INN PRESSME

Open Innovation Test Bed

Multilayer Barrier Packaging

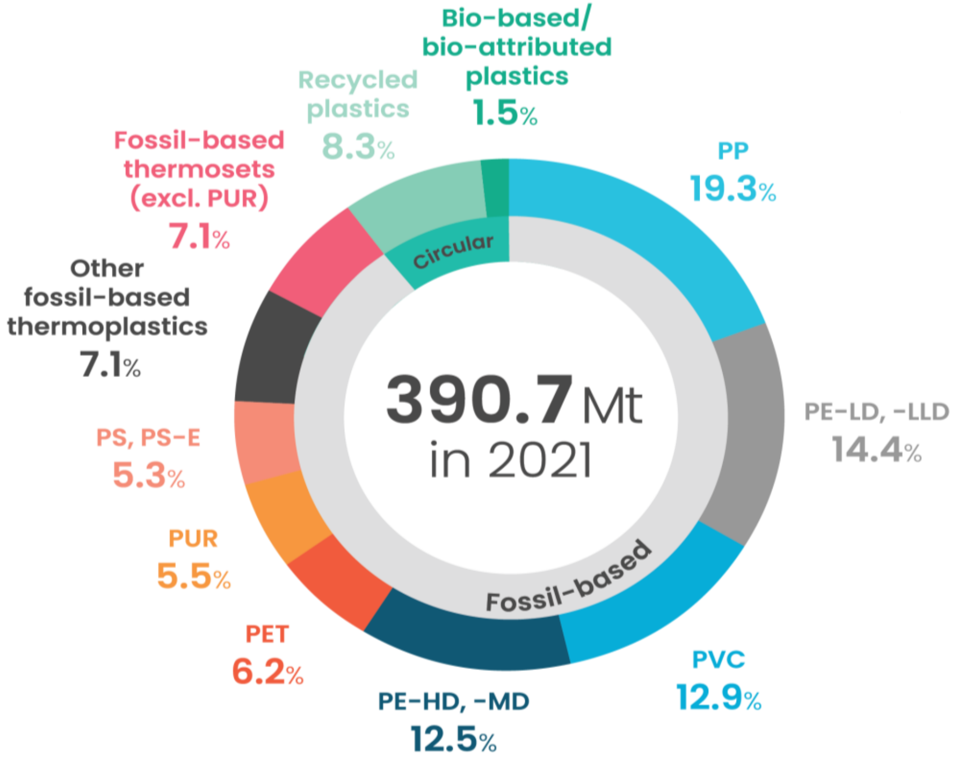
Ilona Leppänen*, *Rajesh Koppolu, Jani Avellan, Eetu Nissinen, Roosa Hämäläinen, Adina Anghelescu-Hakala, Ferdinand Somorowsky, Sylvia Larsson, and Ulla Forsström

INN-PRESSME policy and dissemination event| 26th Jan 2024

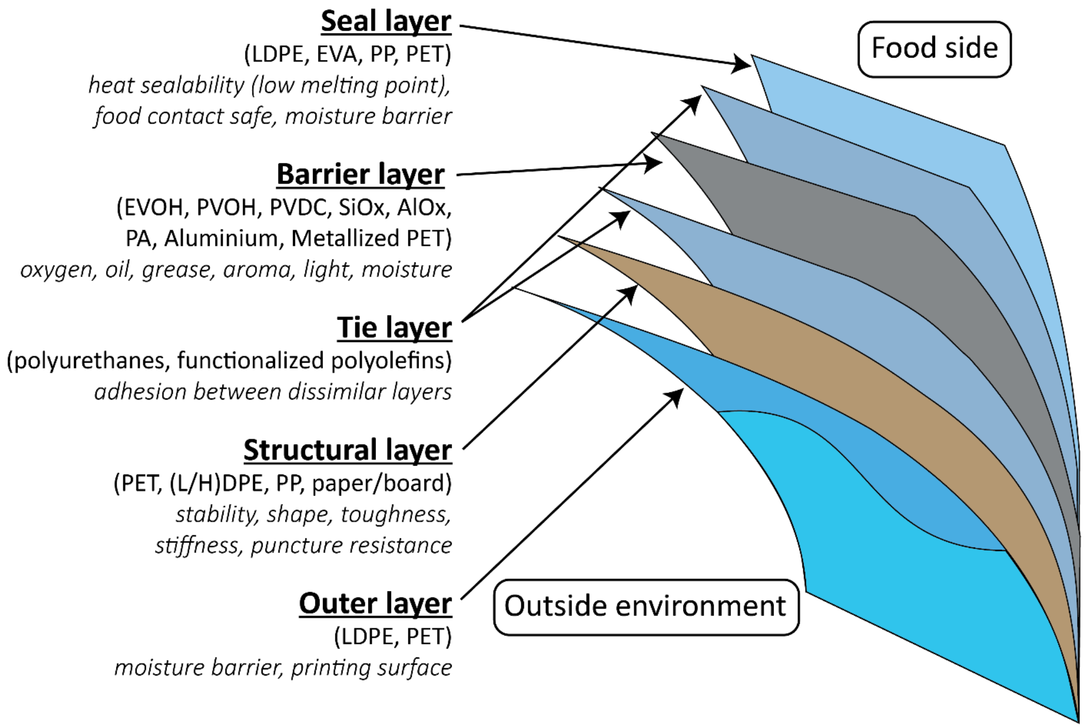
Brussels, Belgium

Plastics in packaging

Approximately 40% of total plastics produced are used for packaging applications and 17-20% is multilayer packaging



Source: Plastics Europe – "Plastics – the facts 2022"



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

Products

INN-PRESSME to **produce & recycle products with as little fossil-based raw materials as possible.**

Usage in the 3 following sectors:

Packaging

- Smart labels
- **Fiber-based pouches**
- Bio foam boxes
- Tubes for cosmetics

Energy & Transport

- Ultracapacitors
- Car parts
- 3D printed elements

Consumer Goods

- Shoe soles
- Sport goods

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

Aim

- Development and scale-up of multilayer fibre-based barrier packaging to replace plastic packaging.
  - Demonstrated using **4 different pilot-lines in INN-PRESSME consortium**

- Apply PLA-X (polylactic acid dispersion), cellulose nanocrystals (CNC), & biobased hybrid nanomaterials as dispersions on papers.

- Aim for packaging materials that can be recycled with other fibre-based packaging materials and material reused.

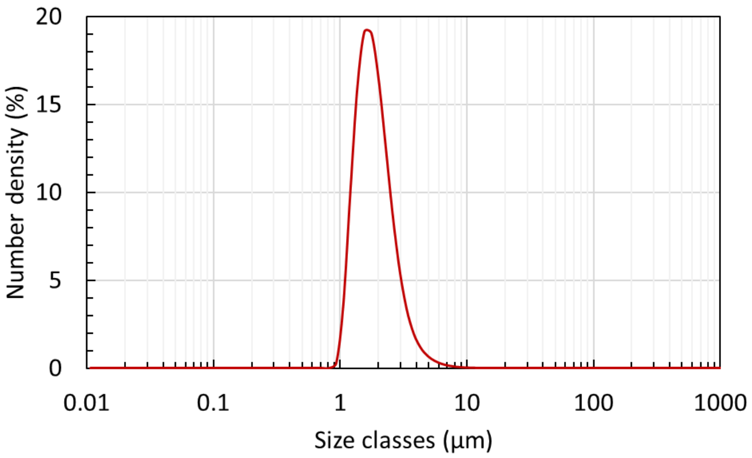
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

Materials: PLA-X

VTT

- **Produced at VTTs formulation pilot line in Finland**
- PLA-X is water-based dispersion based on poly lactic acid (PLA)
- 20% polyvinyl alcohol (PVOH) as dispersing agent
- Solid content of the dispersion – ca. 20%
- **Enhance moisture barrier and to provide heat-sealability**

Size distribution

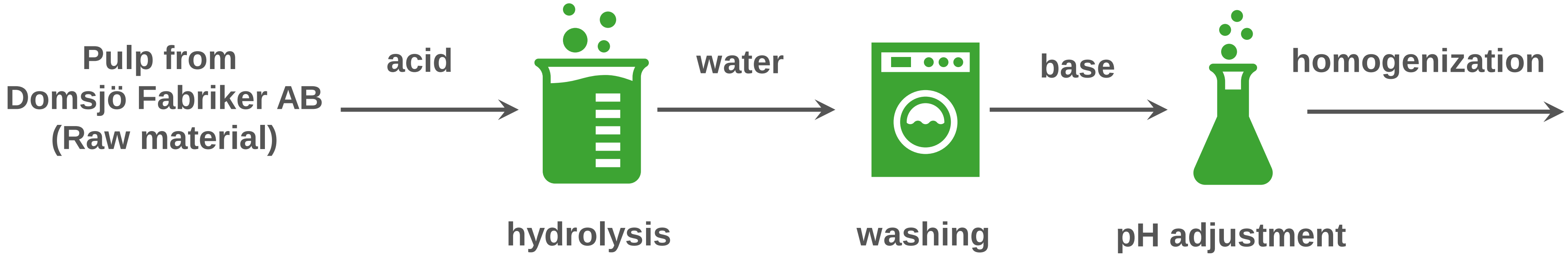


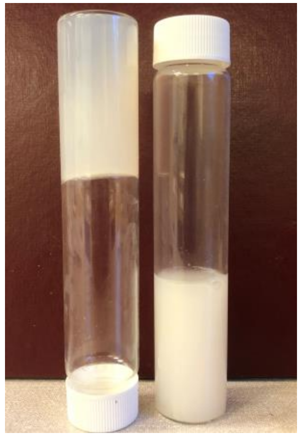
Scaled up from 2 L to 600 L reactor

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

Materials: CNC

- **Produced at RISE, Sweden utilizing their CNC conversion pilot line**
- Cellulose nanocrystals (CNC) produced via acid hydrolysis of chemical pulp
- Suspension concentration up to 6%, scaled up to 200 kg batch size
- **Enhance oxygen barrier in the multilayer structure**





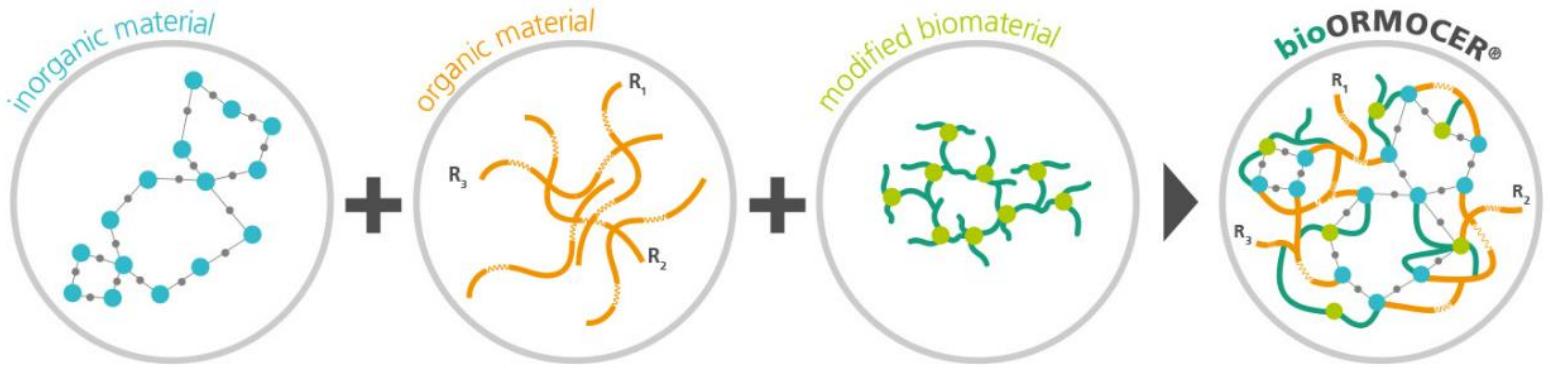
CNC suspension

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°952972

Materials: bioORMOCER®

Fraunhofer ISC

- **Produced at Fraunhofer-ISC NP pilot line → Up-scaled to 40 L**
- Biodegradable lacquer made from inorganic nanoclusters (silanes, inorganic complexes, and salts)
- Stabilized by modified organic biopolymers (hydroxypropyl cellulose – HPC)
- Solid content – ca. 30%
- **Provides barrier against oxygen in the multilayer structure**



Source: Fraunhofer Institute for Silicate Research ISC (https://www.barrier.fraunhofer.com/en/research-and-development/bioORMOCER-coatings-high-performance_biodegradable_functional_layers.html)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

Materials: Base papers

Base paper – A

- Commercial reference: Label – ‘A’
- Basis weight: 64 g/m^2
- Thickness: 59 µm
- Coated one-side for improved barrier properties

Base paper – B

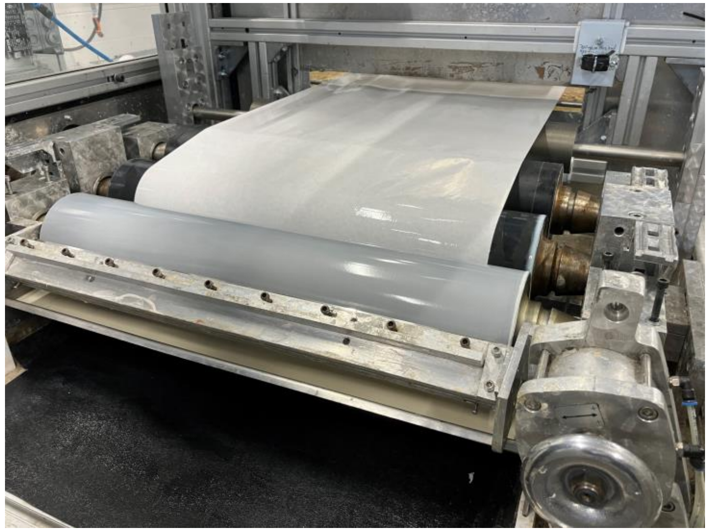
- Commercial reference: Label – ‘B’
- Basis weight: 60 g/m^2
- Thickness: 47 µm
- Uncoated base with high smoothness

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°952972

Coating process at VTT SutCO pilot line

SutCo: Modular pilot line for aqueous coatings

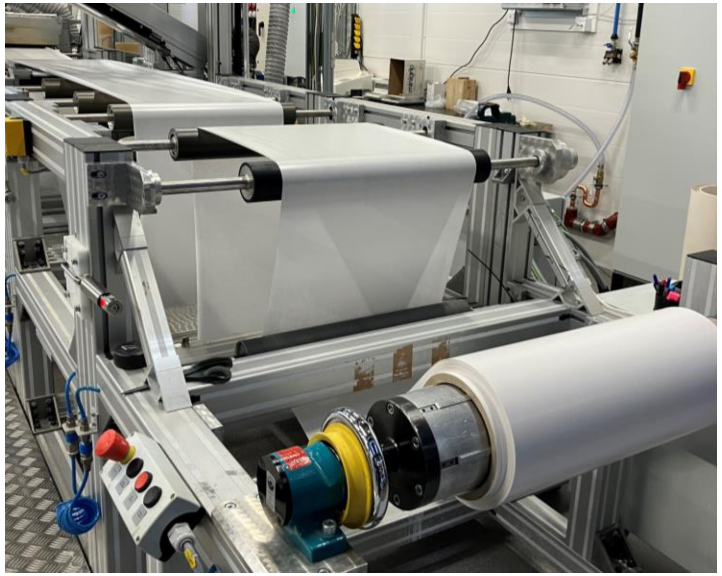
Various coating methods possible



Reverse gravure coating method used in this project

Max. coating width: 500 mm

Max. coating speed: 90 m/min



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

Trial points

Trial point 1

(A-POP)

- PLA-X
- bioORMOCER®
- PLA-X
- Base – ‘A’

Trial point 2

(A-PCOP)

- PLA-X
- bioORMOCER®
- CNC
- PLA-X
- Base – ‘A’

Trial point 3

(B-POP)

- PLA-X
- bioORMOCER®
- PLA-X
- Base – ‘B’

Multilayer coat weight: 10-12 g/m^2

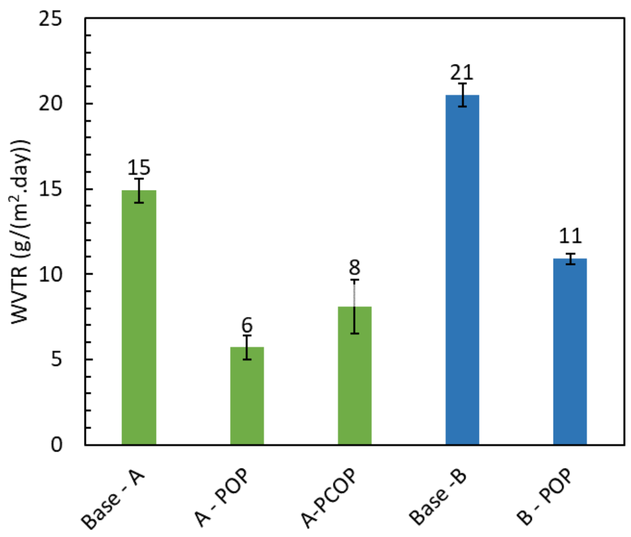
Multilayer thickness: 7-8 µm

- Good coating quality for all materials.
- Surfaces are corona treated before coating each layer
- No issues with wetting/spreading
- Good adhesion between layers

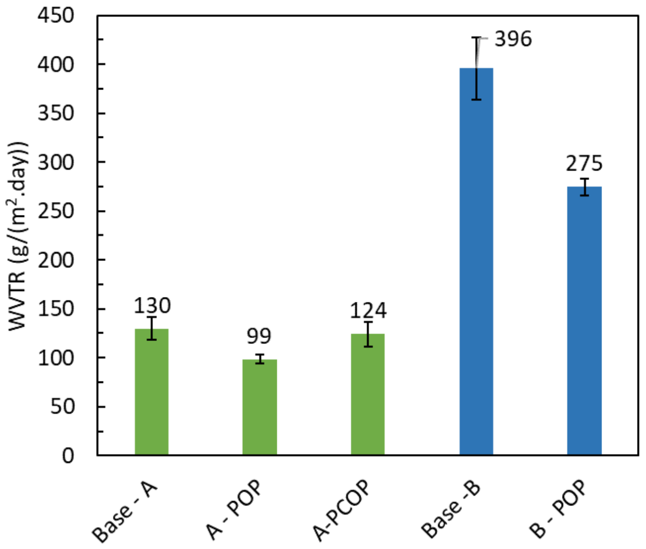
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°952972

Water vapour barrier

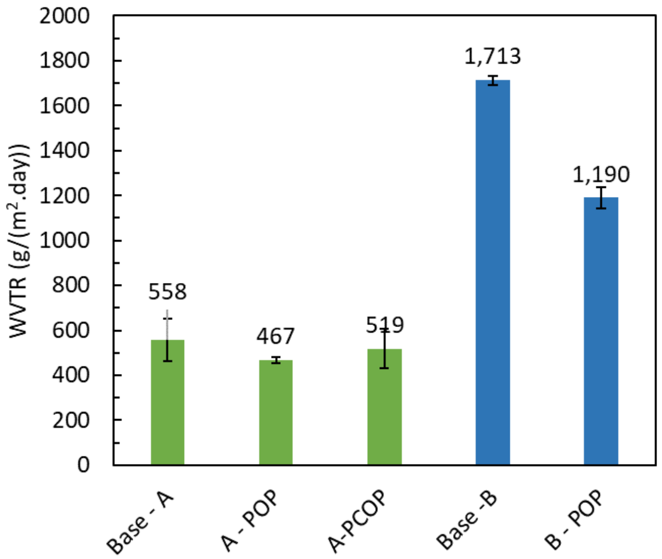
23 °C / 50%



23 °C / 80%



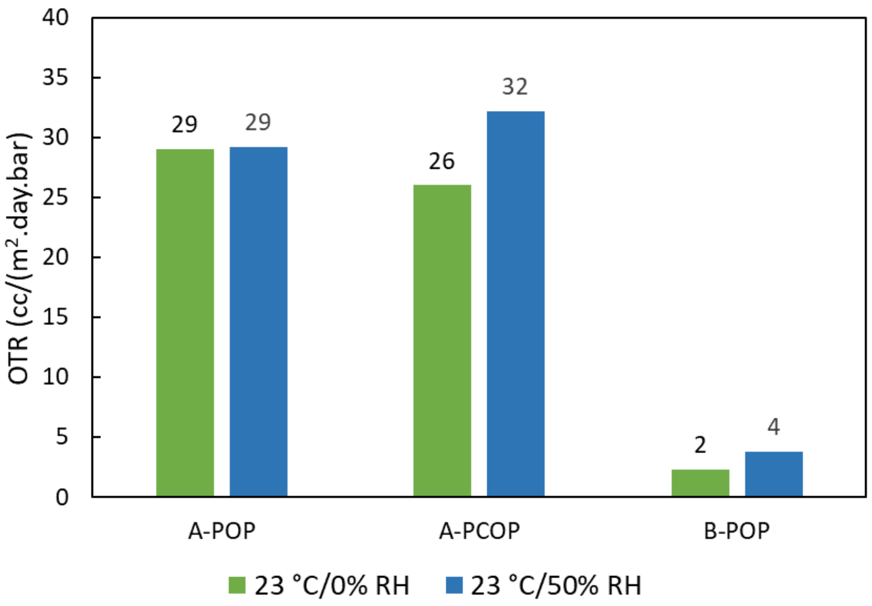
38 °C / 90%



- Base – A has lower water vapour transmission rate (WVTR) than B due to pre-coat
- Multilayer coatings lower the WVTR by:
  - 50-65% at 23 °C / 50% RH
  - 25-30% at 23 °C / 80% RH
  - 15-30% at 38 °C / 90% RH
- Backside coating or thicker coatings might improve WVTR at higher humidities

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

Oxygen barrier



- Two test conditions: 23 °C / 0% RH and 23 °C / 50% RH
- Both base papers do not have any oxygen barrier
- Base B shows excellent barrier to oxygen at both test conditions
- Base B has higher smoothness → better coating holdout (especially considering the low coat weights)

Grease and Mineral oil barrier

- All multilayer coatings have the max. KIT value of 12
- All multilayer coatings do not allow any n-Heptane vapours to pass through

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

Scale up to industrial demonstrators

- Three-layer: PLAX + bioORMOCER + PLAX configuration for industrial scale pilot trials
- PLAX coated at 80 m/min on WALKI's production line located at Ylöjärvi, Finland
- 5000 m coated for each base paper with good coating quality and reproducibility
- bioORMOCER and PLAX to coat were applied using SUTCO pilot line at 20 m/min
- 2000 m of the final multi-layer structure was produced.

- Barrier properties similar to that of lab-scale samples – Results reproduced on large scale trials

- Oxygen barrier for large scale coated samples as low as 0.8 and 2 cc/m^2/day/bar at 0% and 50% RH, respectively at 23 °C.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

Recyclability

- ➢ Pilot-scale samples for scale-up were tested for recyclability according to CEPI test method.
- ➢ Multilayer samples with CNC-layer passed the test and can be recycled in paper stream
- ➢ Samples without CNC-layer failed the test → CNC layer helps with delamination
- ➢ Tests on-going for large-scale demonstrator samples

Heat-sealability

- ➢ Pilot-scale samples for scale-up studies showed good heat sealability
- ➢ Large-scale demonstrator samples had reduced heat sealability → Corona pretreatment and thicker top PLAX layer will improve this.
    - ➢ Poor heat sealability is due to practical reasons and can be solved easily.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

Summary

- ➢ Multilayer coating done on two different base papers using:
  - PLA-X (crosslinkable PLA-based aqueous dispersion)
  - CNC (cellulose nanocrystals)
  - bioORMOCER® (biodegradable inorganic nanoparticles stabilized by biopolymers)

- ➢ Traditional coating methods such as gravure coating can be used to apply these materials into multilayer structures
- ➢ Low coat weight and coating thickness (below 12 g/m^2 and 8 µm) for all three layers combined
- ➢ Promising water vapour barrier properties at 23 °C/ 50% RH
- ➢ OTR as low as 0-8 - 2 cc/(m^2.day.bar)
- ➢ Excellent grease and mineral oil barrier
- ➢ Good heat-sealing properties

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N°952972

INN PRESSME
Open Innovation Test Bed

Rajesh Koppolu
Research Scientist, VTT
Rajesh.Koppolu@vtt.fi

Jani Avellan
R&D Director, Innovation,
Walki Group
Jani.Avellan@walki.com

Eetu Nissinen
Research Scientist, VTT
Eetu.Nissinen@vtt.fi

Roosa Hämäläinen
Research Scientist, VTT
Roosa.Hamalainen@vtt.fi

Adina Anghelescu-Hakala
Senior Scientist, VTT
Adina.Anghelescu-Hakala@vtt.fi

Ulla Forsström
Principal Scientist, VTT
Ulla.Forsstrom@vtt.fi

Ferdinand Somorowsky
Head of Chemical Coating Technology,
Fraunhofer ISC
ferdinand.somorowsky@isc.fraunhofer.de

Sylvia Larsson
Research and Business
Developer, RISE
Sylvia.Larsson@ri.se

www.inn-pressme.eu

linkedIn.com/company/inn-pressme

twitter.com/inn-pressme