ADDITIVE MANUFACTURING WITH GLASS FOR FACADE APPLICATIONS

POTATO SCRAPS HAVE A NEW PURPOSE AT SEA

DURABLE DIKE CLADDING MADE OF SLUDGE

ARE FUNGI THE NEXT BUILDING MATERIAL FOR MARS?

UNEXPECTED PROPERTIES FOR PHOSPHATE GLASS WITH FLY ASH
High-Tech Materials form the key to innovative and sustainable technology

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Over the last decades, the role of glass has become more and more prominent in modern facade engineering. Because of its rare combination of strength, transparency and durability, glass offers a unique combination of material properties. Glass is perceived - depending on the mixture - as transparent or translucent, as colored or clear. The TU Darmstadt, specifically the Institute of Structural Mechanics and Design (ISMD), the Center for Structural Materials (MPA-IWW) and the Glass Competence Center (GCC), are exploring the potential of additively manufactured glass components in terms of material behavior, printing technology, structural behavior, design and envisioned applications.

19 Nature structure: Potato scraps have a new purpose at sea
Dutch marine biologists recycle potato waste into mats that they use for nature restoration, like salt marshes, reefs and seagrass meadows. These Biodegradable Elements for Starting Ecosystems, or BESE-elements, consist of stackable layers that build up into a biodegradable matrix structure. The modular design combines porosity with a complex structure. In a way it resembles the well-known building blocks: a simple design with endless possibilities. Now worldwide tests for nature restoration have been set up with the material.

24 Durable dike cladding made of sludge
Water board Scheldestromen is responsible for the safety of all dikes and dunes in the Zeeland region, the southwest of The Netherlands. To perform its core tasks in a more sustainable and smarter way, Scheldestromen is searching constantly for innovation partners. The water board is currently preparing a dike reinforcement near the village of Hansweert. Within this project, Scheldestromen, together with innovation partner NETICS, is investigating a way to make the required new stone cladding of the dikes more sustainable by making it from dredging sludge.

29 Are fungi the next building material for Mars?
Living on the harsh environments of the Moon and Mars will require new architectural ideas. Earlier this year, Nasa Techbriefs spoke with dr. Lynn Rothschild, the principal investigator on the early-stage development called ‘myco-architecture project’ of NASA’s Ames Research Center. The idea is simple: don’t carry the materials to Mars, with huge energy costs, but simply grow them, using mushrooms, or more specific: the threads that make up the main part of the fungus, known as mycelia.

32 Unexpected properties for phosphate glass with fly ash
Glass is transparent and strong, but the melting temperature is high and the material is brittle. PhD research by Clarissa Justino de Lima shows that it is possible to improve its properties. She developed a type of glass from phosphate and fly ash with a low melting temperature and an unusual strength. On 30 March, Clarissa Justino de Lima defended her PhD thesis ‘Innovative low-melting glass compositions containing fly ash and blast furnace slag’.

34 From petroleum to wood: cost-efficient and more sustainable
An interdisciplinary team of bioscience engineers and economists from KU Leuven has mapped out how wood could replace petroleum in the chemical industry. They not only looked at the technological requirements, but also whether that scenario would be financially viable. A shift from petroleum to wood would lead to a reduction in CO₂ emissions. Their study was recently published in Science, titled ‘A sustainable wood biorefinery for low-carbon footprint chemicals production’.
In collaboration with TU Darmstadt and the University of Oulu (Finland), the paper technology department of the Duale Hochschule Baden-Württemberg in Karlsruhe (DHBW Karlsruhe) did research on so-called All-Cellulose Composites (ACCs): cellulose composites. These are fiber composite materials that mainly consist of modified cellulose fibers and are fully recyclable. The developed process has now been patented. Based on the results the company Plafco Fibertech was founded. The company focuses on the industrial production of the ACC material that is marketed under the name ‘Plafco’. The new material is 100 percent based on paper that is available in bulk. It’s inexpensive, non-toxic, biodegradable, dissolves in water and can even be recycled.

As part of the project, new sustainable packaging solutions are being developed for areas previously dominated by plastics, introducing completely new applications and innovations. An example is the packaging for handkerchiefs, which is special because the handkerchiefs and packaging are made of the same material. Plafco also says it’s able to produce drinking cartons with 40 percent less material than the classic Tetra suit.

The new Plafco material can be used as substituting plastics products such as single-use plastic drinking straws, cutlery and wrapping materials, as well as to replace multilayer paper packaging solutions by a more stiff and wet resistant one-layer product.

Plafco can be provided as ready for use material designed for the special use cases and needs of customers with various specifications.

According to the Plafco-website the material can also be provided as multi-layer product. Plafco can be combined with another layer of Plafco itself, paper, PE, PP, glue etc. to a multi-layer composite.
A construction work has been completed in Morocco that combines hemp construction with a high-tech solar energy system for total independence from the electrical grid. Earlier this year Hemp-Today payed attention to the so-called SUNIMPLANT project. The SUNIMPLANT building was designed as a single-family dwelling. It was created as an entrant in the recent ‘Solar Decathlon’ organized by the United States Department of Energy and Morocco’s Centre de recherche en Energie solaire et Energies nouvelles. The biannual international competition challenges teams of students to design and construct off grid solar-powered buildings, using sustainable materials. The most recent edition was hosted in Ben Guerir, Morocco, the first time the competition has been held on the African continent. The challenge was to create a hemp composite using vegetable-based bio-resins, avoiding technical or synthetic components. The building is constructed with a double skin façade that employs a mixture of hemp, earth, pozzolan and lime, all sourced locally; and bio-composites incorporating hemp technical fibers that were produced via vacuum injection technology.

The spherical, aerodynamic outer skin comprises 24 semi-flexible photovoltaic panels. Curved bio-composite panels are made with hemp wool, which increase the performance of the photovoltaic panels by protecting their back side against the weather extremes of the semi-arid region of Ben Guerir. The glass High-performance glass was supplied by French glassmaker Saint Gobain. Moroccan cooperative Adrar Nouh contributed the architectural design, developed the hemp materials and cooperated in the construction of the building.

Off grid with hemp and solar

Other participants on the SUNIMPLANT project were Morocco’s National School of Architecture and National School of Applied Sciences, both based in Tetouan, Morocco, and Germany’s Fraunhofer Center for Silicon Photovoltaics.

https://sunimplant.com/sunimplant-project/
https://hemptoday.net/moroco-hempcrete-project/
Lightweight wood constructions: less costs and more sustainable

The world’s urban infrastructure will undergo a major transformation in the coming decades. Lighter building materials, such as wooden elements, are cheaper and more energy-efficient to transport and process on the construction site. Reason for wood producer MetsäWood to draw attention to light, technical wood products such as Kerto LVL (laminated veneer wood). Using lightweight materials, such as wood elements, material handling and internal logistics on-site will be reduced and leads to less waste production. Furthermore, lighter construction materials are less costly and more energy efficient to transport.

According to Matti Kuittinen, architect and researcher from Aalto University, depending on material and transportation distances, logistics can form an important part of all production costs, ranging from 12 to 30 per cent. Research has shown that if materials are provided by one central supplier instead of many, 6 per cent cost savings in logistics can be accomplished. One significant cost in logistics is the consumption of fuel. It has been shown that in a situation where the distances from the factory to the construction site and the terrain profile of the route were the same, the transportation of Kerto LVL element had the lowest CO₂ emissions and the best fuel efficiency.

Material handling at the building site may take up 14 per cent of working time and can control up to 80 per cent of the schedule of the entire construction project. Prefabricated building products may improve the efficiency in material handling. For example, the extension structures of the Paris Police headquarters had to be built fast, since the site was in a busy area in the old centre of Paris. The pre-fabricated elements were brought to the site at night and erected during the day. The light wood was handled on the site without the need for heavy machinery, so the drawbacks caused by building in the busy city centre were minimized.

An example of innovative lightweight construction comes from Switzerland in the form of the SPA-Bungalow, a small transportable house complete with sauna, bathroom and shower, and a relaxation area with a bed. The entire bungalow is built with Kerto LVL elements of MetsäWood, and can be transported as modules to remote locations: the first one was helicoptered to Lötschenpass, a stunning location in the Alps at an altitude of 2690 metres, and ready to use within a few hours of arriving.
Researchers from Germany-based Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut, WKI, have used a new recycling technique to recover and process balsa wood contained in wind turbine rotor blades to turn them into products like insulation mats for buildings. There are 30,000 wind turbines in operation in Germany, many of which are starting to age. In 2019, 2000 rotor blades had to be discarded. A study by the Fraunhofer Institute for Chemical Technology ICT predicts that around 15,000 rotor blades will have to be discarded in 2024 and around another 72,000 more in 2027.

Rotor blades are made largely of glass-fiber-reinforced plastic (GFRP) and balsa wood bonded with epoxy or polyester resin. This bond is extremely strong. It has to be: the rotor blades reach top speeds of more than 250 kilometers per hour, subjecting them to an enormous force. For single-origin recycling, however, this is precisely the problem, as it is very difficult to separate the individual components of the composite material. A rotor blade contains around 15 cubic meters of balsa wood, which is not only one of the world’s lightest woods, but also extremely resistant to pressure. Although it has hardly any energy content, it is burned as a composite material, usually in cement factories.

Fraunhofer and industry partners have developed a new recycling technology to recycle this balsa wood: the so called ReRoBalsa-project: Recycling of rotor blades in order to recover balsa wood/foam for the production of insulation materials. First the discarded rotors are cut in large pieces with a water jet lance, after which blade segments are fed into a mobile shredder that breaks them into pieces about the size of the palm of a hand. Finally, the research team uses an impact mill to separate these pieces into their individual components. To this end, they are set in rotation and hurled against metal at high speed. The composite material then breaks apart because the wood is viscoplastic, while glass fibers and resin are very hard.

At Fraunhofer WKI, the balsa pieces are processed to make, for instance, ultra-light-weight wood-fiber insulation mats. With a density of less than 20 kilograms per cubic meter, these mats provide insulation like common polystyrene-based materials.

In conclusion, Fraunhofer said the recycled balsa wood can also be used to produce elastic wood foam and insulating material.

Fraunhofer>
ReRoBalsa>
The Floating Bricks House is a project that originates from ROFFAA’s fascination of the building industries residual flows and a reaction to the esthetic application of brick strips. ROFFAA based in Rotterdam, is an innovative architect/design studio, committed to make building healthier and combining this with the development of new building products and applications.

Many producers of building products have standardised their processes in such a way that they produce their product in the, for them, most efficient way. The remaining materials are recycled again. For example, wrongly cut glass, chipped panes or panes of glass that do not fit the standard size go into the glass container and are processed again into glass, faulty produced bricks are crushed and used in another brick or used as road fill.

Can these residual flows not be applied directly? Is there a way to intercept these flows and change the production lines of the producers? Are we able to come up with new products and create new value for these mostly high-quality materials?

With the Floating Bricks ROFFAA combines two residual flows. On the one hand rejects from an indoor wall system producer that don’t fit their module size and on the other hand rejected brick strips from a brick producer. The idea is, the brain fills in. People
think they know what they see. If we see bricks, we expect traditional brickwork with cement joints and we will see that. With the Floating Bricks you will initially see a brick wall. The moment you get closer, you will discover that there are no cement joints holding the wall together. Every brick floats in the air, together they form that solid brick wall. ROFFAA created a facade element that brings the illusion of a brick wall, but turns out to be transparent. With this principle it’s possible to build an archetype house of 2 by 3 meters with a 45 degree roof. And that’s exactly what ROFFAA did.

The front facade of the house can be fully opened with two Floating Bricks doors, in the house you can sleep in a bed or in the mesh under the attic. The ordered glue dots create a sixties wallpaper on the interior of the house. Curtains made from recycled PET bottles are giving privacy to the users and the romantic experience of a four poster bed in the same time. The shadow of the bricks appear as a brick pattern on the curtains while lightened from the outside. The house is standing on short posts and is lifted 40 cm above the ground.

Team: Renske van der Stoep, Georges Taminiau, Rêve Deijkers, Ehab al Hindi, Nino Vogels, Maurits Maas Partners: Wienerberger, Qbiq, Culture Campsite, Bergman fietsen

https://roffaa.nl

The goal of the 4TU.HTM research programme ‘New Horizons in Designer Materials’ (2016-2019) was to develop new topics in materials science into research areas at the four universities of technology (Delft University of Technology, Eindhoven University of Technology, University of Twente and Wageningen University.) Within this programme, six research projects conducted by high-potential post-docs have provided a strong stimulus to materials science in the Netherlands. In collaboration with international experts and various research groups at the four TU’s, they contributed to the high level of materials science research in the Netherlands. As a result they published a series of papers in leading scientific magazines.

As a conclusion of the research programme, 4TU.HTM made a booklet in which the scientific director and the coordinator of 4TU.HTM and the researchers look back at the 4TU.HTM research programme. On the 4TU.HTM website you can find a page for the book, at which pictures are shared, as well as images and the pdf file of the book. You are welcome to share this information with colleagues.

The publication ‘Stretching the boundaries of materials’ was released March 2020 by the 4TU.Research Centre High-Tech Materials. It is available online>

www.4tu.nl/htm>
How can the energy transition be connected to creating a circular economy? Using a circular renovation module for the energy-retrofitting of housing offers a combined answer to the two challenges. TU Delft is developing the Circular Skin, together with AMS Institute, Dura Vermeer, housing association Ymere. Students from Rotterdam University of Applied Sciences created the first prototypes, exploring different materials and construction methods.

In a circular economy, less material is used, components and materials are used longer, and resource loops are closed. Additionally, many homes in the Netherlands need to be made more energy efficient. This is often done by insulating the façade, requiring a lot of additional material. Research project ‘REHAB’ focuses on the development of circular building components for housing retrofits, taking on both challenges at once.

The research distinguishes five variants for the Circular Skin:

- Construction from renewable and biodegradable materials;
- Constructions from re-used materials;
- Construction from recycled materials;
- Construction from high-quality building products with easy dis- and reassembly, making the products easy to re-use;
- Construction of a modular façade, made out of building blocks, making the facade easy to adapt and re-use.
Prototypes

Students from the Rotterdam University of Applied Sciences have developed prototypes for the five variants. From the Building Sciences programme, ten student groups designed, built, and tested the variants in several weeks. These tests range from testing building physical properties to the ease of disassembly and re-assembly. Together, TU Delft, AMS Institute, Dura Vermeer, and Ymere are further developing the Circular Skin by combining the strengths of the different skin variants. This will lead to the development of a prototype for a first demonstration home. Additionally, the possibilities for making the supply chain and business model circular are explored.

Accelerating the energy transition

Circular principles provide both a more sustainable product, and an opportunity to accelerate the energy transition. By developing a design which consists of modules, an initial renovation could be expanded in the future. Renovations could take place in different cycles, going towards energy neutrality step-by-step. In addition, circular business models offer opportunities to keep initial investments low.

Project partners

The prototypes were made possible by the contributions of Lomax Systems, Mosa, STO, Oskam V/F, BMN, Dura Vermeer Projectteam, Erasmus MC, Ecomat, Metisse, VRK-isolatie, Wovar, Aannemersbedrijf Batenburg, Davelaar interieur, Bouwcenter, Alblashout en bouwmateriaLEN, Eco-boards, Soprema, Kruyt bouw en industrie, and TOM SOLD.

BK TU Delft>

More about REHAB>

Video
The world’s first aerogels made from scrap rubber tyres

A research team of the National University of Singapore (NUS) has developed a new process to convert waste rubber tyres into super-light aerogels that have a wide range of applications. According to NUS it’s the first time that aerogels are made from waste rubber tyres. The new rubber aerogels demonstrate remarkable properties: they are extremely light, highly absorbent, very durable, and they are also very efficient at trapping heat and sound.

Last year, this novel technology was published in the print version of scientific journal Colloids and Surfaces A: Physicochemical and Engineering Aspects, titled ‘Advanced fabrication and multi-properties of rubber aerogels from car tire waste’.

Every year, about 1 billion scrap tyres are generated worldwide. Only 40 percent are recycled into low-value-added products, while 49 per cent are incinerated to generate energy, and at least 11 per
To create the rubber aerogels, recycled car tyre fibres are first blended into finer fibres. These fine rubber fibres are then soaked in water and very small amount of chemical cross-linkers. Next, the mixture of rubber fibres and eco-friendly solvents is dispersed uniformly using a stirrer for 20 minutes. The uniform suspension gel is then freeze-dried at minus 50 degrees Celsius for up to 12 hours to produce rubber aerogels.

According to Assoc Prof Duong, leader of the research team, the fabrication process is simple, cost-effective and eco-friendly. The entire production process takes between 12 to 13 hours to complete and can be easily scaled up for mass production.

According to the NUS-researchers, the novel rubber aerogels possess remarkable properties for many applications. They are for instance extremely light and stiffer than commercial foam and highly porous. They are two times more absorbent than conventional absorbents such as the polypropylene mat. The material has an excellent sound absorption: rubber aerogels are believed to be 27% more effective than the commercial foam absorber with the same thickness. And last but not least: rubber aerogels have high heat resistance.

According to professor Nhan Phan-Thien, senior member in the research team, the potential markets of rubber aerogels are huge. They are extremely suitable as insulation material for industrial purposes such as in subsea systems, oil refineries and industrial buildings, and also in homes, refrigerators, as well as vehicle noise propagation and thermal comfort, both vital in vehicle designs.

The study was sponsored by real estate developer Mapletree Investments. The process has been patented.

NUS>
Pomastic

Pomastic is a bio-based plastic material which is made by using olive pomace and other fully bio-based ingredients. The material design is still in progress. The project team is working towards improving the functional and mechanical properties of the material as well as its aesthetic qualities such as glossiness, texture and colour.

First laminated bamboo bicycle

Veltra is a sustainable, lightweight bicycle handcrafted in Romania and made of laminated bamboo said to be the first in the world. Bamboo, was not chosen by accident. It’s the fastest growing plant on earth, making it very sustainable, and it has a high strength to weight ratio. Plus, the material is a natural shock absorber, resulting in a vibration-dampening bike.

BIPV

BIPV, Building Integrated Photo Voltaic, are full-colour PV-panels with huge freedom of design. With this product it is now possible to make beautiful facades and to harvest energy. By choosing different metals, the most amazing facades can be constructed.
DEDOTS

Picture a canvas on which you can depict the grandest stories. Vivid imagery, intriguing patterns or bold graphic art; this is possible with DEDOTS. Coloured 3D DOTS are mounted on a wire mesh panel in any desired pattern. Aside from its aesthetic properties, DEDOTS is manufactured to fit a wide array of indoor and outdoor uses. The DOTS are manufactured to meet the highest possible standards. They are fire, UV, and weather resistant, vandalism proof and the ECO DOTS are made out of 100 % recycled materials.

More at MaterialDistrict>

Freebooter

Called Freebooter, the biophilic house in Amsterdam, designed by architectural studio GG-loop, was inspired by the Dutch maritime past, using only materials that were used in the construction of a ship. The main material used was limited to wood, steel, and glass, like a ship’s hull. The building is a hybrid structure of Cross Laminated Timber (CLT) and steel, and was prefabricated offsite.

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Recycled polycarbonate waste furniture

Dutch company Plasticiet produced recycled plastic sheet material with a marbled, or pearlescent look, which they used to make a series of furniture. Plasticiet takes inspiration from rock formations. Each type of plastic has its own viscosity, and they often work with contaminated sources. This means that the material needs to be tested thoroughly before it can be resold as sheet material.

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Antique mirror glass

The studio of Dominic Schuster Ltd creates finishes that authentically replicate the natural degradation of mercury/silvered mirror to bespoke effects incorporating silver and gold for a more contemporary look. According to Dominic Schuster, the process of creating an antiqued glass mirror panel or tile is very much an artistic one; a variety of secret techniques will be used to build up the right level of ‘foxing’ (aging) and achieve the exact look sought. The result is a decorative feature which can be inset into joinery, used as wall-panelling, or simply as tableware.

More at MaterialDistrict>
Additive manufacturing with glass for facade applications

Over the last decades, the role of glass has become more and more prominent in modern facade engineering. Because of its rare combination of strength, transparency and durability, glass offers a unique combination of material properties that trigger the imagination from a variety of industries such as buildings, cars, yachts, interior design, optics, glassware, art, tableware, data cables, etc. Glass is perceived - depending on the mixture - as transparent or translucent, as colored or clear. Despite the fact that glass is often addressed as such, glass however is never invisible. The TU Darmstadt, specifically the Institute of Structural Mechanics and Design (ISMD), the Center for Structural Materials (MPA-IfW) and the Glass Competence Center (GCC), are exploring the potential of additively manufactured glass components in terms of material behavior, printing technology, structural behavior, design and envisioned applications.
Additive Manufacturing
When we think about 3D printing, there is a great variety of additive processes available today. What connects these techniques, such as Rapid Manufacturing, Rapid Tooling, Rapid Prototyping or, more generally, Additive Manufacturing (AM), is the fact that they are all based on 3D computer generated data as a framework for a manufacturing process. The desired components are digitally designed via a computational tool before this data is then converted in an applied computer language, which commands the AM system to manufacture this specific component. The most commonly used methods of additive manufacturing are (figure 2):

a) Stereolithography (SLA): This technique describes a layer by layer printing style in which a light source causes monomers in a bath to link together to form polymers.

b) Selective Laser Sintering (SLS): In this technology, a laser beam is used as power source in order to locally sinter powdered material together. The laser is aimed at specific points derived from a 3D model, only creating a solid structure where desired. The technology is closely related to Selective Laser Melting (SLM), whereas the main difference is that the material in SLM fully melts rather than being sintered leading to differences in material properties such as crystal structure, porosity, etc.

c) Fused Deposition Modelling (FDM): This technology is a continuous filament fed process through a heated nozzle, thereby depositing a complex geometry layer by layer. By moving the nozzle and/or the building plate, any 3-dimensional coordinate within the printer’s volume can be reached.

d) Digital Light Processing (DLP): This technology presents a similar process as SLA, the main difference being the source of the light. By using a more conventional light source and applying it to the entire surface of the resin in a single pass, it is generally faster than SLA.

e) Direct Ink Writing (DIW): This technology, which is also known as robotic material extrusion, shows great similarity to FDM printing, since a small nozzle extrudes filament or a paste whilst it is moved across a building platform. It differs from FDM as it does not rely on direct solidification or drying to retain its shape after extrusion. Instead, the entire printed and often still fragile part is afterwards dried and sintered to attain its final mechanical properties.

All these methods have in common that they convert 3D data into physical models without extra tooling by solidifying layers of material on top of each other. Having a large pool of applicable materials enables the engineer to develop a wide range of fields for which products can be manufactured. Nowadays, all these methods of AM use either one or two materials at a time, and crossing these processes and thereby improving material properties seem to be the core of the matter.

Next to cost and material efficiency as arguments to justify the usage of AM technologies, a third and at least equally important argument can be given in terms of freedom of form. The freedom that is provided by these technologies in terms of form might include better structural and technical material or product properties, next to an increase of individual design options.

If we look at the current state of additive manufacturing, it can be seen that components made of metals and plastics have experienced severe attention from researchers worldwide over the last years and can be considered a state-of-the-art technology in several industries. Compared to metals and plastics, AM of glass can still be considered within an embryonic state of research.

Figure 2: The most commonly used methods of additive manufacturing, a) SLA, b) SLS, c) FDM, d) DLP & e) DIW

AM Glass
Until now, roughly 25 documented projects have focused on AM with glass, with the earliest project dating from 1995 by the University of Texas, USA. In recent years, the spectrum of research on this topic has increased significantly. The projects are driven by a wide range of industries such as optics, architecture, bio engineering, microfluidics and more. In these projects, many different printing techniques and glass types have been investigated. Moreover, a variety in scale level can be identified ranging from printed glass samples of less than 5 mm in diameter and a resolution of 150 µm up to glass objects with a diameter of around 25 cm with a resolution of around 5 mm. The most well-known projects concerning AM glass were done by MIT as is published in Innovative Materials volume 1 2019. At the TU Darmstadt, the reason for researching AM with glass was initially driven by the Institute of Structural Me-
chanics and Design (ISMD), department of Façade Technology. By analyzing the current way of fixing glass façade panels it became imaginable that it would be possible to eliminate the necessity for adhesives or boreholes including their associated disadvantages such as ageing and premature failure of the glass plate. As a potential solution, the TU Darmstadt envisioned the option to print glass connection sockets directly on top of a glass plate in order to connect them (see figure 1). To investigate this, a proof of concept needed to be established which initiated the cooperation between ISMD, the Center for Structural Materials (MPA/IfW) and the Glass Competence Center (GCC) of the TU Darmstadt. The aim for this proof of concept was to obtain a connection between a glass plate and the deposited glass in such a way that load transfer would be possible through this fused area. The research included experiments with soda-lime-silica and borosilicate glass and produced point, line and stacked spline samples as shown in figure 3.

A decision was made to manufacture these samples by hand using the experience of the glass blowers from TU Darmstadt’s faculty of Chemistry. These hand-made samples offer sufficient quality for a proof of concept and will also form a base of knowledge on which the blueprints for a future glass 3D printer are based. The main challenge for building this printer is namely converting the knowledge and experience of craftsmen into an automated machine, translating subjective skill into objective parameters such as temperatures, printing speed, extrusion rate and many more (see video on page 18: Workshop glass fusing). This machine is necessary to make objects with repeatable quality in a highly controlled environment in which process temperatures range from room temperature to more than 1000 °C. A great challenge in the manufacturing process is the thermal and brittle material behavior of glass. Thermal residual stresses, pores and material inhomogeneity (e.g. crystallization) can occur during manufacturing, with the result of possible glass breakage. After producing the glass samples, material and component investigations were conducted in order to analyze homogen-

Figure 3: Hand-manufactured fused glass samples: a) point fused sample b) line fused sample c) stacked spline fused sample
ity (residual stress, morphology, etc.) and performance (strength, hardness) of the joining area and the interface between fused glass layers and flat glass (figure 4). The point fused samples were then subjected to a destructive bending test which showed promising results. Results show that load transfer through fused glass joints is possible, thereby proving the concept and passing a green light for building a 3D printer to automate the process and take the research to the next level in 2020.

Potential applications
As already shown in figure 1, a potential application that logically comes to mind from the perspective of the department of Façade Technology is to use AM glass for the design of glass connections directly on top of a glass plate. From a design perspective, you can imagine the range of options available in terms of transparency and freedom of form whilst eliminating current engineering problems related to adhesives or boreholes. Moreover, it would be possible to locally print glass on top of a glass façade panel in order to stiffen the plate where necessary according to its structural analysis, thereby minimizing both the amount of material used and the total weight of the glass panel.

A third application from the perspective of façades would be to use AM glass for a new generation of Vacuum Insulated Glazing (VIG) in which the small black spacers between the two glass plates could be replaced with transparent glass spacers directly printed on one of the glass plates. It would also be a possibility to use AM glass in a way to seal the...
perimeter of the glass unit, comparable to a welding process. As a fourth, it is imaginable that a higher degree of transparency is desired for insulated glass units (IGU). AM Glass could eliminate the necessity for the (highly visible) spacer, reducing the size of the seam (often Butyl) to minimal proportions.

From the perspective of other industries, it is imaginable to use AM glass in the car or yacht industry as stand-alone objects or to add new functionality directly printed on the glazing of a car/yacht. Also for interior designers, this technology could open an entire new spectrum of design possibilities, with direct bathroom applications imaginable such as taps, shower enclosures or decoration. The optics industry is also directly a potential area for implementation of AM glass, based on their desire for complex glass objects with extremely high quality and accuracy which is imaginable with a computer controlled technology such as AM glass. Whichever way additive manufacturing with glass will exactly develop, the TU Darmstadt aims to be on the frontier with state of the art research, continuously pushing the boundaries.

Robert Akerboom, Matthias Seel
TU Darmstadt

The article ‘Fused glass deposition modelling for applications in the built environment’ is online (pdf)

Research team: Robert Akerboom¹, Matthias Seel², Ulrich Knaack¹, Matthias Oechsner³, Jens Schneider³, Peter Hof²

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Video: Short video on how the glass samples are fused by hand
The material was created by a collaboration of parties who consider it important that materials that we use in nature and for nature restoration do not remain in nature. To this end, a link has been established between a party with knowledge of nature practice, a university with knowledge of how nature functions, a company with experience in injection moulding and a company specialized in processing waste streams into biopolymers. After two years of development, with numerous challenges, the first batch of BESE-elements was available in 2013. A first test was carried out in 2014 in the Wadden Sea, the Netherlands.

Nature structure: Potato scraps have a new purpose at sea

Dutch marine biologists recycle potato waste into mats that they use for nature restoration, like salt marshes, reefs and seagrass meadows. These Biodegradable Elements for Starting Ecosystems, or BESE-elements, consist of stackable layers that build up into a biodegradable matrix structure (fig 1). The modular design combines porosity with a complex structure. In a way it resembles the well-known building blocks: a simple design with endless possibilities. Now worldwide tests for nature restoration have been set up with the material.

Figure 1: BESE-elements. Module composed of 6 layers. The layers have a size of 92x455x20 mm each
Nature foundation

The modules serve as a starting point: a temporary structure that provides adhesion, stability and protection for organisms, both plants and animals. Normally nature provides this, but, due to human activities, structure-forming plants and animals in nature have disappeared in many places. Many young plants and animals are not able to start in a new place without the protection of the parents: the conditions are just too harsh. The artificial structure temporarily takes over protection, inhibits currents and waves on a small scale. After establishment, nature itself forms a structure and artificial support is no longer necessary. After a while, nature can take over and the material can slowly break down.
Material properties
The material consists of single layers, that are stackable for transport and can then be clicked together on site (fig 1). The clicked layers form a complex 3-dimensional structure, with a large surface-area and many cavities. The renewable raw material, Solanyl, is biodegradable, carbon neutral and non-toxic.

Shape
The material is designed for modular assembly and installation, allowing for different combinations, structure heights and dimensions depending on the needs (fig 1). The basic element is a rectangle of approximately 0.5 x 1 meter. The number of layers and the shape are adjusted to the desired location, application or type of restoration needed. The color can be adjusted as desired with a biodegradable dye.

Biodegradable
The material is made from Solanyl, a renewable raw material consisting of a mixture of biopolymers. An important component that has been used as raw material consists of potato residues from the French fry industry (fig 2). The material complies with Vincotte OK Compost and is certified in accordance with EN13432 (industrial composting). The degradation is done by micro-organisms and ultimately results in water, carbon dioxide and microbe biomass.
Outside the controlled composting environment used by the certifying bodies, biodegradability is a process that is subject to its environment. In comparison, a table made of bare wood, a material that is biodegradable, can last for centuries in a dry indoor climate, but will quickly rot away in a moist forest. Thus far, a strongly varying breakdown time of the material is observed at different locations. In a freshwater spring in Florida the material was totally soft after only three years. In open water, situated in the temperate climate zone of the Netherlands, it may take one or more decades. Therefore a second mix of the material is available since 2019 that breaks down more quickly, in approximately one or two years.

Worldwide applications
The main application, currently used in locations across four continents, are water systems and coastal ecosystems that suffer from human activities. These ecosystems are of great importance, including for coastal protection, drinking water supply, recreation and aquaculture. That is why it is especially important for these systems to protect and restore nature, for example by using Biodegradable Elements for Starting Ecosystems. The possible applications for these 3D structures are numerous. A selection of the possibilities (fig 3, 4, 5):

- Nature restoration, including salt marshes, mangroves, sea grass, dune vegetation, reefs and peat bogs;
- Aquaculture and water quality;
- (Underwater) habitat creation.

Award and expo
The structure was awarded the first prize of the Circular Innovation Challenge of the Water Boards in 2018. The material has also inspired architects and artists and has been exhibited at Art Park, Warapuke, New Zealand (‘Biobased Experiments’ Natasja Rodenburg 2017), the Boston Society of Architects (‘NatureStructure’ 2018, with book edition in 2020) and in Amsterdam, Huis Marseille, (‘When Red Disappears’, Elspeth Diederix 2019). The material is used at exhibitions and in shop windows (Fig 6).

Tekst: Bureau Waardenburg

Figure 5: Mangrove restoration with BESE-elements® in Pumicestone passage, Australia (photo: HLW)

Figure 6: BESE-elements in a shop window
Glass-foam-concrete sandwich

Last January, detail-online.com paid attention to the research project ‘Composite connection in glass rigid-foam concrete sandwich elements’ of the University of Siegen. The research focussed on a new type of sandwich element made of concrete, polyurethane rigid-foam and glass for use in facades. Composite thermal insulation systems are not new. They usually consists of a load-bearing supporting shell of reinforced concrete, a thermal insulation layer of rigid foam and a facing shell. The connection between these separate layers is usually mechanical and accomplished with fasteners. Skipping these fasteners would be interesting in terms of material savings and manufacturing complexity as well as improved thermal resistance with a lower component thickness. And that’s exactly what the Siegen researchers have investigated.

In a research project in cooperation with the Chair of Structural Design at the University of Siegen, a new type of sandwich construction was developed in which glass panels as facing layer are connected via the insulation layer to a reinforced concrete bearing layer without any mechanical anchorage. The tensile and shear forces, are transferred in the interface layers between the three materials exclusively by adhesion.

Various tests were carried out to characterise the bond between various rigid foam panels and cast-on ordinary performance concrete (OPC) as well as ultra-high performance concrete (UHPC). The rigid foam panels consisted of expanded polystyrene (EPS), extruded polystyrene (XPS) and polyurethane (PUR) and had different surface textures. Especially different surfaces in the composite joint between the glass and insulating material were investigated, as well as between the concrete and insulating material. The analysis of the fracture surfaces shows the importance of the use of an adhesion promoter. The rigid foam processed with an adhesion promoter has significantly smaller pores in higher numbers at the interface to the glass. Compared to rigid foam without adhesion promoter, this results in a larger effective area for the transfer of adhesive tensile and shear forces, which leads to higher strengths between the glass surface and the rigid foam.

The research shows the technical feasibility of strong glass rigid-foam concrete sandwich elements. However, further tests are required to understand how the material behaves under mechanical and climatic stresses.
Scheldestromen manages 424 km of primary flood defences. The safety of these barriers is currently being assessed on the basis of the new so-called WBI2017-standard. The Westerschelde Dike around Hansweert, with a length of 4.5 km, is a ‘primary water defence system’ and according to this legal standard it should be extra safe, given the low location of the village. Thus, after calculating and checking the dike, it appeared that there’s a reinforcement challenge to make this dike future-proof.

The dike at Hansweert is part of the Dutch Flood Protection Program (HWBP). Within this cooperation of the water boards and Rijkswaterstaat, efforts are being made to strengthen the primary flood defenses so that they meet the legal standards laid down in the Water Act by 2050. In addition to the ‘normal’ work, the Flood Protection Program (HWBP) encourages water boards to innovate. In this way, it could reduce the costs of the enormous task that awaits the Netherlands: reinforcing approximately 1100 km of dikes until 2050. Scheldestromen has set up an innovation program for Dijkverzwarend Hansweert for both process and technical innovations.

Fully circular
Scheldestromen aims to be completely energy-neutral by 2025 and fully circular by 2050. In this perspective, producti-on and transport of cladding stones is a point of attention. Previously, these stones came from quarries hundreds to thousands of kilometres away. In recent decades, these blocks have mainly been...

Durable dike cladding made of sludge

Water board Scheldestromen is responsible for the safety of all dikes and dunes in the Zeeland region, the southwest of The Netherlands. To perform its core tasks in a more sustainable and smarter way, Scheldestromen is searching constantly for innovation partners. The water board is currently preparing a dike reinforcement near the village of Hansweert. Within this project, Scheldestromen, together with innovation partner NETICS, is investigating a way to make the required new stone cladding of the dikes more sustainable by making it from dredging sludge.
produced in concrete plants. One of the technical innovations that Scheldestromen wants to achieve in the Hansweert project is the use of the dredged waste material in the production of dike covering stones. By using dredge as a building material, concrete no longer has to be produced and transported. With the NETICS innovation ‘GEOWALL cladding made of dredged material’, the raw material is extracted from the immediate vicinity and will thus make an important contribution to lower CO₂ emissions. The cladding stones are easy to reuse because there’re recovering techniques available. This ensures more circularity, not only in Zeeland but worldwide.

**Building with sludge**

In cooperation with the Dutch engineering company NETICS, Scheldestromen will start this year a research project on sludge based cladding stones. Earlier, NETICS has developed various innovations within the theme of ‘building with sludge’ and at the end of 2019, the idea was nominated for the Water Innovation Prize in the Water Safety category¹. The sludge based cladding stones are innovative blocks, which will be produced according to the so called GEOWALL technology² patented by NETICS. This technique makes it possible to develop high-quality construction elements from low-grade dredging waste. These building elements are created by mixing natural binders with the dredged sediment, which are then mechanically stabilized into blocks by means of a specialist press operating under very high pressure. These blocks can be produced in various sizes, shapes and strengths, depending on the desired application requirements and the preconditions that follow from the design of the construction. The challenge is to obtain the desired product properties, based on the locally extracted dredging sludge. In the past, NETICS has successfully developed various block shapes of sludge material for various applications, such as the monastery mop (30 x 14 x 9 cm), quarry stone (40 x 40 x 40 cm) and mega blocks (160 x 80 x 80 cm).

**Closed chain**

By building with sludge, a closed circular chain is created, in which no waste is generated, making building projects more sustainable, contributing to a circular economy. Thanks to the GEOWALL technology, dredged material no longer has to be regarded as waste, but rather as a gift from nature. Now and in the future, many primary raw materials can be re-

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1. Water Innovation Prize
2. Geoward Technology

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**Diagram:**

- **Dredging market**
  - Sediment
  - Dredging
  - Waste
  - Deposits
- **Construction market**
  - Raw materials
  - Construction project
  - Structure
- **Resource efficient Circular economy**
  - Sediment
  - Dredging
  - Structure
  - Construction project
placed in many constructions, including dikes, banks, dams, breakwaters, but also buildings, noise barriers, cable ducts and infrastructure. Each application has different requirements for the quality and shape of the block. In the past seven years, basic technology has been developed and the first simple blocks of dredging sludge have been made. For example, banks, quay walls and small buildings have now been made with these blocks. The next step is to make the blocks suitable for applications in port and coastal areas as a sustainable and cheaper alternative to quarry stone or as a covering layer for a dike.

**Technology**
Developing sludge based cladding stones is a complicated process. For instance, the applicability of dredging sludge is strongly related to the environmental and geophysical quality of the material. The environmental quality of dredged material is characterized by the degree of contamination and crucially determines whether the application of the dredged material is legally allowed. On the other hand, the geophysical quality determines the workability of the sludge and therefore is a measure of the potential of dredged material to be reused as building material.

In any case, to transform wet dredging sludge into strong and durable blocks, the geophysical quality must be significantly improved. Various reprocessing techniques are available for this, which can be roughly divided into four main methods:

- **Biological stabilization** = improving structure through natural maturation/land farming
- **Physical stabilization** = improving grain distribution by adding another type of soil
- **Chemical stabilization** = increase bonding forces by adding fibers & binders
- **Mechanical stabilization** = improved packing degree under the influence of compaction

In addition to stabilizing the dredged material into blocks, the correct dimensions and shapes are important too. Large blocks are more difficult to make, because the core of the block must also be stabilized. Furthermore, block shaping is crucial to produce dike cladding, but
at the same time it also presents a huge challenge in the production process.

**Pilot starch Hansweert**
For the innovation project ‘Cladding made of sludge’, both laboratory research and practical tests will be carried out. This means that it will first be investigated how the dredged material can be stabilized to the maximum to meet the requirements. After this, the stabilization method is scaled up and tested in both a test setup and a full size dike section. It is being investigated whether the developed technology meets the preconditions and requirements. Through continuous monitoring, it is studied how the cladding will perform with various types of loads and under varying weather conditions.

During the first phase, the most suitable stabilization method is determined in the laboratory. The new cladding stones to be developed will largely, for an estimated 80 percent, be made from locally dredged high organic sediment. Unique recipes are developed to produce the stones of any type of dredging sludge, including the possible addition of primary and secondary binders. The influence of pozzolans, geopolymers, fibers such as cellulose and many other available binders is also being investigated.

In addition to chemical stabilization, mechanical stabilization is also an essential part of the production process. Compressing the stone under a high compressive force gives it the right shape, strength and durability. Determining the correct recipe and pressure force is done during high-quality practical tests. Finally, the cladding is tested for strength, density, stability, erosion sensitivity, deformation, structure and leaching. It is also examined whether the developed starch is suitable for large-scale use with current techniques and machinery.

The GEOWALL cladding stone is also extensively tested outside the laboratory and examined for properties such as strength, durability, physical properties and dimensional stability. The full scale pilot test is also important to investigate.
whether the implementation is feasible and whether the cladding stone is suitable for withstanding all occurring loads and climate fluctuations. In addition to investigating the implementation, it is important to study the ecological value of the sludge based cladding stone as well. For example, algae growth and seaweed development will take place on the stones, which should also be monitored. In 2020, NETICS and the Scheldestromen water board will take the first steps to produce sludge based cladding stones for dikes. When lab research has determined how and with which the GEOWALL sludge stones can be produced optimally, a test location will be set up on an existing dike covering in 2021. The aim is already to benefit from this innovation in the HWBP project Dyke Reinforcement Hansweert, which will be carried out between 2022 - 2024.

After Hansweert, this technique could be applied in many dyke reinforcements in the Netherlands, but also beyond.

1 The Water Innovatie Prijs (Water Innovation Prize) is a yearly award, granted by the Dutch association of internal drainage boards (Unie van Waterschappen: UVW)

2 GEOWALL is a NETICS patented technology (patent: NL B1 2012739)

Ir. J.J. Pieterse (Scheldestromen Water Board), ir. H.H.M. Ekkelenkamp (NETICS), drs. L.J. Kranenburg (NETICS)
Are fungi the next building material for Mars?

Living on the harsh environments of the Moon and Mars will require new architectural ideas. For instance, how to get the construction materials over there? And how to construct them anyway. Earlier this year, Nasa Techbriefs spoke with dr. Lynn Rothschild, the principal investigator on the early-stage development called ‘myco-architecture project’ of NASA’s Ames Research Center. The project is investigating an innovative way of making habitats on the Moon and Mars. The idea is simple: don’t carry the materials to Mars, with huge energy costs, but simply grow them, using mushrooms, or more specific: the threads that make up the main part of the fungus, known as mycelia.
The ‘myco-architecture project’ ultimately envisions a future where human explorers can bring a compact habitat built out of a lightweight material with dormant fungi that will last on long journeys to places like Mars. Upon arrival, by unfolding that basic structure and simply adding water, the fungi will be able to grow around that framework into a fully functional human habitat - all while being safely contained within the habitat to avoid contaminating the Martian environment.

So imagine a self-pitching habitat made of a light, fibrous material, with - according to NASA - excellent mechanical properties. The material could be used dry, wet, frozen with water or as part of a self-produced composite which could allow such enhancements as radiation protection and a vapor seal. It is self-replicating so the habitat could be extended at a future date, and self-repairing.

Mycelial materials, already commercially produced, are known insulators, fire retardant, and do not produce toxic gases. As mycelia normally excrete enzymes, it should be possible to bioengineer them to secrete other materials on demand such as bioplastics or latex to form a biocomposite.

In this way, a mycelium structure can be made, consisting of “stand alone” mycelium composite, whether or not in combination with sintered regolite (surface material from Mars). After the arrival of humans, additional structures could be grown with for instance mission-produced organic waste streams. When protected, the mycological materials can have a long life, but at the end of its life cycle the material could be become fertilizer for mission farming. Fungal mycelia is a lifeform that has to eat and breathe. That’s where something called cyanobacteria comes in - a kind of bacterium that can use energy from the Sun to convert water and carbon dioxide into oxygen and fungus food.

Nasa envisions an habitat concept with a three-layered dome. The outer-most Graphic depiction of Myco-architecture off planet: growing surface structures at destination (Credits: L. Rothschild)
layer is made up of frozen water, perhaps processed from the resources on the Moon or Mars. That water serves as a protection from radiation and trickles down to the second layer - the cyanobacteria. This layer can take that water and photosynthesize using the outside light that shines through the icy layer to produce oxygen for astronauts and nutrients for the final layer of mycelia.

According to Rothschild this is just the beginning. Mycelia could be used for water filtration and biomining systems that can extract minerals from wastewater - another project active in Rothschild’s lab - as well as bioluminescent lighting, humidity regulation and even self-generating habitats capable of healing themselves. All these techniques can also be valuable for application on Earth. ‘When we design for space, we’re free to experiment with new ideas and materials with much more freedom than we would on Earth,’ Rothschild said on the NASA website. ‘And after these prototypes are designed for other worlds, we can bring them back to ours.’

1 Regolith is a layer of loose, heterogeneous superficial deposits covering solid rock. It includes dust, soil, broken rock, and other related materials and is present on Earth, the Moon, Mars, some asteroids, and other terrestrial planets and moons. It’s believed regolith can be used as a construction material, for building structures like habitats on the Red Planet’s surface, which could make human missions to Mars less complicated to pull off.

More at NASA>

Further reading:

‘A new approach to biomining: Bioengineering surfaces for metal recovery from aqueous solutions’>

Direct Formation of Structural Components Using a Martian Soil Simulant>
Unexpected properties for phosphate glass with fly ash

Glass is transparent and strong, but the melting temperature is high and the material is brittle. PhD research by Clarissa Justino de Lima shows that it is possible to improve its properties. She developed a type of glass from phosphate and fly ash with a low melting temperature and an unusual strength. On 30 March, Clarissa Justino de Lima defended her PhD thesis ‘Innovative low-melting glass compositions containing fly ash and blast furnace slag’.

Standard glass consists largely of silica or silicon oxide and has an incredible theoretical strength of up to 7000 MPa. But unfortunately, due to its brittleness, it achieves a practical strength of only 35 to 70 MPa. Fragility remains the achilles heel, even in architectural applications such as glass bricks. Are there no possibilities to improve that, De Lima wondered? She experimented in the laboratory with new glass compositions, starting with phosphorus pentoxide ($P_2O_5$) and a little fly ash and blast furnace slag - waste products from incinerators and blast furnaces.

Phosphate glass is not entirely new. Advanced types of glass have been de-
Developed with phosphate since the 1950s, which reduces melting temperature and viscosity. According to La Lima, an important problem is that phosphate absorbs a lot of water. The glass produced turned out to be extremely hygroscopic. To test the quality, she submerged the produced workpiece in water for a month. The result: the glassware lost 100 percent of its weight; all phosphate had disappeared.

When she tested glass with an 85 percent potassium phosphate content, half of the mass had disappeared after a month. It wasn’t glass anymore; it became a kind of gel. This changed when she reduced the potassium phosphate content to a percentage of 50 to 75 percent and added at least 15 percent aluminium oxide ($\text{Al}_2\text{O}_3$) to increase water resistance. She also increased the content of fly ash and blast furnace slag considerably. In this case the loss of mass turned out to be negligible.

Fly ash and blast furnace slag are widely used as additives in cement, but also prove to be very suitable for use in glass in this experiment. Their transparency only appears to be affected at a content of over 35%. At a higher percentage, the fly ash causes crystallization during cooling - which is not favourable for its strength and transparency. When the composition of the aggregates changed, De Lima also saw the colours of the glass change. She produced colourless, but also brown, blue, yellow, and green glass.

The various mixtures of phosphate glass that rolled out of the tests already had one pleasant property: a low melting temperature. It melted around 1200 °C instead of 1500 to 1600 °C, such as borosilicate and soda lime glass. This makes a big difference in energy costs and environmental impact. Moreover, the price per kilo is roughly three times lower than the above-mentioned types of glass. This makes it potentially an interesting product, provided the mechanical properties are sufficient.

De Lima carried out laboratory tests to determine those properties. The tests showed that the modulus of elasticity and hardness of the phosphate glass produced is lower than that of standard silicate glass, but the breakage resistance of some mixtures is higher. This may come in handy when phosphate glass is used as a construction material. Thermal stability is also high, while expansion remains limited. Some mixtures could therefore be suitable for use in 3D printers.

The lab research yielded another interesting discovery. For certain compositions, the developed phosphate glass - different from any other type of glass - can be anisotropic. According to De Lima this is exceptional, because it means that it could have a large deformation in one direction, while there is only a small deformation in the other direction. This could mean that it’s much stronger in one direction than in the other. Remarkably, the anisotropic glass retained its transparency. In theory, this glass allows for extraordinary properties. A construction made of this type of phosphate glass could withstand specific loads through clever orientation. Is it therefore suitable for applications in construction, for example as glass bricks or elements for building bridges? De Lima: ‘It could very well be. But that’s a subject for further research.’

Faculty of Architecture and the Built Environment, TU Delft

Text: TUDelft>

Innovative low-melting glass composites containing fly ash and blast furnace slag
From petroleum to wood: cost-efficient and more sustainable

An interdisciplinary team of bioscience engineers and economists from KU Leuven has mapped out how wood could replace petroleum in the chemical industry. They not only looked at the technological requirements, but also whether that scenario would be financially viable. A shift from petroleum to wood would lead to a reduction in CO₂ emissions. Their study was recently published in Science, titled ‘A sustainable wood biorefinery for low-carbon footprint chemicals production’.

The pulp can be used to produce second generation biofuels or natural insulation, while the lignin oil, like petroleum oil, can be further processed to manufacture chemical building blocks, such as phenol, propylene, and components to create ink. The lignin can also be used to make alternative building blocks for plastics. Chemical compounds based on lignin are less harmful to humans, compared to those made out of petroleum. According to professor Bert Sels of the Department of Microbial and Molecular Systems KU Leuven, in the paper industry, lignin is seen as a residual product and usually burned. That’s a pity, since just like petroleum, it can have many high quality uses if it can be properly separated from wood and the right chemical building blocks are extracted. Wood could replace petroleum in the chemical industry. The new publication is an important milestone in the team’s long-term
research. What’s so special about this study, Sels said, is that the economic viability of a switch from petroleum to wood is calculated. To create a realistic scenario, the researchers joined forces with a Belgian-Japanese ink company. This is because certain compounds from lignin can be used to make ink. The calculations indicate that a chemical plant that uses wood as a raw material can be profitable after a few years.

Through smart forest management, wood can be harvested sustainably. Moreover, as a result of the shrinking paper industry, there is currently a surplus of wood in Europe. The researchers are also collaborating with waste processors and landscape managers to use prunings and other waste wood. The environmental cost of using wood would be smaller than when using petroleum, since chemical compounds made from wood cause less CO₂-emissions. Moreover, products made from wood derivatives can store CO₂, just like trees do.

To demonstrate the application of their research, the team will now scale up the production process. The first test phase has already started. Ultimately, they want to create a wood biorefinery in Belgium. In the meantime, the researchers are in conversation with various business partners who can process the cellulose pulp and lignin oil in a variety of products.

The paper ‘A sustainable wood biorefinery for low-carbon footprint chemicals production’ by Yuhe Liao, Steven-Friso Koelewijn, Gil Van den Bossche, Joost Van Aelst, Sander Van den Bosch, Tom Renders, Kranti Navare, Thomas Nicolai, Korneel Van Aelst, Maarten Maesen, Hironori Matsushima, Johan Thevelein, Karel Van Acker, Bert Lagrain, Danny Verboekend and Bert F. Sels was published online by the journals Science and is available upon request.

KU Leuven>

Pim Groen passed away

We are very sad to report that Pim Groen, Professor and Chairman of Aerospace Structures and Materials, passed away on Wednesday 6 May 2020. Pim Groen was Professor of Smart Materials in the research group Novel Aerospace Materials at the Faculty of Aerospace Engineering. He graduated in Chemistry from the University of Leiden in 1987. In 1990 Pim obtained his PhD on the subject of ceramic superconductors. From 1987 to 2002 Groen worked for Philips Research in both the Netherlands and Germany and then as R&D manager for the company Morgan Electroceramics. From January 2008 to September 2011 Groen worked as head of the Materials Performance group at TNO Science & Industry. From 2011 he was programme manager ‘Large Area Printing’ and ‘Printed Conductive Structures’ at the TNO Holst Centre. In 2009 Pim Groen joined the Novel Aerospace Materials department in the field of smart materials and sensors. In 2012, he became Professor of the Smart Materials chair at this group. He combined this position with his work at the Holst Centre. Together with the people in his group, he focused on the development of smart, multifunctional materials, such as piezoelectric composites. Since 2018 he has provided a series of articles on Smart Materials for Innovative Materials. Our thoughts are with Pim’s wife Nelleke, his family and his friends and colleagues.
The corona crisis makes it uncertain whether events will actually take place on the scheduled date. Many events are postponed, sometimes to 2021. The agenda below shows the state of affairs as of May 2020. For recent updates: www.innovatiememmaterialen.nl

Challenging Glass, Genth
Postponed until September, 2020

Techni-Mat 2020
7 - 8 October 2020, Kortrijk

17th Brick and Block Masonry Conference; online
5 - 8 July 2020, Kraków, Polen

Architect@Work 2020
Germany
7 - 8 October 2020, Berlijn

Digital Concrete; online
6 - 9 July 2020, Eindhoven

Nationale Staalbouwdag
2020 13 October 2020, Rotterdam

ESEF 2020
1 - 4 September 2020, Utrecht

Fakuma 2020
13 - 17 October 2020, Friederichshafen

Architect@Work 2020
16 - 17 September 2020, Rotterdam

HK Härterei Kongress 2020
20 - 22 oktober 2020, Keulen

9th Forum on New Materials
21 - 29 September 2020, Montecatini Terme

Glasstec 2020
20 - 23 October 2020, Düsseldorf

CeramicExpo 2020
22 - 23 September 2020, Cleveland

81th Congress on Glass Problems
26 - 29 October 2020, Columbus

Aluminium Association Annual Meeting
23 - 25 September 2020, Washington DC

SurfaceTechnology GERMANY,
27 - 29 October 2020, Stuttgart

SE Conference 20 Amsterdam
30 September - 1 October 2020, Amsterdam

EuroBLECH 2020,
27 - 30 October 2020, Hanover

EFIB 2020
5 - 6 October 2020, Frankfurt

iENA Nuremberg
29 October - 1 November 2020, Neurenberg

Plastics Recycling World Exhibition 2020
7 - 8 October 2020, Essen

Composites Europe
10 - 12 November 2020, Stuttgart
Innovative Materials, the international version of the Dutch magazine Innovatieve Materialen, is now available in English. Innovative Materials is an interactive, digital magazine about new and/or innovatively applied materials. Innovative Materials provides information on material innovations, or innovative use of materials. The idea is that the ever increasing demands lead to a constant search for better and safer products as well as material and energy savings. Enabling these innovations is crucial, not only to be competitive but also to meet the challenges of enhancing and protecting the environment, like durability, C2C and carbon footprint.

By opting for smart, sustainable and innovative materials constructors, engineers and designers obtain more opportunities to distinguish themselves. As a platform Innovative Materials wants to help to achieve this by connecting supply and demand.

Innovative Materials is distributed among its own subscribers/network, but also through the networks of the partners. In 2019 this includes organisations like M2i, MaterialDesign, 4TU (a cooperation between the four Technical Universities in the Netherlands), the Bond voor Materialenkennis (material sciences), SIM Flanders, FLAM3D, RVO and Material District.