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CHALLENGES AND ADVANCES OF

COMPOSITE

STRUCTURES AND MATERIALS

CENTEXBEL International Conference

-- 19 (& 20) OCTOBER 2021 --

Centexbel's second edition of the International Conference on Composites - Challenges and Advances of Composite Structures and Materials - will bring together industry innovators, technology providers, researchers, economic promoters, and other actors of the Composite Industry from all over Europe.

CALL FOR PAPERS

WE WOULD LIKE TO INVITE ALL EXPERTS IN THE FIELD TO DELIVER A SPEECH AT THE CONFERENCE ON ONE OR MORE OF THE FOLLOWING TOPICS:

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

More information, deadlines for submission and templates:
https://www.centexbel.be/en/agenda/challenges-and-advances-composite-structures-and-materials
Organisation: Bernard Paquet | bp@centexbel.be
Secretariat: Phoebe Strassart | pst@centexbel.be

COMPOSITES IN SPACECRAFTS

This month marks the 60th anniverserary of one of two iconic dates in the history of space travel, when Yuri Gagarin made the first manned space flight in the Russian "Vostok" spacecraft on April 12, 1961. The second iconic date being July 20, 1969 with the first Apollo moon landing.

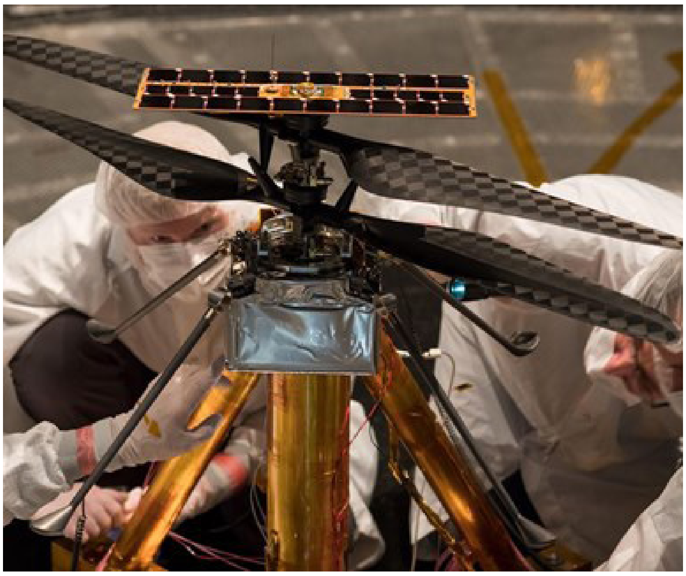
Although, at the time the Apollo capsule was built, the composites industry was still in its infancy and the materials were not yet in widespread use, the Apollo capsule used early composite technology in the form of an ablative heat shield made from Avcoat, an epoxy novolac resin with silica fibres in a fibreglass-phenolic honeycomb matrix. A fibreglass honeycomb was bonded to the primary structure and the paste-like material was injected into each cell individually.

Apollo's heat shield was made of epoxy phenolic novolac resin in a fibreglass honeycomb. © CW photos | Scott Francis

Since Apollo, advanced composites have played a significant role in space programmes and are applied in launch vehicles, the space shuttle, satellites, space telescopes and the International Space Station ISS.

Today, we are witnissing a renewed interest in space travel in the increasing funding (mainly by the US and China governments) of space programmes to the explosive growth of commercial space-travel enterprises (e.g. SpaceX of Elon Musk, Boeing with the CST-100 Starliner, Blue Origin of Jeff Bezos), where composites and advanced materials play a key role in the manufacturing of launchers, spacecrafts and instruments.

The CW article **Composites in Space**[1] gives a overview of today's US based composite developments, from large-scale rocket parts comprising sandwich structures of more than 8 meters in diameter made of carbon fibre skins with an aluminum honeycomb core over the Z-2 spacesuit prototype featuring a carbon/epoxy torso and hip elements to the Mars helicopter, where more than 1,500 individual pieces of carbon fibre were used in its construction.



More than 1,500 individual pieces of carbon fibre were used in the construction of the Mars helicopter. Source | NASA

NASA's new EVA suit provides improved range of mobility. Source | NASA

1 https://www.compositesworld.com/articles/composites-in-space(2)

BREPLA

Biobased fibre REinforced PLAstics

Frederik Goethals: frg@Centexbel.be

The BREPLA project aims to accelerate the transition to the production and application of bio-based composites. To that end, we expand our knowledge of bio-composites and stimulate and activate their industrial implementation. Cooperation with companies is key to a successful transition. BREPLA focuses on 3 sectors with the greatest potential: furniture, transport and consumer goods.

WITH THE BREPLA PROJECT, FLANDERS IS TAKING BIO-COMPOSITES TO A HIGHER LEVEL: FROM DEMONSTRATOR TO COMMERCIAL PRODUCT!

By means of collective actions and a broad, easily accessible awareness raising, we involve the entire value chain in the transition to bio-composites:

- technological training for frontrunners
- hands-on workshops for innovation followers
- composite demonstrators
- a project website, blogs, etc. show companies whether and how quickly they can implement the technology.

DISCOVER HOW THIS TRANSFER OF KNOWLEDGE CAN HELP YOUR BUSINESS AND JOIN THE BREPLA PROJECT

https://www.centexbelpresents.be/en/brepla

ACKNOWLEDGEMENTS

BREPLA is a COOCK project of Centexbel in cooperation with Sirris and receives funding from Flanders Innovation & Entrepreneurship (VLAIO HBC.2020.2567)

AGENTSCHAP INNOVEREN & ONDERNEMEN

https://www.centexbel.be/en/projects/suscomtrab

Frederik Goethals: frg@Centexbel.be

During the Cornet project Suscomtrab we have developed several sustainable thermoset composites with a good flame retardancy, which is a requirement in transport and building applications. We selected basalt (natural rock) and flax fibres (vegetal), two sustainable fibres. For the matrix we selected polybenzoxazine and bio-epoxy.

1. FLAX – BIO-EPOXY COMPOSITE

The flax fibres underwent a FLAM-FIX treatment by Veramtex[1]. In our burning behaviour lab, we determined the FR properties by conducting the limited oxygen test (LOI) on:

- non-treated flax fibres (LOI: 20 => not flame retardant)
- FLAM-FIX treated fibres (LOI: 30 => flame retardant)

LIMITED OXYGEN INDEX (LOI)

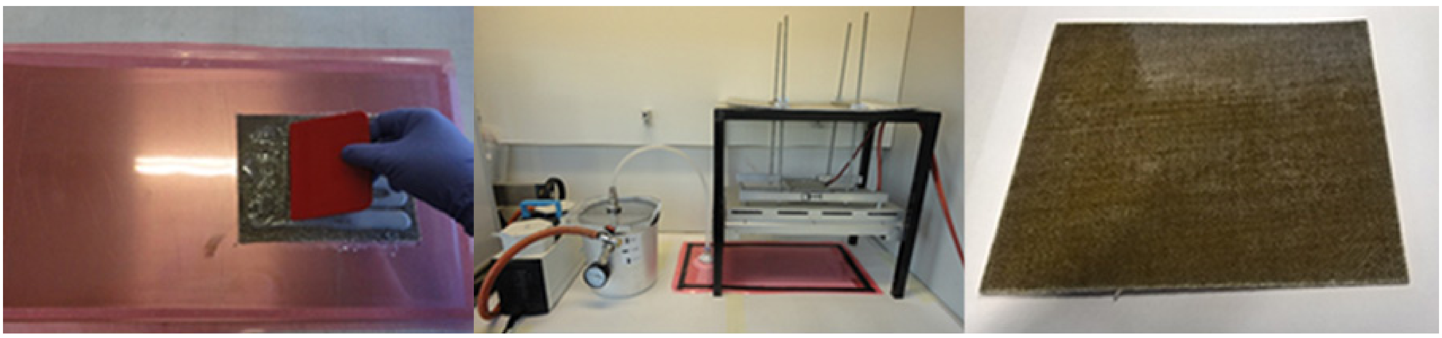
This method is used to determine the flammability of plastics with the help of the limiting oxygen index.
The test calculates the minimum oxygen concentration that will just about support combustion of the test specimen in a mixture of oxygen and nitrogen. The results are referred to as the limiting oxygen index (LOI).

Pre-treatment:

> 88 h / 23 °C / 50 % relative humidity

Summary of the test method:
A test specimen is placed vertically in a mixture of oxygen and nitrogen flowing upwards through a transparent chimney and ignited with a propane gas flame. The flammability of the specimen is observed and the burning time or the burned distance calculated.

The FR treated flax fibres were then impregnated with a bio-epoxy and cured under vacuum (vacuum bagging process) to form the composite.



Impregnation | Vacuum Bagging | Composite

[1] https://www.veramtex.com/flamfixe_en_GB.html

We also added flame retardants (APP and ATH) to the epoxy matrix that was then submitted to the UL94V test to determine the FR effect.

Left: Flax epoxy composite without FR additives

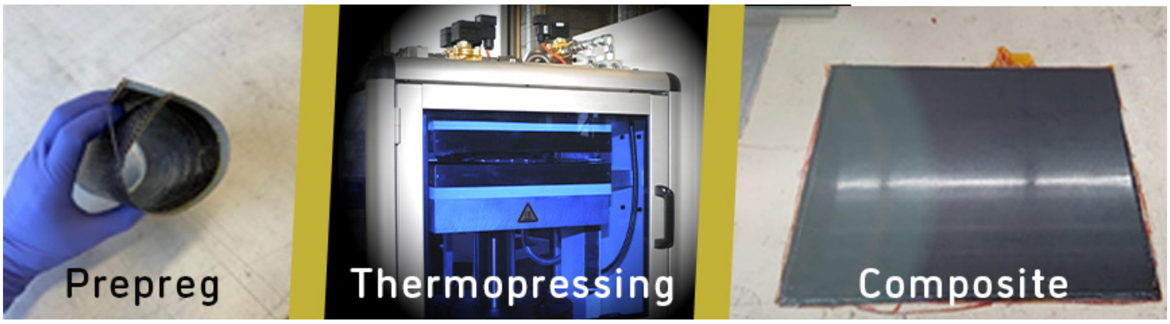
Right: FR treated flax epoxy composite

2. BASALT – BENZOXAZINE COMPOSITE

Benzoxazine resin has good mechanical as well as good thermal properties. Benzoxazines also show better fire, smoke, and toxicity properties than epoxies.

However, as benzoxazine resins typically require curing temperatures of ± 200° C they are not very suited to be treated together with natural fibres. Therefore, we decided to combine the benzoxazine resins with basalt fibres.

We prepared the prepregs by heating the resin to 100°C to impregnate the basalt fabric and then cured the prepregs in a press at 200°C to form the composite.



The UL94V flame test on the basalt-benzoxazine composite resulted in an excellent V-1 score. The addition of an APP flame retardant resulted in an even superior V-0 score.

Flammability rating according to vertical flame test method UL94V:

Test criteria	V-0	V-1	V-2
Burning time of each individual test specimen (s) (after first and second flame applications)	≤10	≤30	≤30
Total burning time (s) (10 flame applications)	≤50	≤250	≤250
Burning and afterglow times after second flame application (s)	≤30	≤60	≤60
Dripping of burning specimens (ignition of cotton batting)	no	no	yes
Combustion up to holding clamp (specimens completely burned)	no	no	no

ACKNOWLEDGEMENTS

SUSCOMTRAB is a Cornet project and received funding from Flanders Innovation & Entrepreneurship Agency (VLAIO HBC.2017.0647)

GoToS3

BIOCOMPAL

http://www.biocompal.eu

Frederik Goethals: frg@Centexbel.be

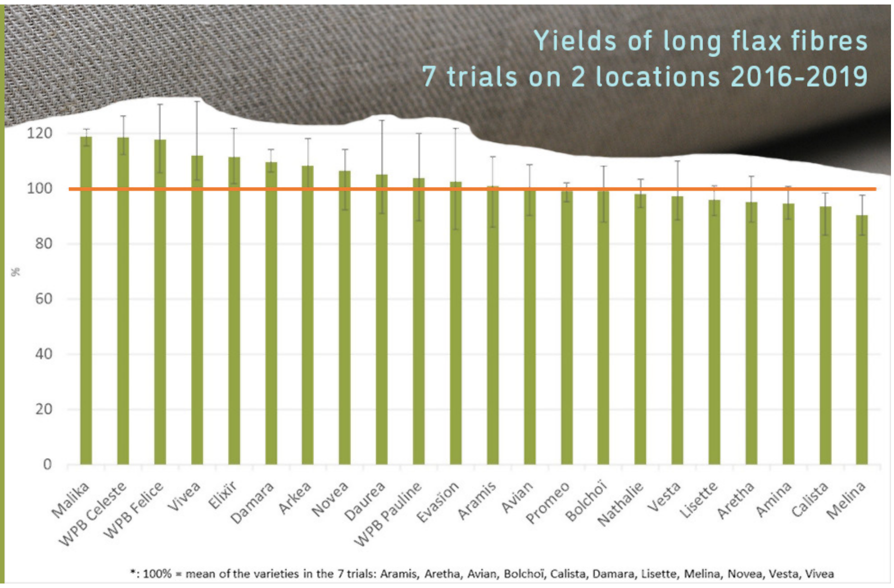
Non-natural fibres (glass, carbon, aramid) are still dominating the market of fibre-reinforced polymers. However, the interest in bio-based fibre-reinforced materials is growing, mainly because they have a lower carbon footprint than traditional composites made from glass and carbon fibres. Bio-based fibres also show other interesting features including low weight, an interesting weight/performance rate, special looks and touch.

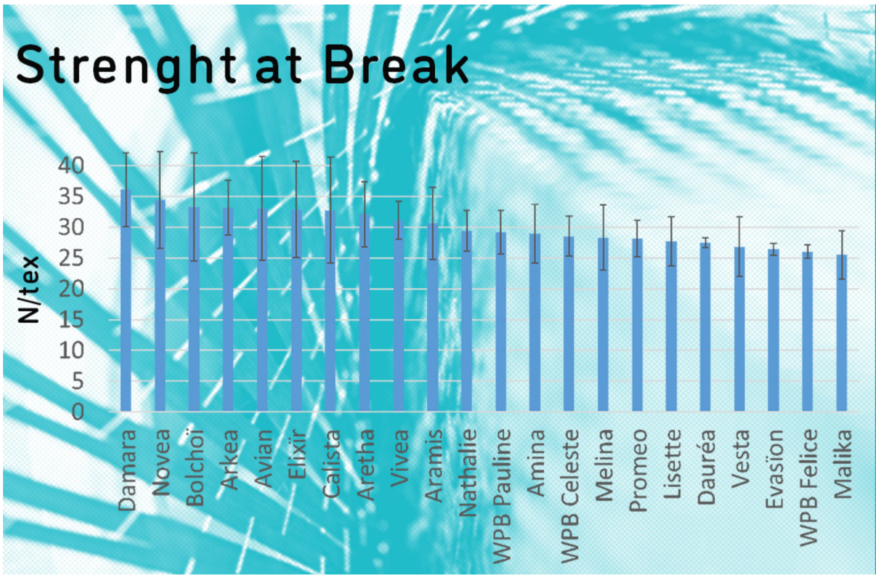
The Interreg project BIOCOMPAL studied the feasibility of using flax fibres as composite reinforcement for it is a crop that can be cultivated in Europe, especially in the region Flanders, Wallonia & France. Moreover, flax fibres have a high strength and stiffness.

One of the objectives of BIOCOMPAL was to define a flax variety that is most suitable for composite applications. Therefore about 20 varieties were cultivated in the period 2016-2019, of which we then determined the long fibre yield (most interesting part of the flax plant for composite applications) and mechanical strength.

Average long fibre yield of the different flax varieties

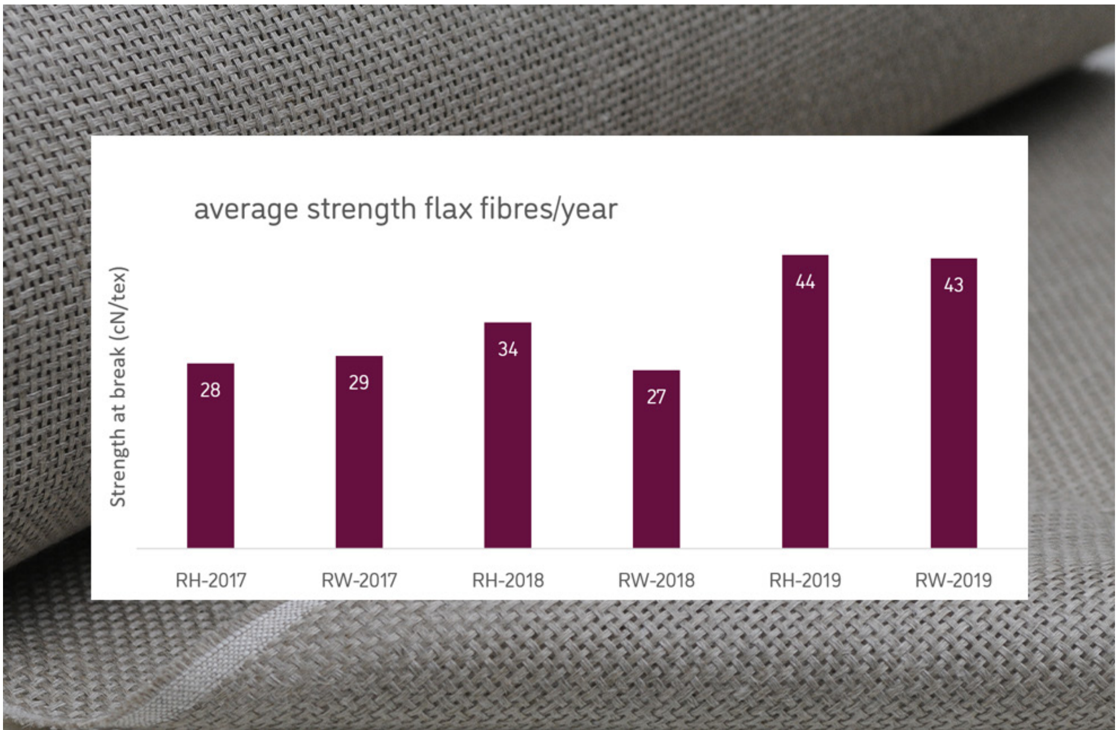
The graph shows that some varieties have higher yields than others; the varieties above the mean value are of course the most interesting ones for composite applications from an economic point of view.





The flax fibres were also tested on fibre strength, another important property in technical applications

The results show that although there is a difference in fibre strength among the flax fibre varieties, there is no real correlation between yield and fibre strength. Therefore, for composite applications, it is advisable to cultivate a flax variety combining a good yield with a good strength such as Damara, Novea and Arkea.



Effect of weather conditions on strength at break

Flax is a natural fibre and therefore, its quality also depends on weather conditions.

2017 - dry and hot

2018 - good, but some flax lodging (flattening of the stems in the field) occured

2019 - good

The heat and draught of 2017 resulted in the low average strengths of all flax varieties cultivated in Rumbeke-Houtem (RH).

The favorable weather conditions in 2019 lead to excellent mechanical properties.

ACKNOWLEDGEMENTS

The Biocompal project was an Interreg V project (Biocompal-tri n° 1.1.04; 2016-2020.) and received funding from the European Regional Development Fund, the Walloon region and the province of West-Flanders

Interreg
EUROPEAN UNION
2 Seas Mers Zeeën
SeaBioComp
European Regional Development Fund

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DURABLE BIO-BASED COMPOSITES FOR A MARINE ENVIRONMENT

The demand for composites in marine applications is boosted by the growing markets for fish & seaweed farming, energy harvesting, boats, pontons, anchoring, and buoy elements. The presently used fossil-based composites have a long-term impact on the environement, including the contamination of the sea by litter and microplastics, and their detrimental impact on sea-life.

To reduce the depletion of natural resources, the emission of greenhouse gases, and the ecotoxic impact of microplastics, it is necessary to develop renewable materials that simultaneously meet the highest technical performance requirements and withstand the effects of a long-term exposure to marine environments including mechanical forces, aggressive environment, and intense UV light.

Simultaneously meeting both sets of requirements is a major challenge.

SEABIOCOMP AIMS TO DELIVER DEMONSTRATORS OF INNOVATIVE BIO-BASED THERMOPLASTIC COMPOSITES WITH

- mechanical properties that are at least equivalent to those of currently used fossil-based materials
- a tailored durability according to the application (2 to >20 years)
- reduced CO_2 emission (30%)
- a reduced ecotoxic impact (by microplastics)

The project will also demonstrate the recycling potential of the recovered thermoplastic composites. It is the overall aim to reduce the ecologic impact by >50% compared to conventional oil-based composites.

The demonstrators will convince the value chain that bio-based composites offer a genuine and realistic alternative for oil-based composites. As a consequence, the implementation of the bioeconomy concept for marine applications can be activated and implemented by a multitude of companies and more in particular by SMEs. This will allow public authorities to take the proven benefits into account in legislation and public procurement procedures.

HIGH-QUALITY THERMOPLASTIC BIO-COMPOSITES WITH A REDUCED ENVIRONMENTAL IMPACT

The first kind of bio-composites that are investigated are **self-reinforced biopolymer composites** where a high melting grade is used as reinforcement and a low melting grade as matrix.

Mono- and multiflaments with mono- and bicomponent (core/shell and islands-in-the-sea) structures were developed from a selection of suitable PLA grades to maximize their properties.

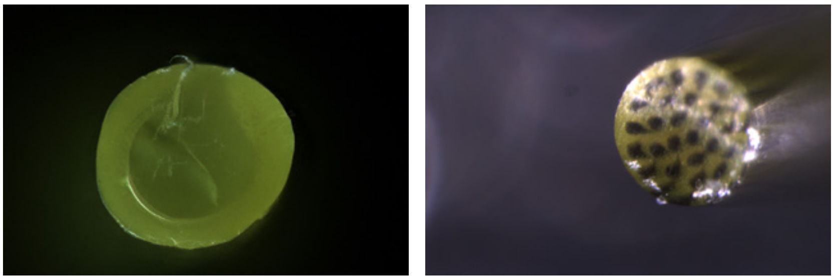

Figure 1: component structures
core/shell (left) and islands-in-the-sea (right)

Figure 2: fibres and matrix of SR-PLA after compression moulding

The filaments are used to produce textiles by intermingling, winding or weaving to obtain preforms. The preforms are then transformed into flat plates by compression moulding.

During compression moulding, the low melting PLA grade melts and forms the matrix while the high melting PLA grade remains solid and serves as reinforcement.

Bicomponent filaments have the advantage that the low and high melting PLA grades are already in close contact, which reduces the compression time.

Centexbel produced the bicomponent core/shell monofilaments on its **FET-line**[1] (Fibre Extrusion Technology).

To optimize the process parameters, we selected PLA L130 as the high melting PLA grade and PLA 6302D as the low melting PLA grade. After optimizing the process parameters for three different C/S ratios (33/67, 50/50 and 67/33) in terms of tensile strength and elongation at break, we also tested other PLA grades to define the best combination of a high melting PLA grade with a low melting PLA grade. These filaments were used to produce small flat plates (14 cm x 14 cm) by compression moulding. We ran tests to determine the best conditions by varying temperature, pressure and the amount of yarns and wraps around the frame.

For self-reinforced composites it is important that the temperature is set higher than the melt temperature of the material that forms the matrix and lower than the melt temperature of the material that serves as reinforcement to guarantee the melting of the low melting PLA grade, forming the matrix, while the high melting PLA grade remains solid as reinforcement.

In most cases, a semi-crystalline grade is used as reinforcement and an amorphous grade is used as matrix to create a broad temperature window for compression moulding. Experiments are still ongoing to produce bicomponent filaments with an islands-in-the-sea structure.

As a second kind of bio-composites, we are examining **natural fibre-reinforced composites produced by compression moulding** by using flax fibres as reinforcement and pure biopolymers or self-reinforced biopolymers as matrix.

To optimize the mechanical performances and processability, hybrid preforms are fabricated by adjusting the ratio between the flax fibres and biopolymer textile intermediates. The compression moulding process is optimized (temperature/pressure/time) by evaluating the mechanical properties and impregnation quality. The flax fibres and the high-melting PLA give the composites their strength and stiffness while the low melting PLA forms the matrix to hold everything together. When using a higher percentage of self-reinforced PLA in the natural fibre-reinforced composites, the modulus and strength stays the same while the toughness of the composite increases.

The third process we investigated is **monomer infusion into long flax fibre preform by RIFT** (Resin Infusion under Flexible Tooling). This technique uses in situ polymerization of bio-based monomers in contact with long natural fibres. Methyl methacrylate is used to produce polymethylmethacrylate (PMMA) and lactide is used to produce PLA. PMMA has the advantage that it can be produced at room temperature whereas PLA requires elevated temperatures. The disadvantage of PMMA is that there is no commercially available bio-based MMA in contrast to bio-based PLA. Preliminary studies show that flax-PMMA has higher flexural properties than flax-PLA.

Research to optimize the flax-PLA composite production is ongoing by looking into its processing parameters: processing temperature, processing duration, monomer/catalyst ratio, cooling method and degassing.

1 https://www.centexbel.be/en/pilot-platforms/extrusion-platform

3D PRINTED BIO-BASED COMPOSITES

A large-scale 3D printer was installed at PolyProducts to process biopolymers into bio-composites. This printer is able to produce large objects (L: 4m, W: 2m, H 1.5m) from pellets. The PLA pellets must be pre-dried to prevent hydrolysis that may corrode the printer's screw.

The first demonstrator, a fender that can be used as a berthing structure for ships was made by 3D printing natural fibre-thermoplastic starch pellets.

Figure 3: Industrial 3D printer for (natural fibre-reinforced) biopolymers

Figure 4: 3D-printed fender

Tests are ongoing to produce flax-PLA pellets to 3D print the fender and to determine whether the structure is suitable to be used in a marine environment.

In addition, test runs are also taking place on 3D printers using filaments of pure biopolymers, self-reinforced filaments or coextruded flax-PLA filaments.

The 3D printing of reinforced filaments requires a constant diameter of the filaments that fits the size of the nozzle.

ANALYTIC PROTOCOLS

In view of the long-term impact on the sea, on global warming and the depletion of natural resources, it is also necessary to develop analytic protocols to determine the product's long-term durability, ecotoxicological effects, and the formation of microplastics. To replace the currently used materials, the newly developed materials must meet the highest technical performance requirements and withstand the effects of a long-term harsh marine environment.

The properties of the newly developed bio-composites are evaluated by performing mechanical tests including tensile, bending flexural and impact tests with fossil-based composites as reference materials.

The preliminary results revealed that the mechanical properties of PLA are similar to the ones of some reference materials in the 0° printing direction and even superior in the 90° printing direction.

Long-term durability is tested by immersing the composites in seawater at different temperatures for one year. The samples are monitored regularly by measuring their weight gain and mechanical properties. The preliminary results show that the weight gain is limited to 2% after one year for samples in seawater with a temperature of less than 40°C. At temperatures of 40°C and higher, the weight gain is significantly higher, up to 12% . Mechanical properties remained unchanged for composites stored in seawater at 25°C for one year, from which we may conclude that PLA is stable in marine environments for at least one year. We are still evaluating the effects on the composite over a longer period.

Microplastic formation under UV exposure in seawater at elevated temperatures is investigated for self-reinforced PLA, using self-reinforced PP (polypropylene) as a reference material. The duration of this accelerated weathering test is 57 days, equivalent to 18 months of sunlight in Central Europe. Self-reinforced PLA forms significantly less microplastics than the currently used self-reinforced PP. Testing over a longer period is planned as well as the testing of natural fibre-reinforced composites.

In additon to the formation of microplastics, the ecotoxicological effects of leachates from the newly developed bio-based composites will be investigated. To assess their ecotoxicological effect on marine organisms, dilution series of leachate solution are used to test algae growth and copepod larvae development. The tests are still ongoing and we will also run other tests with oyster larvae during the project.

During the next two years of the project we will continue to improve the mechanical properties of bio-based composite materials, made by compression moulding, RIFT or additive manufacturing. We will also study the microplastics formation, ecotoxicity and recycling of these composites in more detail so the results can be used to develop the analytical protocols on durability and ecotoxicology.

Interreg
EUROPEAN UNION
2 Seas Mers Zeeën
SeaBioComp
European Regional Development Fund

CALL FOR APPLICATIONS

The goal of the SeaBioComp project is to develop bio-based composites and to demonstrate that they are suited to replace traditional composites used in marine environments.

The demo products and analytical protocols will help convince marine and maritime industries that bio-based composites represent a realistic and feasible alternative to less sustainable materials.

The consortium now calls upon the industry to propose applications for bio-based composites in an offshore environment, including, but not limited to utensils (e.g. fishing gear, boats), floating structures (e.g. buoys, floaters) and infrastructure components (e.g. ships, anchors) in various areas of the blue economy (aquaculture, offshore energy, shipping, coastal defense, tourism).

DO YOU HAVE AN IDEA FOR AN APPLICATION, CONTACT

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Elke Demeyer | edm@vkc.be

WOULD YOU LIKE TO FOLLOW THE DEVELOPMENTS OF THE SEABIOCOMP PROJECT, JOIN THE ADVISORY GROUP!

http://seabiocomp.eu/

Interreg
Euregio Meuse-Rhine
AACOMA

EUROPEAN UNION
European Regional Development Fund

START OF THE INTERREG EMR CROSS-BORDER PROJECT

AACOMA - ACCELERATE ADVANCED COMPOSITE MANUFACTURING

The Euregio Meuse-Rhine (EMR) - Belgium, the Netherlands and Germany - is a focal point for advanced composite materials and technologies. The Euregio Meuse-Rhine offers a huge potential with its numerous companies and in particular SMEs active in the field of advanced materials manufacturing for many industrial sectors, such as automotive, aerospace, electronics, construction and infrastructure.

The advanced materials sector is growing, with a consolidated offer, from raw material producers to technological development to production, research and development and OEMs. Interreg EMR is investing €96 million from the European Regional Development Fund (ERDF) over the period 2014-2020. Through investments in these cross-border projects, the European Union is investing in the economic development, innovation, territorial development and social inclusion and education of this region.

The Euregio Meuse-Rhine region is ideally suited for the development of advanced materials and production technologies. Research centres and universities located in the area of Liege, Hasselt, Eindhoven and Aachen have been awarded the new AACOMA project. The design of innovative materials and their advanced implementation offer great opportunities for SMEs. The aim of the project, which runs for three years until the end of 2022 with a budget of approximately €3 million, is to network SMEs with technological research partners.

The consortium consists of 7 partners from the three countries: CENTEXBEL, the project leader, together with the University of Liège, SIRRIS and Flanders Make in Belgium, the University of Applied Sciences FONTYS and AMIBM of the University of Maastricht in the Netherlands and AMAC in Germany. The launch of the AACOMA project took place in Aachen on the campus of RWTH University with partner AMAC in early 2020.

Interreg Euregio Meuse-Rhine Interreg is supporting the AACOMA project with almost €1.5 million from the Development Fund (ERDF). The project is co-financed by the Walloon Region (BE), the Province of Noord-Brabant (NL), the Dutch Ministry of Economic Affairs and Climate (NL) and the Province of Limburg (BE).

partners

CENTEXBEL sirris LIÈGE université FLANDERS MAKE AMI Fontys University of Applied Sciences AMAC

https://aacoma-interreg.eu

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co-financed by

Wallonie
Ministerie van Economische Zaken en Klimaat
Provincie Noord-Brabant
provincie Limburg

STATEMENTS BY THE PARTNERS

Bernard Paquet, project coordinator of CENTEXBEL/Belgium:

"Centexbel, with a strong background in textiles and composites, will identify with its Interreg partners and an international expert advisory committee several demonstrators that will accelerate the implementation of advanced composite parts. This could include new materials and intermediates, high performance additives, bio-based products and new composites through additive manufacturing."

Michael Effing, Managing Director of AMAC/Germany:

"The main objective of the project is to connect around 200 innovative SMEs and establish links with world-class institutes in the MRE region. We will host 6 roadshow events, addressing key topics such as automated manufacturing, additive manufacturing or bio-based material systems, combined with matchmaking and training events. The first roadshow took place in September 2020 on the university campus in Aachen."

Professor Gunnar Seide from AMIBM/Netherlands:

"Our AMIBM institute already offers an international master's programme on bio-based materials. The AACOMA project will be an important element of cross-border research and will identify new players in the value chain from the MRE region. Innovative companies are finding markets for their new bio-based products, building blocks, chemicals and polymers. Their successes and future technological breakthroughs are necessary for a sustainable future."

PROGRAMME FOR THE COMPOSITE INDUSTRY

The consortium is organising **networking events**, including matchmaking sessions and training sessions on topics related to composite materials.

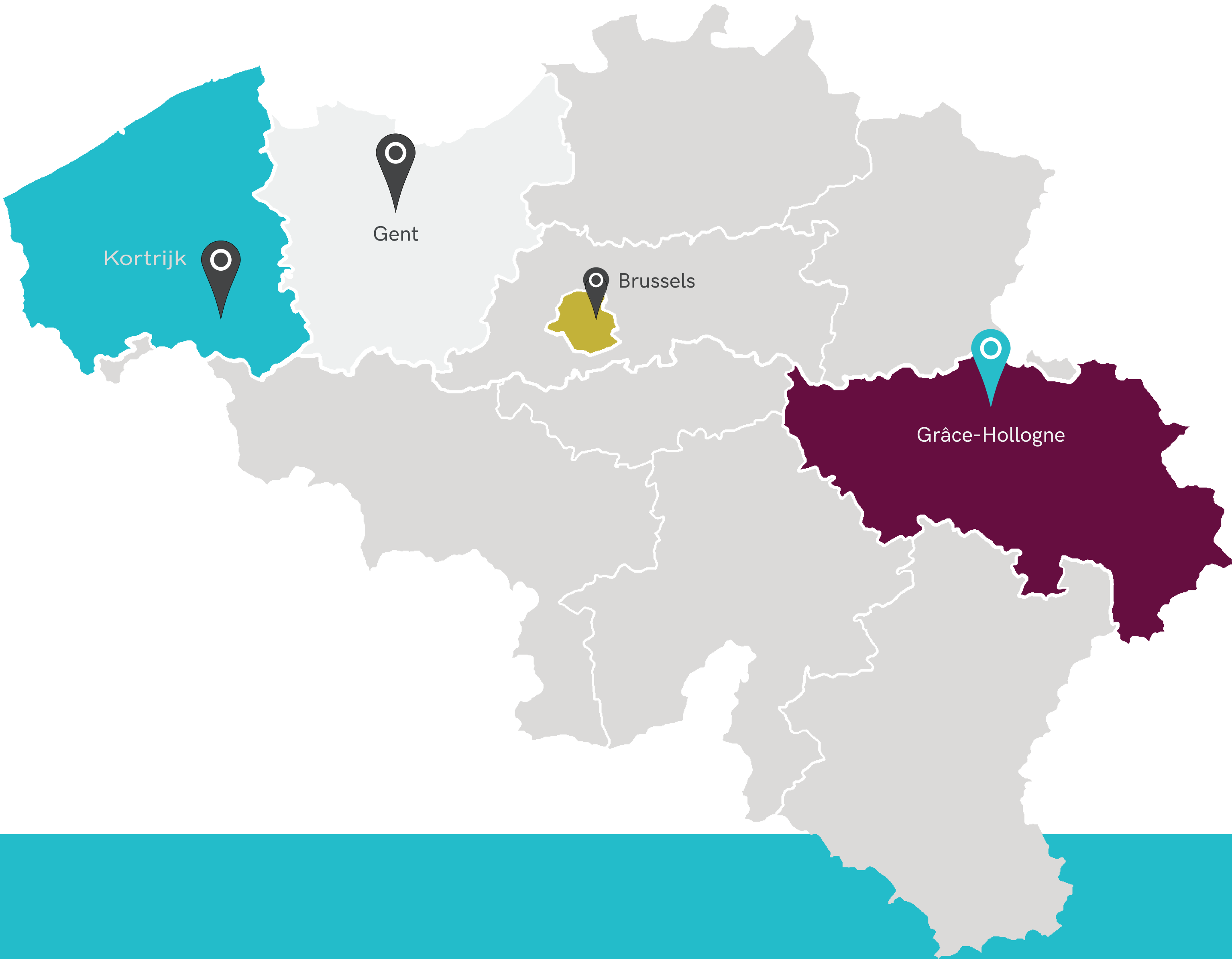
An **Advisory Committee** made up of members of the composites industry has been set up. Any interested company can become a member by applying to us.

The technology partners will also develop a series of **demonstrators** to show the possibilities through the use of innovative functionalized materials, the use of robotics and augmented reality, and the possibilities of rehabilitating the structural functionality.

Through **interactive workshops** companies can follow the evolution of these projects and learn from the experience of the partners.

Roadshows (see pictures below) are organised so that the partners can show their ability to support companies in their intentions to innovate and inspire them to launch new projects to innovate in the field of composite materials.

CREATE CONNECT INSPIRE SOLVE



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