3/2025

EVONIK
Leading Beyond Chemistry

# ELEMENTS

Research. Knowledge. The future.


# Better plastic

**An issue about the future of plastic**

# Recycling

Processing and reuse of raw materials

Recycling is the process of recovering raw materials from used products or materials in order to use them again, either for the same or a different purpose. Two technical approaches dominate for plastics: chemical recycling and mechanical recycling. Depending on the process, recycling can be upcycling or downcycling The aim of recycling is to keep raw materials in the material cycle for as long as possible in order to avoid waste, save energy, and reduce emissions.

**Chemical recycling** A process in which polymers are broken down into monomers or chemical raw materials so that these can be used to manufacture polymers or other chemical products again.

**Mechanical recycling** The reprocessing of plastics through physical processes such as collecting, sorting, shredding, and melting. The chemical structure of the material remains unchanged.

**Upcycling** Processing waste into products of higher quality or greater value than the original material, e.g. backpacks made from fishing nets.

**Downcycling** Processing waste into products of lower quality or lower value than the original material, e.g. plant pots made from PET bottles.

## DEAR READERS,

"We're going around in circles!" This statement usually doesn't mean anything good. People are annoyed because something is not moving forward. It just isn't happening—the breakthrough to the solution of a problem.

But things are different in the chemical industry. Here, going around in circles itself represents a breakthrough that makes production more sustainable. If you keep materials in circulation for the long term, you don't have to use new materials to make good products. In the case of plastics, the circular economy offers a double advantage. Fossil petroleum can remain as a raw material where it is: underground. And aboveground, plastic will disappear from landfills and the environment if it supersedes petroleum as the basis for new plastics.

In this issue, we show how Evonik is helping to bring about this paradigm shift. We will also be presenting technologies that we are already using today to make plastics fit for the future—from the use of bio-based raw materials to the application of the mass balance approach and the employment of artificial intelligence, which greatly accelerates the development of sustainable materials.

Only time will tell whether our society will ultimately succeed in achieving a circular economy. However, it is essential that customers accept products and processes and are prepared to possibly spend a little more money on them than on established alternatives. Only then will the cycle develop the necessary pull effect.

I wish you pleasant reading and new insights. If you have any questions about this issue, recommendations or criticisms, please write to me at elements@evonik.com

**Jörg Wagner**
Editor in Chief

All of the articles from the printed magazine, as well as additional current contents, are also available on the Internet at elements.evonik.com


How can printed plastic be deinked after use? Researchers are looking for ways to recycle materials as often as possible

THE FUTURE OF PLASTIC


PA12 in the form of TROGAMID® eCo makes lenses for sunglasses scratch-resistant—and particularly sustainable




The data experts Thomas Asche (right) and Johannes Dürholt have developed an artificial intelligence that can help researchers come up with new ideas

**At the 2015 Sustainable Development Summit, the United Nations defined the 17 Sustainable Development Goals (SDGs). Evonik contributes to supporting sustainable development in many different ways. We present them here.**


in 2024, around 673 million people, which is around 8.2 percent of the world's population, were suffering from hunger. The United Nations wants to **end hunger,** achieve **food security,** and **improve nutrition.** The **promotion of sustainable agriculture** is also on the agenda.

Evonik is carrying out research into biostimulants so that crops can be grown in a more environmentally compatible way in the future. In combination with bio-based additives, these natural bacteria help plants such as corn absorb nitrogen from the air and make it usable for their growth. This could significantly reduce the use of nitrogen fertilizers—while yields would remain the same. Another microbial solution goes into action before germination. It protects crop seeds from fungal infestation and is therefore an effective and sustainable alternative to chemical fungicides.

*The husks of the corn plant protect the cob from harmful environmental influences. Climate change is putting such natural defense systems under increasing pressure. This makes it all the more important to specifically strengthen the resistance of crops to stress factors such as heat or drought. Biostimulants with microbes that have adapted to extreme environmental conditions help to do this.*

# Aquatic adhesive

Japanese researchers have developed particularly strong underwater glues, with a little help from nature and AI

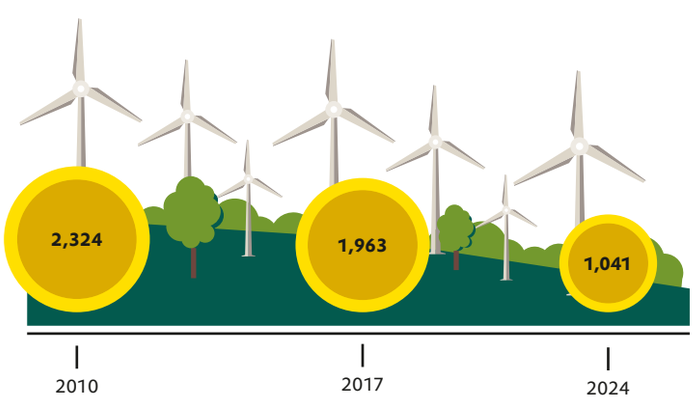
A model from nature: Thanks to special adhesive proteins, mussels stick firmly to rocks, even in strong currents

If materials are to be bonded together in a wet environment, hydrogels often provide the answer. They consist of water and a polymer network. By combining various methods, researchers at Hokkaido University in Sapporo, Japan, have significantly improved the underwater adhesion of hydrogels. The starting point was a data set with around 25,000 adhesive proteins that help mussels, for example, anchor themselves to wet surfaces. Using data mining, the researchers identified sequence patterns that influence this adhesion and used these results as the basis for producing 180 hydrogels, which they tested in the laboratory. An AI algorithm helped them select and optimize the best-performing candidates. The result was underwater adhesives with an unprecedented adhesive strength of more than one megapascal—enough to support 63 kilograms of weight with an adhesive surface the size of a postage stamp. As the hydrogels adhere immediately and are especially robust, they offer new possibilities in areas such as medical technology and deep-sea research.

THAT'S BETTER

## Cheaper wind

**Total costs for the installation of onshore wind turbines, in U.S. dollars per kilowatt**




The average total installed costs (TIC) for the installation of onshore wind turbines has declined by more than 50 percent since 2010. In 2024, it reached a new low of around US$1,000 per kilowatt. The TIC includes all costs up to commissioning, for example those for turbines, project development, and assembly. Lighter and more durable composite materials could lead to a further reduction in these costs.

Source: International Renewable Energy Agency (IRENA)

## 90

**PERCENT**

yields were achieved in three of the reaction steps of a new four-step process for menthol synthesis at the Technical University of Cologne. A further step achieved a yield of 65 percent. The researchers used oil of turpentine, a by-product of the paper industry, as a raw material. They extracted 3-carene from it by means of a thermal separation process (rectification) and nanofiltration. To convert the 3-carene into menthol, they needed four synthesis steps, three of which were particularly effective. The process could replace petroleum-based menthol in the pharmaceutical, cosmetics, and food industries.

## PORPHYRINS...

...are ring-shaped molecules that occur in substances such as chlorophyll. The centers of such rings can accommodate metal ions, the properties of which can be specifically controlled. A European research team integrated these molecules into a strip just one nanometer wide made of graphene, a carbon material known for its conductivity. The result is a hybrid system that is magnetically and electronically coupled and can open up new applications, for example in quantum technology. In order to improve the properties, the researchers now want to test the effects of different metal centers and a wider graphene strip.

PEOPLE & VISIONS

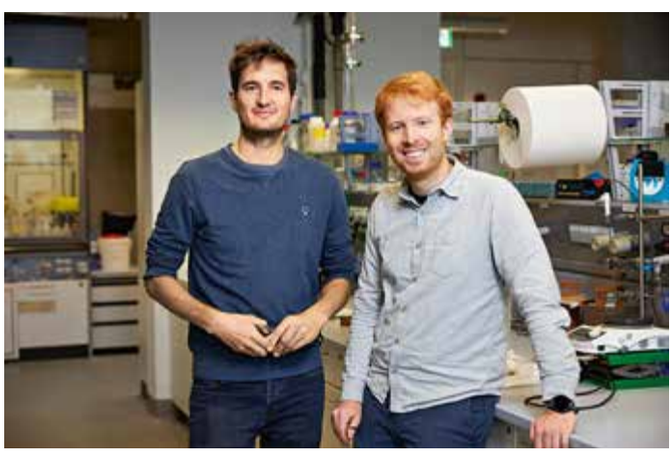
# "We wanted to get into action with chemical recycling"

**THE PERSON**

Alexandre Kremer became interested in polymers at an early stage of his chemical engineering studies in Lyon. "I was fascinated by the fact that just a few monomers can create so many different materials," he says. The Frenchman became aware of the downside—the enormous amounts of plastic waste—while studying chemistry in Vancouver. Ever since then, he has wanted to make plastics recyclable. Kremer completed his third master's degree—with a focus on "Sustainability and Social Innovation"—in Paris. "That's where I acquired a strategic and entrepreneurial perspective to go with my specialist knowledge," he says.

**THE VISION**

in 2024, together with the Austrian Andreas Wagner, he founded the Munich-based start-up Radical Dot: "We wanted to get into action," he says. In a laboratory at TU Munich's ChemSpace Venture Lab, they developed a chemical recycling process for mixed plastic waste. "We use oxygen to split polymer chains and from these we produce carboxylic acids that then serve as raw materials for new products," says Kremer. "Our process is fast and energy-efficient." Radical Dot plans to set up a demonstration plant by 2027, after which it aims to make the transition to industrial application.



Alexandre Kremer (left) wants to promote the recycling of plastics together with Andreas Wagner

# Charged concrete

A mixture of cement and microorganisms makes it possible for walls to store energy

Researchers at Aarhus University in Denmark have developed a new approach for using house walls, house foundations, or bridges as buffers for the fluctuating supply of solar and wind power in the future. The scientists mixed cement with the bacterium *Shewanella oneidensis*. This bacterium is able to survive without oxygen and can also exchange electrons with its environment. This creates a conductive network in the cement matrix that can absorb and release electrical energy. The storage capacity of the building material exceeds the performance of previous cement-based approaches, which work with carbon, for example, many times over. As the activity of the bacteria decreases over time, they are supplied with a nutrient solution via fine channels in the cement. The researchers restored up to 80 percent of the original storage capacity in this way. The project is still at an early stage.

GOOD QUESTION

## Mr. Soh, can electricity be generated from rain?

Yes. However, it has been challenging for researchers to harness the enormous amounts of energy in rainwater. Until now, one focus has been on the interface between water and solid surfaces, where the electrical charges separate from the water and electricity is generated. However, this phenomenon takes place on the nanoscale; on a larger scale, the effect is negligible. We use another natural phenomenon, which is known as plug flow. In our experiments, we allowed rain to flow through a pipe coated with an insulating polymer. This changes the flow properties of the water in such a way that it becomes electrically charged throughout its entire volume—the charge separation is not limited to the boundary surface. Our approach significantly increases the electricity yield and thus opens up an efficient way of harvesting rain energy.

*Siowling Soh is an Associate Professor in the Department of Chemical and Biomolecular Engineering at the National University of Singapore.*

TEGO® Res 1100, which makes it easier to remove printing inks from packaging, is produced at the Darmstadt site. The polymerization takes place in the tank

# AS GOOD AS NEW

It is impossible to imagine our world without plastic. The circular economy is bringing about a paradigm shift in order to conserve fossil resources and reduce waste. Recycling is already being taken into account in the design and manufacture of new products. To speed up this process, Evonik is working with partners to develop new solutions. Its motto is "Design for circularity"

TEXT **MICHAEL PRELLBERG**


Alexander Azzawi demonstrates how easily adhesive bonds can be broken if necessary thanks to a new type of binder

Click, click. Alexander Azzawi opens the black plastic case. Inside are two plastic bars glued together, connected by a silver metal strip and fixed between two clamps. Next to them is a key. "Just turn it," Azzawi says, as he often does at trade fairs. A light comes on immediately and something in the suitcase begins working. "We use the metal foil to heat the adhesive," says Azzawi, "then the two plastic parts can be easily separated from each other." While everything quietly hums away in the demonstration case, Azzawi, Head of Lifecycle Solutions at Creavis, explains why this works. His team has developed a special binder for →


During tensile tests at the Essen Goldschmidt site, working student Anneke Henschel investigates how effective the debonding solution is compared to conventional adhesives

polyurethane-based adhesives that replaces conventional binders. During bonding, the other components of the adhesive react with the innovative binder and form a three-dimensional network. However, the bonds are designed so that they break at temperatures above 100 degrees, and the adhesive no longer sticks. That's exactly what's happening now. Azzawi pulls the two plastic bars apart without any problems. "It's a bit like cutting a thread in a knitted sweater in some places and the fabric falls apart.

The principle is called "debonding on demand." Glued joints are released from each other exactly when necessary. Thanks to this technology, products are easier to dismantle or repair, and it's easier to recycle the individual components. That's how debonding on demand helps to close recycling loops. This works for smartphones and laptops as well as other everyday items such as shoes. For example, if the sole and the upper can be separated more easily, the components can be recycled according to material type. But manufacturers of electric cars are also interested in bonding the body and battery together rather than screwing them together in the future. This lowers weight and simplifies the design. Evonik is currently in various discussions, for example in a development partnership with the adhesives specialist Delo, regarding where and how debonding on demand can already be used today.

The time is ripe for alternatives to the classic "make and throw away" approach. This is especially true for plastics. Currently, more than 400 million tons of plastic are produced every year, and demand is expected to almost double by 2050 (see Data Mining, page 21). One reason for this is that the superior product properties of high-performance polymers in many applications make lightweight construction possible and thus enable electric cars to drive further, for example, while the mechanical properties of fiber-reinforced plastics stabilize the rotor blades of wind turbines and ensure that more green electricity is generated.

The greater the increase in demand, the more urgent it is to retain these valuable materials in the material cycle at the end of their service life. This is because the global plastics industry is still largely linear. On the one hand,

more than 90 percent of plastics today are produced from petroleum, while on the other hand, a substantial proportion of plastic worldwide ends up in landfills, in combined heat and power plants, or even in the environment. An alternative is needed. The circular economy closes material cycles, turns waste into raw materials, and thus helps to conserve resources and protect the climate.

### RETHINKING RECYCLING

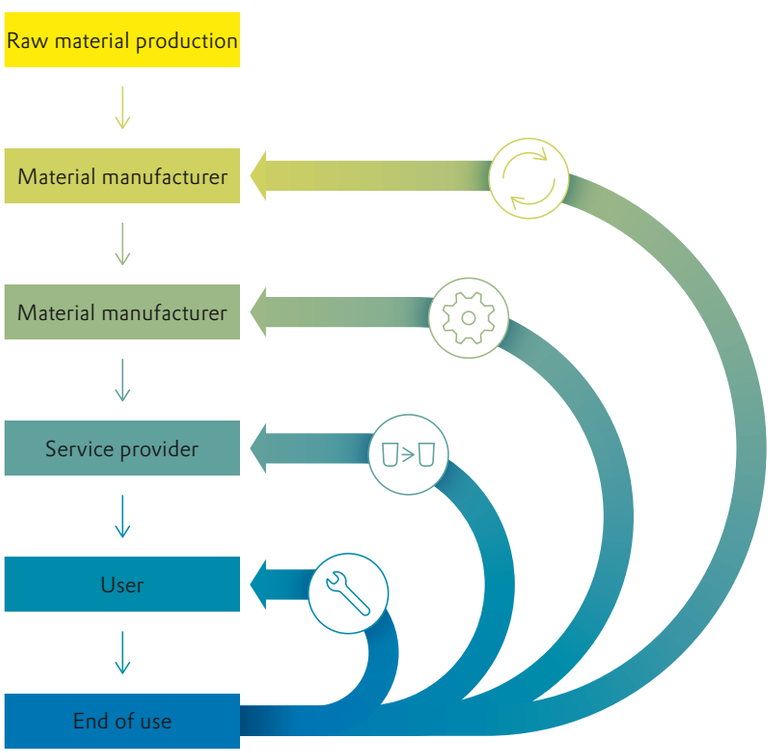
In mechanical plastic recycling, plastic waste is sorted after collection. Only unmixed waste can be recycled without any loss of quality. This already works well for beverage bottles made of polyethylene terephthalate (PET), for example. However, this route is blocked for mixed or heavily contaminated waste, which cannot be reused and is therefore directly landfilled or incinerated.

**“It’s about conserving fossil resources and minimizing the incineration of residues”**

PATRICK GLÖCKNER, HEAD OF THE NEXT MARKETS PROGRAM AT EVONIK

## MORE THAN RECYCLING

The aim of design for circularity is to design a product in such a way that it can be used as energy-efficiently as possible for as long possible. Ideally, it should go through various stages before it is recycled




Circularity must therefore be rethought: not from the end, but from the beginning. The goal is to design products from the outset in such a way that they can be kept in circulation or recycled for equivalent applications and in the highest possible quality. That’s how to get started in the resource-conserving circular economy. “To establish cycles, we need ‘design for recycling’ and mechanical and chemical recycling methods,” says Patrick Glöckner. He heads Evonik’s Next Markets Program, which focuses on circular packaging and plastics recycling. “Ultimately, it’s about conserving fossil resources and minimizing the incineration of residues.”

Legal requirements support this process, so that circularity has become an important part of the industry. Evonik bundled its activities for the plastics cycle in the Global Circular Plastics Program as early as 2020 and expanded the focus to other material flows a little later with the Circular Economy Program. The idea is to design products and processes in such a way that less and less fossil raw materials are required and these meet recyclability requirements. In addition, increased →

efficiency and better quality recyclates make recycling more economical for Evonik's business partners. The aim is to create plastics that can be recycled in an ecologically and economically sensible way, "And for this to succeed," says Glöckner, "you need the right design from the start."

## EVONIK BUILDS NETWORKS

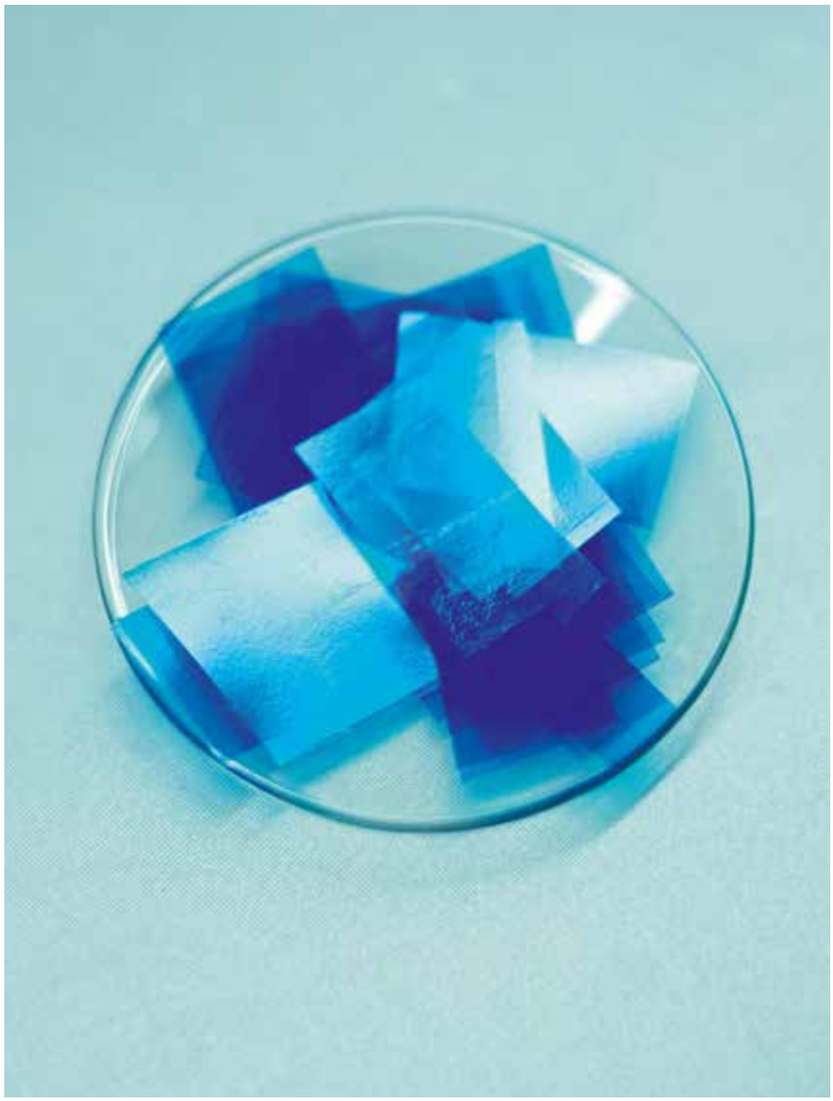
Anyone who takes circularity seriously must consider all parts of the cycle. This means asking questions of all the companies in a value chain: What quality requirements does a particular material have? How do the material flows work? Which processes are used? To explore this, Evonik is also increasingly approaching brand manufacturers and other stakeholders, such as recycling companies, with its Next Markets Program. "Everyone has very different priorities and often isn't aware of the challenges facing the others," says Glöckner. Evonik intends to change this by establishing networks and opening up markets that tie in with existing businesses.

Thanks to its long-standing, established business relationships, Evonik has insights into the needs and capabilities of many companies along entire value chains. This holistic view enables the company's experts to provide partners with advice and support—as well as the right additives to decisively advance the circular economy in many areas. The result is a system solution that makes plastic packaging materials easier to recycle.

Every network begins with the first links. When it comes to printed plastic, this is where hubergroup comes in. hubergroup is an internationally active printing ink manufacturer that produces 172,000 tons of ink annually at seven locations. Its products are sold to print shops—for example to those that provide packaging with logos, content information and best-before dates. To ensure that plastic films, bottles or cups can be used several times, the printed ink must be completely removed. Deinking—removing printing ink—is the keyword.

The challenge is that the components of the ink are tightly bound to the polymer structure of the plastic, and can interfere with the recycling process and reduce the quality of the recyclates. There is still no solution that washes off nitrocellulose-based printing inks on an industrial scale in an economically viable way. Methods involving solvents, high energy consumption or other disadvantages do exist, but there is no simple approach.

The deinking solution developed by Christian Schirrmacher and his team starts directly with ink manufacturers



In order to recycle plastic packaging to a high standard, the printed ink must be removed. The experts in the Essen Goldschmidt laboratory test this process on pieces of plastic

"We wanted to change that," says Christian Schirrmacher, Head of Research & Development for Printing Ink Additives in EMEA at Evonik Coating Additives. "We analyzed the entire value chain and saw that we needed to start directly with the ink manufacturers. Thanks to our solution, they can incorporate the deinking functionality directly into the ink without having to adapt further production steps, so the hurdles are minimal."

TEGO® Res 1100 is the name of the co-binder from Evonik that is added to the ink at formulation. It's a polymer that reacts to changes in pH. It works as soon as the mechanical recycling of the shredded packaging begins in a kind of giant washing machine. If sodium hydroxide (NaOH) is added as a base, the pH of the lye changes. This pH shift activates TEGO® Res, weakening the bond between the components of the ink and the plastic so that the ink is released. "Our tests show that TEGO® Res delivers excellent deinking results—quickly and even at temperatures as low as 40 degrees Celsius."

Once TEGO® Res had passed the laboratory tests, Schirrmacher called hubergroup: "We've got something, would you like to try it out?" hubergroup wanted to. The company not only confirmed the laboratory results but also tested them on an industrial scale. And the co-binder really can be easily integrated into standard formulations of solvent-based inks. The inks are just as easy to work with, and retain their performance. Processes and machinery do not have to be changed. But the most important thing is that deinking during subsequent recycling is so efficient that the recyclates are of a higher quality than in conventional processes. "Everything worked. The Evonik product is an interesting option, both technologically and economically," says hubergroup manager Lars Hancke.

## NEW RULES IN THE EUROPEAN UNION

Industry's interest in integrated recycling solutions is growing, especially in the European Union. Take packaging, for example: Starting in 2026, a new packaging regulation will apply to all EU member states. In terms of recycling, it places comprehensive requirements on packaging in the European market. This makes a deink- →

A pH shift activates TEGO® Res 1100, weakening the bonds between the components of the ink and the plastic so that the ink is released

Together with BMW and other partners, Evonik has developed a process for stripping paint from old bumpers in order to obtain high-quality recyclate

ing solution that is already applied with the ink a selling point. Consequently, Evonik Laboratory Manager Christian Schirrmacher speaks of a unique product with huge market opportunities far beyond Europe.

## RECYCLING IN THE AUTOMOTIVE INDUSTRY

Paint removal plays an analogous role in the automotive industry. In a consortium project with BMW and other partners funded by the German Federal Ministry for Economic Affairs and Energy, Evonik has investigated the question of how painted bumpers can be reused. "The parts are made of polypropylene and are not actually made to be recycled," says Michael Hagemann, Head of Marketing for the plastics additives business of Interface & Performance at Evonik. "After all, the paint on the bumpers should still adhere firmly to the surface even after years of road use."

Two steps need to be completed for recycling. The first is to remove the paint from the old bumpers. The second challenge is that the polypropylene that is separated from the paint and then recycled must be of such high quality that it can be used to produce new bumpers that meet the highest standards in terms of both performance and safety. And the new paintwork must remain attractive for many years.

To meet the first challenge, Evonik has developed a water-based and environmentally friendly process in which the old bumpers are shredded and stripped of paint. Only very few residual particles of paint remain. This is crucial in order to produce a high-quality recyclate.

The polypropylene granules are injection molded into new bumpers and then painted. This second challenge was also mastered in the project with BMW: "The paint looks just as good and is just as durable as on new bumpers without recycled content," says Michael Hagemann. In the Next Markets Program, the experts are working on commercializing the solution, which can also be used for recycling other painted plastics.

This is good news for the automotive industry and its suppliers. The automotive sector also has a responsibility to use more recyclates. The corresponding regulation could even go into effect this year. It requires that cars be built in the future in such a way that parts can be removed and replaced more easily and that a minimum proportion of recycled plastics is used in production. →

### THE TREND TOWARD MONOMATERIALS

The European Union is by no means alone in its efforts to promote recycling and the transition to a circular economy. Legal requirements to reduce $CO_2$ emissions and conserve resources exist worldwide (see box on page 18). Both can be achieved, for example, by recycling more plastic and then reusing it.

This is sometimes a problem. "Some food packaging, for example, looks like it's made from one material and is therefore recyclable, but in reality it consists of five, seven or even nine ultra-thin layers of different plastics—and with the best effort it's impossible to separate them," says Hagemann. "One solution is to work with monomaterials wherever possible." Hagemann aims to ensure that unmixed plastics can be mechanically recycled particularly well.

This places high demands on the packaging design. Packaging made of pure PET, for example, has rarely been used until now, partly because the individual pieces of the packaging are difficult to join together. Evonik has therefore developed heat-sealing coatings that can do just that. Instead of the multi-layer composite systems commonly used today, monomaterial packaging for food can thus be used more frequently.

### A NEW LIFE FOR MATTRESSES

If monomaterial can not be used, the chemical structures must be broken up. This makes it possible to recycle more complex plastics. The usual food packaging made of poly-

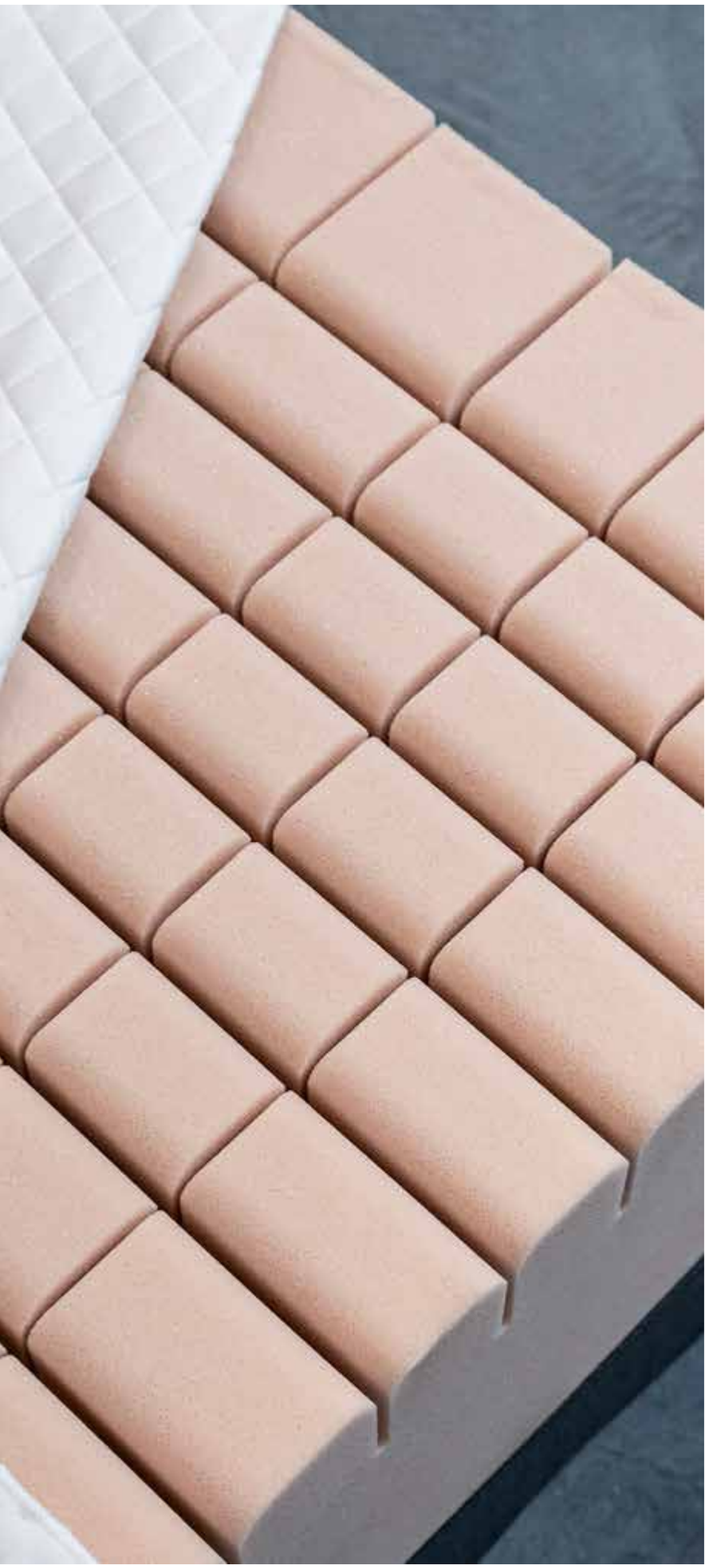
## THE GLOBAL CIRCULAR ECONOMY

We are currently part of a largely linear economy. What has been produced is used and then discarded. In the circular economy, on the other hand, products and materials are ideally completely recycled. Products also last longer and are easy to repair. All over the world, there are initiatives and legislative projects to promote the recycling of plastics

The Packaging and Packaging Waste Regulation (PPWR) will go into effect in the EU from 2026. EU-wide rules on the right to repair have been in effect since June 2025. The EU also wants to ensure more recycling in the production of cars by means of a regulation and plans to introduce recycled material quotas for plastics in new vehicles.

The Unites States wants to increase the nationwide recycling rate to 50 percent by 2030. However, this target set five years ago by the U.S. Environmental Protection Agency is not legally binding. Some U.S. states and municipalities have enacted their own regulations for recyclable materials, ranging from landfill bans to mandatory recycling—including fines. States such as California and Illinois have also set themselves recycling targets and encourage consumers to recycle with a deposit system on cans and bottles.

In 2018, China was the first country to ban the import of unsorted plastic waste—a model that has since been followed by numerous countries. in 2021, the government made the development of a circular economy a priority of the new five-year plan. Today, the People's Republic is regarded as a leader in this area.



This mattress from the British manufacturer The Vita Group consists of up to 100 percent recycled polyol—thanks to a hydrolysis technology developed by Evonik

olefins can be liquefied. The resulting pyrolysis oil can then be fed back into the cycle. Chemical recycling can even be advantageous for monomaterials—such as polyurethane foam mattresses, which cannot be mechanically recycled as they cannot be melted.

An example of how this process works can be seen in a mattress from the British manufacturer The Vita Group. The mattress is made from up to 100 percent recycled polyol. The mattress' $CO_2$ footprint is 70 percent lower than that of standard mattresses. This feat is made possible by a new hydrolysis technology from Evonik that enables polyurethane to be split and polyols to be recovered in the process.

This is accomplished using a catalytic system to break the chemical bonds quickly and efficiently. Polyol and toluene diamine (TDA) can be recovered in this way. The latter can be converted to the isocyanate toluene diisocyanate (TDI) in a subsequent reaction. TDI and polyol are exactly the substances required for the production of polyurethane. "Our process enables a major step toward a closed material cycle in the polyurethane industry. Thanks to the high-quality recovered material, significantly less fossil raw materials are needed to produce new mattresses," says Emily Schweissinger, Technology Manager at Evonik Comfort & Insulation.

Given that 40 million mattresses are produced every year in the European Union alone, the Vita Advanced Mattress is a real step forward. "Just five years ago, this technology was considered impossible," says Natalie Watson, Group Director of Sustainability at The Vita Group, in the trade press. "Today we have proven that foams →


TEGO® Res 1100 is filled into bags fully automatically in Darmstadt

can be produced with a high recycled content, significantly reduced emissions and without compromising on durability. Innovations like these only come about when suppliers, partners, and internal teams work together with a common goal."

The process is currently being tested in a pilot plant in Hanau: The prospects for scaling up to the next size are good. An independent panel of experts has recommended that the state of North Rhine-Westphalia use the European Union's Just Transition Fund to support the construction of a demonstration plant at the Marl Chemical Park. As soon as official approval has been granted, the technical planning can begin.

## RECYCLING NEEDS CYCLES

Deinking with printing ink manufacturers such as hubergroup, chemical recycling for mattress producers such as The Vita Group, debonding on demand with adhesives specialist Delo—Evonik is in talks with players at various stages of the value chain in order to achieve success together. "To close the cycle, we need cooperation with all partners," says Glöckner. This type of collaboration is the foundation of a functioning circular economy. "Only if everyone understands what drives the various partners can we work together to develop the best solution for each case."

This enables plastics to be kept in circulation over a long period of time. "And for this to succeed," says Glöckner, "you need the right design from the start." —

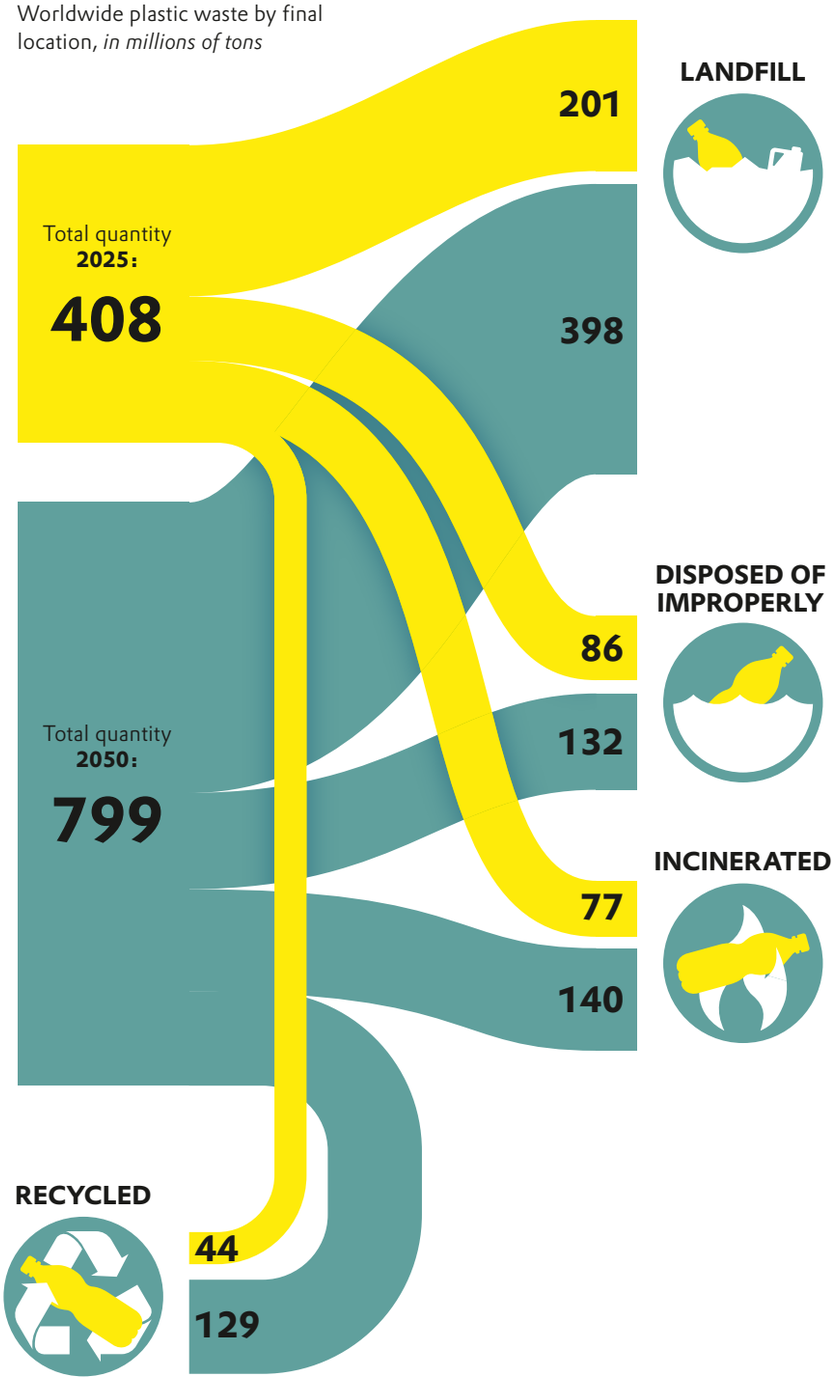
**Michael Prellberg** lives and works as a freelance editor and journalist in Berlin and Hamburg

# BACK TO THE BEGINNING

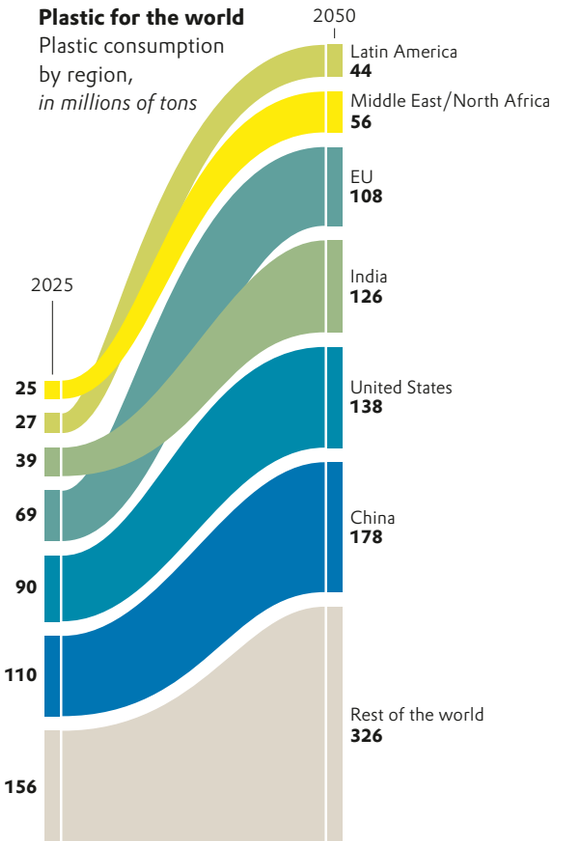
Human beings are using more and more plastic. The global recycling rate must also increase in order to protect the environment and the climate. A look at facts, figures, and data

INFOGRAPHIC **MAXIMILIAN NERTINGER**

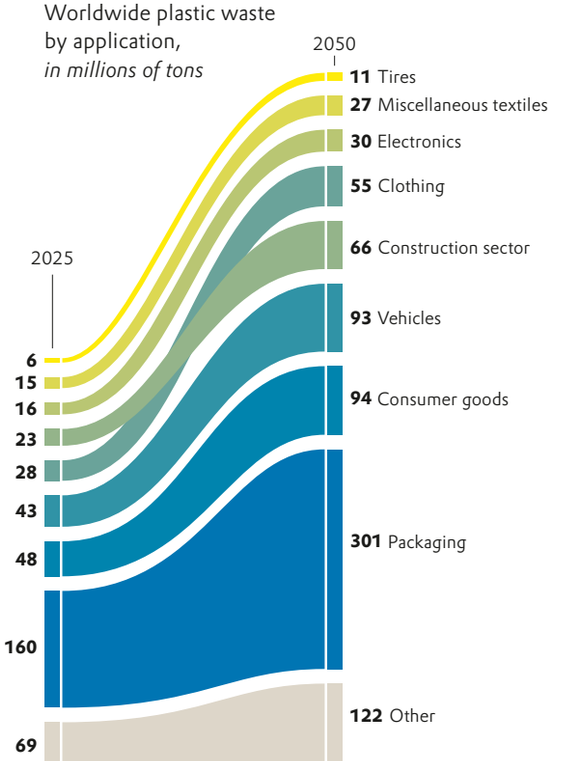
**Where to put it?**
Worldwide plastic waste by final location, *in millions of tons*



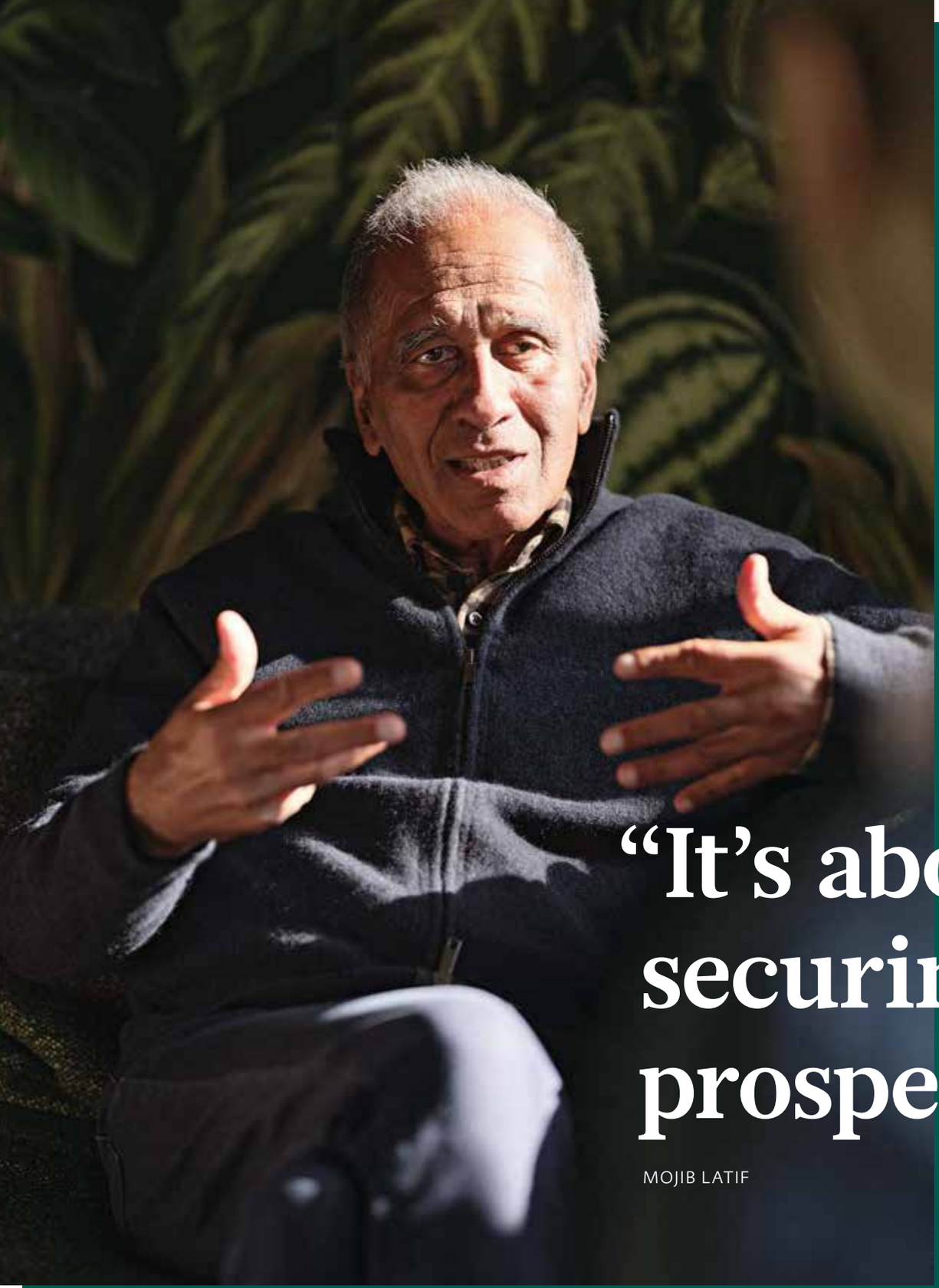

**Plastic for the world**
Plastic consumption by region, *in millions of tons*




**More than bags**
Worldwide plastic waste by application, *in millions of tons*




Source: OECD



# “It’s about securing our prosperity”

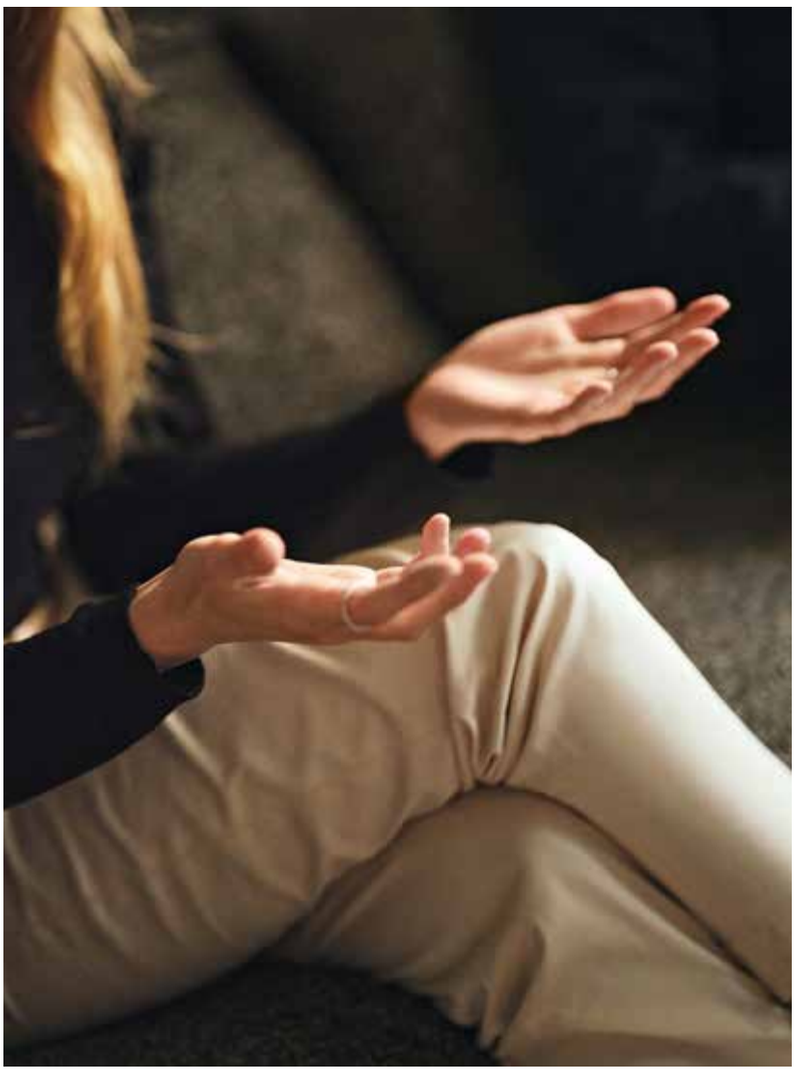
MOJIB LATIF

Climate change mitigation and nature conservation are currently having a hard time: The economy is weakening, the geopolitical situation is fragile, and major players such as the United States are pulling back. Climate researcher Mojib Latif and conservationist Myriam Rapior discuss the consequences for global warming and biodiversity loss

INTERVIEW **BERND KALTWASSER** & **CHRISTIAN BAULIG**

# “We should see environmental protection and nature conser-vation as an opportunity”

MYRIAM RAPIOR



# “There is no point in becoming climate-neutral but destroying our nature in the process”

MYRIAM RAPIOR

**Professor Latif, the delegates of the UN member states are currently meeting at the United Nations Climate Change Conference in Brazil. You have repeatedly expressed skepticism about such events. Are you following the conference?**

**MOJIB LATIF** Of course I’m following it. After all, this is one of the few times these days when the issue of climate is brought into the public eye. But at the same time, I’m not expecting anything from it. There have already been 29 world climate conferences, and yet global greenhouse gas emissions have continued to rise—except during the time of the coronavirus.

**MYRIAM RAPIOR** The assessments are correct, Mr. Latif, but we must remain optimistic. It’s important to keep reminding people and saying that we can still manage to limit the global temperature rise to 1.5 degrees. Although many environmental trends are pointing downwards, we have to keep at it and try to create positive momentum. If we no longer believe in the climate turnaround, then no one will believe in it.

**LATIF** That’s true. But the climate agreement that was concluded in Paris ten years ago has de facto collapsed. This has nothing to do with pessimism, but with physics. Even if we do everything humanly possible now, we will exceed a global warming of two degrees. However, I am not one to talk about tipping points. Even if we do not achieve the Paris climate targets, the world can still be worth living in. However, we should try not to get close to three degrees.

**So you’re giving the all-clear?**

**LATIF** No, I just mean that we should take out some of the drama. Otherwise, people will end up so desperate that they resort to actions like the “last generation,” which are totally counterproductive.

**The United States, one of the biggest emitters of greenhouse gases, has withdrawn from international climate protection initiatives. At the same time, China has announced that it will massively reduce its $CO_2$ emissions. So can we have some hope?**

**LATIF** Possibly. On the one hand, China is still the biggest emitter of $CO_2$, accounting for almost a third of global emissions. On the other, more capacity for renewable energy is being created there than anywhere else. I believe that with China in the lead, the world is indeed moving towards renewable energies—and the United States will have to do the same.

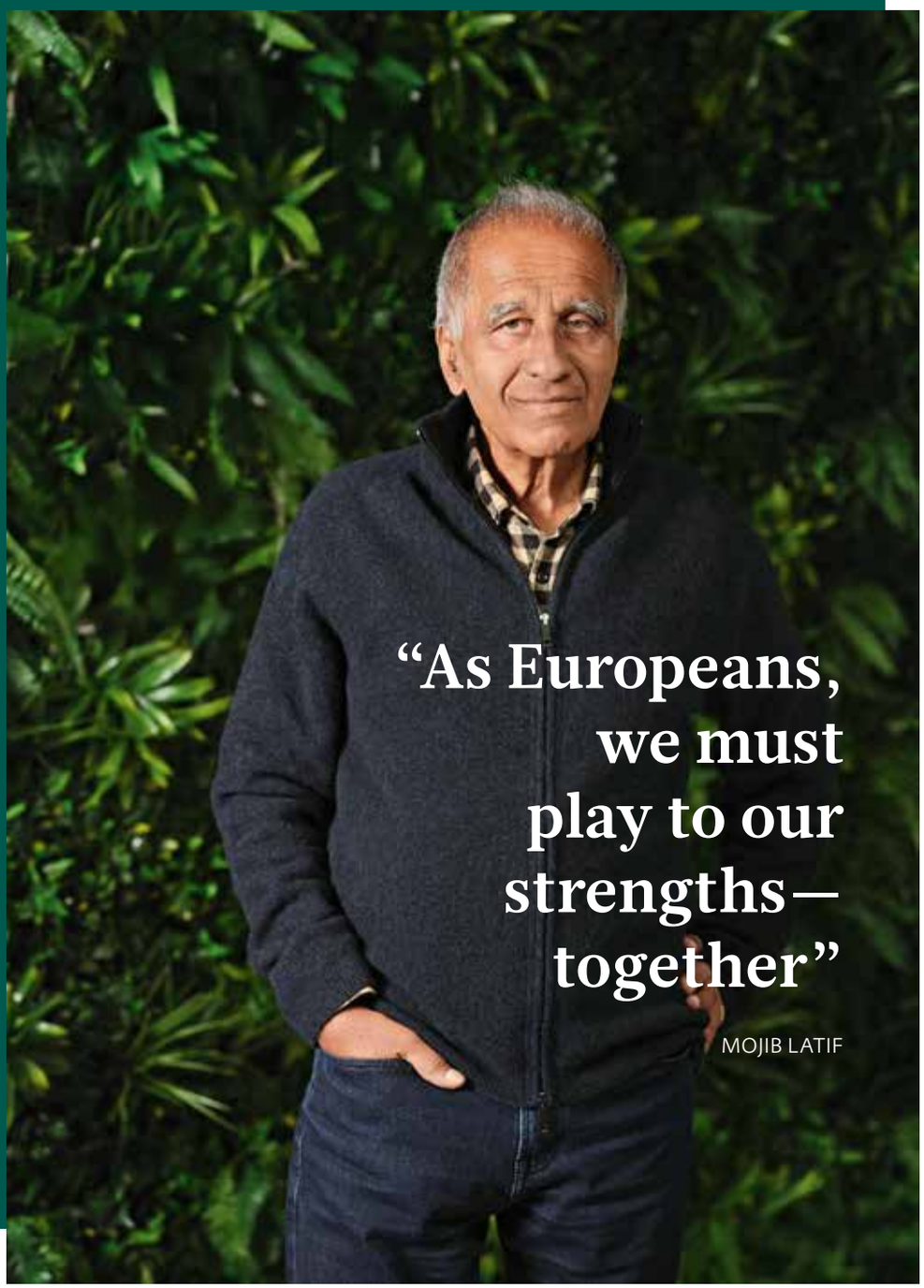
**Dr. Myriam Rapior** (29) is the Vice President of Friends of the Earth Germany (BUND). In 2022, she received the honorary award of the German Environmental Prize for her work on the Commission on the Future of Agriculture, and a year later was appointed to the German Council for Sustainable Development, which advises the German government. Rapior worked as Biodiversity Officer at the University of Hamburg and was a co-founder of Kuyua, a company that uses AI to analyze natural and climate risks in companies and supply chains

**A few years ago, Germany led the way with the claim "We will be climate world champions." Can we still do justice to this?**

**RAPIOR** I would at least like to see Germany make this claim again. And not only in terms of climate change mitigation, but also in terms of nature conservation. We need to find a different way of dealing with the environment and nature and see this as an opportunity for Germany as a business location. We have the underlying conditions necessary for this.

**In Berlin, on the other hand, there is currently a debate as to whether we can still afford the current level of climate change mitigation in view of the weak economy. How can we ensure that these terms are not perceived as opposites?**

**RAPIOR** We already have a very active start-up scene that reconciles the two. Young entrepreneurs are rethinking processes and products so that we can at least make small advances in climate and nature conservation. Older companies are also distinguishing themselves, for example by implementing climate protection programs. There's a lot going on. So we shouldn't problemize the issue to such an extent. We are currently facing major changes, let's call them crises. But Germany can emerge from them stronger than before. →




**Dr. Mojib Latif** (71) is a professor at the Geomar Helmholtz Centre for Ocean Research Kiel and was honored with the Max Planck Award for Public Science in 2000. Latif is a meteorologist. He has been President of the Club of Rome Germany since 2017. In 2022, Latif was elected President of the Academy of Sciences in Hamburg. He has published numerous books on climate change mitigation, most recently “Klimahandel – Wie unsere Zukunft verkauft wird” (the climate business—how our future is being sold)

**For many companies, the predominant concern is that more climate change mitigation will drive up costs and impair competitiveness. Isn’t this argument understandable, especially in times of crisis?**

**LATIF** No. Take the German automotive industry. It has always avoided leading the way in environmental protection, it has rarely kept its voluntary commitments, then came the diesel scandal… Unfortunately, it has completely missed out on e-mobility. Electric vehicles are booming in China. How are we going to get anywhere with our combustion engines? Climate change mitigation isn’t just about the climate—it’s about securing our prosperity. It’s about future viability. And we will only be fit for the future if we recognize global trends: Electrification is one of them.

**Ms. Rapior, you were involved in the start-up Kuyua, which analyzes natural and climate risks for companies. Evonik is one of its customers. Is the business community aware of the risks and costs of climate and environmental change?**

**RAPIOR** There is greater awareness of climate risks because many people are already affected by the effects of climate change. With Kuyua, I have just completed a major project with a company in the consumer goods industry for which heat is a major problem: Some products expire at above a certain temperature and can then no longer be sold. To prevent this from happening, the logistics must be adapted. In the event of flooding, production facilities may be unusable for months. That’s extremely expensive. In the

area of nature and biodiversity, the effects are more indirect. Textile companies must be prepared for supply chain failures because there may not be enough insects to pollinate the cotton plants. You have to act today to be prepared for tomorrow.

**LATIF** Every two years, for its Global Risk Report, the World Economic Forum asks almost 1,000 people in science and business about the greatest risks in the coming years. Even on the two-year horizon, weather extremes are pretty high on the list, and looking ahead to the next ten years, it's really only "green" issues, i.e. climate, biodiversity and so on. The economy has long recognized where the major risks lie.

**Nevertheless, in your view, there's not enough action going on. Why?**

**LATIF** We're coming from a very high level of prosperity, so people are not ready for change. But standing still is a step backwards. And that is why it is completely wrong for the German government to continue to promote fossil fuels through energy price and transport subsidies, for example. Discussions such as the one about postponing the end of the combustion engine are damaging the economy because they create uncertainty. Entrepreneurs have told me in confidence: "We can actually cope with all decisions, but we need a fixed framework."

**RAPIOR** In addition, there are different approaches at the national and the European level. For example, it is absolutely incomprehensible to me why subsidies for agriculture in the EU continue to be distributed indiscriminately, "with a watering can." In the Commission on the Future of Agriculture, which was set up under Angela Merkel's government and of which I was a member, we came to the conclusion in a broad social alliance of agriculture, business, science and environmental associations that these funds should be allocated according to ecological and social criteria. So far, this has not been implemented.

**So is closer coordination between European countries necessary?**

**LATIF** Absolutely. The geopolitical situation has changed completely and we as Europeans are more or less on our own. We must finally play to our strengths—together. In the energy sector, for example: We have a lot of sun in southern Europe, we have a lot of land elsewhere where wind power can be generated, and we have geothermal energy. It will be to our economic advantage if we use this low-cost energy. Energy is one of the major challenges of the future. We have been experiencing this since Russia started the war against Ukraine. We must finally become independent and a relevant player on the global stage. →

Green space: The two environmental experts spoke with *Elements* editors Bernd Kaltwaßer (left) and Christian Baulig in the jungle-style break area of the Hamburg agency KNSK, which produces the magazine

**“It’s the task of the state to protect us from negative consequences for the climate and nature”**

MYRIAM RAPIOR

**Renewable energies serve the goal of becoming climate-neutral, but can come into conflict with nature conservation. The energy crop corn is often grown in monocultures, wind turbines endanger wild birds, and solar installations shade large areas. How can these problems be solved?**

**RAPIOR** There is no point in becoming climate-neutral but destroying our nature in the process. We currently use too much space for generating energy. The nature aspect is neglected. From the outset, planning should also take into account the creation of habitat structures for endangered species. In general, we should focus more on protecting nature. This also requires unusual measures, such as temporary protection status. A company may be prepared to renaturalize an area that is currently not needed—but only temporarily. Why shouldn't habitats, ponds, dry stone walls and so on be created there so that species can colonize, and in 15 or 20 years the company can use the area for other purposes? Regulation is needed here.

**LATIF** Nothing is 100 percent sustainable. We always have to choose between two evils. Take the discussion about the environmental friendliness of electric cars. Of course, electric cars consume resources, and the batteries in particular have been criticized. Back in 1972, the Club of Rome was already talking about resource consumption and the need to move toward a circular economy. Electric mobility is already half a step in that direction. The batteries can be recycled or, in some cases, reused. In addition, work on batteries that do not require lithium has been underway for quite some time.

**Where should we focus our efforts—on minimizing the rise in temperature or on improving adaptability?**

**LATIF** On both. We should do everything we can to reduce greenhouse gas emissions. At the same time, we have to adapt because we cannot stop the rise in temperature in the short term. We are already seeing this in heavy rainfall events, the likes of which we have never seen before in Germany. We need to give nature more space again, because this is the best protection against heat, flooding, etc. Unfortunately, at the moment I'm seeing the opposite. We are sealing more and more surfaces, and this is making the effects even worse. Just think of the Gendarmenmarkt in Berlin: It's unbelievable! I don't know if there's a single tree there. Cities must become like sponges, and the best sponge effect is provided by nature through trees, green spaces, etc.

**Climate change mitigation and nature conservation are associated with costs and often disproportionately affect poorer sections of the population. How can we get society as a whole on board?**

**RAPIOR** Innovations are often expensive at first. Later, when economies of scale are achieved through larger quantities, things become cheaper. This is also true in the area of climate change mitigation and nature conservation. The state must bridge this phase with subsidies. There are climate targets and biodiversity targets, and it's the task of the state to meet these targets in order to protect us from negative consequences. Promoting innovations for greater sustainability now also offers a great opportunity: It's only a matter of time before these innovations are in demand. Once we have developed the right products, we can then export them around the world.

**LATIF** The state must support the transformation. Take electric mobility, for example. I bought an electric car two years ago. As I don't have my own home, like many people I am dependent on a good charging infrastructure. We need state provision for something like this. You can't expect it to happen on its own. The state must enable people to be sustainable—for example by making organic products cheaper than conventionally produced ones. Or ensure good rail connections so that commuters don't use their cars. Climate change mitigation must be fun for people.

**Which sustainable activity do you personally enjoy?**

**LATIF** For me, leaving the car behind and using public transportation is a win-win situation.

**RAPIOR** I love being outdoors. There is nothing better than relaxing in unspoiled nature. —

# IT'S GETTING EVEN BETTER

Polyamide 12 makes products more robust, more durable, and more environmentally compatible. Evonik produces the high-performance polymer in various sustainability levels: the customer decides how much the climate benefits, but the inner values of the material always remain the same

TEXT **TIM SCHRÖDER**

The material, which helps components in vehicles, pipelines or medical products to achieve top performance, makes a discreet arrival—as a simple granulate. In a functional factory hall with a concrete floor, a packaging machine fills it into 25-kilo bags, which are stacked 40 to a pallet. A truck then transports them out of the Evonik Chemical Park in Marl to the customers.

But their content is something special: It's polyamide 12, or simply PA12. It belongs to the premium class of plastics. It is needed where things get technically demanding—for example in the production of fuel lines and coolant pipes in cars. Such components have to deliver maximum performance in order to withstand chemicals, constant vibrations, and dirt. PA12 is processed into lightweight and robust tubes for the energy industry and is also used to make crystal-clear, scratch-resistant sunglasses in the eyewear sector.

Evonik has been the global market leader and a reliable supplier of this plastic for more than 60 years. "PA12 is mainly used in special applications, but demand is growing: As recently as 2021, we further expanded PA12 capacity here in Marl, making it the world's largest production plant for this high-tech material," says Florian Hermes, a sustainability expert in the High Performance Polymers business unit at Evonik. →

A robust plastic for tough everyday use: PA12 is used to manufacture hoses for brake fluid, fuels, and coolants, among other things

One of the properties expected of a contemporary material today is sustainability. The European Union aims to achieve a climate-neutral Europe by 2050. Many of Evonik's customers are facing the challenge of reducing carbon dioxide emissions and making a contribution to greater sustainability within the supply chain—including in the plastics industry. Reducing the $CO_2$ burden that the raw materials bring with them is a major lever for reducing greenhouse gas emissions.

# "We want to meet all customer requirements"

DR. FLORIAN HERMES, HEAD OF SUSTAINABILITY AT EVONIK HIGH PERFORMANCE POLYMERS

"Making our PA12 even more sustainable is a key aspect of our strategy," Hermes explains. The challenge here is that as customers use the material in very different applications, they also have different requirements. "We want to do them all justice," says Hermes. "There can't be a universal solution based on the motto 'one size fits all.'" So an entire product family has grown up around the core material. For companies, this means that they can choose between several PA12 variants with different levels of sustainability. This helps them to meet their own carbon reduction targets and legal requirements without having to make costly changes to their production processes. That's because the plastic always remains the same—PA12, with all its outstanding properties.

## SUSTAINABLE IN STAGES

The polyamide 12, which is individually tailored to each customer and each application, is produced in a large plant network in the heart of the Marl Chemical Park. In the uppermost section of the complex, the raw polymer is mixed with other additives. These include pigments, and sometimes also glass fibers that make the plastic particularly strong, or impact modifiers—additives that give the plastic certain mechanical properties. The plastic mixture passes through a long pipe to the next


The raw polyamide is mixed with various additives in the compounding plant

Laboratory Group Leader Svenja Schulte enters analysis results into the laboratory management system

part of the system—the heated extruder, where rotating metal elements knead the ingredients until a homogeneous mass is created. This is then pressed through dies into pencil-thin continuous strands. Finally, razor-sharp steel blades shred the cooled strands back into fine granules. The granules then go to the filling department and from there to the customers—automotive industry suppliers, eyewear manufacturers or shoe factories. It's an apparently simple process that results in a genuine high-tech product.

How sustainable the respective polyamide 12 is in the end is determined at various points along the production chain. In principle, every variant of PA12 granulate is produced using 100 percent electricity from renewable sources. Evonik purchases corresponding quantities of green electricity for this purpose. But customers can also choose additional sustainability options for an extra charge. For example, polyamide production requires a lot of steam and heat. These are usually generated from natural gas. As a green alternative, Evonik offers steam and heat from waste-based biogas.

Florian Hermes and his colleagues have also tackled the issue of petroleum. For example, customers can opt for polyamide 12 that is made entirely or partly from recycled materials—from end-of-life tires, used plastics or oil from agricultural waste. These raw materials enter the production chain at the very beginning, where petrochemical base materials for polyamide production are also processed, in the refineries of the energy companies. The oil is broken down into its components—including a gaseous mixture of carbon chains with four carbon atoms each—in so-called crackers. This mixture is called crack C4. It's the basic feedstock for the polyamide synthesis. The crack C4 is transported via a pipeline or by ship →

## A MATERIAL THAT MADE HISTORY

62 years ago, a versatile plastic called VESTAMID® caused a sensation. It went on to form the basis for Evonik's current range of high-performance polymers.

**1963**

The company then known as Chemische Werke Hüls AG presents the polyamide 12 VESTAMID®, produced on a pilot plant scale, at the K'63 plastics trade fair in Düsseldorf. Production starts a year later in Marl.

**1966**

A reactor with an output of 1,200 tons of PA12 per year goes into operation. Among other things, the material is processed into plastic components for the automotive industry under the brand name VESTAMID® (photo: K'71 trade fair).

# “Many customers want sustainably produced eyeglasses”

JENNIFER HASSELBERG, HEAD OF GLOBAL MARKETING FOR TROGAMID®


Bags from the roll: PA12 is filled into 25-kilo sacks in a packaging machine

to Marl, where it is further processed: first into butadiene, then into a chain of twelve carbon atoms, which gives PA12 its name. The polyamide is then produced via further steps. All these steps take place on a large scale at a single location, making the Marl plant unique in Europe.

If, instead of crude oil, the crackers in the refinery are fed with used cooking oil, for example, the carbon footprint improves. “When a customer opts for the variant based on such bio-circular raw materials, we ensure that appropriate quantities of used fats are purchased for the overall process and then processed in the refinery,” says Hermes. The quantity of sustainable materials used is reflected in what is called the mass balance. This determines the proportion of environmentally friendly raw materials contained in the end product (see diagram on p. 36).

The concept behind it is comparable to that of green electricity from energy suppliers. If you want, you can buy electricity from solar and wind, which is usually somewhat more expensive. Although in the end it is not possible to determine whether an electron that the customer draws from the socket at home was fed into the grid by a wind farm or a coal-fired power plant, the calculation balances overall. “That’s also how our mass balance works. You can no longer chemically distinguish whether a molecule in the finished product comes from petroleum or frying fat,” explains Hermes. For PA12, the raw materials that previously came from fossil sources can thus be completely replaced by recycled, bio-circular or bio-based raw materials.

“For the mass balance approach to work, transparency and trust are important,” says Hermes. “That’s why we have our procedures checked by independent auditors every year.” Evonik has received the ISCC Plus sustainability certification. This ensures that the product actually delivers the environmental effect it promises. Chemically, it is ultimately identical to PA12 made from petrochemical raw materials. The quality of the plastic therefore does not change due to sustainability.

## PAVING THE WAY FOR CUSTOMERS

“Our aim is to reduce the carbon footprint of our product as much as possible—and through the various sustainability approaches to give customers the opportunity to choose between the sustainable variants,” says Hermes. Evonik is thus a pioneer that supports buyers in achieving their own sustainability goals. After all, if a company offers products made from sustainable raw materials, this contributes to reducing its own carbon footprint and that of its customers.

Evonik sells the sustainable polyamide under different names: the standard version produced with green electricity as VESTAMID®, and the version that uses steam and heat from biogas as VESTAMID® RFP—for reduced

The particularly sustainable TROGAMID® eCO is popular among eyewear manufacturers, as it enables the production of scratch-resistant lenses

footprint. The third particularly sustainable variant brings everything together: green electricity, biogas, and sustainable raw materials, especially from plant waste. It is offered under the name VESTAMID eCO. VESTAMID® eCO achieves a $CO_2$ reduction of up to 70 percent compared to a polyamide made from petroleum and electricity generated using coal.

The RFP variant is currently particularly popular with customers from the 3D printing industry. However, they do not use granules, but a fine polyamide powder with the name VESTOSINT®. This is sintered layer by layer in the 3D printer so that an object grows in height.

## SUSTAINABILITY IS A SALES DRIVER

The eCO variant has also already taken off in the market—especially among eyewear manufacturers. They require a crystal-clear, unbreakable, and scratch-resistant plastic. These properties are provided by the polyamide that Evonik offers to the optical industry under the name →

**1982**

The addition of VESTOSINT® brings more color to the PA12 range. The new product in powder form is used in coatings and paints, for example for baskets in dishwashers.

**1988**

The compounding plant for technical plastics at the Marl site commences operations.

**2000**

The continuous production facility in Marl begins operating. VESTAMID® is produced here in continuous operations around the clock.

**2006**

The polyether block amide (PEBA) from the VESTAMID® E series, an elastic polymer that is used in the soles of sports shoes, for example, hits the market.

**2019**

The groundbreaking ceremony for the polyamide 12 plant in Marl, where VESTAMID® and VESTOSINT® are produced. The plant is commissioned in 2021.

TROGAMID®. "Many customers want sustainably produced eyeglasses," says Jennifer Haßelberg, who heads the corresponding market segment. As a pioneer in the optical industry, Zeiss Sunlens has already converted its entire polyamide portfolio for non-prescription sunglass lenses to this sustainable high-tech plastic. According to Haßelberg, fashionable sports or lifestyle eyewear are often luxury goods. "The slightly higher material costs can be offset by a slightly higher sales price. That works in this market, as all sides are calling for sustainability," he says. Demand is currently increasing, particularly on the Italian fashion market. Customers can have a clear conscience if they buy sustainable eyeglasses, and manufacturers can not only score points with their customers, but also improve their own carbon footprint.

The high-performance material can be used to produce both spectacle lenses and frames. "End customers want lightweight and robust eyeglasses that can withstand sun creams and disinfectants—and are forgiving if you accidentally sit on them," says Haßelberg. But this is just the beginning. "Especially in the high-priced fashion world, you also want to sell a unique feeling, and that's exactly what we create with TROGAMID® eCO: sustainable and flawless. The customers are delighted that top-quality, crystal-clear plastic that does not have a yellow tinge or residues such as crumbs or stains can be produced from plant waste.

## A NEW LIFE FOR OLD PLASTIC

And the ambition of Evonik's researchers goes even further, because they also want to intensely focus on recycling the PA12. That is why they have launched another sustainable variant on the market—VESTAMID® R, where "R" stands for recycling. For VESTAMID® R, Evonik collects polyamide residues, among other things, from customers' production facilities in order to shred them and then add them to the mixture of polyamide ingredients in the compounding process. "This diversification of raw material sources is important in order to obtain material in sufficient quantities," says Florian Hermes.

Hermes and his colleagues have also examined the recycling of products made from PA12 that have reached the end of their useful life. Together, they went to scrap dealers and waste recyclers to get an idea of what the polyamide 12 residues look like when they are removed from cars and trucks years later. On their tour, they also wanted to find out whether enough PA12 residues in total were being collected. One of the results: As a rule, brake pipes or fuel lines are so heavily soiled that it does not make sense to reprocess them for mechanical recycling. In such cases, chemical recycling makes it possible to close the material cycle. Mixed plastics that are not used

TROGAMID® can also be used to produce flexible, break-resistant and crystal-clear frames

Evonik cuts PA12 precisely to customer specifications and supplies the plastic in countless colors

**2021**

Development of TROGAMID® eCO, the first sustainable polyamide for the eyewear market manufactured in accordance with the mass balance standard.

**2025**

Launch of the new VESTAMID® R product series based on mechanical recyclates; the series is to be continuously expanded over the next few years.

for mechanical recycling are heated until a dark brown liquid known as pyrolysis oil forms. In the future, it could be produced from so-called shredder light waste. This fraction makes up around a quarter of the final material when end-of-life vehicles are shredded as part of the vehicle recycling process.

The pyrolysis oil could be cracked again in a refinery to obtain crack C4 for PA12. The European Union is currently pushing ahead with a regulation in the form of the new End-of-Life Vehicles Regulation, one of the aims of which is to increase the recovery rate in the automotive industry. The draft provides for the use of more recycled plastic. "Such European and international regulations are increasing the demand for sustainable products among many manufacturers. Our PA12 made from pyrolysis oil will help with this," says Hermes. "Our different PA12 variants give customers the opportunity to decide for each product how much sustainability they want and how much they are willing to pay."

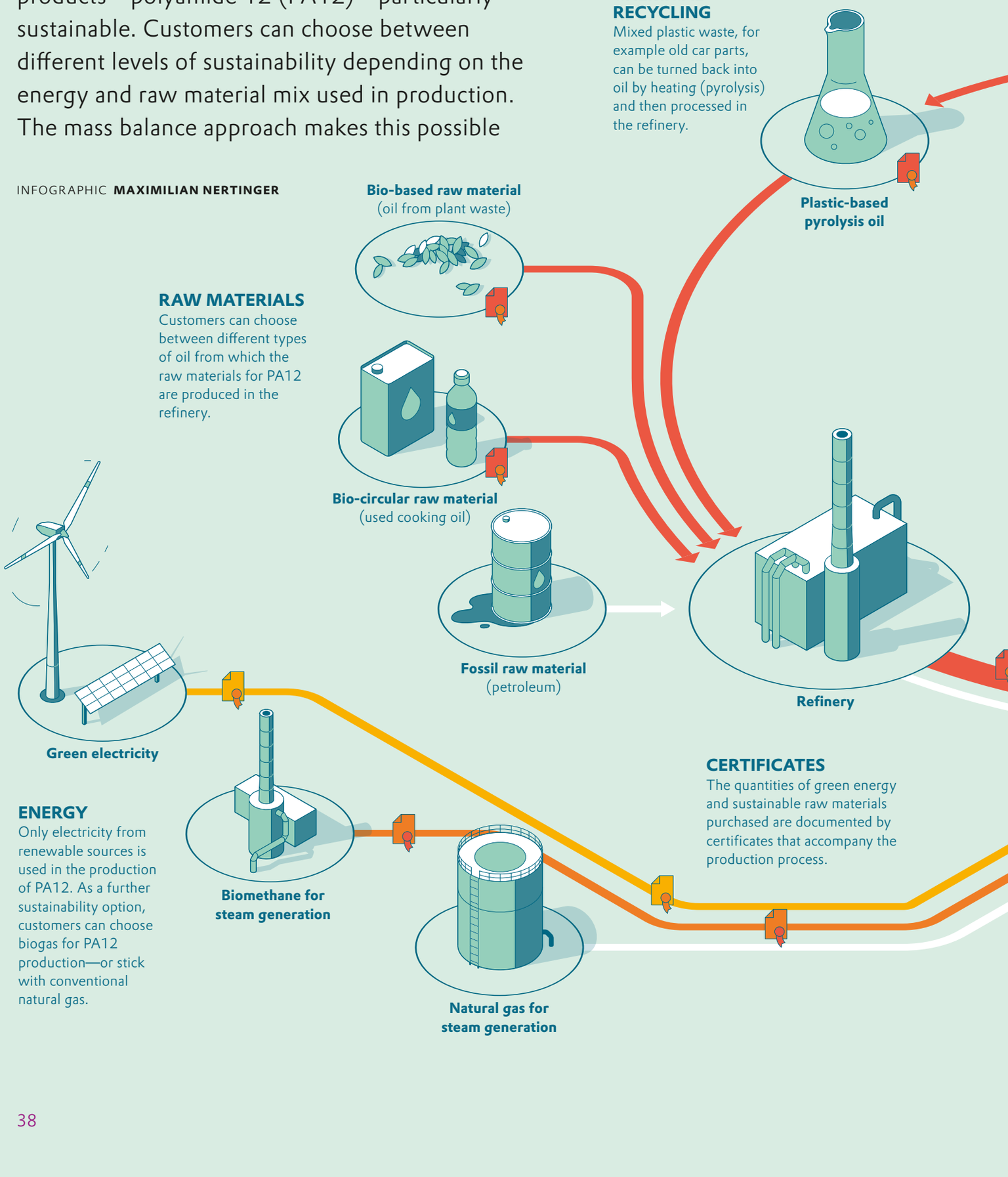
Evonik's lifecycle management team has compiled all findings and data on energy consumption, carbon dioxide emissions, and land and water use in a polyamide 12 life cycle assessment. The assessment calculated which sustainability paths—from the oil to the finished product to recycling and the alternative raw materials—lead to the biggest $CO_2$ savings. The results of the life cycle analyses are openly available on the Internet. This provides maximum transparency—especially for customers. "They should be able to understand the sustainability of our PA12 in detail. Not least for their own climate balance and a smaller carbon footprint," says Hermes. Transparency is fundamental when it comes to making the economy more sustainable and working together across company boundaries. "Ultimately, you can only make a difference together. The entire supply chain must work together, from the raw material supplier to the end customer."

**Tim Schröder** is a science journalist who lives in Oldenburg

# Retained profit

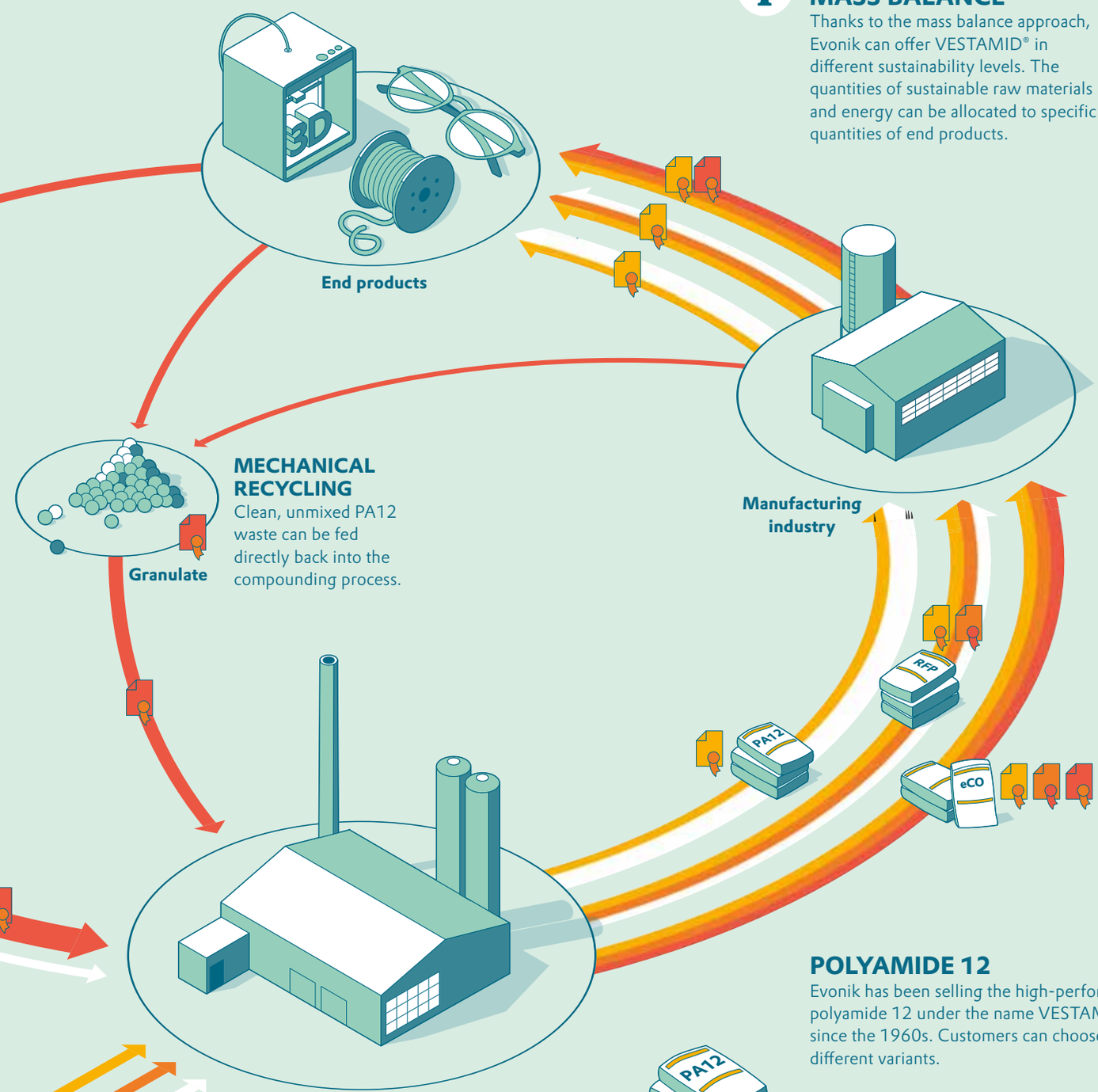
Evonik has made one of its most important products—polyamide 12 (PA12)—particularly sustainable. Customers can choose between different levels of sustainability depending on the energy and raw material mix used in production. The mass balance approach makes this possible

INFOGRAPHIC **MAXIMILIAN NERTINGER**



## MASS BALANCE

Thanks to the mass balance approach, Evonik can offer VESTAMID® in different sustainability levels. The quantities of sustainable raw materials and energy can be allocated to specific quantities of end products.




## MECHANICAL RECYCLING

Clean, unmixed PA12 waste can be fed directly back into the compounding process.

## PA12 PRODUCTION

All stages of PA12 production take place at the Marl Chemical Park—from the C4 cut, which is supplied by the petrochemical industry, to the mixing of the customer-specific PA12 in the compounding plant.

## POLYAMIDE 12

Evonik has been selling the high-performance polyamide 12 under the name VESTAMID® since the 1960s. Customers can choose between different variants.


### VESTAMID®

The conventional variant is obtained from petroleum. The energy for production comes from green electricity.


### VESTAMID® RFP

RFP means "reduced footprint." This VESTAMID® is produced using green electricity and steam from biomethane.


### VESTAMID® eCO

The particularly sustainable VESTAMID® variant is produced using green electricity, biomethane, and circular raw materials.

Game, set, match: AIChemBuddy helped find a process with which rubber from end-of-life tires can be used in tennis balls

# ON GOOD TERMS WITH AI

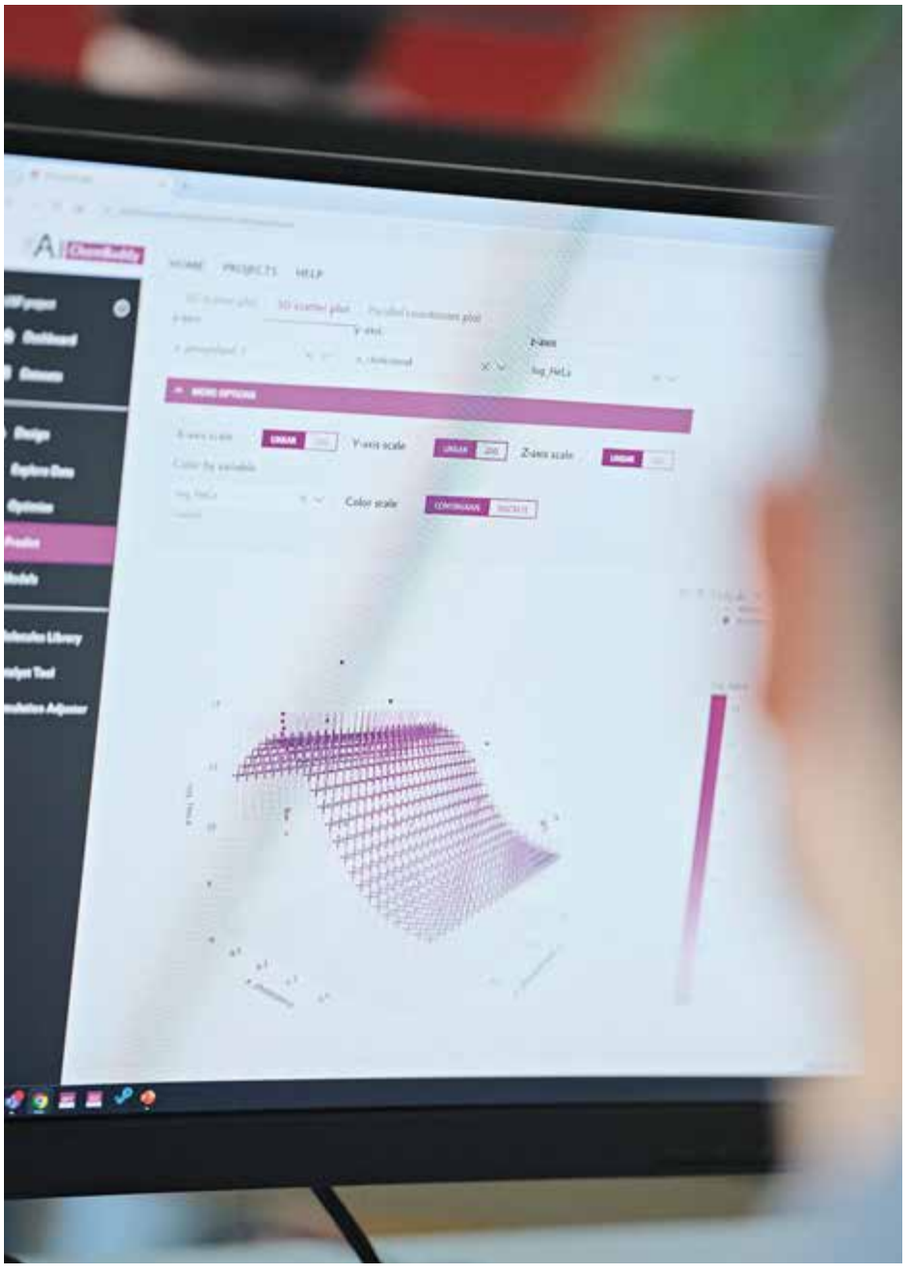
Sometimes researchers come up against their limits. Experiments are too complex—there are too many possibilities, and that prevents them from achieving their goal quickly and efficiently. In cases like these, artificial intelligence can get a project moving again. At Evonik, AIChemBuddy supports its human colleagues with advice and provides space for new inspiration

TEXT **KARSTEN LEMM**

The task ahead of them was trickier than expected. Sabine Kanbach and her team were looking for a production process for a new lipid. This chemical building block can be used to produce lipid nanoparticles, which form a protective shell around active ingredient molecules, for example in vaccines. This protection should be stable. In addition, a high degree of purity is mandatory, and the lipids must be easy to process. The expert team's goal was clear, but the path to it lay hidden in a fog of unknown factors.

"We had a lot of different parameters," recalls Kanbach, a chemist working in the Research and Development department of Evonik's Health Care division in Hanau. The starting materials could still be narrowed down without computer assistance—but after that things became difficult. Which solvent should they choose and what temperature? How could the desired reaction be triggered, and how long should it run?

Normally, Kanbach would have worked to achieve a result with the help of empirical values and experiments—a lengthy and cost-intensive procedure. But this time, the 33-year-old turned to AIChemBuddy, an expert system that combines artificial intelligence with specialist knowledge. Evonik developed it precisely for cases where the sheer abundance of possible combinations pushes the human imagination to its limits. Fed with all the important data and initial test results from the project, the software narrowed down the list of reagents, helped optimize the synthesis, and found a way to double the purity. "It wouldn't have been possible for us to calculate by ourselves everything we needed to vary," says Kanbach. With the help of computers, her team was →



The output of the AI model changes when typical variables for reaction optimization, such as substance quantities or temperatures, are varied

finally able to "precisely adjust the parameters to decimal places" and achieved their goal just a few weeks after they started work. "We got to the sweet spot," she concludes.

The support provided by AIChemBuddy enabled the development phase to progress extremely quickly. This gave the team of experts scope to focus at an early stage on other parameters that are important in process development, for example.

## INSPIRATION AND SUPPORT

AIChemBuddy is a prime example of how AI helps make complex processes more efficient and speeds up the development of new products. One in three companies in the chemical and pharmaceutical industry in Germany is already using the smart algorithms for these purposes, according to a current study from the German Economic Institute. In the authors' view, the most innovative companies are those that do not buy AI off the shelf, but instead invest in their own systems that are tailored to their needs.

Evonik has several AI tools, including the company's internal chatbot Evonik-GPT, which can generate texts and process files. AIChemBuddy is aimed at employees in research. "The classic user that we always have in mind gets stuck at some point during the lab work," says Thomas Asche. "AIChemBuddy is there to provide inspiration or calculate an optimum." As a materials researcher, 37-year-old Asche is familiar with the challenge of juggling a large number of open parameters. In 2021, his interest in digital topics led him to the digitalization department of Research, Development & Innovation at Evonik in Marl. RD&I initially provided inspiration and ideas and then implemented AIChemBuddy together with Process Engineering and Evonik IT.

When Asche joined RD&I, the first attempts to use machine learning to develop new materials were already under way. The results were encouraging, but the partners—external software companies—demanded a revenue share or access to sensitive data. This was unacceptable for Evonik. "So we asked ourselves: Can we do this on our own?" Asche recalls. "And then we hired Johannes."

Johannes Dürholt is sitting next to Asche in a conference room at Creavis in Marl. In the world of Evonik, Creavis is the strategic innovation unit and business incubator. Dürholt, a 34-year-old expert in theoretical chemistry, feels just as comfortable in the world of algorithms as he does on excursions into the periodic table. As a data scientist at Process Engineering, he frequently works together with researchers in the laboratory. "It's often about planning experiments," says Dürholt. "And that's exactly what AIChemBuddy takes care of now."

The name indicates what the AI system is supposed to do: act as a buddy to support people in the chemical laboratory. “It’s not our aim to offer ‘hyperintelligence,’” Asche explains. Instead, the objective is to provide researchers with “a virtual colleague at their side who they can ask in tricky situations: ‘What would you do?’”

The developers repeatedly emphasize one thing: All the decisions are still made by humans—and if you want to elicit helpful tips from the AI, you have to know your subject pretty well. The system has nothing in common with talkative chatbots. For all its user-friendliness, it is nonetheless a specialist for specialists. When you log in, you will find an intuitive user interface that prompts the user to create a project, upload data or evaluate the results of calculations. Some things are similar to the spreadsheet program Excel, others to the presentation tool PowerPoint. The system offers a wide range of options.

## TENNIS BALLS MADE FROM END-OF-LIFE TIRES

Thomas Asche and Johannes Dürholt give interested parties a personal orientation session. In this onboarding, they explain what AIChemBuddy can do—and what it can’t. Some people, says Asche, have the idea that you can just throw anything into an AI—a little experimental data here, a handful of research reports there, mixed with a vague idea of what the end result should be. But that’s not the role of artificial intelligence, he emphasizes in his role as a digital manager. “AIChemBuddy is not a crystal ball.”

The smart assistant is particularly useful if results that can be significantly improved are already available from experiments, or if a screening should show which variables are relevant for a project. “We propose experiments on the basis of the desired outputs,” says Asche. “This optimization is the core element of the platform.”

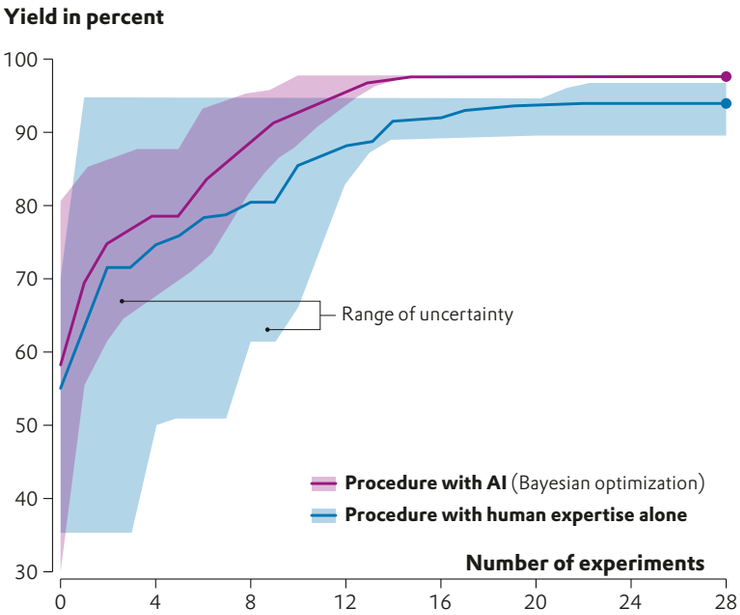
The rebirth of car tires in the form of sports equipment shows how sober analysis can still result in magic. Two years ago, Dürholt learned about Vestaro, a joint venture between Evonik and the Munich-based development company Forward Engineering. The partners had set out to develop a raw material made from end- →

**“AIChemBuddy often takes care of things like experiment design”**

JOHANNES DÜRHOLT, DATA SCIENTIST IN PROCESS ENGINEERING AT EVONIK

## BETTER WITH AI

Number of chemical experiments with and without artificial intelligence (AI) that lead to the best possible result and the maximum achievable yield




Source: Angewandte Chemie International Edition, March 2025

of-life tires for the production of tennis balls. Around 25 million tons of waste rubber is produced every year because tire treads wear out—so the source material for possible recycling exists.

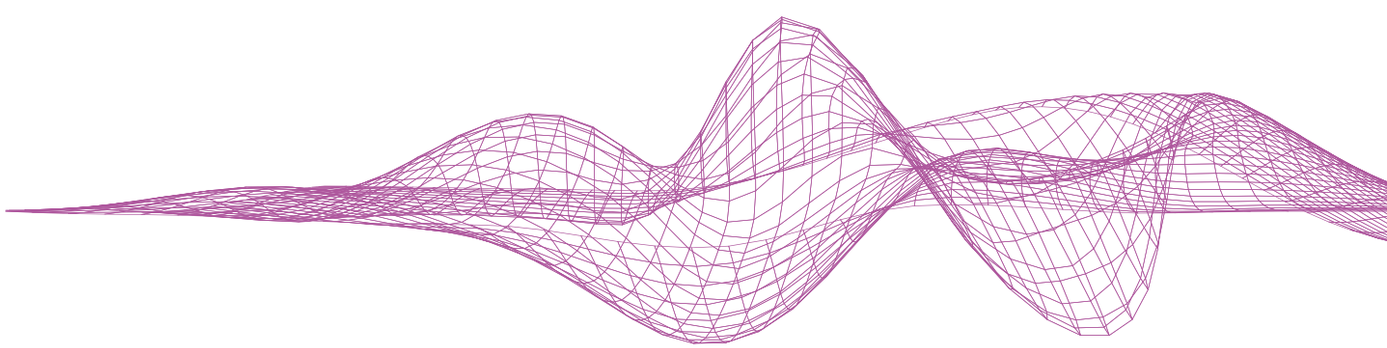
Or at least, it should. However, it turned out in the laboratory that it's very difficult to find the right mixture of recycled material, additives from Evonik, and natural rubber to give the environmentally friendly tennis balls the same properties as those produced conventionally. "In addition, there was a lot of time pressure in the project," Dürholt recalls.

The chemists and product developers consulted Dürholt and a colleague as experts in Process Engineering. The first step both of them took was what experts call "data hygiene." They checked which values could be used by AI, removed outliers and deleted information that was not very promising. That's because the cleaner the data, the more reliable the results delivered by AI. After a few days of this preparatory work by humans, the algorithm behind AIChemBuddy only needed a few minutes to provide suggestions for several compositions of old and new. "The rubber experts were very impressed," says Dürholt. The ball has recently gone on sale under the name "Code Planet." With it, the manufacturer Balls Unlimited is presenting the first sustainable tennis ball. According to the company, 40 percent of the ball core is made from recycled end-of-life tires.

### NO MORE RULE OF THUMB

This success impressively demonstrates how the internally developed AI solution can drive projects forward in key areas. And it reinforces the view among experts that companies that make targeted use of artificial intelligence have a clear competitive advantage in those areas where other companies focus on personal experience and intuition. Jakob Zeitler, Pioneer Fellow at the Statistics and Big Data Institute at the University of Oxford, says that too many laboratories are still working according to the rule of thumb.

"When we go into the lab and run experiments, it's a bit like baking a cake," he explains. Here too, there are different variables, ranging from the ingredients to the mixing ratio and the temperature and time in the oven. Every change has an influence on whether the cake tastes good, the dough rises or the cake base burns. These variables may still be manageable in the kitchen, says Zeitler, but in chemistry there are many "interactions between complicated factors that are not directly visible to us." AI is guided only by numbers, patterns and mathematical relationships—parameters that often remain hidden to



the human eye, and whose alteration can lead to astonishing results. Zeitler remembers chemistry experiments in which the algorithm repeatedly suggested an acidity level that seemed absurd. In practice, however, the calculated recipe proved to be superior. “It suddenly worked after all, because the acid interacts with other factors in a very complicated way,” the researcher explains. “Since the statistical model understands this high-dimensional space better than any human being, it can predict reactions that contradict our intuition.”

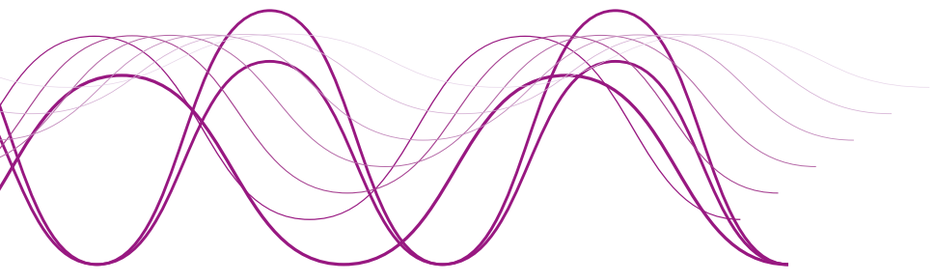
Mathematically, such successes are based on a method called Bayesian optimization. It uses a limited amount of initial data—such as results from laboratory experiments—and uses models to calculate what happens when individual parameters change. AIChemBuddy uses the available experiences to look for promising ways to achieve a result that the researchers have specified. The AI finishes its job with a proposal for a promising experiment. The method is therefore particularly suitable for exploring a given search space in which the best conditions for the interaction of certain factors are to be determined.

AIChemBuddy relies on a software library for Bayesian optimization called Bofire. Johannes Dürholt is wearing a T-shirt with the AI’s logo visible in black through his light blue shirt. Bofire is the result of a cooperation between companies that may seem unusual at first glance: In addition to Evonik, BASF, Boehringer-Ingelheim and, more recently, Bayer are also involved in the further development of the AI system. “They’ve all worked on sim- →

## “It’s not our aim to offer ‘hyperintelligence’”

THOMAS ASCHE, DIGITAL EXPERT AT EVONIK RD&I

The team led by Thomas Asche (right) and Johannes Dürholt provides AI ChemBuddy—a tool that makes it easier for researchers and developers to achieve their goals



ilar problems," Dürholt explains. They all had costs for the same approach to a solution. "That's when we said, 'Why don't we join forces and make it open source?'"

This was the next step, which was an unusual one from a management perspective: The source code for Bofire is openly available on the Internet. Isn't anyone worried that competitive advantages and company secrets are being revealed? No, answers Thomas Asche. "The intelligence ultimately comes from the data we use to train the models. This means that everything that generates value for us remains within Evonik," he explains.

AIChemBuddy also belongs exclusively to Evonik as an application. Put simply, Bofire is the drive system that all participants develop together—but it only becomes a powerful engine through fine-tuning with internal company data. Each company also builds its own chassis—the app that determines what users can do with the AI. Evonik has taken on a pioneering role in the chemical industry for the use of Bofire and paved the way for this instrument in the sector. The company also contributed a large part of the code base. "Other participants are welcome, because together we can make Bofire even more powerful," says Dürholt.

## NO SUBSTITUTE FOR HUMAN EXPERTISE

AIChemBuddy has its virtual home in a data center in Frankfurt am Main, and it's frugal when it goes into action. "The energy consumption corresponds to that of two to three laptops," says Asche.

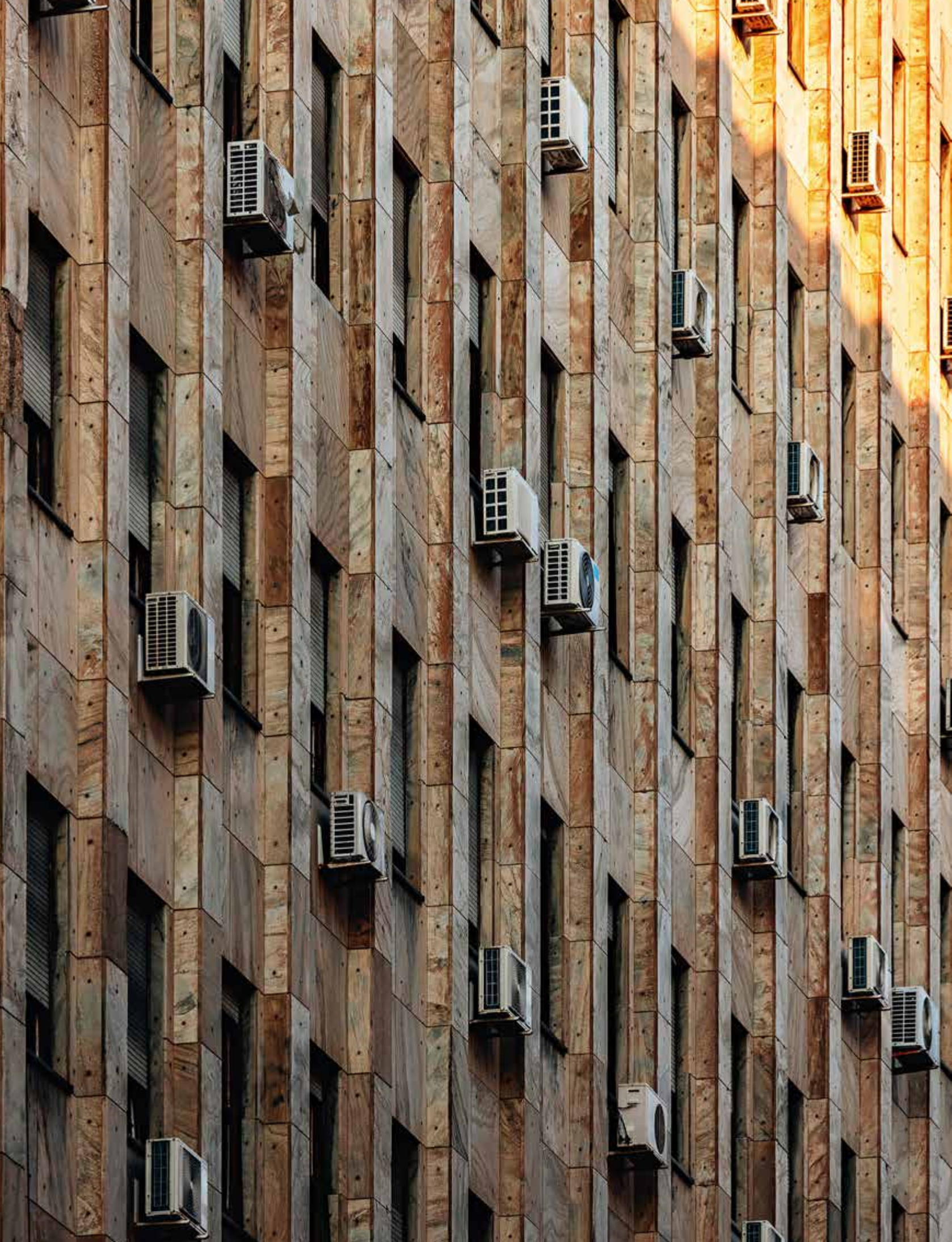
At Evonik, AIChemBuddy is available to all employees. Among other things, this is based on the hope of finding as many new fans as possible for the AI system. That's because the more often the digital assistant gets projects up and running, the more likely it is to pay off for the company. The same applies to the acceleration of development work, as in Sabine Kanbach's project.

Kanbach already sees the opportunities to use insights from her current project for future tasks. "We have now optimized our lipid nanoparticles to a very high degree," she reports. "These findings can be easily transferred to other excipients that work in the same way." She is so enthusiastic about the results that she wants to recruit more colleagues for AI. So far, many have been hesitant, she reports. For some, habit probably prevailed, while others were worried that AI could jeopardize their jobs.

Kanbach believes the concern is unfounded: "I don't have the feeling that AIChemBuddy is replacing me," she says. "After all, we specify the experiments ourselves and deal with the results." The developers also believe that the special value of their system lies in this close cooperation between human and machine. "The chemist's knowledge is super important," Johannes Dürholt emphasizes, adding that the more knowledge that humans provide to the AI, for example in the form of limits for the individual parameters, the easier it is for the machine to find good solution approaches.

"If you feed it with your knowledge, you'll achieve your goal faster," adds Thomas Asche—and the word is spreading in the company. So far, around 300 employees from all business units are using AIChemBuddy. "We have many use cases from the areas of research and process engineering development. It's also already being used for simulations and process optimization." But there should be even more users. "This is not a race of 'AI versus chemists,'" Asche emphasizes. "Instead, it's a race of 'chemists without AI' versus 'chemists with AI.' And it's a race we will win." —

**Karsten Lemm** is a freelance author who writes about business and technology. After 16 years in San Francisco, he now lives in Berlin.



# KEEP COOL...

…and keep going—with the development of sustainable air conditioning systems. Because as pleasant as a cool room is when it's hot outside, we need modern technologies that don't further accelerate global warming

TEXT **BJÖRN THEIS**

In the summer of 1902, New York was groaning under a record heatwave. This also caused problems for machines. Due to the high temperatures and humidity, the paper in a print shop in Brooklyn warped to such an extent that production was no longer possible. The print shop commissioned the 25-year-old mechanical engineer Willis Carrier to remedy the situation. Carrier delivered. He developed a system in which fans blew the warm, humid room air over evaporator coils filled with ice-cold water. Cold, dry recirculating air was the result. The first modern air conditioning system had been invented.

## THE NEED FOR COOLING IS INCREASING

Today, according to estimates, around two billion appliances worldwide are cooling air—and have gone from being the solution to being part of the problem. Air conditioning systems account for around ten percent of global electricity consumption and around three percent of greenhouse gas emissions. And the demand for cool air is growing. The International Energy Agency estimates that the number of air conditioning systems will triple by 2050. We therefore urgently need more efficient and environmentally friendly cooling technologies.

Cooling using the elastocaloric effect is considered to be one of the most important alternatives. Materials that display this effect—such as nickel-titanium alloys and some polymers—absorb heat from the environment and release it as soon as they are exposed to external stimuli. These stimuli include magnetic pulses, pressure, mechanical tension, and electric fields. This technology works entirely without climate-damaging refrigerants. This is one of the reasons why the U.S. Department of Energy and the European Commission regard elastocaloric cooling as one of the most important alternatives to vapor compression. The World Economic Forum calls this form of cooling one of the "Top 10 Emerging Technologies."

Membrane heat pumps offer another way of cooling rooms efficiently and sustainably. They are equipped with a selectively permeable membrane for heat transfer. In the electrochemical version, an electrical voltage generates ion transport which drives the liquid compression and thus the cooling. In the sorption-based heat pump, vapor is passed through a membrane to separate an absorbent (e.g. a salt solution) from a refrigerant and thus create cooling. Both systems use liquids that release hardly any greenhouse gases.

## A LIQUID SOLUTION

Even NASA has entered the race for the most advanced air conditioning system. The U.S. space agency recently founded the company Helix Earth. This company aims to halve the energy consumption of air conditioning systems by equipping conventional vapor compression units with liquid desiccants for pre-dehumidification.

In the future, there will be a variety of ways to keep a cool head and protect the environment at the same time. Progress in this area is urgently needed, because one thing is certain: Rising temperatures worldwide will increase the need for cool rooms. That's why Foresight is analyzing this topic as part of the "GameChanger 2035" project with a view to future potential for Evonik

**Björn Theis** heads the Foresight department at Evonik's innovation unit Creavis

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# "This Blue Is Divine!"

LOG **NADINE ALBACH**
PHOTOGRAPHY **JONAS OPPERSKALSKI**

Physicist and electrical engineer **Baruch Sterman** is a senior executive in Israel's high-tech industry and holds over 30 patents in the fields of optics, speech technology, and cybersecurity. As co-founder of the nonprofit Ptil Tekhelet Association, he is recognized as an expert on the ancient blue dye *Tekhelet*. Together with his wife, Judy Taubes Sterman, he has published a book on the subject. The couple lives with their seven children in Efrat, Israel.

Nature has tucked a chemistry lab into a tiny sea snail: *Hexaplex trunculus* produces three molecules—indigo, monobromoindigo, and dibromoindigo. It's this unique combination with brominated compounds that gives rise to a blue deeply significant in Jewish tradition. A heavenly blue. We call it *Tekhelet*.

Over 30 years ago, when Rabbi Eliyahu Tavger approached me to ask if I could support him in an important endeavor, I only knew the snail from diving. Nevertheless, we founded the Ptil Tekhelet Association in Jerusalem in 1991. Since then, we have been the only ones in the world producing the blue-and-white *Tzitzit* strings dyed with *Tekhelet* for the Jewish prayer shawl and passing on the knowledge about the color.

Every Jew knows the Torah passage that obligates us to attach these strings to our garments as a reminder of God's commandments. But the ancient method of dyeing them had been lost to history. It wasn't until the 19th century that Mediterranean sea snails of the genus *Hexaplex* (previously *Murex*) were identified as the source of the dyes. The challenge: they yielded purple—not blue. The breakthrough came in the 1980s, thanks to Israeli chemist Otto Elsner. He discovered that exposing the dye solution to sunlight during the process triggered oxidation—transforming the color into blue.

In 1988, Rabbi Tavger succeeded in dyeing the strings as our ancestors once did. But the method was inefficient. So I took a break from the high-tech industry. With a PhD in physics and expertise in infrared spectroscopy and molecular behavior, I understood how light interacts with the snail's molecules. I developed a more efficient dyeing technique—one that also met religious requirements. It worked: We've since sold over 300,000 strings to around 70 countries.

In ancient times, the purple and blue dyes from the snails were worth more than gold—reserved for the elite. Today, anyone can wear *Tekhelet*. It evokes the sky and the aspiration to reach beyond what is within our grasp. Even the blue in the Israeli flag is inspired by *Tekhelet*.

Being part of this story is a gift."

# Masthead

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# “I really do want to save things …

… so they can be used again someday,” explained Andy Warhol in 1975. Until his death in 1987, the pop artist stored thousands of objects in 610 cardboard moving boxes, including a wealth of items that bear witness to American consumer society.

Today, the objects from Warhol’s “Time Capsules” actually have a second life—as exhibits that attract art enthusiasts to museums all over the world. In this way, Warhol gave seemingly useless disposable products a new value—a principle to which the modern recycling industry is also committed.