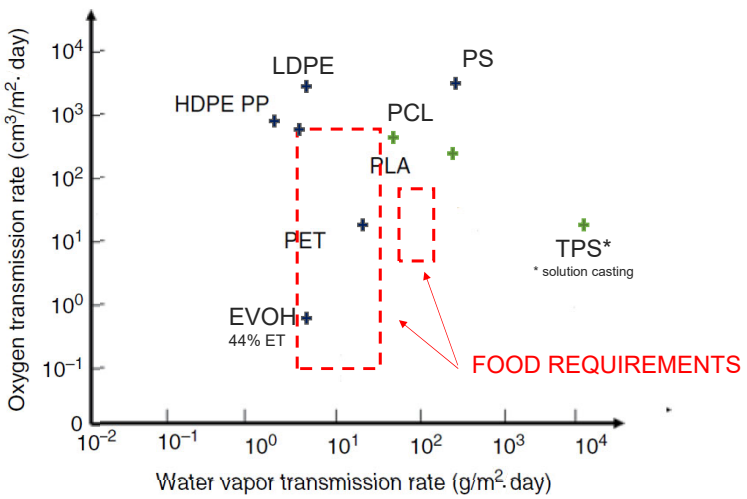
Improving barrier properties with cellulose nanocrystals

Presented by:
Richard Berry
CelluForce
Montreal

CelluForce

Example for barrier properties



Source: Ortega-Toro, Collazo-Bigliardi, Talens, Chiralt. Thermoplastic starch: improving their barrier properties, 2016

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Use of a new material to improve properties:

Cellulose NanoCrystals

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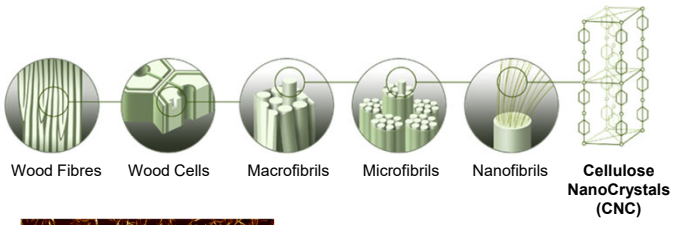
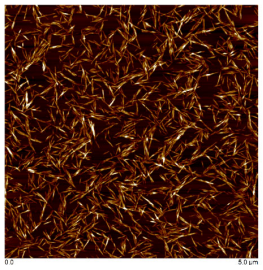
What are Cellulose Nanocrystals?





- Needle-shaped
- 5 nm x 100 nm (20:1 aspect ratio)
- 0.1-5% addition typical addition levels
- Stable up to 280 °C

CelluForce NCC®

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Safe and sustainable additive

- Numerous human health and safety tests have shown that CelluForce NCC® is benign
- CelluForce NCC® is a biomaterial produced from a sustainable source
- Provides GHG and water emissions reduction in several applications validated through independent sources

- Celluforce NCC® has received regulatory clearances in multiple jurisdictions
  - Complies with Canada's DSL
  - Complies with TSCA regulations in the United States
  - REACH exempt under the polymer exemption rule

Environment and Climate Change Canada

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How to use CNC in biopackaging?

Three main approaches:

1. Incorporate CNC into the main biopolymer matrix as an additive to native biopolymers
2. Incorporate CNC during the polymerization step of a synthetic polymer
3. Coat films with a CNC-based formulation

(Can also apply to conventional polymers)

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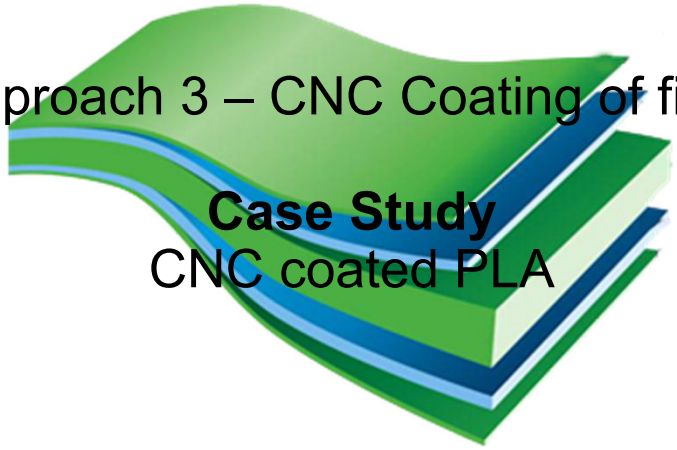
Approach 3 – CNC Coating of films



Case Study
CNC coated PLA

Source: Youngblood et al., 2018. Continuous Roll-to-Roll Fabrication of High-Performance Transparent CNC Coatings for Plastic, Purdue Research Foundation.

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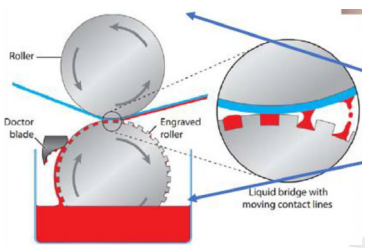
Materials & Coating Process

- Materials
  - Coating: CNC aqueous dispersion + plasticizer
  - Substrate: commercial grade PLA film
- Coating process
  1. Increase of substrate's surface energy by Corona treatment
  2. R30 microgravure
     - Gravure surface: 30 mesh lines/inch
     - Average wet coating thickness: 30-45 µm



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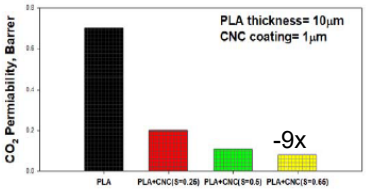
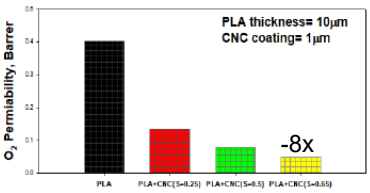
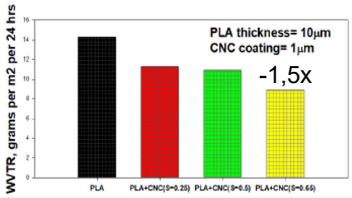
Results

- Preservation of optical clarity
  - Very high optical transparency with small roughness difference for various loadings
- Improvement of barrier properties







$$1\ \text{barrer} = 3.35 \times 10^{-16} \frac{\text{mol} \cdot \text{m}}{\text{m}^2 \cdot \text{s} \cdot \text{Pa}}$$

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Challenges & future developments

- Materials challenges
  - Coating formulation must be optimized to fit existing industrial processes
  - CNC is considered a moderate water-vapor barrier
- Processing challenges
  - Substrate-ink compatibility is key to coating quality
  - Barrier results depend on CNC particle's alignment during coating process
- How to overcome limitations?
  - Work closely with industrial partners to understand their processing constraints & needs
  - Test different technologies to improve CNC/substrate compatibility
  - Combine different technologies to attain multiple barrier targets such as multilayer and multiadditive biopackaging

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Industrial production of CelluForce NCC®

- Located in Windsor, Quebec, Canada
- Plant built in 2012
- Largest facility of its kind in the world
- Capacity of 300 tonnes per year
- Excellent product quality and batch to batch reproducibility
- Shipped as dried powder or liquid
- Next step: 3 000 tpy

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"Thank You" for your patience

Presented by:

Richard Berry
CelluForce
Montreal
Richard.berry@celluforce.com

PLACE

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