NanoCellulose Opportunities

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Why Nanocellululosics

- Improve the biopolymer properties:
  - Mechanical (strength, modulus and strain)
  - Thermal stability
  - Toughness
  - Barrier
  - Biodegradability
  - Optics
- Use renewable raw materials
- New applications
  - Packaging, medical, transport, electronics etc.
Cellulose Whiskers

**Surface Area**

- E-Glass Fibers: approx. 1
- Paper Fibers: 4
- Graphite: 25 - 300
- Fumed Silica: 100 - 400
- Fully Exfoliated Clay: approx. 500
- **Nanocellulose Whiskers**: 400 - 700
- Carbon Nanotubes: approx. 100

- Size: width ~5 - 30 nm, length ~ 150-500 nm
- Estimated Modulus ~150 GPa
NanoCellulose

Commonly Prepared From A Variety of Cellulosic Fibers
Nanocellulose Whiskers Preparation

Cellulose Nanocrystal Production

Native cellulose

Amorphous region

Crystalline regions

Acid hydrolysis

Individual nanocrystals

Individual cellulose polymer

Tensile
Carbon Fibers > Cellulose Nanocrystals >> S-Glass > Aramid
Cellulose Nano Balls vs. Whiskers

Applications
- Composites
- Drug Delivery

5% Cellulose Balls
Latex Film

5% Cellulose Whiskers
Latex Film
MicroFibrillated Cellulose

Preparation:

Web-Like: Diameter: 5 – 40 nm, Length > 1000 nm

Mechanical treatments
- Homogenization
- Microfluidizer
- Grinding, supermasscolloider
- Cyrocrushing
- Sonification
Nano Cellulose Whiskers Composites

- Rubber, Resole-type phenolic resins
- Poly(vinyl alcohol), Poly(oxyethylene), Poly(lactic acid)
- Poly(styrene-co-hexylacrylate) copolymer
- Poly(vinyl chloride), polyurethane
- Polypropylene, polystyrene

- Whiskers act as efficient reinforcement due to high aspect ratios, surface areas and high modulus.
- Common benefits observed in tensile strength, elongation rate, elevated thermal decomposition
Nano Cellulose Whiskers Films

- Hydroxypropyl Methyl Cellulose
- Xylan, Starch, Chitosan, Glucomannan
- Styrene Butyly acrylate latex

General Benefits Due to Whiskers
- Enhanced moisture and oxygen barrier properties
- Tensile strength, TEA, Young's modulus
Microfibrillated Cellulose Composites

- Paper board
  - Improvement in tensile index
- Polypropylene, poly(ε-caprolactone)
  - Improved tensile and flexural strength
- Polysodium acrylate superabsorbents (SAPs)
  - Improvements in shear modulus

General Benefits Due to Whiskers
- Enhanced moisture and oxygen barrier properties
- Tensile strength, TEA, Young's modulus
Microfibrillated Cellulose Films

- MFC
- MFC/Layered Clay
  - Enhanced oxygen barrier properties
  - Paper board, Galactoglucomannans
  - Improvement in physical and barrier properties
- Polypropylene,
  - Improved tensile and flexural strength

General Benefits Due to Microfibrillated Cellulose
- Enhanced moisture, oil and oxygen barrier properties
- Tensile strength, TEA, Young's modulus, transparent
Nanocellulose Applications

- Polymer Composites & bioplastics
- Films, foams, and gels
- Cosmetics
- Dimensionally stable thickener and emulsion
- Implant material, biodegradable tissue scaffold
- Suture, drug delivery vehicle,
- Filter paper, speaker membrane
- Battery membrane
- Concrete
- Drilling muds & enhanced oil recovery
- Water treatment
Nanocellulose Applications

- Electronics - flexible circuits
- Flexible solar panels
- Paints pigments and inks
- Screens and coatings