2/2025

EVONIK
Leading Beyond Chemistry

ELEMENTS

Research. Knowledge. The future.

All in one

Process technology

Engineering the conversion of materials

Process technology is an interdisciplinary area of study concerned with the technical implementation and optimization of material conversion processes. As the connecting element between raw materials production and product manufacture, it is indispensable to many branches of industry. Its central task is to transfer laboratory processes to an industrial scale and to implement specific customer requirements. Process technology encompasses many specialist disciplines such as mechanical, thermal, chemical, electrochemical, and bioprocess engineering. Its objective is to make production processes more efficient and products more sustainable.

Material conversion processes Mechanical, thermal, chemical, and biological processes in which the nature, properties, and composition of the materials are changed.

Industrial scale The final stage of process development, in which the process is applied in practice under real-life production conditions.

DEAR READERS,

There is an often-quoted saying in English: "Too many cooks spoil the broth." The meaning is quickly understood: If too many people are involved in the kitchen, nothing good will come of it. But is it true? Ever since the animated film *Ratatouille,* everyone knows that cooking at star level only works as a team. The best ingredients in the hands of the greatest experts in their respective fields—this is the way to create excellent dishes for the most discerning palates.

It's no different in chemistry. Only those who have mastered the entire range of process steps to the highest level and also know and understand the customer's requirements precisely can be successful today. The aim is not to serve up the same solution for everyone, but to create one that is tailored precisely to the needs of each specific customer and is both easy to use and sustainable.

In our cover story, we show how many different skills, processes and techniques have to come together in perfect orchestration in order to successfully bring a complex product such as biostimulants to its use by the customer. Evonik prefers to have a kitchen full of chefs. Because bringing together differing skill sets gives us an advantage in terms of innovative strength.

In another story, we present a lone fighter. Thilo von Osterhausen is a passionate surfer, inventor, and entrepreneur. With his start-up Kanoa, he wants to make surfboards much more durable and recyclable at the same time. But he too went looking for partners for success—and came across Evonik. Together, they now have their sights set on a market that is far bigger than surfing.

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 content, are also available on the Internet at elements.evonik.com

Tomorrow's superforce: Evonik experts at the BioHub in Hanau are working on microorganisms such as rhizobia. Here, sensitive bioactive ingredients are processed into storable products that work optimally at the point of use

In and down: Pre-coated capsules from Evonik make medication more convenient for patients who previously had to resort to injections

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.

Millions of people around the world lack access to secure work and a stable income. A life without poverty requires **permanent, broad-based and sustainable economic growth, full and productive employment and decent work** for all. Education, equality, and equal opportunities are key prerequisites for this.
To create sustainable prospects in economically weak regions of Africa, Evonik supports the United Nations' Great Green Wall initiative. One focus is the sustainable use of the baobab tree—especially in the Sahel region. Evonik buys baobab seeds in the region to produce a high-quality oil for the cosmetics industry. The project creates new sources of income for women in particular, strengthens the local economy and preserves traditional knowledge.

In western Madagascar, baobabs of the species Adansonia grandidieri, up to 800 years old and around 30 meters high, tower through the morning mist. Baobabs are widespread in many parts of Africa, including the Sahel region, where the species Adansonia digitata is particularly common. As part of the Great Green Wall initiative, millions of trees are being planted from Senegal to Djbouti to stop the Sahara from advancing southwards.

The researchers used balloon dogs made of foam to demonstrate the versatility of the new material

The stuff that foams are made of

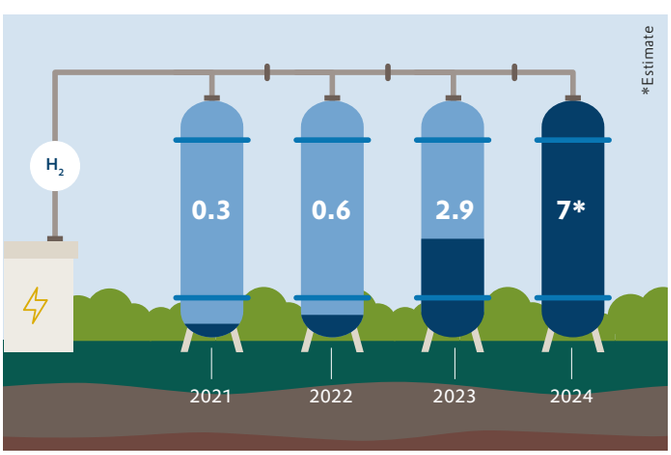
Landfills are a thing of the past: US researchers are developing a recyclable foam alternative

Conventional foams usually consist of thermosetting materials that are chemically hardened during production. Although this means they retain their shape permanently, until now they could not be melted down or recycled. Researchers at the University of Texas at Dallas wanted to develop a material that is both robust in use and recyclable. The solution: a new type of foam based on dynamic covalent chemistry. This creates chemical bonds between the molecules. These bonds can be broken again under certain conditions. The new material is recyclable and can even repair itself. Complex geometries can also be created from the foam by means of 3D printing—ideal for applications such as shock absorbers, insulation or protective clothing. Even if the material cannot be completely reshaped, its structure makes it much more durable and sustainable than conventional materials. The aim of the continuing research is to make the foam even easier to recycle and to use it in larger workpieces.

THAT'S BETTER

Turn on the hydrogen

Newly installed electrolysis capacity, in billions of US dollars



Hydrogen plays a central role in the energy transition for industry, mobility, and electricity storage. As a result, so does electrolysis, which enables the production of the gas from renewable sources. Between 2021 and 2024, global investment in electrolyzers increased 22-fold. This underlines the growing political and industrial will to make hydrogen technologies ready for the market.

Source: IEA

11

GRAMS

is the weight of the heaviest piece of chicken meat grown in a laboratory to date. A Japanese research team took living cells from animals and used them to cultivate muscle tissue around a network of semi-permeable hollow fibers. A newly developed circulatory system supplied the growing tissue with nutrients and oxygen. The technology could help to produce meat more sustainably in the future and also find new solutions for regenerative medicine.

INTUMESCENCE...

...describes the increase in volume of a solid without chemical transformation. A research team at Northeast Forestry University in China is using this effect in a new type of fire protection coating for wood. It is based on a modified amino resin that has been further reacted with tannic and phytic acids to form a resin containing nitrogen and phosphorus (PTP). The team added silicon dioxide and applied layers of the solution to wood. In the event of fire, it expands to form a foam-like ceramic layer that protects the wood. This significantly reduces heat, smoke development and CO release—a plus for sustainable building concepts.

PEOPLE & VISIONS

"My concept is based on paper fibers that are biodegradable and recyclable"

THE PERSON

Even as a child, Franziska Kerber was driven by curiosity—a trait she shares with her father, who is a physicist and inventor. Having grown up in Tyrol, she moved to Graz to study industrial design, where she mainly focused on sustainable materials. She is particularly interested in the interface between design, technology, and the environment. "Design goes beyond aesthetics—it can initiate new ways of thinking and create sustainable alternatives," she says. Kerber was nominated for the European Patent Office's Young Inventors Prize in 2025 for her final thesis "PAPE".

THE VISION

During her studies, the researcher Franziska Kerber focused primarily on sustainable electronics. She noticed that sustainability often ends with the plastic housings of the appliances. This gave rise to PAPE, an alternative concept for the covers of WLAN routers or smoke detectors, for example: "It is based on pressed paper fibers that are biodegradable, recyclable and at the same time functionally stable," she explains. A return system is intended to close the material cycle. Kerber's aim is to further develop PAPE and bring it into real-life applications so that it can also assume social responsibility.

Don't burn, recycle

Viennese scientists use a quantum light source for sustainable gas production from biomass

Used correctly, waste is a valuable source of energy and raw materials. The controlled utilization of biomass, for example, produces both usable heat and producer gas that can be further processed into basic chemicals such as hydrogen, methane or methanol. Precise monitoring of the process is a prerequisite. Researchers at TU Wien have developed a process for producing gas from biomass in a more efficient and environmentally friendly way. The centerpiece is a quantum cascade laser that emits terahertz radiation. This allows the water vapor content in the resulting gases to be measured precisely—an important factor, as the water content influences the quality and composition of the producer gas. Conventional methods reach their limits here. Terahertz technology, on the other hand, allows the selective detection of water molecules and thus delivers more reliable results.

GOOD QUESTION

Will the battery of the future be elastic?

Yes. Soft batteries have potential in soft robotics, i.e. for the development and application of robots made of compliant structures, in medical technology and the Internet of Things. Unlike conventional batteries, they can be integrated into any shape. We have developed "redox-active electrofluid materials" as electrodes. These decouple the mechanical from the electrochemical properties and thus enable a higher capacity—regardless of the rigidity of the battery. Previous designs were based on rubber-like binders, but their increased stiffness slowed down capacity expansion. Our approach is based on sustainable, organic materials such as polymers and lignin. The result is a cost-effective, environmentally friendly solution for scalable and adaptable energy storage systems of the future.

Saeed Mardi is a postdoctoral researcher at the Department of Chemistry, Ångström Laboratory, Uppsala University, Sweden.

ENGINEERING THE PERFECT MIX

For a product to develop its optimum effect at the point of use, many skill sets are required—from material and process selection to shelf life and customer applicability. Process tchnology plays an important role here

TEXT **MICHAEL PRELLBERG**

The star of process technology: the spray dryer. Here, experts remove so much water from the formulation that the microorganisms are made dormant and remain viable for longer

For more than 100 years, nitrogen fertilizer on fields has ensured high crop yields. However, an oversupply can acidify the soil and displace important microorganisms. In the water, eutrophication leads to the growth of algae and ultimately to oxygen deficiency. It also increases the nitrous oxide content in the atmosphere, which exacerbates climate change.

To protect the environment, modern agriculture is therefore increasingly relying on microorganisms—for example by using nodule bacteria, known by experts as rhizobia. These rhizobia draw nitrogen from the air, convert it, and pass it on to plants. →

Microorganisms are tomorrow's superforce: They protect plants or allow them to grow, are good for the gut or the skin, and some even ward off their harmful counterparts or other pathogens. They are even used in technical applications such as "self-healing" concrete.

However, biologically active ingredients are often very sensitive. They must be processed into products that can survive storage, reach their point of use undamaged, and develop their full effect there. Experts call this further processing, in which components are mixed, formulation. This requires many steps, in which experts from Evonik's Process Technology (VT) department, such as Max Braun, play a decisive role. They look for the right auxiliary agents and process steps for the perfect formulation: "Nowadays, it's no longer enough to simply throw a finished material over the fence to the customer. We need complex solutions that are tailored to the customer and can be handled easily and well," explains process engineer Braun, who is responsible for bioformulation topics at Process Technology. "Our competence platform brings together various specialist disciplines for the best formulation of biologically active ingredients."

An example of how this collaboration works can be seen in the special rhizobia developed in the Agriculture Solutions program of Creavis, Evonik's strategic research unit and business incubator. These rhizobia are biostimulants that improve the growth, resistance, and quality of plants and soil in a natural way.

POOLED EXPERTISE

However, their use is not trivial. Rhizobia, for example, are picky about who they supply with nitrogen. Peas, soybeans, and broad beans are among the plants that have benefited from rhizobia since time immemorial. How- →

MICROORGANISMS AS A SUPERFORCE

Biological active ingredients promote the well-being of humans, animals, and plants.
Evonik uses bacteria, viruses or fungi in various bioactive substances or their formulation

ANIMAL

- Evonik is researching microorganisms that prevent pathogens from colonizing chicken intestines and help to reduce the use of antibiotics.
- Under the name ECOBIOL®, Evonik has developed products based on the bacterium *Bacillus amyloliquefaciens* , which are added to chicken feed and enable a balanced intestinal microbiome. One new product is an effervescent tablet that can be added to drinking water during periods of stress.

PLANT

- The microbiome is important for health and yield. For example, bacteria can eliminate pathogens and thus reduce the use of crop protection agents.
- Biostimulants help with the supply of nutrients, among other things. For example, bacteria in the leaf fix nitrogen from the air and thus improve growth and yield. Evonik products help plants that are not naturally able to benefit from this. They also help plants to cope better with abiotic stress such as drought and cold.
- In nature, pheromones ensure that female and male insects find each other. Evonik is developing solutions that release these attractants in a targeted manner and thus prevent mating.
- Among other things, dsRNA products can affect a specific pest. Other insects remain unaffected. Evonik is working on solutions to formulate the sensitive dsRNA molecules for use in the field.·
- Biofungicides based on bacteria or fungi combat harmful fungi on leaves. Evonik's formulation expertise helps customers make their biofungicides more effective and longer lasting.

HUMAN

- Probiotic bacteria assist the intestinal microbiome. The products in Evonik's IN VIVO BIOTICS® portfolio use microorganisms to promote metabolites that support health or to break down undesirable food ingredients. They are used, for example, to accompany treatment of gluten intolerance or chronic inflammation.
- The skin microbiome supports the epidermal barrier and plays a role in the skin's aging process. Evonik uses lactic acid bacteria for its BEAUTIFERM® Resurf products, which promote the multiplication and diversity of beneficial skin bacteria.

Tomorrow's superforce: Bacteria of the genus ***Rhizobium***, which can supply plants with nitrogen, are isolated and propagated at the Biotech Hub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Jasmin Reiner pours additives into the dispersion

During spray drying in the laboratory (top) and dispersion (left), the engineers adjust parameters such as temperature and the composition of particles and auxiliary agents until they reach the optimum

“We need physical and biological stability at the same time”

JASMIN REINER,
PROCESS ENGINEER AT EVONIK

ever, the most important crops—cereals, canola, beet, and potatoes—do not interact with them. Evonik scientists are working to change that. There are already promising results for potatoes, corn, and wheat. “Our advantage is that we benefit from the concentrated know-how in microbiology, agricultural science, chemical formulation, and process technology,” says Ines Ochrombel, Program Manager at Creavis.

Microbiological knowledge is required to convert the bacteria into a storable and usable form. A suitable formulation is needed to keep the bacteria alive until they are used in the field. Comprehensive material and process knowledge is required as well: How are the tiny creatures stabilized, how are they made storable and ready for use? “Biostimulants are a good example of how new products and markets are created when people from different specialist areas work together,” says process engineer Braun.

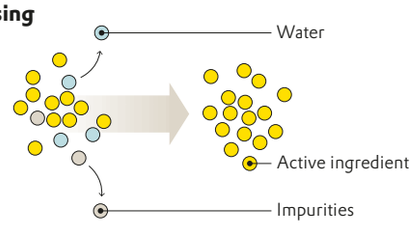
CULTIVATE FIRST, THEN HARVEST

Work begins at the Evonik Biotech Hub’s largest site in Halle-Künsebeck, not far from Bielefeld. Rhizobia, which can extract nitrogen from the air for cereals and potatoes, are isolated and characterized here. The microorganisms are then cooled before being sent to colleagues at the Biotech Hub in Hanau. There, they are cultivated in bioreactors—usually steel vats. “To ensure that this works optimally, we change the pH, the oxygen supply or the feed rate—the speed of the sugar supply—in order to achieve the best possible growth,” says Philipp Glembin, who is responsible for the Biotech Hub’s laboratory team. →

BIOFORMULATION

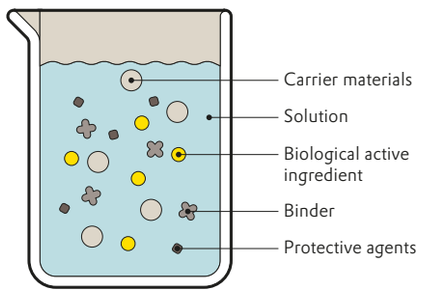
1 Downstream processing

The biological active ingredient is concentrated and, if necessary, purified to ensure the required concentration in the end product.



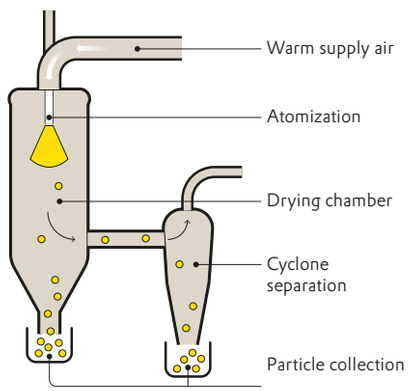
2 Formulation

The selection, quantity, and concentration of materials is crucial for developing stable and effective products. Carrier materials facilitate processability; the right excipients such as binders and protective substances keep the active ingredients stable.



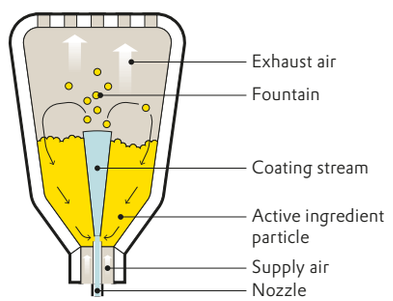
3 Spray drying

Spray drying is a key technology in bioformulation. It removes water from the formulation and puts microorganisms into a dormant state. The process enables the production of storable powders with specifically adjustable particle properties.



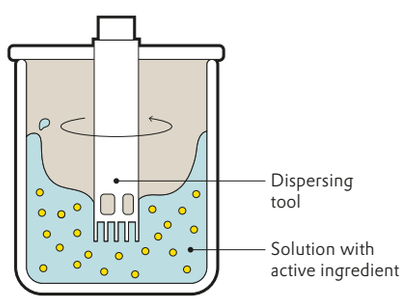
4 Coating

A coating increases the stability of the biological active ingredients by protecting them from environmental influences such as light, moisture and oxygen, improves solubility or controls the targeted release of the active ingredients.



5 Dispersion

Dispersion ensures an even distribution of particles in liquids through targeted energy input—crucial for stability, effectiveness, and optimized product properties.



Once fermentation is complete, the microorganisms are centrifuged and thus concentrated. Bioprocess engineers refer to this as harvesting the bacteria grown in the bioreactor. The milky soup they obtain is far from ready for use by the customer; the actual product still requires formulation. To determine the formulation, the soup first has to go to Process Technology.

"With formulation, just like with a cake, everything depends on the right ingredients, the perfect quantity, and the concentration," says Jasmin Reiner, a process engineer who specializes in bioformulation. The experts at Process Technology look for the right auxiliary agents and technologies for the perfect mix. "We need physical and biological stability at the same time."

Putting the rhizobia into temperature-independent dormancy is crucial task for the specialists. This is necessary in order to keep the microorganisms viable for longer and thus permanently preserve the product at room temperature.

To do this, they remove the moisture from the milky white liquid. A common technique for this is spray drying, in which a solution is atomized into fine droplets and then dried by a stream of hot air to produce a powder. However, it's all about nuances. If too little water is removed, the bacteria continue to metabolize and die due to a lack of nutrients—long before they are used in the field. However, the powder should not be too dry. "If we remove all the water, the cultures die too," says Reiner. "We have to find just the right balance so that the cultures live but are dormant."

NOTHING WORKS WITHOUT ADDITIVES

The experts at Evonik also consider many other customer requirements. If biostimulants are used in agriculture, for example, it is important that they can be mixed with water and sprayed on the field without clogging the nozzles of the agricultural machinery. They must also be compatible with the crop protection products that a farmer is already using. "We can't expect someone to drive across the field twice or even buy new machinery just to use our biostimulants," says Stefan Gilch, Project Manager for Agricultural Solutions at Creavis. "So we have to align ourselves with the end customers' equipment."

To meet these requirements, the process engineers add a silicate carrier material—SIPERNAT® specialty silica—to the rhizobia solution that is fed into the spray dryer. With its help and the various spray drying settings, the process engineers can influence both the size and the properties of the particles in the powder, which end up small and round so that the nozzles of the sprayers do not clog.

To ensure that the rhizobia are not damaged during storage and on the way to the field, they are also coated with a special sugar during spray drying. This coating

protects the microorganisms from environmental influences such as light, moisture, and oxygen, thus increasing their stability. As soon as a farmer mixes the finished formulation with water, he wakes up the microorganisms and the sugar coating dissolves at the same time. The sugar can then serve as food for the microorganisms. "We copied this from nature," explains Braun.

But the process isn't finished yet. Before the biostimulants are ready for use, they have to undergo a further process engineering step: dispersion. The particles from the spray drying process are mixed with a special anhydrous liquid consisting of various Evonik additives. "We draw on the broad expertise and existing products from our businesses," says Reiner. Products from the Break-Thru portfolio are used as biodegradable carrier liquids and as dispersing additives for the finest possible distribution. In addition, AEROSIL® fumed silica ensures that the particles are kept in suspension and do not settle on the bottom of the container.

A BREAK-THRU® product also performs another important task as an adjuvant: It ensures that the microorganisms arrive at their site of action and remain →

"We benefit from the concentrated know-how in microbiology, agricultural science, chemical formulation, and process engineering"

INES OCHROMBEL, PROGRAM MANAGER AT CREAVIS

Quality control: Max Braun uses in-house analysis to check whether the particles have the desired size and composition

Experts for sensitive microorganisms: Process engineers Jasmin Reiner and Max Braun combine interdisciplinary work, broad expertise, and process technology in bioformulation

“Our competence platform brings together various specialist disciplines for the best formulation of biologically active ingredients”

MAX BRAUN, PROCESS ENGINEER AT EVONIK

there, even when it rains. “If we simply sprayed the biostimulants onto a plant, the drops would remain on the top of the leaves or be washed off by the rain,” explains project manager Gilch. The effect would be zero. Thanks to the adjuvant, the biostimulants spread out over a large area of the leaf and also spread to its underside, where they reach the inside of the leaf through tiny respiratory openings (stomata). There they are protected from wind and weather and supply the plant with nitrogen from the air.

FINDING THE SWEET SPOT

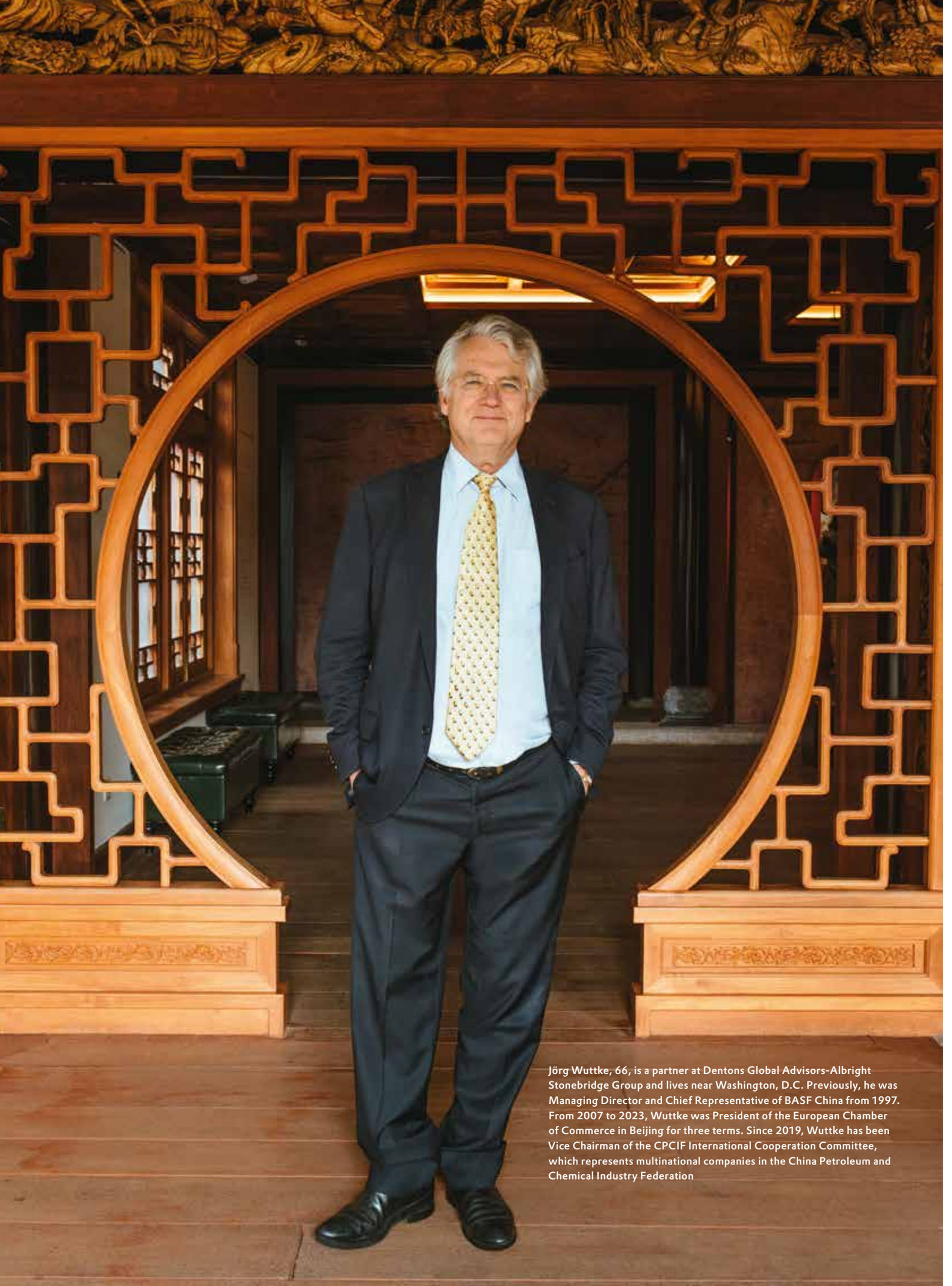
All these processes and requirements are taken into account at Process Technology. “We know that we need staying power,” says Reiner. Figuring out the right combination of microorganisms, materials, and stabilizers for each customer’s requirements is the real challenge. Individual parameters such as temperature, pressure or throughput rates are changed step by step. “This is how you make progress,” she adds. Her colleague Braun describes the balancing of drying speed and temperature, auxiliary agents and stabilizers as “finding the sweet spot.” Still, the process technology experts do not start from scratch every time. “We have the experience to choose the best solution from the many options available,” says Braun. “The rest is fine-tuning.”

However, this fine-tuning is what counts. After all, farmers expect the microorganisms they want to supply their crops with nitrogen to still be effective even after months of storage. Creavis has mastered this challenge in cooperation with Evonik’s Process Technology department. Test results show that the effectiveness of rhizobia is just as high after two years in storage at room temperature as it is after two weeks.

Farmers aren’t Evonik’s direct customers. “We work together with companies such as Agravis and Helm from the agriculture and chemical sectors,” says project manager Gilch. Agravis is conducting field trials to investigate the effect of various biostimulants on potatoes and, in cooperation with Helm, on wheat and corn. The effect is substantial. In field trials last year, potato yields were increased by an average of 28 percent. The increase is lower for wheat and corn. “We haven’t found the best way yet,” says Stefan Gilch. He is currently using different fields to test whether it is better to apply the biostimulants once or twice. And at what stage of plant growth?

The first biostimulants that can be used stably by farmers thanks to Evonik technology and materials will be launched on the market in 2027. “We are already preparing everything for this launch,” says Creavis program manager Ines Ochrombel. “Our innovation has the potential to become a building block in the agriculture of the future.”

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



Jörg Wuttke, 66, is a partner at Dentons Global Advisors-Albright Stonebridge Group and lives near Washington, D.C. Previously, he was Managing Director and Chief Representative of BASF China from 1997. From 2007 to 2023, Wuttke was President of the European Chamber of Commerce in Beijing for three terms. Since 2019, Wuttke has been Vice Chairman of the CPCIF International Cooperation Committee, which represents multinational companies in the China Petroleum and Chemical Industry Federation

“Things Don’t Look Bad for Europe”

Compared to Chinese competitors, European companies often find it difficult to bring innovations to market quickly. Jörg Wuttke, long-standing head of the European Chamber of Commerce in Beijing, explains how European companies can catch up—and why Europe can benefit from the discord between China and the USA

INTERVIEW **CHRISTIAN BAULIG** AND **BERND KALTWASSER**

Mr. Wuttke, you are European, have spent more than 30 years in China, and have been living in the United States for a year now. In your opinion, which region is currently decisive for global innovation?
China plays a big role here. Customers there are extremely demanding and always want the latest products straight away. Take mobility, for example: In Germany we make cars, in China they make cell phones on wheels. Adjusting to this is putting incredible pressure on the entire supply chain—including the chemical industry, for which China accounts for around half of the global market.

How does China manage to produce this amount of innovation?
It does this by producing talent like no other country. You have a huge pool of people there who drive developments forward and a large number of top universities for engineering and chemistry. At the same time, the government in Beijing is promoting strategically important industries on a grand scale: electric vehicles, wind turbines, batteries, solar, and so on. There is money and a clear commitment to make certain sectors the best in the world. In Europe, especially in Germany, we have too much “on and off”—such as with the Building Energy Act—which makes planned innovations difficult.

In many sectors, from solar energy to battery technology, Chinese companies have left Europe behind—even though the underlying inventions were not even made there. Why did that happen?
The razor-sharp competition in the Chinese economy means that companies there rarely conduct basic research. They are more interested in developing a product from an existing idea. The Chinese are superb at bringing technologies to market faster, better, and cheaper than their inventors. They didn’t invent the battery, the Koreans and Japanese did. But they have understood best how to further develop and market the product to meet the needs of users.

In other words, precisely what European companies sometimes find difficult.
Exactly. European companies that are active in China have an easier time of it. The country resembles a fitness center. The people in the laboratories of European companies in Shanghai, Chengdu or Nanjing know that they have to be fast to keep up with their local competitors. At the same time, the customers’ willingness to take risks is transferred to the developers. You don’t always need a solution with a belt *and* suspenders to keep your pants from slipping. You have to put a development on the market now and then. →

“The formula for success for a sustainable econ-omy is ‘brain meets money meets market’”

JÖRG WUTTKE

However, Beijing is increasingly regulating access to this fitness center. Imports from Europe to China are falling—as is direct investment. How will this affect the innovation process?
The figures are actually going down—at least when it comes to products from the “sunset industry,” such as cars with combustion engines. At the same time, the country is striving for greater self-sufficiency, for example in medicine. These efforts are a huge challenge. Foreign companies working in China for China can continue to benefit from the clusters in the country. It is important that they also apply the knowledge they gain there elsewhere. The compartmental thinking in some companies is still very rigid.

Despite all our admiration for the Chinese spirit of innovation, an autocratic system that can control many things also leads to problems.
Yes. Corruption, nepotism, and financial waste are the order of the day. Out of 140 car brands in China, no more than 20 make a profit. Although a lot of money is put into the system, in the end only a few champions emerge. But they have it all, just think of the AI company DeepSeek.

What can pluralistic systems learn from the Chinese?
We don’t have a government in Europe that pushes the battery market by creating the necessary demand itself, for example. We tend to do this via regulations. That costs speed. However, we have already succeeded once in providing the money for a product that is now a global market leader thanks to a clever industrial policy.

Are you talking about the aerospace group Airbus?
That’s right. The state should stay out of market-based mechanisms and generally tend to deregulate. But sometimes the complexity and risk are so great that the state has to provide support.

Is there any other sector that you think has such strategic importance?
The arms industry is an example. Developments in this field could enable European companies to move into high-tech areas that also have an impact on other sectors of the economy, such as the development of drones for civilian use or high-performance alloys. Similar to the US space agency NASA, whose developments also gave rise to products such as Teflon and the Internet. Biotechnology is another field that Europe can occupy. We are already really good there and the Chinese are comparatively weak.

In 2024, former ECB President Mario Draghi was commissioned by the European Commission to investigate why Europe is falling behind when it comes to innovation. In his report, he proposes, among other things, increasing government spending on research by 200 billion euros. Would that help?
The formula for success is “brain meets money meets market.” We need the right people to drive innovation. Our education system needs to generate more enthusiasm for science—especially in Germany. That starts in kindergarten. Second is digitalization. I took my children out of the German school in Beijing in 2020, where there was still a strong emphasis on books and paper. They switched to the American school, where everything took place on tablets and the students even built robots. That’s another reason why we moved to America in 2024, not Germany. It is of course ironic that the new US president is now so vehemently opposed to an open society and is trampling on science. I’m becoming more and more Chinese here.

It will be many years before chemistry sets in nurseries and tablets in schools have an impact. We probably don’t have that much time.
Correct. That’s why we should now bring in top people from abroad. Europe has a good opportunity for this right now: on the one hand because of the over-politicized landscape in China, and on the other because of the tensions between Beijing and Washington. Things don’t look bad for Europe.

How can Europe's economy become fit for the future? Former ECB chief Mario Draghi investigated this question on behalf of EU Commission President Ursula von der Leyen

How can we attract these people to Europe?
We have to show that we are attractive to highly qualified specialists. Governments must follow suit and reduce regulations for foreign workers. Of course, we have to make sure that we don't invite anyone who will just siphon off knowledge. We could very easily identify people we would like to bring here via European companies in China. This is another reason why we should not withdraw from this market, even if it becomes smaller.

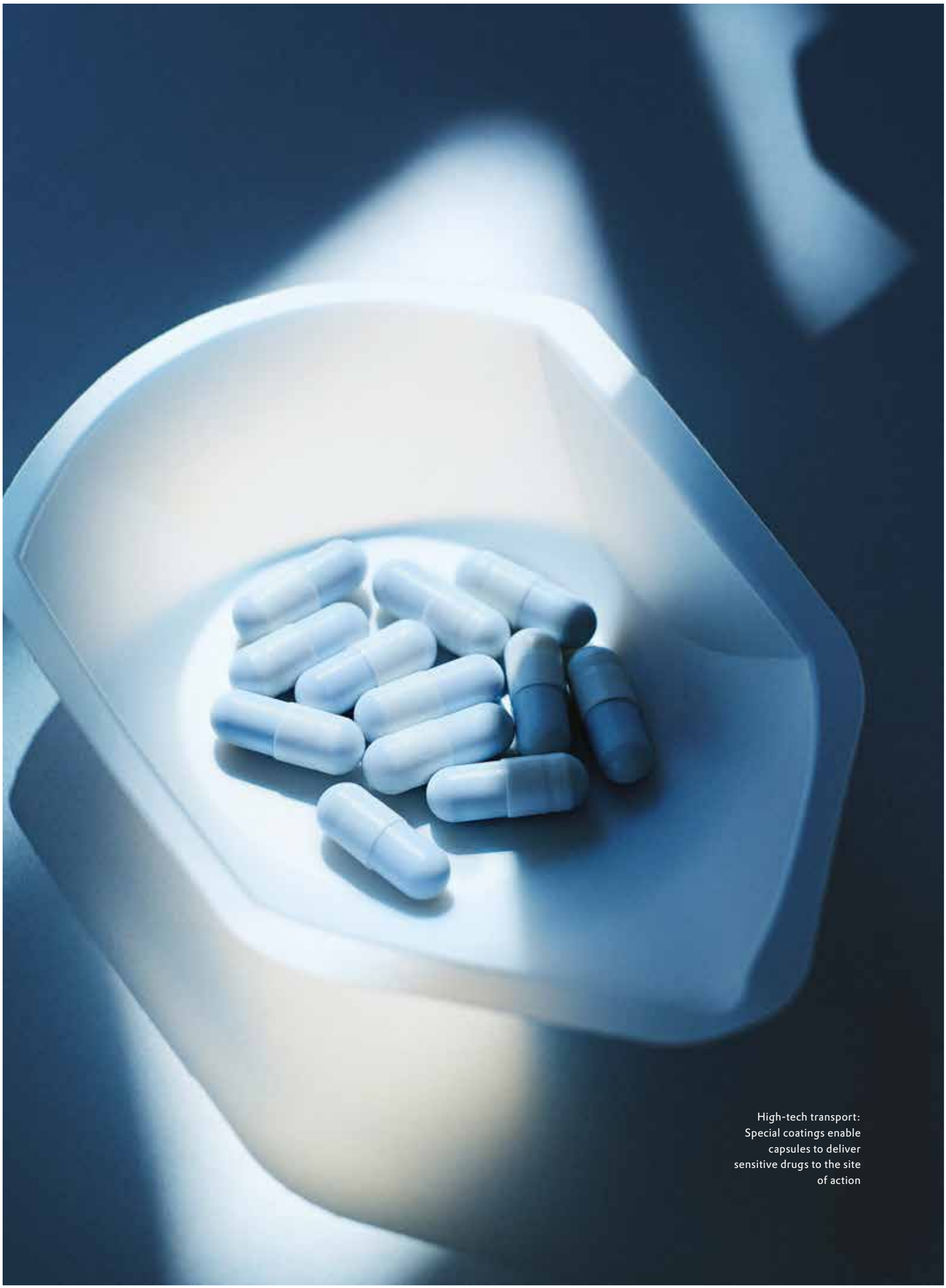
How do we mobilize more venture capital? Without venture capital, Silicon Valley would not exist. And in China, 80 percent of research funding comes from the private sector.
The willingness of investors to take risks will be of enormous importance in the coming years in order to fund research and development expenditure and reduce the gap with China. Many venture capitalists I dealt with in Beijing are leaving the country because of the growing uncertainty in the economy. They go to Tokyo, Abu Dhabi or Singapore. I couldn't get anyone interested in Germany. This is due to the language. But people are also noticing that parties like the AfD are gaining support—and are drawing their own conclusions.

So we have to make it on our own?
Most importantly, we need to overcome the fragmentation of the European venture capital market. There is no uniform legal framework, which hinders investments and fundraising across borders.

We have talked a lot about what Europe can learn from China. Can you give us any lessons from your new home in America?
America's great strength has always been the capital market: Wall Street and the venture capital system. This is how people were supported who set up "unicorns" in their garages. It's worth taking a look at this. In addition, the USA has long been able to attract the best minds in the world. It is difficult to understand why this is currently being prevented—and certainly not something we should take as an example.

Production of lithium-ion batteries in Hai'an: When it comes to high-tech products, Chinese companies are increasingly pulling ahead of the global competition

You have been living abroad since the 1990s. What would have to happen for you to return to Europe?
The mood in the USA has changed completely since the beginning of the year. My colleagues are increasingly asking themselves: What can I post? What will be viewed critically? My wife has a Russian passport. And although she has a valid visa, we hope that she will be able to return without any problems after our vacation in Germany. First of all, our youngest son has to finish school here. We'll see what happens afterwards.



High-tech transport:
Special coatings enable
capsules to deliver
sensitive drugs to the site
of action

FOR THE SENSITIVE

Until now, many modern therapeutics could only be administered by injection, which is less convenient than taking them orally. EUDRACAP® colon is the first capsule that changes this, releasing sensitive contents specifically in the colon, where they are most effective

TEXT **BJÖRN LOHMANN**

The equipment looks like an oversized washing machine: A drum rotates slowly behind the round window in the rectangular housing. It holds 56 liters and spins 30,000 white capsules like those we know from medications. A fine mist spraying from two nozzles is barely visible as it applies a coating to the capsules. It's pretty loud in this room on the ground floor of an Evonik laboratory at the Darmstadt site. That's why chemical laboratory technician Peter Niepoth is standing in the next room and monitoring the process through a pane of glass. As Innovation Project Manager, he is responsible for technical implementation during the development of EUDRACAP® colon—the capsule that's visible next door.

"The sprayed suspension should not form drops that are too large, because then the capsules will stick together. But the drops should not be too small either, because then the spray mist will be dried by the process air before it hits the capsule," says Niepoth, explaining the challenge.

The coating turns a simple cellulose capsule into a high-tech mode of transport that enables completely new treatment methods in medicine. Thanks to EUDRACAP® colon, sensitive biologics such as biotechnologically produced proteins and peptides, RNA therapeutics, and living microorganisms that alter intestinal flora can be reliably delivered through the stomach and released only when they reach the colon, where they are most effective.

Intestinal cancer or intestinal infections and chronic diseases such as ulcerative colitis or Crohn's disease could be treated in this way. Active ingredients for numerous other serious diseases would also be optimally absorbed via the mucous membrane of the large intestine if they could get there—including drugs for Parkinson's, Alzheimer's, diabetes, obesity, and chronic pain. Until now, the lack of oral administration options has meant that patients have usually had to resort to injections, which can be time-consuming and unpleasant.

HUGE MARKET POTENTIAL

EUDRACAP® colon makes it possible to conveniently administer active pharmaceutical ingredients, also known as APIs or actives, against all these diseases in the form of capsules. More than 750 drug candidates for oral application in the areas of the microbiome, oligonucleotides, and biologics are currently in clinical development. →

Peter Niepoth, Innovation Project Manager for Eudracap colon, prepares the suspension for coating the capsules (left) and controls the coating process

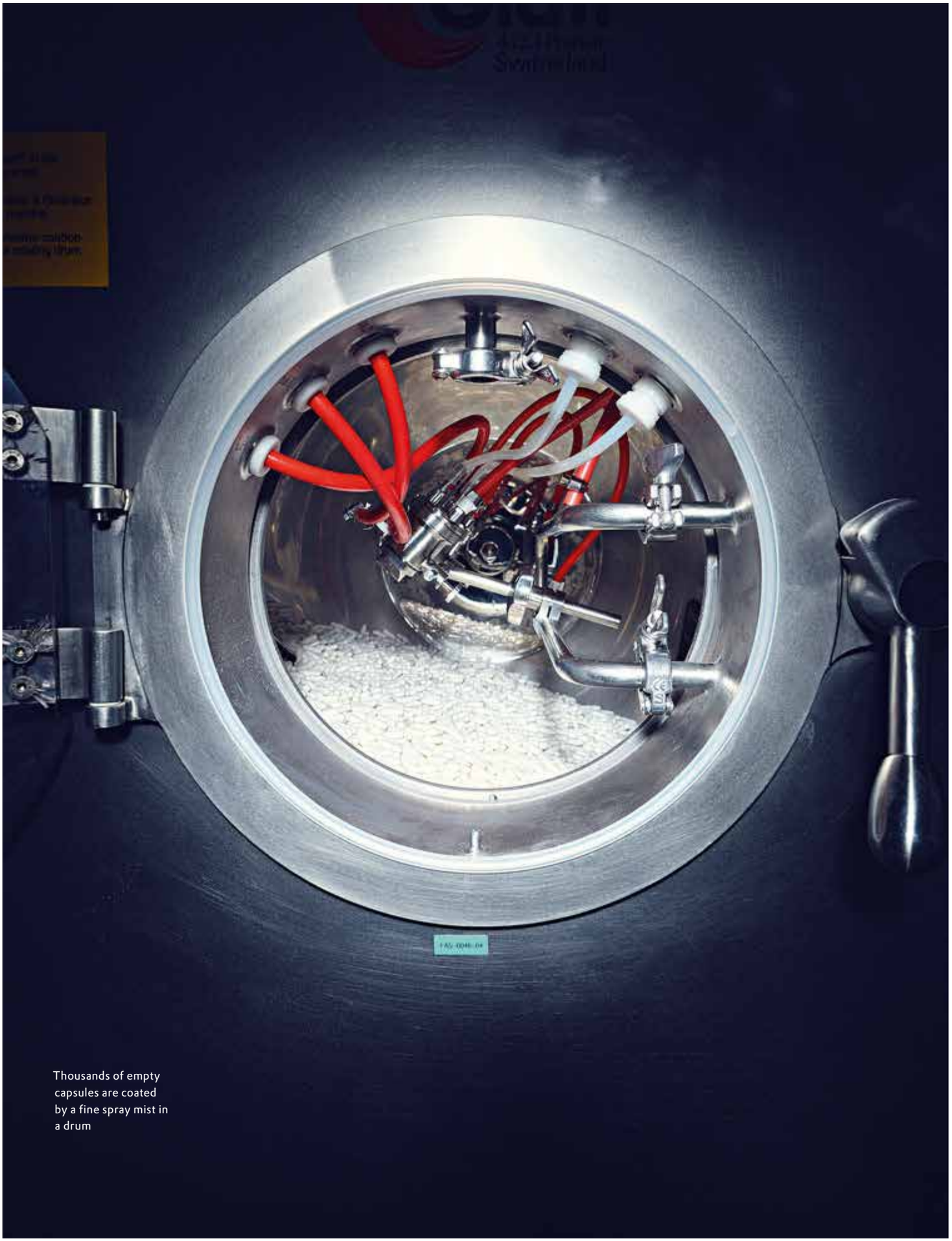
Product Manager Dr. Bettina Hölzer describes the timing of the development of EUDRACAP® colon as a "stroke of luck". "When we evaluated the market potential for such a capsule a few years ago, it was clear that there was a need for this product," she recalls. But a lot has happened during its development, and the size of this market is now much bigger than we expected."

The covid-19 vaccination, for example, drew unexpected attention to RNA technology. Since then, the development of RNA active ingredients has been booming. Until now, these have almost always had to be injected. Research into the intestinal microbiome and bacterial strains as a therapeutic approach has also increased significantly. It opens up treatment options that no one would have thought possible ten years ago. In addition, the pharmaceutical industry has great interest in oral biologics such as GLP-1 receptor agonists, which among other things help to regulate blood sugar levels and gastric emptying. Most recently, the injectable weight loss drug Wegovy has even made such peptide active ingredients popular in the lifestyle sector.

EUDRACAP® colon builds on 70 years of success: That's how long pharmaceutical manufacturers in particular have been using the functional polymer EUDRAGIT® from Evonik as a coating to pass tablets, pellets, particles or capsules made of gelatine or hydroxypropyl methylcellulose (HPMC) through the stomach. If left uncoated, these dosage forms would be broken down by gastric acid and enzymes and release the active ingredient too early. However, classic EUDRAGIT® technology is only suitable for actives that can withstand the coating process.

SENSITIVE FREIGHT

This does not include therapies that use bacteria to change the gut microbiome. The microorganisms cannot be compressed into tablets because the pressure, humidity, and heat would kill them. "The classic alternative would be to fill and coat an HPMC capsule so that it passes safely through the stomach," says Hölzer. However, the bacteria cannot survive the heat and mechanical stress associated with a coating process either. The situation is similar for peptides and RNA, which must be protected from digestive enzymes in the stomach. However, just like bacteria, peptides and RNA often do not withstand the coating process. That's why a solution that protects the active ingredient and safely transports it into the large intestine had to be found. →



Thousands of empty capsules are coated by a fine spray mist in a drum

Chemistry lab technician Jessica Huppertz carries out the disintegration test with placebo-filled capsules

"The obvious idea was to functionalize a pre-locked HPMC capsule with EUDRAGIT®," recalls Hölzer. "The manufacturer of the active ingredient could then open the capsule, fill it with its active ingredient, and, finally, close it again." However, this sounds easier than it actually is. If the empty capsule were to open during the coating process, there would be a risk that it would deform and the halves would no longer fit together. However, if the capsule was completely coated, it could no longer be opened easily to fill it. And if the coating had an interruption in the area of the gap, the protection against stomach acid and enzymes would not work reliably.

"Initially, my biggest concern was whether our idea could be implemented on a commercial scale," says Hölzer. But this concern proved to be unfounded: A pre-locked capsule falling apart during the coating process remains the exception thanks to technical countermeasures. Thanks to its many years of experience with coating processes, the team was also able to master the challenge of ensuring a seamless coating after the final closing of the capsule. The most important part of the solution was to spray the suspension homogeneously in exactly the right thickness: thin enough that the capsule can be opened and closed again easily; thick enough that the layer in the gap compresses when closed and seals it without gaps. The team was in for a pleasant surprise: Upscaling, i.e. increasing the number of units, made the coating for EUDRACAP® colon even more homogeneous.

LOWER COSTS, FASTER PACE

For pharmaceutical companies, the pre-coated and pre-locked capsule has advantages in both the development and manufacturing process. "The capsules are functionalized containers. This means that a complex formulation no longer needs to be developed to transport the active ingredient through the digestive tract," says Hölzer. "This reduces development and production costs and shortens the time to market for the new drug." In addi-

Dyes reveal how a coated capsule dissolves under certain pH conditions

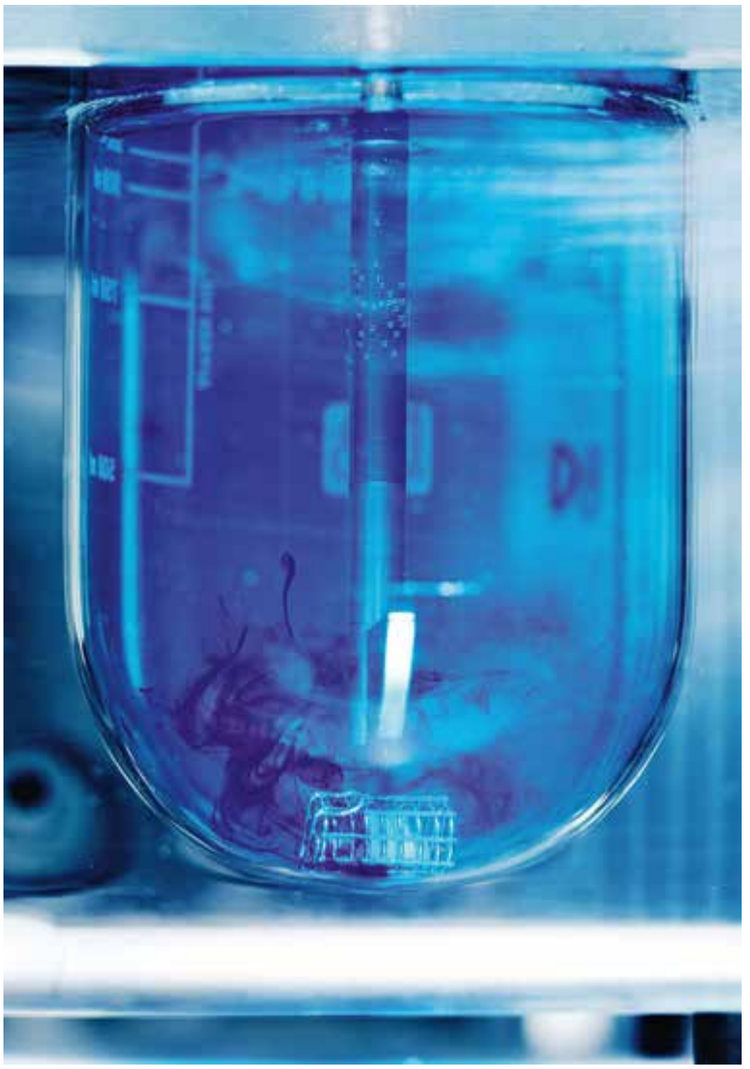
> **“The size of the market for functionalized capsules exceeds our expectations”**
>
> BETTINA HÖLZER, PRODUCT MANAGER EUDRACAP

tion, the pre-coated EUDRACAP® capsules can be filled in the pharmaceutical companies’ factories using the existing machines that are also used for other capsules. As the filled capsule no longer needs to be coated, customers can eliminate an entire additional process step.

The project team had thus solved one of the two major problems. The second challenge was to ensure that the active ingredient was really only released in the large intestine. This is because acids and enzymes in the preceding regions of the digestive tract break down most of the active ingredients before they can be absorbed. In addition, only the large intestine offers the possibility of absorbing active ingredients evenly over a longer period of time.

Basically, the capsule is functionalized with a special polymer mix so that it only dissolves above a certain pH. This is because the pH normally rises steadily from the stomach, where it is between 1 and 5, depending on the level of saturation due to the digestive juices. In healthy people, the pH in the small intestine is around pH 5.5 and only in the large intestine does the pH exceed 7.0.

“However, the pH in the intestine is often somewhat lower in patients with intestinal diseases,” explains Hölzer. The team therefore had to take another factor into account: the mechanical pressure loads in the digestive tract. Laboratory tests that simulate both the pH curve and mechanical stress helped to develop a solution that ensures the release of the active ingredient in the large intestine. Peptides and RNA are optimally absorbed there and microorganisms find the ideal place to colonize. →



In the release test, an optical sensor measures how much content passes from the capsule into the solution (right)

Chemical laboratory technicians Kirsten Korzer (left) and Fatou Diop supervise the dissolution test in the Darmstadt laboratory

"But are we hitting the exact point we want to reach?" asks Niepoth. To ensure this, the team analyzed the release of the active ingredients on two similar devices. The first device, a disintegration tester, is located on the ground floor of the Darmstadt laboratory. Several transparent vessels are lowered into a water tank. Inside the vessels are tubes, each containing a capsule. A small weight on the capsule, known as a disc, acts as a sensor. An arm that moves up and down keeps the capsule and liquid in motion, simulating transportation in the digestive tract.

"We set different pH values in the vessels as well as a temperature that corresponds to that of the human body," explains Niepoth. At pH 1.0, the capsule should not disintegrate even after two hours. And the entire filling should only be released in no more than one hour when pH 7.2 is reached. When this happens, the capsule first softens and then disintegrates. The sensor sinks to the ground and triggers a signal: Once the capsule has completely disintegrated, timing is stopped.

ON THE PATH TO APPLICATION

One floor up, a dissolution tester with an optical sensor measures how much of the content has already been released into the solution. "Initially, we used both devices to develop the right coating," explains Niepoth. Now that development is complete, this floor is used to carry out quality control. The capsules are filled manually, either in a single holder with a funnel or using a board that can process 30 to 50 capsules at a time. In commercial production, this step is automated: A small production machine needs less than an hour to produce several tens of thousands of capsules.

EUDRACAP® colon has been available for animal studies and laboratory tests since September 2024 and should also be available as an IPEC-GMP-certified product by the end of this year—a prerequisite for its use in human medicine. A sister product is already further along: EUDRACAP® enteric has the same properties, but the coating is adjusted so that the capsule releases the active ingredient in the upper small intestine.

Successful together: Innovation Project Manager Peter Niepoth and Product Manager Dr. Bettina Hölzer

"For EUDRACAP® enteric, we have a customer whose therapeutic is already in Phase III clinical development—the last stage before approval. After Phase II, this customer decided to switch to our capsules and achieved better results than with anything else on the market to date," says Hölzer. Another customer reports that thanks to the Evonik capsule, around 90 percent of the filled bacteria survive the passage through the stomach. This figure was significantly lower with the previously used method. Both customers' products are designed to treat infections with *Clostridium difficile*, a bacterium that is resistant to many antibiotics and can cause abdominal pain and diarrhea, which can be fatal in the worst cases. Hölzer is particularly pleased that one customer is based in Europe, while another is in the United States. "This means that the two key regulatory authorities are already familiar with EUDRACAP®," she says.

A third platform is called EUDRACAP® Select. "This enables us to meet customer-specific requirements," explains Hölzer. If, for example, a different pH is required for the dissolution, the polymer mixture can be adjusted. Different capsule sizes are also possible. "In addition, the capsules not only safely transport microorganisms, peptides, and RNA to their targets, they can also be filled with any conceivable active ingredient," reports Hölzer. Now that the technical development of EUDRACAP® colon is finished, the team can turn its attention to new projects. Hölzer says "There are still no satisfactory formulations and dosage forms for many of today's treatments. This is where we come in." —

Björn Lohmann works as a freelance science journalist in Essen. His work focuses on sustainable innovations

Delivery done right

Pre-coated capsules enable extremely sensitive active ingredients to be transported to their target in the small or large intestine via the gastrointestinal tract.

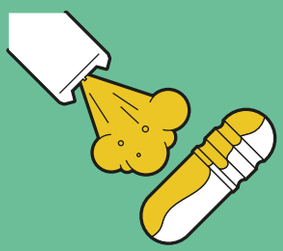
An innovative technology from Evonik makes modern therapies available to patients faster and increases the ease of administration.

INFOGRAPHIC **MAXIMILIAN NERTINGER**

COATING AND FILLING

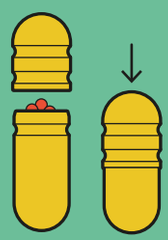
The empty, pre-locked **capsules** are delivered by a supplier.

Evonik or a contract manufacturer applies a **functional coating**.



The capsules are filled with the respective **active ingredient** at the customer's facility.

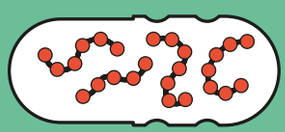
There, the capsules are **closed** and packaged.



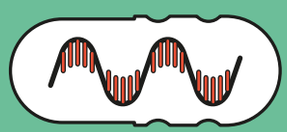
ACTIVE INGREDIENT

Bacteria are an important therapeutic approach to many intestinal disorders.

Medications based on **peptides** can be used for the treatment of cancer, diabetes or multiple sclerosis among other illnesses.



Since the Covid-19 pandemic, **RNA** therapies have presented a new treatment option.



Other active ingredient classes also contain sensitive molecules that require packaging.

COATINGS

EUDRACAP® enteric
transports active substances to the small intestine.

EUDRACAP® colon
releases active ingredients at the beginning of the large intestine.

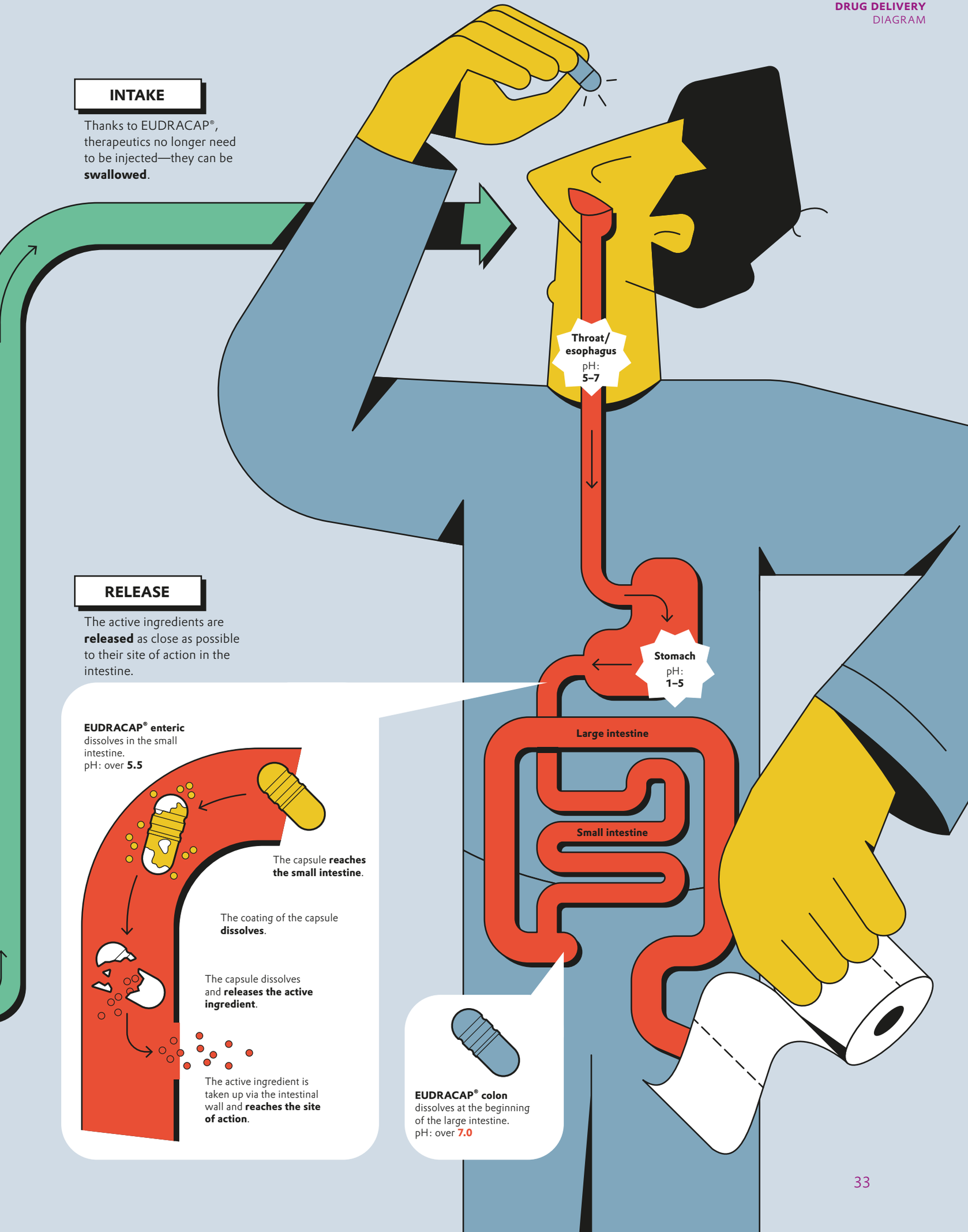
EUDRACAP® Select
offers customized functionalities.

INTAKE

Thanks to EUDRACAP®, therapeutics no longer need to be injected—they can be **swallowed**.

RELEASE

The active ingredients are **released** as close as possible to their site of action in the intestine.



EUDRACAP® enteric dissolves in the small intestine.
pH: over **5.5**

The capsule **reaches the small intestine**.

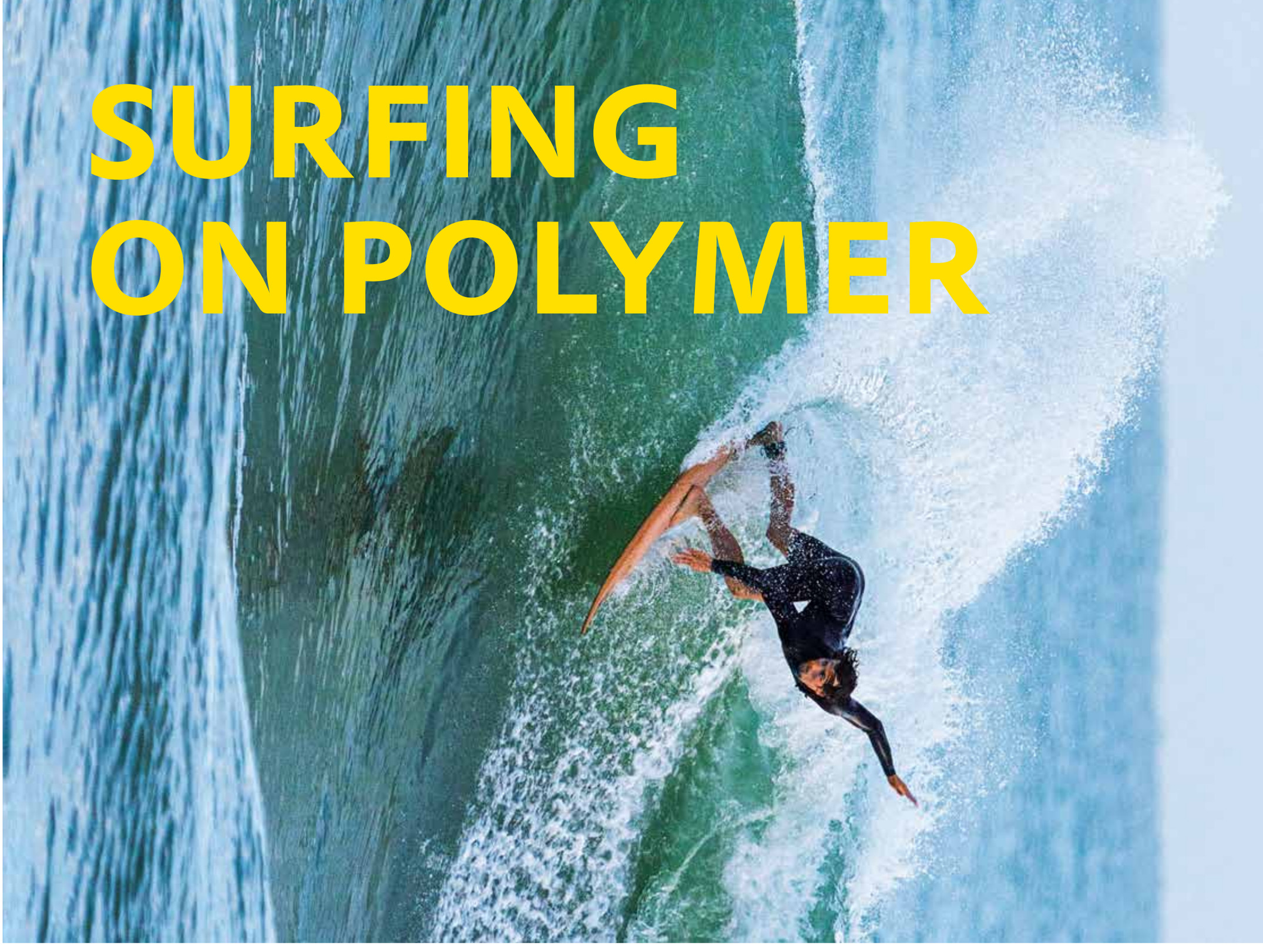
The coating of the capsule **dissolves**.

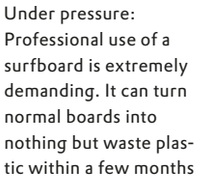
The capsule dissolves and **releases the active ingredient**.

The active ingredient is taken up via the intestinal wall and **reaches the site of action**.

EUDRACAP® colon dissolves at the beginning of the large intestine.
pH: over **7.0**

SURFING ON POLYMER





Under pressure: Professional use of a surfboard is extremely demanding. It can turn normal boards into nothing but waste plastic within a few months

An entrepreneur and passionate surfer is now making surfboards better and more environmentally compatible at the same time, while an additive from Evonik is playing a decisive role in making surfing greener

TEXT **CHRISTOPH BAUER**

The way surfers look at nature is often described as the surfer-environment paradox. On the one hand, many of the athletes are very close to nature: They love clean water and pristine beaches, organize waste collection campaigns, and observe climate change with concern. On the other hand, they also surf in remote corners and often open them up for tourism. The professionals also travel frequently and far to reach the top spots around the world. Most importantly, however, the material from which surfboards are made is a problem. Until now, the boards have been made from a firmly bonded collection of plastics that can hardly be separated and therefore cannot be recycled.

Thilo von Osterhausen wants to change that. With the help of Evonik, the 35-year-old entrepreneur is building boards for a circular economy. Von Osterhausen grew up in the surfing sector. His father founded the Gunsails company in Saarbrücken in 1984, in the early days of the windsurfing boom in Europe. The family-run company still exists today and is the largest German manufacturer of windsurfing products with sales of around five million euros. Thilo first stood on a surfboard at the age of three, and since then any board has meant the world to him. He surfs with and without sails, rides skateboards, and was coach of the German national snowboard team from 2014 to 2016.

3

KILOGRAMS—the approximate weight of a high-performance surfboard. It has to be both light and especially stable at the same time. Comparable polyurethane boards are sometimes twice as heavy.

Early on, he tried to optimize the sports equipment he was using. In the beginning, he was primarily concerned with stability. "When I rode my self-bought surfboard for the first time, it was already dented afterwards," recalls Von Osterhausen. The problem lies in the structure of the board: It consists of a foam core that provides buoyancy. Polyurethane is still mainly used in cores today. Around it, and usually lying smoothly against it, is the skin or laminate. It is made of glass fiber-reinforced plastic, similar to that used in boat building or wind turbine blades.

What lasts a long time for many hobby surfers is quickly degraded in sporting or professional use. "A professional surfer wears out a board within three months," says von Osterhausen, "then it's soft." By then, the core and the laminated skin have separated in many places and the surface is covered in dents. This makes the board unstable and harder to control. It still floats, but in principle it is plastic waste.

In his industrial engineering studies at the Technical University of Munich, von Osterhausen approached the problem scientifically. For his master's thesis, he researched a structure that is light, resilient, and durable at the same time. He found a model in nature, namely the honeycombs of honeybees. His approach is to finish the outside of the core material as a hexagonal honeycomb structure with cells extending into the core. Mats →

A lot of manual work goes into the Kanoa boards. Thilo von Osterhausen works on the perfect edges in the workshop near Biarritz

made of glass or flax fibers are laid on top. This laminate no longer lies flat over the honeycomb, but protrudes into the core like roots and connects the two much more firmly. The technique's name refers to the animals that provided the idea for the construction and its rootedness in the core: Honey Roots Technology, or HRT for short.

Back in 2018, Von Osterhausen received funding for his innovation from Germany's Federal Ministry for Economic Affairs and Energy. With the help of various universities, he continued to tinker with the technology for the perfect board, alongside his work as head of development at the family company Gunsails. He launched the Kanoa brand to market his innovative surfboards. "After graduating, I thought I would have this on the market in one or two years. Now it's become more like eight to nine," says Von Osterhausen. "The innovation process involves an incredible amount of trial and error."

9

YEARS
were needed for Thilo von Osterhausen's product to reach market maturity after the first model. That's because Gunsails took a lot of work and more trial and error was needed than he initially thought.

TESTED INSIDE AND OUT

Right from the start, Von Osterhausen wanted a solution that would be successful on the market: "I focused on innovation theory and also geared my master's thesis towards it," says the board builder today. "The structure should therefore not only be technically feasible, but also economically viable." In addition, the idea of environmental compatibility became increasingly important. This required partners from industry. The entrepreneur met an important one in 2023 at JEC, a leading global trade fair for composites in Paris. Stephan Sprenger, chemist and engineer at Evonik, has been researching fiber composites for many years. He is always interested in new applications in which sustainable technologies can be used.

Sprenger told Von Osterhausen about a proven Evonik product for the new idea: ALBIDUR®, a core-shell elastomer. This consists of an inner core and an outer shell, each of which has different properties. ALBIDUR®'s skin-like shell binds to the surrounding resin. The elastic core absorbs external forces on the mixture and prevents damage or breakage. This turns the brittle material into an extremely resistant one. ALBIDUR® has been used in adhesives and resins for many years, including in wind turbine rotor blades. The additives also make it easier to separate the components by type as soon as the products have reached the end of their life cycle.

Von Osterhausen began experimenting with ALBIDUR®. "That's the good thing about being a small startup," he says today, "you're flexible and can try out new things without any detours, even if it's not necessarily obvious at first." He used the Evonik material, and thus the hexagonal roots, as part of the board's skin. Due the material's white color, these are clearly visible in the transparent resin of the skin and are virtually a trademark of the boards. "On the one hand, this allows us to use a recyclable epoxy resin," explains Stephan Sprenger,

“Before that, we didn’t know that ALBIDUR® dampens vibrations”

STEPHAN SPRENGER, FIBER COMPOSITES EXPERT AT EVONIK

The Honey Roots: A hexagonal pattern, interwoven here and recognizable from the outside as a honeycomb structure, is also the distinguishing feature of the Kanoa boards

who works at the Evonik site in Geesthacht near Hamburg. “On the other hand, ALBIDUR® does not affect the subsequent recycling process of the surfboard and makes the resin usable for a complete material cycle.”

SUNSCREEN AGAINST YELLOWING

After a short development period, the addition proved to be a real multi-talent in the boards. Thanks to a reactive resin matrix in which the silicone elastomer particles are evenly distributed, external forces are better absorbed by the laminate skin. “This impact resistance is important if the surfer ever hits a rock or other hard object,” adds von Osterhausen. ALBIDUR® also helps to ensure that the composite parts retain their original shape and remain firm and rigid. The material therefore fatigues much more slowly. There are hardly any dents like in Von Osterhausen’s first in-house development. And there is another advantage that is important when surfing. The Evonik product protects the epoxy matrix from UV radiation. The transparent resin of the cover therefore does not yellow even when exposed to a lot of sunlight.

The improved properties of the boards now allow further steps towards sustainability. Until now, materials such as carbon or glass fiber usually had to be used to reinforce the boards. At Kanoa, they can be replaced with natural fibers or recycled materials and then manufactured using the core-shell elastomer-enriched matrix. But the inside of the boards can also be improved. In the innovative boards, their foamed core now consists of 70 percent recycled material, such as old polystyrene packaging. The remaining 30 percent is lignin, a vegetable waste material from the paper industry, which has recently become increasingly popular as a raw material. The blanks are shaped using a CNC milling machine, the waste is returned to the manufacturer and recycled.

3

MONTHS
is the length of time that a standard surfboard can withstand the stress of professional use. Initial tests with HRT promise three times longer durability—and perhaps even more.

Despite all the love of nature, the decisive factor for success on the market is above all how well surfers get on with the boards in the waves. Here, Kanoa and Evonik were in for a surprise: The additive even provides good vibration damping during normal surfing. “We weren’t even aware of that before,” says Sprenger. Kanoa found this out during testing. “We call the phenomenon of the board starting to flutter and feel unstable when surfing ‘chatter’,” explains von Osterhausen. Boards with a conventional polyurethane core are usually superior here, as these are more flexible than rigid foam cores. But ALBIDUR® gives the epoxy boards the same properties, without the disadvantage of the rapid material fatigue of PU boards. →

The surface is crucial because it's the only place where a surfer's feet are in contact with the board when they ride the waves. Dents interfere greatly with board control

"We are currently having one tested by a professional surfer," reports the head of Kanoa. "After eight months, it still feels as good as new." Although this is not a scientific test, it does give an indication of longevity. The first generation of boards contain some glass fiber, which is still cheaper than cellulose fiber. This is Kanoa's way of convincing the market of the Honey Roots Technology. However, such a board will be around twice as expensive as a conventional one. After all, ten hours of manual work go into every surfboard from Kanoa. That is half as much as at the beginning, but this figure is also set to fall. In the next generation, the proportion of cellulose fibers will be increased to the maximum possible.

THE SURFBOARD AS A TECHNOLOGY PLATFORM

The honeycomb structure offers many opportunities outside the niche market of water sports. "For us, the surfboard as a technology platform is proof that the Honey Roots Technology design works," says Sprenger. This can also be used for other components. The focus is on the mobility market. Wherever people or goods need to be moved, the means of transportation have to be durable, stable, and light in weight. Moreover, the reusability of raw materials is becoming increasingly important. With his hybrid sandwich semi-finished product Hy-Core, Thilo von Osterhausen wants to offer a new core material for train car construction, boat and shipbuilding, the automotive sector, as well as the construction industry and furniture manufacturing. ALBIDUR® can also be used in these areas. As the material flows in all directions thanks to a special vacuum process, it is ideal for complex shapes. As von Osterhausen explains, "Hy-Core incorporates Honey Roots Technology with the 3D laminate structure. We can therefore make the advantages of our surfboard design available to various industries."

30

PERCENT
plant-based ingredients are in the core of the board, which provides the buoyancy. The basic material is wood, which is combined with recycled foam.

The first product to be launched on the market will be an all-round panel for a wide range of applications and with a thickness of 3.5 millimeters. The distribution network is currently being set up. "During discussions with material manufacturers, I quickly realized that sustainability was becoming standard," says Thilo von Osterhausen. "Many recycled plastics still have disadvantages in terms of performance, but my development can remedy this." He can advertise this fact with an award: This year, HRT won him the World Innovation Award at the JEC trade fair.

Incidentally, von Osterhausen solved his personal surfer-environment paradox in his own way: He moved the Kanoa headquarters from Saarbrücken, where Gunsails is still based today, to the French Basque Country along the Atlantic coast. Long journeys for testing or just surfing for fun are now a thing of the past: "It's only five minutes from the beach." —

Christoph Bauer is a journalist who works at Evonik's Communications department.

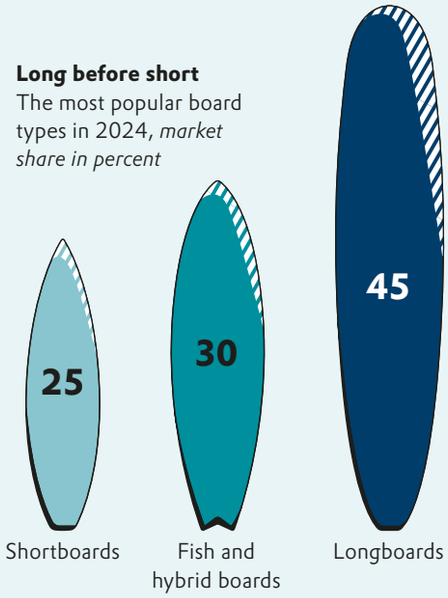
WAVE OF SUCCESS

Surfing is becoming increasingly popular—and this is reflected in the production figures for surfboards. The market growth poses a major challenge for athletes and manufacturers: How can the environmental impact be reduced?

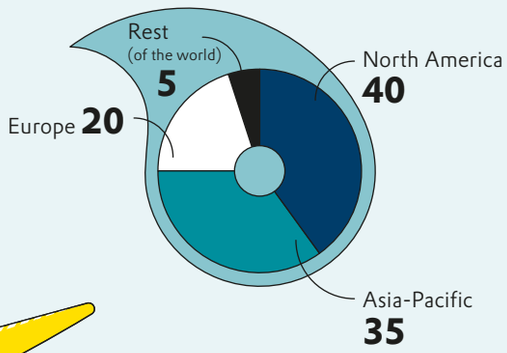
Sources: Business Research Insight, Ocean Impact Organization, European Environment Agency

INFOGRAPHIC **MAXIMILIAN NERTINGER**

Long before short
The most popular board types in 2024, *market share in percent*



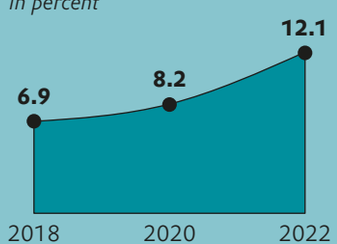
Surfin' USA
The largest surfboard markets in 2024, *market share in percent*



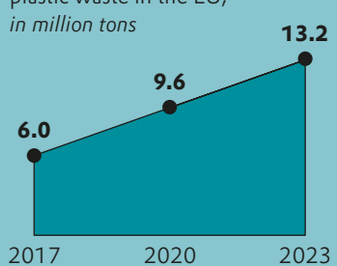
Every year, surfboards made of foam and fiberglass cause

160,000 tons of plastic waste

Be seeing you
Share of secondary plastics in total plastics consumption in the EU, *in percent*



More facilities
Mechanical recycling capacities for plastic waste in the EU, *in million tons*




Gas Inlet
IKA RC 2
23.3
S-01
Feed
RECYCLING
P-02

The Max Planck Institute for Chemical Energy Conversion is testing the process conditions under which valuable specialty chemicals can be produced from CO_2 in a miniplant

GREENER USES FOR CARBON

The chemical industry is gradually moving away from fossil raw materials. However, the transition to alternative sources poses huge challenges for the industry. In the Power2ValueChemicals project, Evonik is working with partners to test how CO_2 can be used for the production of fragrances

TEXT **TIM SCHRÖDER**

The new methanol plant from project developer European Energy is one of the largest of its kind anywhere in the world. Located in the Danish town of Apenrade, it is set to supply 42,000 tons of this alcohol per year in the future, including as fuel for the container ship *Laura Maersk*. The special feature of the plant with the gray-green halls and the many pipelines is that it manufactures methanol in an environmentally friendly way—from carbon dioxide and from hydrogen, which is produced directly on site in an electrolysis plant. In this electrolyzer, water is split into its components oxygen and hydrogen using electricity from solar and wind energy.

The hydrogen is then processed directly on site. Specialists refer to such technologies as Power-to-X systems. This means using electricity from renewable energy to produce valuable raw materials such as methanol that were previously obtained from natural gas, coal or mineral oil. The energy sector and industry have high hopes for Power-to-X. Analysts expect the Power-to-X market to grow strongly in the coming years. Last year, it was valued at around 700 million US dollars worldwide. It is expected to rise to more than 1.6 billion US dollars →

Chromatographic analyses provide Andreas Vorholt (left) and Robert Franke with a precise insight into the composition of mixtures of substances

by 2032. However, much remains to be done. It is still unclear whether and how quickly it will be possible for Power-to-X to make industry sustainable, not least the chemical industry.

After all, in the future, Power-to-X will supply not only hydrogen and methanol but also other chemicals, of which the industry requires large quantities and which have so far been obtained to a large extent from petroleum and natural gas. "The chemical industry is facing a paradigm shift. In the long run, we'll have to say goodbye to fossil raw materials," says Professor Robert Franke, a chemist at Evonik subsidiary Oxeno. In the large-scale Power2ValueChemicals project, experts from Oxeno have therefore teamed up with industry and research partners to explore how Power-to-X can make traditional chemical processes greener. They want to use carbon dioxide as a raw material to produce carbon monoxide (CO), which industry has so far obtained from natural gas. CO is needed for the production of perfumes, lubricants, active pharmaceutical ingredients, and polyamide, among other things. The Power2ValueChemicals approach would make the chemical industry greener in two ways. For one thing, the greenhouse gas carbon dioxide would be used as a raw material and be bound in products. Moreover, the fossil raw material natural gas would no longer be needed.

BUT IS THE EFFORT WORTH IT?

Power2ValueChemicals is an unusual project, because the entire chain from making CO from carbon dioxide to the finished chemical product has rarely been tried out on an industrial scale. One of the two case studies will deliver methyl valerate as an end product. This is a compound that is found in ripe pineapple fruit, among other things, and serves as an important fragrance in the perfume industry. "We not only have to solve technical issues, but also analyze how high the energy consumption and costs of the entire value chain are," says Franke, who coordinates the Power2ValueChemicals project. "A valid and critical practical assessment is needed to decide whether such a facility could be set up on an industrial scale." In this respect, it will be exciting to see what happens when the experiments gradually start and the test facilities go into operation.

The process can be roughly divided into two main areas. It starts with electrolysis, in which carbon dioxide (CO_2) is split into its components: one CO molecule and one oxygen atom (O). The CO is then used to produce methyl valerate. Two electrolysis pilot

"The chemical industry is facing a paradigm shift"

PROFESSOR ROBERT FRANKE,
POWER2VALUECHEMICALS PROJECT COORDINATOR

plants from Siemens Energy are used for electrolysis in Power2ValueChemicals. They were developed and tested by the project partner in Erlangen and Munich and reliably deliver carbon monoxide. However, the yield of CO is still too low, so the process needs to be optimized. "We are now tackling this task together with Siemens Energy," says Dr. Alexander Bauer, an electrochemist at Forschungszentrum Jülich, another project partner. "We systematically and simultaneously change the parameters pressure and temperature as well as other settings to obtain more CO."

The researchers are delving deep into the chemical and technical details of the electrolysis. At its heart is a silver catalyst embedded in a plastic membrane. The CO_2 splits into CO and an oxygen atom at this catalyst. "We developed the catalyst membrane and the entire system for carbon monoxide production ourselves over a number of years," explains Dr. Elfriede Simon from Siemens Energy. The company currently has two electrolysis facilities.

First, the smaller system will now go into operation in Jülich. Its catalyst-membrane reaction surface measures around 300 square centimeters. Later, the large facility with its 5,000 square centimeter membrane will be brought to Jülich. "It's much easier for us to carry out experiments on small systems first," says Bauer. "You need less gases and liquids, and the whole handling process is easier." →

The same reactions take place in the miniplant as later in the large demonstration plant. The system was developed by chemical engineer Lisa Steinwachs

The yield of the electrolysis is usually optimized by successively changing individual parameters such as the pressure. “In contrast, we change several parameters at the same time in order to tease out the optimum conditions,” explains Bauer. For each setting, he conducts several experiments to determine whether the process improves significantly. “Ultimately, this is a statistical optimization process,” he says. This approach is also known as “experimental design”.

THEORY MEETS REALITY

However, even an optimally adjusted electrolysis system always produces byproducts, such as hydrogen or oxygen compounds. In addition, carbon dioxide that has not been split into CO and oxygen is left over. “Electrolysis always produces a mixture of gases. That’s why we talk about product gas instead of pure carbon monoxide,” says Bauer. One challenge for the Power2ValueChemicals partners is that such gas mixtures are unusual in the chemical industry. At present, carbon monoxide is obtained from natural gas via steam gas reforming. This supplies very pure CO. “In Power2ValueChemicals, we also have to find out whether our established production processes can deal with the other components in the product gas,” says Evonik expert Franke.

The production of methyl valerate will now show whether this works. The central chemical reaction for its production is methoxycarbonylation, during which the CO molecule is incorporated into a butene molecule—a small chain molecule consisting of four carbon atoms and eight hydrogen atoms (see diagram on the right). The project partners are testing how well methoxycarbonylation works with the gas mixture from the electrolysis in two ways—firstly in the laboratory with extremely sensitive measuring equipment and secondly in a large test facility.

The laboratory experiments are taking place at another project partner, the Max Planck Institute for Chemical Energy Conversion (MPI CEC) in Mülheim an der Ruhr. The test facility, in turn, will go into operation at the Evonik site in Marl. In a long-term test last-

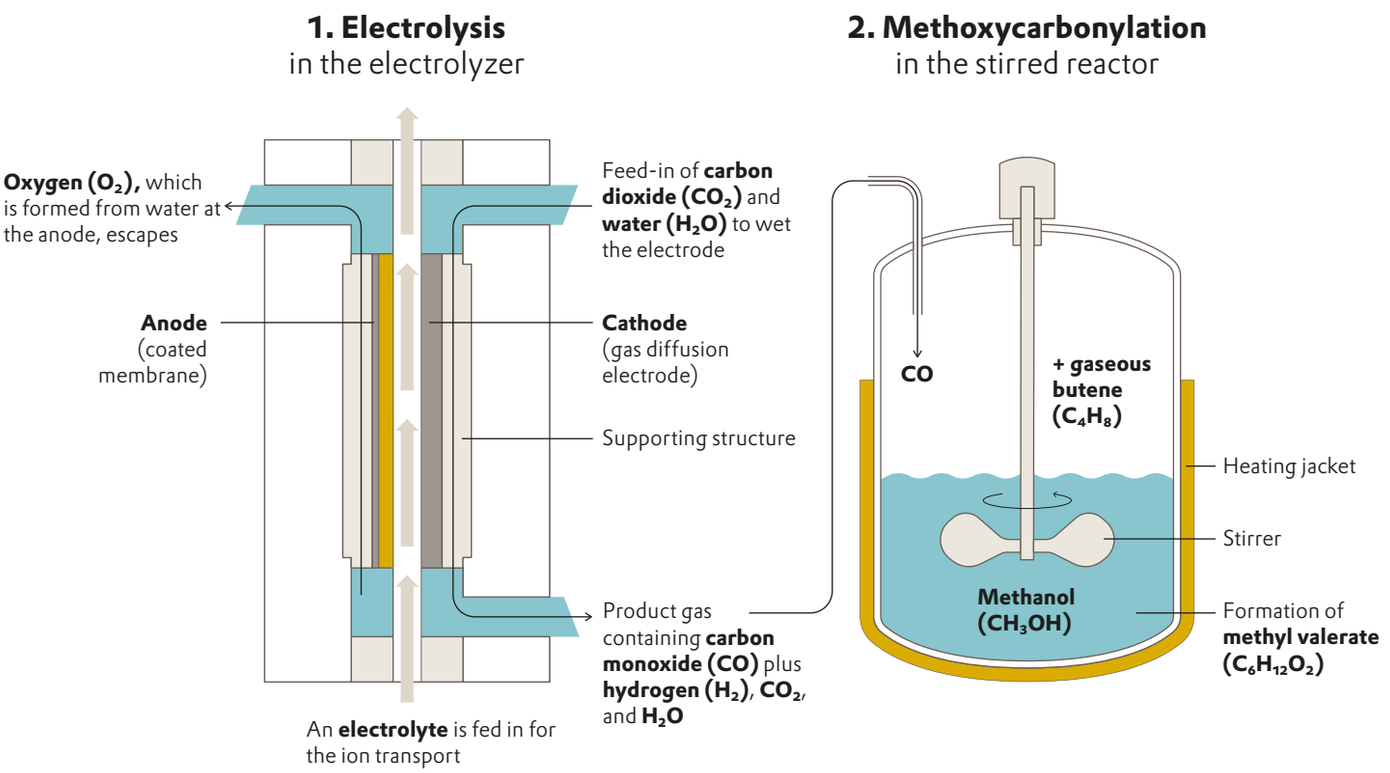
ing 4,000 hours, which corresponds to just under half a year, the experts there check whether the methoxycarbonylation using the gas mixture is stable in operation. If this is not guaranteed, the consequences are far-reaching. The system would have to be cleaned and possibly even dismantled, causing production downtimes of many hours or even several days.

The research team at the MPI CEC in Mülheim is therefore looking in detail at how the chemical reactions take place. Chemical engineer Lisa Steinwachs has developed and constructed a head-height laboratory system made of stainless steel containers and tubes, which is shielded by transparent acrylic glass walls in one of the Mülheim laboratories.

The actual methoxycarbonylation reaction takes place in a stainless steel container the size of a coffee pot. It is about half filled with methanol. The product gas containing CO is fed in from above. In addition, a catalyst is pumped into the reactor in precisely metered doses. It drives the decisive reaction—the incorporation of CO into the short hydrocarbon chain molecule. Instead of butene, which is needed to make methyl valerate, Steinwachs is currently using a different hydrocarbon: hexene. Hexene is liquid and therefore easier to mix with liquid methanol. Butene, on the other hand, exists as a gas. "This makes it easier to control the reaction," says Steinwachs. "Once we have gained some initial experience, we will switch to gaseous butene and produce methyl valerate." →

SEPARATE AND FEED IN

Carbon monoxide is obtained from carbon dioxide by means of electrolysis. It serves as an input for methoxycarbonylation, which produces methyl valerate as a product—an important starting material for the perfume industry



The decisive factor for methoxycarbonylation is how the catalyst behaves. Can it deal with the gas mixture? Or does it react with the CO_2 in the reaction gas to form solid complexes, causing it to fail at some point? Or does it even break down all by itself in an autocatalytic decomposition? “We clarify such questions on our small system before the long-term trial in Marl starts,” says Steinwachs, “because it’s easier to dismantle and clean if the reaction suddenly breaks down.”

IT GETS EXCITING FROM 70 BAR

In Mülheim, chemical reactions can be observed live in an operando analysis. To accomplish this, the laboratory is equipped with appropriate analytical equipment that allows scientists to track which molecules are produced in the reactor and react with each other—and whether the catalyst is inhibited by carbon dioxide or its reaction products. The lab’s inventory includes nuclear magnetic resonance spectrometers, which identify molecules using magnetic fields, and devices that detect substances using infrared light. “The operando method is something special,” says Dr. Andreas Vorholt, a chemist and research group leader at the MPI CEC. “It greatly helps us in taking a step-by-step approach to improving methoxycarbonylation with the electrolysis-generated product gas.”

Another challenge is that the carbon dioxide in the product gas dilutes the CO. For the reaction with the catalyst, this means that the catalyst and CO come together less frequently and the process only produces a small amount of methyl valerate in the end. Ultimately, the pressure in the reaction tank must be increased so that the CO and the catalyst get closer together. “The process is currently running at 30 bar. We may need higher pressures,” says Lisa Steinwachs. If around 70 bar is required, it would get exciting. The carbon dioxide could

“We tease out the optimum conditions”

ALEXANDER BAUER, ELECTROCHEMIST AT FORSCHUNGSZENTRUM JÜLICH

In thick-walled steel vessels, carbon monoxide and other gases react to form valuable fine chemicals such as the fragrance methyl valerate

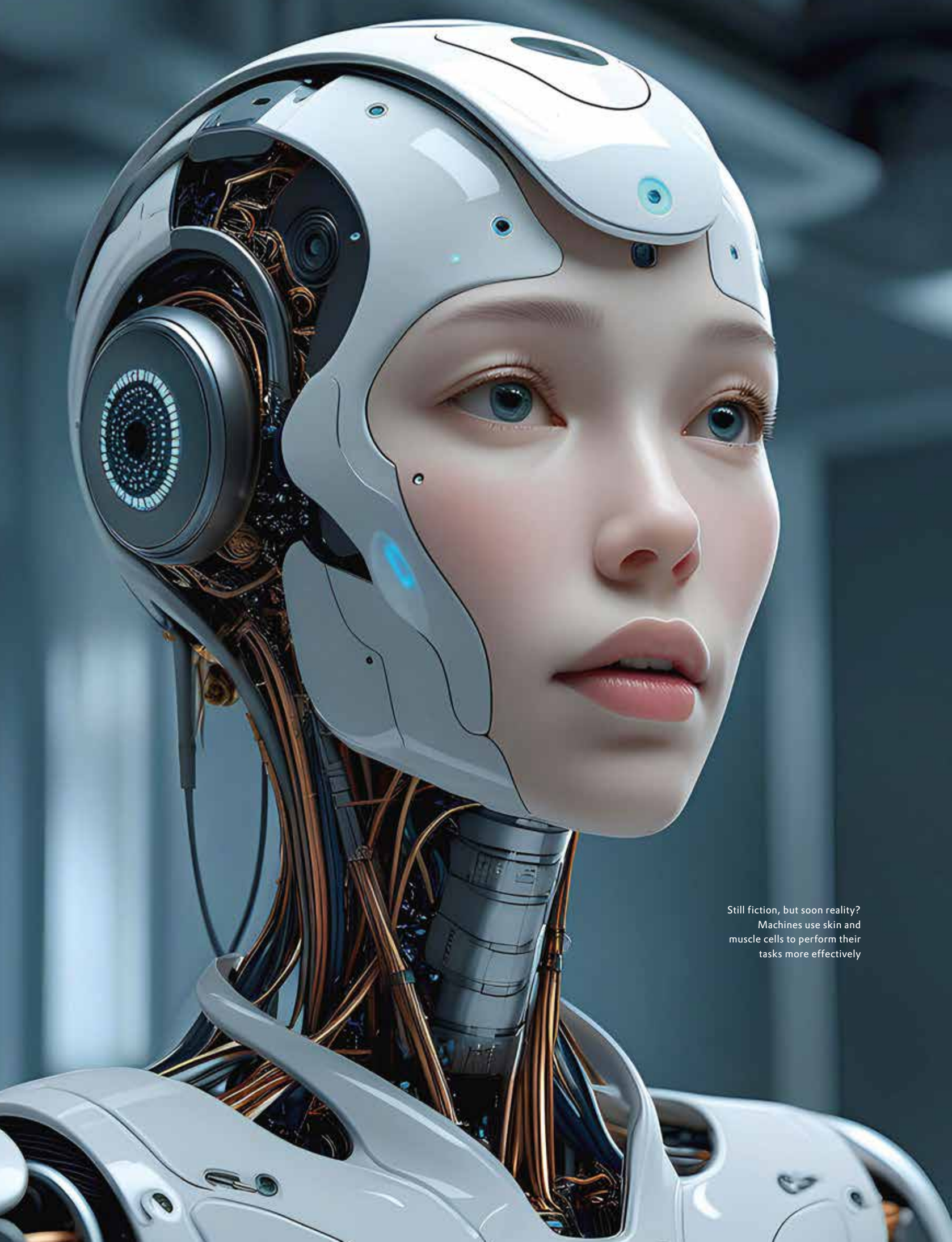
The Max Planck Institute for Chemical Energy Conversion in Mülheim an der Ruhr is one of the four project partners of Power2ValueChemicals

then enter the supercritical state, a kind of hybrid state between solid and liquid, in which it is particularly reactive. This would make the process much more demanding because the plant would have to be designed more robustly—for example with thicker steel containers and more robust seals and hoses. "We are also responsible for de-risking in the project. We are finding out what problems and risks there are before the large test facility in Marl, which is expensive to run, goes into operation," says Andreas Vorholt.

All in all, Power2ValueChemicals is an extraordinary project, emphasizes Robert Franke. It is supported by the Kopernikus initiative of the Federal Ministry of Education and Research, which funds large-scale energy projects. "Our project is one of the most chemistry-oriented under the Kopernikus umbrella," says Franke. "We have created a practice-oriented large-scale chemical production network and thoroughly examined complex catalyst systems with which we can run through the entire value chain." As an industrial partner, Evonik has the necessary expertise to assess whether green methoxycarbonylation will ultimately pay off.

Evonik and Siemens Energy are therefore also carrying out a life cycle analysis in the project, from electrolysis to the finished ester. "The outcome is still open," says Franke. However, Power2ValueChemicals is making a significant contribution to finding out how the chemical industry can move away from fossil raw materials.

Tim Schröder is a science journalist who lives in Oldenburg



Still fiction, but soon reality? Machines use skin and muscle cells to perform their tasks more effectively

MUSCLES NOT MOTORS

Robots with skin surfaces? Game controllers made of cellulose? Biohybrid materials—created from the fusion of biological and non-biological components—could make this possible in the future and herald the age of a completely new class of materials

TEXT **BJÖRN THEIS**

What the team from the Biohybrid Systems Laboratory led by Professor Shoji Takeuchi from the University of Tokyo presented in June of last year was fascinating, but also somewhat reminiscent of Dr. Frankenstein's experiments. The researchers had attached a piece of living skin to a robot and were able to move it at the touch of a button. They had succeeded in binding living tissue to an artificial surface in such a way that it was not destroyed. They used collagen, a fibrous protein in human skin, and human skin fibroblasts, the most common cell type in human connective tissue. The result is a new composite material made from biological and non-biological components: a "biohybrid".

BIOLOGY MEETS ROBOTICS

This fusion makes materials with completely new functions possible. Takeuchi's main goal was not to give robots human characteristics—rather, he was looking for a way to harness the advantages of biology for robotics. In a subsequent experiment, the scientist therefore used the composite material to combine cultivated muscle tissue with plastic elements to create multi-tissue actuators that stimulate or influence several tissue types simultaneously. He then built these actuators into a robotic hand to show that in the future, robots may use real muscles instead of bulky and heavy electric motors to move. This would be a revolution for robotics.

But it is not only artificial robot muscles that are made possible by the biohybrid approach. A variety of new smart materials that react to external stimuli such as light, temperature or chemical signals are conceivable.

Biohybrid materials may also be able to improve recyclability. At Saarland University, for example, a prototype game controller was created whose housing is made of bacterial cellulose instead of plastic. To do this, the researchers allowed the cellulose to grow around the electronic components such as buttons and microswitches. New biohybrid components are also being researched as part of the Fraunhofer-Gesellschaft's flagship project Sustainable Bio-based and Biohybrid Materials.

EFFECTIVE MATERIAL SOLUTIONS

Even if it will be some time before robots are exercising their biological muscles in the gym, biohybrid materials will open up a new chapter in materials science. In the future, they have the potential to create more functional, sustainable and effective material solutions in numerous applications and areas such as automation, medicine, robotics, and environmental sciences.

Evonik has recognized this potential and already has a first biohybrid in its portfolio in the form of a biosynthetic cellulose. That's a good reason for Foresight to analyze the topic in depth as part of the GameChanger 2035 project and to identify future potential for Evonik.

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

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Thorium

“We want to build the world’s most precise clock”

LOG **BERND KALTWASSER**
PHOTOGRAPHY **ANDREAS JAKWERTH**

Thorsten Schumm has been Professor of Quantum Metrology at the Vienna University of Technology since 2011. Before moving to Austria, he studied the behavior of certain subatomic particles at the University of Toronto, Canada. In his free time, the physicist explores the practical aspects of gravity together with his sons: Free climbing, bouldering, and extensive mountain tours are on the agenda.

At the Atomic Institute of the Vienna University of Technology, we want to build the most precise timepiece in the world, a nuclear clock. At its heart is thorium, or more precisely the isotope thorium-229.

Atomic clocks measure time so precisely that they are only one second off in 20 billion years. What sounds very precise is nevertheless not always precise enough. Navigation satellites with atomic clocks on board help to determine a person’s position on earth to within a radius of approximately ten meters. But would you get into an autonomous car that simply drives ten meters into an intersection?

We can improve time measurement with nuclear clocks. Instead of examining the oscillations of electrons as in atomic clocks, we observe changes in the atomic nucleus. These are hardly affected by external factors such as magnetic fields or temperature fluctuations.

In the case of thorium-229, comparatively little energy is required to trigger these changes. In addition, their frequency of 2,000 billion oscillations per second is very high. This enables precise measurements and makes thorium the ideal time signal source for a nuclear clock.

Experimental physicists usually try to grow crystals with the largest possible volume. We want the opposite: small crystals in which the laser light only excites the thorium nuclei.

In fall 2024, together with US colleagues, we presented the first prototype of a nuclear clock with our crystal at its heart. We have shown that thorium is the right material for ultra-high precision measurements. The next step is technical development work. For example, shrinking the crystals further—to such an extent that a single thorium ion may ultimately be sufficient for measurements.”

Masthead

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“Talent wins games…

…but teamwork and intelligence win championships,” Michael Jordan is reported to have said. The US basketball player played in the North American professional league NBA for 19 years and is considered one of the best athletes in history.

Biologically based innovations also depend on the right interaction between many specialists. Microorganisms are sensitive, and only the combined expertise of microbiology, formulation technology, and process technology leads to stable and effective products.