Empa Quarterly

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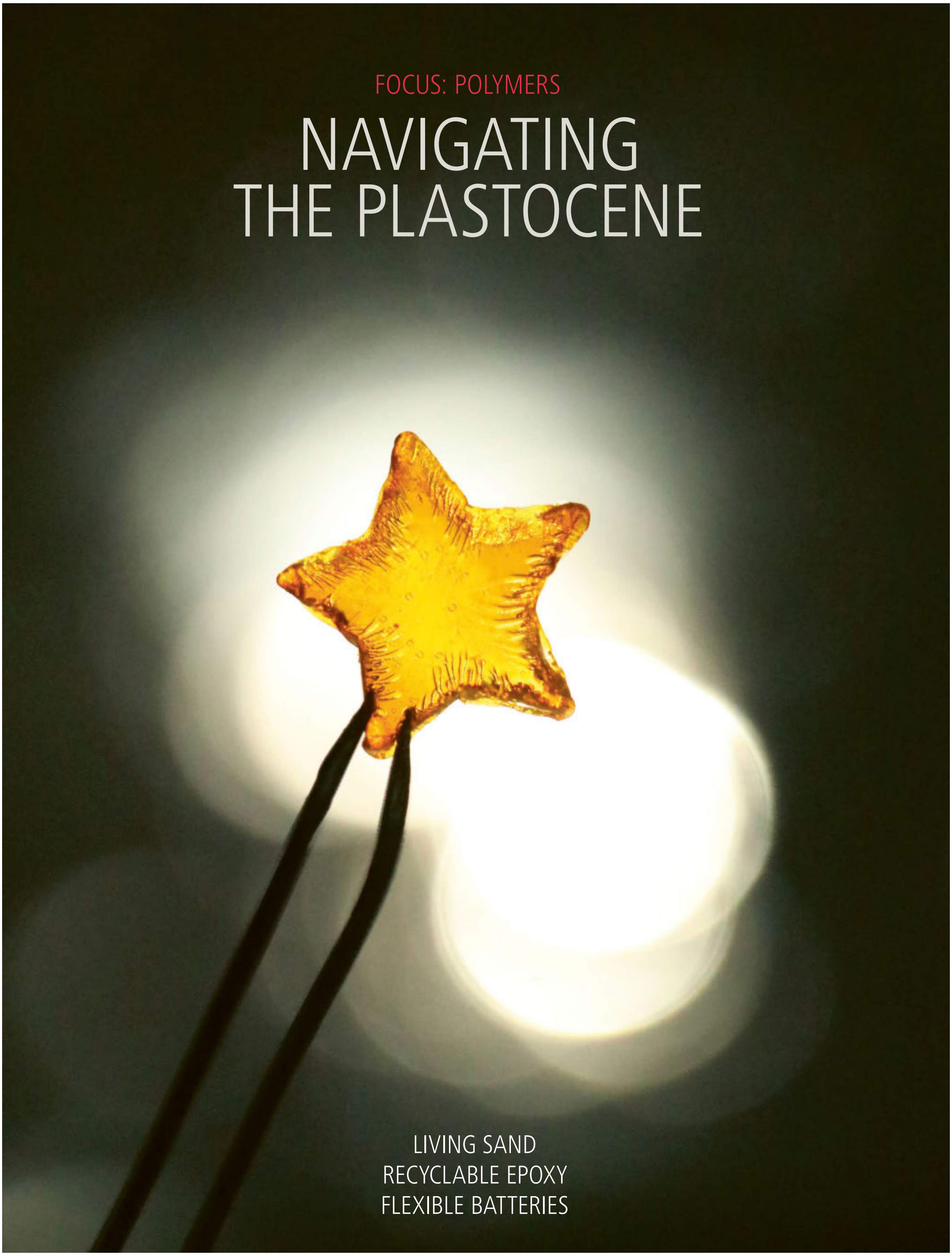

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NAVIGATING THE PLASTOCENE

LIVING SAND
RECYCLABLE EPOXY
FLEXIBLE BATTERIES

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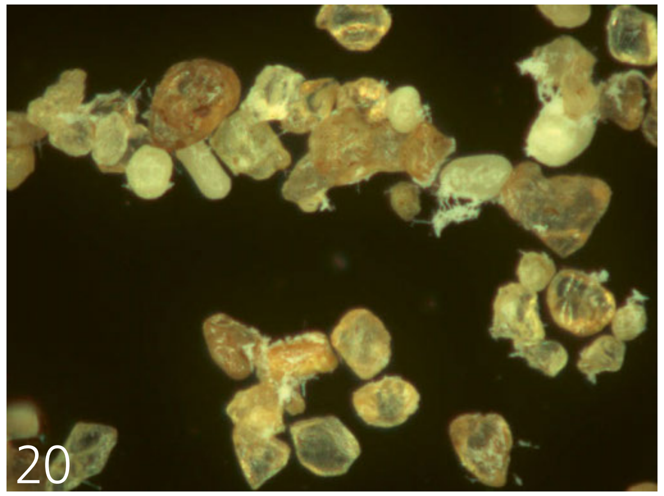

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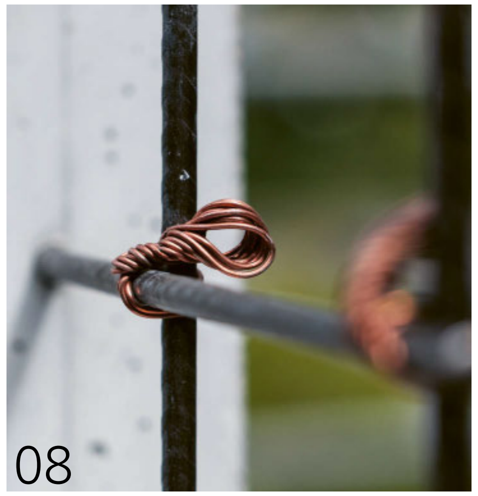

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Photos: Adobe Stock, Khalifa University, Empa

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Aerogels are the lightest known solid materials. These nanoporous structures enable applications in pharmaceuticals, thermal insulation, and catalysis. Aerogels made from the biopolymer cellulose, such as this star, are also biodegradable.

Photo: Michal Ganobjak, Empa

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CONTACT Phone +41 58 765 47 33
redaktion@empa.ch
www.empaquarterly.ch

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WE'RE TURNING IN CIRCLES – FOR THE BETTER!

Dear Reader,

We live in the Plastocene. Polymers are true all-rounders and have become an integral part of our lives. But their degradation products are just as omnipresent – from the Great Pacific Garbage Patch, the gigantic garbage vortex in the North Pacific, to microplastics in our food and PFAS in the environment. We thus need to fundamentally rethink how we use polymers. This is precisely the goal of the Sustainable Polymers Competence Cluster that was just set up by Empa and Eawag. Polymers need to become more sustainable and – crucially – recyclable (p. 14).

In any case, thinking in terms of cycles is the order of the day for a future-proof approach to dealing with our resources. This goes far beyond plastics, of course. In the EU project CARBCOMN, Empa researchers want to make concrete both more climate-friendly and recyclable through intelligent design, digital manufacturing, and alternative binders (p. 31). And in the NEST unit Beyond.Zero, currently in planning, the ultimate cycle is to become reality: the carbon cycle, in which buildings will serve as CO_2 sinks in future, meaning they will bind more CO_2 than was emitted during their production (p. 11).

However, we can also get by with fewer resources in the old-fashioned way – i.e., simply by using things longer. Smartphones or bridges, for instance. Since the latter lose stability over time, this is not trivial, however – think of the Morandi Bridge. Thanks to an innovative reinforcement system with "intelligent" steel, Empa researchers want to give aging bridges a second life (p. 8).

Enjoy reading!
Your MICHAEL HAGMANN

Photo: Empa

HEIDI GOES HIGH-TECH

In the Swiss pavilion at the Expo in Osaka, the Swiss cult figure met Swiss cutting-edge technology. There, little Heidi symbolizes how industrial processes can be defossilized with the help of captured CO_2 – while also representing the cultural exchange between Switzerland and Japan. Empa's exhibit Mining the Atmosphere showed how researchers capture, store and convert CO_2 into new materials, such as CO_2-negative building materials or platform chemicals for industry. The exhibit is based on Empa's research initiative of the same name.

RAILWAY BRIDGE WINS AWARD THANKS TO SWISS CARBON CABLES

DELICATE
88 carbon hangers, co-developed at Empa, stabilize the delicate structure over the Oder River.

The Oder Bridge near Küstrin is supported by a network arch with prestressed carbon cables. The ultra-lightweight yet extremely stable tension members made of carbon fiber reinforced plastic (CFRP) were developed by Empa spin-off Carbo-Link and tested and evaluated at Empa. The innovative material not only enables a particularly material-efficient construction method, but also significantly reduces CO_2 emissions compared to a conventional steel structure. The bridge has received two awards for this groundbreaking design – the British Bridges International Award and the German Bridge Construction Prize.

THREE RESEARCHERS RECEIVE START-UP FUNDING

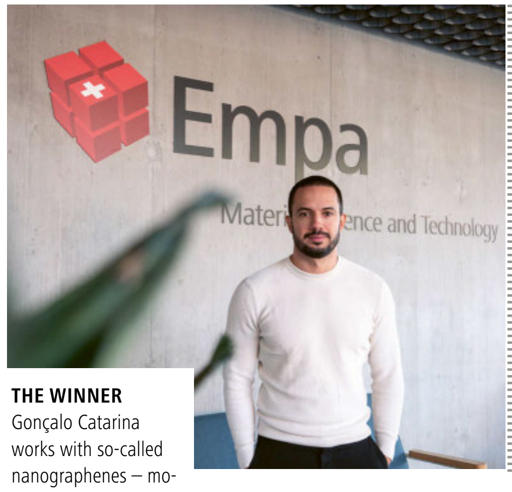
Ultra-thin terahertz optical components, large-area strain sensors, and high-throughput surface microstructuring – three Empa researchers, Elena Mavrona, Mohammad Jafarpour, and Nicolas Zaugg, have been awarded this year's Empa Entrepreneur Fellowship for these developments. The one-year fellowship is awarded to candidates who want to found a start-up based on their research at Empa and become entrepreneurs.

YOUNG TALENTS
Elena Mavrona, Nicolas Zaugg, and Mohammad Jafarpour (from left) are this year's recipients of an Empa Entrepreneur Fellowship.

Photos: Deutsche Bahn AG / Volker Emersleben; Empa

YOUNG SCIENTIST FELLOWSHIP FOR QUANTUM RESEARCHER

Researchers from Empa's nanotech@surfaces laboratory are leaders in the production and research of two-dimensional nanostructures made of carbon, known as nanographenes. These special molecules exhibit promising (quantum-)physical properties. The research group is now receiving reinforcement on the theoretical side: Gonçalo Catarina wants to develop reliable theoretical models that can be used to explain or even predict the properties of nanographenes. He has been awarded Empa's two-year Young Scientist Fellowship for his project.



THE WINNER
Gonçalo Catarina works with so-called nanographenes – molecular structures that can exhibit quantum effects.

EMPA'S RESEARCH IN THE BANKNOTE FINALS

The Swiss National Bank (SNB) is working on designs for the new series of banknotes. The original twelve designs were evaluated in a public opinion poll and by an external advisory board. Among the six finalists is Concept J from the design agency Emphase Sàrl in Lausanne and Bern. The 20-franc note in the series features Empa's research building NEST, while the 1000-franc note shows the research station on the Jungfraujoch and the Monte Rosa hut, in which Empa is also involved. The decision is expected to be made in early 2026, with the new banknotes scheduled to appear in the 2030s at the earliest.

MADE IN SWITZERLAND
One of the proposed designs for the new banknotes features Empa research.

Photos: SNB; Empa

STRENGTHENING BRIDGES WITH "SMART" STEEL

Many bridges in Switzerland were built before the 1980s – and are therefore approaching the end of their service life. Empa researchers are now developing a novel strengthening system to retrofit damaged reinforced concrete bridges. For the first time, they have combined ultra-high-performance fiber-reinforced concrete with memory steel, which attempts to contract after being heated, therefore prestressing concrete structures.

Text: Manuel Martin

UNDER TENSION
Empa researcher Angela Sequeira Lemos and her team have deliberately caused the concrete slabs to crack during their experiments.

Photo: Empa

Today, bridges are being strengthened with an additional layer of ultra-high-performance fiber-reinforced concrete (UHPFRC). This high-strength concrete is applied directly on the deck slabs and is particularly dense and resistant to water. Conventional reinforcing steel is embedded in it to increase its load-bearing capacity.

An Empa team led by researcher Angela Sequeira Lemos, working with Christoph Czaderski in the Structural Engineering lab has now gone one step further: They are replacing conventional steel reinforcement with iron-based shape memory alloy (Fe-SMA) bars – a "smart" material that can remember its original shape. After installation, the bars are heated to around 200°C. As they attempt to contract but are restrained by the concrete, internal stresses develop. These internal forces can close cracks, lift deformed elements, and extend the service life of a bridge – without the need for complex tensioning devices. "The beauty of this strengthening system is its simplicity," says Sequeira Lemos. "You anchor the bars, heat them up, and they do the rest themselves."

TESTS IN EMPA'S CONSTRUCTION HALL

First, the Empa team investigated the interaction between shape memory steel and ultra-high-performance fiber-reinforced concrete, being combined here for the first time. The researchers examined how well the two materials bond to each other even after the shape memory steel was heated, and what forces could be transmitted.

This was followed by large-scale tests at Empa's construction hall with five concrete slabs, each five meters long. The slabs intended to represent cantilevered bridge decks. One slab remained unstrengthened, while the others were strengthened with a layer of ultra-high-performance fiber-reinforced concrete, combined either with conventional reinforcement or Fe-SMA bars. In order to simulate real-life conditions, the team first deliberately cracked the slabs before strengthening them – just as in a real bridge rehabilitation. After installation, the researchers heated the Fe-SMA bars, causing them to attempt to contract to their original shape and to prestress the reinforced concrete structure. Already during the activation, existing cracks were closed and remaining deformations completely disappeared.

SIGNIFICANTLY STIFFER AND MORE DURABLE

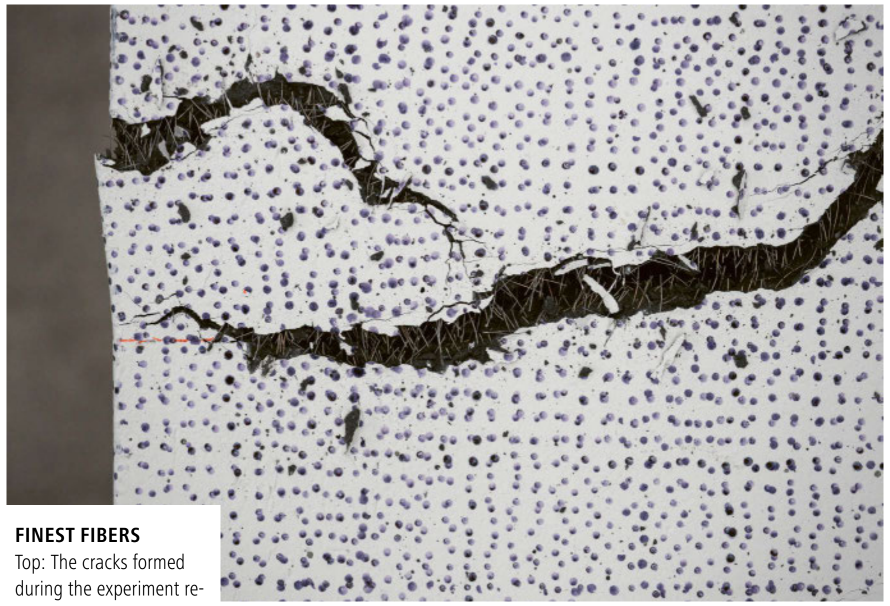
Using state-of-the-art measurement technologies, the researchers continuously tracked deformations in the slabs. Digital cameras monitored cracks on the concrete surface, while tiny fiber optic sensors were embedded along the bars. "We use sensors that work similarly to fiber optic cables in telecommunications," explains the Empa researcher. "However, instead of sending encoded data through the fibers, we analyze the backscattered light. This allows us to see exactly how the bars are deforming."

The tests showed that both the conventional and the novel strengthening system with shape memory steel increased the load-bearing capacity of the unstrengthened slab by at least a factor of two. Under everyday conditions, however – such as those caused by normal road traffic – the combination of fiber-reinforced concrete and shape memory steel proved to be superior: It makes the bridge slab stiffer, delays permanent deformations, and can close existing cracks or slightly lift bent components. "We were able to show that our system not only works, but can actually revitalize existing bridges," says Sequeira Lemos.

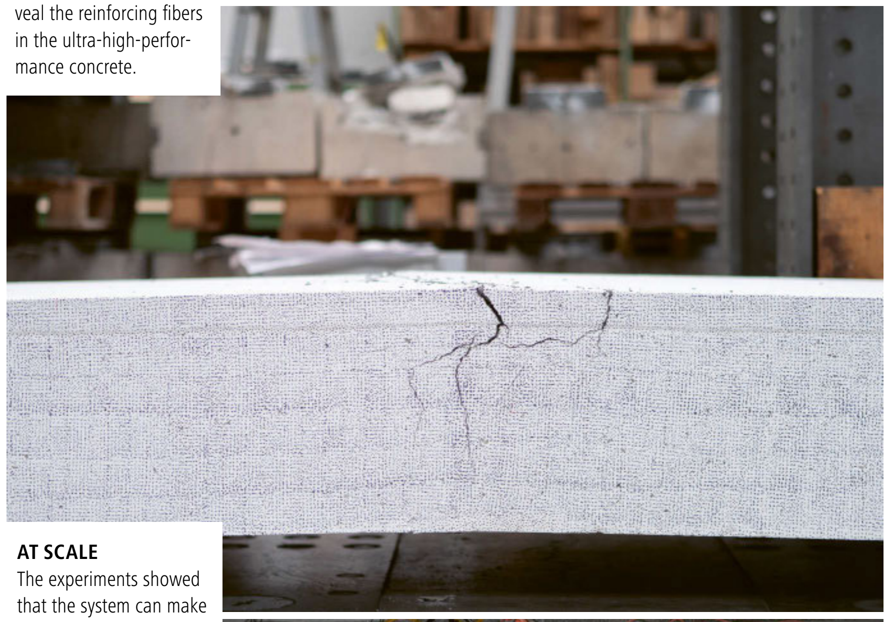
THE PERFECT SOLUTION FOR DAMAGED BRIDGES

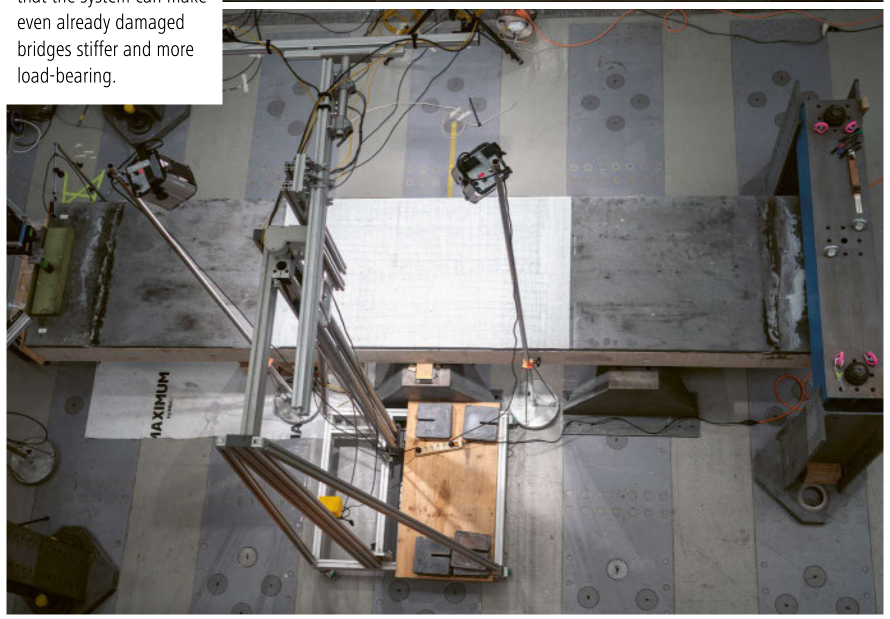
The materials the Empa team used are still rather expensive. The system is therefore particularly suitable for heavily deformed or already damaged bridges – in other words, where conventional reinforcement methods reach their limits. According to Sequeira Lemos, it could also be used in building construction, for example on balconies or flat roofs, where compact solutions or good sealing properties are required.

The project, funded by Innosuisse, was developed in close collaboration ►



FINEST FIBERS
Top: The cracks formed during the experiment reveal the reinforcing fibers in the ultra-high-performance concrete.





AT SCALE
The experiments showed that the system can make even already damaged bridges stiffer and more load-bearing.

HOW SHAPE MEMORY STEEL WORKS

The Fe-SMA (iron-based shape memory alloy) bars are manufactured like normal ribbed reinforcing bars and are delivered to the construction site in a pre-stretched condition. They are then positioned and anchored in the existing reinforced concrete structure, heated, and then covered with concrete. When heated, the steel "remembers" its original shape and tries to recover it. By being restricted to move, it develops internal forces instead which are transferred to the concrete via the anchor zones.
This shape memory effect is made possible by a special iron alloy that contains manganese, silicon, and chromium, among other elements. By initially stretching the bars, the atomic crystal structure is altered. When heated to around 200°C, the atomic structure reverts back. Since the steel is fixed in place, the resulting forces prestress the existing structure, closing existing cracks, and lifting deformed elements.

with the Eastern Switzerland University of Applied Sciences, the Empa spin-off re-fer, and the Association of the Swiss Cement Industry cemsuisse. Following the successful tests, the team is now looking for a suitable bridge for its first practical application. "If we can reinforce a real bridge with our system, interest from industry is likely to grow rapidly," says Sequeira Lemos. "And as demand increases, material costs are also likely to fall – then this technology could bring a lasting change in bridge renovation." ■

Photos: Empa

A COLLABORATION TO BUILD UPON

Since August 2025, Omya is involved in realizing the new NEST unit Beyond.Zero as an official partner. The project aims at demonstrating how buildings could serve as carbon sinks in the future, meaning that they emit less CO_2 than they store inside their structures and materials. In our interview, Philipp Hunziker, Vice President Research and Development at Omya, elaborates on the appeal of this collaboration.

Interview: Christoph Stapfer

A STRONG TEAM
The new cement-reduced concrete forms the foundation for the partnership between Omya and Empa in the NEST project Beyond.Zero.

Photo: Empa

Philipp Hunziker, what was going through your mind when you first heard about the project Beyond.Zero?
Several years ago, I had the opportunity to visit NEST and see some of the units from the inside. So I was very pleased and interested when I heard about the Beyond.Zero project and realized that it addresses an issue that is also a high priority at Omya.

Omya specializes in the use of natural minerals in a wide variety of products and industries. How does that affect reducing carbon emissions in buildings?
Omya offers both specialty chemicals and industrial minerals for the building materials sector. For the Beyond.Zero project, our focus lies on minerals, particularly natural calcium carbonate. Compared to other substances used in the construction sector, calcium carbonate has a relatively low carbon footprint. Using this product can therefore reduce the carbon footprint in applications such as concrete or dry mortar without compromising performance.

At the same time, however, we can also positively influence technical properties such as flow behavior and ▶

GRAY IS NOW GREEN
The new cement-reduced concrete significantly lowers emissions from cement production while maintaining the same mechanical performance.

Photos: Empa

water requirements, thereby achieving a further improvement of the environmental perspective. Within Beyond.Zero, we also aim to explore the limits of our application on a real scale. To this end, we have worked with researchers at Empa to develop different formulations with various calcium carbonate recipes.

> "Ambitious goals are key for driving the necessary change forward."

What motivated you to become a partner at Beyond.Zero?
Omya has been collaborating with Empa for many years now. In various projects, we have come to know and appreciate Empa's great expertise and top-notch research. This experience made the decision to become a partner a lot easier. What we particularly appreciate about NEST and the Beyond. Zero project is the opportunity to bring new concepts from our research and innovation to life in a real-world environment for a wider audience. It also provides us with an ideal platform for engaging in discussions with decision-makers and interested experts.

Does that mean Beyond.Zero is helping you bring new materials – with a reduced carbon footprint – from development to market more quickly?
We have been developing CO_2-optimized solutions for our customers in the building materials sector for several years. Some of these are already commercially available and are being used successfully. We remain committed to investing in the development of carbon-reduced building materials. At Omya, however, we are not only focusing on reducing the carbon footprint of building materials, but are also committed to replacing components in building materials that are harmful to health and to using recycled minerals. Successful commercial implementation of this work requires close cooperation between partners from industry, academia, and government …

… as it is prevalent in our NEST projects. What are your biggest obstacles, at present, in bringing new products from research to market?
Omya operates in industries where the introduction of innovations is carefully considered and implemented gradually due to the complexity of the solutions and the high safety and quality requirements. This means that perseverance is particularly important. As a research and development department, we benefit from the fact that Omya is a privately owned company. High price sensitivity and, in many cases, the regulatory environment are further challenges that our researchers and developers face in their work.

Speaking of product development: How do you manage to integrate your involvement in Beyond.Zero into your day-to-day business?
From our experience, financial commitment in and by itself does not automatically lead to the desired benefits of a cooperation. In accordance with the decision to enter into the NEST partnership, we have therefore put together an internal project team that has been allocated a dedicated time budget for this collaboration.

Let's be honest: Beyond.Zero's goals are quite radical. You are aiming for nothing less than a carbon-negative building. Is this ambition inspiring or rather inhibiting?
Ambitious goals are key for driving the necessary change forward. Omya's development department is already working on next-generation concepts, such as solutions for scalable carbon storage in building materials and buildings. At the same time, we should not forget that CO_2-optimized solutions are already commercially available, not just from Omya. Even small steps can have a big impact if we start to implement the appropriate solutions on a large scale. ■

ABOUT BEYOND.ZERO

The NEST unit Beyond.Zero is investigating whether and how buildings can act as carbon sinks in the future – in other words, emit less CO_2 overall than they store. To this end, innovative building materials developed at Empa, such as concrete and insulation materials, are being used that have a significantly lower carbon footprint or can bind carbon over the building's lifecycle. You can find more information about the project here:

CLOSING THE CIRCLE

Synthetic polymers are extremely versatile materials that have applications in almost every area of life. However, it is also evident that we must use these substances in a more sustainable manner. Making polymers and polymer products ready for a circular economy requires a holistic approach that considers the entire life cycle of materials in the context of the environment, industry, and society. In a new joint initiative, the two research institutes Empa and Eawag have founded the Sustainable Polymers Competence Cluster (SPCC), which aims to facilitate comprehensive interdisciplinary collaboration in research and development.

Text: Anna Ettlin

Take a small molecule, for example a simple sugar, and link it together several hundred or even thousand times into a long chain: The result is a polymer. Biopolymers enable life – they provide structure and function, for example in wood, hair, and DNA. For around 150 years, humans have also been producing synthetic and semi-synthetic polymers, which are now found in countless everyday products. Plastics are made from polymers with additives and are used in packaging, buildings and road construction, electrical appliances, medical technology, automobiles, textiles, and many more. Some researchers and journalists therefore pointedly refer to the era we live in as the "plastocene."

Many plastics contain hazardous chemicals and are mostly based on fossil fuels, which are non-renewable raw materials. Because most plastics are not recyclable, burning them contributes to global warming: At least 4.5 percent of global greenhouse gas emissions are attributable to the production and disposal of plastics. In addition, using plastic products releases microplastic and nanoplastic particles, which accumulate everywhere. Polymers are also used in paints, adhesives, coatings, and cleaning agents. These types of products are difficult or impossible to recycle and thus inevitably end up in the environment.

Various new initiatives from politics, society, and the industry are attempting to find solutions to these complex problems. In short, we need to develop polymers and products that are harmless, recyclable, and, where possible, made from renewable resources such as recycled materials, biomass, or CO_2.

EAWAG AND EMPA IN TANDEM

Eawag is a research institute within the ETH Domain that focuses on pioneering strategies, technologies, and monitoring for securing and providing water for people and the environment. Empa and Eawag share their main campus in Dübendorf. In addition to the SPCC, the two institutes are also strengthening their cooperation through other competence centers, for example in the field of PFAS analysis or within the framework of the new Climate Solutions Hub.

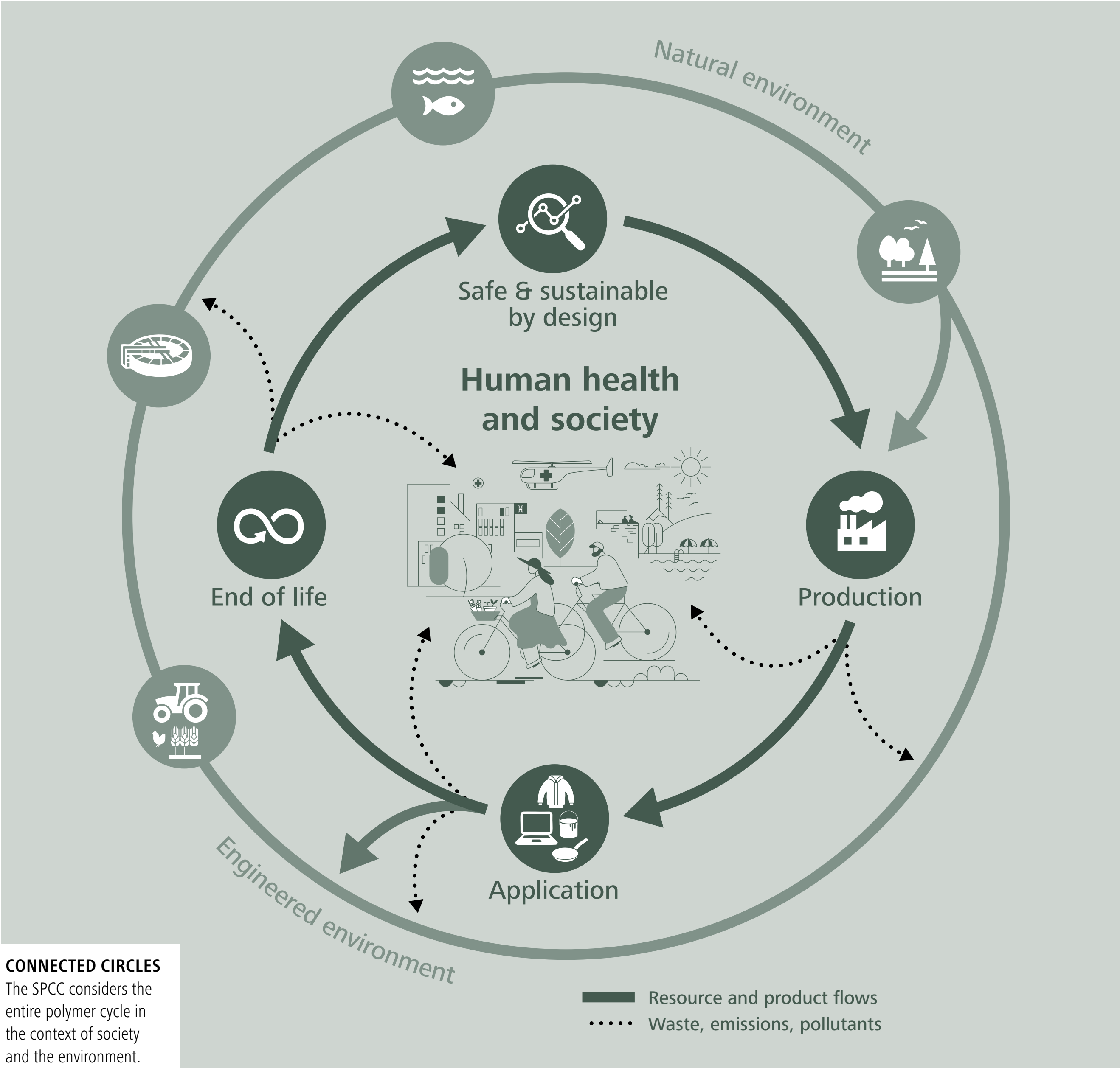
Developing a sustainable polymer system requires a wide range of skills from the fields of materials science, technology, and environmental science, as well as expertise in risk assessment and life cycle analysis. To this end, Empa and Eawag have founded the Sustainable Polymers Competence Cluster (SPCC). The two research institutes of the ETH Domain aim to pool their strengths and work together on the development, application, and evaluation of sustainable polymers.

WORKING TOGETHER TO SEE THE BIG PICTURE

"Among other things, Eawag contributes extensive expertise in the field of environmental behavior of chemicals, including their prediction and measurements," explains Tim Börner, head of the SPCC. "Empa, on the other hand, has strengths in materials development, technologies, life cycle assessments, and industrial cooperations." These complementary skills will be incorporated into SPCC research projects, enabling a comprehensive, systemic view of polymers and product systems. "In order to develop sustainable solutions, we don't just look at individual aspects of a product system, but at its entire life cycle," elaborates Börner.

The goal is ambitious: "We need to defossilize our polymers as much as possible and switch to renewable raw materials. The polymers should be reusable and recyclable, but still enable functional and durable products that are also manufactured in an energy- and resource-efficient manner," explains Börner. Where polymers enter the environment directly – for example, as additives in cosmetics or as carriers and protective agents in fertilizers and seed coatings – the material must be harmless and biodegradable in sewage treatment plants, soil, and waterways.

The SPCC was founded in April 2025. The first projects to emerge from the cluster are already underway, including projects on biodegradable plastics for agriculture and the design of easily recyclable yet functional polymers.
"The SPCC serves as a central interface for collaborations between Eawag and Empa and with partners from industry and government agencies, promoting exchange and public communication," summarizes Börner. "Together, we can map out a large part of the life cycle of plastics and develop ways to produce and use polymers sustainably."



CONNECTED CIRCLES
The SPCC considers the entire polymer cycle in the context of society and the environment.

Graphic: Empa

STRETCHABLE
The solid silicone-based electrolyte is elastic, thereby compensating for the voids that form in solid-state batteries during charging and discharging.

A FLEXIBLE SOLUTION FOR SOLID BATTERIES

Solid-state batteries do not use flammable liquid electrolytes and are therefore safer than conventional lithium-ion batteries. Empa researchers have developed a solid electrolyte based on a stretchable polymer. The scalable material could allow the development of better solid-state batteries and be used in flexible batteries for medical applications.

Text: Anna Ettlin

This is a battery: two electrodes with different polarities and between them, an electrolyte, which enables the transfer of ions (and disables the electronic conductivity) between the electrodes and thus the charging and discharging of the battery. In most batteries, the electrolyte is a flammable liquid. So-called solid-state batteries use a solid substance as an electrolyte instead. This not only makes them safer, but the solid electrolyte also allows the use of alternative materials for the electrodes, such as pure lithium metal for the anode. As a result, solid-state batteries can potentially achieve much higher energy densities, i.e., store more electricity per volume – an advantage for a wide range of applications, from electric cars to portable electronics.

However, as is often the case, this promising technology still has a few "teething problems" that pose challenges for research and industry. Empa researchers from the Laboratory for Functional Polymers are working on a novel electrolyte that could remedy several issues at once. Unlike most electrolytes for solid-state batteries, which are made of rigid materials, their solid electrolyte is soft and stretchable.

SILICONE-BASED ION CONDUCTOR

This innovation is the result of some clever chemistry. The starting polymer for the electrolyte is a polysiloxane, better known as silicone. This elastic compound has one major disadvantage for battery research: It is nonpolar and thus unable to dissolve the charged particles, the ions. The researchers led by Dorina Opris have succeeded in adding functional groups to the "backbone" of the polymer, making it a good ion conductor while retaining its advantageous elastic properties.

Elasticity is a key strength of the polymer electrolyte. Today's lithium-ion batteries use an anode based on lithium salts. Using pure lithium metal as the anode material instead could potentially achieve higher energy densities. When the battery is discharged, lithium ions "migrate" away from the metallic anode; when it is charged, they return. However, they do not deposit themselves in an even layer on the surface of the anode, but form so-called dendrites: tree-like lithium structures that can "grow" to the cathode within a few charging cycles and cause a short circuit.

The use of a solid electrolyte hinders dendrite growth. However, when ions move away from the anode, they leave behind empty spaces – voids – which can cause the anode to lose contact with the electrolyte and reduce the battery's capacity. This is where the elastic electrolyte developed by Empa researchers kills two birds with one stone: It is solid enough to prevent dendrites, but elastic enough to fill the voids and compensate for the volume changes in the anode during charging and discharging.

TOWARDS FLEXIBLE BATTERIES

With the appropriate electrode materials, the electrolyte could also be used to manufacture flexible batteries. "Today's batteries for medical implants, such as pacemakers, are usually hard and uncomfortable for patients," explains Dorina Opris. "Our polymer can serve not only as an electrolyte, but also as a binder material for the cathode." Empa researcher Can Zimmerli adds: "The flexible polymer can be combined with different cathode active materials, enabling batteries for various applications."

Flexibility and safety are not the only advantages of the innovative electrolyte. "The material can be processed into thin films of a few micrometers in thickness, and it is scalable", says Opris. "If produced on an industrial scale, it is also cheaper than conventional solid polymer electrolytes." The researchers are now working on further improving the ionic conductivity of the silicone electrolyte – and at the same time looking for a suitable industrial partner to begin commercializing the technology. ■

APPLICATIONS IN THE WORKS
Dorina Opris (bottom right) and Can Zimmerli are testing their electrolyte in various battery prototypes.

Photos: Empa

RECYCLING INSTEAD OF INCINERATION

Epoxy resin is a clear, robust polymer that is widely used – especially as part of fiber-reinforced materials in aviation, the automotive industry, and more. Until now, however, it has not been possible to recycle it. Researchers at Empa have developed an epoxy resin that can be reprocessed and chemically recycled, in addition to being flame-retardant and easy to manufacture.

Text: Anna Ettlin

Most people are aware that plastic waste is a problem. Almost all types of plastics that we use in our everyday lives are derived from fossil sources. When they end up in the environment, they cause pollution for generations. When incinerated in a waste incineration plant, they release climate-warming CO_2 into the atmosphere. Recycling is therefore the better option: Used plastics provide the raw materials for new ones, closing the loop.

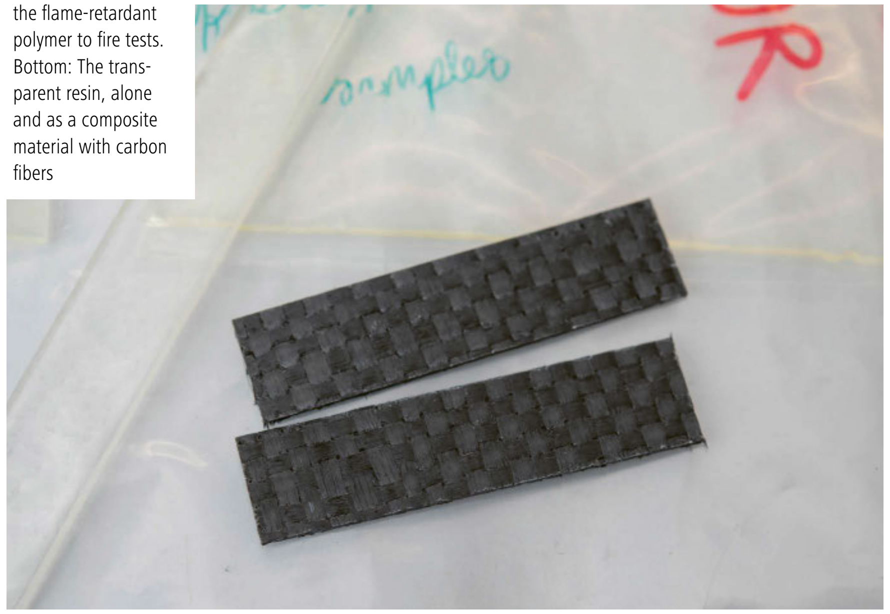
However, not all plastics can be recycled. What is already standard practice for PET, for example, is all but impossible for epoxy resin. This is because epoxy belongs to the group of so-called thermosets. In these polymers, the long molecular chains are cross-linked in such a way that they cannot be melted down again after initial curing. "Today, we only have two options for disposing of epoxy resin: incineration or landfills," says Empa researcher Arvindh Sekar from the Advanced Fibers laboratory in St. Gallen. Nevertheless, this durable plastic is widely used, both in its pure form, for example in coatings or adhesives, and as part of fiber-reinforced materials, where epoxy resin is combined with carbon or glass fibers for everything from aircraft and car parts to sports equipment and wind turbines. Now, the Empa team has succeeded in developing a recyclable epoxy resin. Their polymer can not only be reclaimed using various methods, it is also flame-retardant and easy to manufacture, paving the way for industrial applications.

IT'S ALL IN THE CHEMISTRY

The element that makes all these properties possible is phosphorus. "Phosphorus-based additives are commonly used as flame retardants," says Sekar. "Normally, they are simply mixed into the epoxy resin as a powder." The Empa researchers go one step further and add a phosphorus-containing polymer to the resin before curing, which reacts with the epoxy. The flame-retardant effect of the phosphorus is retained, as are the advantageous mechanical properties of the resin.

However, the phosphorus polymer allows the cross-links between the polymer chains in the cured epoxy to rearrange themselves when heated. After use, the material can simply be ground into powder and pressed into a new shape while heated, causing the bonds to rearrange themselves. This is known as thermomechanical recycling. "We have carried out ten such recycling cycles, and the epoxy has not lost any significant mechanical strength in the process," states Sekar.

But what is to be done if the epoxy is part of a composite material mixed with fibers and cannot simply be ground down? Even here, the new material is at an advantage, because in addition to thermomechanical recycling, it can also be chemically dissolved, enabling fiber recovery without significant damage – a step that was previously almost impossible. "In addition to the fibers, we can also recover over 90 percent of the epoxy and phosphorus," adds Sekar. Unlike thermomechanical recycling, however, chemical recycling requires a lot of energy and larger quantities of solvents, the researcher warns – as does the chemical recycling of other polymers. "Chemical recycling should always be the last resort. Thermomechanical recycling is preferable wherever possible," he says. However, for fiber-reinforced epoxy resins, there is currently no alternative.



NO FEAR OF THE FLAMES
Top: Arvindh Sekar with the novel epoxy resin
Center: The researchers subjected the flame-retardant polymer to fire tests.
Bottom: The transparent resin, alone and as a composite material with carbon fibers

Photos: Empa

INDUSTRY-READY

The Empa researchers have been working on their epoxy resin for several years. They have now improved the manufacturing process so that it can be scaled up for industrial production. "We are looking for industrial partners who would be interested in commercializing the flame-retardant recyclable epoxy," says Sekar. The first areas of application could include indoor and outdoor coatings. Here, the material scores additional points because, thanks to the addition of phosphorus, it has enhanced color stability and reduced yellowing than conventional epoxy resin.

Another area of application would be as an adhesive in the construction of wind turbines. "Wind turbines are vulnerable to fire incidents because short circuits or lightning strikes can cause fires," says Sekar. "In addition to improving fire safety, our material would facilitate maintenance and component replacement because it can be reshaped under the right conditions even after curing." In the meantime, the researchers are working on combining the phosphorus additive with other polymers to make them fire-resistant and recyclable as well. ■

WHEN SAND STICKS TOGETHER

Desert sand is not suited for agriculture – but perhaps that might change. Researchers at Empa and Khalifa University in Abu Dhabi have investigated a first step in this direction by introducing microorganisms into the sand. The bacteria and fungi secrete biopolymers that make sand more resistant to erosion and slow down the rate at which water seeps through. This could potentially enable the growth of further microorganisms and plants.

Text: Anna Ettlin

STABILIZED
Thanks to the biofibers, the sand samples were able to retain their shape better and hold water for longer.

Photos: Khalifa University

Excessive land use, deforestation, and climate change are leading to increased desertification in many regions of the world. Once started, the process often triggers a chain reaction: The loss of nutrients in the soil causes vegetation to become increasingly sparse, which exposes the soil to erosion by wind and water. Turning desert back into fertile soil requires enormous resources – especially water, which is a precious commodity in desert regions. Researchers at Empa and Khalifa University in Abu Dhabi have now investigated a novel first step that could enable further soil improvement in sandy deserts: They have breathed life into the sand.

Sand is a particularly challenging substrate for agriculture. It contains no organic nutrients that could sustain microorganisms or plants. Sand grains do not stick together, which makes sandy soils susceptible to erosion. And sand allows water to seep through quickly, resulting in a very high demand for irrigation. Researchers from Empa's Cellulose and Wood Materials laboratory, together with their colleagues in Abu Dhabi, tackled all these challenges at once. They added specific bacteria and fungi to the sand, which form structured networks across sand grains, giving them more cohesion. Their results were published in the journal "Carbohydrate Polymers."

A NATURAL BINDING AGENT

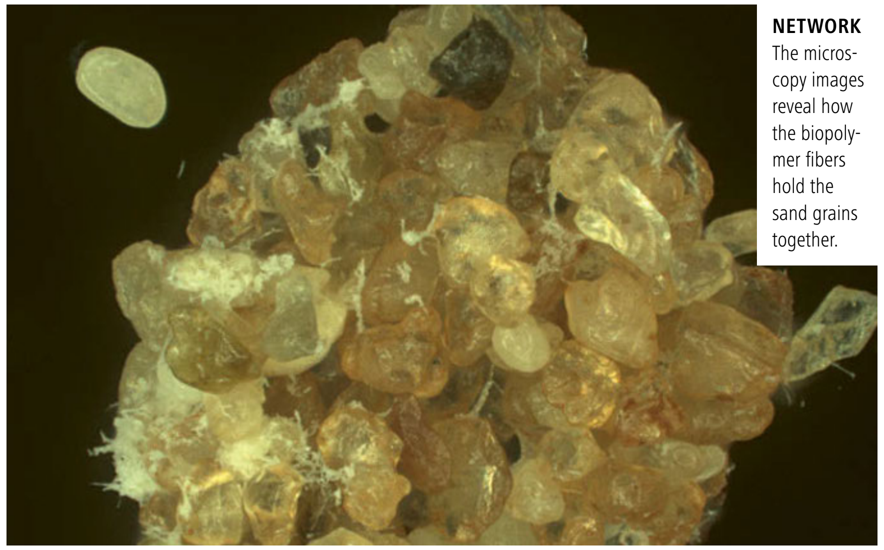
The basis of these microbial networks is formed by so-called biopolymers: natural molecules consisting of long chains – similar to plastics. The microorganisms form long biopolymers into fibers that permeate the sand. "This creates a kind of natural composite material," says Gustav Nyström, head of the Cellulose and Wood Materials laboratory and co-author of the study.

To test their approach, the researchers incubated sand samples from Abu Dhabi with different microorganisms in a nutrient solution and then checked their mechanical strength and water permeability. The result: The samples mixed with bacteria in particular were significantly more robust than pure sand and slowed water permeation up to six times.

In addition to the experiments in which the microbes did their work directly within the sand samples, the researchers pursued a second approach. Here, they used the microorganisms – specifically, bacteria that secrete nanocellulose – to make so-called geotextiles. In the laboratory, the bacteria produced mats of cellulose, which the researchers then combined with the sand to form layered structures. This more labor-intensive process yielded the best results in terms of stability and water permeability. The latter was slowed down by a factor of 28 in the layered samples.

A STARTING POINT FOR GROWTH

Even with the addition of the biopolymers, sand is not overly stable – but it doesn't need to be. "This approach allows us to introduce organic matter and water into the sand and stabilize it somewhat," says Nyström. "Ideally, this will then enable the growth of further microorganisms and plants, thereby initiating the process of making the soil more resilient and fertile." Blaise Tardy, professor at Khalifa University and co-author of the work, adds: "The deployment of these microorganisms is not science fiction: The desert is there, and the nutrients are readily available in the United Arab Emirates, for instance sugars from food waste and complex nutrients in green municipal wastes." The sand experiments in the laboratory were only the first step, the researchers caution. The next step is to use the biopolymers in controlled field studies or greenhouses to see what effect they have on plant growth and how great the potential of the technology is for agriculture. Empa's materials scientists are leaving this task to other researchers from corresponding fields. ■



NETWORK
The microscopy images reveal how the biopolymer fibers hold the sand grains together.

NO ENTRY FOR METALS

Anyone who has ever had to get a magnetic resonance imaging (MRI) scan knows that magnetic and highly conductive materials are a no-go in the tube-shaped scanners. However, for complex diagnoses and medical research, this imaging technique often needs to be combined with other methods that require conductive cables. As part of an Innosuisse project with the Swiss company TI Solutions, researchers at Empa have developed polymer-based cables that function safely and reliably in MRI machines.

Text: Anna Ettlin

Magnetic resonance imaging, MRI for short, is a powerful imaging technique in medicine. It can be used to produce high-resolution images of tissues and organs that reveal even the tiniest injuries, sites of inflammation and early-stage tumors. The procedure uses radio waves and extremely strong magnetic fields. Metal is therefore problematic inside an MRI: Unless they are specially designed, metallic objects such as implants can heat up and cause burns – even if they are not directly attracted by the magnetic field.

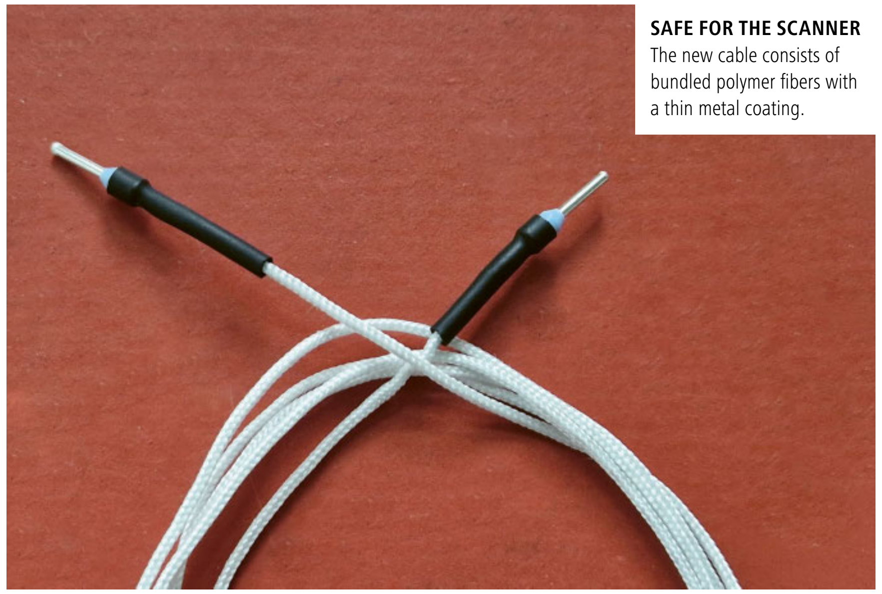
MRI can also be combined with other diagnostic and therapeutic procedures, such as electrical examinations of the heart (electrocardiogram, ECG) and the brain (electroencephalogram, EEG), or stimulation of deep brain structures using temporal interference (TI) technology. To do this, the patient must wear additional electrodes on their chest or head while inside the MRI scanner. And this is precisely where the combined methods reach their limits: The electrodes must be connected to a measuring device by cable, and cables are usually made of copper. In the MRI scanner, they can heat up – plus, they interfere with the MRI imaging.

DANGEROUS METALS
Many metallic objects can fly through the air or become uncomfortably hot in an MRI scanner.

Photos: Adobe Stock, Empa

Researchers from Empa's Advanced Fibers laboratory in St. Gallen have developed a surprising solution in collaboration with their industrial partner TI Solutions AG. Their electrode cables are not made of copper, but of plastic – at least for the most part. Instead of metal wires, researchers led by Dirk Hegemann have used bundles of polymer fibers coated with only a thin layer of metal.

"Our goal was to develop a cable with a very low but precisely defined metallic conductivity," says Hegemann. "The conductivity must be high enough for the signal to be transmitted, but not as high as to interact with radio waves." TI Solutions, a company that develops electrodes for stimulating and measuring brain waves, specializes in brain stimulation using TI and EEG – thus a perfect match for the collaboration, which took place as part of an Innosuisse project. "With 'MRIComplead', the MRI-compatible cables developed in the Empa lab, our medical research partners now have the opportunity for the first time to visualize the effect of TI in the brain using MRI safely and without interference," says Sven Kühn, Head of Research and Development at TI Solutions.



SAFE FOR THE SCANNER
The new cable consists of bundled polymer fibers with a thin metal coating.

ROBUST AND SCALABLE

The predefined electrical conductivity is just one of the requirements that the polymer cables had to meet. In order to be usable in medicine and research, they also had to be durable and resistant over an extended period of time, both to corrosion of the coating and to the mechanical stresses that arise, for example, when plugging and unplugging the cables.

The researchers tested around a dozen coatings using different materials and coating techniques. A thin film made of silver and titanium proved to be the winner. "Silver has very good electrical conductivity," explains Hegemann. "Titanium reduces the conductivity somewhat so that we can achieve our specified range." The two metals also stabilize each other against corrosion. The researchers have already tested the first coated plastic cables for a year and demonstrated that the conductivity has hardly changed over this period.

The researchers applied the ultra-thin coating, which is less than half a micrometer thick, to the fiber using magnetron sputtering: an established process that can be used in an industrially scalable roll-to-roll process. The Empa team has already produced around one kilometer of coated fibers for the first cables. The Innosuisse project was successfully completed in 2025. Nevertheless, the partners remain in contact. "We continue to support our industry partner when it comes to demonstrators and initial sampling," says Hegemann. "Empa's efficient and uncomplicated support in the pilot series phase is another benefit of our collaboration," says Niels Kuster, President of TI Solutions AG. If the polymer cables prove themselves in these initial applications, they will go into industrial production. ■

PFAS IN THE WAX
Although the International Ski Federation (FIS) prohibits fluorinated ski waxes in its races, they are still in use.

FOREVER CHEMICALS ON THE SKI TRAIL

When the forever chemicals known as PFAS enter the environment, they remain there for generations and can harm humans and nature. Despite increasing bans, many PFAS are still in circulation – including on Swiss ski slopes and cross-country trails, where the toxins enter the environment through abrasion from ski wax. Empa researchers have detected elevated PFAS concentrations in snow samples from the Engadin region – and are urging cross-country skiers to switch to fluorine-free waxes.

Text: Anna Ettlin

PFAS – short for per- and polyfluoroalkyl substances – are currently the subject of numerous discussions and legislative proposals. Many of these so-called "forever chemicals" (see box) are harmful to human health and the environment. Since they can potentially remain in the environment for centuries and accumulate in humans and animals, it is important to restrict their use as much as possible. This is a challenge, as PFAS are widely used in numerous everyday objects and industrial processes.

Although industry is the largest emitter of PFAS, consumers also have a responsibility. This is because some of the applications where PFAS are currently used are not strictly necessary. One example that is particularly relevant for Switzerland is their use in certain ski waxes. The International Ski Federation (FIS) has already taken action: Since the 2023/2024 season, fluorinated ski waxes have been banned from all FIS races; their use leads to disqualification. This also applies to Swiss events, such as the Engadin Ski Marathon. Ski wax manufacturers have already responded by switching their product ranges to fluorine-free products.

However, Swiss ski slopes and cross-country trails are not yet completely PFAS-free. This was discovered by researchers from Empa's Analytical Center during a random sample taken at the Engadin Ski Marathon in March 2025. A few hours after the skiers had set off, they took snow samples from the various tracks directly after the starting line, as well as around two kilometers after the start and a blank sample far away from any cross-country ski trail.

A SHORT DISTANCE TO THE LAKE

"We measured relatively high levels of the typical PFAS found in ski wax," says Markus Zennegg, head of the Analytical Center. "These are primarily perfluorinated carboxylic acids with an even chain length of 6 to 14 carbon atoms." The highest concentrations were found at the starting line, where the skiers started with freshly waxed skis. After two kilometers, significantly less PFAS remained in the snow, as the skis quickly lose their fluorinated wax coating through abrasion. Nevertheless, the concentrations were still measurably elevated even there. "This is a cause for concern directly above Lake Sils," says Empa researcher Stefan Reimann from the Air Pollution / Environmental Technology laboratory, who collected the snow samples. When the snow melts in spring, these forever chemicals enter the water and can accumulate in aquatic organisms and fish.

The fluorinated substances in ski wax are intended to improve the gliding properties of skis and thus help ambitious cross-country skiers go faster. However, the differences between these and modern fluorine-free waxes are minimal. "The skis of the ten fastest professional skiers in the Engadin Ski Marathon were all tested, and no PFAS were found," says Reimann. "Obviously, you can be fast even without fluorine."

RESPONSIBILITY IS CALLED FOR

The researchers suspect that most of the PFAS did not end up in the snow due to malicious intent on the part of the athletes, but rather owing to a lack of awareness among recreational skiers. This is also supported by the fact that the elevated PFAS concentrations were not only measured in the tracks reserved for the marathon, but also in areas where normal cross-country ski trails run. "A block of wax can last for several years," says Zennegg. "And almost all older ski waxes contain PFAS." He recommends replacing old ski wax with fluorine-free alternatives, which are commercially available and labeled accordingly. "It simply makes no sense to release such stable substances into the environment for a few minutes' advantage in a race," adds Reimann.

The researchers have now also taken soil samples from the same locations. These too show significant contamination with the persistent chemicals. "At such concentrations, there is already a risk that PFAS will accumulate in excess of the permissible limits in the meat of cattle grazing there," warns Zennegg. Further PFAS studies are also in the works: Over the past few months, researchers at the Analytical Center have built up analytical capacities to determine around 30 of the most common PFAS in various material and environmental samples, for example from recycling processes. ■

PFAS, THE FOREVER CHEMICALS

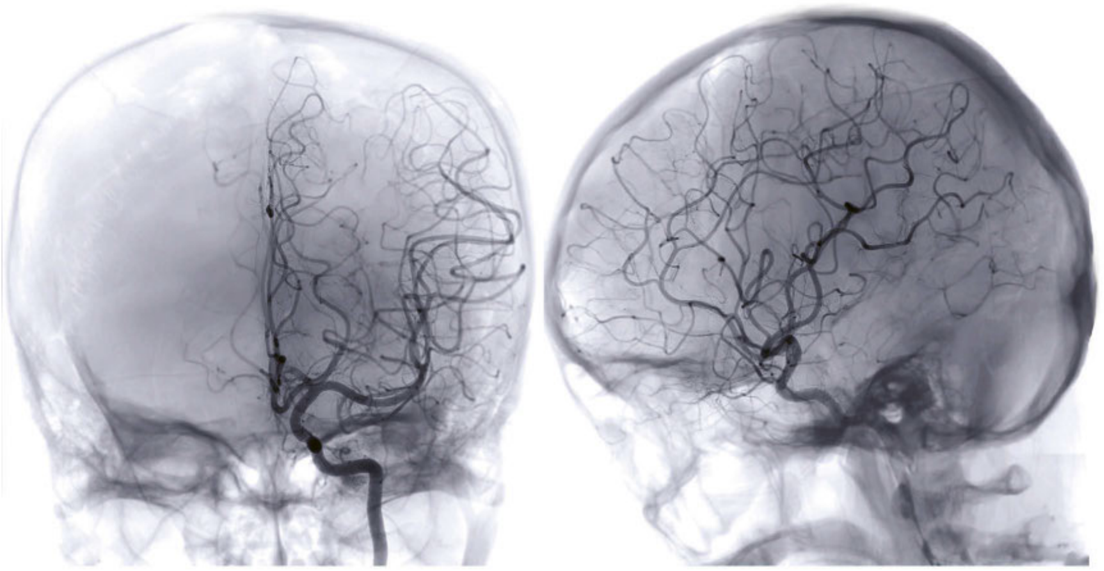
The PFAS class of substances comprises thousands of chemical compounds. They have two things in common: They contain fluorocarbon bonds, and they are extremely stable, meaning that they hardly decompose in the environment. The health effects of PFAS are not yet fully understood, but they are associated with a variety of diseases, from organ damage to cancer. In a new edition of Pocket Facts, Empa, Eawag, and the Ecotox Center provide information about these forever chemicals and how they can be avoided.

Photo: Adobe Stock; Graphic: Empa

SPOT THE CLOT

By the time micrometer-sized blood clots are detected, it may already be too late. Empa researcher Peter Nirmalraj and his team are investigating the occurrence and composition of these tiny blood clots, aiming to assess medication efficacy and individual patient risk more accurately.

Text: Alina Vogel



A CRUCIAL NETWORK
If the finely networked blood vessels in the brain become blocked by tiny blood clots, there is a risk of stroke.

A stroke is life-threatening. When a blood clot impairs the oxygen supply to the brain, every second counts. Various factors increase the risk of thrombosis. These include diabetes, obesity and Long COVID, a condition that occurs after a coronavirus infection. This increases the risk of complications in blood clotting. Up to 30 % of coronavirus patients are affected by Long COVID after their recovery, which can have devastating effects on their health. How microclots in the blood of Long COVID patients affect cardiovascular and neurological risks is not yet fully understood.

Empa researcher Peter Nirmalraj and his team want to work up a comprehensive understanding of blood clots in patients with stroke, COVID complications or rare types of dementia such as vascular dementia, which is caused by strokes. Together with Susanne Wegener from the University of Zürich, the researchers utilize various imaging and measurement methods to precisely characterize blood clots of stroke patients based on their composition, shape and size. Furthermore, they investigate how various clots react to different treatment methods.

To allow everyone to benefit from the collected data and findings, the team wants to provide the model on an open source platform. This enables earlier detection of blood clotting complications and more accurate prediction of individual stroke risk. The project can be carried out thanks to the generous donations from the Peter Bockhoff foundation, the Theodor Naegeli Foundation, the Immanuel und Ilse Straub Foundation, as well as two other foundations. ■

ZUKUNFTSFONDS
Empa's Zukunftsfonds is looking for private funding for outstanding research projects and talents that are not (yet) supported elsewhere. More information can be found here:

Photo: Adobe Stock

TWO DIMENSIONS, INFINITE POSSIBILITIES

INTERDISCIPLINARY
The postdocs Afsheen Zahra Syedah, Aamir Iqbal, Nick Goossens, and Cesare Roncaglia (from left) from four different Empa laboratories are working on MXenes in collaboration.

Photo: Empa

There is more than just graphene: In an interdisciplinary project, Empa researchers have focused on a new class of two-dimensional materials known as MXenes. This versatile group of materials is suitable for a wide range of applications, from energy storage to medicine. The project team has made significant progress in modeling and synthesizing MXenes.

Text: Anna Ettlin

Two-dimensional materials consisting of a single layer of atoms are currently the subject of intense research. Their 2D nature gives them many advantageous properties, whether in terms of electrical conductivity or mechanical robustness, and it can lead to special quantum effects. The best-known two-dimensional material is graphene, a form of carbon. But it is not the only one. The rising stars in the 2D sky are called MXenes (pronounced "maxenes").

Unlike graphene, which consists only of carbon atoms, MXenes can contain one or more transition metals in combination with nitrogen or carbon. They are produced from so-called MAX phases: ceramic crystals with a layered structure – "a little like a lasagna," compares Empa researcher Jakob Heier. The intermediate layers are etched out by adding acid. The remaining layers, which are no longer chemically bonded to each other, are separated from each other in an ultrasonic bath, and the MXenes are ready to go.

This novel class of materials is particularly interesting for research because: "The MAX phases can consist of many different elements and combinations thereof, allowing us to produce tailor-made MXenes for numerous applications," explains Heier. However, as of yet, these potential all-rounders, which were only discovered around 15 years ago, are neither widely used nor well understood. A research initiative at Empa led by Jakob Heier aims to change that.

INTERDISCIPLINARY PERSPECTIVE

The research initiative, named TailorX, is a so-called research booster in which several research groups within Empa work together to thoroughly examine an emerging topic over a period of two years and establish it as a research activity. Scientists from four different Empa laboratories are working on MXenes: Functional Polymers, to which Jakob Heier is associated, High-Performance Ceramics, Building Energy Materials and Components, and nanotech@surfaces.

The comprehensive approach is worthwhile because, as Heier explains, "We cover the entire spectrum, from basic research and modeling to the production of MAX phases and MXenes, right through to their applications. It is one of Empa's great strengths that all these areas of expertise are brought together in a single institute."

> "With their flexibility and adaptability, MXenes offer such great advantages that applications will not be long in coming."

The project was launched in 2024 and is now drawing to a close. The co-initiators are satisfied with the results. "We now have a large portfolio of different MAX phases that we can synthesize with a high degree of purity," says Michael Stuer from the High-Performance Ceramics laboratory. Synthesizing the precursor crystals is not entirely straightforward – it is not enough to simply mix the desired elements in the right proportions. "By gaining a better understanding of the synthesis process, we were able to synthesize numerous MAX phases with various degrees of chemical complexity that are not yet available on the market," explains Stuer.

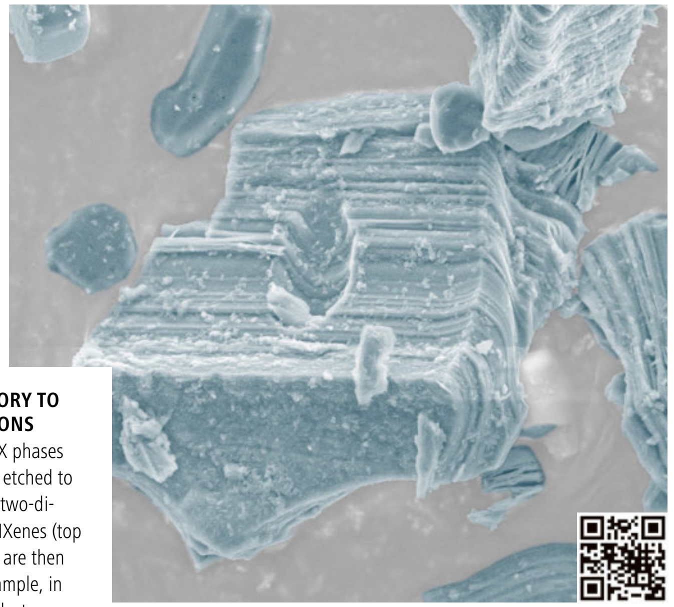
CAPTURING CO_2 AND TREATING CANCER

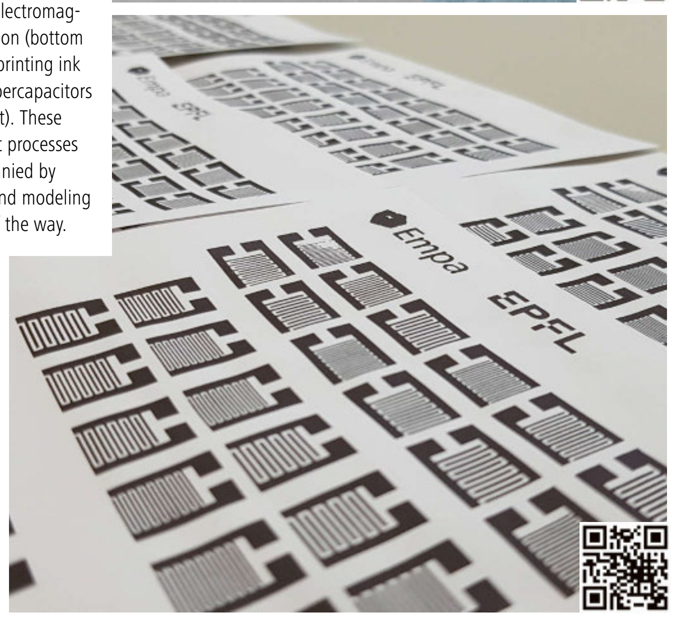
The synthesis experts received support from the nanotech@surfaces laboratory, whose researchers have developed various AI models for MAX phases and MXenes. These models enable the synthesis of the phases and their individual geometry to be predicted and understood. However, modeling is also central to the application of MXenes. "We are currently developing a model that describes the interaction of MXenes with CO_2," says nanotech@surfaces researcher Cesare Roncaglia.

The absorption and conversion of carbon dioxide is a key focus among the potential applications for MXenes. Thanks to their large surface area, these 2D materials have the potential to capture CO_2 from the air – and also help convert it into usable raw materials, in line with Empa's large-scale research initiative Mining the Atmosphere. However, this does not exhaust the MXenes' potential. The versatile 2D nanoparticles could also be used in broader catalysis, energy storage, or sensor technology. In medicine, certain MXenes promise antimicrobial effects or targeted cancer therapy. With this in mind, the project participants are working with researchers at Empa in St. Gallen to investigate their effects on living cells and the environment.

ENVIRONMENTALLY FRIENDLY AND SCALABLE

Environmental compatibility is also a key consideration in the production of MXenes. Strongly corrosive acids are typically used to etch them from the MAX phases. This is not only dangerous for humans and harmful to the environment, but also costly. "The etching process is one of the reasons why only a few MXenes are commercially available," says Shanyu Zhao from the Building Energy Materials and Components laboratory. In the TailorX project, he and his team not only worked on the applications and characterization of MXenes, but also developed an alternative "green" method for exfoliating them from the MAX phase. "Our approach avoids the use of ▸





FROM THEORY TO APPLICATIONS
Ceramic MAX phases (top left) are etched to produce the two-dimensional MXenes (top right). These are then used, for example, in aerogel for electromagnetic insulation (bottom left) or as a printing ink for novel supercapacitors (bottom right). These development processes are accompanied by simulation and modeling every step of the way.

the aggressive and hazardous hydrofluoric acid, and the entire process is more effective and gentle, making it both sustainable and scalable," says Zhao.

For the researchers, the conclusion of the Research Booster program is merely the beginning of their work with these versatile 2D materials. They have already launched further projects aimed at incorporating MXenes into a wide range of applications, such as high-performance supercapacitors, innovative batteries, electromagnetically insulating aerogels, and medical sensors.

At the same time, basic research into this young class of materials is ongoing. "With their flexibility and adaptability, MXenes offer such great advantages that applications will not be long in coming," summarizes Jakob Heier. ■

Photos: Empa

LESS MATERIAL, SAME STABILITY

Instead of using more and more concrete and steel, a European research team including Empa is focusing on intelligent shapes, digital manufacturing, and alternative binders. The aim is to create a climate-friendly building material that is delicate yet stable – and can be custom-made using 3D printing, dismantled, and reused.

Text: Manuel Martin

Using as little mass as possible, without complex steel reinforcement and without cement, researchers at Empa, ETH Zurich, and other European partners aim to fundamentally change the way concrete is used in construction. In the EU project CARBCOMN, concrete components are also designed so that they can be easily dismantled after use and reused elsewhere. "On the one hand, we are using digital manufacturing methods to build in a resource-efficient manner. On the other hand, we are replacing conventional cement with binders that have a lower carbon footprint," says Empa researcher Moslem Shahverdi. Instead of cement, for example, steel slag is used – a waste-product from the steel industry.

STABILITY THROUGH FORM RATHER THAN MATERIAL

The low-carbon footprint concrete used in the CARBCOMN project consists exclusively of industrial waste. It is formed into individual components using 3D printing and later assembled into load-bearing structures. Instead of conventional steel reinforcement, the consortium relies on so-called compression dominant structures. "Concrete can withstand a lot of compression, but little tensile stress," explains Shahverdi. That is why the researchers are developing structures that are primarily subjected to compression – similar to historic stone bridges with their arches.

Digital manufacturing enables them to precisely plan such geometrically optimized shapes and significantly reduce the amount of material used. Since the concrete is printed layer by layer, the need for concrete formwork is eliminated. Cavities are deliberately left where no reinforcement is necessary. "We plan these openings directly in the digital model so that the robot automatically leaves them open during printing," explains Shahverdi. ▸

PRECISION
The structure was 3D printed at Ghent University in Belgium.

Lighter elements not only reduce material consumption, but also seismic stress in proportion to the weight loss – a decisive advantage in earthquake-prone regions. "Even a ten percent reduction in weight makes a big difference," says Shahverdi.

SURGICALLY IMPLANTED STEEL REINFORCEMENT

However, the concept cannot do entirely without steel rebars. They are only used where they are really necessary. This is where Empa brings one of its specialties to the project: iron-based shape memory alloys (Fe-SMA, see p. 8). These pre-stretched metals contract when heated – instead of expanding – and thus subsequently place components under compression. "We have been working with these special alloys for around 20 years," says Shahverdi. The Empa spin-off re-fer is therefore also contributing its expertise in the field of shape memory alloys to the CARBCOMN consortium.

Conventional steel reinforcements have to be pre-stressed in a complex process; shape memory alloys, on the other hand, are simply inserted into the concrete after printing. This has several advantages: The printing process remains automated and undisturbed, and the Fe-SMA rebars can be placed precisely where they are actually needed. Moreover, they can be separated from the concrete again later – which is crucial for being able to dismantle the components at a later date. According to the Empa researcher, these work steps are also to be automated in the long term. "In the future, a second robot could insert the Fe-SMA rebars directly after printing."

CO_2 AS A HARDENING AGENT

After 3D printing, the concrete components are placed in a chamber where CO_2 is injected. This leads to a chemical reaction with the steel slag-based concrete mixture. "This process hardens the concrete and binds CO_2 at the same time," says Shahverdi. The aim is to further increase strength with an optimized concrete mixture. If this is not sufficient, a small amount of cement could be added. "For normal civil engineering applications, this would already be a good starting point," Shahverdi is convinced.

Parallel to the material, the teams are developing new digital tools: A common platform is to cover the entire process from design to production – including sustainability and life cycle analyses. Architectural firms such as Zaha Hadid Architects are working closely with the engineers and materials scientists involved in the project. While the architects design free-form structures, the Empa team investigates the technical feasibility, tests materials, and develops connection technologies that allow for later dismantling. "We combine unique expertise here – 3D printing, structural performance, and our specialty: iron-based shape memory alloys," summarizes Shahverdi. A prototype is to be created by 2028 – a 3D printed building module that demonstrates the feasibility of the new approach. ■

Photo: Ghent University

Photos: Empa

THE CARBCOMN PROJECT

In the EU project CARBCOMN (Carbon-negative compression dominant structures for decarbonized and de-constructable concrete buildings), Empa researchers are working with European partners to develop a climate-friendly and recyclable concrete construction method. The innovative building material binds CO_2, consists exclusively of recycled materials, and minimizes the requirement of conventional steel reinforcement. Digital manufacturing and 3D printing are used to create filigree yet stable structures. The focus is less on spectacular shapes and more on robust components for residential construction that can be connected in an earthquake-proof manner and reused. The four-year project, which started in 2024, is funded by Horizon Europe and brings together eleven leading research institutions and architectural firms from across Europe, including Ghent University, TU Darmstadt, the University of Patras, ETH Zurich, and Empa, as well as Zaha Hadid Architects, Mario Cucinella Architects and the companies Tesis, orbix, incremental 3D and refer. The total budget is around six million euros, with Empa and its spin-off receiving more than one million of this amount.

A SMART SHAPE
Top: The 3D printed structures require less material and do not need as much steel reinforcement. Bottom: Empa researcher Moslem Shahverdi inspects the component.

SWITZERLAND'S ENERGY FUTURE

IN BALANCE
Nathalie Casas spoke about the balance between sustainability, security, and affordability in energy supply.

From 10 to 14 November, ETH Zurich hosted its Energy Week @ ETH 2025. The event focused on pressing issues surrounding the energy transition and, with an exhibition and various talks, provided a platform for exchange, inspiration, and discussion between research and practice, politics, and society. Nathalie Casas, member of Empa's directorate and head of department, spoke at the symposium about how Switzerland's energy system is changing, how a balance between sustainability, security, and affordability can be achieved, and what the future might look like.

INTRODUCTORY EVENT ON THE REVISED SIA 166 STANDARD

On 1 November 2024, the revised SIA 166 standard "Adhesive reinforcement for strengthening existing structures" came into force. It reflects the current state of the art, integrates new methods such as single-slot lamellas and prestressed systems, and provides clarity on dimensioning, durability, and long-term behavior. The introductory event will explain the key changes to the standard and use practical examples to show how bonded reinforcement can be used efficiently and in compliance with the standard. Deepen your expertise and exchange ideas with experts on 14 January 2026 at Empa in Dübendorf. SIA members receive an exclusive discount.

REINFORCING LAMELLAS
Standard SIA 166 concerns adhesive reinforcement for existing structures.

Photos: ETH Zürich, Alessandro Della Bella, S&P

RESEARCH MEETS ART

ON DISPLAY
On the left is a sensor shirt for monitoring breathing, developed by designer Laura Deschl in collaboration with Empa.

TaDA, the Textile and Design Alliance, promotes collaboration between creative artists and textile manufacturers in eastern Switzerland through an international residency program and public exchange platforms. In September and October, the exhibition TADA: TOGETHER was held in Arbon to celebrate the program's fifth anniversary. The exhibition also featured a number of works created in collaboration with Empa, including pieces by artists Sonia Li, Michelle Letelier, Marce Norbert Hörler, Elizabeth Hong, and Victoria Manganiello. "Artists-in-residence do not fundamentally change our everyday research, but they do bring new perspectives. This helps us to develop a more concrete idea for the implementation of technological developments in the direction of applications and products, also with a view to later funding opportunities," says Empa researcher Simon Anaheim.

Photo: Andri Vöhringer

EVENTS
(IN GERMAN AND ENGLISH)

30. JANUAR 2026
Kosteneffizienz trifft Klimaschutz
Zielpublikum: Wissenschaft und Industrie
www.empa-akademie.ch/renowave
Empa, Dübendorf

10.–12. FEBRUAR 2026
1st International Conference on Mg-based cements
Zielpublikum: Wissenschaft
www.empa.ch/web/MgO2026
Centre Loewenberg, Murten

10. MÄRZ 2026
Kurs: Additive Fertigung von Metallen
Zielpublikum: Industrie und Wirtschaft
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