Innovative cellulose-based multilayer packaging films

Presented by:
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Motivation for alternative material solutions

- Consumers demand for materials made from bio-based and sustainable resources that are more recyclable, carbon neutral, and have low (post-use) environmental and health impacts,
- Consumers in Europe and US want to buy products with a minimal environmental impact, and most are also willing to pay more for environmentally friendly products – at least up to a point,
- 92% of business executives in our industry see a trend towards green materials at least a fact with real value (McKinsey, 2012),
- Companies rethinking plastic packaging as a whole and aiming for increased sustainability and circular economy,
- Policy developments (European and national strategies).
Our solution

• Our material looks like plastic and performs like plastic, but it is 100% biobased and made from nature’s very own raw material – cellulose,

• Cellulose is the most abundant and broadly distributed organic compound and industrial by-product on Earth produced by trees, nonwood crops and other plants, algae, bacteria, etc.

Background: Biobased multilayer barrier films

CNF = cellulose nanofibrils
Tools for creating biobased multilayer films

**SutCo:** Modular pilot coating line for aqueous coatings.

**PlasCo:** **UPDATED** Cast film and extrusion coating pilot line.

Application demos of biobased multilayer films

- **Bag-in-Box:** Bio-HDPE / CNF / (Bio-LDPE)
- **MAP:** Bio-LDPE / CNF / PLA / Paper
- **Stand-up pouch:**

More information: TAPPI European PLACE 2017
**Next step: Cellulose-based 3 layer film**

- Circular Materials Challenge 2018 Award, Ellen MacArthur Foundation
- Ecopack Challenge 2018 Award, Packaging Innovations in assoc. with Marks&Spencer
- Sustainability Awards 2018, Bio-based Packaging, Packaging Europe

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**Key enabling technologies**

- **Fibrillated cellulose**
- **ThermoCell technology**
- **Films/coatings from fibrillated cellulose**
Fibrillated cellulose (CNF/CMF)

Over 90 raw materials tested!

- Pulp
- Straw
- Sugar beet

Examples of fibrillated cellulose

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUND CNF</td>
<td>Number of passes through mechanical treatment, Yield ~ 95%</td>
</tr>
<tr>
<td>TEMPO-CNDF</td>
<td>Cellulose fibers oxidized with specific chemical mediator, followed by low consistency treatment to disintegrate fibers.</td>
</tr>
<tr>
<td>HefCel</td>
<td>High consistency enzyme assisted cellulose fibrillation, mechanical low energy agitation – high fiber-fiber friction, Valuable by-products</td>
</tr>
</tbody>
</table>
**High consistency enzymatic fibrillation (HefCel)**

**RECENT UPDATE**

70-75 liter mixer

**Recyclability and biodegradability**

*Tensile strength (MPa) at yield*

<table>
<thead>
<tr>
<th></th>
<th>Uncoated LDPE</th>
<th>Ground CNF coated LDPE</th>
<th>Plasticized Ground CNF coated LDPE</th>
<th>HeFCell coated LDPE</th>
<th>Plasticized HeFCell coated LDPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>15 ± 2</td>
<td>12 ± 1</td>
<td>15 ± 1</td>
<td>15 ± 1</td>
<td>12 ± 1</td>
</tr>
</tbody>
</table>

| CO₂ release in aqueous solution |

- Positive control
- Cellophane
- PLA
- CNF

50% virgin LDPE +
50% LDPE film coated with 0.9-2.2 µm CNF
ThermoCell technology

Ozone/enzymatic pre-treatment → Dissolving → Esterification → Precipitation and washing

ThermoCell;
Thermoplastic cellulose fatty acid esters
ThermoCell; Thermoplastic cellulose fatty acid esters

**WVTR (23 °C, 100/50% RH)**

From films ~90 µm thick

P. Willberg-Keyriläinen et. al. 
Cellulose (2017) 24, 505-517

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ThermoCell; Thermoplastic cellulose fatty acid esters

**Seal strength (C16)**

Film thickness affects seal strength!

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**Transparency**

15 Mika Vähä-Nissi - Innovative cellulose-based multilayer packaging films - 17th TAPPI European PLACE Conference 2019 Porto - Session 2 - Paper 2

16 Mika Vähä-Nissi - Innovative cellulose-based multilayer packaging films - 17th TAPPI European PLACE Conference 2019 Porto - Session 2 - Paper 2
Films/coatings from fibrillated cellulose

- CNF film made at Surface Treatment and Coating pilot line (SutCo) with casting on plastic substrate,
- Typically sorbitol as plasticizer,
- Both film surfaces coated with ThermoCell

Cellulose-based pouch prototypes

Migration

- **ThermoCell**:  
  - DIN EN 1186-3 Materials and articles in contact with foodstuffs - Plastics - Part 3: Test methods for overall migration (OM) into aqueous simulants by total immersion,  
  - From three parallel migration tests,  
  - **OM well below limit (10 mg/dm²)**  
- **Fibrillated cellulose**:  
  - Not expected to migrate through Thermocell layers – to be tested!

<table>
<thead>
<tr>
<th>Simulant</th>
<th>Duration/Temperature</th>
<th>OM (mg/dm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3% acetic acid</td>
<td>10 days / 40 °C</td>
<td>1.5</td>
</tr>
<tr>
<td>10% ethanol</td>
<td></td>
<td>2.2</td>
</tr>
</tbody>
</table>

No visual changes in the aqueous simulants!

Summary

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3 layer barrier film structure

ThermoCell
Layer of fibrillated cellulose
ThermoCell
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- **RAW MATERIAL FLEXIBILITY**
- **BIO-BASED / RENEWABLE**
- **CUSTOMIZABLE**
- **HEAT SEALABLE**
- **EXISTING MACHINERY**
- **COMPOSTABLE / RECYCLE READY**

Oxygen, gas and grease barrier
Acknowledgements

• The Ellen MacArthur Foundation,
• Team:

Call for collaboration

• Project: "ThermoCell for application tests" primarily for brand owners and converters,
• Joint effort for proof of application and to create market pull,
• Larger batch of ThermoCell will be produced for application testing together in partners’ business environment,
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“Thank You”
for your attention

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