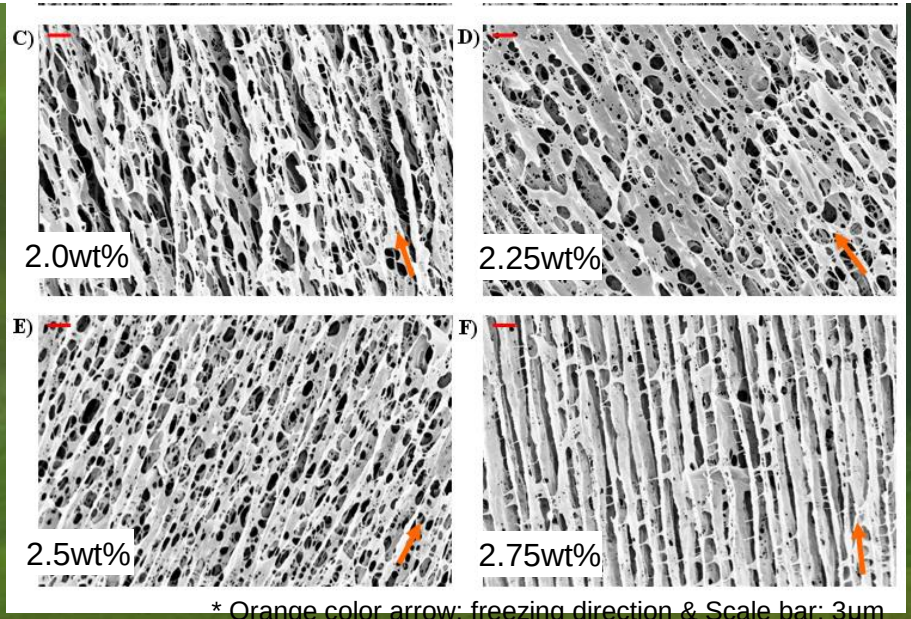






Morphology of cellulose nanowhisker samples freezed at 13 °C min^{-1} cooling rate (a) 0 wt%, (b) 20 wt% and (c) 50 wt% of PVA.

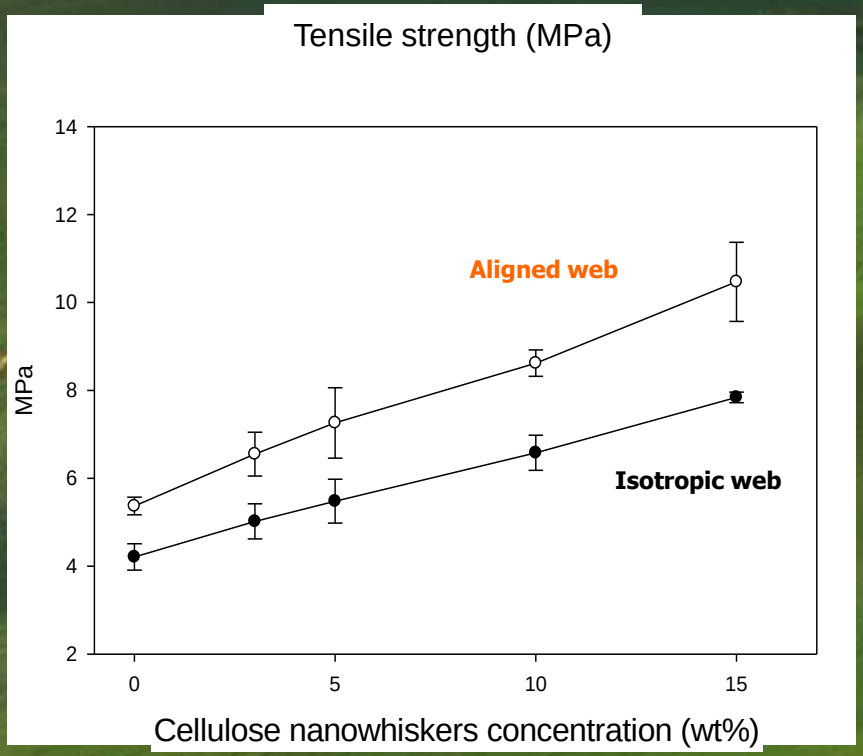


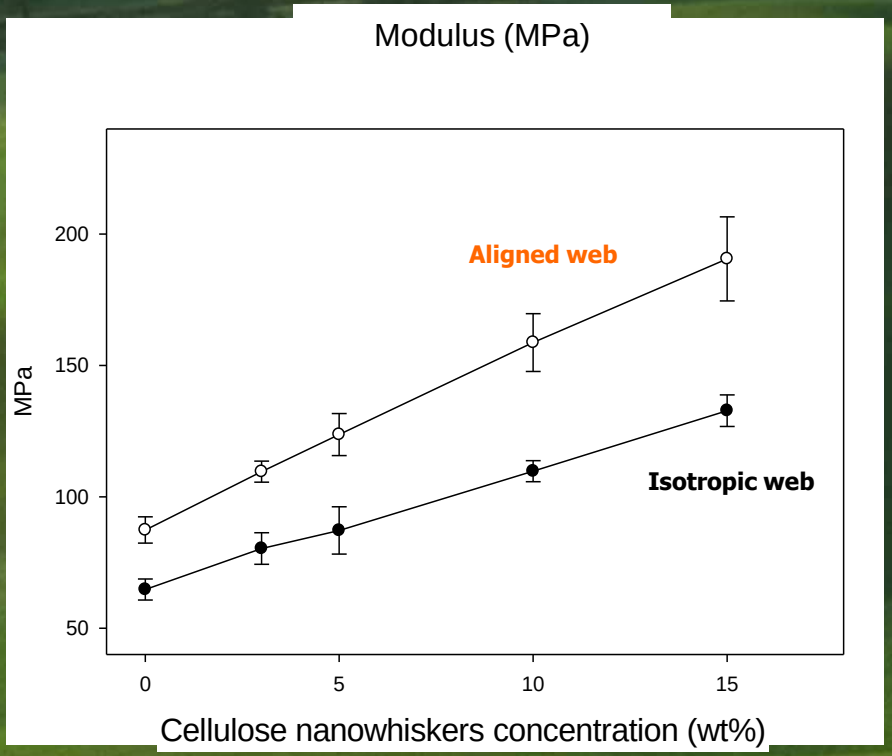


* Orange color arrow: freezing direction & Scale bar: 3μm

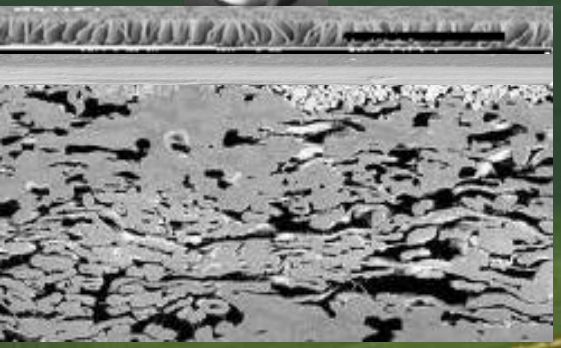
Advanced Materials: Cellular Level ElectroSpun

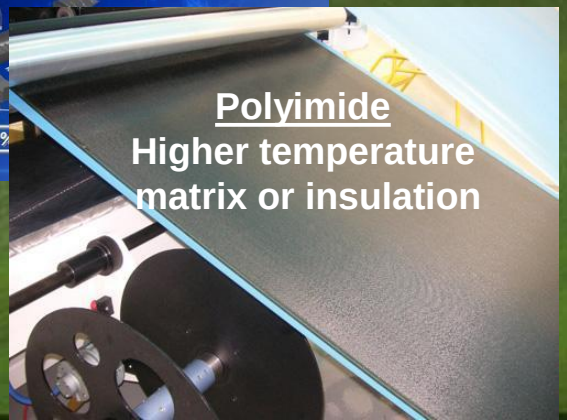
- Cellulose nanowhisker/PVA aligned and isotropic electrospun webs





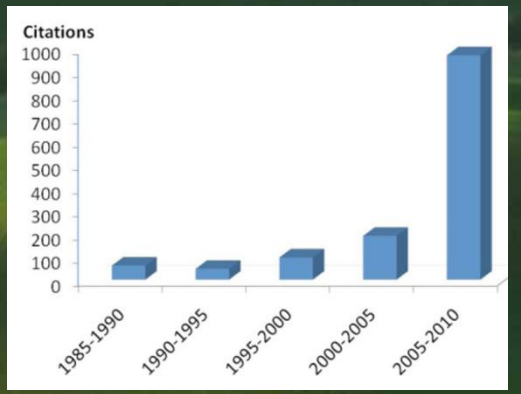
Advanced Materials: Cellular Level





Select Applications

- Thickner/binder
- Thixotropic additive/rheology modifier
- Films
- Barrier
- Batteries
- Battery membrane
- Strength aid for paper
- Composite
- Absorbent material
- Emulsions Stabilized
- Aerogel
- Polymer molds
- Food, drugs, tissue, cosmetics, paints
- Filters



Cellular Level

- ***NC – Polymer interactions***
- ***NC composite engineered structure***
- ***NC functionalization***

“The tipping point is that magic moment when an idea, trend, or social behavior crosses a threshold, tips, and spreads like wildfire"

by Malcolm Gladwell

Special Thanks

- Current research team members
- Visiting researchers from China, France, Sweden, Brazil, Italy
- USDA