INN-PRESSME Project and Pilot lines for nano-enabled bio-based materials

Ulla Forsström, VTT

ulla.forsstrom@vtt.fi

16.11.2022

Facts & Figures

Developing materials & solutions for industry to replace fossil resources with sustainable, efficient, & cost-competitive bio-based materials.

European Union
H2020 Funding:

16.338.121,95 €

Start:
1st
January 2021

End:
31st
January 2025

49 months

Lead by VTT from Finland

VTT

Ulla Forsström (coordinator)

www.inn-pressme.eu

27
Partners

9
Countries

9
Demosites

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

OITB Pilot lines - conversion of feedstocks

- **To produce nanomaterials and novel bio-based materials**
- To formulate novel nano- and biobased materials
- To process them and test product performance

Bio-based nano and micro materials

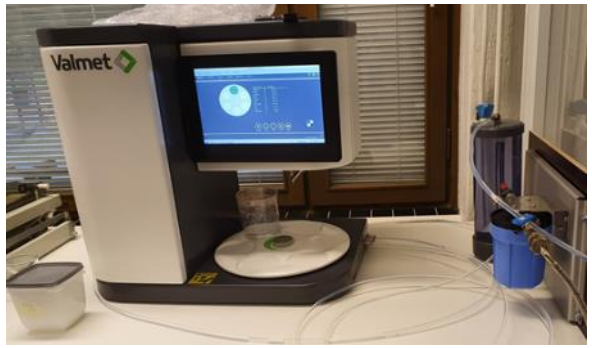
Bio-based thermoplastic materials

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

Cellulose Nano and Micro Fibrils, CNF and MFC PLs (VTT)

- VTT's nanocellulose facilities allow testing of wide range of raw materials and production of trial samples from a few dozen grams upwards
- Low and high consistency production
- Systematic process and quality data collection in digital data storing and management application

CNF/MFC pilot halls in VTT Bioruukki



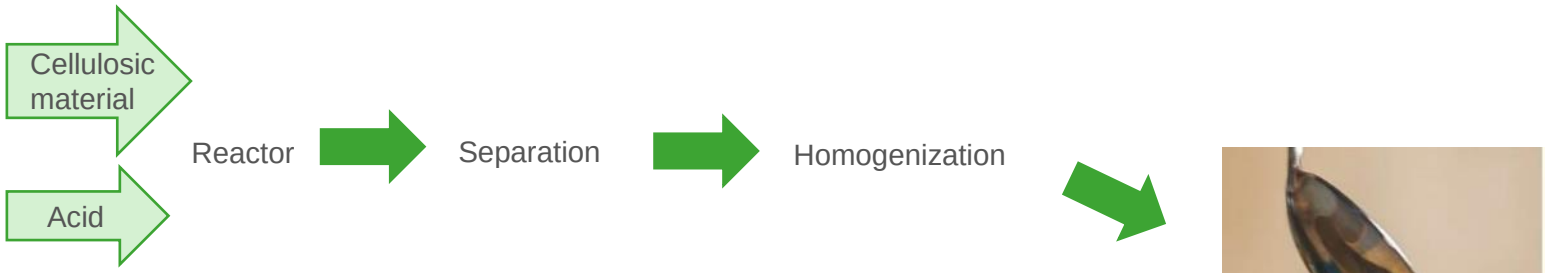
Fiber analyzer FS5

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

Cellulose Nano Crystals, CNC PL (RISE/Processum)

Pilot

- Capacity 1400L



Labscale

- Capacity 1-50 L
- Glas/Hastelloy reactor

Reaction | Separation | Homogenization by sonication

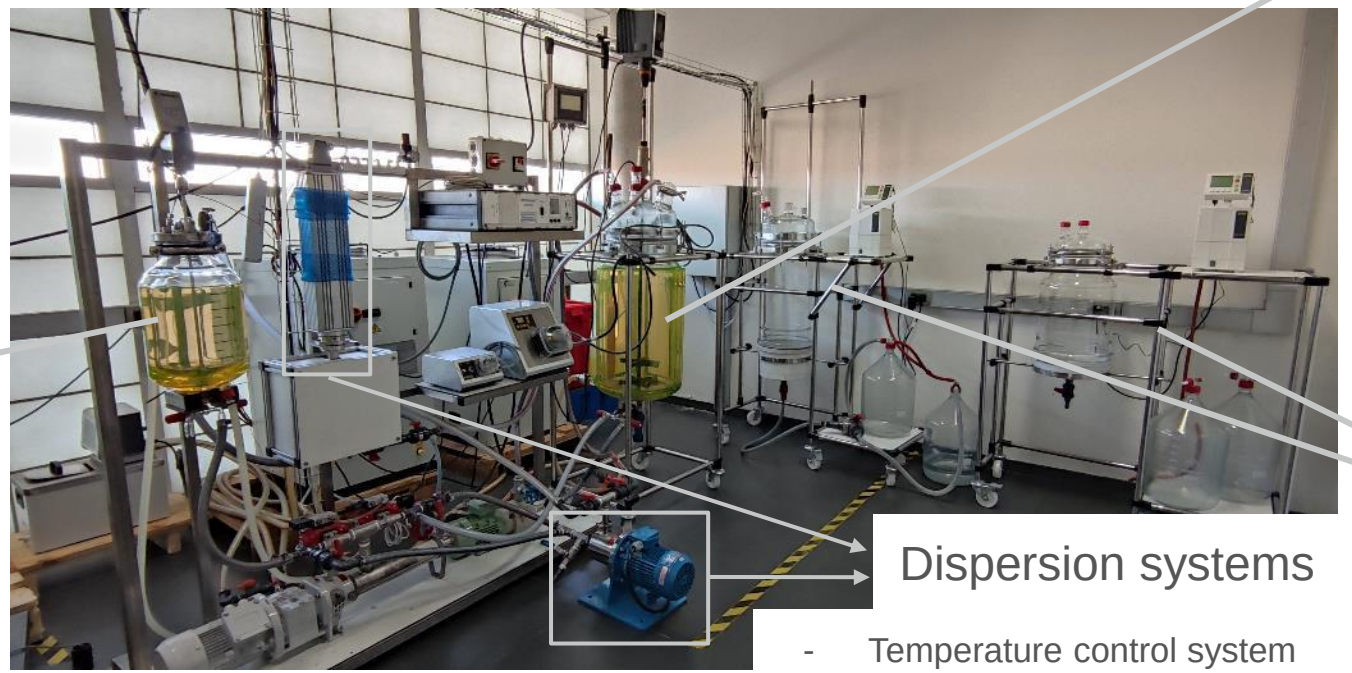
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

Carbon-based nanomaterial PL (Gnanomat)

- **Formulation** and optimization of carbon-based nanomaterials functionalized with metal oxide nanoparticles.
- Synthesis parameters adjusted as function of the **material characteristics of active electrode material.**

Reactor 50L

Reactor 5L



Filtration systems

Dispersion systems

- Temperature control system
- pH control system

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

Flax/hemp microfibre PL (IWNIRZ)

Pilot line combines following processes in semi-pilotscale:

- Degumming of long flax and hemp fibres aiming to their separation, e.g. dividing technical fibres on elementary fibres with diameter 20-30 µm,
- Silanization and crosslinking in order to improve adhesion between hydrophilic bast fibres and bioplastics
- Drying after wet processes
- Cutting and grinding to obtain micro-size flax and hemp fibres as dry material

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

Process Chemistry PLs (VTT)
PLAX and other bioplastics (polymers, dispersion)

- ➢ Polymerization reactors for production of bio-based polymers
- Reactors for preparation of polymer dispersions and formulations
- Characterization of synthesized polymers and dispersions
- Online measurements and data collection to support production, process control and processing results

- ➢ Scale-up possibilities for polymers and dispersions
  - Vacuum shovel reactors available from 10 L to 600 L
  - Temperature up to 200 °C
  - Vacuum up to 10-20 mbar
  - Ability to mix high viscous products

Lödige DVT 10

Lödige VTA 600

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

PHA PL (Polymaris)

Fermentation volume 1000 L

- The fermentation pilot for production of PHA powder by the fermentation of marine bacteria.
- Two ultrafiltration units for dia-filtering biomass to increase consistency before drying.
- Spray drying biomass before extraction of PHA
- Dried PHA powder can be used for foam extrusion and multi-nano extrusion coatings.

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

OITB Pilot lines
- formulation of the materials to intermediate products

- To produce nanomaterials and novel bio-based materials
- **To formulate novel nano- and biobased materials**
- To process them and test product performance

Printing inks/pastes

Coating dispersions/colours

Granulates

Filaments

Lacquers

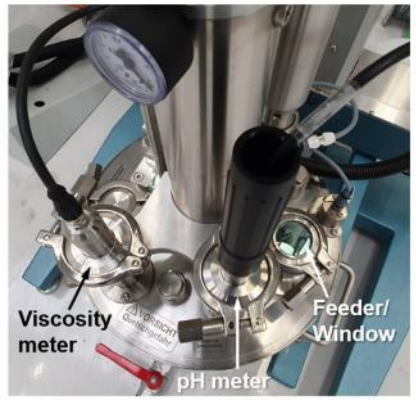
Foam beads

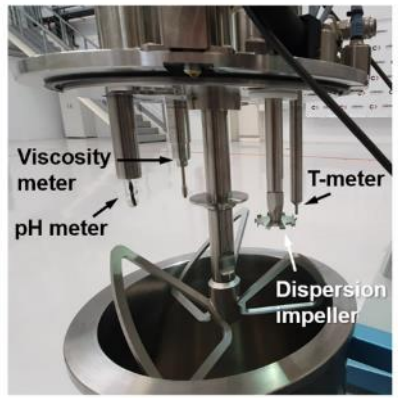
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°952972

INK PL (Cidetec)

Pilot Line Outcomes

- Scaled-up production of bio-based printable inks and coatable slurries based on cellulose aqueous mixtures
- **increased ink production capacity to test new ink compositions and functionalities at semi-industrial level** to assess benefits of eco-friendlier solutions in printed electronics.





Pilot Line Upgrades

➢15 L capacity dissolver to disperse non–flowing/high viscosity blends under vacuum (suitable for cellulose inks and slurries) equipped with pH and viscosity control systems integrated to the vacuum dissolver for in-line process control

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

POUD PL (CEA)

Pilot Line Outcomes

- Bio-based thermoplastics formulations containing natural fibres or nano-fillers **using mixers and extruders for compounding of nano-enabled bio-based polymers**, for injection moulding
- **Production of nano-enabled biocomposites with a better management of the nanosafety**
- Possibility to produce biobased films for packaging or 2D substrates for electronics applications (lack identified in current trade)

Pilot Line Upgrades

- Acquisition of a cast film extrusion line to extrude films for packages and 2D substrates
- Integration of protective equipment to secure the handling of nanomaterials

Single screw extruder equipped with a flat die and a calendaring system

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

METEOR PL (IPC)

Pilot Line Outcomes

- Unique compounding capabilities based on extensional shear rates to process complex Thermoplastics compounds.
- The inline rheometer allows unique compounding capabilitites with a quality control integrated inline. Process parameters will be optimized
- **Inline production of Fused Filament Fabrication (FFF) 3D printing filaments (20 kg/h)**
- Films width up to 600 mm

Pilot Line Upgrades

- Installation of an inline viscosimeter
- 3D filament producing line an improved pull system
- Flat die 750mm & Chill-Roll

3D filament producing line

Flat die and chill roll

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

NP PL (FhG)

Pilot Line Outcomes

- **Semi-automatically lacquer and nano-particle production and processing up to 100 l;** 5.000 m2 substrate; wet coatings on films/foils (2D)
- Pre-treatments (Corona, flame pyrolysis, post-treatments like UV, thermal curing)

Pilot Line Upgrades

- Automatic temperature control for lacquer reactor
- Semi-automatically dosing unit for lacquer reactor with 2 peristaltic pumps
- Planning of the SiOx-pre-treatment module for the R2R processing, order process completed

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

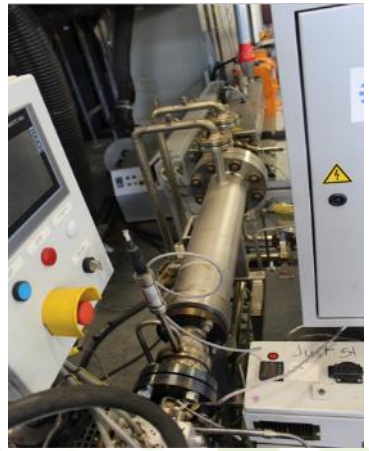
FOAM PL (FhG)

Pilot Line Outcomes

- Development of materials and products scaled to SMEs needs in the field of bio-based nano-reinforced particle foams
- **Formulations for the foaming of nano-functionalised bio-polymers, foaming processes for formulations in particle and extrusion foaming technology.**

Pilot Line Upgrades

- Inline-viscosity measurement for improved process control and monitoring
- Particle coating device for functionalization of foam beads
- Parameter monitoring and database establishment in whole process chain for monitoring and documentation of all relevant data during trials



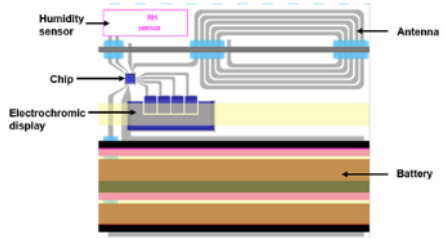
Inline viscosity meter

Particle coating device

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

OITB Pilot lines
- processing of nano-enabled biomaterials

- To produce nanomaterials and novel bio-based materials
- To formulate novel nano- and biobased materials
- **To process them and test product performance**



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

PICTIC PL (CEA)

Pilot Line Outcomes

- **To print large flexible surfaces functionalized with electronic functions made from bio-based materials.**

Pilot Line Upgrades

- Integration of a vision measuring system to characterize shrinkage/expansion coefficients in X and Y directions of the flexible substrates.
- Software development ensuring the following features:
  - Scanning the area
  - Fiducial elements recognition
  - Measurement of distances between fiducial elements to define shrinkage/expansion of the substrate.

Vision Measuring System from In-Core®

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

SutCo PL (VTT)

Pilot Line Outcomes

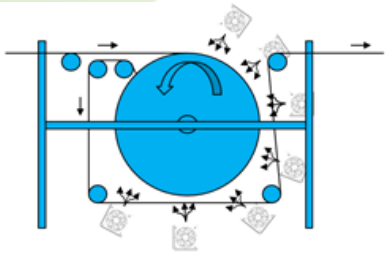
- To trial **new surface treatments for special applications using only small material amounts for fibre based and plastic materials** compared to traditional pilot machines.

Pilot Line Upgrades

- A mixing unit added
- Infrared drying unit up-dated for better control of drying section
- Cooling roll will be added for better control of roll quality in rewinding
- A data collection system to source data variables up-dated, reporting will be improved.

Mixing Unit

Infrared drying unit



Cooling roll

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

MULTINANO PL (IPC)

Pilot Line Outcomes

- **To produce films composed of multinanolayered films with high gas barrier and optical properties.** The line is made of three extruders and is modular to connect any of the extruders to desired positions.

Pilot Line Upgrades

- To integrate a quality control system to monitor film features
- To widen the film exit die thanks to a new chill-roll, to produce film of a width from 350 to 800 mm.
- Bi-axial stretching to improve gas barrier properties via subcontracting.

Flat die with deckling system & Chill-Roll

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

COAT PL (CID)

Pilot Line Outcomes

- Continuous coating line for electrodes/electrolytes
- **Coating electrodes using waterborne slurry optimized formulations**

Thickness measurement sensor

Pilot Line Upgrades

- Integration of an automatic slurry feeder to supply very precisely specific volume of slurry to ensure the uniformity of coating thickness
- Addition of an in-line thickness sensor
- Implementation of laser alignment for both sides electrode widths

Slurry feeder

Laser alignment

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

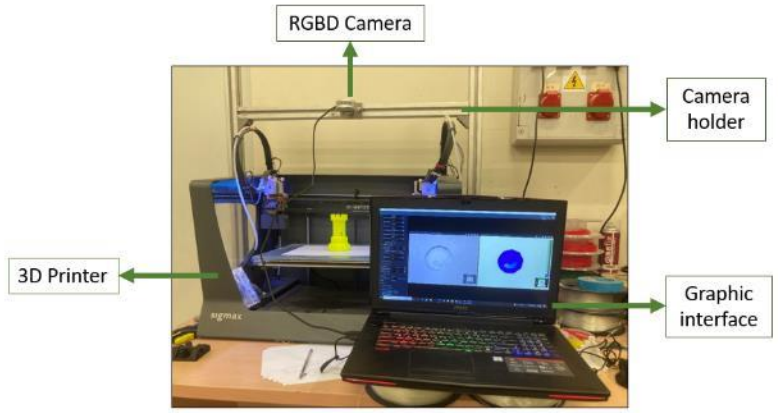
3DP PL (AIT)

Pilot Line Outcomes

- **Additive Manufacturing technologies** including fused filament fabrication and printing of large parts. **Thermoset printing of large components with bio-based resins.** Automated application of functional biocoatings over printed products

Pilot Line Upgrades

- To implement an artificial vision system integrated in a double head FFF to allow quality control of the used parts layer by layer.



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

Example Test cases – validation on going

A set of **9 test-cases** will be used to validate the improved materials' performances & functionalities of the solutions developed by INN-PRESSME at real scale testing, & demonstrate the expected impacts, mainly those related to circularity.

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

TC 2- Bio-based stand-up pouch (WALKI)

CONVERSION → FORMULATION → PROCESSING → END-USER

PL2-RISE-CNC
CNC nanofillers

PL7-VTT-PLAX
PLAX formulations

PL10-FISC-NP
PL14-VTT-SutCo
KCL
Lacquer production
PLA and lacquer coating
Recyclability assessment

WALKI: Demonstrator production & validation

Current production	Unwinding → Coating station 1 → Drying (Hot air) → Coating station 2 → Drying (Hot air) → Cooling → Rewinding	Coatings at RT
Current materials	Base paper, some with precoating layer. Sticky heat sealable coatings. No released chemicals.	
Current barriers	Not renewable raw materials. Current renewable coatings do not meet barrier requirements. **Target: biobased pouches to be recycled in Fibre-based packaging value chain.**	
Quality assurance	Coating viscosity with Brookfield rheometer; Barrier performance of coated paper: standard protocols (ASTM E96, ASTM D 3985). Slushing /Recyclability assessment.	
Safety consideration	Use of water-based lacquers for the coatings.	

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

TC 3- Bio-based reusable boxes (WSVK)

CONVERSION → **FORMUL & PROCESSING** → **TRANSFORMATION** → **END-USER**

PL1-VTT-CNF
PL3-POL-PHA
PL4-IWN-NF

Fillers (MFC, NF) & biopolymers (PHA, PLA)

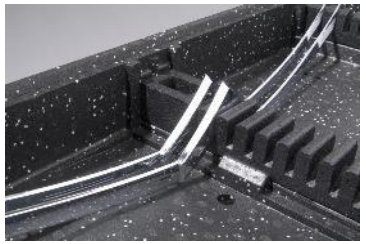
PL8-CEA-POUD
PL9-IPC-METEOR
PL11-FICT-FOAM

Compounding
Filament extrusion
Foam production & moulding to boxes

PL16-AIT-3DP

3DP introduction/ connection elements

WSVK: Demonstrator validation



Current production	Steam moulding (pre-treatment option), steam pressure adjustable, tempering range 30-120ºC for drying, mat volume: 0.1 to 12 m³/batch; post-processing options: milling, thermal cutting, bonding, mirror welding.
Current materials	Expanded polypropylene (EPP), polystyrene (EPS) and polyphenylene ether (E-PPE), Piocelan (hybrid of PS&PP)
Current barriers	Non-biodegradable materials. **Target: recyclable or biodegradable after use, end of life assessments needed.**
Quality assurance	Safe for food & skin contact, chemical, heat & fire resistance, insulating, high strength with low density. Recyclability assessment in Plastic value chain and Biodegradability assessment.
Safety consideration	No air contamination, no residues in water cycle & wastewater, product well tolerated by skin

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

TC 5- 3DP Automotive components (CRF)

CONVERSION → FORMUL & PROCESSING → TRANSFORMATION → END-USER

PL4-IWN-NF
Natural microfibre additives

Commercial bioplastics

PL8-CEA-POUD
PL9-IPC-METEOR
PL10-FISC-NP
Biopolymer compounding
Filament extrusion
Functional coatings

PL16-AIT-3DP
3DP automotive components

CRF: Demonstrator validation

Current production	Injection moulding, thermoforming and foaming are main technologies for automotive plastic parts production. Additive manufacturing such as FFF and MJF for manufacturing prototype parts/low volume series production
Current materials	For AM: polyamides (PA12, PA12 GB), acrylonitrile butadiene styrene (ABS), propylene carbonate (PC)+ABS, acrylonitrile styrene acrylate (ASA) and ULTEM™ polyetherimide (PEI).
Current barriers	Non-biobased; with bio-based materials: higher cost and poor mechanical properties for operating temp above RT. **Target: mechanically recyclable plastic parts.**
Quality assurance	Raw material: mechanical properties; moulded component: density, melt flow index and filler content. Recyclability studies, mechanical recycling.
Safety consideration	Evaluate VOC emissions according to VDA 277 or 278 standard testing methods.

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

TC 7- Ultracapacitors (SKELETON)

CONVERSION → FORMULATION → PROCESSING → END-USER

PL1-VTT-CNF
PL2-RISE-CNC
Nanoadditives for electrode slurries

PL5-CID-INK
PL6-GNA-CNM
Electrode slurries

PL12-CID-COAT
Electrode coating

SKELETON: Demonstrator production & validation

Current production	1) Slurry mixing, 2) R2R coating & electrode calendering; 3) Electrode slitting & jelly roll winding; 4) Cell assembly; 5) Cell drying & electrolyte filling; 6) Pin welding & soaking
Current materials	Activated carbon & binders; organic salt electrolyte; Al foil current collector; cellulose membrane
Current barriers	Non-biobased electrode materials. **Target: use safe and more sustainable biobased materials**.
Quality assurance	Materials: Low contamination (organic functional groups, metal and halogen ions), temperature, electrical & chemical stability; Electrode: capacitance, ESR; Supercap: SKE's internal procedure (ISO 16750-3, RoHS, UL 810A)
Safety consideration	Toxicity and flammability of organic electrolyte.

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

Thank you!

Contact
Ulla Forsström
VTT
Ulla.Forsstrom@vtt.fi
+358 40 8202191

www.inn-pressme.eu

linkedIn.com/company/inn-pressme

twitter.com/inn-pressme