INN PRESSME

Open Innovation Test Bed

WP4: TC3 Bio-based boxes

Policy and dissemination event

26/01/2024 – Brussels, Belgium

Christoph Mack – Fraunhofer ICT

Motivation

- Climate change as global challenge
- Oil often sourced from non-reliable countries – corruption, human rights, military conflicts,…
- Recycling rate still too low for many products made from polymers

(Collage: The Guardian)

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

Aim

Socio-economical and ecological aim

- Reduction of CO2 footprint of used materials
- Increase use of renewable resources
- Avoidance of petro-based materials
- Increase recycling rate of bio-polymers

Technical aim of test case

Finding a bio-based substitute for expandable polystyrene (EPS) bead foam which has similar properties and can be used in packaging applications

→ Improvement of temperature stability, mechanical properties / fusion of beads

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Approach

- Polylactid Acid (PLA) as bio-based matrix material
  - recyclable
  - low price
  - high availability
  - high stiffness
- Lightweight EPLA (expandable PLA) foams
- Testing of various fibres for reinforcement of components
  - Cellulose nanofibrils (CNF)
  - Hemp
  - Flax
- 3D printing for individualized packaging solutions
- Process development for insitu combination of foam with 3D printed parts

(TOTAL Corbion Energies)

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Partner structure

FIBRES

VTT

INSTITUTE OF NATURAL FIBRES & MEDICINAL PLANTS
NATIONAL RESEARCH INSTITUTE

RECIPE

cea

BEAD FOAM

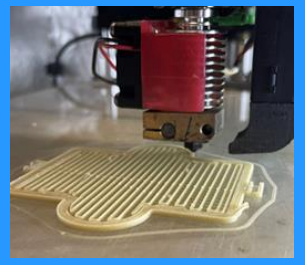
Fraunhofer ICT

FILAMENT

I P C

3D PRINTING

aitiip centro tecnológico



DEMONSTRATOR

WSVK ®

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CNF fibre provision - VTT

- Development of several batches of unmodified and modified (coupling agents, epoxidized linseed oil (ELO)) cellulose nanofibrils (CNF) powders from bleached kraft pulp

Mixing of oil with CNF powder in z-blade mixer

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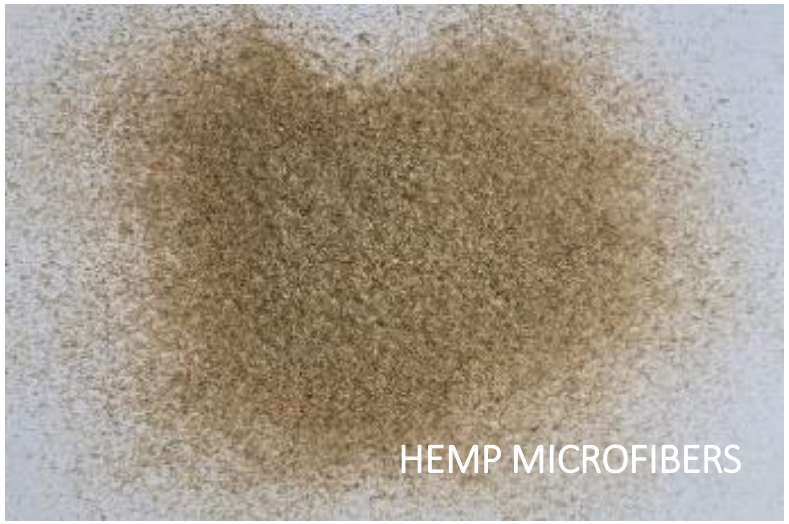
Flax and hemp fibre provision - IWNiRZ

- Development and production of different unmodified and modified hemp and flax microfibers for incorporation into PLA



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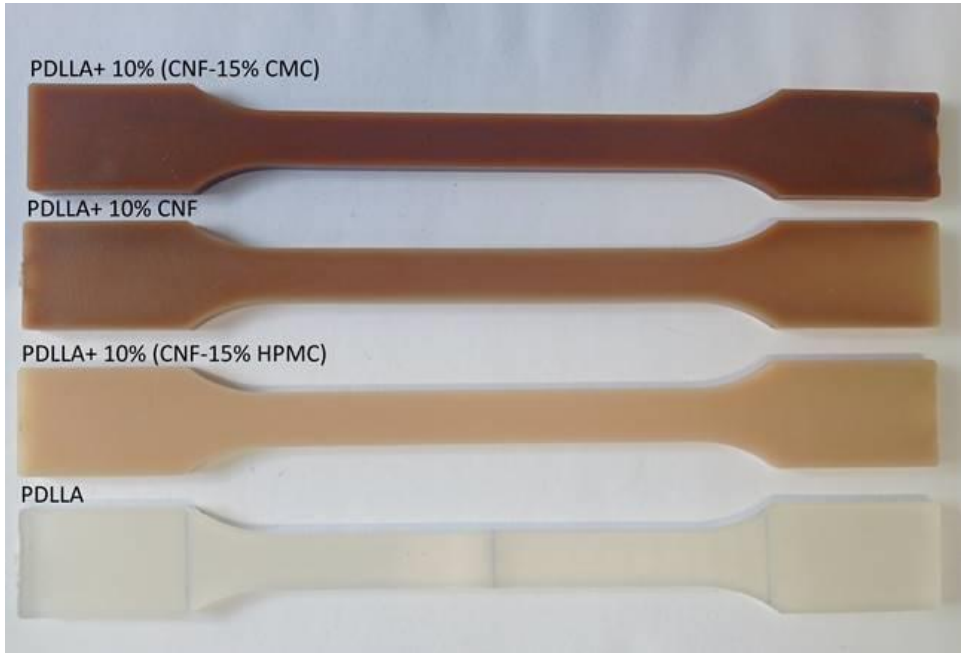
Material development - CEA

- Compounding of different PLA grades with micro- (flax, hemp) and nano-fibrils (CNF)
- Characterization of the compounds (mechanical and thermal properties)
  - Influence of the fiber nature
  - Influence of the fiber treatment
  - Influence of the fiber concentration

All the tested fibers act as reinforcing agent (increasing of the material rigidity).

PLLA+ 10 wt% of CNF was chosen for the 3D printing part of the test case



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Filament production - IPC

- Filament development for 3D printing made from compounds developed by CEA
- Tensile modulus was improved with addition of CNF
- Filament for demonstrator printing trials at AITIIP was produced

- Without METEOR

Screw speed

6 rpm 12 rpm 20 rpm

- With METEOR

Browning of the filaments after processing probably linked to the **residence time.**

Screw speed 15 rpm
*METEOR speed **5 rpm***

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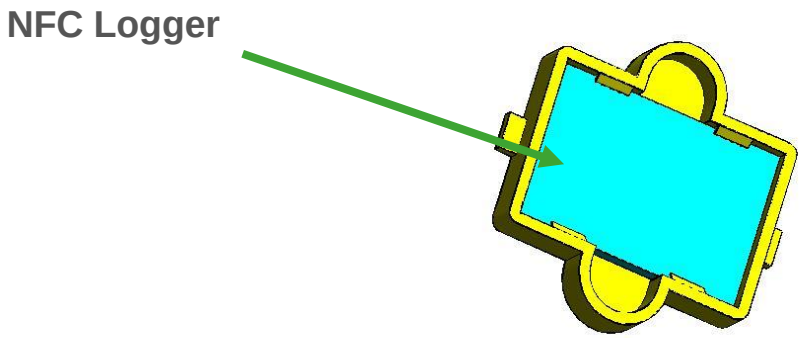
3D printing - AITIIP

- Printing of test samples to evaluate properties of filaments
  - Fibre reinforced PLA is easy to handle and print
- Printing of NFC temperature sensor holder with CNF fibre reinforced materials



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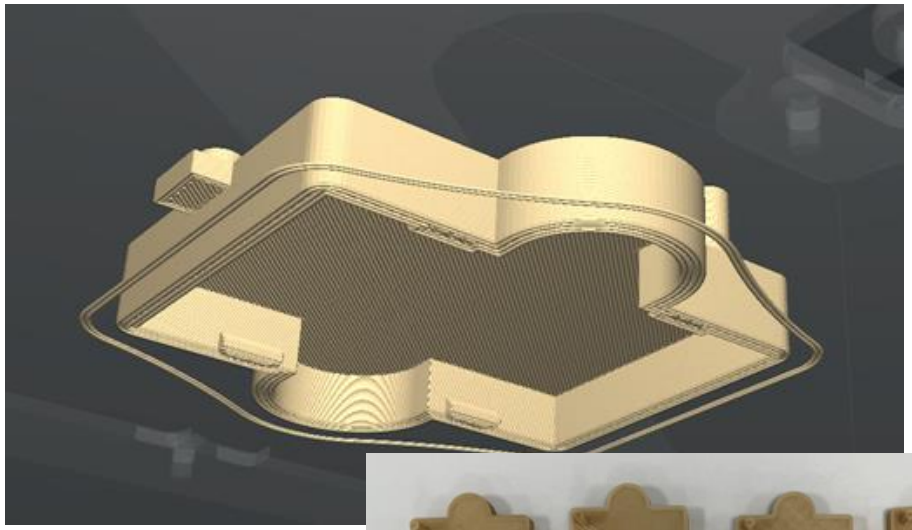
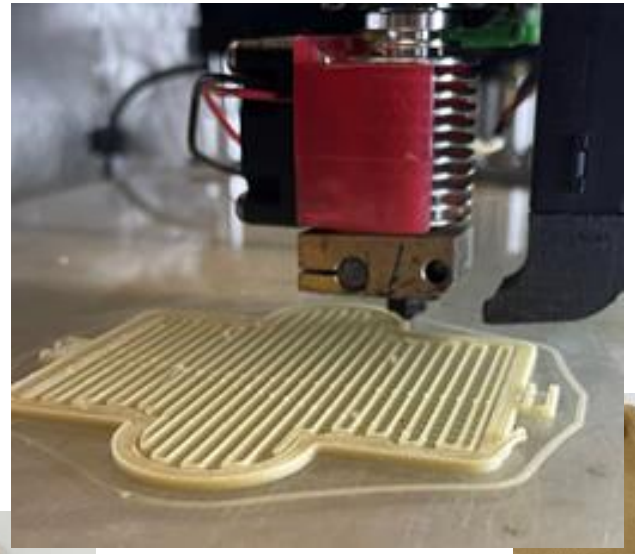
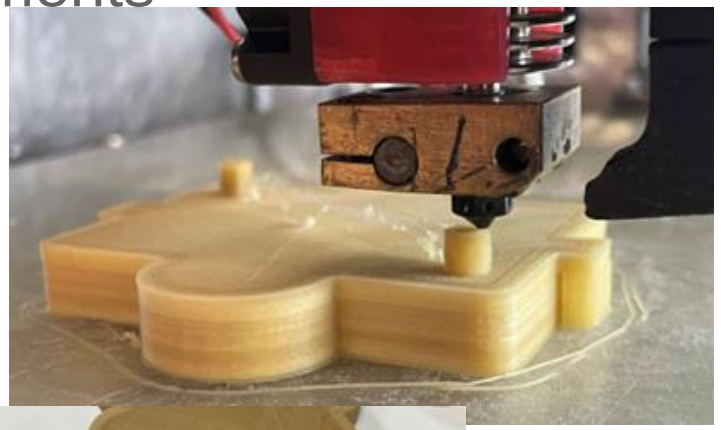
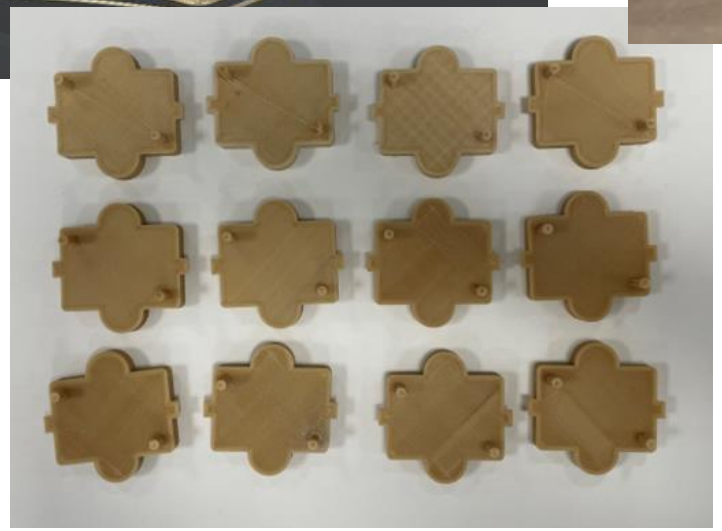
3D printing - AITIIP

3D printing of new design with CNF fibre reinforced filaments









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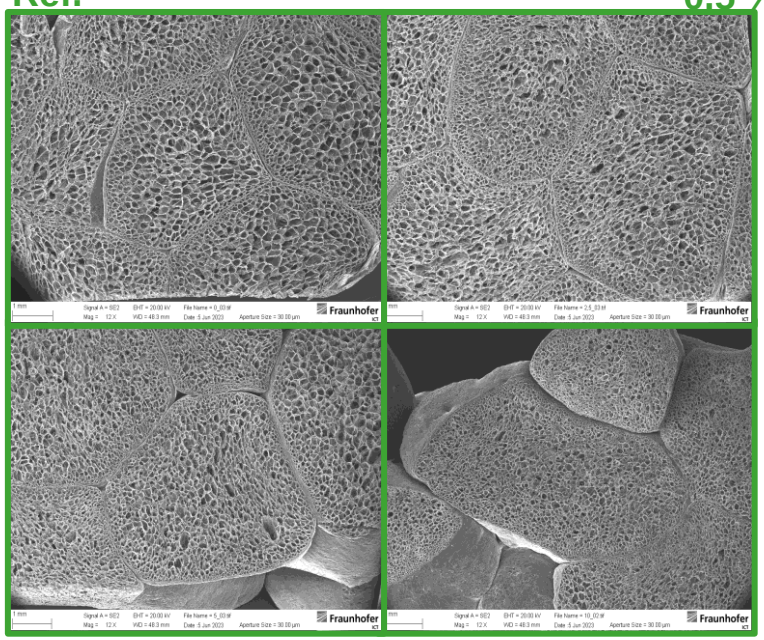
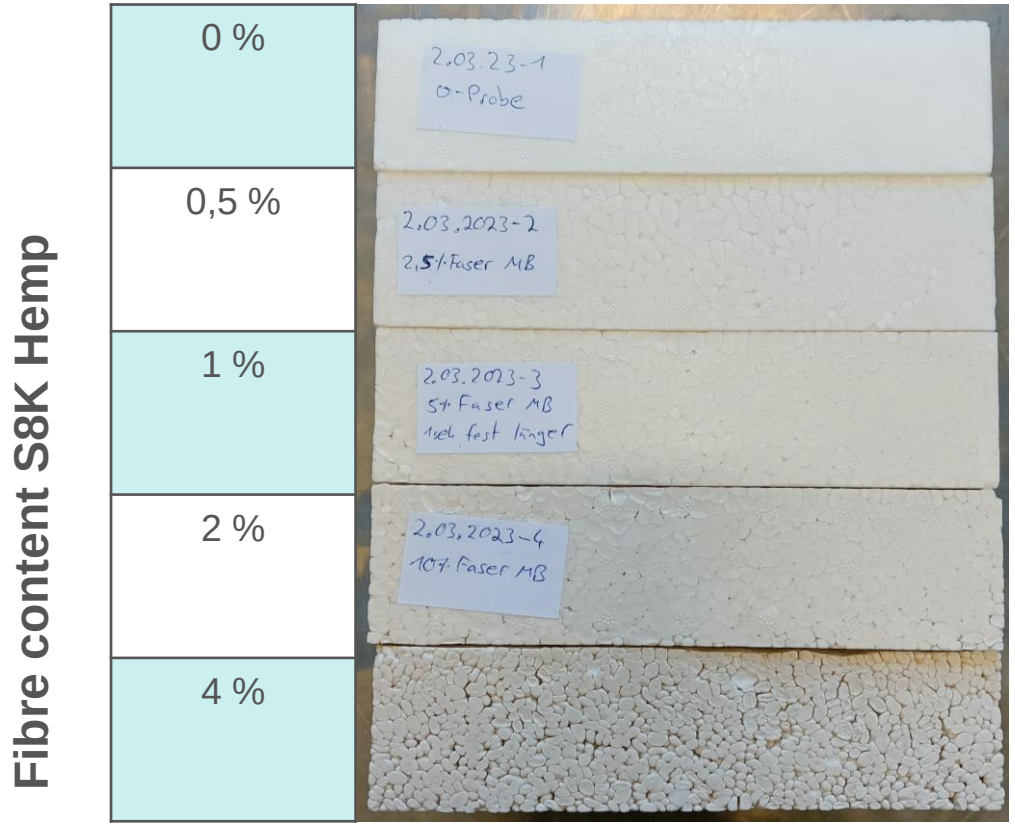
Bead foam – Fraunhofer ICT

Foaming of fibre reinforced masterbatches from CEA

- PLA compounds including fibres did result in decreased foam properties and foamability independent from fibre type (CNF and hemp)





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Bead foam – Fraunhofer ICT

Alternative approach: Modification of PLA recipe to evaluate crystallization behavior to improve temperature stability and mechanical properties

- 55 samples incl. 5 recipes have been produced with demonstrator tool
- Characterization has taken place at ICT
  - Density
  - Compression and tensile strength
  - Crystallization grade

→ leading to improved temperature stability and mechanical properties

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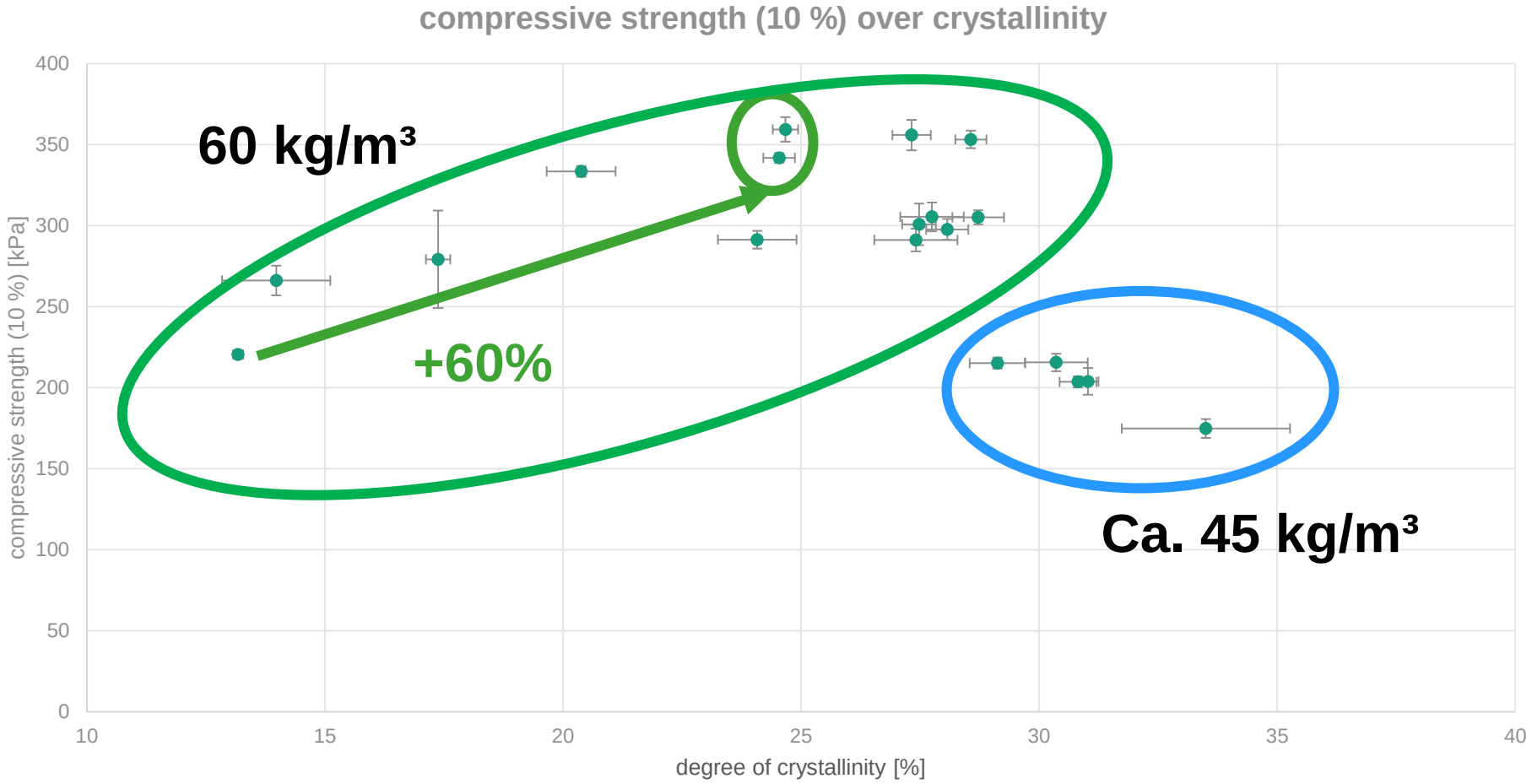
Bead foam - Fraunhofer ICT



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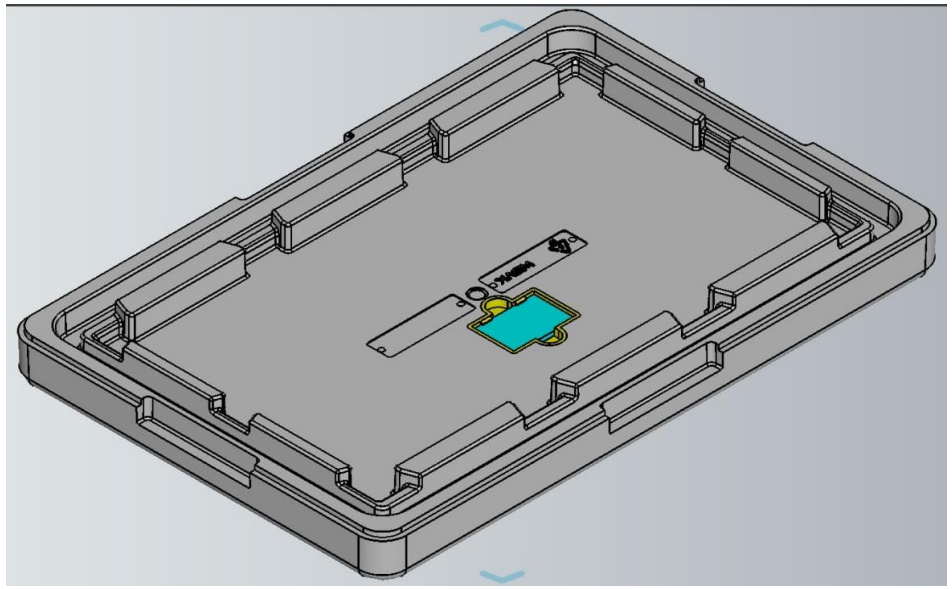
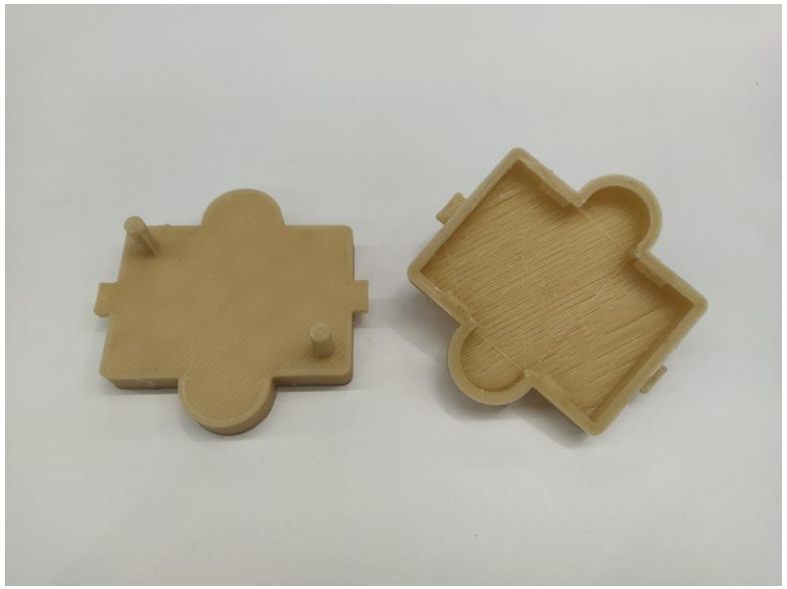
Demonstrator - WSVK

- After first EPLA foaming tests a lid of a thermobox was chosen as demonstrator part
- Design for 3D-printed element was made and sent to AITIIP for verification and test printing
  - Holder of NFC-logger which is difficult to produce with injection moulding





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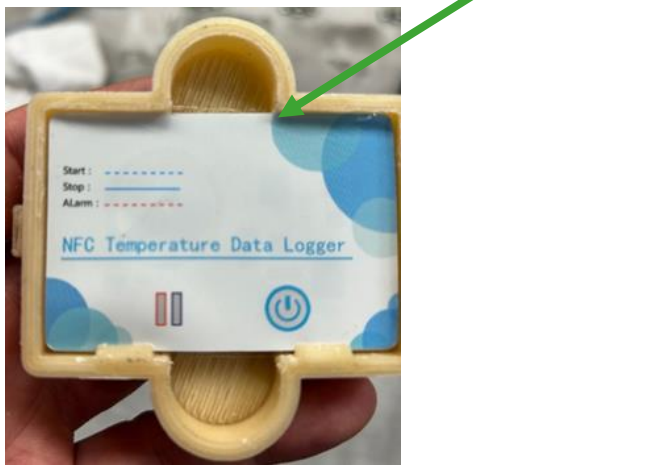
Demonstrator - WSVK

- WSVK received from AITIIP the printed inserts from PLA filament modified with 10% CNF fibers
- WSVK received EPLA from Fraunhofer ICT for testing and demonstrator production



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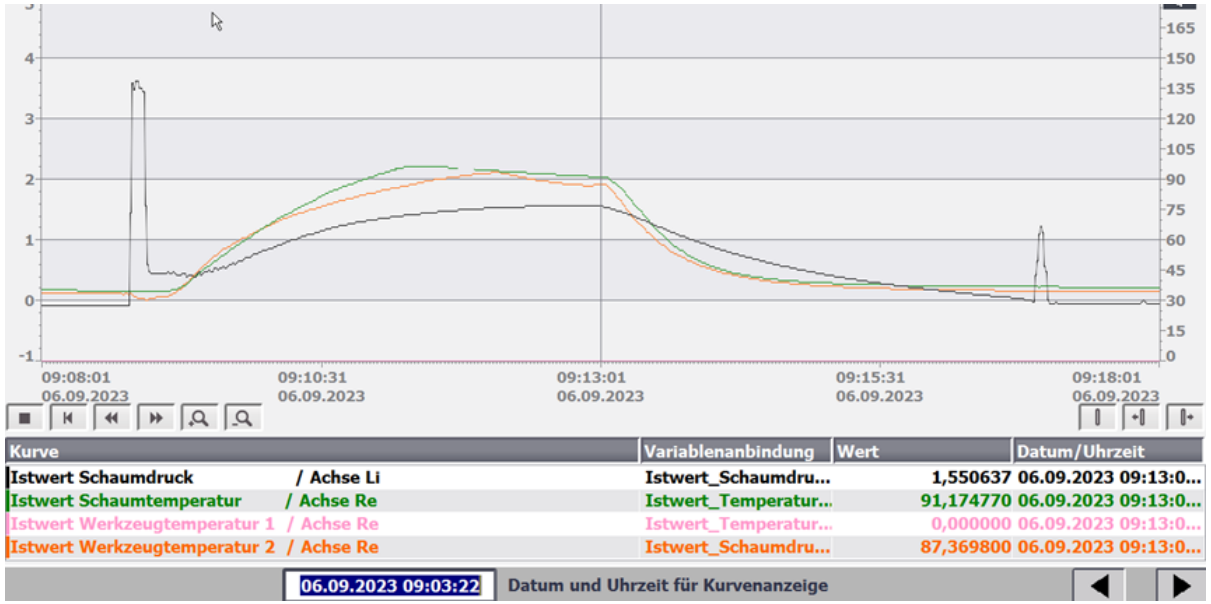
Demonstrator - WSVK

- After modification of the existing foaming tool WSVK could carry out industrial scale demonstrator production including the 3D printed insert
- New sensors in tool enabled the exact control of temperature sensitive EPLA to avoid shrinkage or post process expansion of the material



Sensor graph

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Conclusions

- Successful optimization of material via recipe and process modification for implementing of bio-materials in demanding products
  → Improved material properties are shown

- Incorporation of 3D-printed elements in foam moulding process proven

- Demonstrator designed and produced

- Potentially recyclable – needs to proven

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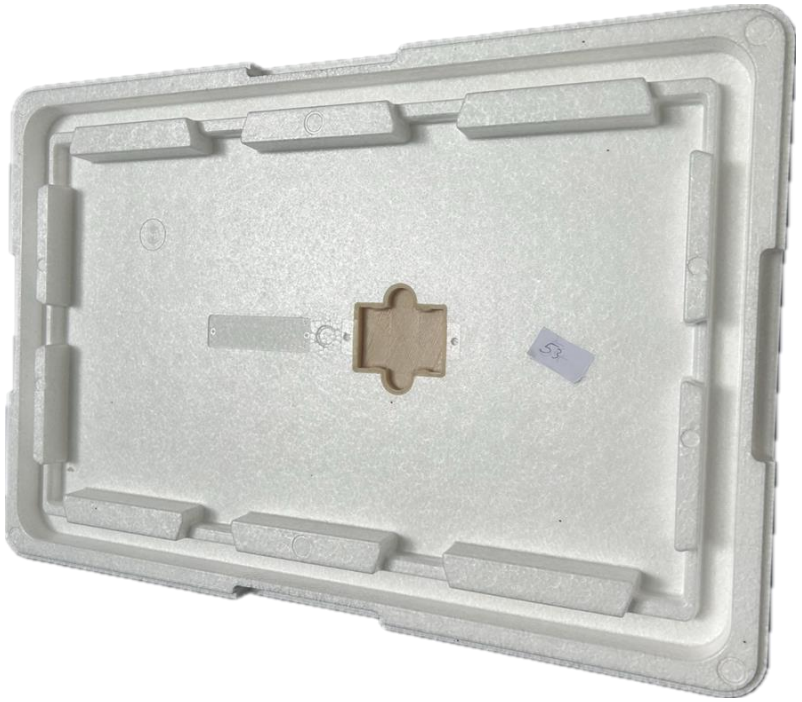
Conclusions

Non-petro based packaging demonstrator made from close to 100% renewable ressources



EPLA Demonstrator part

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Thank you!

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