



GREEN-LOOP

Overview and discussion of wood composites production and properties – identification of opportunities and risks

Internal training session on Wood Composite Material
– 21 February 2025 –

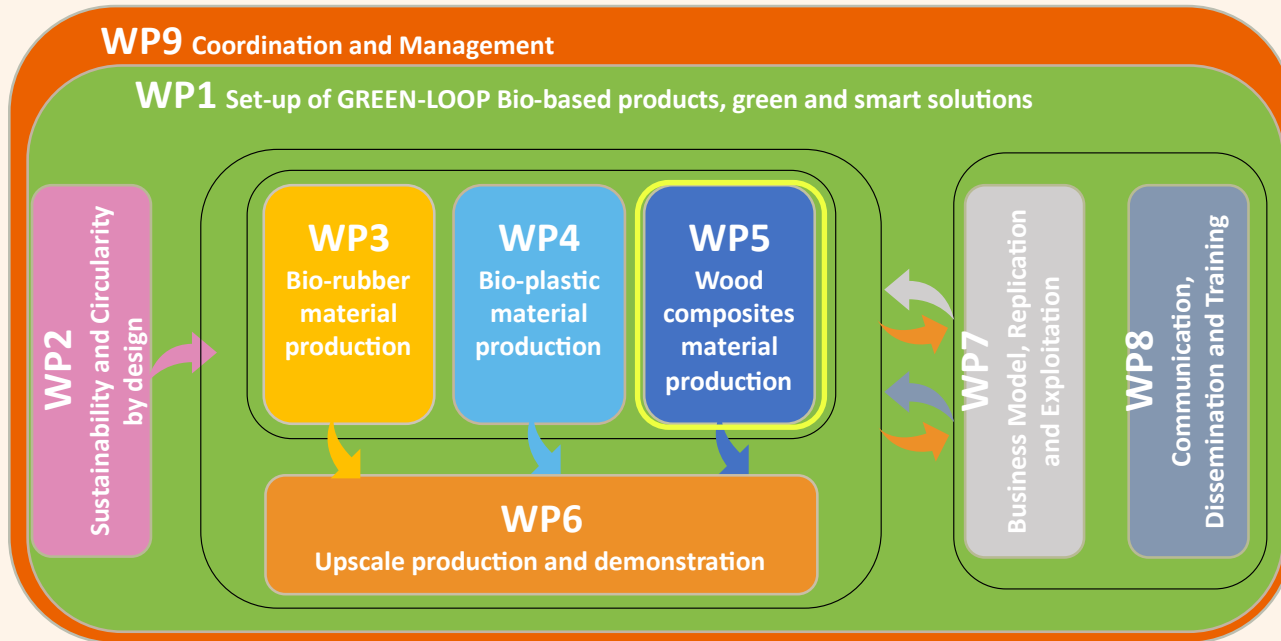


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Key features (Kick-Off Meeting)

- Bio-based raw materials: compounds with 50-60 % wood fibres/Particles, 30-40 % biopolymer, 5 % filler
- Recyclability, reusability or refurbishing of the product: > 50 % recyclability of bearings, reduce of maintenance costs
- Advantage over conventional materials: 100 % regenerative resources, eco-friendly, cost efficient, only use water or bio-lubricants
- Use in other sectors: building sector/floor plates, transport sector/rollers



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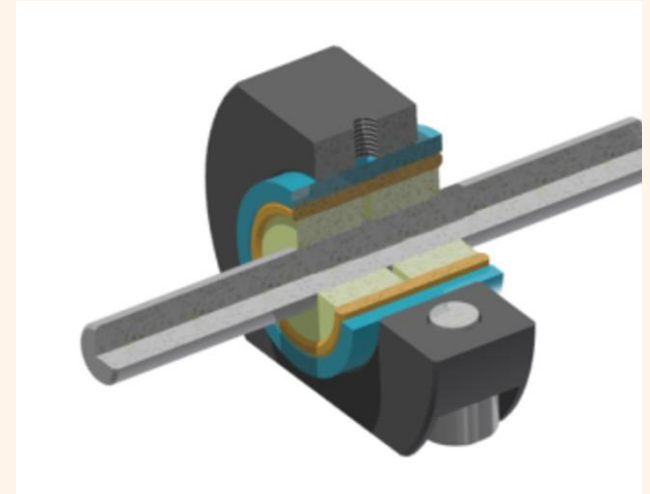
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Final product (Kick-Off Meeting)

- Wood composite (WC) bearings
- Application in appliance and tool industry (injection unit)
- Demonstration by bio-plastic manufacturing system (Injection)
- Samples such as rings, cylinders, half shells
- Prototype features /design defined by Labrenta (Guala)
- WC Production in small series



Wood Composites as Precision-Engineered Mechanical Components

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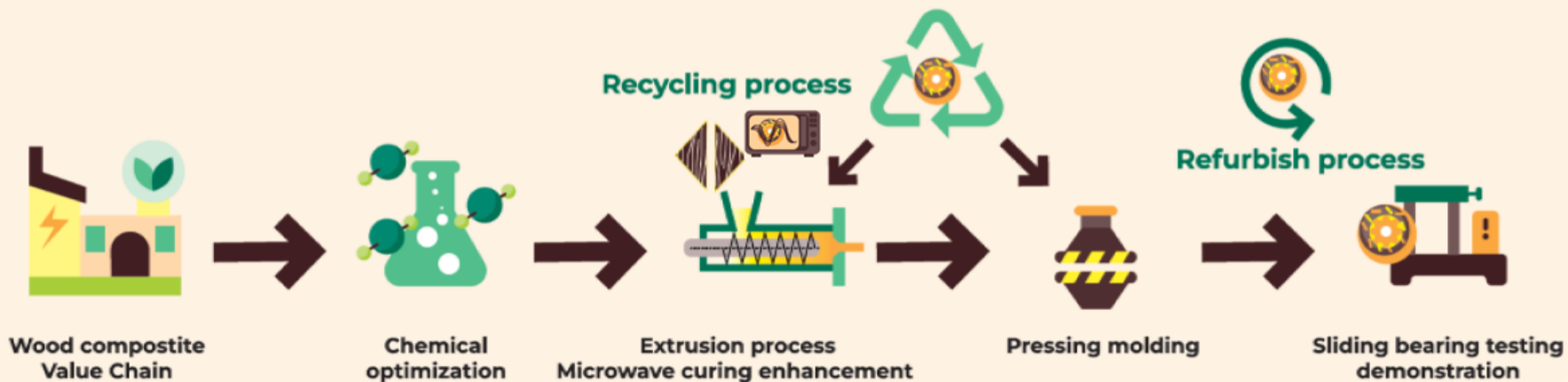
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Wood composites material production

Flow Chart



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Wood Composites

Definition:

Wood composites are engineered materials made from wood fibers, particles, or veneers combined with adhesives, resins, or polymers.

Common Types:

- **Plywood** – Thin layers of wood veneer glued together in alternating grain directions for strength.
- **Particleboard** – Made from wood chips and sawdust bonded with resins.
- **Medium-Density Fiberboard (MDF)** – Compressed wood fibers mixed with adhesives, offering a smooth surface.
- **Wood-Plastic Composites (WPCs)** – A blend of wood fibers and plastic, commonly used for decking and outdoor applications.



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Historical Context & Modern Applications

Historical Context:

- Plywood dates back to ancient Egypt.
- Particleboard & MDF emerged in the 20th century as cost-effective alternatives.
- WPCs gained popularity in the late 20th century for durability.

Modern Applications:

- 🏠 **Construction** – Flooring, roofing, wall panels.
- 🪑 **Furniture** – Cabinets, tables, shelving.
- 🚗 **Automotive Industry** – Door panels, dashboards.
- 🌿 **Outdoor Uses** – Decking, fencing, park benches.



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Comparison with Traditional Materials

Key Characteristics:

-  More stable than natural wood (resistant to warping & cracking).
-  Can be customized for strength, moisture resistance, and aesthetics.
-  Often made using recycled or reclaimed wood, supporting sustainability.

Property	Wood Composites	Solid Wood	Plastics	Metals
Strength & Durability	Moderate to High	High	Moderate	High
Moisture Resistance	Treated composites are good	Poor	Excellent	Excellent
Workability	Easy to shape, cut	Moderate	Easy	Difficult
Sustainability	Uses recycled materials	Natural but slow-growing	Varies	High energy use in production
Cost	Generally affordable	Expensive	Affordable	Expensive

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Key Takeaways

- Wood composites offer a balance between cost, durability, and sustainability.
- Their applications span multiple industries.
- Choosing the right material depends on performance, cost, and environmental impact.

Why bioplastics?

- Reduce limited fossil resources
- Close the CO₂-loop
- Smart combination of natural synthesis with chemistry
- New End-of-life options: biodegradation in a composting environment or energy recovery (CO₂-neutral)

Advantages to conventional plastics

- Moulded parts replacing plastics
- „wooden“ moulded parts with new 3D design options
- REDESIGN WOOD!

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Key Components of Wood Composites

1. Key Components of Wood Composites

•Wood Fibers or Particles:

- Sourced from sawdust, wood chips, or recycled wood.
- Provides structure and natural appearance.

•Binding Agents (Resins or Adhesives):

- Synthetic (e.g., phenol-formaldehyde, urea-formaldehyde).
- Bio-based (e.g., lignin, starch, bioplastics).

•Additives for Performance Enhancement:

- **Water Resistance:** Waxes and hydrophobic agents.
- **Fire Retardants:** Borates or other flame-resistant compounds.
- **UV Stabilizers:** Protect against sunlight degradation.
- **Colorants:** Dyes or pigments for aesthetic appeal.

2. Typical Composition Ratios (Varies by Type)

Component	Percentage (%)
Wood Fibers/Flour	50–80%
Resins/Binders	10–30%
Additives	5–15%

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Renewable & Biodegradable Aspects of Wood Composites

Wood Fibers/Flour

Renewable Resource:

- Sourced from managed forests and fast-growing species.
- Supports sustainable forestry practices.



Biodegradability:

- Natural fiber-based composites break down over time.
- Some composites are designed for compostability.

Lifecycle Impact:

- Lower environmental footprint than non-renewable materials like plastics and metals.

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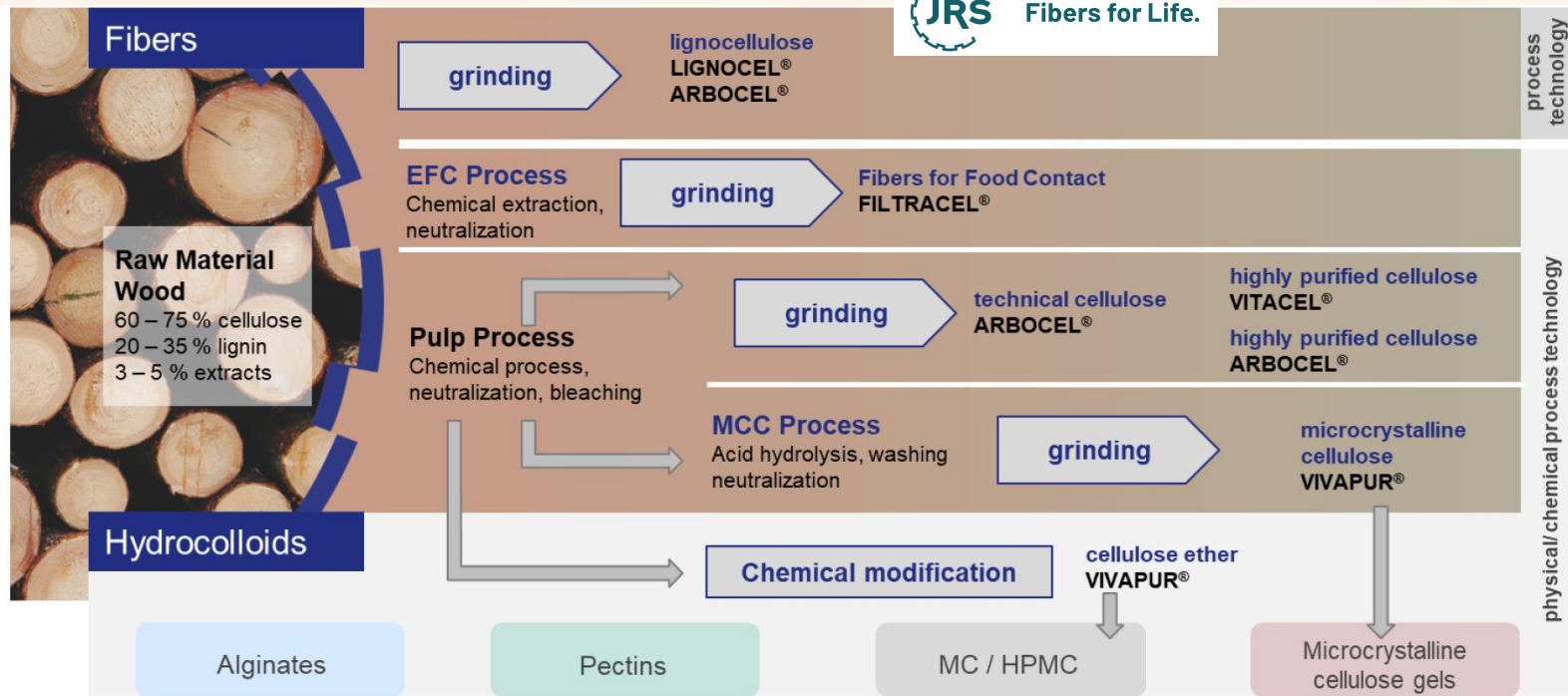
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Renewable & Biodegradable Aspects of Wood Composites

Wood Fibers/Flour



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Renewable & Biodegradable Aspects of Wood Composites

Wood Fibers/Flour

ARBOCEL® product overview

	µm	5 - 13 µm	15 µm	30 µm	60 µm	100 µm	200 µm	300 µm	700 µm	1000 µm	2000 µm
Micrystalline cellulose											
UFC-100	8 - 10	■									
Heweten 101	65				■						
Heweten 12	150						■				
Micrystalline cellulose spheres											
CS 300	300							■			
Spheres 700	700								■		
Cellulose granules											
EPG 70	300							■			
Native cellulose (Hard wood)											
BE 600-10-TG	18		■								
B 600	60				■						
B 800	130					■					
BC 200	300						■				
BC 1000	700							■			
B 400	900								■		
Native cellulose (soft wood)											
FDY - 600	60				■						
FIC 200	300							■			
FIC 500 P	600								■		
FIF 400	2000										■
Off-white cellulose / technical grades											
FD 600-30	45			■							
FD 00	150					■					
PWC-500	500							■			
Grey fibers / technical grades											
ZZC-500	400								■		
ZZ 8-1-G	1000									■	
Wood fibers (soft wood)											
CW 630-PU	30			■							
C 750-FP	70				■						
C 100	100					■					
C 400	250-600								■		
Wood fibers (hard wood)											
HB 120	40-120				■						
HB 300-900	300-800								■		
HBK 750-2000 LT	1200-1800									■	

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Renewable & Biodegradable Aspects of Wood Composites

Wood Fibers/Flour

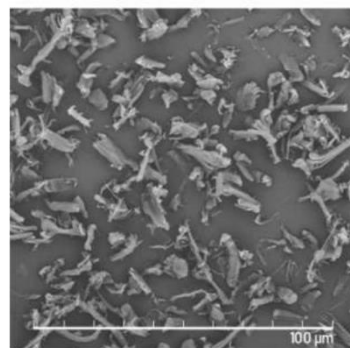
ARBOCEL® cellulose fibers

- › RS celluloses are powdery to fibrous cellulose additives used in various application areas

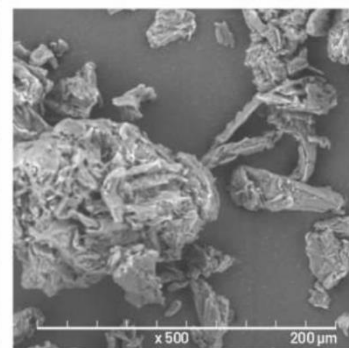


Application examples:

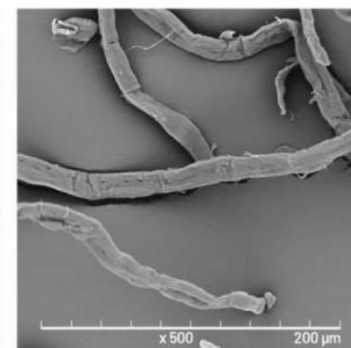
- › biodegradation tuning (bioplastics)
- › porosity formation (ceramics)
- › crack-stopping properties (rubber)
- › rheology adjustment (glue, ceramics)
- › green strength (brake pads)



ARBOCEL® UFC-100



HEWETEN®101



ARBOCEL® B-400

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Renewable & Biodegradable Aspects of Wood Composites

Wood Fibers/Flour

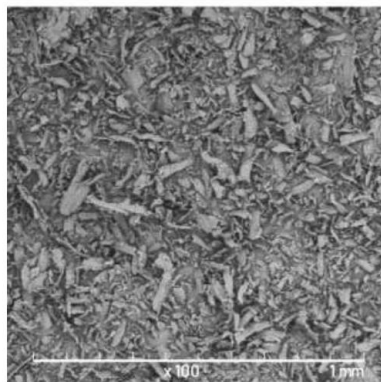
ARBOCEL® and LIGNOCEL® wood particles and fibers

- › Produced from untreated softwood sidestreams

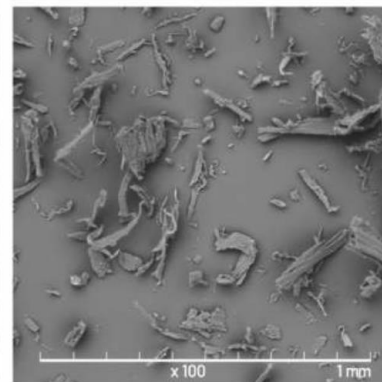


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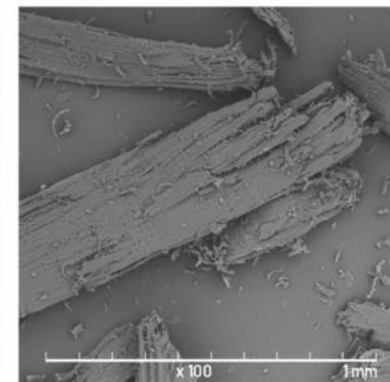
- › bio-based content (plastics)
- › natural look & haptics (bioplastics)
- › processing aid (paper)
- › damping effect (rubber)



ARBOCEL® CW-630-PU



LIGNOCEL® C-120



ARBOCEL® C-400

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Renewable & Biodegradable Aspects of Wood Composites

Binding Agents: Bio-based polymers

1. What are Bioplastics?

There is no standardized definition of a bioplastic

- A bioplastic is a biobased material and/or biodegradable

There are three major categories of bioplastics:

- Biosourced (obtained from renewable resources) and biodegradable materials
- Materials made using fossil fuels (oil) and biodegradable resources
- Biosourced and sustainable materials (non biodegradable)

BIODEGRADABLE	PBAT, PCL, PBSA	PBS, TPS, Starch-based compound, biobased TPE	PLA, PHAs, TPS
NON BIODEGRADABLE	PE, PP, PS, PET, PVC, PUR, PC, ABS, PA, etc.	Biosourced PET, biobased PA 6-10, biobased PC, biobased PUR, biobased TPE, PTT, biobased Copolyesters, Cellulose esters, Hybrids	Biosourced PE, biobased PP, biobased PA-11, biobased PA 10-10
	NON BIOBASED	PARTIALLY BIOBASED	BIO SOURCED

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Binding Agents: Bio-based polymers

MATERIALS	ORIGIN / END OF LIFE	RESOURCES	PROPERTIES	APPLICATIONS
Equivalents to oil-based versions (BioPET, BioPE, BioPA, BioPP, etc.)	20 to ≈ 100 % biobased, not biodegradable nor compostable	Sugar cane, molasses, vegetable oils	Equivalent to standard polymers, remain recyclable and not biodegradable, easy to process	All kind of applications
PLA	≈100% biobased and 100% biodegradable and compostable	Corn starch, sugar cane, sugar beet, etc.	Transparent, rigid, low thermal resistance, low barrier properties	Food and cosmetic packaging, consumer goods, fibres, 3D printing
PHAs	≈100% biobased and 100% biodegradable and compostable	Corn starch, sugar cane, sugar beet, other biomasses	Opaque to translucent, rigid to very soft, good thermal resistance and barrier properties	Consumer goods, agriculture, packagings, water treatment
Biopolyesters	Partially biobased and 100% biodegradable and compostable	Corn starch, sugar cane, sugar beet, etc.	Opaque to translucent, rigid to very soft, good thermal resistance, low barrier properties	Bags, agriculture, packagings, consumer goods
Cellulose based	Mainly biobased and could be biodegradable and compostable	Wood pulp Transparent, rigid, low thermal resistance, low barrier properties	Transparent, rigid, good thermal resistance and barrier properties	Packagings, consumer goods, cosmetic and luxury
Biobased elastomers	Mainly partially biobased	Biobased polyols (vegetable oils, sugars, etc.)	Very soft, low hardness, good mechanical properties	Consumer goods, construction, automotive, sport and leisure
Starch based	Partially biobased and could be biodegradable and compostable	Starch (corn, potatoes, tapioca, etc.)	Soft, sensitive to moisture, controlled biodegradation	Bags, agriculture, packagings, consumer goods
Biocomposites	Partially biobased and could be biodegradable and compostable	Natural fibers with standard or biopolymers	Rigid, good mechanical properties, natural aspect	Consumer goods, automotive, construction

Renewable & Biodegradable Aspects of Wood Composites

Binding Agents: Bio-based polymers

THE DIFFERENT CATEGORIES OF BIOMASS



1st generation (food)

Vegetable oils : soybean, palm, sunflower, colza, etc.

Starch : corn, wheat, potato, tapioca, etc.

Glucose : sugar cane, beetroot, etc.



2nd generation (non-food)

Lignocellulosic biomass: wood, by-products or waste material from agriculture or wood (bagasse from sugarcane, straw, etc.)

Non-food vegetable oils : castor beans and wastes from other vegetable oils production



3rd generation (non-food soil-less farming)

Sugars or oils produced by micro-organisms : Micro-algae, bacteria, mushrooms, yeasts, etc.

Municipal waste material : organic waste, waste water, etc.

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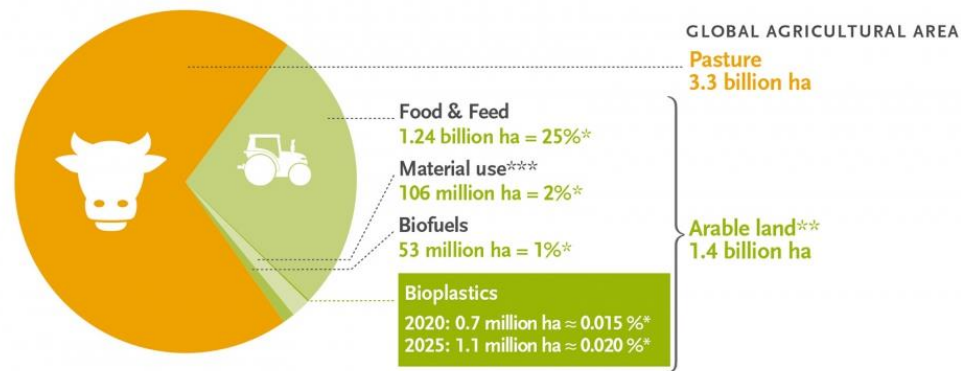
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Renewable & Biodegradable Aspects of Wood Composites

Binding Agents: Bio-based polymers

Today, the main resources are from cereal resources (cornstarch or hydrolysed wheat) or directly obtained from the sugar industry (sugarcane, beetroot, molasses). or from vegetal oil such as castor oil.

Land use estimation for bioplastics 2020 and 2025



Source: European Bioplastics (2020), FAO Stats (2005-2014), nova-Institute (2020), and Institute for Bioplastics and Biocomposites (2019). **More information: www.european-bioplastics.org**

* In relation to global agricultural area
** Including approx. 1% fallow land
*** Land-use for bioplastics is part of the 2% material use

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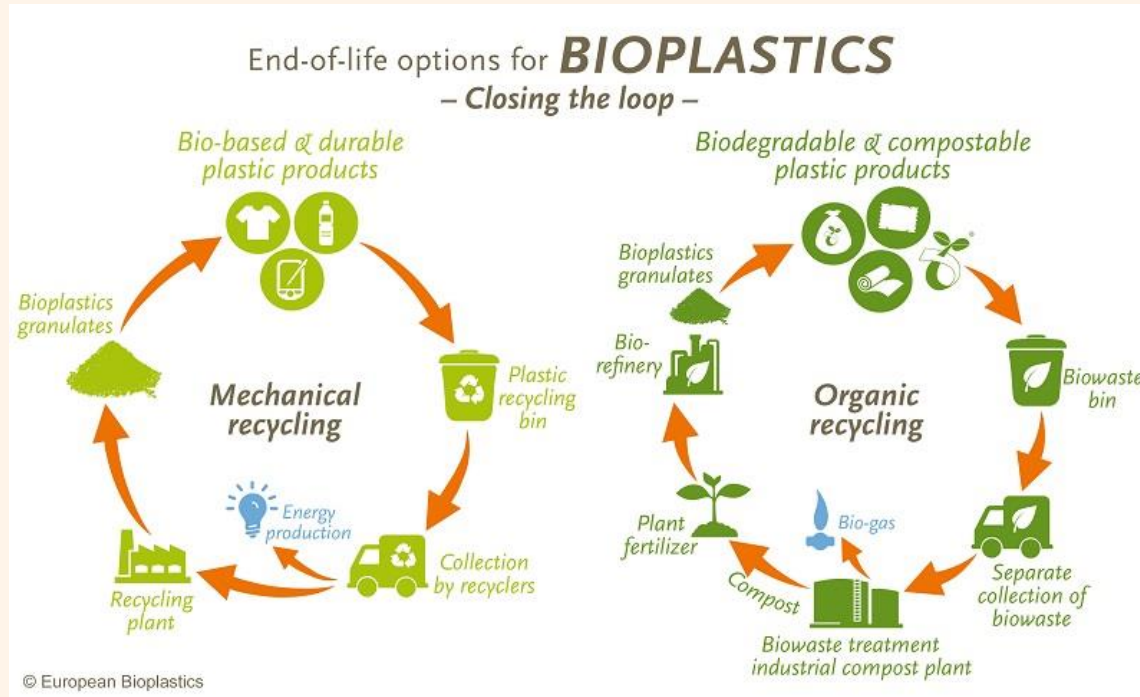
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Binding Agents: Bio-based polymers



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Renewable & Biodegradable Aspects of Wood Composites

Additives

Plasticizers:

- › To improve dispersion of filler material in matrix and prevent aggregation of filler material together
- › Increase ductility
- › Polyethylene glycol (PEG), glycerol and tributyl citrate (TBC)
- › Proportion of plasticizer also important
- › Dispersion of filler material is directly proportional to mechanical properties
- › Fiber surface treatment is important

Surface treatment:

- › Physical treatments
 - Stretching, Calendaring
 - Hydrothermal treatment
 - Plasma processing system
 - Thermo treatment
- › Chemical treatments
 - Alkali treatment (NaOH)
 - Benzoylation (NaOH + Benzoyl chloride and peroxide)
 - Bleaching (NaOH + Hydrogen peroxide)
 - Acetylation treatment (esterification)
 - Silane treatment (Coupling agent)



Renewable & Biodegradable Aspects of Wood Composites

Biocomposites by Stora Enso

Made from almost 100% bio-based materials, contains natural fibers

Grade	Wood Content	Tensile Strength <i>ISO 527-2/50</i>	Tensile Modulus <i>ISO 527-2/2</i>	Tensile E@B <i>ISO 527-2/50</i>	Flex Modulus <i>ISO 178</i>	Carbon footprint <i>ISO 14067</i>	Carbon footprint Eco-grades <i>ISO 14067</i>
Pure							
Pure S30	30 %	35 MPa	3600 MPa	2,2 %	3200 MPa	0,84 Kg/CO2	-0,92 Kg/CO2
Pure S40	40 %	43 MPa	4500 MPa	2,2 %	4200 MPa	0,5 Kg/CO2	-1,06 Kg/CO2
Pure S50	50 %	49 MPa	5700 MPa	1,8 %	5300 MPa	0,13 Kg/CO2	-1,22 Kg/CO2
Pure L40	40 %	37 MPa	4600 MPa	1,6 %	4300 MPa	0,5 Kg/CO2	-1,06 Kg/CO2
Pure L50	50 %	44 MPa	5500 MPa	1,6 %	5300 MPa	0,13 Kg/CO2	-1,22 Kg/CO2
Plus							
Plus S40 Impact D	40 %	50 MPa	4600 MPa	3,5 %	4400 MPa	0,75 Kg/CO2	-0,81 Kg/CO2
Plus S30 Flex K	30 %	27 MPa	1900 MPa	8,0 %	1900 MPa	0,84 Kg/CO2	-0,42 Kg/CO2
Plus S40 Flex K	40 %	31 MPa	2300 MPa	7,0 %	2300 MPa	0,5 Kg/CO2	-0,55 Kg/CO2
3D S50 Flex K	50 %	30 MPa	2700 MPa	7,0 %	2800 MPa	0,13 Kg/CO2	-0,67 Kg/CO2
Prime							
Prime C20 High GK	20 %	60 MPa	2600 MPa	12,0 %	2300 MPa	2,09 Kg/CO2	0,39 Kg/CO2
Prime S30 High GG	30 %	50 MPa	2800 MPa	9,5 %	2600 MPa	1,33 Kg/CO2	-0,28 Kg/CO2
Prime S40 Impact I	40 %	64 MPa	4600 MPa	6,0 %	4300 MPa	1,26 Kg/CO2	-0,30 Kg/CO2



storaenso

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!!! Stora Enso produces no more biocomposites as to 2023 !!!



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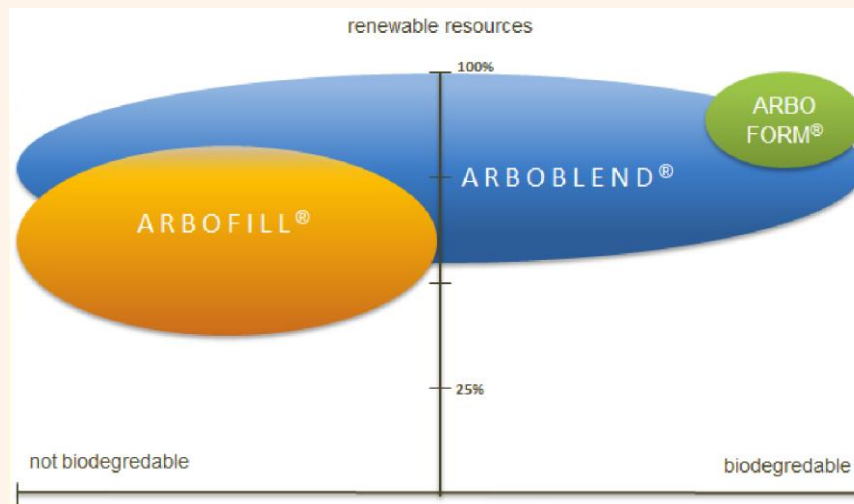
Renewable & Biodegradable Aspects of Wood Composites

Biocomposites by Tecnar

The Tecnar GmbH is an innovative company that develops and produces its own bioplastics and biocomposites based on renewable raw materials.



Product overview



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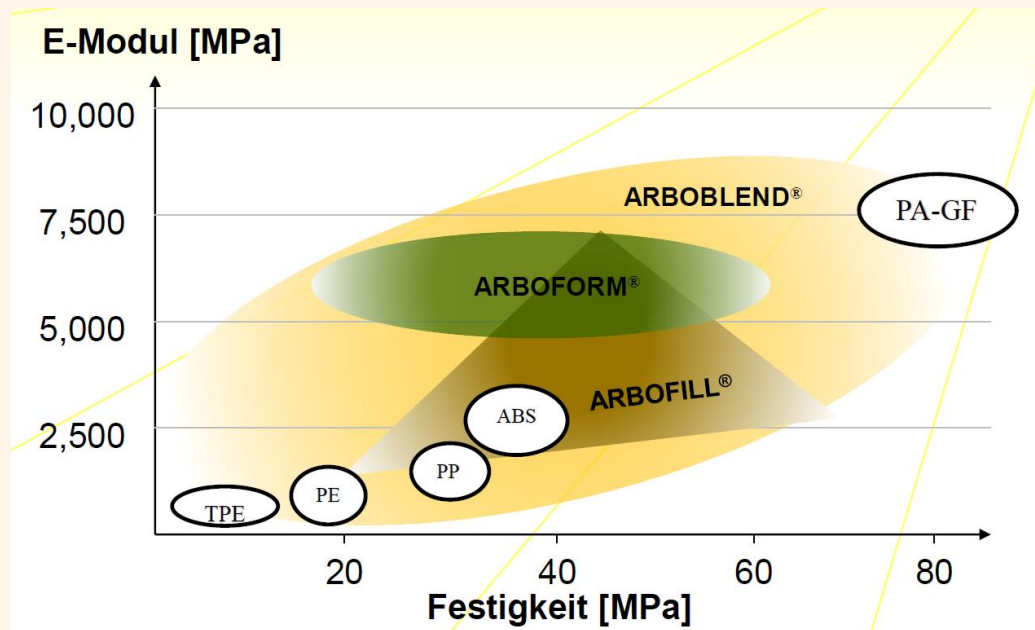
Biocomposites by Tecnar

Product overview

ARBOFORM® is based on the nearly unlimited, abundant raw material LIGNIN (by-product from the pulp industry), adding natural waxes, resins and fibers. Fully bio-based, it is also widely known as *LIQUID WOOD*.

ARBOBLEND® granules are customized blends of different biopolymers with a wide range of properties from soft, flexible to reinforced and stiff grades and can be 100% biodegradable, also.

ARBOFILL® hybrid compounds made from renewable resources and plastics. By combining plastic and organic materials, ARBOFILL® achieves new property profiles and aesthetic finishes at very competitive prices.



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Renewable & Biodegradable Aspects of Wood Composites

Biocomposites by Tecnar

Product overview: ARBOBLEND®

- › ARBOBLEND® combines a great number of material types and a wide range of property profiles.
- › The materials on offer are up to 100% bio-based.
- › Depending on the formula, ARBOBLEND® materials contain biopolymers such as polyhydroxyalkanoates (PHA), polycaprolactone (PCL), polyester (e.g. bio-PET), starch, polylactic acid (PLA), bio-polyolefins (bio-PE), bio-polyamides (bio-PA), lignin, natural resins, natural waxes, natural oils, natural fatty acids, cellulose, organic additives and natural reinforcing fibres.
- › ARBOBLEND® materials are designed to be biodegradable or resistant depending on the intended application. Biodegradability is a property that offers an additional benefit in applications such as urns, plant aids, mulch films and many other uses.




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Manufacturing Process of Wood Composites

 Biopolymer Mix

 Wood Fibers
size < 1 mm

 Fillers (Fibers)/
additives

Batch 1	Batch 2	Batch 3
12 Materials	7 Materials	12 Materials
Biopolymer Mix 1	Biopolymer Mix 2	Biopolymer Mix 2
+ Graphite	+ Wood Fibres	+ Wood Fibres
	+ Recycled Glass Fibres	+ Recycled Glass Fibres
	+ Lignin	+ Lignin



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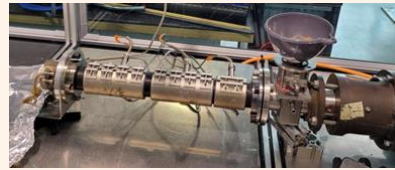
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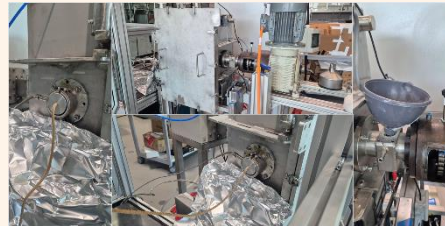
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Manufacturing Process of Wood Composites

Compounding
with Eirich Mixer



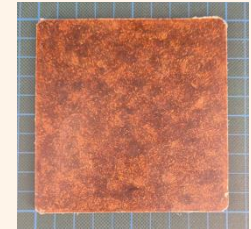
Extrusion



Extrudate
cutting



Test plate
moulding (100 x
100 x 5 mm)



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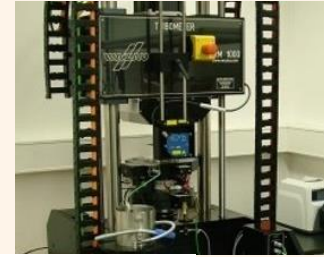
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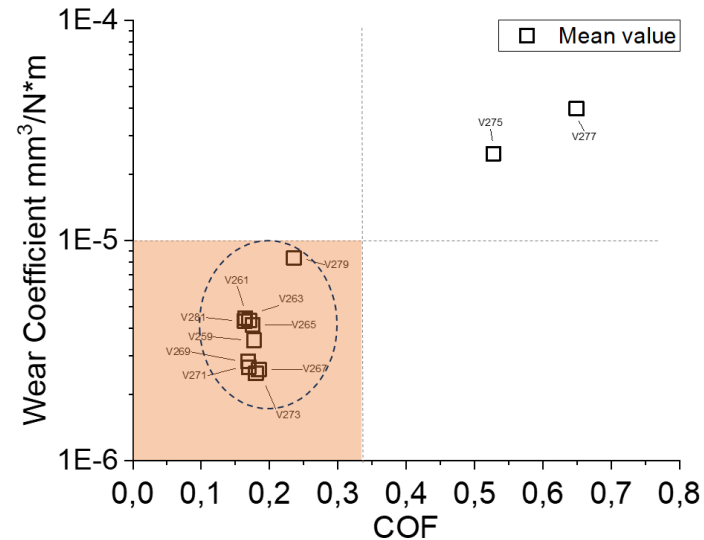
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Tribological testing and validation



Overview of friction and wear results of batch 3 materials

→ *Very good wear properties confirmed and materials selected*



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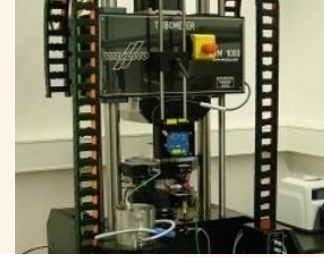
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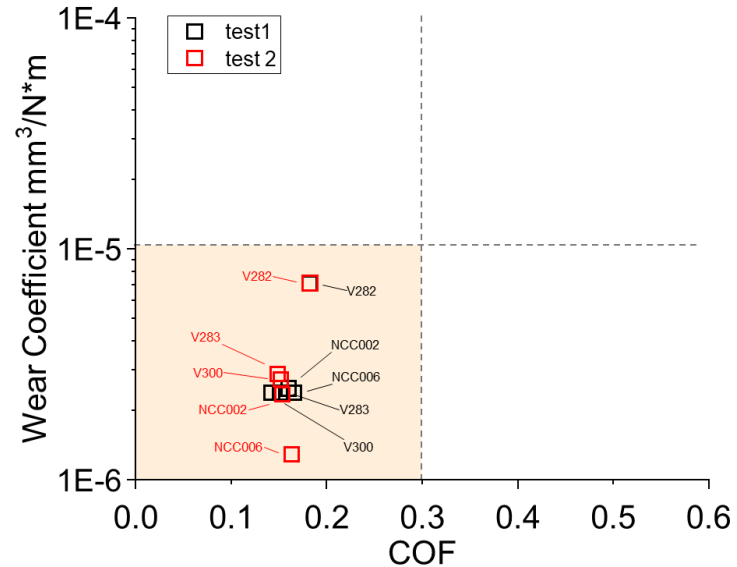
Tribological testing and validation



Overview of friction and wear results of

- *Material panels from NCC (NC*)*
- *Material produced with MW assistance (V300)*

→ *Very good wear properties reproduced and confirmed*



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Challenges in Recycling Wood Composites Based on Bio-Based Polymers

1. Difficulty in Separation & Processing

- **Complex composition** of bio-based polymers and wood fibers makes separation challenging.
- **Mechanical and chemical recycling methods** are not always optimized for bio-based materials.

2. Degradation of Bio-Based Polymers

- Bio-based resins (e.g., soy, lignin, starch-based) may **degrade faster** than synthetic ones, limiting recyclability.
- **Heat sensitivity** of some bio-polymers makes reprocessing difficult.

3. Limited Industrial Recycling Infrastructure

- Few facilities specialize in **bio-based polymer composite recycling**, leading to disposal in landfills.
- **Inconsistent recycling technologies** across regions hinder large-scale adoption.



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Challenges in Recycling Wood Composites Based on Bio-Based Polymers

4. High Costs & Economic Viability

- **Separation and purification** of bio-based composites can be expensive.
- Lack of established **closed-loop recycling** systems makes sustainable recycling less cost-effective.

5. Variability in Material Properties

- Bio-based composites have **inconsistent performance** after multiple recycling cycles.
- Potential for **lower mechanical strength** in recycled bio-based composites compared to virgin materials.

 *Future Solutions: Development of advanced biodegradable resins, efficient separation techniques, and improved industrial recycling processes!*

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Conclusions

-  Eco-Friendly Choice: Wood composites reduce reliance on solid wood, promoting responsible forest management.
-  Waste Reduction: Utilizing recycled wood fibers and plastics minimizes landfill waste and promotes circular economy principles.
-  Lower Carbon Footprint: Compared to traditional materials, wood composites have a smaller environmental impact due to energy-efficient production and carbon sequestration.
-  Durability & Longevity: Longer lifespan and lower maintenance reduce resource consumption over time.
-  Sustainable Future: Wood composites offer a practical solution for eco-conscious industries, balancing performance with environmental responsibility.

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Conclusions



Future Trends

- Smart composites with **self-healing properties**.
- Integration of **fire-resistant and antimicrobial additives**.



Greater use of **agricultural and forestry waste** for truly circular materials.

✂ Development of lightweight, high-strength composites for structural applications.



Use of **3D printing technology** for customized and efficient composite production.

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Thanks for your attention!

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Q&A / discussion

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