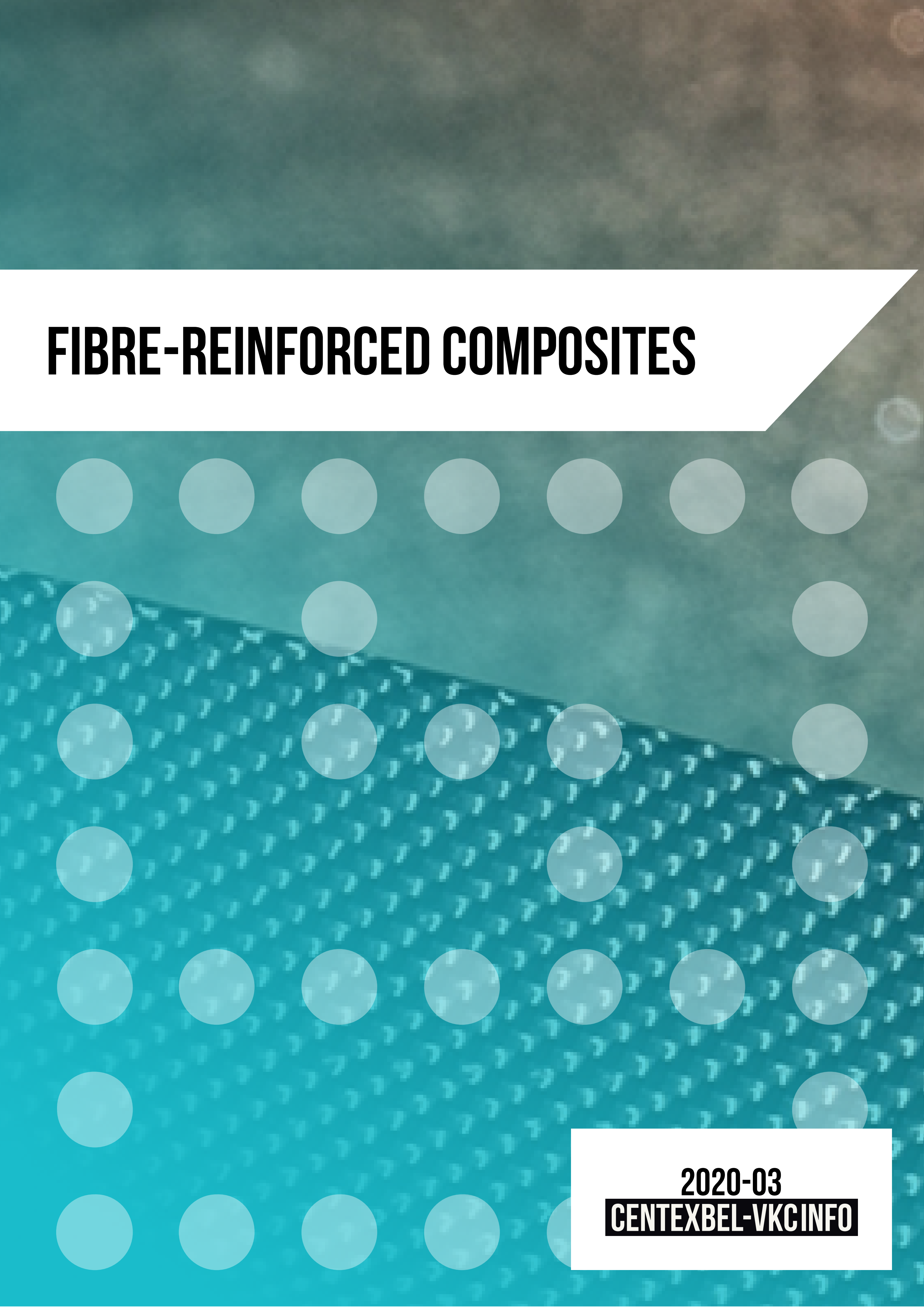


FIBRE-REINFORCED COMPOSITES

2020-03
CENTEXBEL-VKCINFO

Verantwoordelijke uitgever | Éditeur responsable | Responsible editor: Jan Laperre, directeur generaal
Redactiecomité | Comité de rédaction | Redation Committee: Jan Laperre, Stijn Devaere, Eline Robin
Tekstredactie en lay-out | Rédaction et mise en pages | Editing and graphics : Eline Robin
Fotografie | Photographie | Photography : Marc Van Hove

CENTEXBEL-VKC

GENT | Technologiepark 70 | BE-9052 Gent | Belgium | +32(0)9 220 41 51 | gent@centexbel.be
KORTRIJK | E. Sabbelaan 49 | BE-8500 Kortrijk | Belgium | +32(0)56 29 27 00 | info@vkc.be
GRÂCE-HOLLOGNE | Rue du Travail 5 | BE-4460 Grâce-Hollogne | Belgium | +32(0)4 296 82 00 | g-h@centexbel.be

www.centexbel.be

Products made from fibre-reinforced plastics (FRP) or composite materials offer significant environmental benefits because of their characteristically low weight, good mechanical properties and excellent resistance to corrosion. For example, composites used in cars can substantially reduce overall weight – by as much as 40% compared to steel. Over the lifetime of the car, this means many thousands of liters of fuel saved and consequent reductions in harmful exhaust emissions.

Fibre-reinforced composites

Composites are strong and stiff, and retain these characteristics at high temperatures. Benefits of using composites in heavy-duty applications instead of more traditional materials, such as metals, include their low weight, long lifespan and low maintenance costs. There are two types of synthetic composites:

1. Thermoplastic composites are plastics filled with short fibres or combinations of plastic with fabric or 'non-wovens'. Important applications of these materials are car parts such as door panels and dashboards.
2. Thermoset composites are resins filled with long fibres, fabrics or non-wovens. This type is used in applications with high material property requirements, such as sailing yachts and wind turbine blades.

Biobased composites

Biobased composites are fibre-reinforced materials that are partly or completely made from renewable raw materials. Both the matrix material and the fibre reinforcement can have natural origins. Biobased composites are applied in the construction industry, automotive sector and in electronics casings.

The first generation of biobased composites had various drawbacks - mainly in processing and pricing - which delayed their market introduction. With the increasing availability of bioplastics, biobased resins and fibrous materials for composite applications, the quality and applicability of biobased composites has substantially increased over recent years.

Traditional fibre-reinforcing materials such as glass can be replaced by biobased fibre reinforcements such as natural fibres (flax, hemp, wood), viscose and PLA. These biobased materials can be used as long or short fibres, non-wovens and fabrics. An important benefit of the use of biobased fibres in composites is that they are suitable for thermal recycling. Bioplastics and biobased resins are mainly used because of their environmental benefits, including a reduction in CO_2 emissions and the fossil fuel depletion.

Single polymer or self-reinforced polymer composites (SRPC)

The advantages of SRCPs include the ability to achieve excellent interfaces between components, their pure chemical functionality, and their higher value as recyclable products due to their relative homogeneity compared to composites composed of different classes of components. Single-polymer composites are particularly important in biomaterials applications, since any additives composed of different chemicals could affect biocompatibility and biodegradation.

In the next chapters we will present our research, unique expertise and developments, and our equipment in the field of composites. 10 of the 12 ongoing or recently finished projects on composites focus on ecology via bio-based raw materials, the recycling of composite materials or by applying composites e.g. in wind turbine blades (Comp2Blades).

AACoMa places the emphasis on increasing knowledge of advanced composite manufacturing, while CobraComp aims to strengthen the competitive position of the composites manufacturing industry.

AACoMA

Accelerate Advanced Composite Manufacturing

Composites used to be mainly developed for the aircraft and aerospace sector because of their combined lightweight and exceptional mechanical properties. The technical progress made in in material design and advanced manufacturing processes (Industry 4.0) opens new ways for their use in many other sectors.

Contact: Bernard Paquet - bp@centexbel.be

Composites offer innovating opportunities for applications in various industrial sectors including automotive, transport, mechanical engineering, and construction to SMEs desiring to develop and market novel and competitive products.

However, for most SMEs the implementation of disruptive technologies by introducing advanced manufacturing techniques is not without any risks. Prior to investing in new production lines, SMEs need to acquire more knowledge in advanced material and processing technologies, and to produce and test some demonstrators or prototypes.

The AACoMa project focuses on accelerating the advanced manufacturing of composite materials by demonstrating the needed processing technologies in close interaction with companies.

New Materials and advanced processing technologies including additive manufacturing, robotics, virtual engineering, virtual reality and artificial intelligence will be addressed to prove the feasibility of enhancing materials, manufacturing quality and productivity.

The project started on January 1st, 2020 and will end on December 31st, 2022.

Project partners

https://www.centexbel.be/nl/projecten/aacoma
https://www.interregemr.eu

Project financing

Total Budget: € 2,956,906

EU funding: € 1,478,453 (50%)

Braided textiles to boost NWE composite materials industry

While the composite market is growing by 5% per year, end users are looking for parts produced in large series. In Northwest Europe, the composite manufacturing industry is subject to competition from low-cost countries. this trend can be reversed by strengthening the competitiveness of companies, allowing them to innovate through rapid, automated and repeatable manufacturing processes. In particular, it is necessary to innovate the manufacturing and processing of textile reinforcements.

Contact: Baptiste Herlin - bhe@centexbel.be

The objective of the Interreg NWE COBRACOMP project is to develop, test and validate a new automated textile braiding process for the production of preforms for composite materials reinforcement.

During the project, two innovative braiding machines will be developed to manufacture two innovative textile braid architectures, as well as digital simulation and part design tools.

Two technological demonstrators will be manufactured to validate the technical and economic feasibility of the new process, from textile reinforcement to final part.

The creation of a transnational network on composite materials using braids will help to disseminate information. This network will also help sustain the use of project results after its completion.

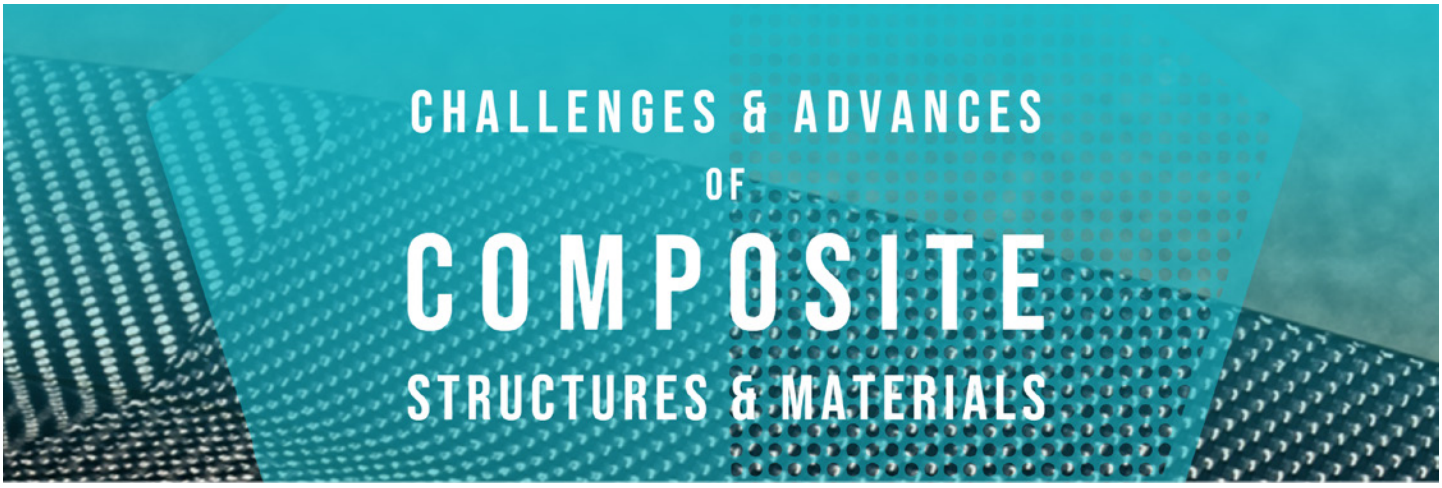
The COBRACOMP project will strengthen the competitiveness of companies in the composite materials production value chain.

Project partners

EU FUNDING : € 2.12 m
TOTAL BUDGET: € 3.54 m

Interreg North-West Europe
European Regional Development Fund

https://www.centexbel.be/nl/projecten/cobracomp
https://www.nweurope.eu/



The second International Conference on "Challenges and Advances of Composite Structures and Materials" - organized by Centexbel on October 7 & 8, 2020 in Liège - will bring together industry innovators, technology providers, researchers, economic promoters and other actors of the Composite Industry from all over Europe.

We would like to invite all experts in the field to deliver a speech at this conference on one of the below topics:

- High performance materials for fibers and matrix
- Processes for composite materials (continuous processes, batch processes)
- Recycling of composite materials
- Repairing, healing composites
- Industry 4.0 in composites production
- FR composites
- Bio-based composites
- Virtual engineering for developing composites
- Applications, including machine building, automotive, transport, aeronautic, aerospace and others
- Regulations for application fields (transport, automotive, etc.)

BLUEPOINT
LIEGE

Call for papers is open until May 31, 2020

Organisation: Bernard Paquet | bp@centexbel.be

Secretariat: Dominique Sacré | dsa@centexbel.be

https://www.centexbel.be/en/agenda/international-conference-composites-2020

Although wood plastic composites or WPCs are usually applied in decking and fencing, other consumer goods are made from this composite material. Within the project Celfi, a 4-year trajectory, in collaboration with wood.be, we have examined whether this class of materials could also offer opportunities for construction applications. Since literature only mentions moduli of elasticity (MOE) and Moduli of rupture in 3-point bending (MOR) on small-scale samples, partner wood.be examined a new testing method to evaluate the potential of market available WPC materials for long-term loading purposes.

Contact: Elke Van De Walle | evw@vkc.be




setup for
long-term evaluation

Long-term testing (up to 8 months) showed that the creep behaviour of WPCs is more simular to the creep behaviour of plastics than of wood. The testing also revealed that only one of the selected market sample had potential for being used in structural applications.

However, a valuable, low-tech and relatively fast method was developed to map long-term mechanical properties. If promising results are obtained with this test method, a more rigorous assessment will be initiated.

In addition, wood.be has invested in a new test set-up to evaluate the impact of infrared ageing on the mechanical properties of WPCs.

In addition to exploring new markets for this class of materials, we have also investigated the **staining of WPCs caused by mould and staining fungi** that are growing more rapidly than decay fungi on WPC materials. Therefore, we have tested several biocides to prevent fungal growth on the surface of the materials.

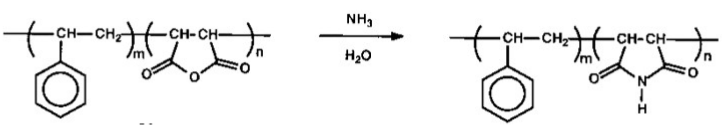
The table below shows the testing scores of all tested methods (1-5), rating the fungal sensitivity of the material. The higher the number, the higher the sensitivity. Biocide 1 showed most effective and offers the best possibility to prevent undesired staining.

Material	Concentration active	Score		
No. of specimen	**Ingredient (%)**	**ASTM D 3273***	**ISO 846-A**	**ISO 846-B**
Scots pine sapwood	/	4	-	-
WPC reference	/	0-1	3-4	3-4
Biocide 1	0,2	0-1	0-1	1-2
Biocide 2	≈ 0,1	0-1	2-3	4
Biocide 2	0,2	0-2	2-3	4
Biocide 2	0,5	0	0-2	4
Biocide 3	7	0-2	0-1	2-3

Anti-fungal test results

The project also addressed the problem related to the **water sensitivity** of WPC materials. We first carried out an extensive comparison of the water absorption properties of different WPC materials, including PVC, HDPE, PP-based and plasticized PVC-based WPCs, before proceeding to the exploration of different routes in view of decreasing the water absorption properties.

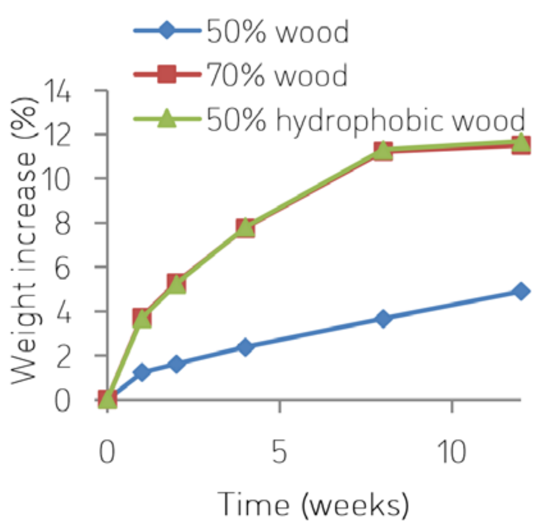
In a first approach, we incubated wood fibres in SMA-based water emulsions, prior to their processing by compounding. We succeeded in transforming wood fibers into hydrophobic (i.e. water repellent) materials: the water was no longer being absorbed by the fibers. However this effect was entirely lost when compounding the fibers in combination with a plastic matrix, at elevated temperatures. The treatment even had a reverse effect on the water absorption properties. The addition of 50% of hydrophobic wood fibres increased the water uptake to the level of WPCs containing 70% of wood fibre.



SMA: poly(styrene maleic anhydride) | SMI: poly(styrene maleimide)

No hydrophobing agent

2% hydrophobing agent



SMA technology resulting in hydrophobic wood (left), however the effect was completely reversed after subsequent processing (right)

As an alternative to the SMA technology, we have evaluated a wood fibre treatment to decrease the water uptake by WPC materials by applying humins as a potential hydrophobing agent for the wood fibres. Humins are a side-product of the PEF (polyethylene furanoate) production process, a bio-based polymer which can be used as a superior alternative for PET.

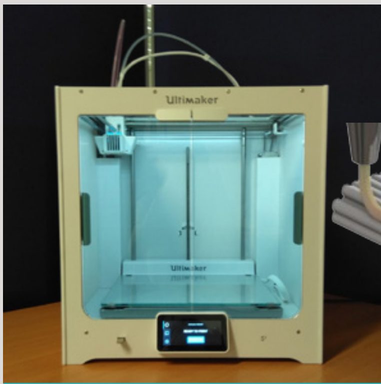
Since significant amounts will become available during PEF production, their use as hydrophobing agent for WPCs seemed an interesting route. Unfortunately, the use of a coupling agent seemed more successful to improve the water absorption properties compared to the humin strategy, so this route has been abandoned.

In sum, we have explored and evaluated different WPC compositions and processing techniques, including extrusion, injection moulding, pressing techniques, and 3D printing.

In this context we have 3D printed PLA-based filaments by means of a filament printer, containing up to 30% of wood fibre and processed PP-based WPC pellets into 3D samples by means of the freeformer technology.

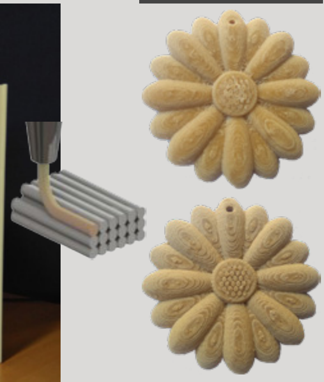
Processing of WPC filaments by 3D printing filament printing technology:

100% PLA | 10% wood | 30% wood



Filament printer

10%wood



30%wood

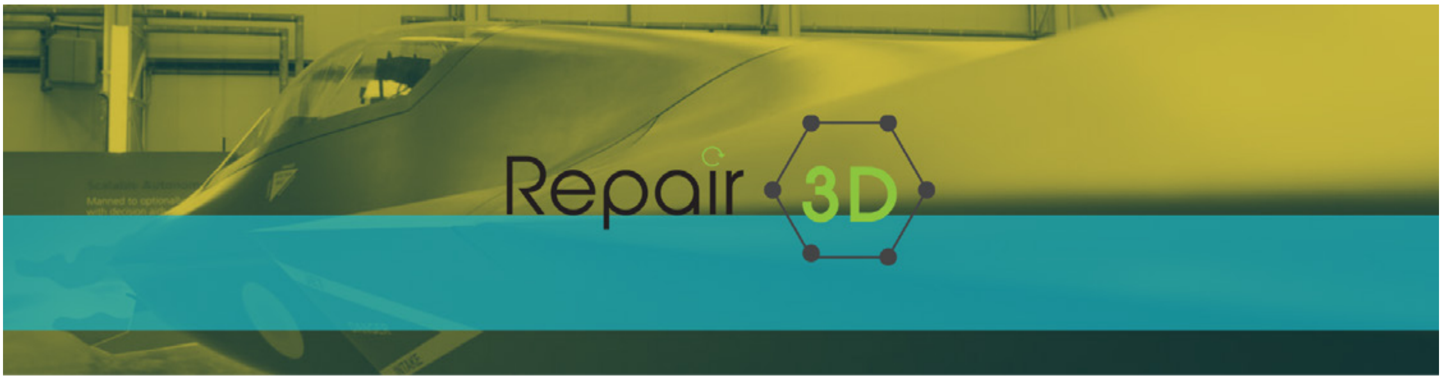
Processing of WPC granulates by 3D printing freeformer technology

WPC granulate

Freeformer 3D printer

90% PP HC250TH
10% lignocel S-150-TR

70% PP HC250TH
30% lignocel S-150-TR



Recycling and Repurposing of Plastic Waste for Advanced 3D Printing Applications

Carbon Fiber Reinforced Polymers (CFRPs) are often used for their high specific strength in a range of different applications, such as aerospace, automotive, civil engineering, and sports. Their 2020 market share is estimated at 155.000 tons[1]. In most cases CFRPs consist of a continuous carbon fiber fabric on which a resin is casted and molded to achieve the desired geometry. But also short carbon fibers can be used to provide significant reinforcement of polymer composites. However, CFRPs components are often discarded after exceeding their lifespan, as they are not suitable for recycling. Their composite nature makes it difficult to separate, recycle and reuse CFRPs.

Contact: Sofie huysman | shu@centexbel.be & Tom Vercoutere | tov@vkc.be

To address this issue, Centexbel participates in the European Horizon2020 project: **Repair3D**.

Repair3D allows us to investigate the use of recycled CFRPs and polymers in the creation of 3D printed products.

Repair3D will demonstrate the circular use of CFRPs through multiple cycles of manufacturing/recycling and provide new ways to use recycled materials.

The goal is to minimize the accumulation of plastic and CFRP waste in landfills. Furthermore, the consortium wants to give a boost to the current technology in the field of CFRP-based 3D printing, recycling and re-use.

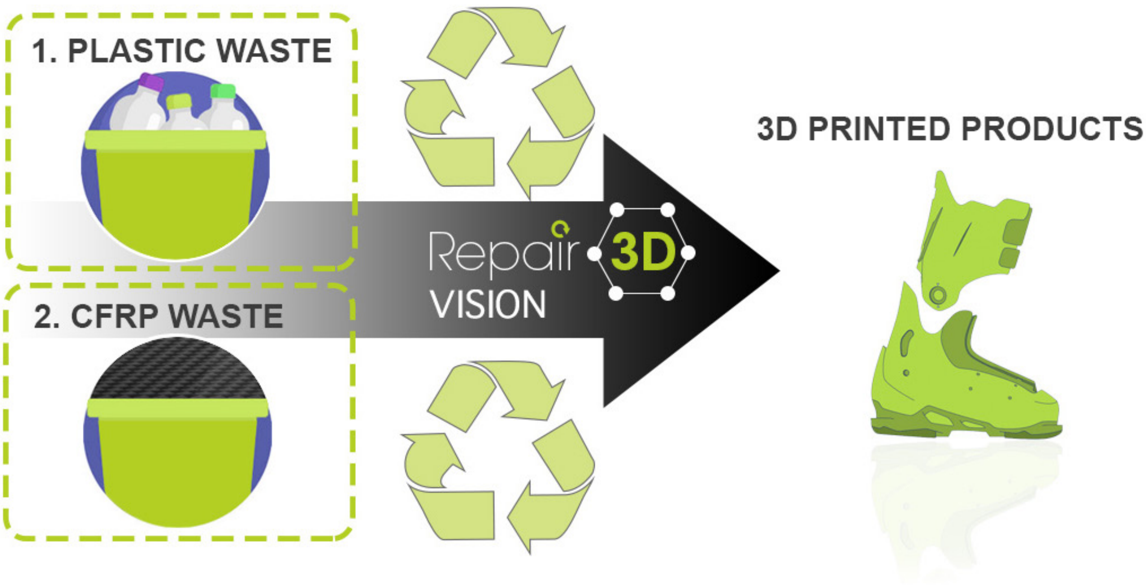


Figure 1: Goal of the repair3D project (CFRP = carbon fiber reinforced polymers)

1 Carbon Fiber Reinforced Plastic Market Worth $27.98 Billion By 2024, Sherry James, grandviewresearch.com, September 2016

Centexbel participates in the following tasks of the Repair3D project:

- production of filaments and pellets incorporating recycled carbon fibers in recycled polymer matrices
- modification and tailoring of the recycled material's properties for the selected additive manufacturing processes
- testing of the produced filaments with fused filament fabrication
- testing of the produced pellets with the Arburg Plastic Freeforming process
- direct 3D printing on textiles for smart textile applications

Figure 2: recycled materials after compounding/pelletization, and used in an additive manufacturing step
LEFT: rPET | RIGHT: rPET reinforced with carbon fibres

Repair3D started on 1/1/2019 and will end on 31/12/2020

Our progress can be followed on
www.repair3d.net
www.centexbel.be/en/projects/repair3d
www.twitter.com/repair3d

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 814588.

Interreg 2 Seas Mers Zeeën
European Regional Development Fund
EUROPEAN UNION

SeaBioComp

There is an increasing demand for composites for applications in a marine environment due to the growing markets for fish and seaweed farming, energy harvesting, boats, pontoons, anchoring and buoy elements, etc. At present only petrol-based composites are being used. Concern is growing about the long-term ecological impact. Litter and microplastics are contaminating the sea, having a detrimental impact on sea-life. There is a need for renewable materials to be developed; reducing the depletion of the fossil based materials, limiting emission of greenhouse gases and reducing ecotoxic impact of microplastics. At the same time, the materials need to meet the highest technical performance and withstand the long term harsh marine environment including mechanical forces, aggressive environment, intense UV light etc. Meeting this duality is a major challenge. SeaBioComp is aiming to address this challenge.

Contact: Gertjan Vancoillie | gvc@centexbel.be

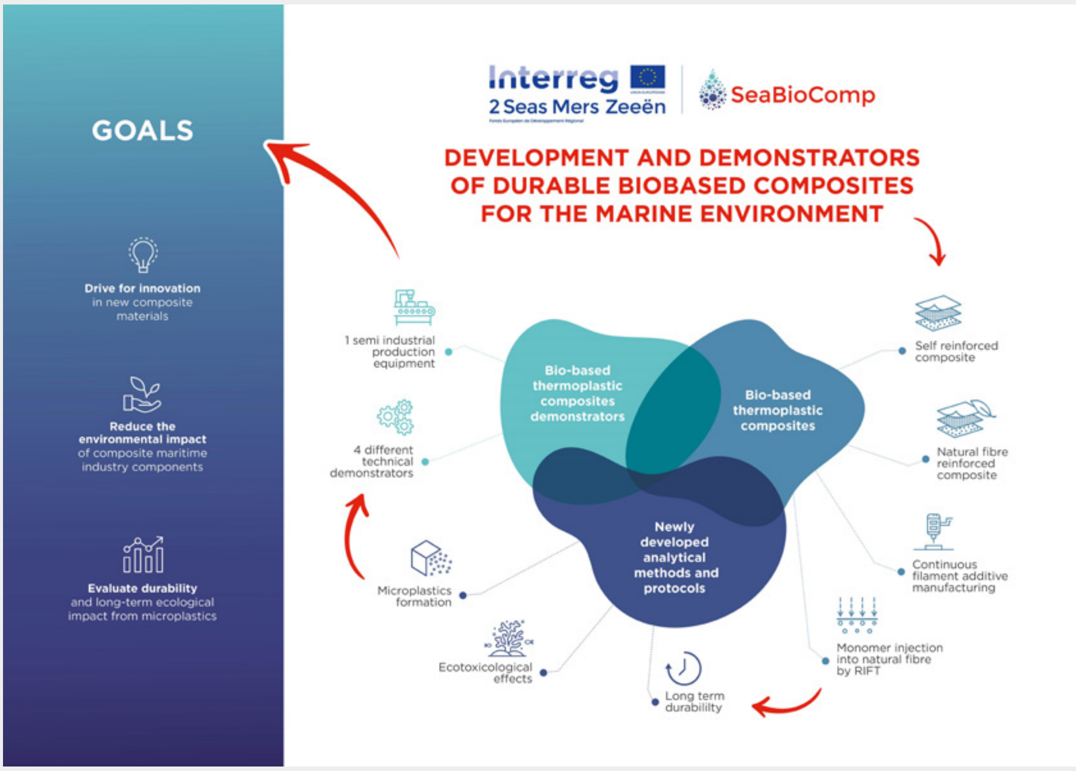
The project will develop 'demonstrator' bio-based composite alternatives to potentially replace traditional fibre-reinforced composites commonly used in the marine industries. Traditional oil-based products including fishing and seaweed farming components, energy harvesting equipment, boats, pontoons, anchoring and buoy parts are potentially being addressed by the project. The bio-composites will not only reduce the depletion of fossil-based resources but should also limit the emission of greenhouse gases and the ecotoxic impact of microplastics, while allowing recycling through the use of thermoplastic bio-polymers. Through the development of the bio-composite demonstrators, the project aims to significantly shift the perception within the marine industries that the use of bio-based composites can offer a realistic and viable alternative. The demonstrators and developed analytical protocols will help both industry and public authorities to address the growing concern regarding the global production and consumption of oil-based plastic materials and the long-term ecological impact of plastic litter and microplastics in the marine environment.

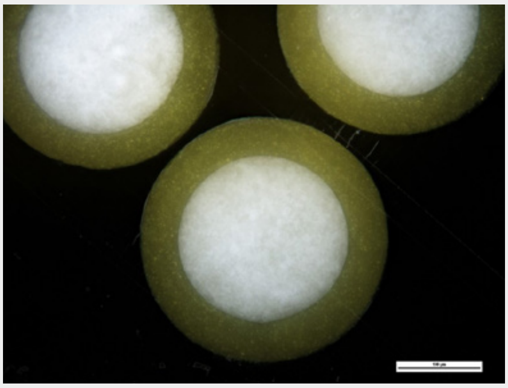
SeaBioComp wants to deliver demonstrators of innovative bio-based thermoplastic composites; with

- at least equivalent mechanical properties
- with -application dependent- tailored durability (2 to >20 years)
- with reduced CO_2 emission (30%), and reduced ecotoxic impact due to microplastics and leachates

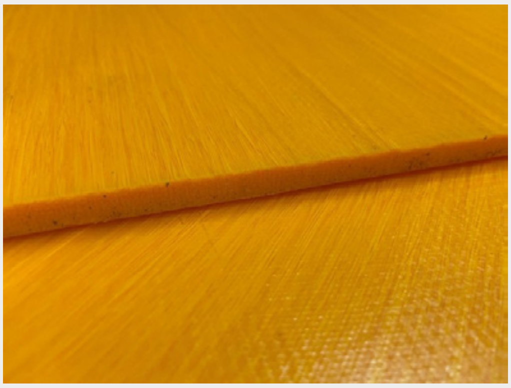
Since thermoplastic composites are envisaged, the recycling potential of recovered materials will be demonstrated as well. Overall the ecologic impact should be reduced by >50% compared to conventional oil-based counterparts. This should lead to a shift in mindset along the value chain, that the biobased composites offer a realistic alternative for the oil based counterparts.

One possible route that will be explored is the use of biobased, self-reinforced thermoplastic polymer composite. By using a bicomponent extrusion technique available at Centexbel and CETI, filaments will be developed containing a high melting thermoplastic biopolymer as core with a layer of low melting thermoplastic biopolymer around it as sheet. After winding these bicomponent filaments on a frame, composites will be made using conventional compression moulding at IMT-Lille Douai. By carefully selecting the parameters of the compression moulding process, the sheet will melt and acts as matrix around the solid high melting cores creating unidirectional fibre-reinforced composites. Currently, the mechanical properties of the composites are further optimized and the first marine aging studies are underway. In the next steps of the SeaBioComp project, these biobased, self-reinforced thermoplastic polymer composite will be further strengthen by combining them with flax-reinforcement fibres.





Microscopic cross-section of core/sheet bicomponent filaments



fabricated unidirectional biobased composites within SeaBioComp.

The project partners include research institutions, university research groups, SME's and specialist cluster organisations. SeaBioComp is co-funded under the EU Interreg 2 seas programme, within the Technical Innovation theme. SeaBioComp runs from March 2019 to August 2022 with an overall budget of €4.1M, €2.5M of which (60%) is funded from the European Regional Development Fund.

SeaBioComp is led by Centexbel (BE) and combines experts in polymer research, textile and composite formation with marine institutes, sector cluster organisations and public authorities.

Anyone interested in this important and growing area of bio-based materials for the marine environment is invited to join the Interest Group at www.seabiocomp.eu/interest_group/

Subscribers to the Interest Group will be kept informed of relevant events and forums, project activities, results etc. The aim of the Interest Group is to stimulate inclusive engagement of external stakeholders and interested parties including the triple helix of academia, industry and public authorities.

http://www.seabiocomp.eu/

CENTEXBEL CETI Centre Européen des Textiles Innovants VLIZ ARMINES IMT Lille Douai École Mines-Télécom IMT-Université de Lille Poly Products Maatwerk in composieten

University of Plymouth University of Portsmouth marine south east EuraMaterials Ifremer REWIN

Fully recyclable and reusable green composites based on bioresins and natural fibres

To create fully recyclable and reusable green composites with bio-resins and natural fibres, we have selected hemp, recycled jute, linseed and flax fibres to produce nonwoven felts. The processing parameters we have examined included felt thickness, needling intensity and fibre quality. We were able to realise a solution between a good resin diffusion and strength by adjusting the needle intensity during processing.

More info: Monika Rymarczyk | mr@centexbel.be

To improve the **adhesion and compatibility between natural fibres and bioresins**, we have performed several surface modification operations on the nonwoven felts to create a perfect surface interaction between the fibre and thermoset matrix, necessary to improve the stiffness and loadbearing properties of the composites.

The surface modification results were analysed by means of the contact angle method and specific absorption tests for nonwovens. Samples of the treated felts were then sent to the project partners for further evaluation.

Thanks to the excellent compatibility between the natural fibres and the thermoset resin we were able to achieve in the laboratory, no further property improvements of the modified samples were needed.

At the same time, the **resin hardener combinations** have been examined. Several hardeners were combined with epoxidized linseed oil (ELO) and humins to obtain a mixture that is sufficiently reactive for biocomposite production.

The different natures of humins - containing many hydrophilic groups - and ELO - which is hydrophobic - prompted to look for an appropate hardner to prepare a reactive mixture.

Therefore, the development of bioresins was split up: a first route focused on generating a bioresin formulation, on maximising the biocontent, on optimising the processability and on being competitive to standard epoxy or phenolic resins. The second route studied the reversibility of the cross-links. The final objective was to combine the results of both research routes in one single formulation.

1. BIOCONTENT

To increase the bio-content of standard epoxy resin formulations we added a small amount of humins (bio compound). A standard epoxy resin was used for reference tests to understand the impact of humins on the resin's processability and on the performance of the final product. It was shown that only a low percentage of humins can be added because higher concentrations tend to decrease the performance of the formulation, due to viscosity and reactivity issues. Additional research was carried out on the viscosity of the formulations. The viscosity was decreased by changing the humins' properties or by incorporating additives.

A high biobased content (> 60%) in the resin was obtained by combining a standard hardener and two bio-compounds (humins and a biobased epoxy). By altering the ratio between bio-compounds and hardener it is possible to shift the resin's properties from elastic and soft to rigid and brittle.

The formulations of bio-resins containing biobased epoxy / humins / hardener were used to produce composite structures with glass fibre, woven flax fibres and hemp and linseed nonwoven reinforcing structures. These structures were submitted to several tests including bending tests, tensile tests, thermal conductivity, etc. The results showed that nonwoven structures based on natural fibres are not strong enough to compete with glass fibre.

On the other hand, reinforcing woven structures based on natural fibres can offer a satisfying level of reinforcement and replace glass fibres. Characterisation tests showed that natural fibre-based nonwoven structures are suitable as isolation or shock absorbent materials.

The bioresin formulations have been evaluated to optimise the processing conditions and to reduce the processing cycle time and are ready to be upscaled.

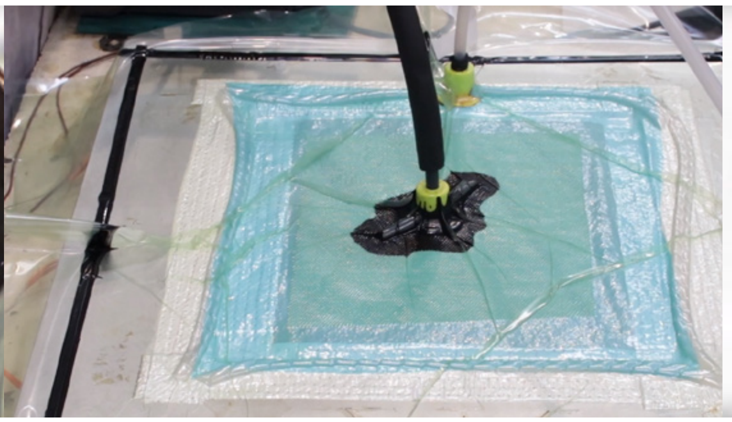
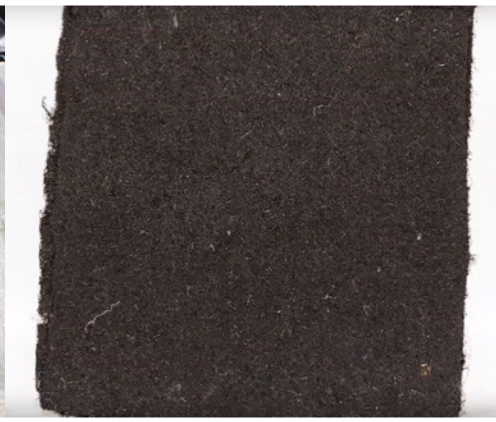
2. Reversibility of cross-links

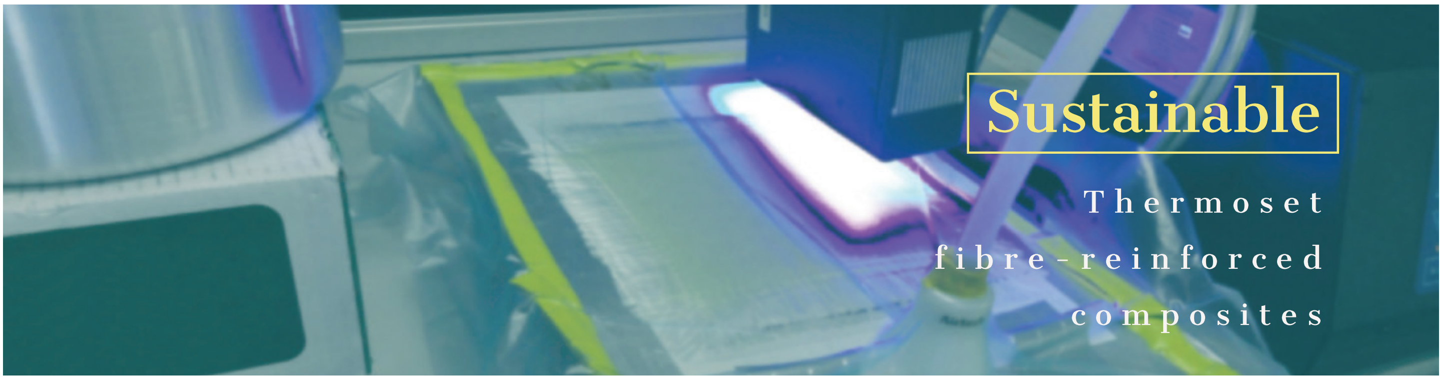
The recyclability and reuse were upgraded by implementing reversible hardeners in the thermoset formulation. Several hardeners were investigated including DTBA (2,2′-dithiobenzoic acid), AFD (4-aminophenyl disulphide) and DTPA (3,3′-dithiodipropionic acid). It could be shown that under lab conditions a reusable formulation is feasible but, in general, processing is difficult. Only formulations with lower humins content offer acceptable properties. The upscaling of the trials pointed out that some solutions have a very promising performance and can be applied in composite structures.

This project has been co-funded by the Life programme
LIFE15 ENV/BE/000204

Co-funded by:
provincie Oost-Vlaanderen

www.recysite.eu
info@recysite.eu



Sustainable thermoset fibre-reinforced plastics

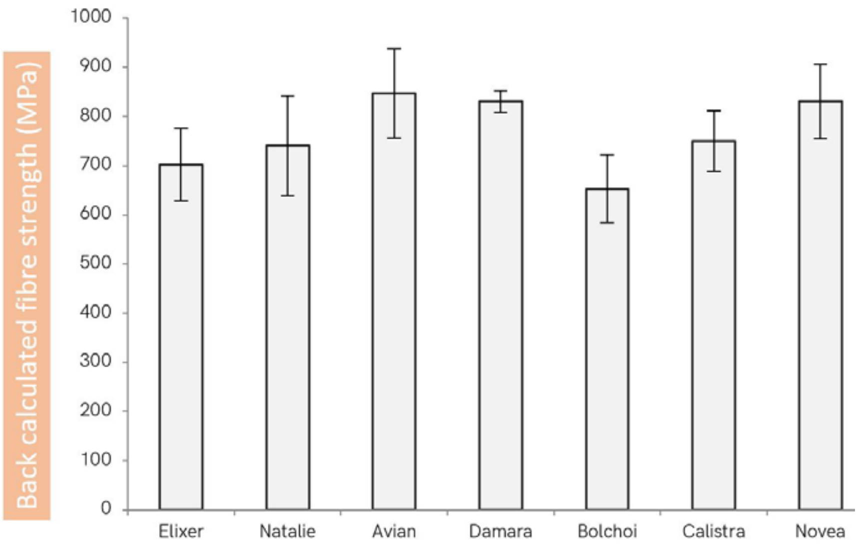
Frederik Goethals | frg@centexbel.be

Thermoset fibre-reinforced plastics are high-quality composite materials that, depending on the composition, can even replace aluminium and steel in structural applications. These materials are durable in themselves because they have a long service life and are lighter than metals. However, recycling these materials is not so easy because thermoset plastics cannot be remelted.

Recycling usually means thermal energy recuperation (incineration) or grinding and reuse as filler material. In addition, research is carried out in order to break down the matrix via solvolysis processes in order to obtain matrix monomers again. On the other hand, it is also possible to make the thermoset composites even more sustainable by:

- Using renewable raw materials
- Using less harmful resins
- Making the curing process more efficient

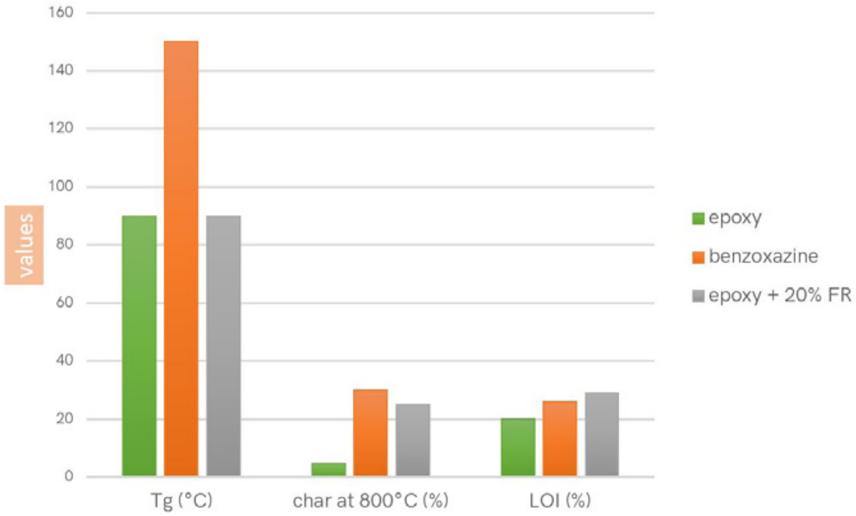
This article focuses on Centexbel's research on these 3 above-mentioned themes. Flax fibres are known for their good mechanical properties and also thrive in our regions, making them a more durable alternative to glass fibres. However, there are different types of flax fibres and in the Biocompal project we will find out which one is most suitable for composite applications. The strength of some flax varieties is shown below.



The graph clearly shows that there is a difference in strength between the fibres, and for composite applications, of course, the higher the strength, the better. This means that Avian, Damara and Novea are the most promising varieties. Research is still ongoing to see if these results are reproducible after different harvests, because flax remains a natural product whose quality also depends on climatic conditions (rain, drought, temperature, soil conditions, and so on).

By combining these fibres with a bio-based resin (e.g. bio-epoxy), high-quality composites with a high bio content are obtained.

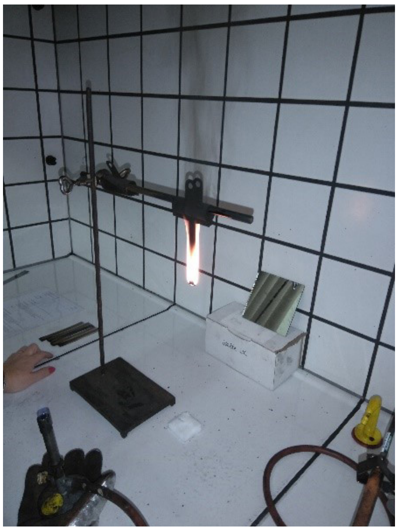
The SUSCOMTRAB project uses resins that are less harmful (CMR and solvent-free) to people who come into contact with them. For low viscosity processes (RTM, infusion) bio-epoxy is again used. For high viscosity processes (prepreg + thermopressing) polybenzoxazines are used as a resin. Benzoxazines are 1k thermoset plastics that harden through a ring opening polymerization reaction in which no side reactions occur. Benzoxazines have a high temperature resistance, good mechanical properties and are also fire retardant. Below a comparison is made in properties between the benzoxazine resin and a conventional epoxy.



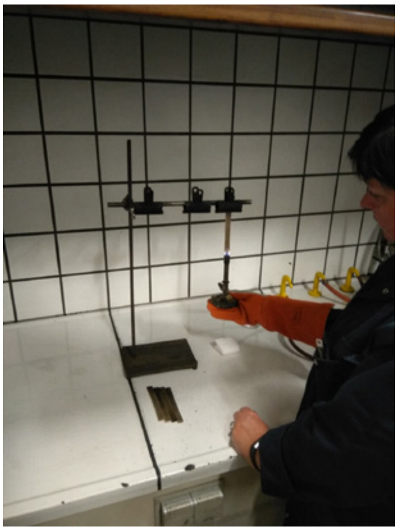
This graph clearly shows thermal (Tg: glass density temperature) and fire-retardant properties (char and LOI: limited oxygen index) in favour of the benzoxazine resin. By adding fire-retardant (FR) additives to the epoxy resin, the FR properties of the epoxy resin can be greatly improved. On the other hand, adding non-liquid flame retardants increases the viscosity of the matrix, making good fibre impregnation more difficult. However, the viscosity can be lowered again by adding additives and the mechanical properties can be increased again.

	FR (%)	Add 1 (%)	Add 3 (%)	Add 4 (%)	Add 5 (%)	Add 6 (%)	Viscosity RT (mPa.s)	Bending Strength (MPA)
suscomtrab 10_01	20						2920	44
suscomtrab 10_02	20	0,5					2350	80
suscomtrab 10_03	20		1				2150	80
suscomtrab 10_04	20			0,2			2130	58
suscomtrab 10_05	20				2		1810	76
suscomtrab 10_06	20					2	2090	70

The resins are combined with basalt fibres and FR-treated flax to produce durable high quality composites with good FR properties.

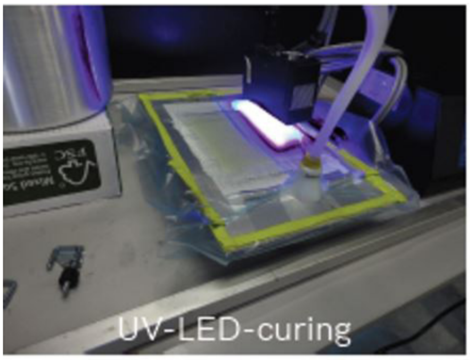


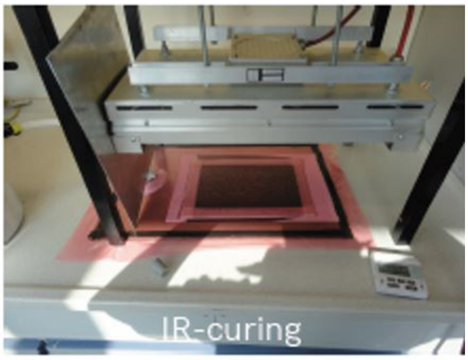
UL94 test:
composite without FR-additives

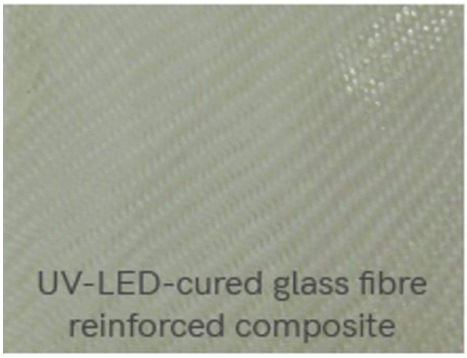


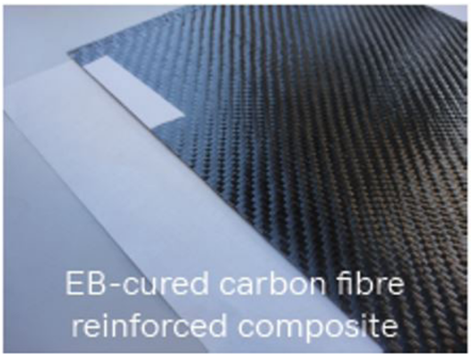
UL94 test:
composite with FR-additives

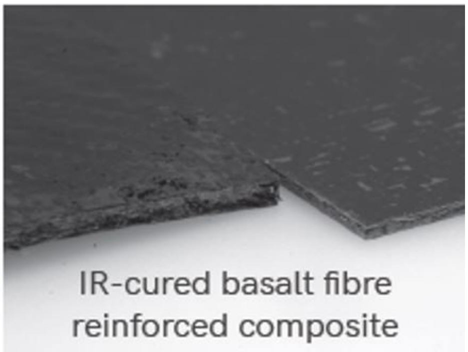
In addition to selecting the right raw materials, more sustainable composites can also be developed by optimising the curing process. In the Fenecom process 3 alternative curing processes to thermal curing were investigated. These techniques are UV-LED curing, E-beam curing and infrared (IR) curing.



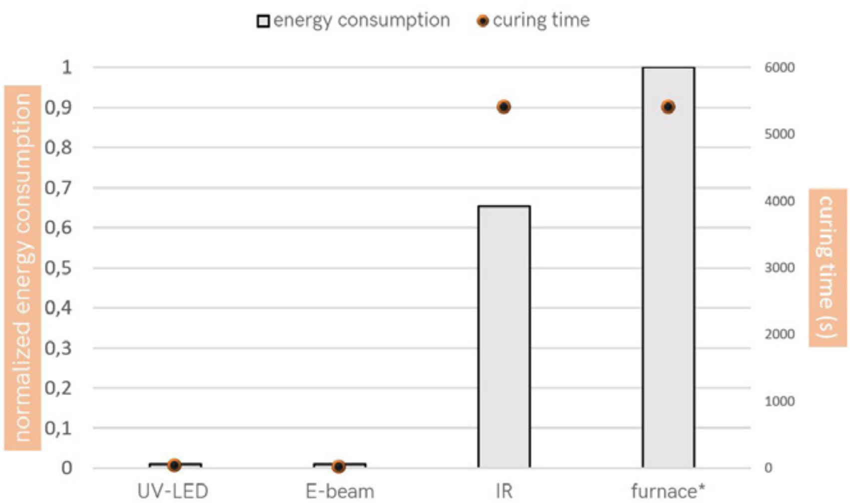








UV-LED, as the name suggests, uses UV radiation to cure the matrix. In order to use this technology, the resin must react to UV light and the fibers must allow the UV light to pass through. This means that this technology is very suitable for making glass fibre reinforced plastics as glass fibres allow UVA radiation to pass through. EB curing, uses electron beams to harden out the matrix. The matrix formulation is quite similar to that for UV curing, but the voltage of the E-beam and the density of the fibers determine the thickness of the composite plate. The lower the density of the fiber, the deeper the electrons can penetrate. Therefore, carbon reinforcements are more suitable than glass fibres as the density of carbon is about 1.8 g/cc while the density of glass fibres is about 2.5 g/cc. In IR curing, the IR radiation is absorbed by the resin and converted into heat. Since it is not necessary to heat a medium (e.g. air) first, this is a more efficient technique than curing with warm air. The graph below shows the potential in energy and time efficiency of the radiation curing technologies compared to thermal curing.

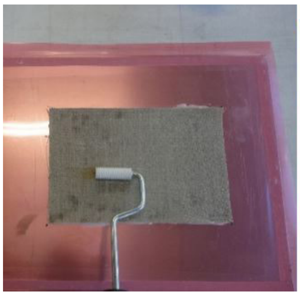
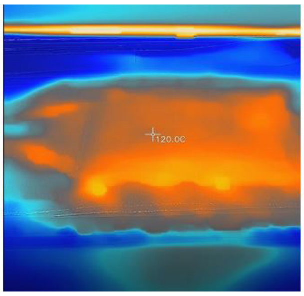
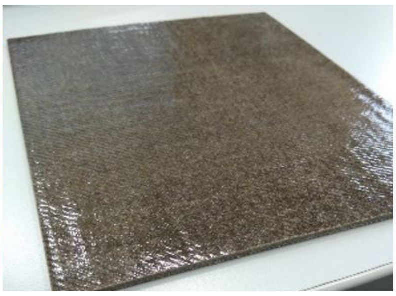
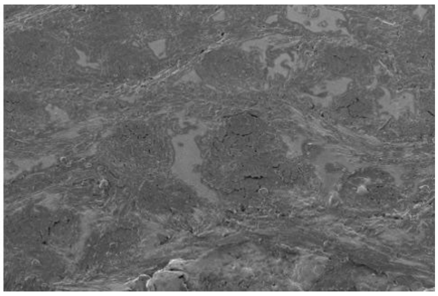


*electrical furnace heated at 120°C for 90 min to cure the epoxy

(= same epoxy resin as used for IR-curing)

This graph clearly shows that UV and electron beam can cure composites quickly and energetically and are therefore a good alternative to thermal curing for glass fibre reinforced composites (UV) and thin carbon laminates (EB). IR curing is less efficient than UV and E-beam curing, but is still more efficient than thermal curing. In addition, IR curing is less dependent on the type of fibre and thickness than UV and EB curing.

Finally, sustainable raw materials and sustainable curing processes can be combined so that the final product becomes even more ecological as is shown below by a flax-bio epoxy composite cured by IR radiation.

Theme-related projects

	website	supported by
Biocompal	http://www.biocompal.eu/	Interreg France-Wallonie-Vlaanderen; Union Européenne Europese Unie; GoToS3 BIOCOMPAL
Fenecom	https://www.centexbel.be/en/projects/fenecom	cornet; Agentschap Innoveren & Ondernemen; Vlaanderen
Suscomtrab	https://www.centexbel.be/en/projects/suscomtrab	cornet; Agentschap Innoveren & Ondernemen; Vlaanderen

The following titles and summaries complete the list of our ongoing research projects in the field of (sustainable) composites:

Comp2Blades

Development of a hightech blade and an innovative production process for small windmills with vertical axes

01 July 2017 - 30 June 2020

ECOxy

Fibre reinforced thermoset composites (FRTCs) are attractive materials for high demanding sectors, such as automotive or construction, because of their lightweight and excellent mechanical properties.

01 June 2017 - 30 November 2020

LIBRE

This project will utilise lignin-rich side stream feedstock from the pulp and paper industry, blended with a biopolymer precursor fibre, to create a more resource-efficient and sustainable carbon fibre production process.

01 November 2016 - 31 October 2020

RECY-COMPOSITE

The project addresses the problems related to the mechanical and chemical recycling of composite materials (pyrolysis and solvolysis) and the energy recovery if recycling is not possible. The applied research is conducted on the production waste stream of thermo-curing composites and of end-of-life in thermo-curing and thermoplastic composite materials.

01 October 2016 - 30 September 2020

MACOBIO

MACOBIO is part of the project cluster FEDER 2014-2020 - Low Carbon Footprint Materials - addressing the validation of natural resources for the production of novel biobased materials. MACOBIO aims to design 100% biobased composite materials, including innovative thermoplastic and thermoset biobased matrixes, reinforced with natural fibres.

01 May 2015 - 30 June 2020

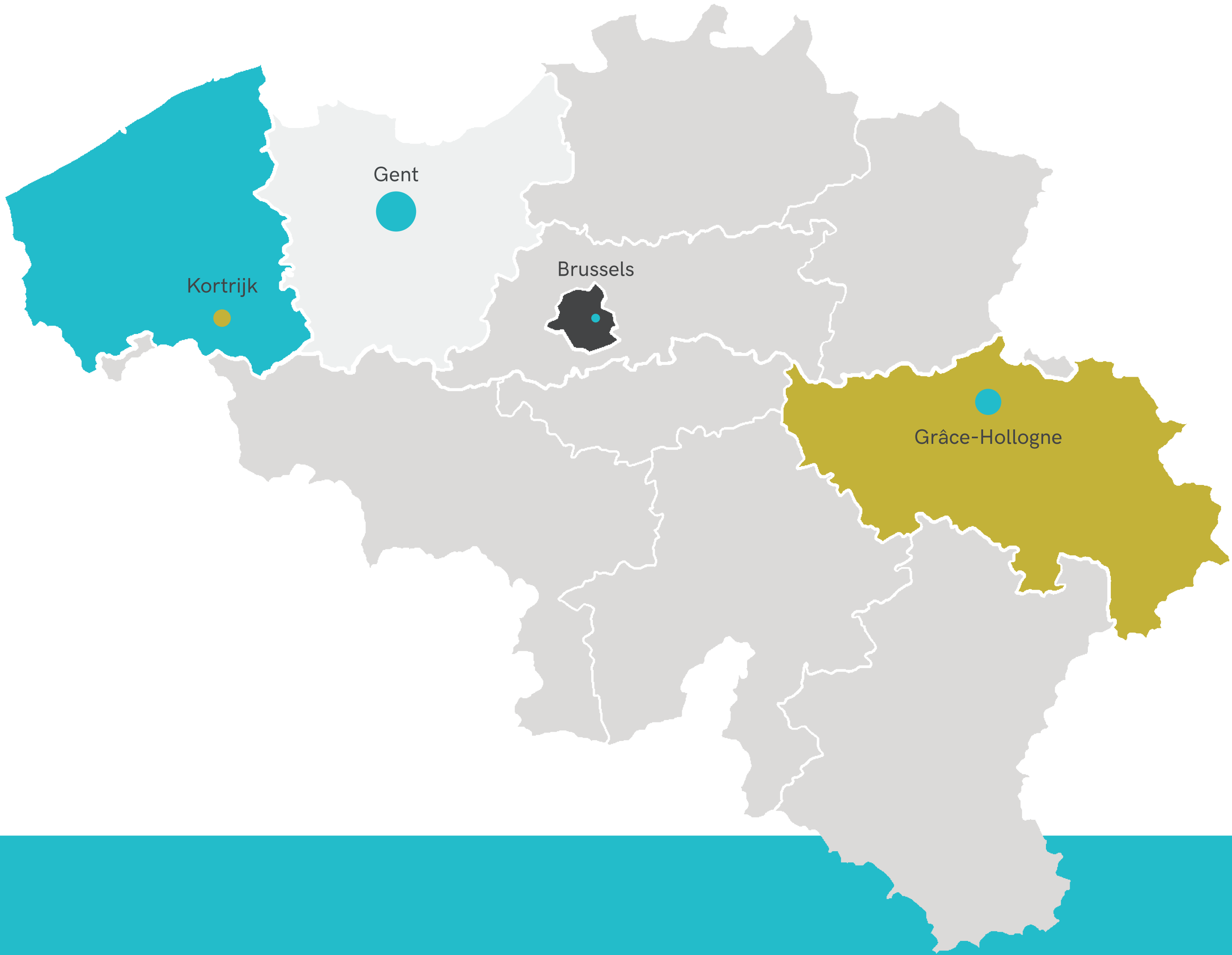
all project can be consulted on https://www.centexbel.be/en/projects

CREATE

CONNECT

INSPIRE

SOLVE



Centexbel-VKC

GENT | Technologiepark 70 | BE-9052 Gent | +32 9 220 41 51 | gent@centexbel.be
KORTRIJK | E. Sabbelaan 49 | BE-8500 Kortrijk | +32 56 29 27 00 | kortrijk@centexbel.be
GRÂCE-HOLLOGNE | Rue du Travail 5 | BE-4460 Grâce-Hollogne | +32 4 296 82 00 | g-h@centexbel.be
www.centexbel.be