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

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Advanced Materials: Cellular Level

- **Chemicals**
- **Enzymes**
- **Mechanical**

1 cm

100 µm

1 µm

10 nm

mm

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

Graph showing tensile strength data with different whisker contents.
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

Graph showing tensile strength versus cellulose content for Whisker and pulp fiber.
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

Dispersion of whisker in Select Organic Solvents: DMF, DMSO

Without any additive or surface modification

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

<table>
<thead>
<tr>
<th></th>
<th>TEA*, J/m²</th>
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<tbody>
<tr>
<td>Polystyrene</td>
<td>8.9</td>
</tr>
<tr>
<td>Polystyrene/NC whisker</td>
<td>+70%</td>
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alkenyl succinic anhydride (ASA) centered around C18 (Mn=300)

isopropenyl-α,α'-dimethylbenzyl isocyanate

phenyl isocyanate

Polystyrene/NC whisker +70%
Advanced Materials: Cellular Level

Cellulosics
Artificial Skin/Blood Vessels

High surface area, Hydrophilicity, Biocompatibility, and Biodegradability

Nanocellulosics – Human Health

Drug delivery, Coupling NC with Protein Chemistry
Organ printing
Advanced Materials: Cellular Level Cross Linking Whiskers

Properties:
Nature linking arm
Crosslinking density

Application:
Hygiene, Drug Delivery Electrodes
Advanced Materials: Cellular Level Cross Linking Whiskers

Preparation of sulphonated cellulose whiskers from ECF SW Kraft Pulps

Application:
Transportation
Construction

Foams

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Advanced Materials: Cellular Level Cross Linking Whiskers

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**Advanced Materials: Cellular Level**

Ice-Templated Organization

Morphology of cellulose nanowhisker samples freeze-dried at 13 °C min⁻¹ cooling rate (a) 0 wt%, (b) 20 wt% and (c) 50 wt% of PVA, temperature gradient.
- Cellulose nanowhisker/PVA aligned and isotropic electrospun webs
Advanced Materials: Cellular Level

Select Applications
- Thickener/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
- \textit{NC} – Polymer interactions
- \textit{NC} composite engineered structure
- \textit{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