



Natural Aligned Fibers and Textiles for Structural Applications in the Building Sector

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- Standard Applications for Natural Fiber Composites
- EU Project NATEX
 - Thermoplastic (Bio-based) Natural Fiber Composites
 - Thermoset Bio-based Natural Fiber Composites
 - Composite Characterization – Volumetric Interaction
 - Demonstration Parts
- EU Project BioBuild
- Summary and Outlook

Standard Applications for Natural Fiber Composites

- Since decades common use in the automotive industry for semi-structural components
 - Door panels
 - Backrests
 - Roof stiffenings



Mercedes E-Class



Mercedes C-Class



Source: Global Hemp

- New application fields
 - Sports
 - Furniture
 - Shipbuilding
- Usage of „Green Composites“

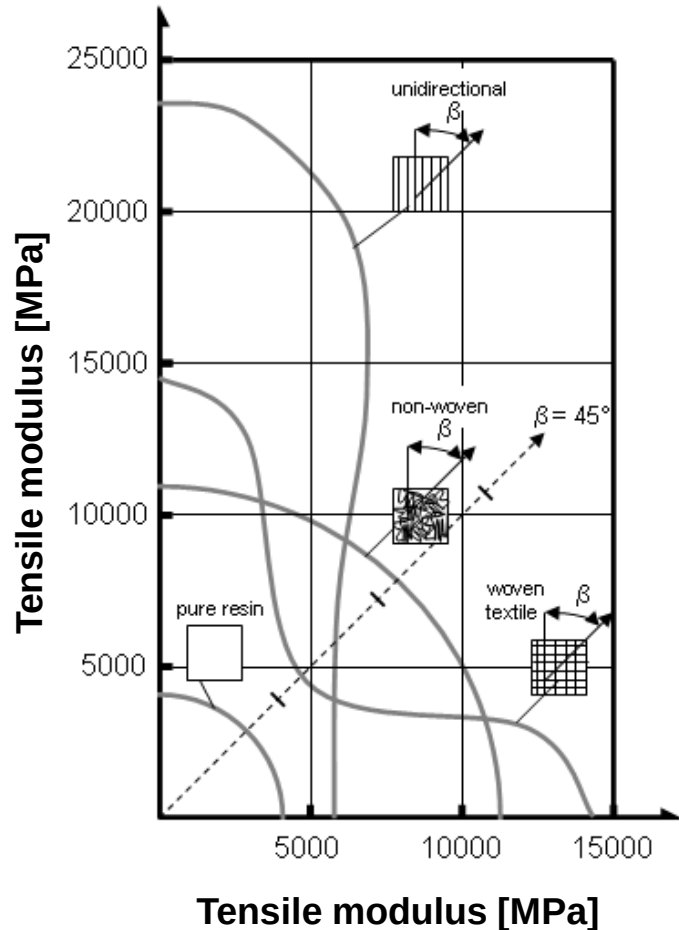


Source: plasmor.fr



Source: warwick.ac.uk

Influence of fiber orientation in reinforcing textiles



NF non-woven
multi-directional



NF textile
bi-directional



NF non-crimp
uni-directional



Fiber treatment

- Increase of fiber matrix adhesion
- Reduction of water uptake and matrix absorption

Yarn modification

- Improving the yarn quality using new spinning processes

Matrix modification

- Improving the flow properties

Process analysis

- Increasing the mechanical performance
- Manufacture of complex shapes

Manufacturing of demonstration parts

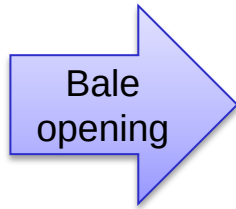
- Prototypes for automotive, energy, agriculture, and shipbuilding sector

Production of Yarns and Fabrics

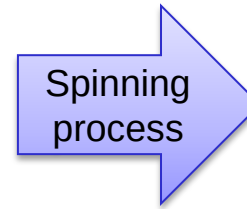
- Spinning process for natural fibers



Raw fibers



Mechanically/chemically
modified fibers

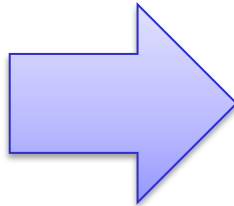


Natural fiber yarns

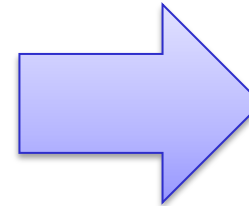
- Manufacturing process of natural fiber textiles



Natural fiber yarn



Weaving procedure



2D Fabric

Thermoplastic (Bio-based) Natural Fiber Composites

Production of thermoplastic natural fiber composites

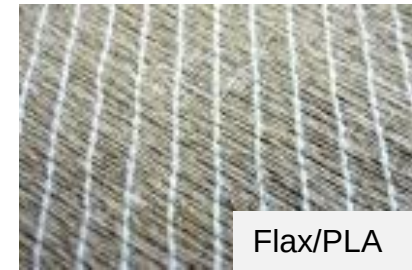
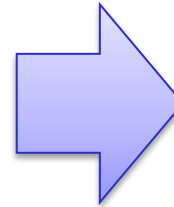
- Commingled yarn method



Natural fibers



Thermoplastic fibers



Flax/PLA

Hybrid reinforcing textile

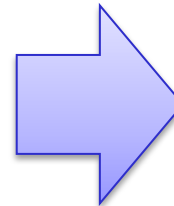
- Film Stacking method



Reinforcing textile



Thermoplastic film



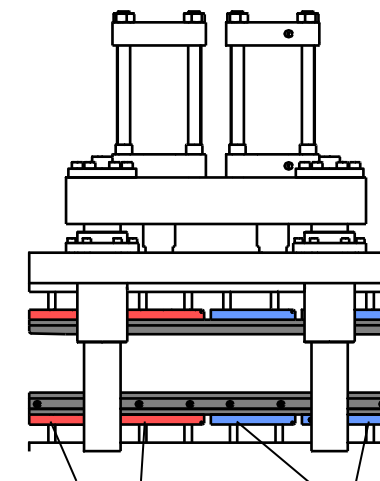
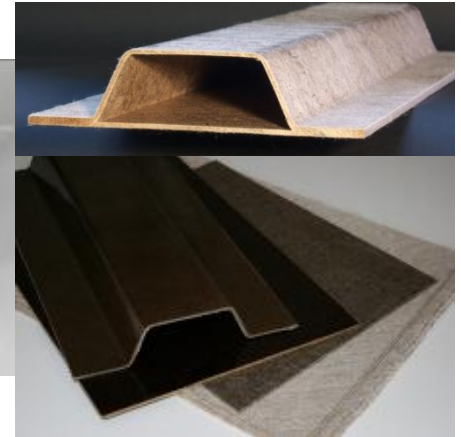
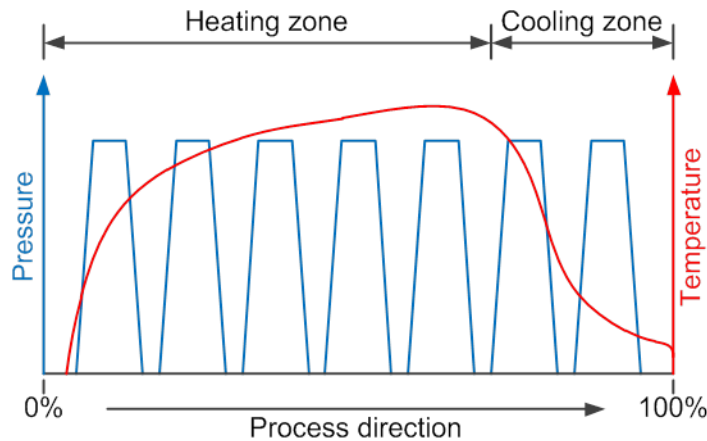
Organic sheets

Processing of Thermoplastic (Bio-based) Natural Fiber Composites 1

Production of organic sheets and profiles

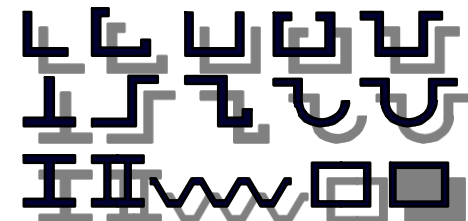


Continuous Compression Molding Machine



Heating and cooling sections

Profiles



Processing of Thermoplastic (Bio-based) Natural Fiber Composites 2

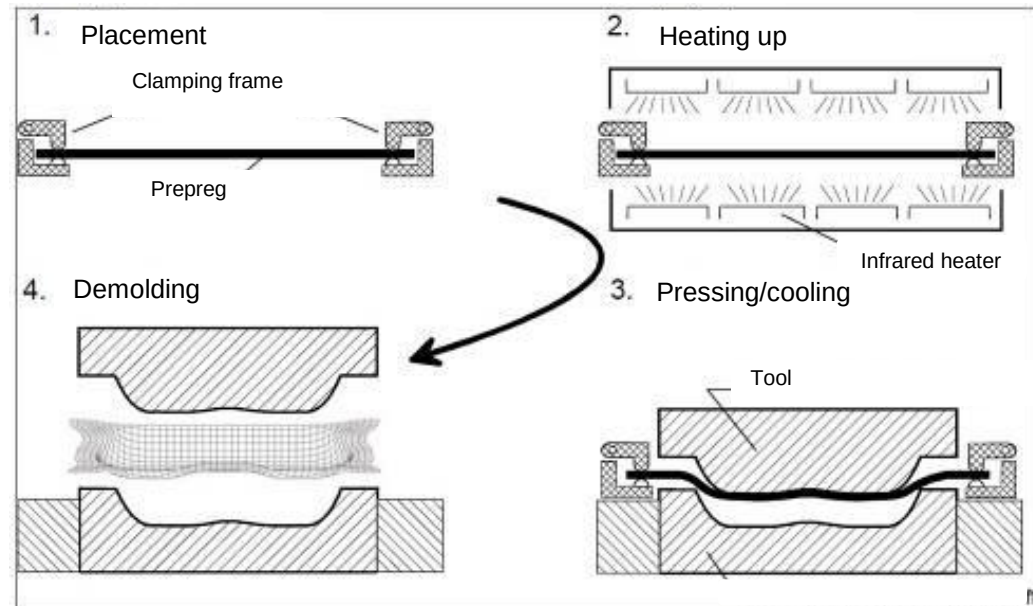
Processing of NF organic sheets using the thermoforming process



NF organic sheets



Half-shell case
flax textile/PLA



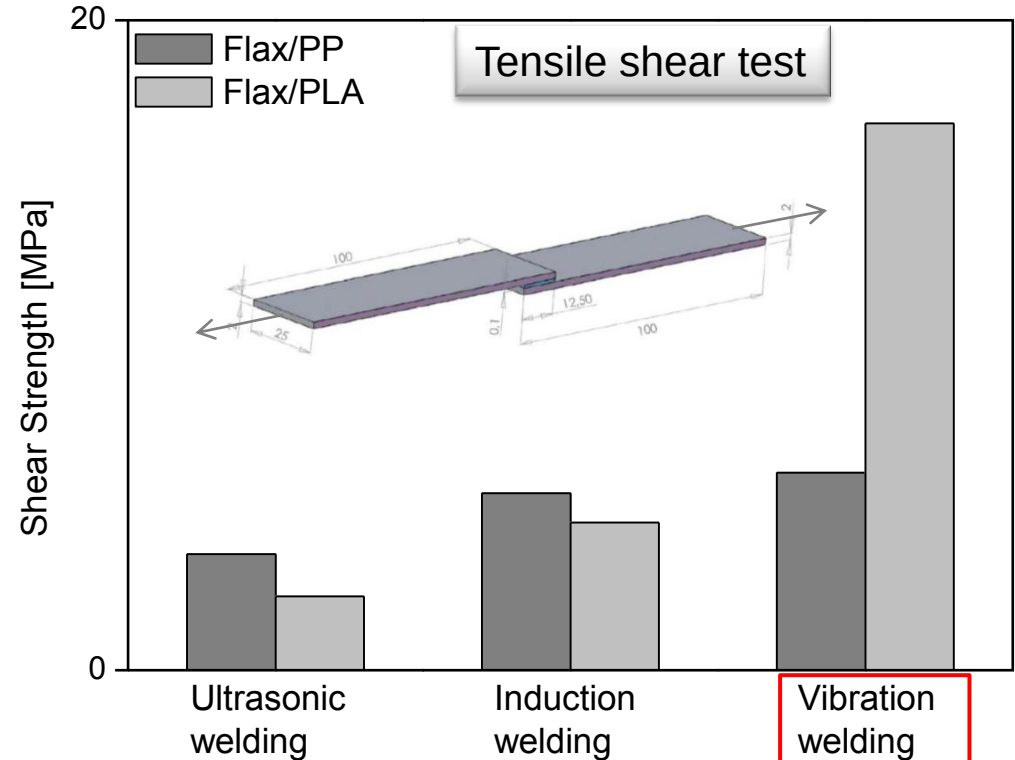
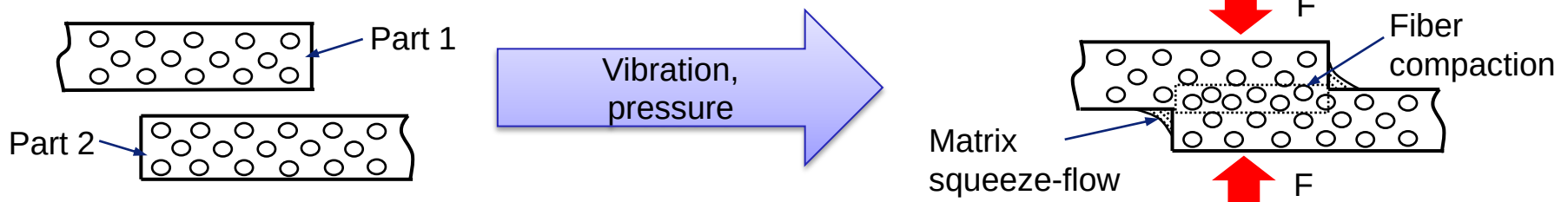
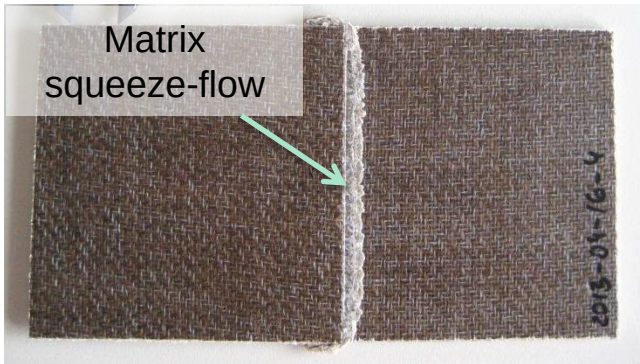
Thermoforming

- Heating by infrared just above T_m
- Cold pressing to components

Joining Process for Thermoplastic Natural Fiber Composites

Welding methods

- Ultrasonic welding
- Induction welding
- **Vibration welding**



Thermoset Bio-based Natural Fiber Composites

Source: TransFurans Chemicals



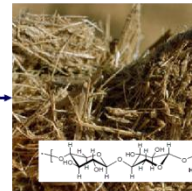
Flax textile



Sugar cane



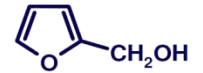
Sugar



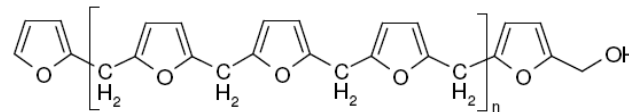
Bagasse



Furfural

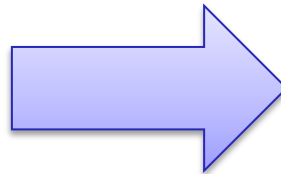


Furfuryl alcohol



Thermoset
furan resin

Natural fibers
+
bio-based
furan resin



Completely
bio-based prepregs

Processing of Thermoset Bio-based Natural Fiber Composites

Flax/furan prepregs

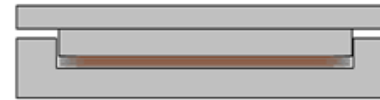


Compression molding process

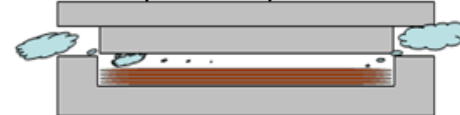
1 Placing the prepreg into the heated tool



2 Heating and compacting the prepreg, chemical reaction starts, vapor arises

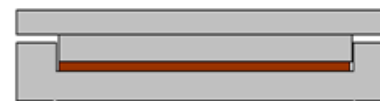


3 Opening the tool, vapor escapes

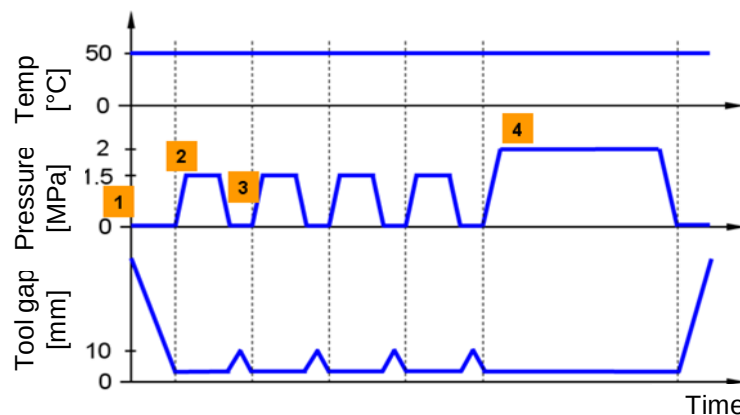


Repeating
cycle

4 Resin cures during closed tool



- The water resulting from the polycondensation of the furan resin reaction must be evaporated
- Mold has to be lifted several times in order to achieve low porosity content (high density)



Composite Characterization – Volumetric Interaction

Textile

- Woven flax textile (Biotex 3H Satin weave) from Composites Evolution Ltd.
- Area weight 420 g/m²
- NF are entangled with 18.5 wt.-% PES multifilaments

Resin

- Furan resin (BioRez 080101) from TransFurans Chemicals bvba
- Density $\rho = 1.334 \text{ g/cm}^3$

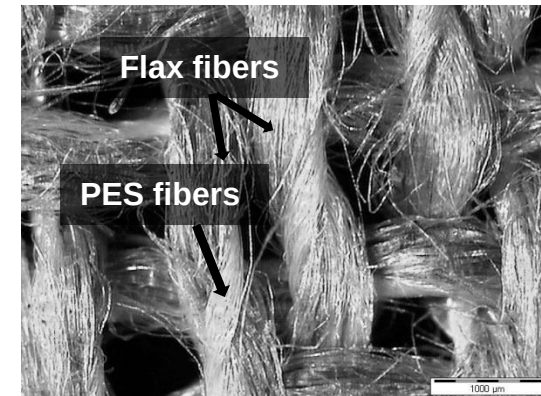
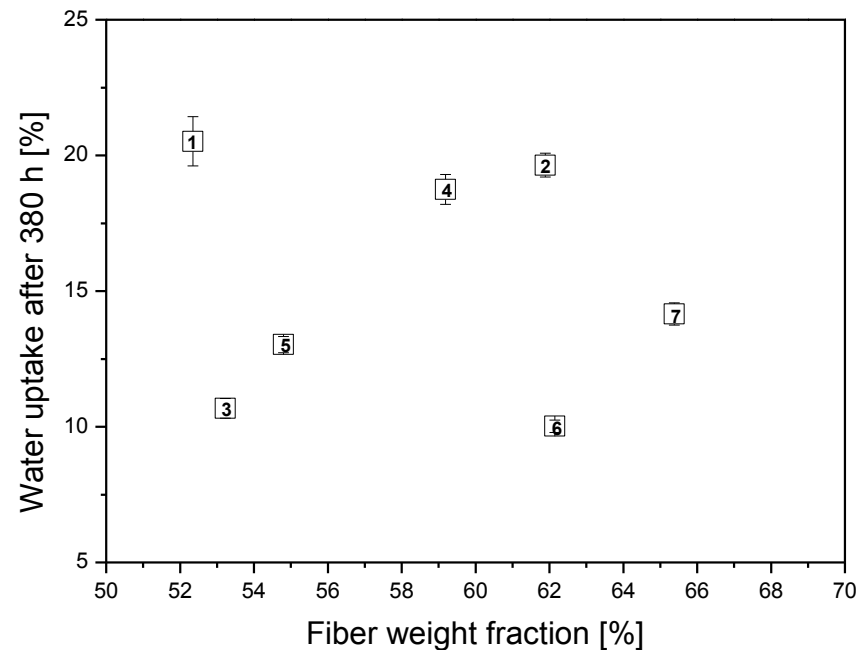
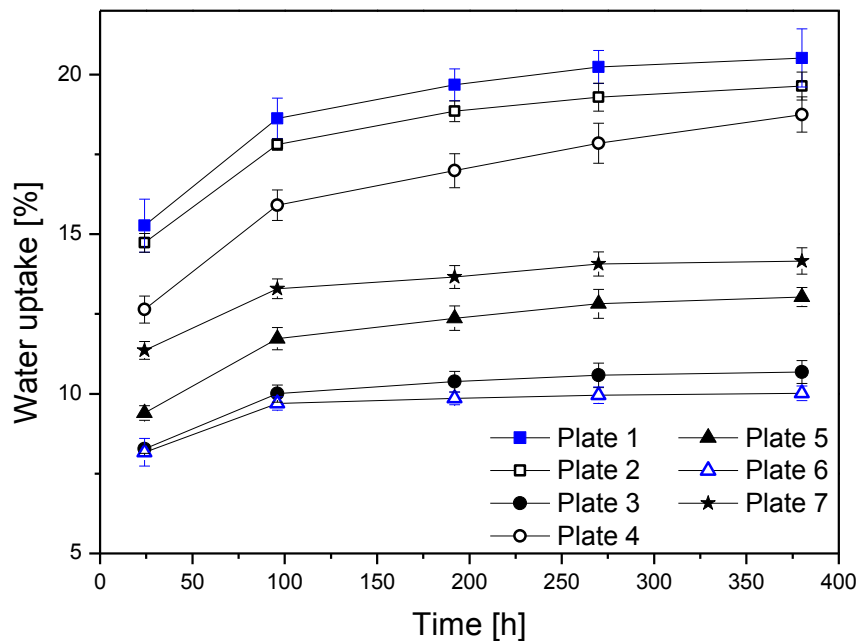


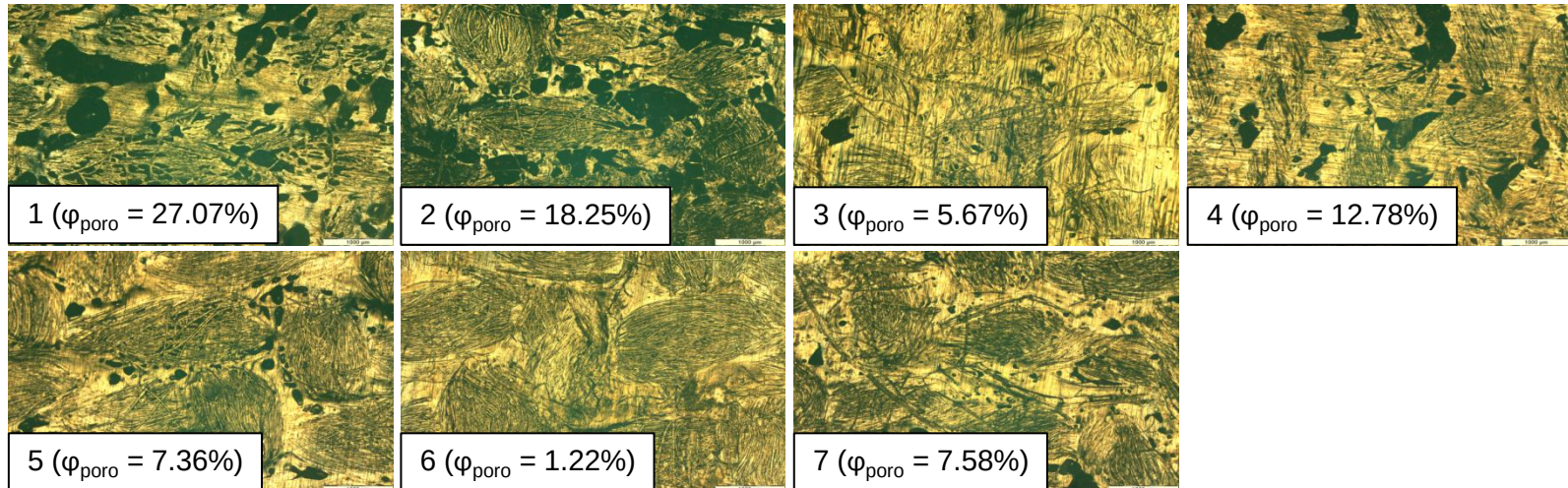
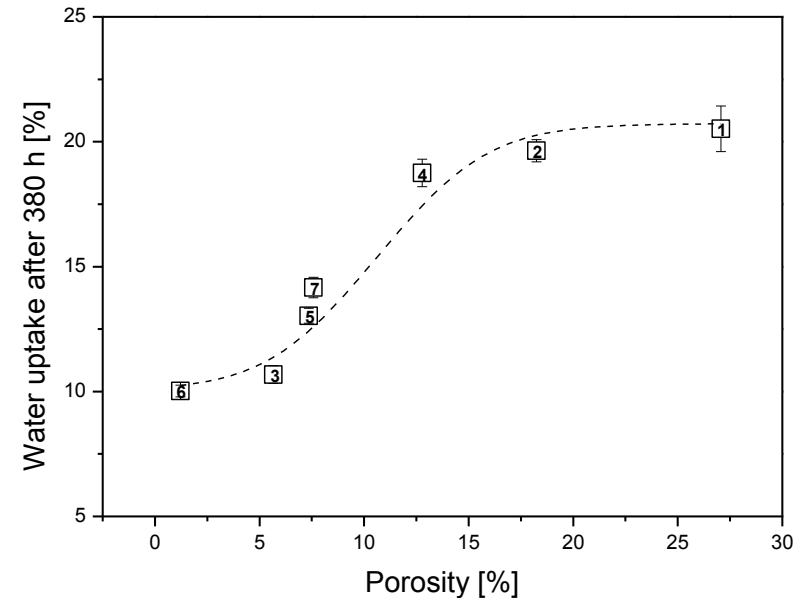
Plate	Prepreg layers	Density	Φ_{textile}	Φ_{resin}	Φ_{porosity}
[-]	[-]	[g/cm ³]	[vol.-%]	[vol.-%]	[vol.-%]
1	3	1.02	36	37	27
2	4	1.16	49	33	18
3	4	1.33	48	46	6
4	4	1.23	49	38	13
5	4	1.30	48	45	7
6	5	1.40	59	40	1
7	5	1.32	58	34	8

Water Uptake Behavior 1

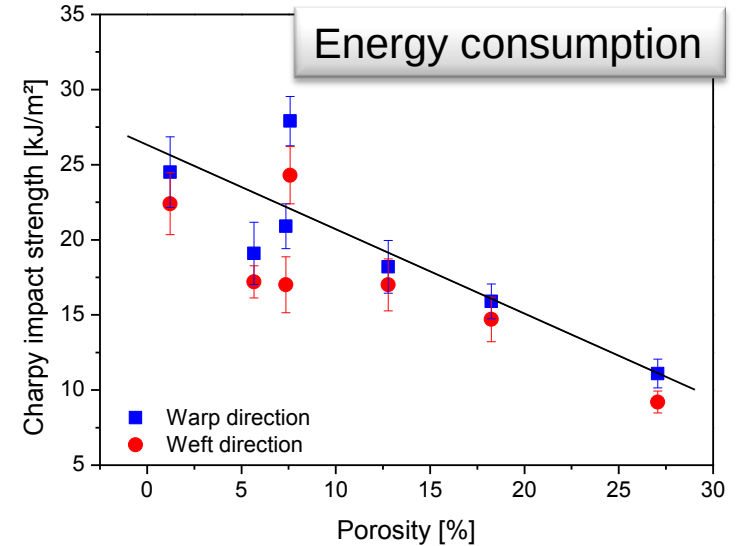
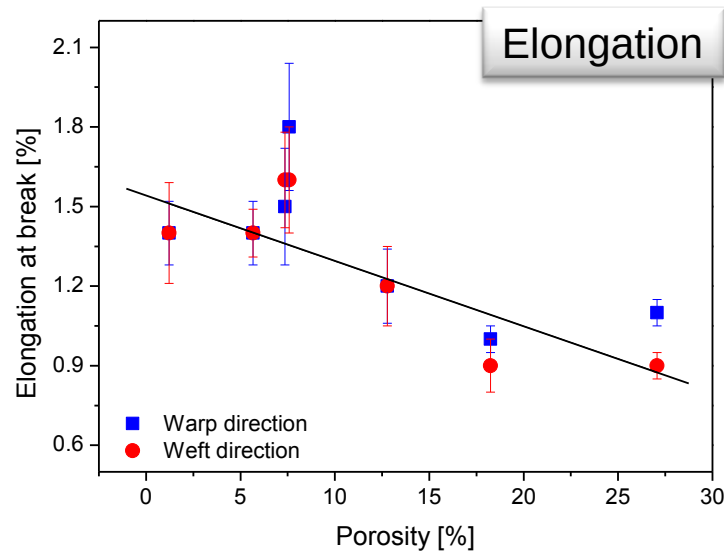
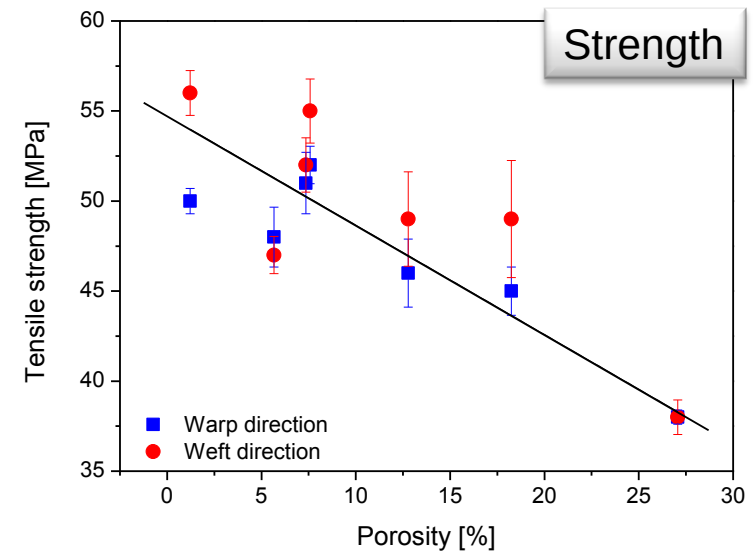
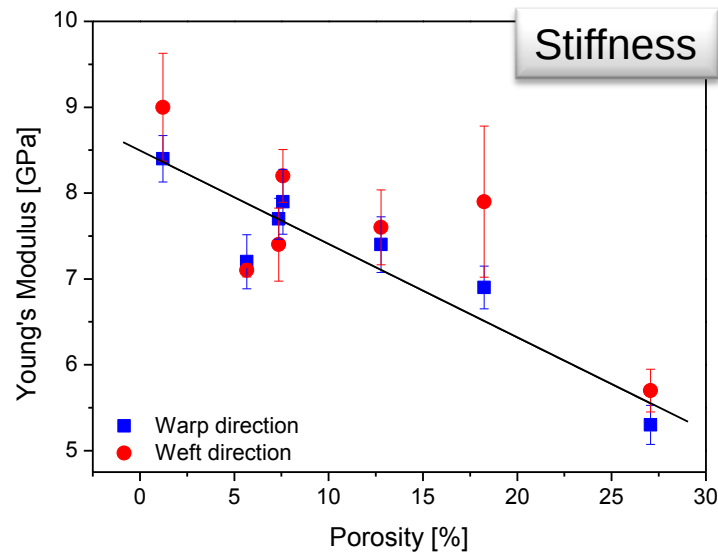
- Hydrophilic properties of natural fibers
- Swelling, loss of mechanical performance due to insufficient fiber-matrix adhesion
- Water uptake of conventional NF materials after 24 h: 30 – 40 %
 - Water uptake of our tested material after 24 h: 8 – 15 %
 - No correlation between water uptake and fiber weight fraction



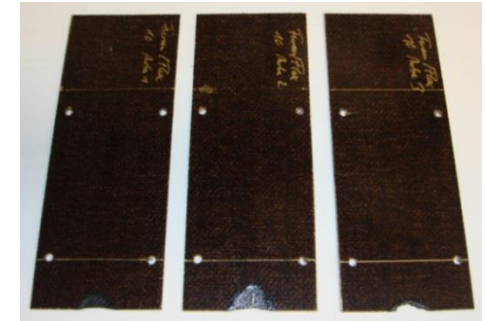
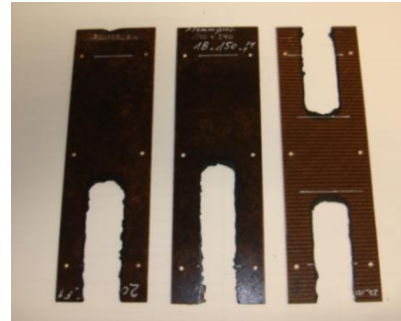
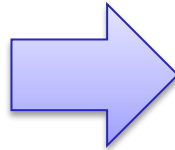
- Correlation between water uptake and porosity
- Larger surface pinholes with increasing porosity cause diffusion of water to the hydrophilic fibers



Mechanical Performance Depending on the Porosity Content

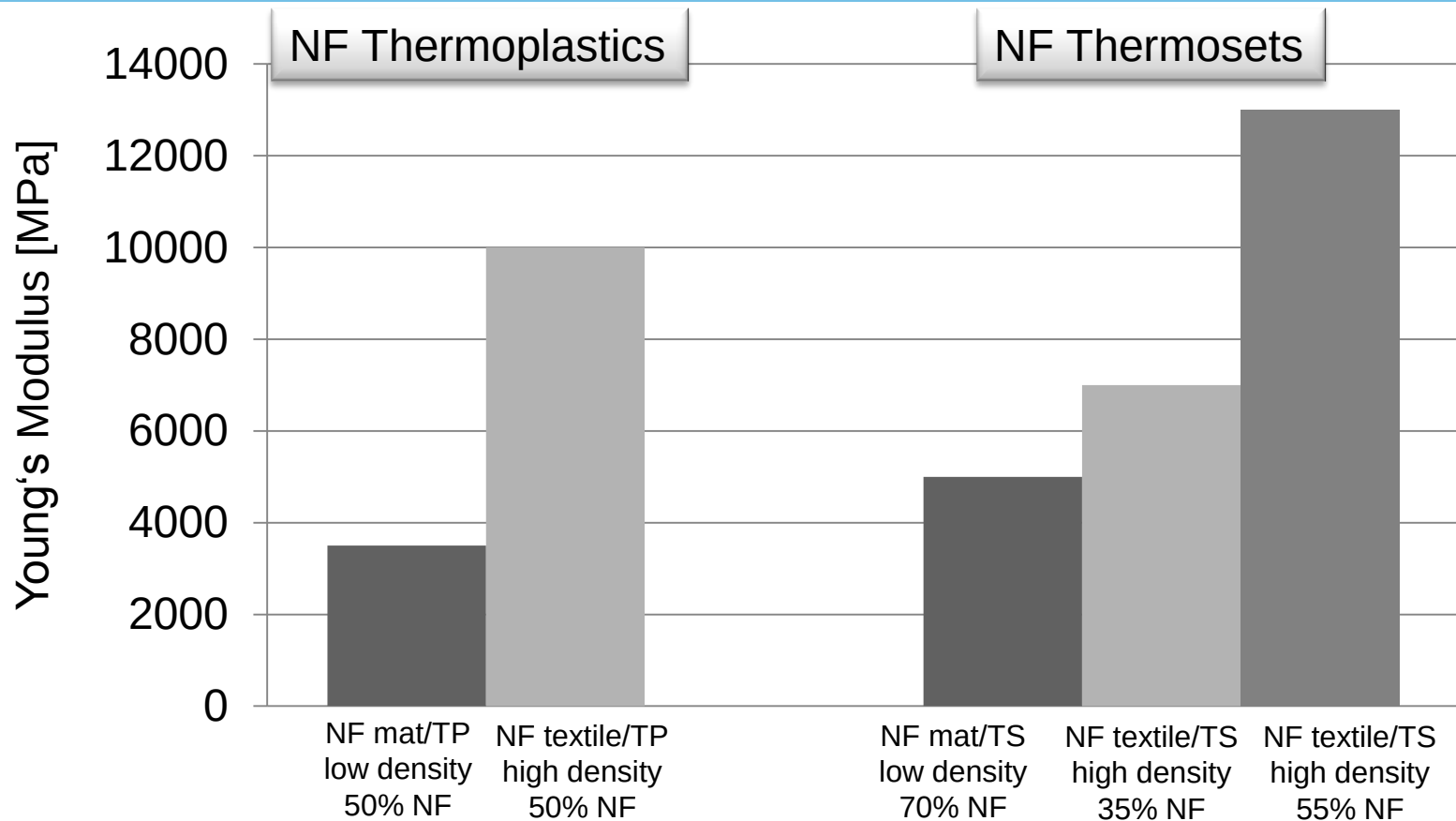


- Burning behavior test according to automotive standard FMVSS 302
- Maximum allowable burning rate up to 102 mm/min for passing the test
- All tested materials passed the automotive standard test



Matrix: Furan resin	Porosity [vol.-%]	Burning rate [mm/min]	Fiber orientation	Remarks
Glass non-crimp	6	0	+/- 45°	Non-combustible
Flax non-crimp	21	15	+/- 45°	-
Flax non-woven	11	22	random	-
Flax textile	1.22	0	0°/90°	Non-combustible

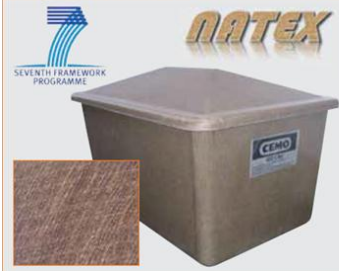
Summary of the Mechanical Performance



Improving the mechanical performance of natural fiber composites by using aligned fibers and optimizing the manufacturing process (increasing the density)

Successfully Manufactured Demonstration Parts

Wir suchen Sie*
für unser Projekt



Behälter mit Wachstum

Im Rahmen des europäischen Forschungsprojektes NATEX leisten wir einen Beitrag um die Ressourcen unserer Erde zu schonen. Anstatt der herkömmlichen Glasmatte verwenden wir zur Herstellung der Behälter Naturfasern aus einem nachwachsenden Rohstoff. Somit dienen unsere Streugutbehälter nicht nur der Sicherheit auf den Straßen, sondern schützen auch die Umwelt. Für einen Feldversuch suchen wir fünf Gemeinden/Kommunen, denen wir eine begrenzte Anzahl von diesen Streugutbehältern zur Verfügung stellen um gemeinsam Erfahrungen vor Ort zu sammeln.

*Bewerben Sie sich unter:
www.cemo.de/kontakt



Grit container – flax/polyester



Frisbee disc – flax/furan



Solar panel frame
flax/PLA



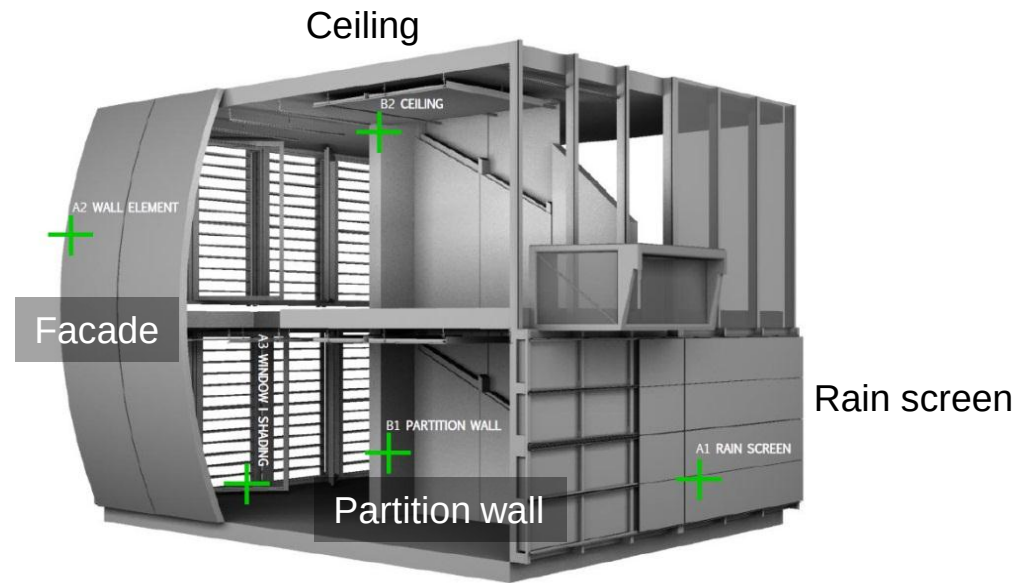
Tractor panel
flax/PLA

- Direct energy use (e.g. heating) of a building has dropped 6-fold from 1973 to 1994 due to legal environmental restrictions and hence the use of better insulation methods
 - Indirect, embodied energy has increased slightly in the same time
- ⇒ Interest in reducing the embodied energy of construction materials

Material	Embodied energy [MJ/kg]	CO ₂ content [kg CO ₂ /kg]	Embodied energy* [MJ]
Bricks	8	1	1968
Aluminum virgin	218	11	1177
Steel sheet galvanized	39	3	612
Timber plywood	15	1	594
FRP (glass/polyester)	100	8	540
Steel sheet virgin	32	3	495
Timber MDF	11	1	462
Hemp/polyester-composite	69		249

* in a 1 m x 1 m typical panel for various materials

- Minimize the embodied energy in the building industry by at least 50 % (over current materials)
- Use of bio-based materials (NF and bio-polymers like furan resin, bio-epoxy, bio-UP resin)
- No increase in costs



Work at IVW

- Modification of reinforcing fibers and matrices
- Processing of biobased panels and profiles for several case studies

Summary

- Standard application fields of natural fibers in Europe in the automotive industry for semi-structural components → recently also new application fields
- For the application as structural parts mechanical performance must be increased
- Increase of mechanical properties due to aligned fibers (textiles) and optimization of the manufacturing process (high density)

Outlook

- Process optimization for other bio-polymers (bio-epoxy, bio-UP resin)
- Introduction of a cork core → sandwich structure
- Production of panels and profiles for BioBuild demonstration parts

Thank you for your attention

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