DEVELOPING ADVANCED BIO-BASED COMPOSITES

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BIOBASED COMPOSITES USED AND DEVELOPED WITHIN THE SSUCHY PROJECT, AN OVERVIEW

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KU LEUVEN

npsp our strength is composites

University of BRISTOL

UNIVERSITÉ DE FRANCHE-COMTÉ

BBI JU

Bio-based Industries Consortium

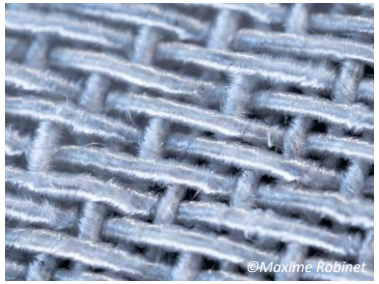
Horizon 2020 European Union Funding for Research & Innovation

3 CATEGORIES OF COMPOSITE CONSTITUENTS

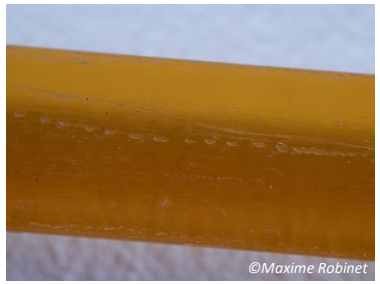
1. FULLY BIO-BASED REINFORCEMENTS & POLYMERS DEVELOPED WITHIN SSUCHY

Hemp woven fabrics balanced & unbalanced (QUD)

Hemp braids



Hemp commingled fabrics



Bio-based polymers (epoxy: BioIgenox, bisguaiacol, aliphatic polyesters)

2. MARKETED BIOBASED POLYMERS (BIO-BASED EPOXY, PFA, PA11)

GreenPoxy®

Epoxy, Sicomin

FUROLITE

Furan (PFA), TFC

RILSAN BY ARKEMA

PA11

3. MARKETED FLAX-BASED REINFORCEMENTS FOR BENCHMARK PURPOSES, PROOF OF CONCEPT, DEMONSTRATION

EcoTechnilin

Flaxtape, Flaxpreg T-UD FR

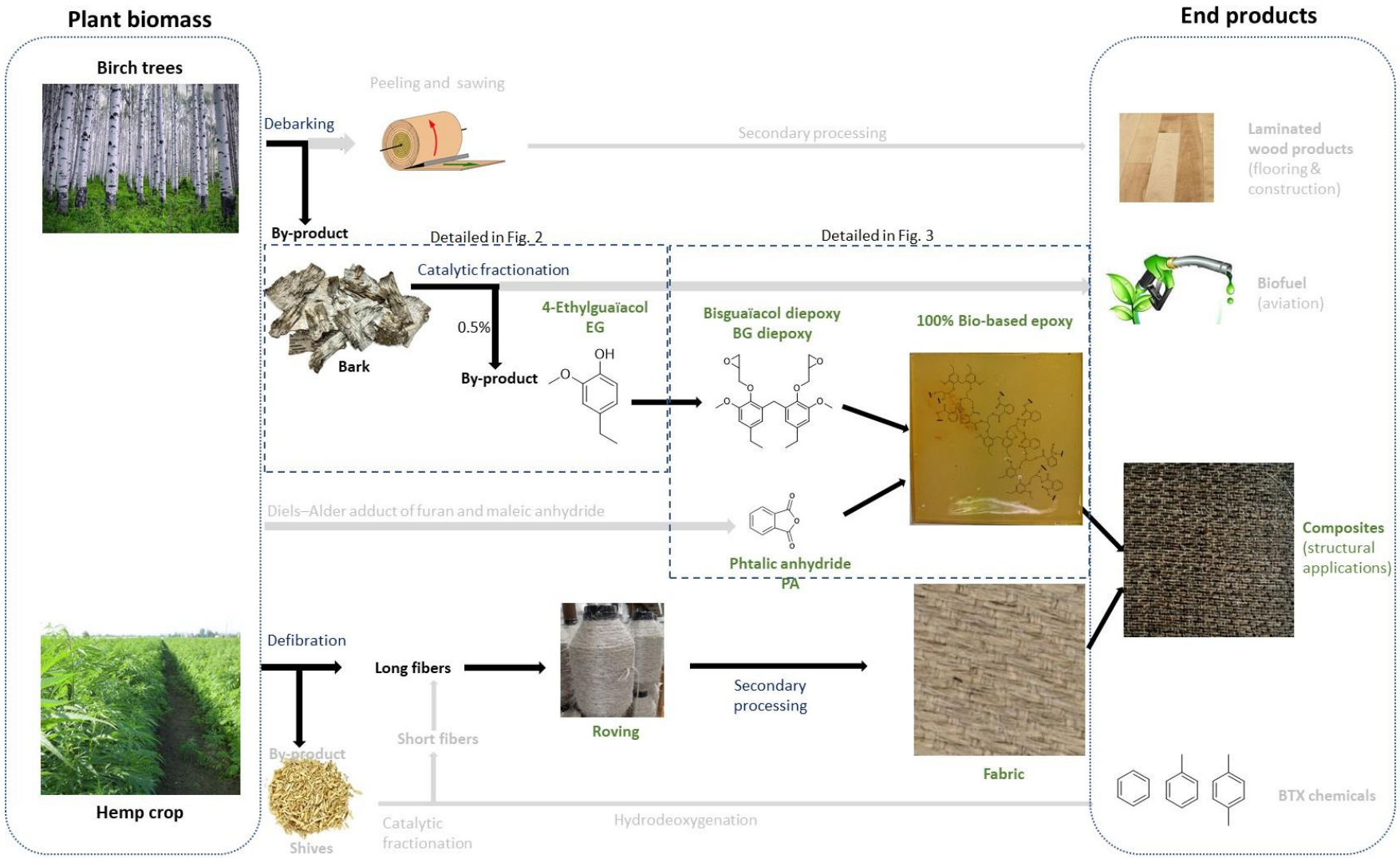
FULLY BIO-BASED MATERIALS DEVELOPED FROM SSUCHY CONSTITUENTS

HEMP/EPOXY

- European hemp processed using the flax machinery

- Woven hemp fabrics made from low-twisted rovings (balanced fabrics and quasi-UD)

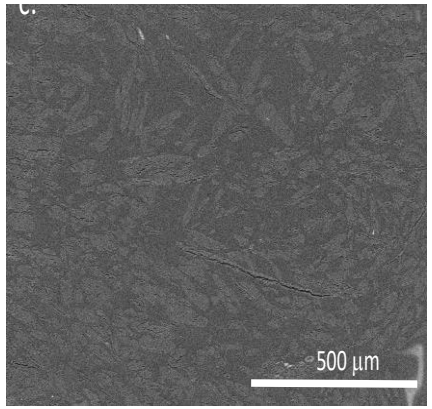
- Bio-based epoxy system elaborated from lignin-derived building blocks and bio-based hardeners

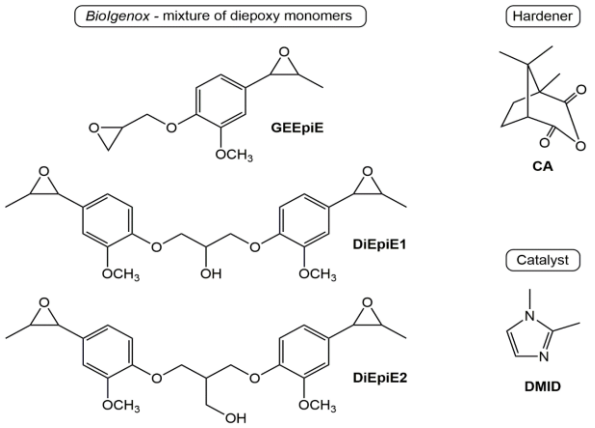


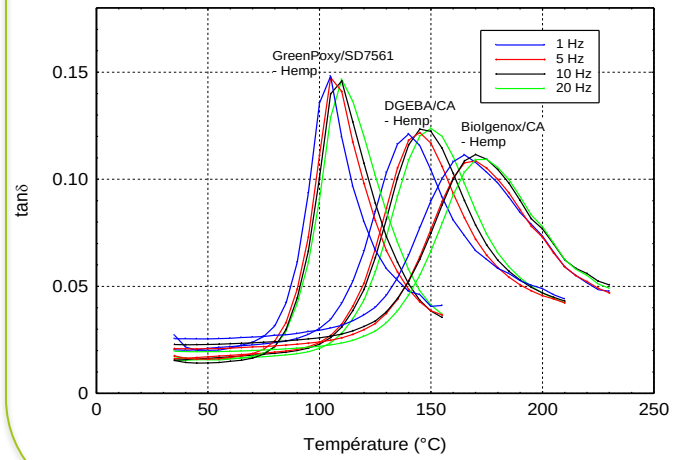
FULLY BIO-BASED MATERIALS DEVELOPED FROM SSUCHY CONSTITUENTS

HEMP/EPOXY

HEMP/BioIgenox based epoxy



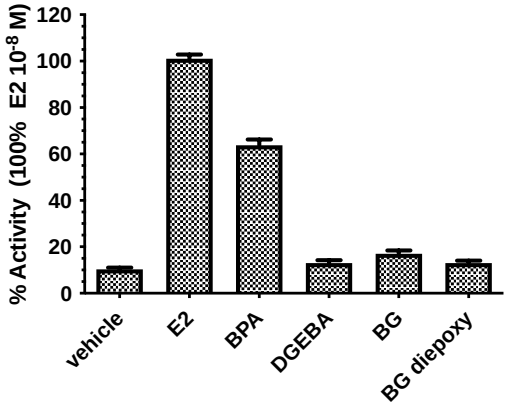


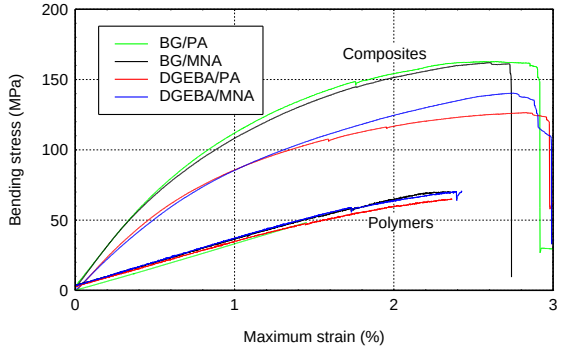


- ❑ **Fully bio-based**
- ❑ **Tg > 150°C**
- ❑ **Mechanical properties similar to DGEBA-based epoxy composites**
- ❑ **Low ecotoxicity**
- ❑ **Scale up** of polymer production remains an **issue**

HEMP/Bisguaïacol-based epoxy

ERα agonistic activity of chemicals

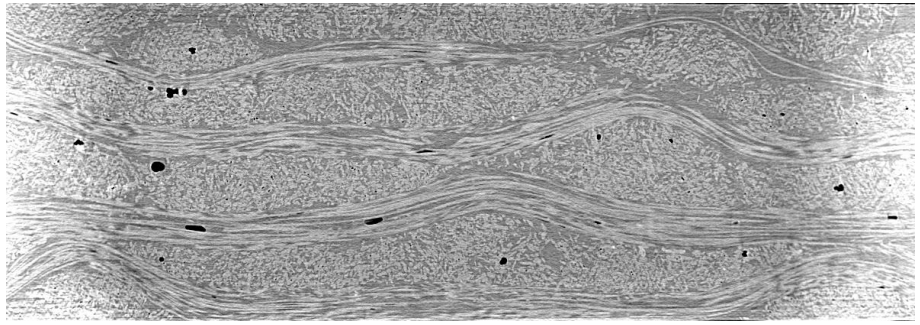




- ❑ **Fully bio-based**
- ❑ **Tg > 100°C**
- ❑ **Mechanical properties similar to DGEBA-based epoxy composites** (E ~ 15 GPa, σ_R~ 150 MPa)
- ❑ **Low human toxicity**
- ❑ **Low environmantal impact**
- ❑ **Potential for scale up**

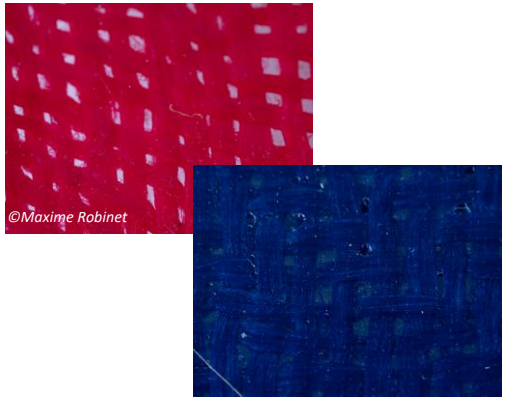
HEMP/GREENPOXY

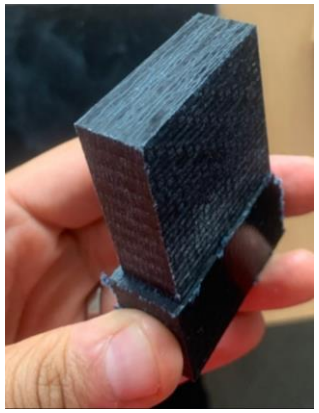
Hemp/Greenpoxy composites



- Corbin et al. Journal of Composite Materials, 2021;55(4):551-564.
- Corbin et al. Composites Part B: Engineering, Volume 181, 2020
- Sala et al. Compos Part A, 2021, 141, 106204

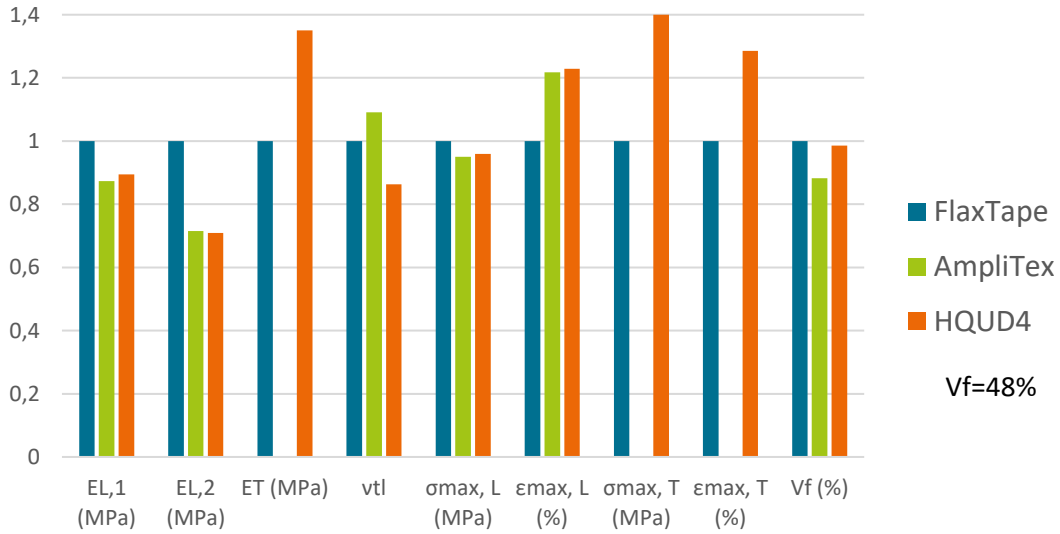
Coloured composites





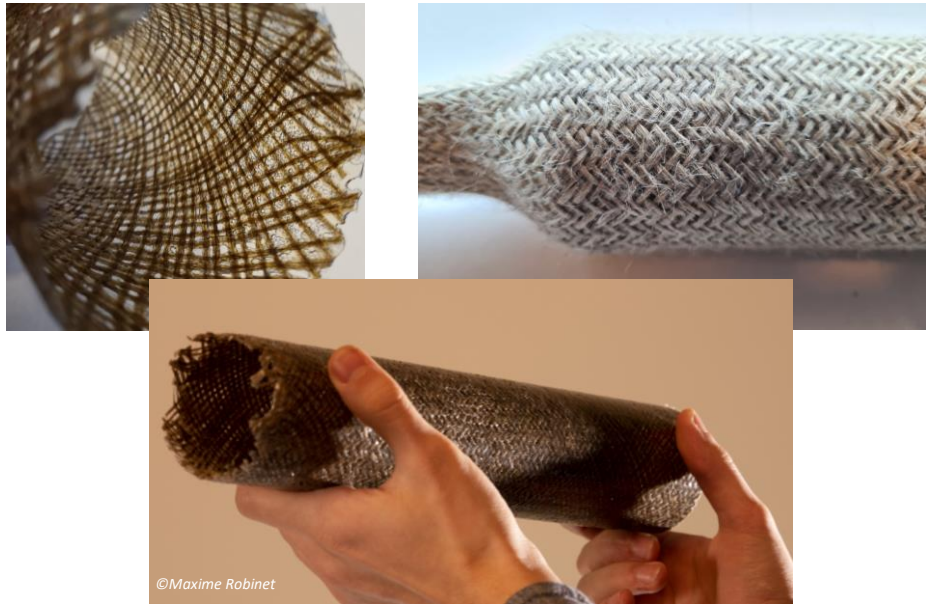
- Fusco Girard et al. Colored Biocomposite Material. Patent EP379028A1

Hemp (QUD) vs. Flax (Flaxtape, Amplitex)



Vf=48%

Braided hemp composites

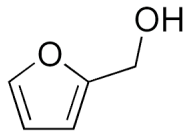


HEMP/FURAN COMPOSITES

Advantages of furan

- Obtained from **sugar cane bagasse**
- Acid digestion followed by hydrogenation
- Available in bulk (relatively cheap)
- Thermoset resin obtained by acid-catalysed **self polymerization**
- Properties: **excellent rigidity and fire retardancy**

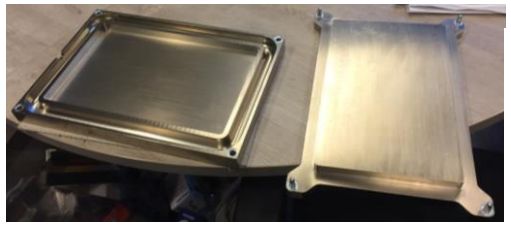
Furfuryl alcohol

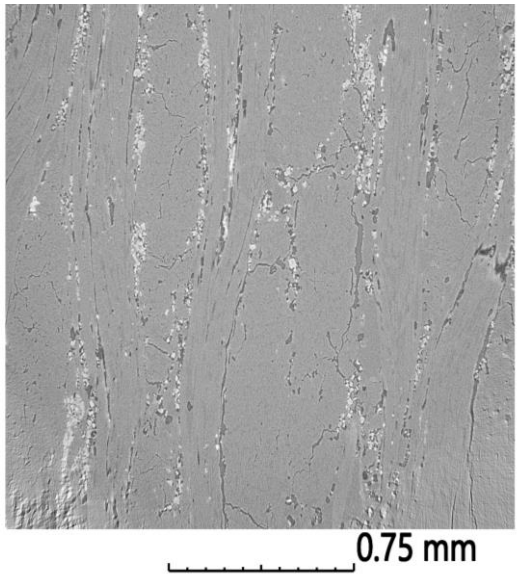


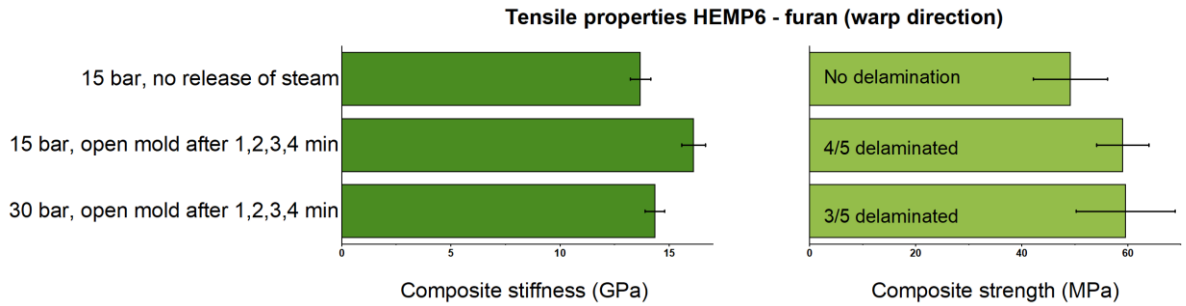
Problematics

- Moisture release during curing
- Porosities
- Acid degradation of fibres
- Brittleness of resin

Prepregs prepared with the woven hemp fabrics developed within SSUCHY (Basaltex)







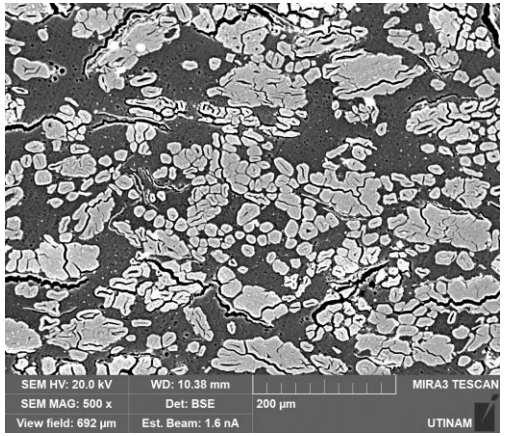
- ❑ Optimisation of the manufacturing process (B-staging, moisture release times…) to reduce porosity level (< 5%)
- ❑ Composite stiffness similar to theoritical predictions but strain and stress at failure are lower than expected
  -> **Suitable for stiffness-based design applications**

❑ Koolen et al. Brightlands polymer days 2021, 7th, 8th or 9th of November, Veldhoven, The Netherlands.

FLAX-BASED COMPOSITES

Flaxpreg T-UD FR (Ecotechnilin) produced by autoclave

Flax/epoxy prepreg satisfying the self-extinguishing constraints of Aeronautics



Specific properties of glass and flax fibre composites.

Load direction	Specific properties ($MPa/g.cm^{-3}$)	Glass fibre composite	Flax fibre composite	Percent variation (%)
Longitudinal	Tensile strength	**521.6**	238.5	↓118%
	Tensile modulus	21.2	**28.3**	↑33%
	Flexural strength	**621.6**	263.6	↓136%
	Flexural modulus	**20.9**	19.5	↓7%
Transverse	Tensile strength	10.8	**15.1**	↑39%
	Tensile modulus	**5.2**	3.4	↓118%
	Flexural strength	**40.9**	11.5	↓255%
	Flexural modulus	**5.9**	2.6	↓129%
45°	Shear strength	13.0	**29.9**	↑39%
	Shear modulus	**40.9**	3.4	↓1100%

- Panzera et al. Compos Part B: 197,2020,108049,
- dos Santos et al. Compos Part B, 202: 108380

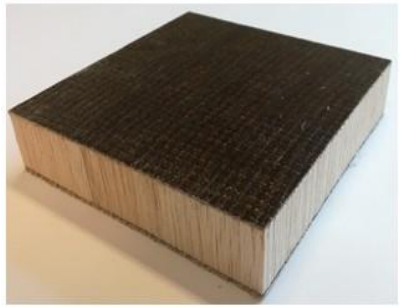
- Higher specific tensile modulus and similar specific flexural modulus of UD flax composites relative to E-glass composites makes
  -> **An attractive material for secondary structural applications**

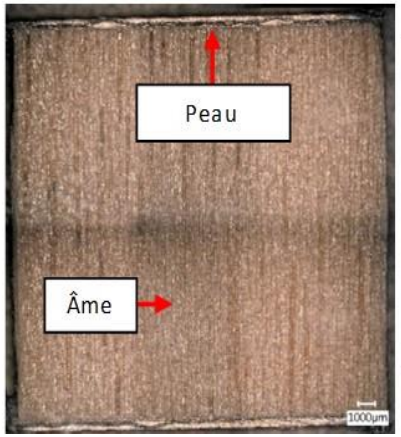
SANDWICH COMPOSITES

Skins: Woven hemp fabrics/GreenPoxy

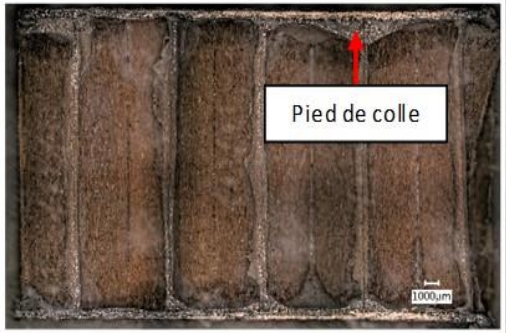
Cores:

Balsa wood (BALTEK)

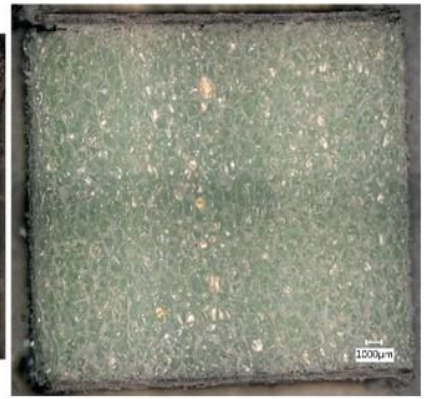




Paper honeycomb (AXXOR)

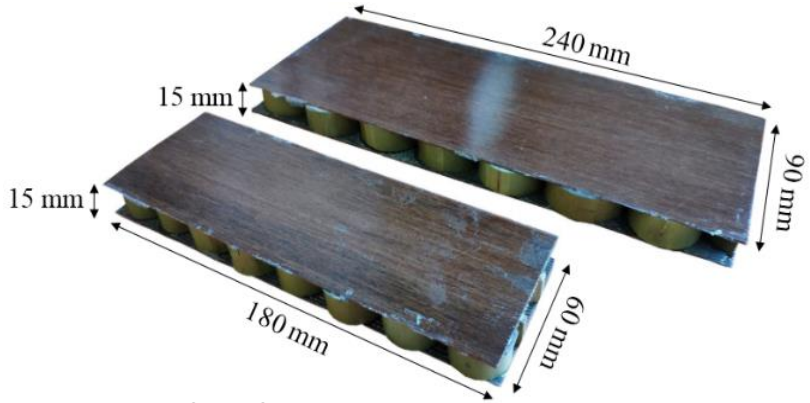


recycled PET foam (ARMACELL)



- PhD Thesis Benjamin Sala, Université Franche-Comté, 2021
- Sala et al. Compos Part B, 2022, 231, 109572

Skins: Flaxtape/epoxy



Core: bamboo rings

- De Oliveira et al. Compos Part C, 2020, 3, 100048

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for Research & Innovation

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