BARBARA PROJECT

FROM AGRO WASTE TO 3D PRINTING

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29TH March 2021

AFTERLIFE

BBI WORKSHOP ON BIO-BASED POLYMERS

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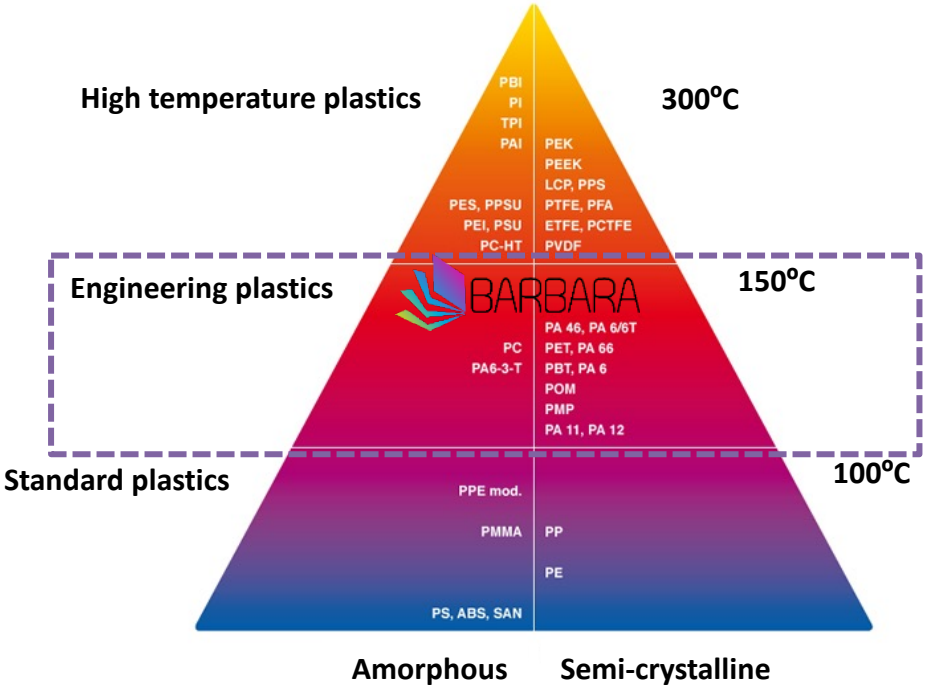
Problem to overcome

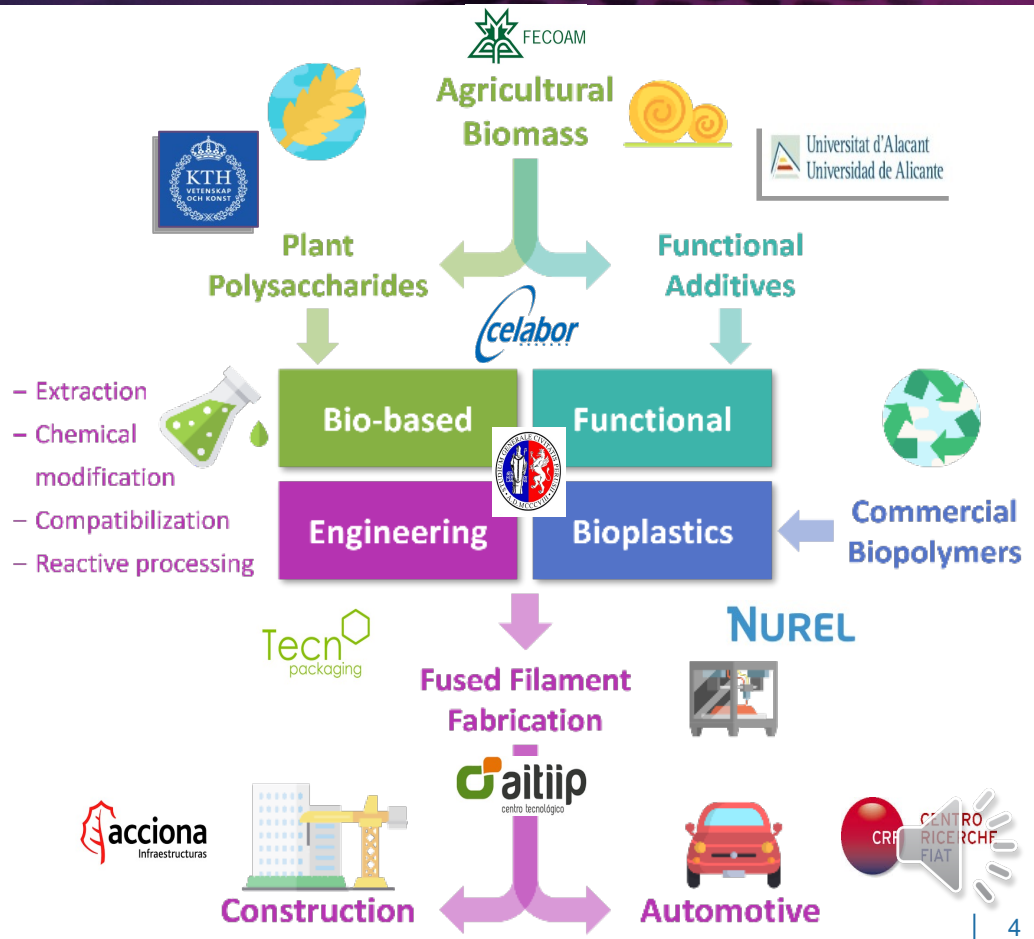
PROBLEMS TO OVERCOME

1. **Technical barrier:** There is a lack of bio-based and biodegradable **engineering materials**
2. **Processes** are not adapted yet (in particular, additive manufacturing technologies → **FFF**
3. Lack of quality generates a **poor perception**
4. There is **no value chain established** (specially for final parts and moulds and tools for hybrid manufacturing)



OBJECTIVES

- Development of **4 new BARBARA materials**: Engineering functionalized biopolymers reinforced with bio additives to achieve customised physical-chemical properties
- **Validating** BARBARA materials **through additive manufacturing FFF (Fused Filament Fabrication)** in 2 key European sectors (**automotive, building**)



EXPECTED PROPERTIES

MECHANICAL

- **Increase the bending, tensile strength, fatigue resistance (in a 40%)**
- **Enhancement of scratch resistance behaviour**
- Change and control in the rheological properties

THERMAL

- Improvement of **thermal and structural degradation at high temperatures**
- **Target: 140ºC**

AESTHETICAL/WELL BEING

- **Colour gamut** and **effects**
- Transparence **high performance colours**
- Improvement of the wet **rubbing fastness** avoiding dye migration phenomena
- Improvement of the radiation exposures **colour fastness from UV-Vis-NIR**
- **Controlled fragrance release**
- **Texturizing: cool touch and soft touch effects**

Extraction and purification of bio additives from fruit/vegetable wastes

- **Lemon peel and broccoli**

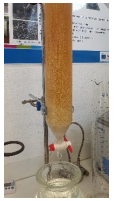
Microwave assisted hydrodistillation

Essential Oil (Antioxidant)

Microwave assisted extraction

Pigment extract

Conc. pigment extract



Amberlite XAD-16N

Pigment powder (14,75% flavonoids - Antioxidants)

Microwave assisted extraction by acetone/ 5% aq. Na_2CO_3 (9/1)

Acetone evaporation

Centrifugal partition chromatography

Pigment powder (2% chlorophyll – health benefits)

- **Discarded pomegranates and almond shells**

Pressing of the discarded fruits

Juice filtering

Amberlite XAD-7HP

Pigment powder (27,7% anthocyanins – antioxidant & antibacterial)

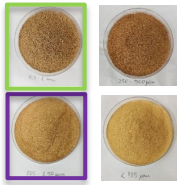
Peels drying

Microwave assisted extraction

Amberlite XAD-16N

Biomordant powder (37,8% punicalagins – natural dye and antioxidant)

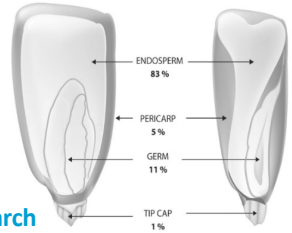
Shell milling



Dried and ground almond shell waste
0.5-1 mm, 250-500 µm, 125-250 µm and <125 µm.

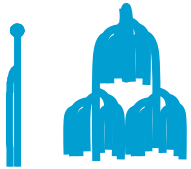
Extraction of starch and arabinoxylans from corn residues

Corn kernel

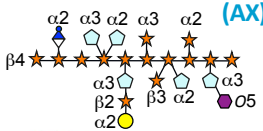


Starch

Target polysaccharides



Corn Arabinoxylan (AX)



Corn Fiber (CF)

↓

Aqueous steeping — Water, 4 h, 80 °C, Bath ratio 1:5 → **Starch (+/- 20% DW)**

↓

Subcritical Water Extraction (SWE) — Water (pH 4, 7, 9), 140 – 160 °C, 5 – 60 min

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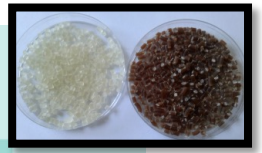
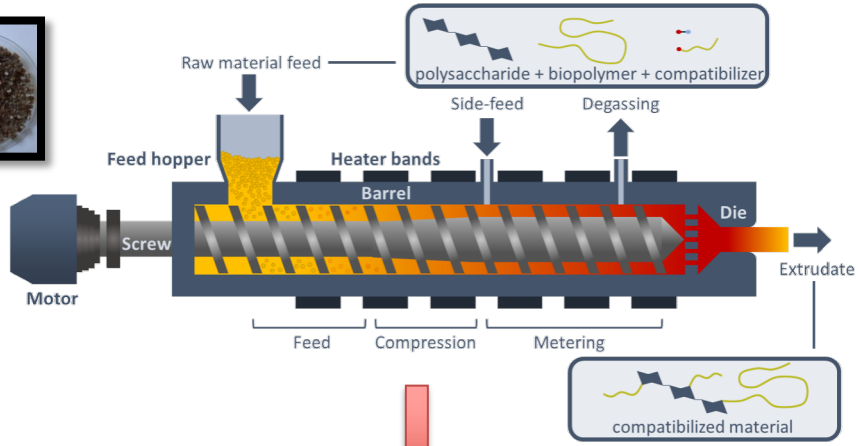
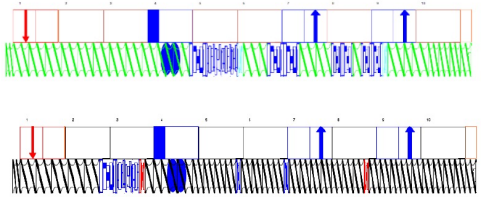
Arabinoxylan (AX)
(Antioxidant & against fungus)

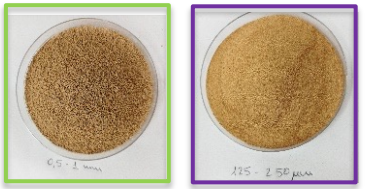
Development of bioplastic matrices







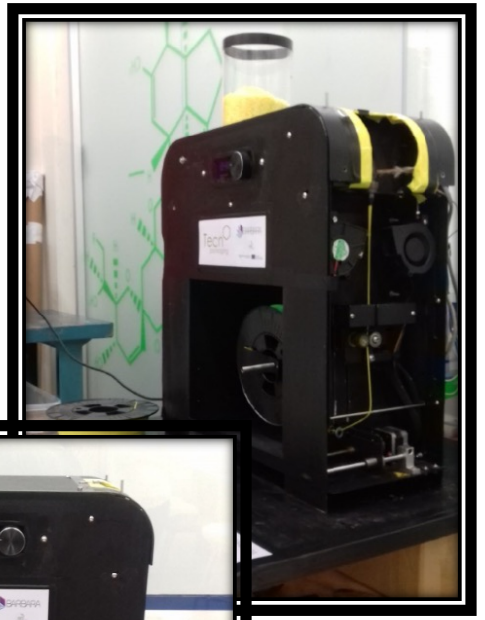
Lemon, Pomegranate & Almond compounds

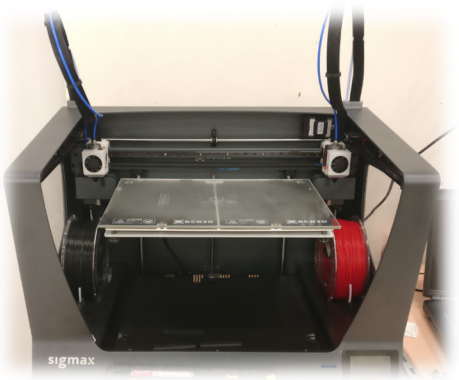


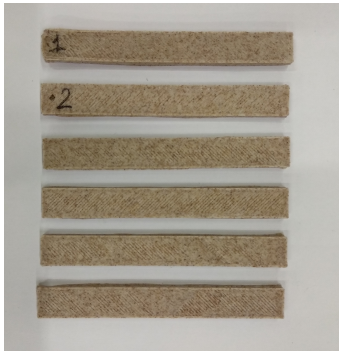
UPSCALING BEST BARBARA CANDIDATES FOR 3D PRINTING

- **Materials for construction moulds & for automotive applications**

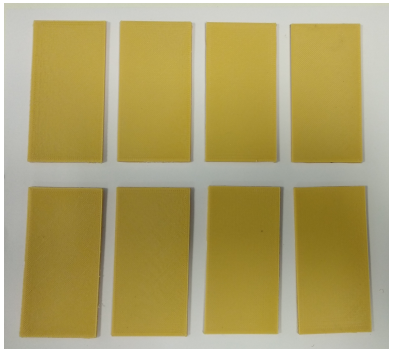
Material
TPS / PA2-IA / PA1
TPS / PA2-IA/ PA1/ Nanoclay
INZEA + LEMON PIGMENT
INZEA + LEMON FRAGRANCE PIGMENT
INZEA + PINK PIGMENT
PA2 + PINK PIGMENT
INZEA + GREY-GOLD PIGMENT (CONTAINING EXTRACTED BIOMORDANT)
PA1 + GREY-GOLD PIGMENT (CONTAINING EXTRACTED BIOMORDANT)
INZEA + ALMOND SHELL FIBER (FINE POWDER)
INZEA + ALMOND SHELL FIBER (GROSS POWDER)



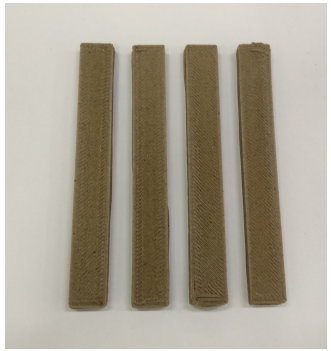




INZEAF2 + ALMOND SHELL FIBER

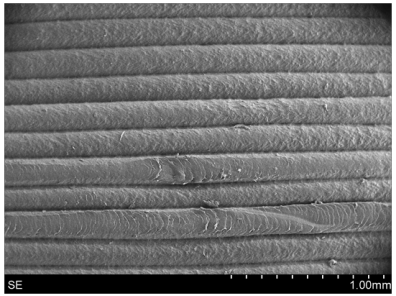


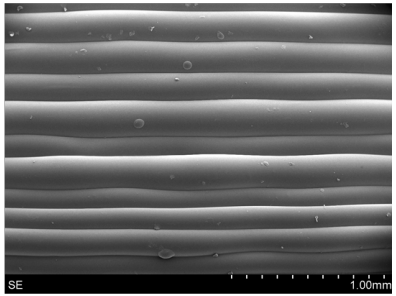
INZEAF2 + LEMON PIGMENT

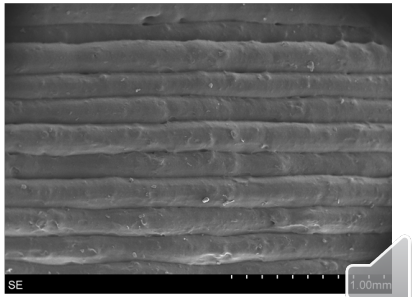


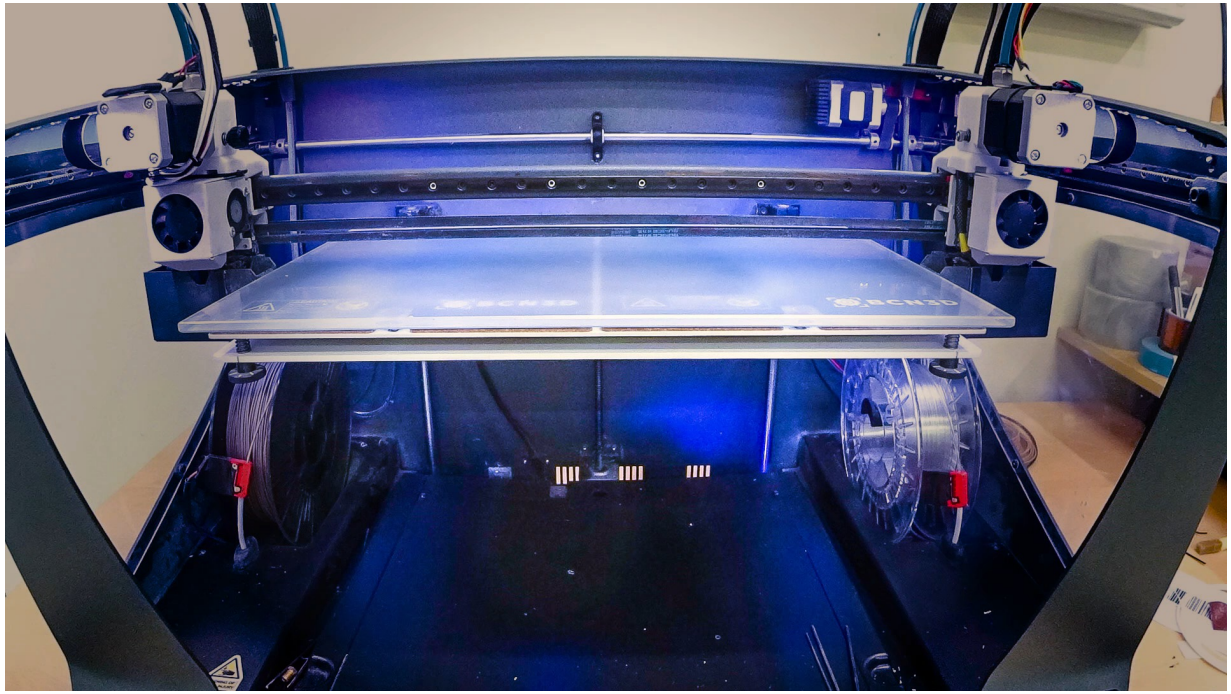
INZEAF2 + GREY-GOLD PIGMENT
(WITH EXTRACTED BIOMORDANT)

50x



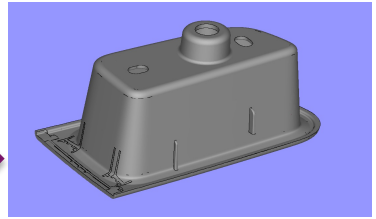


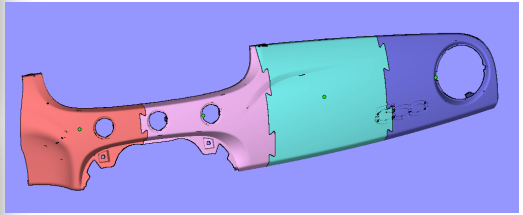




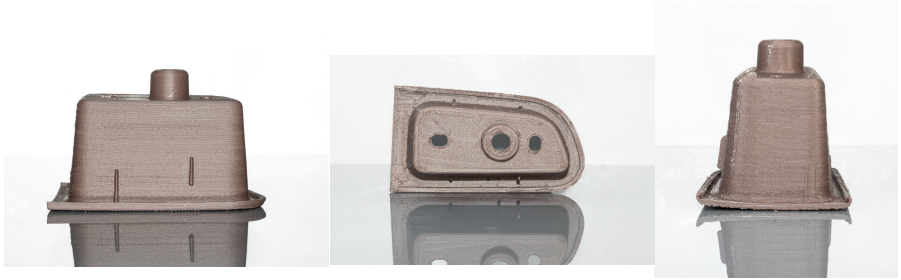
Automotive prototype

From concept

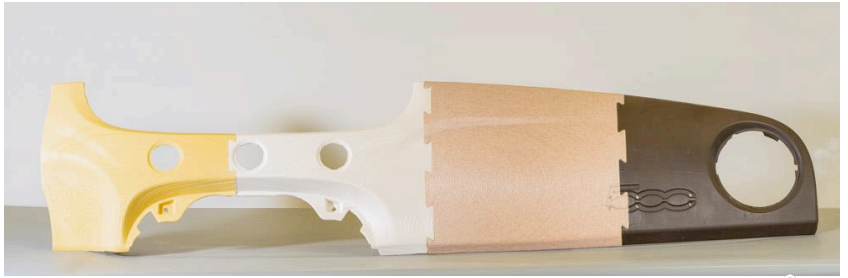




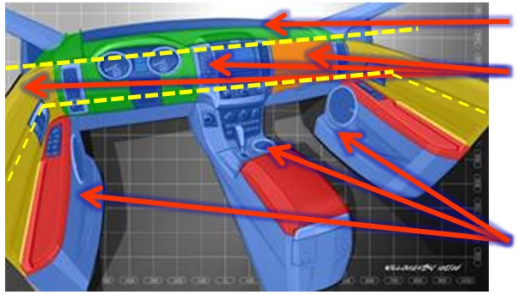
To reality



TRIM PART OF DOOR HANDLE



DASHBOARD FASCIA OF FIAT 500 MODEL



1240 kJ/m²
Instrument Panel Horizontal Surfaces

601 kJ/m²
Upper Pillar trim, Instrument Panel vertical surfaces, Package Tray & Door Roll-over trim materials

225 kJ/m²
Seating trim, Door Trim, Floor Console, Lower Pillar / Cowl trim, Overhead Console / Trim materials

3 Climatic tests: Thermal cycles -40°C/+80°C , Heat aging 90°C, Humidity Aging 40°C / 95% RH

Flammability test (Slow rate combustión & even self extinguish)

Fluid resistance (All OK)

Light Aging (Partially OK, still some room for improvement)

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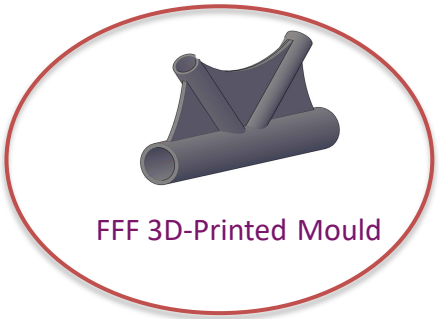
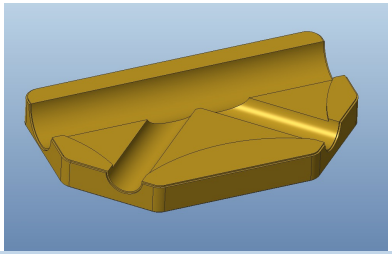
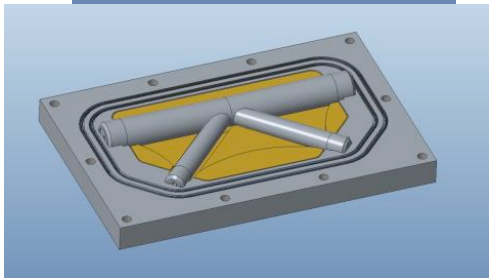
Building prototype

3D-RTM mould and its specific mandrel for the complex joint shape will be developed by FFF additive. It will allow to fabricate (40 units per mould) one **single joint piece for civil engineering with a continuous reinforced material**

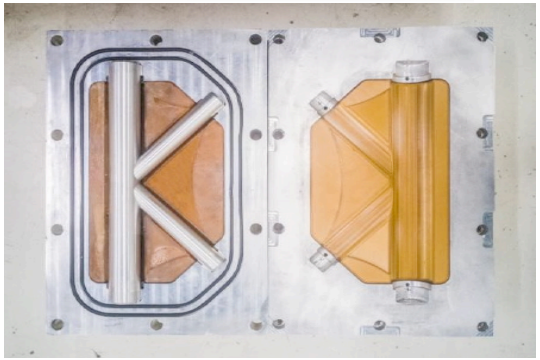


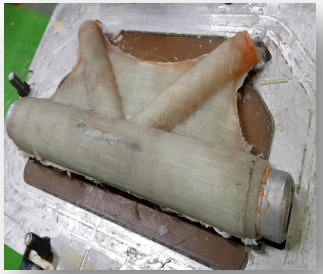
From concept

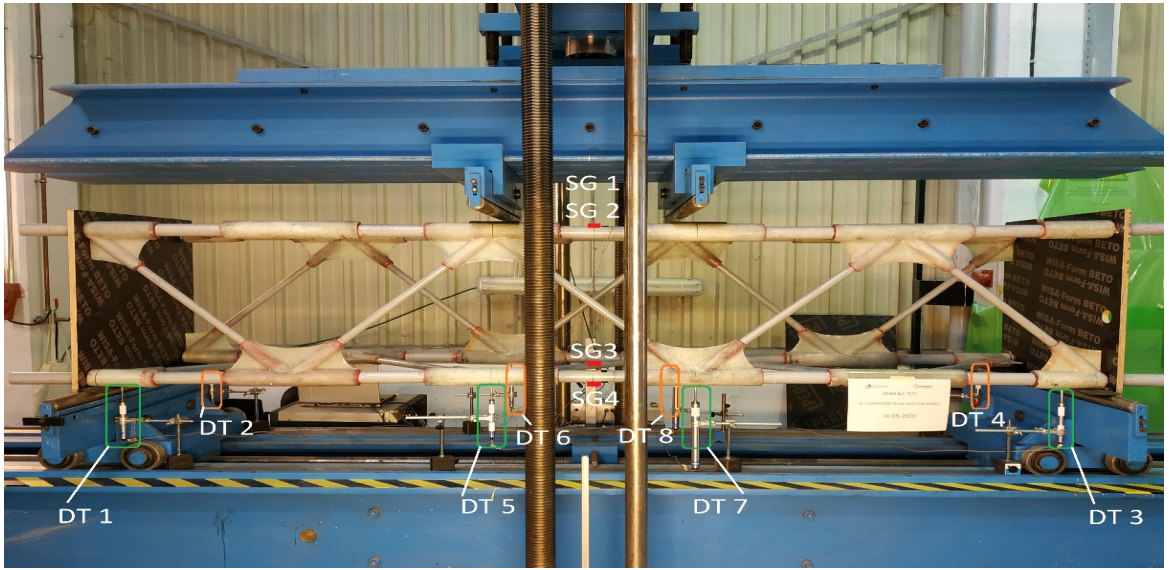




To reality






SG 1
SG 2
SG3
SG4
DT 1
DT 2
DT 3
DT 4
DT 5
DT 6
DT 7
DT 8

Scientific Publications

Extraction of biobased molecules

Optimisation of Sequential Microwave-Assisted Extraction of Essential Oil and Pigment from Lemon Peels Waste.
A. Martínez-Abad, M. Ramos, M. Hamzaoui, S. Kohnen, Al. Jiménez, M.C Garrigós. Foods (2020), 9(10), 1493

Functionalisation of biobased molecules

Tuning the molar mass and substitution pattern of complex xylans from corn fibre using subcritical water extraction.
R.C. Rudjito, A. Jiménez-Quero, M. Hamzaoui, S. Kohnen, F. Vilaplana. Green Chemistry (2020),22, 8337-8352;

Organocatalytic esterification of corn starches towards enhanced thermal stability and moisture resistance.
B. Imre, F. Vilaplana. Green Chemistry (2020), 22, 5017-5031;

Scientific Publications

Designing biobased materials

Reactive Compatibilization of Plant Polysaccharides and Biobased Polymers: Review on Current Strategies, Expectations and Reality.

B. Imre, L. García, D. Puglia, F. Vilaplana. Carbohydrate Polymers (2018), ISSN 0144-8617, E-ISSN 1879-1344;

Effect of Almond Shell Waste on Physicochemical Properties of Polyester-Based Biocomposites.

M. Ramos, F. Dominici, F. Luzi 2, A. Jiménez, M.C. Garrigós, L. Torre, D. Puglia. Polymers 2020, 12(4), 835;

Effect of Lemon Waste Natural Dye and Essential Oil Loaded into Laminar Nanoclays on Thermomechanical and Color Properties of Polyester Based Bionanocomposites.

B. Micó-Vicent, V. Viqueira, M. Ramos, F. Luzi, F. Dominici, L. Torre, A. Jiménez, D. Puglia, M.C. Garrigós. Polymers 2020, 12(7), 1451;

Effect of Chlorophyll Hybrid Nanopigments from Broccoli Waste on Thermomechanical and Colour Behaviour of Polyester-Based Bionanocomposites.

B. Micó-Vicent, M. Ramos, F. Luzi, F. Dominici, V. Viqueira, L. Torre, A. Jiménez, D. Puglia, M.C. Garrigós. Polymers 2020, 12(11), 2508;

Thank you!

AFTERLIFE

BBI WORKSHOP ON BIO-BASED POLYMERS

29th March 2021 – 13:00 CET – online – free registration

www.afterlife-project.eu/bbi-workshop-2021

BARBARA · Bio Barr · BioMotive · BIOSMART · PEFerence · POLYBIOSKIN · nova Institute

Questions time!