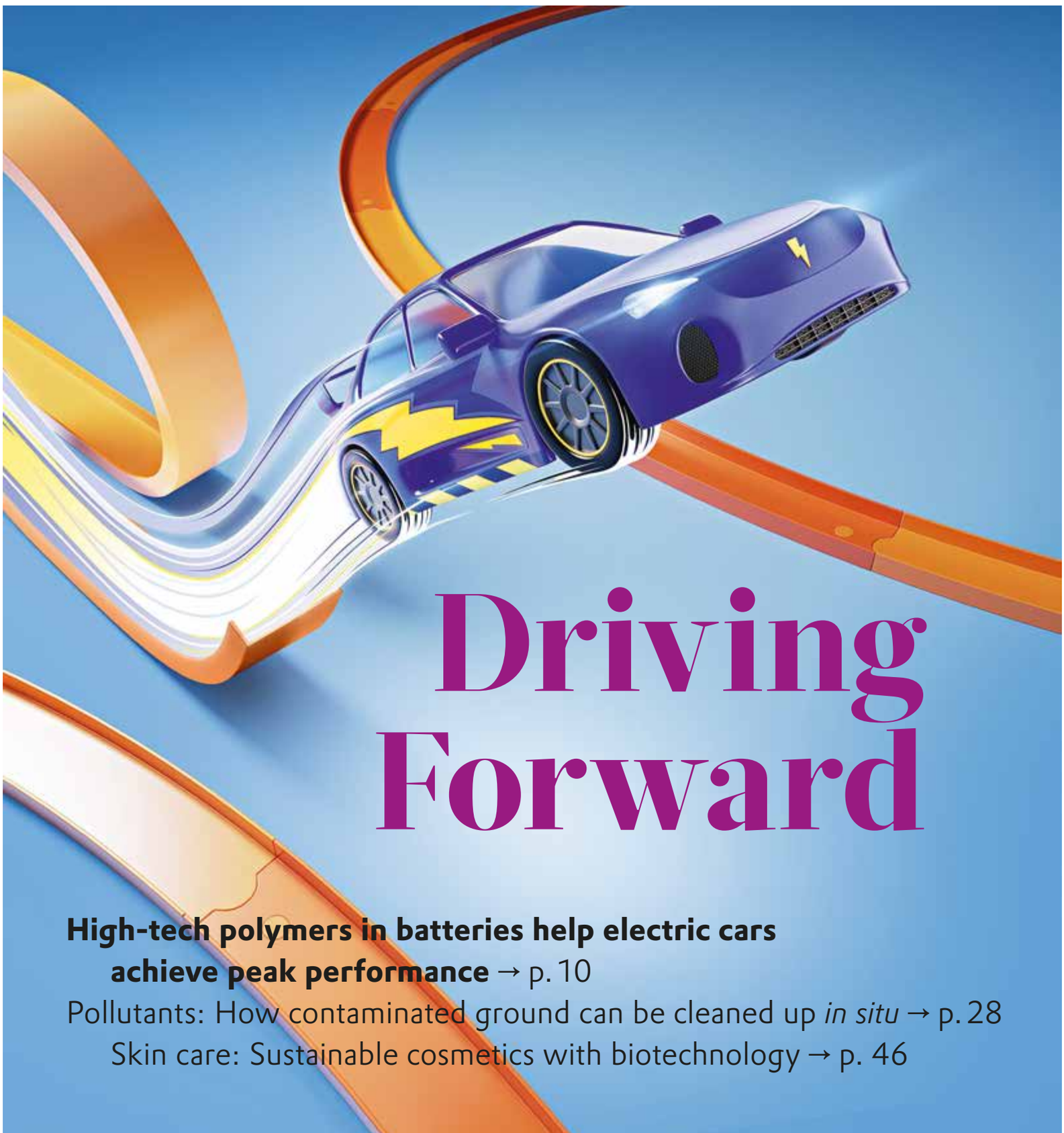
1/2025

EVONIK
Leading Beyond Chemistry

ELEMENTS

Research. Knowledge. The future.



Driving Forward

Battery

An electrochemical energy store

A battery has four main components: a positively charged electrode—the cathode; a negatively charged electrode—the anode; and between them, the electrolyte and a separator. Lithium-ion batteries (LIBs) play a central role in electric mobility. They can be recharged, and they contain liquid electrolytes. The latest technologies aim to replace these liquid electrolytes with ion-conducting solids such as polymers, sulfides or oxides. Such lithium-based solid-state batteries (SSBs) promise higher capacity, increased safety, and longer service lives.

Electrolyte A liquid or solid that enables the ion transport between anode and cathode and thus the charge equalization in the battery.
Separator The separator is permeable to ions while preventing a short circuit between anode and cathode.
Polymer A chemical compound composed of many long-chain molecules.
Sulfide A chemical compound consisting of sulfur and one or more other elements.
Oxide A chemical compound that contains at least one oxygen atom and another element.

DEAR READER,

I admit that I'm still not enamored of electric cars. My first extended experience with electric mobility was last fall. If anything, it increased my skepticism: That's supposed to be the future of individual mobility? It was an 800-kilometer vacation drive. Although I kept the speed low the whole way, I still needed three recharging stops. The journey took more than ten hours—even without tailbacks. It wasn't very convincing, even though other electric car drivers were acting as if it was completely normal to sit beside a charging column for half an hour in a grim industrial zone at half past midnight.

However, the battery expert Maximilian Fichtner eased my skepticism considerably in the *Elements* interview. He is convinced that higher performance batteries are not a topic for the future—they're already here. Electric cars no longer have to take a back seat to vehicles with internal combustion engines in any respect. And when technological leaps such as solid-state batteries make it to mass production, ranges and performance beyond anything we've known so far will become possible. Research teams around the world have made progress in battery research. We show where the most intensive research is currently being carried out and what contribution Evonik intends to make to the batteries of tomorrow.

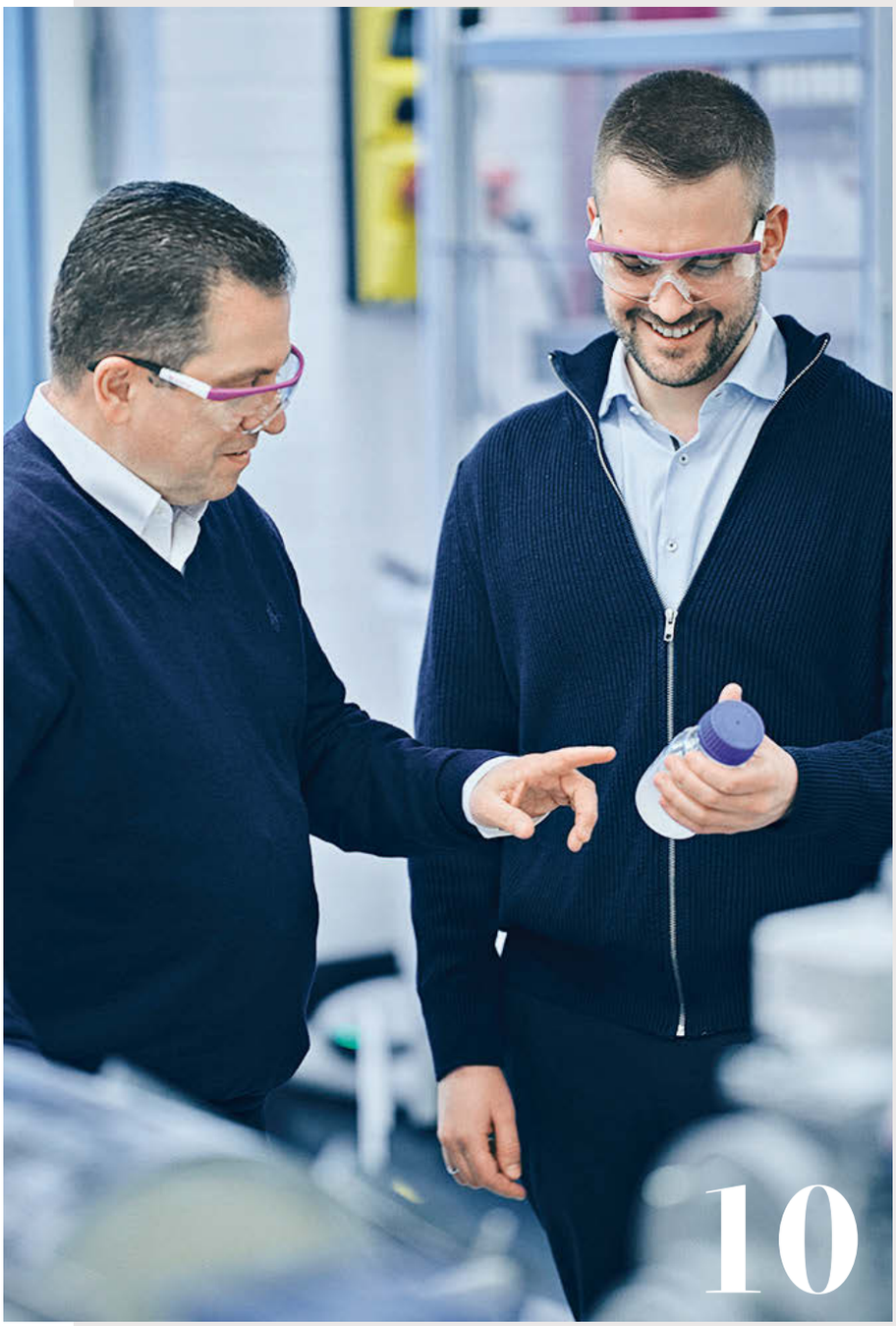
Our second topic area digs into the underground. Contaminated soil is a problem all over the world. Until now, in Germany, the problem has mostly been tackled by digging up the ground or pumping out the groundwater. But there are smarter ways to cleaner soil. We show them.

Cleanliness is also important in the cosmetics industry. There, biobased ingredients are playing an increasingly important role. L'Oréal and Evonik, two leaders in their respective sectors, have discovered a small French company that is delivering promising innovations. The result is a perfect *liaison à trois*—a three-way partnership.

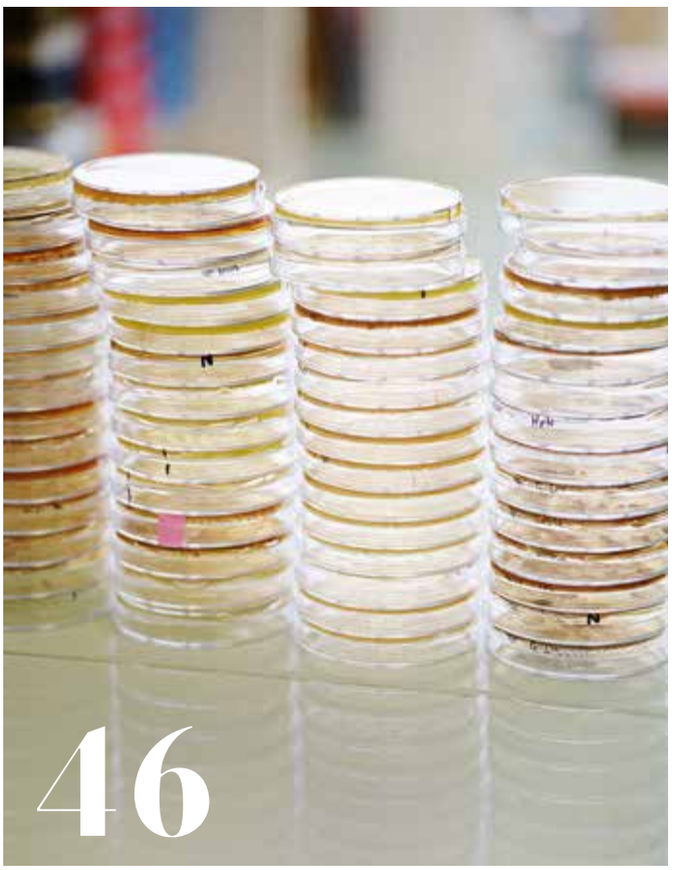
I wish you a fascinating and thought-provoking read. If you have any questions, recommendations or criticisms concerning this issue, please write to me at elements@evonik.com

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



Power duo: Christos Sarigiannidis (left) and Jan Blankenburg work at Creavis, Evonik's strategic innovation unit. Their specialty is polymers that could be used as the electrolyte in lithium-ion batteries



Abolis uses biotechnological processes to modify yeasts so that they produce specific molecules for care products

SOIL REMEDIATION

28 Going underground

Until now, soil contaminants have mostly been dug up or pumped out during construction projects. A new process enables toxic materials to be converted or immobilized directly *in situ*. Evonik is using it in two projects in Hanau

DIAGRAM

36 Made harmless

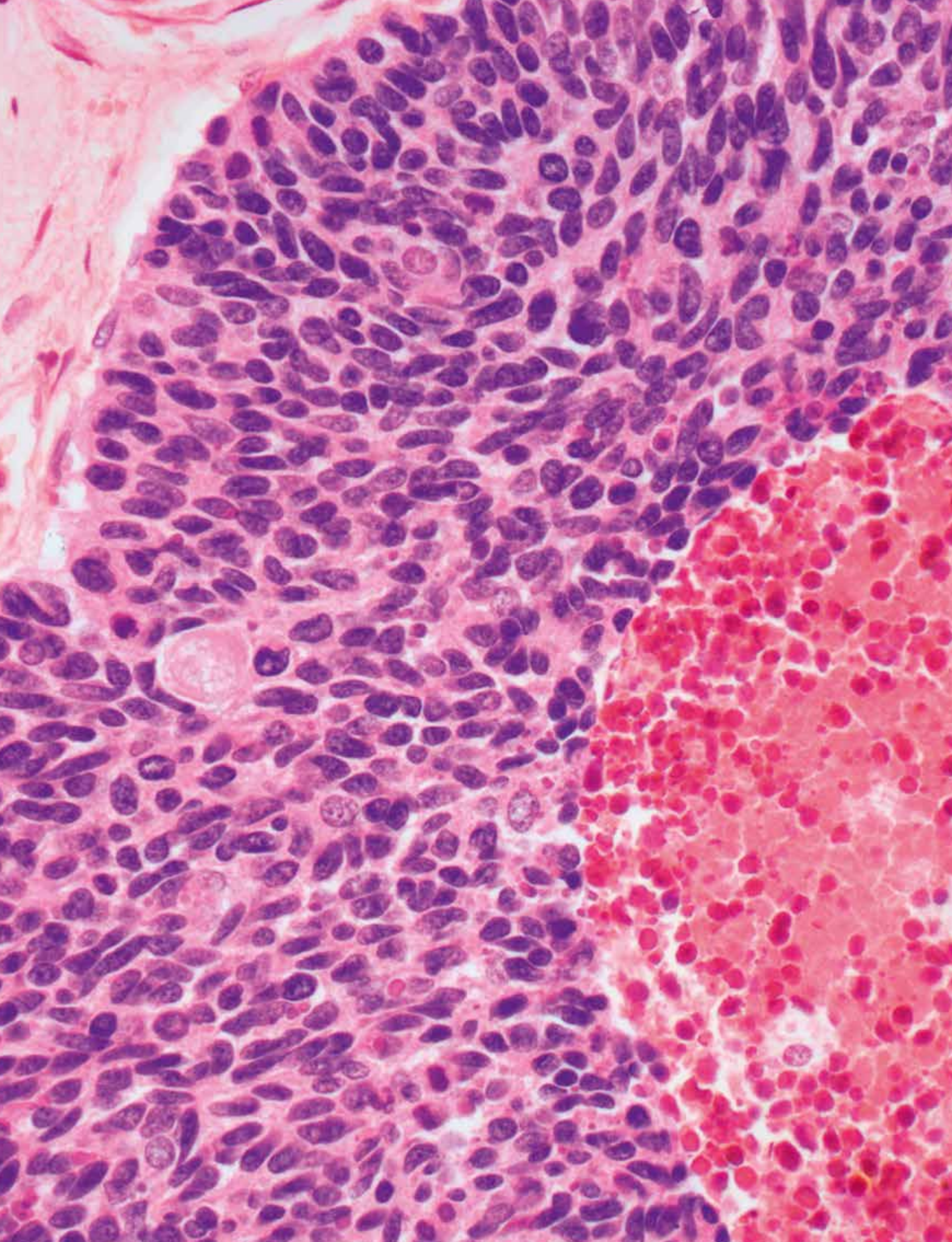
How the *in-situ* soil remediation works in the Pioneer Park conversion site in Hanau

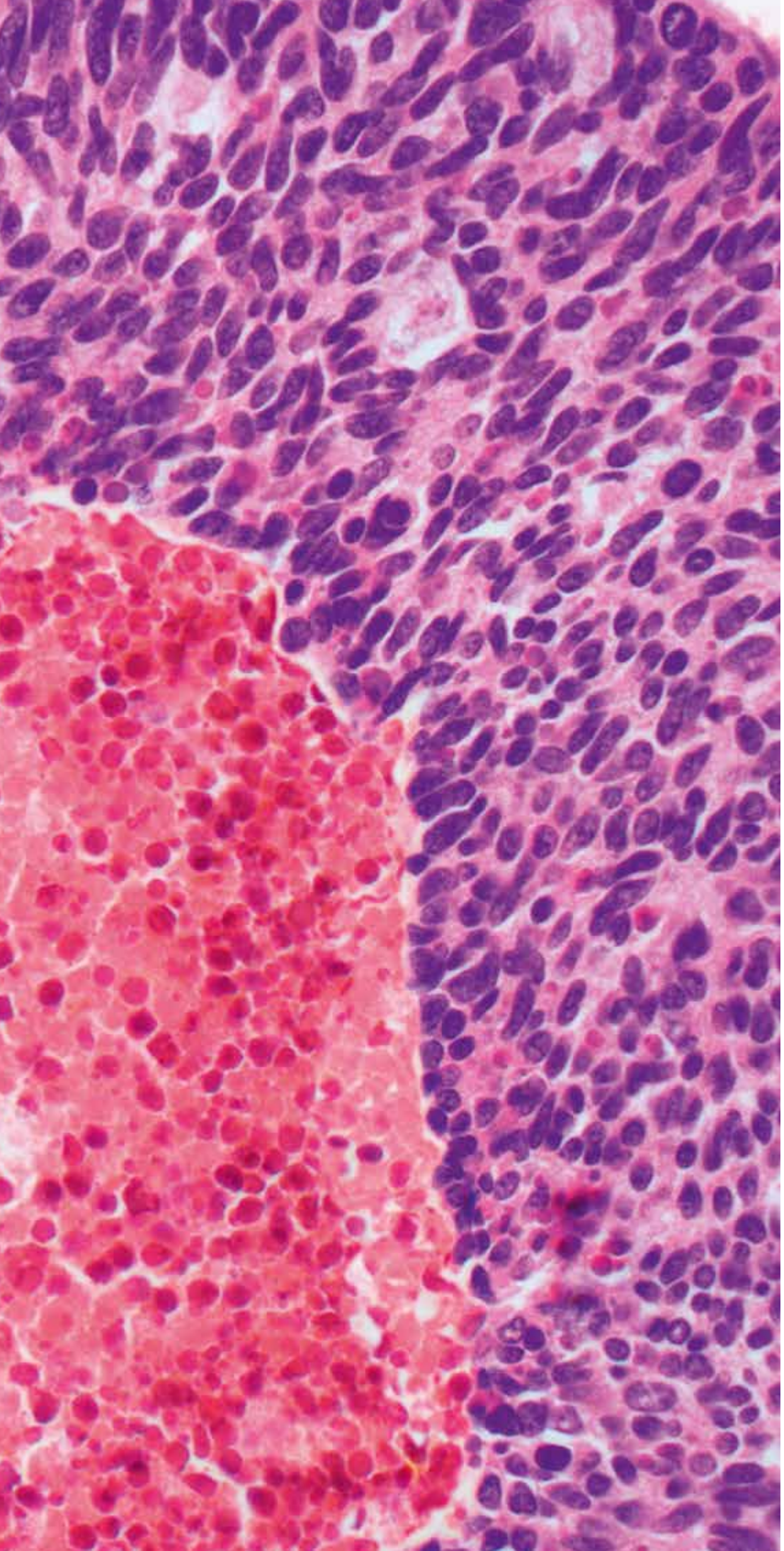
SUSTAINABLE COSMETICS

46 So close to nature

Evonik is investing worldwide in companies that develop biobased ingredients for cosmetics. Evonik and cosmetics giant L'Oréal intend to use biotechnological techniques to manufacture ingredients with one such company—Abolis in France. A site visit

Thanks to a product from Evonik, chlorine compounds can be turned into harmless reaction products. Peter Martus from the Aecom environmental consultancy is using exactly this process in two conversion projects in Hanau





At the Sustainable Development Summit in 2015, the United Nations defined 17 goals that are known as the Sustainable Development Goals (SDGs). Evonik too is contributing in many different ways to supporting sustainable development. We present them here.

In order to build prosperous societies, it's crucial that everyone can lead a **healthy life and that the well-being of people of all ages** is promoted. As a globally active company, Evonik wants its innovative solutions to help drive medical progress.

People's health is improving worldwide. Nevertheless, the industry and politicians must work continuously to create fair healthcare and combat diseases. The Lipid Innovation Center at Evonik's Tippecanoe site in the US state of Indiana, which opened in 2023, plays an important role here. Lipids produced there will serve as raw material for mRNA vaccines, which are used in cancer immunotherapies, for example.

A section of lung tissue viewed under an optical microscope. It shows many small and medium-sized cancer cells; the bright red spot in the center is dying tissue. The image shows a so-called oat cell carcinoma, a type of lung cancer that is normally treated with radiotherapy and chemotherapy. As a therapeutic measure, mRNA vaccination is a beacon of hope in the fight against cancer.

Human charging

Thanks to a thermoelectric generator, smartwatches could be powered by body heat in the future

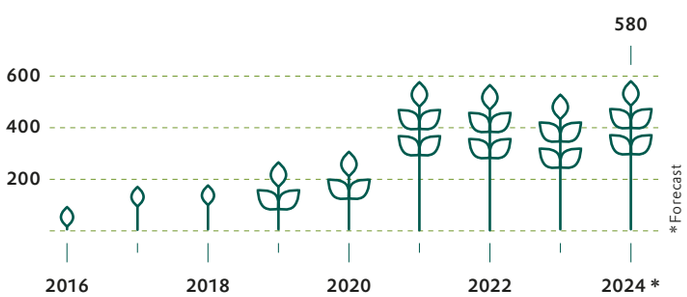
Heat from the skin can serve as a power source

Scientists at the University of Limerick (Ireland) and the University of Valencia (Spain) have succeeded in generating environmentally friendly energy from body heat. Under the leadership of Muhammad Muddasar, they are continuing the work of a team from the Technical University of Darmstadt. The research uses thermoelectric generators (TEGs) made of semiconductor elements, which can generate electricity with the help of small temperature differences. Previously, cadmium, lead or mercury were used for this purpose. Muddasar and his team have now developed a sustainable variant in which the semiconductors are based on the wood waste material lignin. These semiconductors consist of tiny channels that are filled with a highly concentrated salt solution. If one side of the TEGs is then exposed to a heat source, the negatively charged ions move towards the heat source, while the positively charged ions in the solution migrate to the cooler side. This generates an electric voltage. TEGs made from lignin are not only suitable for portable electronic devices, but could also become interesting for converting industrial waste heat into electricity.

THAT'S BETTER

Sustainable greenbacks

Global green bond issues per year, in billions of US dollars



Renewable energy, water management, electrification of transportation: Companies and governments are increasingly issuing green bonds to finance investments that mitigate climate change. Most recently, bonds worth between 500 and 600 billion US dollars were issued annually—around seven times as much as in 2016. The interest of institutional investors remains high, not least because investment companies, asset managers, insurance companies, and pension funds are required by their investment guidelines to include green bonds in their portfolios.

Source: Moody's

7

DAYS

That's how long surfaces remain frost-free if they have been coated with a new type of coating. Researchers at Northwestern University have developed an innovative surface with millimeter-sized structures and a wafer-thin layer of graphene oxide that attracts water vapor and binds water molecules. The coating is scratch-resistant, insensitive to dirt and can be produced using 3D printing. Applications range from car windows to cooling systems.

MECHANOPHORES…

…are dye molecules that make mechanical stresses in plastics visible. When forces act on the plastic, they change its color. If the force decreases, the molecules return to their original color. A research team at Chemnitz University of Technology has now developed new types of mechanophores that can also indicate how strong a load is by changing color. Among other things, this property opens up new possibilities for analyzing damage to plastic components.

PEOPLE & VISIONS

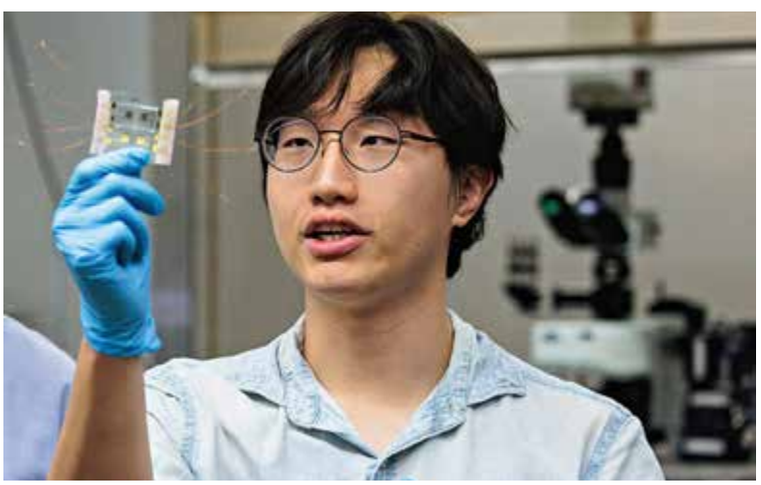
Electrical impulses combat antibiotic-resistant bacteria

THE PERSON

Saeyhun Kim is mainly driven by his curiosity and the desire to contribute to solving important problems. "I love uncovering secrets," he says. The young researcher is particularly fascinated by microbiology. During an exchange program at the University of Cambridge (UK), the Korean scientist discovered the potential of bacteria as biocatalysts and for curing infections. Kim is currently pursuing a combined master's and doctoral program in chemistry at the University of Chicago, USA, where he is continuing his research.

THE VISION

Kim investigated whether bacterial cells can be electrically stimulated. He discovered that this is possible with certain bacteria and a specific acidic pH. On this basis, he developed a type of plaster for the skin that uses electrical impulses to combat antibiotic-resistant bacteria. The secret is the pH: "It causes ions to migrate in and out of the bacteria. This prevents them from forming biofilms, which can cause serious infections." Kim's discovery is an important step for biomedical research.



Super sorting machine

A research team from Germany is developing an efficient process for separating aromatic and aliphatic compounds

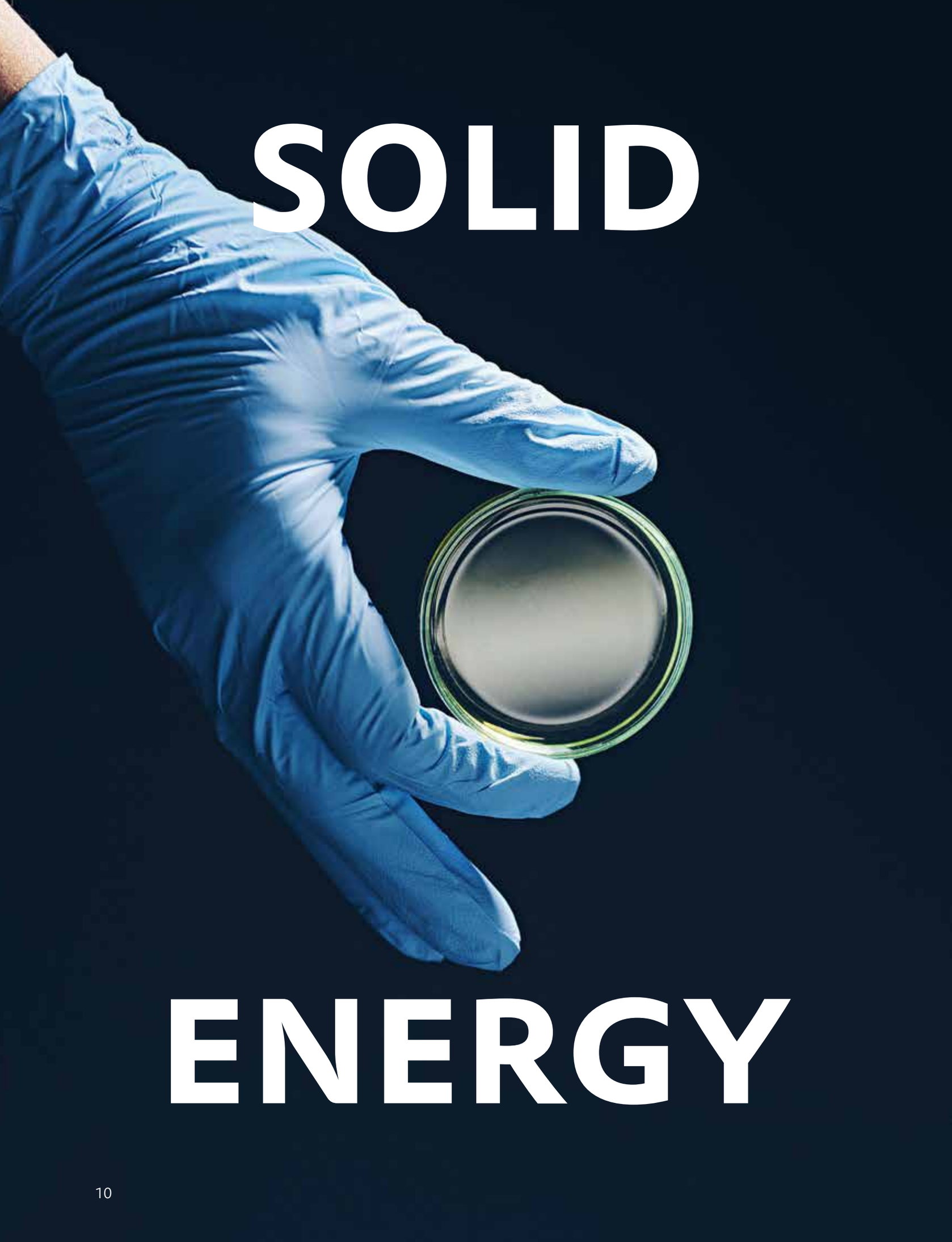
If two substances with similar physical properties are present in a mixture, it is difficult to separate them. One example from organic chemistry is aromatic compounds. They must be separated from other organic substances such as aliphatic compounds so that they can be used as a raw material for plastics, for example. However, as aromatic and aliphatic compounds are structurally similar, this separation has so far required a great deal of energy. This is now changing, thanks to the supramolecular sorting machine of a research team led by Dr. Bernd M. Schmidt from Heinrich Heine University in Düsseldorf. The key element is a molecular sieve of electron-poor, fluorinated macrocyclics called squareimines. These combine to form a pore network that attracts aromatic molecules and leaves aliphatic molecules behind. The researchers optimized the cross-linking in such a targeted way that the substance classes can be selectively separated from each other. Squareimines offer great potential for separating compounds that are otherwise difficult to separate.

GOOD QUESTION

Is electronic waste a goldmine?

We have, in fact, managed to convert recycled gold into catalysts for green chemistry. The key is covalent organic frameworks (COFs), a class of highly structured, porous materials based on the organic compound tetrazine. This allows gold to be selectively recovered from electronic waste. Other metals, such as nickel and copper, are contained in this recovered material only in minimal quantities. COFs adsorb gold ions and facilitate their reduction, so that gold nanoparticles form in their structures. We can use these gold-loaded COFs as reusable catalysts for the conversion of CO_2 into valuable organic compounds. Our approach shows that the upcycling of electronic waste has potential for sustainable applications in addition to the recovery of precious metals.

Amin Zadehnazari is a postdoctoral researcher at the College of Agriculture and Life Sciences at Cornell University in Ithaca, New York (USA).

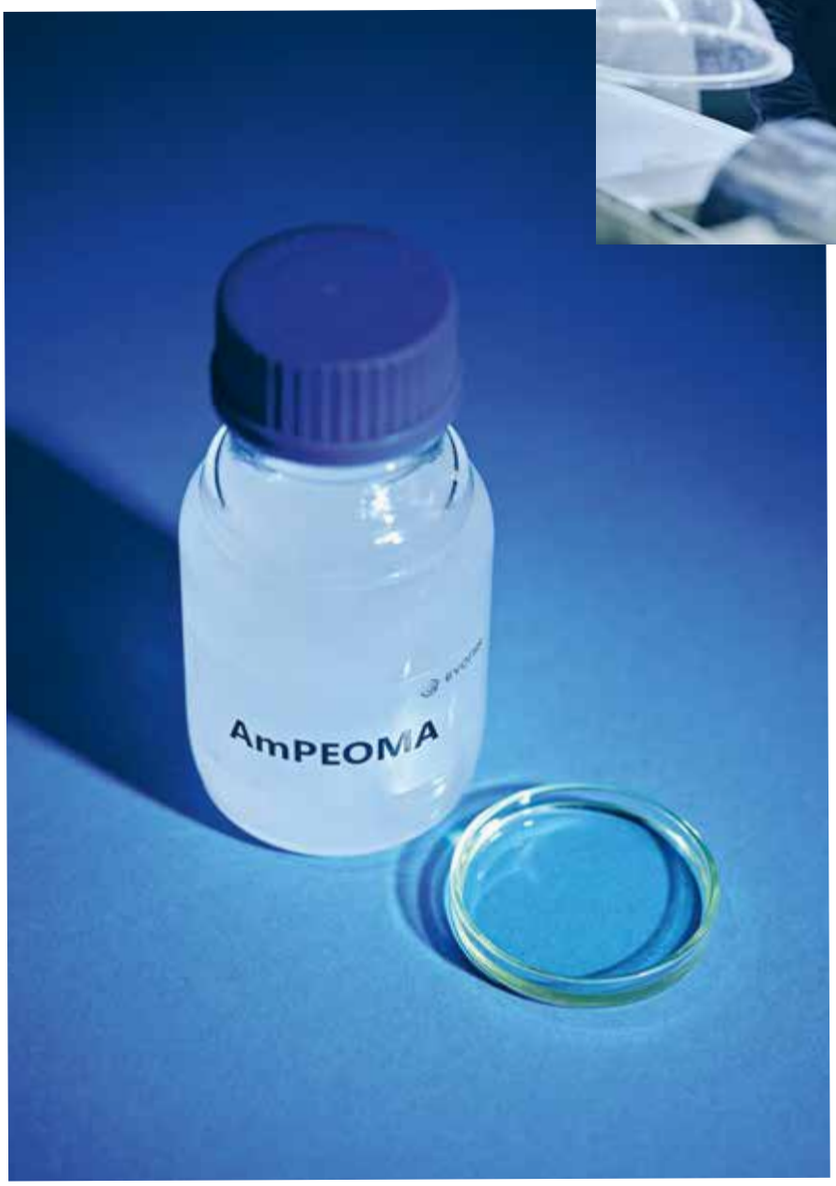

SOLID
ENERGY

A high performance polymer (left) is created in a Petri dish at Evonik. The polymer's suitability for use as an electrolyte will be tested in coin cells

Researchers are working hard to create more powerful batteries for electric mobility. Solid-state batteries are one approach because they enable significantly extended range and are safer. Evonik has developed a building block for polymer electrolytes that could overcome the disadvantages of existing solid-state batteries

TEXT **KARL HÜBNER**

A team headed by the Creavis researchers Dr. Christos Sarigiannidis and Dr. Jan Blankenburg is developing monomers for use as starting materials for solid state electrolytes



When Dr. Christos Sarigiannidis travels from the Creavis headquarters in Marl to the Evonik location in Hanau, some 300 kilometers away, he prefers to take the train. At Creavis—Evonik's strategic innovation unit and business incubator—Sarigiannidis is working on the future of mobility. One of his most important topics at the moment is technologies and materials that make batteries for electric vehicles even better.

On this winter's day, Sarigiannidis, who hails from Greece, is visiting Evonik's Electrochemistry & Exploration unit at Process Technology in Hanau. He looks through a pane of glass into an apparatus that holds several Petri dishes containing a slightly cloudy liquid that are being irradiated with UV light. "The main component of the liquid is a monomer we have developed, which we are now polymerizing," explains Sarigiannidis. The finished polymer can be examined in other Petri dishes, the bases of which are covered by a transparent, slightly yellowish mass. What looks like a fairly solid jelly is a great hope for one of Sarigiannidis' projects. "This could one day serve as the electrolyte in solid-state lithium-ion batteries," he says.

Millions of lithium-ion batteries (LIBs) are used to store electricity in electric vehicles. In the LIBs commonly used today, the space between the electrodes is filled with a liquid electrolyte. Solid-state electrolytes could help the tried-and-tested rechargeable batteries to make a leap forward in development, and accelerate electromobility. For Sarigiannidis, the advantages of solid-state batteries (SSBs) are obvious: "Solid-state batteries store more energy and are even safer than conventional LIBs," he says. Scientists and developers around the world are currently pursuing many approaches to further optimizing the range, charging speed, safety, and costs of these batteries. They have great expectations for SSBs. Some in the battery scene call them the "Holy Grail" or a

game changer. “It’s an exciting field of work,” says Sarigiannidis. “At Evonik, we have expertise in a wide range of areas such as electrochemistry and polymer chemistry that enables us to be successful here.” There’s also a great deal of expertise in particle technology and materials science that is relevant to batteries.

The market for automotive batteries is already huge. According to the International Energy Agency, demand in this segment reached a record 750 gigawatt hours (GWh), or 750 million kilowatt hours (kWh), in 2023. Of this, 415 GWh was attributable to car production in China, while a further 185 GWh was used in Europe. The capacity of a car battery is currently between 30 and 100 kWh.

THE LIMITS OF THE LIQUID ELECTROLYTE

The expected growth rates are even more impressive. According to market researchers, the global electric vehicle fleet (including hybrid models) could grow from just under 45 million vehicles in 2023 to between 500 and 800 million vehicles in the next ten years. The battery capacity required increases accordingly by a factor of seven to twelve. This will hardly be possible without technological leaps. →

Evonik employee Dr. Julian Teichmann prepares the polymerization of a monomer building block (left) before pouring the liquid into a Petri dish (above)

Dr. Frank Löffler builds the solid-state electrolytes into coin cells in order to test the materials' practical suitability

The biggest shortcomings of the current battery generation are relatively long charging times and that the range is usually exhausted at 300 to 400 kilometers. "No more great leaps are to be expected with the existing LIB technology," says Sarigiannidis.

The fact that current technology is coming up against limits is due to compatibility issues between the anode and cathode materials with current liquid electrolytes. The switch to a solid electrolyte would also make it possible to use new materials for the electrodes. Conventional anodes consist of graphite in which lithium is embedded. Anodes made of pure lithium could significantly increase the batteries' capacity. "The potential storage capacity is significantly higher—by 30 to 40 percent," says battery researcher Maximilian Fichtner from Ulm (see the interview starting on page 20). A solid-state electrolyte also increases safety due to the elimination of the flammable organic liquid. In addition, a solid-state battery no longer requires a separator.

Established cell manufacturers have long been working on such batteries, and well-known car manufacturers are supporting startups that are working on SSBs. More than 1.5 billion US dollars have been invested in this field in recent years. Evonik also wants to benefit from the SSB market and supply monomer building blocks for polymer electrolytes to battery manufacturers in the future.

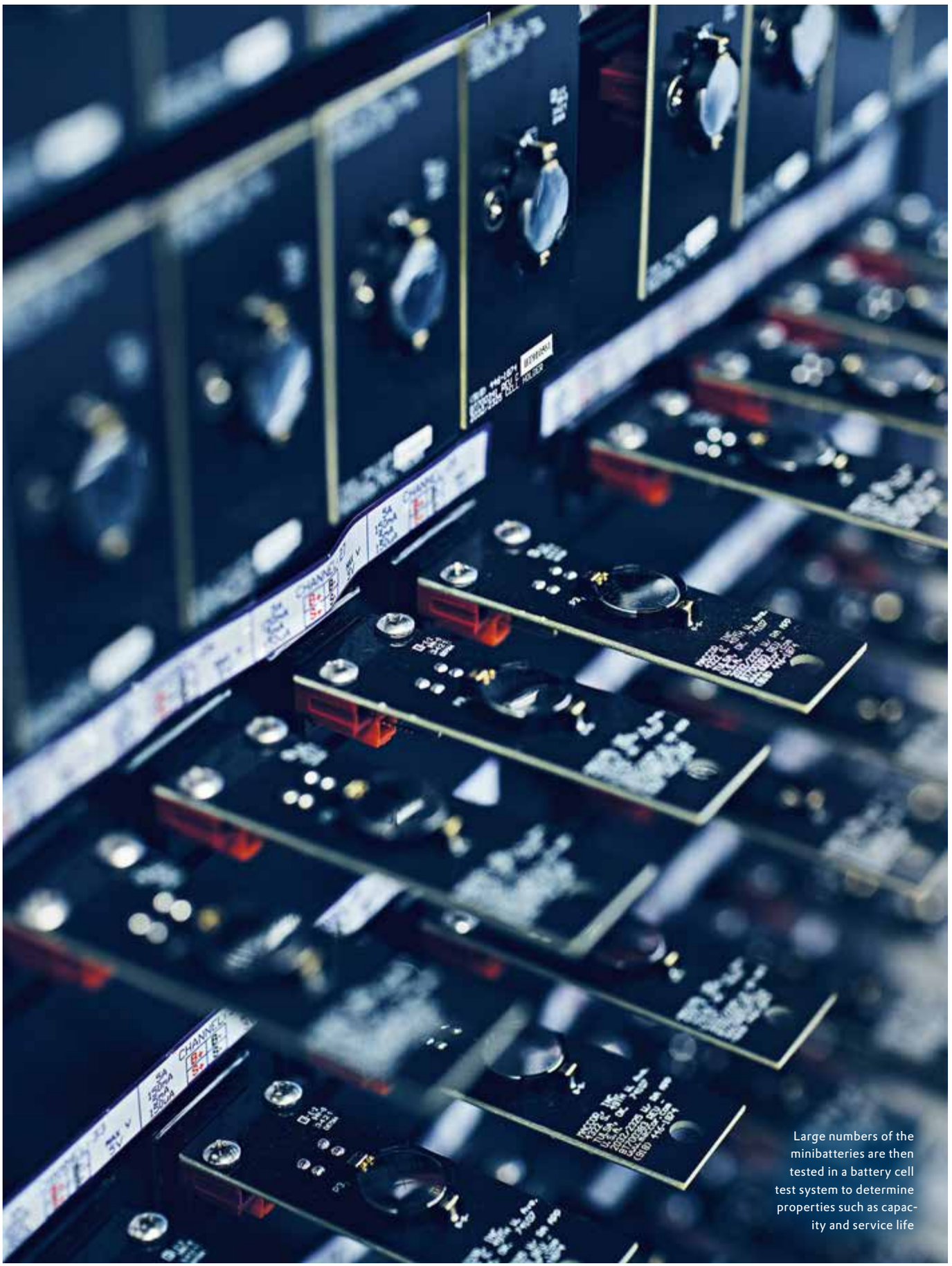
The biggest challenge with solid electrolytes is to find a material that allows lithium ions to migrate through the rigid mass. "Developers are currently pursuing two fundamental approaches," explains Sarigiannidis. "The first approach uses inorganic substances based on oxides or sulfides, the second organic polymers." Combinations are also possible.

Despite intensive research worldwide, however, no material has yet been suitable for mass production. Every candidate has disadvantages. Sulfide materials, for example, are excellent conductors of lithium ions, but are not very chemically stable, says Sarigiannidis. Moreover, inorganic materials generally have the disadvantage that they are not flexible. However, this property is required to ensure a consistently good contact surface between the electrolyte and the electrode material during the volume fluctuations typical of LIBs. By comparison, solid polymers are much more flexible, but their conductivity is usually inadequate.

NO HEAT NO POWER

However, there is already a promising polymer that is able to conduct lithium ions well: polyethylene oxide (PEO). This is a chain of ethylene units, each of which is linked to the next by an oxygen atom. According to Sarigiannidis, a commercial vehicle equipped with a solid-state battery based on such a PEO electrolyte is already on the market in Europe. "However, this electrolyte only conducts ions well at or above a temperature of 70 degrees Celsius," admits the researcher. So it has to be brought up to its operating temperature. But heating and insulation increase the amount of material and thus counteract the weight savings that SSBs are supposed to achieve.

Nevertheless, PEO is still considered an important candidate for solid-state batteries. In Sarigiannidis' Creavis project, this material is also the starting point for development. It's therefore very convenient that Evonik has decades of experience with PEO chemistry at its Essen location. This is where Dr. Jan Blankenburg comes in. Sarigiannidis hired the then recently graduated chemist at the end of 2019. Blankenburg has been rapidly pushing ahead with the solid electrolyte project since 2021. →



Large numbers of the minibatteries are then tested in a battery cell test system to determine properties such as capacity and service life

The solid-state electrolyte has the consistency of a stiff jelly. Jan Blankenburg is driving the polymer project at Creavis forward

“The monomer fills the space between the electrodes perfectly”

JAN BLANKENBURG, PROJECT MANAGER FOR THE MOBILITY OF THE FUTURE AT CREAVIS

“One problem with pure PEO is the formation of crystalline zones,” explains Blankenburg. These zones arise when polymer chains align themselves parallel to each other. “Lithium ions are practically unable to pass through such zones,” Blankenburg adds. Only above a certain temperature does the crystalline arrangement change to an amorphous one, enabling the ions to migrate between the electrodes again. “So our aim was to create a polymer that is also amorphous at lower temperatures.”

PEO should continue to play a role here because its oxygen atoms support ionic conduction. “We soon came up with the idea of combining PEO with another polymer,” says Blankenburg. The researcher likes to speak of “we,” but his boss Sarigiannidis is quick to clarify that the decisive considerations were solely thanks to his colleague.

Blankenburg’s idea was to use a polymer with a PMMA main chain that contains PEO in the form of side chains. Side chains are shorter, which makes them more flexible. In addition to oxygen, this flexibility is another factor that promotes the conductivity for the lithium ions. Blankenberg found what he was looking for in-house. Evonik had already developed the combination of PEO and PMMA in Darmstadt. As a first step, colleagues at the Karlsruhe Institute of Technology (KIT) helped to measure how well such molecular constructs transport lithium ions. It was only at a later stage of the project that Sarigiannidis and Blankenburg also began to use the Evonik laboratories in Hanau. In the meantime, Blankenburg, who like Sarigiannidis initially had his office in Marl, moved his workplace completely to Hanau. The polymer layers in the Petri dishes that Sarigiannidis is shown on this day are the result of his work there.

COMBATING CRYSTALS

However, this work began with a disappointment. “PMMA polymers with PEO side chains also conducted poorly at low temperatures,” says Blankenburg. Contrary to expectations, they also formed crystalline zones. But Blankenburg soon had another idea: “Why not simply incorporate an additional polymer building block into the

PEO side chains—and have these blocks randomly distributed?" This irregularity should make crystal formation more difficult, so that the overall polymer remains conductive even when cooled.

The additional polymer building block was quickly found. Since then, the project has operated under the name AmPEOMA—an abbreviation for amorphous polyethylene oxide methacrylate.

In order to maintain the ionic conductivity over the widest possible temperature range, changes such as optimizing the lengths of the side chains were necessary. After all, an electric car should work just as well in sub-zero temperatures as it does at the height of summer. Many syntheses and material tests were necessary. The partners from KIT and later the Evonik colleagues at Electrochemistry & Exploration in Hanau also helped with this.

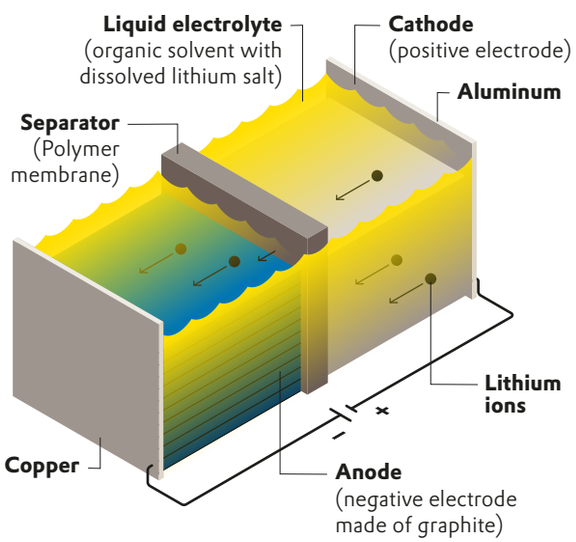
The first tests recently started there. To do this, the employees punch out a small circle from the jelly layer in the Petri dishes and insert it, together with two electrodes, into an empty coin cell. This cell is then clamped in an apparatus in which different currents can be applied and the voltage is then recorded. "This gives us an indication of the capacity," explains Dr. Frank Löffler, a materials scientist at the Hanau laboratory. Long-term tests determine the cycle stability and thus the service life of a possible battery containing the AmPEOMA electrolyte. The findings for the coin cells can be transferred to later LIB cells for cars, says Blankenburg.

In the meantime, Sarigiannidis and his team have sent first samples of the new monomer to LIB battery cell manufacturers. More precisely, they sent the monomer—the cloudy liquid. "The actual polymerization is carried out by the manufacturer," he says. "And it's done directly in the battery cell." Jan Blankenburg sees this as a particular process advantage. "Because it's liquid, the monomer fills the space between the electrodes perfectly," he says. In contrast to inorganic electrolytes, an optimum contact layer to the electrodes is created during curing. Furthermore, no additional solvent is required in the process. →

Liquid or solid? How the concepts compare

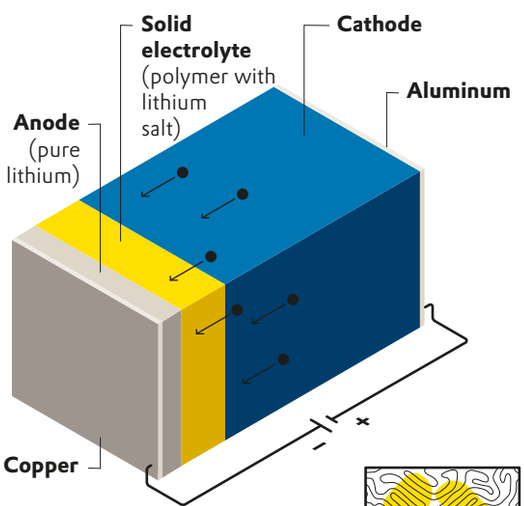
Lithium-ion batteries work with a liquid or a solid electrolyte. This is how their structures differ

Battery with liquid electrolyte

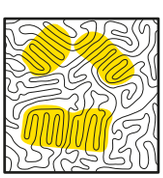


Stored in graphite
During charging, the positively charged lithium ions stored in the cathode are transported through the electrolyte and the separator to the anode, where they take on an electron from the externally applied charging current and are stored in the graphite. The process runs in reverse during discharging.

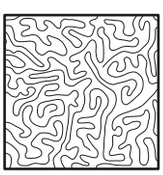
Battery with solid electrolyte



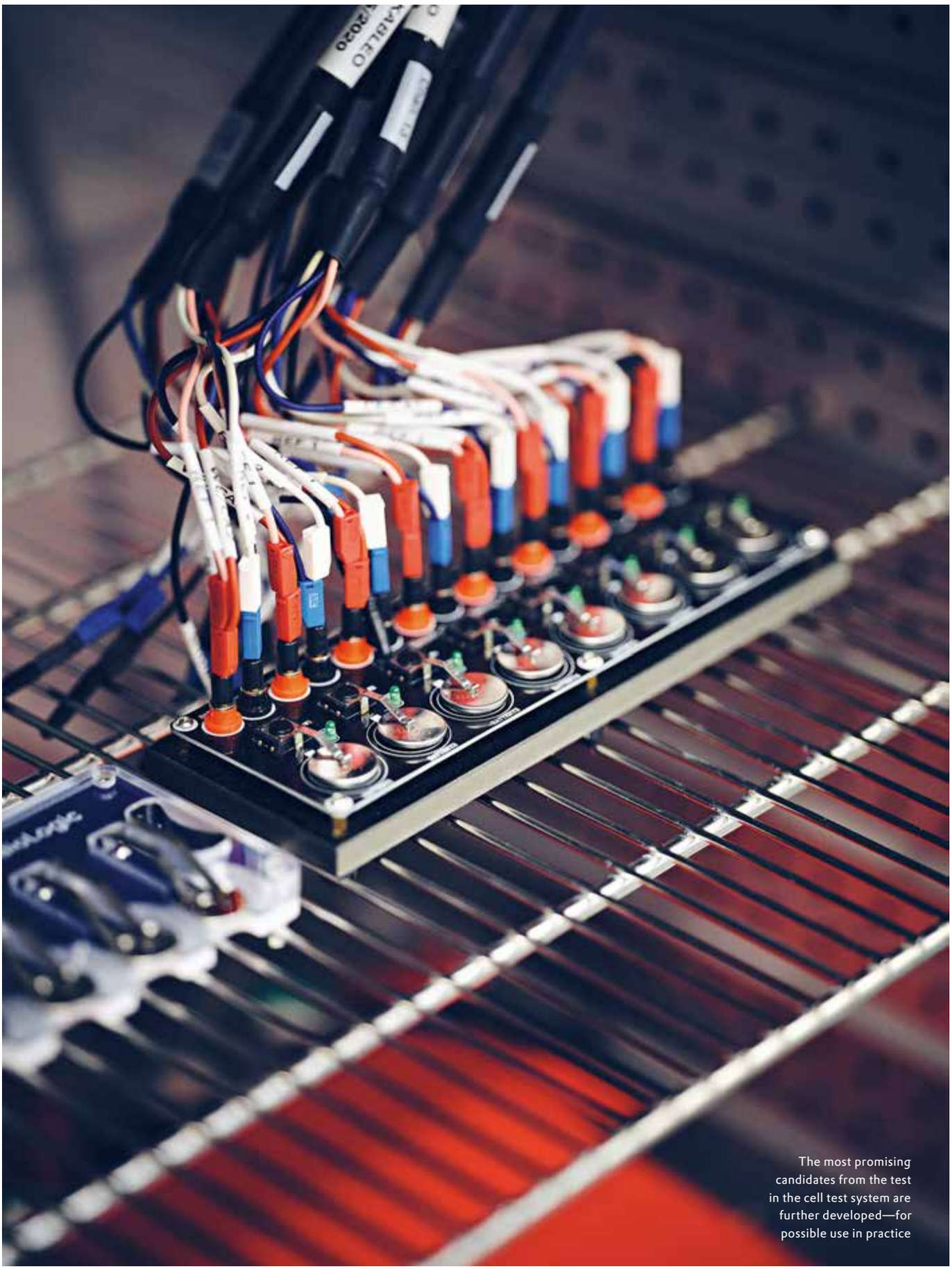
Precipitated as metal
The charging process proceeds exactly as in the conventional LIB. However, the lithium ions are not stored in graphite after the electron has been absorbed at the anode—instead they are deposited as pure lithium metal. This lithium anode layer grows during charging; during the discharging process, it is once again removed and grows thinner. The solid electrolyte also takes on the role of the separator.



Until now: At low temperatures polymers form **crystals** that hinder the lithium-ion conductivity.



With AmPEOMA: Crystal formation is hindered so that the lithium ions are conducted more rapidly



The most promising candidates from the test in the cell test system are further developed—for possible use in practice

“Solid-state batteries store more energy and are even safer than conventional LIBs”

DR. CHRISTOS SARIGIANNIDIS,
HEAD OF THE MOBILITY
OF THE FUTURE UNIT AT CREAVIS

The feedback from manufacturers has been positive so far. However, there is still more work to be done. “We are currently trying to increase the mechanical stability, for example,” says Blankenburg. This means that the polymer, once cured, should be able to cope even better with the volume changes that typically occur in LIBs during the charging and discharging process. Blankenburg soon had an idea for this too: “We are currently trying to increase the mechanical stability of the polymer,” he explains. This is achieved by incorporating linkage points in the side chains of the monomer. Bonds to other molecules can be formed at these sites during curing.

AS FAST AS FILLING A GAS TANK

For the tests so far, the Evonik researchers have produced polymer layers with a thickness of 200 micrometers (one-fifth of a millimeter). Later, in a commercially viable battery cell, the solid electrolyte layer will perhaps only measure 20 micrometers, making it thinner than a human hair. The team around Christos Sarigiannidis also has to ensure that the material can be produced in these dimensions without losing the desired properties.

In addition, the team also intends to further increase the ionic conductivity in order to shorten the charging time. Researchers hope that one day fully charging a solid-state battery will not take much longer than filling a gas tank.

And the signs are also positive when it comes to greater range. This is because SSBs will store more energy per kilogram of battery weight, as they have a higher energy density due to the use of a pure lithium anode. For LIBs currently available on the market, this is a maximum of 250 watt hours per kilogram of battery (Wh/kg), according to Christos Sarigiannidis. Battery experts expect that an SSB could achieve up to 400 Wh/kg. Energy densities of up to 700 Wh/kg have even been measured in laboratory tests. The Creavis researcher estimates that SSBs will be fitted in new vehicles on a significant scale from the 2030s onwards.

Given the significant increase in range and greater safety, even Sarigiannidis, a die-hard train traveler, can imagine making electric cars his main means of transport in a few years’ time.

Karl Hübner is a journalist who has a PhD in chemistry. He works as a freelance author and frequently writes about research topics

“Our engineering approach is hindering us”

According to Maximilian Fichtner, it’s only a matter of time before gasoline- and diesel-powered vehicles will be replaced by electric cars. In this interview, the renowned battery expert explains why Chinese storage technology is faster and more powerful—and why Europe is in danger of missing the boat

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

Professor Fichtner, as one of the “battery pundits”, you naturally drive an electric car. How satisfied are you with it?
We have an electric car at the institute, which I use to drive to lectures in Munich, for example. It works well. The charging speed is a bit too slow for me, but I mostly charge here at the institute, where it doesn’t matter. However, colleagues sometimes use it to travel longer distances, such as to a conference in Trieste.

Short range, long charging time, high price—until now there have been many reasons not to buy an electric car. Can you give the skeptics hope that battery technology is making progress?
The next generation of batteries, which are already being installed in vehicles in Asia in particular, can be charged with 6C. This means that the battery is charged from 10 to 80 percent in eight and a half minutes. A 350-kilowatt column is enough for this.

You’re talking about lithium-ion-based batteries that have a liquid electrolyte. Hasn’t this technology reached its limits?
Things are still happening. But our engineering approach is a hindrance, particularly in Germany. In Europe, we rely on lots of small battery cells that we then put together in a module. Then we connect several modules in a small space and the compact battery pack is ready. It consists of an incredible number of small parts, there’s a lot of packaging, cables, and housings, and the amount of actual storage material inside is comparatively low. This is also the reason why Europe has to rely almost exclusively on batteries with the high-performance NMC material, i.e. batteries based on nickel, manganese, and cobalt. That’s not the case in China.

Why is that?
In China, the interior of the batteries in a battery pack is much more spaciously designed. Larger cells with more space for the storage material allow the use of cheaper material, such as lithium iron phosphate, which is found in the positive pole of the battery, the cathode. Lithium iron phosphate has a low density and is quite voluminous. But these battery packs have the space for this. The first vehicle models with iron phosphate batteries are now being launched on the market in China. They have a range of 1,000 kilometers and can be charged in ten minutes.

Impressive! But are these cars really more environmentally friendly? A study by the Association of German Engineers (VDI) comes to the conclusion that an electric car—depending on the type of electricity used for production and operation—is only environmentally superior to a combustion engine after 60,000 to 90,000 kilometers.
This is just a recent study with some questionable basic assumptions. Institutions such as the International Council on Clean Transportation (ICCT) or →

Maximilian Fichtner, 63, is Director at the Helmholtz Institute Ulm (HIU) for Electrochemical Energy Storage, Professor of Solid State Chemistry at the University of Ulm, and Head of the Energy Storage Systems Department at the Institute of Nanotechnology of the Karlsruhe Institute of Technology. The chemist is also Scientific Director of the Center for Electrochemical Energy Storage Ulm-Karlsruhe (CELEST) and spokesperson for the German Post Lithium Storage (POLiS) Cluster of Excellence for battery research. Before working on the batteries of the future, Fichtner carried out research into hydrogen drives and electrofuels, among other things.

the Fraunhofer ISI in Karlsruhe have been carrying out such life cycle analyses for a very long time and come up with different results. Their analyses show that the CO_2 breakeven point is already reached after 20,000 to 40,000 kilometers, depending on the battery and electricity mix. Tesla uses almost 100 percent renewable energy at its factory in Texas—so after just 8,000 to 9,000 kilometers, the carbon footprint is already better than that of a combustion engine.

That leaves the issue of safety. Spectacular cases of battery fires occur time and again.
There is now data on this as well: In the United States, the figures have been compiled by insurers and America's road safety organization. For every billion kilometers driven, there were 96 fires in combustion engines and three to four in electric vehicles. This means that combustion engine vehicles burn 25 times more frequently than electric cars. Swedish figures show a similar ratio. So a supposedly higher fire risk really can't be an argument against electric mobility.

When will battery technology be competitive with combustion engines?
It is already on a par technologically, now it's all about the costs. However, if you compare the engine and battery, which dominate the price, you are also comparable here. Here's one example: One kilowatt hour of battery capacity currently costs around 90 US dollars to produce. For a battery with 70 kilowatt hours, I am therefore looking at production costs of 6,300 US dollars. My old Alfa Romeo Spider, a fun car for the summer, needed a new engine a few years ago—it cost me 8,000 euros. Batteries are therefore no longer more expensive than gasoline or diesel drives. In China, two thirds of all electric cars are already cheaper than their combustion engine counterparts. Models are already available there for the equivalent of 10,000 euros. Technologies such as the sodium-ion battery will become even cheaper in the future. The first such cars are already on the road in China—city runabouts with a range of 300 kilometers.

Why are EVs so much more expensive in Europe?
China clearly has an advantage here. What has now happened at Northvolt…

…the Swedish battery manufacturer has become insolvent due to quality issues…
…that happened in China as well. At the beginning of almost every series production run, 20 to 30 percent of the cells have faults. However, while the timetables here have barely taken this into account and Northvolt has run into difficulties due to overly optimistic promises, people in China have shown patience, stayed on the ball, and simply carried on. It took five years to adjust all the little screws in production—and in the end the result was practically perfect. Today, the Chinese are the world market leader.

So we lack patience in Germany?
Yes. Battery cell production is a highly complex topic. If we lose patience too quickly and unsettle investors by repeatedly discussing the possibility of staying with the combustion engine, then we will not succeed. We have bought ourselves some time in Europe by imposing tariffs on Chinese electric vehicles. But if the time is not used, I think the situation will become really bleak.

There is also a lot of money at stake. Billions and billions have been invested in the expansion of electric mobility in the USA—at least under Joe Biden's presidency. Do we need more subsidies in Europe in order not to miss the boat?
As part of the Inflation Reduction Act, the US government has made 650 billion US dollars available to support companies in the green sector—including battery companies. The companies in China have also received support over the years. Here in Germany, on the other hand, this is castigated as state *dirigisme* and a planned

Maximilian Fichtner in the meeting room of the Helmholtz Institute Ulm for Electrochemical Energy Storage

economy. Moreover, unlike in Germany, Chinese battery and car manufacturers reinvest almost all of their profits. This has given them a head start and enabled them to build up huge development departments. Samsung and LG in South Korea have also made it to the top in this way. You have to be prepared to take entrepreneurial risks.

That's easy to say. In Germany, companies have learned the hard way about battery projects—including Evonik in the Litec joint venture, which the company left in 2014. There are limits to shareholders' patience with loss-makers.
And it is precisely because of this attitude that we will eventually have to buy everything that requires a longer development time from abroad.

You are focusing on the development of solid-state batteries. What advantage does the technology offer over batteries with a liquid electrolyte?
The potential storage capacity is significantly higher—by 30 to 40 percent. You would therefore have around 350 to 400 watt hours per kilogram of storage material. With the same range, the battery would be correspondingly lighter.

Where does research start to drive this process forward?
A lot of work is currently being done on anode-free or "zero-excess" cells. The anode, i.e. the negative pole, is currently still made of graphite. However, it has now been discovered that the cell also works if the graphite is omitted. If lithium passes through a solid electrolyte, it is deposited directly on the collector foil instead of in the graphite and forms a metal layer. This saves a lot of volume and mass. The laboratory cells, which have now been manufactured in Canada and China, store around 700 watt hours per kilogram. This would more than double the current capacity. A vehicle would be able to travel 1,900 kilometers, or the battery pack could be only half as heavy, but still have the previous range.

But it will probably also be significantly more expensive. Are we talking about cutting-edge technology for high-end vehicles and sports cars?
There's a wide variety of concepts. Solid-state batteries usually contain a ceramic based on lanthanum-zirconium or phosphorus-sulfur. However, you are going to have problems with a rigid ceramic that is only a few micrometers thick and has a storage material in front of it that expands when charging and shrinks when discharging. The membrane only allows lithium to pass through when it is in direct contact with the material. For this reason, a little liquid is often added to fill gaps or the electrolyte is applied as a gel. There are also lithium polymer batteries in which lithium passes through a polymer and is deposited on the negative pole during charging. Such batteries have accumulated 50 million fleet kilometers in the French car sharing system Bluecars.

So why don't they play a major role?
For most everyday applications, we already have very good solutions that are affordable and comparatively sustainable. Iron phosphate, for example, is a common mineral. If you sprinkle iron salt into municipal wastewater, you will get iron phosphate as a white powder. →

“Technologically, battery technology is already on a par with the combustion engine. Now it’s primarily about costs”

MAXIMILIAN FICHTNER

Which part of the world do you think is currently leading the way in the development of next-generation batteries?
It’s hard to assess developments in China. But at the moment, the USA seems to be ahead. There are simply a lot of companies working on it there, and there is a different startup culture. Banks there don’t ask how money can be saved, but how much money can be spent in a certain amount of time in order to reach the goal faster.

While the majority of newly registered vehicles in China have an electric drive, we are still far away from this in Europe. In Germany, not even 14 percent of new cars are currently all-electric. Is it even possible to meet the target set by the European Union that newly registered vehicles should no longer emit CO_2 from 2035?
The abolition of purchase incentives in some countries has certainly caused a lot of damage. An additional factor in Germany is that we led the way with combustion engines for decades and are therefore attached to them. In other parts of the world that don’t have this history, electric mobility is seen as a great thing because it makes cities clean and quiet. New industries are emerging to support the whole, and countries are less dependent on oil and gas supplies from some potentate.

Nevertheless, some regions will probably remain dependent on combustion engines for longer due to a lack of infrastructure or thanks to alternative fuels—Africa, for example, or parts of South America.
But perhaps things will turn out quite differently. I was recently invited to an international energy and mobility congress in India, which had 70,000 participants. Electric mobility is growing rapidly there, albeit from a low level, and the state and industry are formulating a path to leadership. It’s also booming in Africa in many places. Electric tricycles, where you simply replace the battery, are becoming increasingly popular there. Ethiopia already banned the import of new gasoline and diesel cars in 2024 and is now fully committed to EVs because the country has a lot of hydropower and they want to get away from expensive oil imports.

When will the last combustion engine roll off the production line?
If you extrapolate the development in China, only five percent of new registrations there will be pure combustion vehicles by 2028. This will probably take longer in Europe. I believe that we will have plug-in hybrids for a while yet. Combustion engines may be slowly coming to an end that way. But as batteries evolve towards shorter charging times, greater safety, longer range, and better charging infrastructure, everyone will ask themselves at some point whether they still need their gasoline or diesel-powered cars anymore.

And what will become of your Alfa Spider?
It will be 25 years old this year and is resting in the garage until the summer. However, if you’ve been driving electrically for a while, it’s quite a change to get into this rattler, which you first have to ramp up to 3,000 rpm until it starts to show power. We will not be able to inspire future generations with something like this.

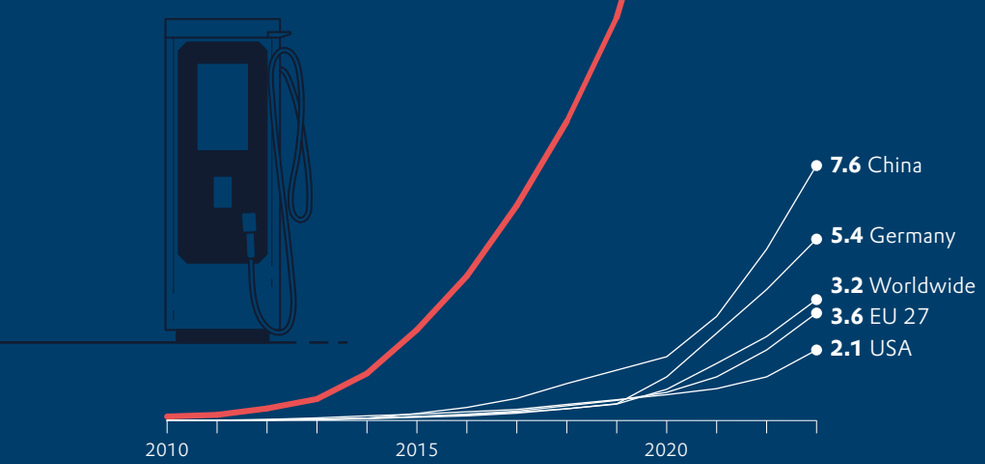
GOING ELECTRIC

The global market for electric cars is growing fast. And at the same time, the balance of power is shifting. Classic car manufacturing nations are falling behind up-and-coming producers such as China. A numerical overview

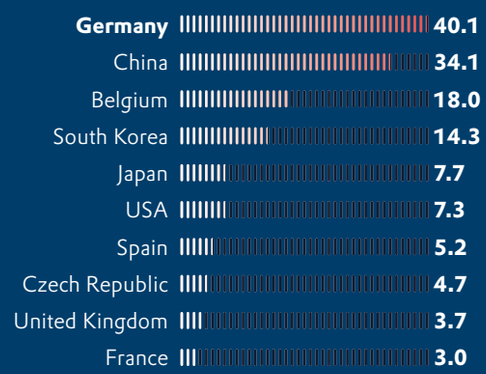
Sources: Our World in Data, Global EV Outlook 2024, Tendata, Statista Market Insights

INFOGRAPHIC **MAXIMILIAN NERTINGER**

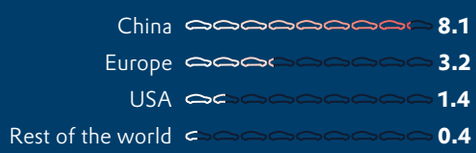
Norway rushing ahead...
Share of electric* cars of the overall fleet of selected countries *in percent*



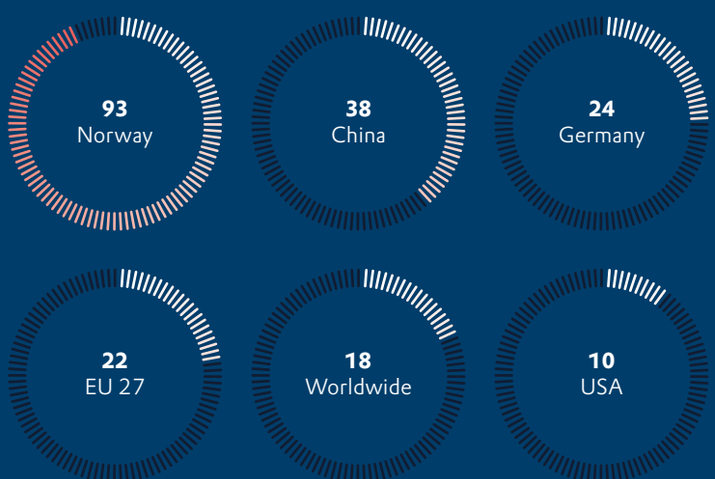
Germany still leading in exports
The value of electric car* exports in 2023, *in billions of US dollars*



China's vast domestic market is powering the business
Number of electric cars* sold by region in 2023 *in millions of units*

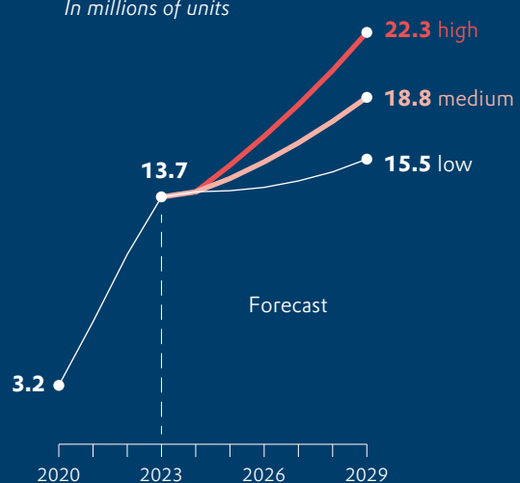


...and the rest of the world is following slowly
Share of electric cars* of new registrations in 2023 *in percent*



* Battery powered vehicles and plug-in hybrids

Hope for further growth.
Unit sales of electric cars* (Forecasts for various scenarios), *In millions of units*



Rules for electric traffic

Electric mobility is picking up speed worldwide. Governments rely on various regulatory measures to manage their markets and drive the transition to sustainable transportation solutions

TEXT **PAULINE BRENKE**

USA: MANY LONE WARRIORS

In the USA, there are 45 sets of regulations on electric mobility—almost as many as there are states. The West Coast state of California is a national leader in the introduction of electric cars and plans to ban the sale of combustion engine cars from 2035. Overall, however, the figures for new registrations of electric cars in the USA are comparatively modest: In 2024, 1.3 million units were sold, which corresponds to a market share of eight percent. This is despite the fact that Tesla, the world's second-largest manufacturer of electric cars, is based in the country. To date, the purchase of battery electric vehicles and the expansion of a charging infrastructure has been supported by the Inflation Reduction Act (IRA) of 2022. However, the government under President Donald Trump has called for the abolishment of subsidies that favor electric drives over other technologies.

BRAZIL: E AS IN ETHANOL

In South America's largest country, electric mobility has only developed slowly so far. Fuel based on ethanol, which is obtained from sugar cane, has dominated the market here for more than 50 years. For a long time, the prevalence of sustainable fuels hampered the breakthrough of electric drives. However, a growing market for electric vehicles is now also emerging in Brazil. Since the end of 2023, companies have received tax incentives for the development and production of low-emission drives. Several major car manufacturers in the country are taking a middle course with hybrid models that run on ethanol and electricity.

SOUTH AFRICA: IN STEP WITH EUROPE

The automotive industry is a key economic sector in South Africa. Around two thirds of production is exported every year, mainly to Europe. In view of increasingly strict emission regulations in the purchasing countries, South Africa is reorienting itself: In order to meet the needs of its trading partners and at the same time strengthen its own automotive sector, the government wants to invest in the production of electric cars—the first models are to be produced locally in 2026. The cost of research and development in particular is to be reduced with a significant tax relief. Another focus is on the development of regional battery production.

NORWAY: A BLUEPRINT

This northern European country is considered a pioneer in electric mobility. Almost 90 percent of all new cars sold there in 2024 were equipped with an electric drive. The recipe for success: The government is promoting the switch to electric vehicles with a variety of incentives that are predictable over the long term. These included the (temporary) abolition of VAT, reduced parking fees, reduced toll and ferry prices, and the option of using bus and cab lanes.

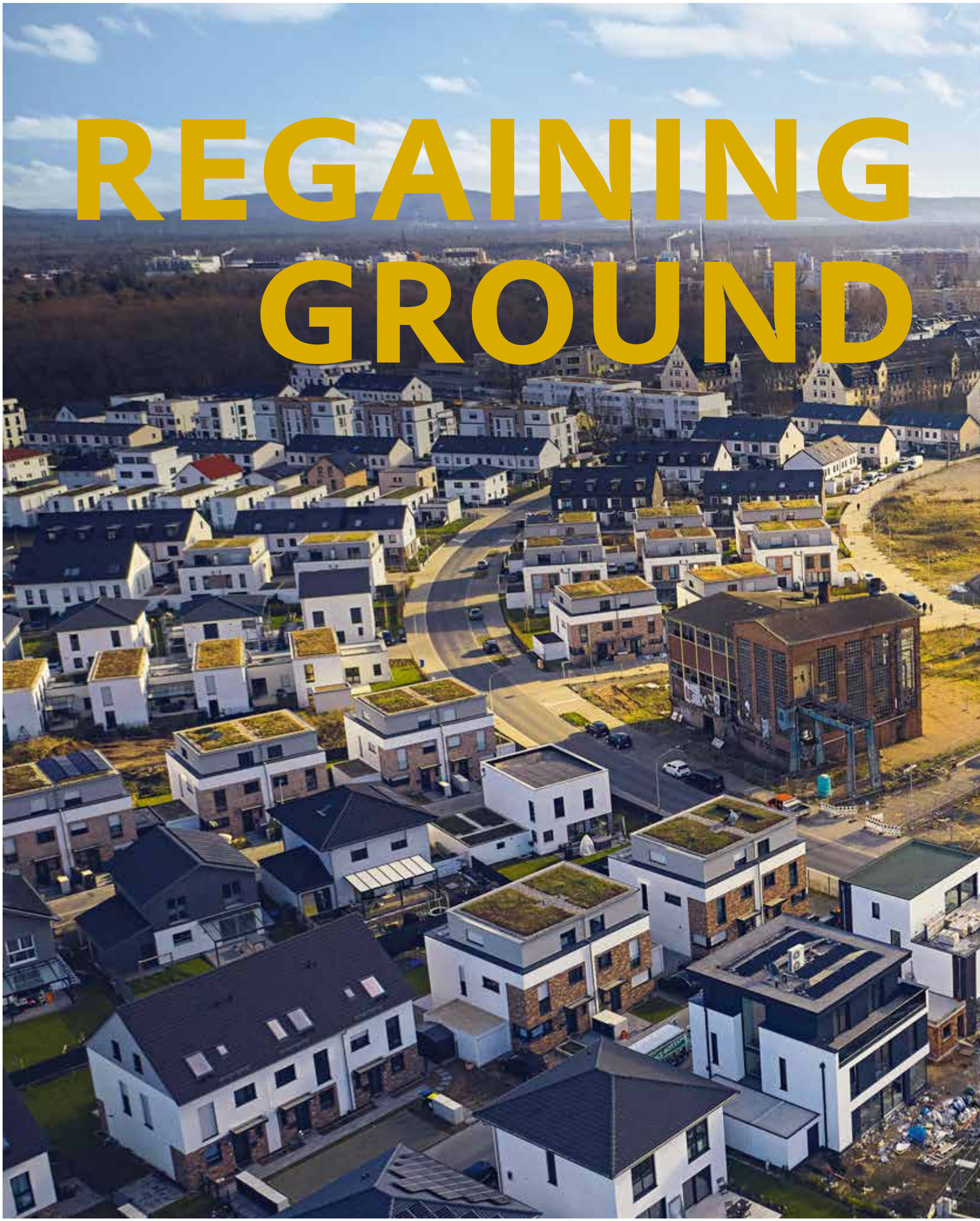
GERMANY: BOUNCING BACK

As the world's fifth largest car manufacturer, Germany is particularly affected by the mobility transition. The automotive sector is a key industry that secures numerous jobs. However, after initial successes in promoting electric mobility, the market slumped by almost 25 percent in 2024. One reason for this was that the state subsidy for e-vehicles expired at the end of 2023, which unsettled consumers. Recently, sales figures have risen sharply, not least due to stricter CO_2 limits that vehicle fleet operators have to comply with. Further subsidies are planned for a nationwide public charging infrastructure in order to increase the attractiveness of e-vehicles for buyers. Whether the political goal of putting at least 15 million all-electric cars on the roads by 2030 can be achieved is questionable. The current figure is less than 2 million.

CHINA: POWER FROM THE GOVERNMENT

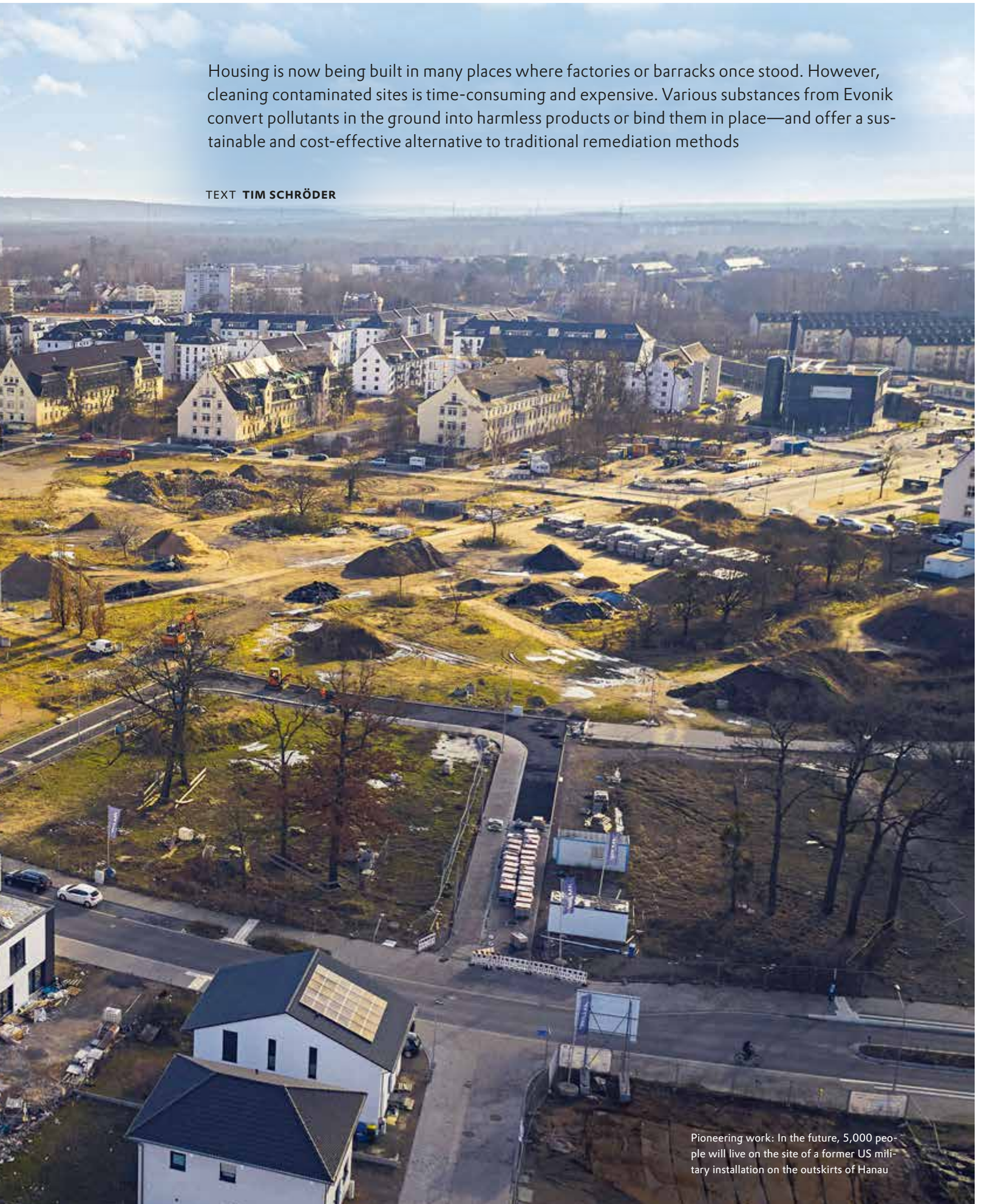
China plays a leading role in the development and production of electric vehicles and batteries. For more than 15 years, the government has been investing billions in promoting these technologies, with a particular focus on the competitiveness of the domestic automotive industry in addition to environmental aspects. The efforts have been successful. The Chinese company BYD is now the world's largest manufacturer of electric cars, with more than four million vehicles sold in 2024. From subsidies for buyers and the rapid development of a charging infrastructure to favorable loans for the industry, China's extensive support measures have enabled the sector not only to serve the huge domestic sales market but also to expand massively into foreign markets.

REGAINING GROUND



Housing is now being built in many places where factories or barracks once stood. However, cleaning contaminated sites is time-consuming and expensive. Various substances from Evonik convert pollutants in the ground into harmless products or bind them in place—and offer a sustainable and cost-effective alternative to traditional remediation methods

TEXT **TIM SCHRÖDER**



Pioneering work: In the future, 5,000 people will live on the site of a former US military installation on the outskirts of Hanau

Peter Martus (left) from the environmental consultancy firm Aecom and Gordon Bures from the remediation company Sensatec at Pioneer Park

Pioneer Park has an idyllic location, next to a forest on the outskirts of Hanau. A small river, the Kinzig, flows nearby. The residents of the new housing area will be able to go for walks here in the future, and children can play in the forest. Around 5,000 people will live on the site of the former US Army installation in a few years' time. The US military moved to the site near Frankfurt am Main after the World War II and decommissioned it in 2008. The old barracks and workshop buildings have been demolished and a residential quarter is now being built here. The site still looks a little bare, but many terraced and detached houses as well as small two-story apartment blocks are already inhabited.

What is unusual about this new development area are the arm-thick metal pipes that protrude from the ground in many places. They reach several meters deep into the ground, down to the groundwater. Technicians regularly visit the site to take water samples, because for a long time the soil contained unwanted residues from the US Army: chlorinated hydrocarbons (CHCs). CHCs are

"We took samples to determine the size of the contaminated area"

PETER MARTUS, TECHNICAL DIRECTOR AT THE ENVIRONMENTAL CONSULTANCY FIRM AECOM

fat-soluble and were used for decades in textile cleaning or to clean machines, including in the former Pioneer barracks. However, the substances are harmful to health if people come into contact with them, for example if they water their vegetables with water from contaminated domestic wells.

The fact that people can now live and work in this place is thanks to a product from Evonik. An environmentally friendly substance called EHC® Reagent causes chlorinated hydrocarbons to be converted into harmless

Special drilling machines drive metal pipes into the ground through which reagents are pumped into the soil

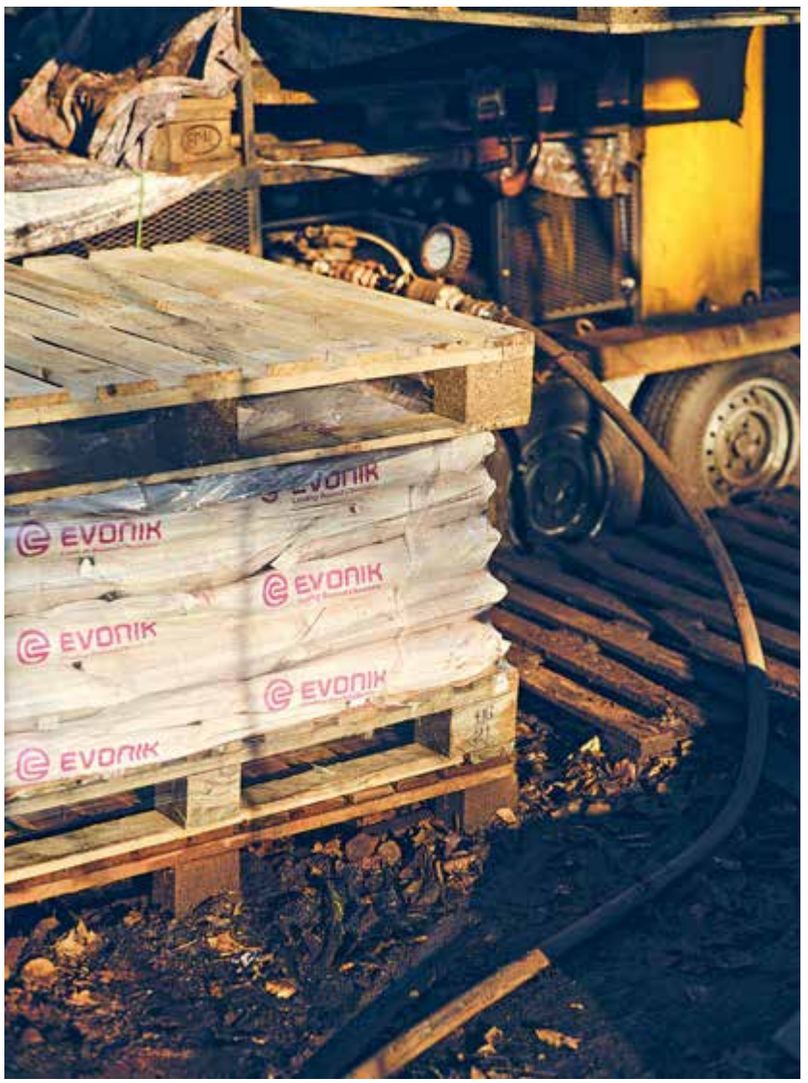
substances in the soil. This cost-effective and sustainable process could be employed in the future on many conversion sites that were previously used for industrial or military purposes, offering local authorities and the real estate sector an interesting solution.

DANGEROUS CLEANING AGENTS

Soil contaminants are a huge problem worldwide. According to estimates by the European Environment Agency, there are around 250,000 known contaminated sites in Europe alone. In addition, there are around 1.8 million areas that are suspected of being contaminated. Extensive preparatory work is required before new apartments or modern commercial areas can be built on these sites. In Germany and other European countries, contaminated material is usually dug up and sent to landfill ("dig and dump"). Alternatively, the contaminated groundwater is pumped out and treated. "These processes account for around 90 percent of the market," says Mike Mueller, who is behind the invention of EHC® Reagent.

Those responsible in Hanau also had to act before the former army site could be put to new use. Over the years, a dry cleaning facility had leaked particularly large quantities of CHCs into the soil. The military used cleaning agents containing these compounds to clean soldiers' clothing. A few hundred meters away at the old workshops, where vehicle parts used to be degreased, CHCs also entered the soil; around three tons in total.

The project development company LEG Hessen-Hanau, which took over the site a few years ago, decided to comprehensively redevelop the 500,000 square meter area. It was supported by the engineering company Aecom from Frankfurt. "The first step was to take soil and groundwater samples to determine the size of the contaminated area," says Dr. Peter Martus, Technical Manager at Aecom. The investigation showed →



The reagents for soil remediation are supplied as granules

that the groundwater flows from east to west underneath the former cleaning building and the workshop area and even transfers the CHCs beyond the barracks site as an underground contaminant plume. At around 11,000 square meters, the contaminated area was larger than a soccer field and up to 15 meters thick.

In the case of smaller contaminated sites such as gas stations, the soil can usually be removed relatively easily or the contaminated groundwater cleaned. Both procedures were ruled out in this case. It would have been uneconomical to replace the soil at several depths and across the entire width. A pump-and-treat procedure would have taken many years. In addition, the strict remediation target would probably not have been achieved. Martus therefore suggested an alternative method, cleaning the soil in situ. In this process, substances that destroy or bind pollutants and thus render them harmless are injected into the soil.

"EHC® Reagent seemed to us to be the method of choice in Hanau"

GORDON BURES, TECHNICAL DIRECTOR AT THE REMEDIATION COMPANY SENSATEC

LEG Hessen-Hanau agreed, and Martus contacted his colleague Gordon Bures from the remediation company Sensatec. Bures hails from Canada and is an expert in contaminants. "There and in the USA, EHC® Reagent from Evonik has been used for some time to clean up contaminated CHC sites," says Bures, "and it seemed to be the method of choice in Hanau too."

IRON AND PLANT FIBERS

EHC® Reagent consists of two environmentally friendly and sustainable main ingredients: coarse iron powder, which is made from scrap metal, and plant fibers, which are a by-product of horse feed production. A thickening agent is also added. If EHC® Reagent is mixed with water, a viscous mass is formed that can be easily pumped into the ground. The combination of carbon from the feed residues and elemental iron gives the product a special property: It attacks the toxic chlorinated hydrocarbon molecules in several ways and thus breaks them down thoroughly.

In view of the enormous size of the site, the partners in Hanau proceeded slowly. In a pilot phase, EHC® Reagent was initially pumped into the ground in the particularly heavily contaminated area around the former dry cleaning facility. "We wanted to see the extent to which the CHCs were actually being broken down," says Bures. After the injection of the EHC® Reagent mass was completed, Aecom employees regularly took groundwater samples. After a few months, they could see that the CHC molecules had been freed from the chlorine atoms, i.e. dechlorinated, by the biological and chemical reactions in the soil. Later, the only decomposition products detectable in the groundwater were small carbon compounds, chloride, and water. "This is a great success," says Bures. Injection wells were then drilled throughout the contaminated area. As the groundwater analyses show, the CHCs have now been broken down almost everywhere in the remediated areas.

Mixing machines are used to mix the reagent with water to form a viscous mass

Bures is one of the developers of the injection method, in which a drill pipe is slowly driven into the ground. The drilling process is paused approximately every 50 to 75 centimeters and EHC® Reagent pumped into the ground via the drill pipe (see the diagram on pages 36–37). The pressure expands the pore space underground so that the mass is distributed in a radius of up to five meters around the borehole. A total of 200 tons of EHC® Reagent were pumped into the ground at Pioneer Park. Little by little, it destroyed the CHC molecules so that the groundwater flowing through the area today no longer contains any pollutants. Because the EHC® Reagent suspension is viscous, the groundwater cannot wash it away. It stays in place for several years.

The CHCs are broken down in three different ways. Firstly with the help of soil bacteria and secondly via two different chemical reaction pathways with the help of iron. The carbon contained in the feed waste serves as food for the bacteria. They break down the food residues and release various fatty acids, including formic, butyric and lactic acid. These fatty acids in turn feed other bacteria that dechlorinate the CHCs. The chemical reaction with the iron takes place directly. In the first case, the iron reacts immediately with the chlorine compounds. In the second, it first dissolves in the groundwater and then breaks down the CHCs via a slightly different reaction path.

FROM A STARTUP TO PART OF EVONIK

The American manager Mike Mueller has accompanied the development of EHC® Reagent from the very beginning. He first established the product in the USA and Canada with his startup. The startup was then absorbed by the US company Peroxychem, which was taken over by Evonik in 2020. Since then, Mueller has been working for the specialty chemicals company, and is now introducing EHC® Reagent to the European market as a promising substance for in-situ processes. “EHC® Reagent’s strength is the combination of bacterial and chemical decomposition. This makes the process particularly efficient,” says Mueller. →

Evonik soil remediation expert Mike Mueller at the Hanau-Wolfgang site

ARSENIC AND OLD IRON

How toxic metals can be bound in the soil

Evonik is also currently dealing with a contaminated site in a second project in Hanau. It involves the *in-situ* remediation of an area on a factory site that is contaminated with arsenic compounds. In 1875, the Royal Prussian Gunpowder Factory was established there, which also processed arsenic during the First World War. Some of the arsenic at the site is geogenic—it comes from natural sources. Under parts of the facility, the arsenic was originally bound in solid iron compounds in bog iron ore deposits in the ground. However, the work in the gunpowder factory and other industrial activities during the long period of use chemically altered the soil in such a way that the arsenic was released from the bog iron ore. "Today we are faced with the task of securing this historic contaminated site so that the arsenic does not continue to pollute the groundwater," says Pascal Endres, who is responsible for contaminated site management at Evonik's Hanau facility. Until now, the groundwater has been continuously pumped out to prevent it from carrying arsenic beyond the plant site. However, pumping consumes a lot of energy and the pumps require regular maintenance. "After considering various options and intensive concept coordination with the responsible authority and our environmental expert, we decided to use an in-situ measure. It's a more sustainable cleanup method," says Endres. Injection drilling is currently being carried out in Hanau, as was previously done at Pioneer Park. However, the products used in Hanau are GEOFORM® ER and METAFIX®, two reagents that create suitable geochemical conditions in the subsurface to immobilize the arsenic. Specifically, they create the extremely durable and inert mineral arsenopyrite, which also occurs in natural rock. "Hydrocarbons such as those at Pioneer Park can be chemically decomposed, but metals such as arsenic cannot," explains Endres, "so it makes sense to chemically bind them permanently on site so that they no longer pollute the groundwater."

"The mixture of bacterial and chemical decomposition makes the process particularly efficient," says Mueller

MIKE MUELLER, EMEA BUSINESS MANAGER FOR SOIL & GROUNDWATER REMEDIATION AT EVONIK'S ACTIVE OXYGENS BUSINESS LINE

Evonik's solution meets even the most stringent requirements. As there is a drinking water extraction point in the immediate vicinity of Pioneer Park, the responsible authorities have set a maximum CHC value of 20 micrograms per liter of water, which corresponds to the standard for potable water. Normally, limit values of a few hundred micrograms are set as a remediation target for urban areas. The water samples that are regularly taken on the site show that the level is already below 20 micrograms in many areas. Measurements will also be taken regularly at a total of 140 locations in the years ahead.

Some investors and agency representatives still tend to remove the contaminated soil, reports Mueller. Some people are not comfortable with the idea of treating the pollutants underground. However, Mueller has since been able to convince the relevant agencies in several federal states that EHC® Reagent is a sensible alternative. In the meantime, it has also been used in more than 200 projects throughout Europe.

Water samples are regularly taken in Pioneer Park to document the progress of the remediation work

A total of 200 tons of EHC® Reagent have been used at Pioneer Park, making it the largest remediation project for the substance in Europe to date. “If the contaminated area had been excavated, hundreds of truck journeys would have been necessary to remove the soil,” says Mueller. Martus and his colleagues at Aecom have analyzed in detail how much more environmentally friendly the in-situ process is compared to excavation or groundwater purification. They took truck transportation, the power consumption of the pumps, and many other parameters into account. This showed that remediation using EHC® Reagent at Pioneer Park produced 90 percent less carbon dioxide emissions than the excavating contaminated ground and 70 percent less than pumping out and treating the groundwater.

The *in-situ* method is also more cost-effective. Soil remediation with excavation, removal, and dumping or treatment of the soil would have been at least three times as expensive as the *in-situ* treatment with EHC® Reagent. For the construction industry and investors, military and industrial wastelands are attractive areas on which apartments can be built, says Mueller. “EHC® Reagent enables land to be sustainably and, above all, quietly freed from contamination.”

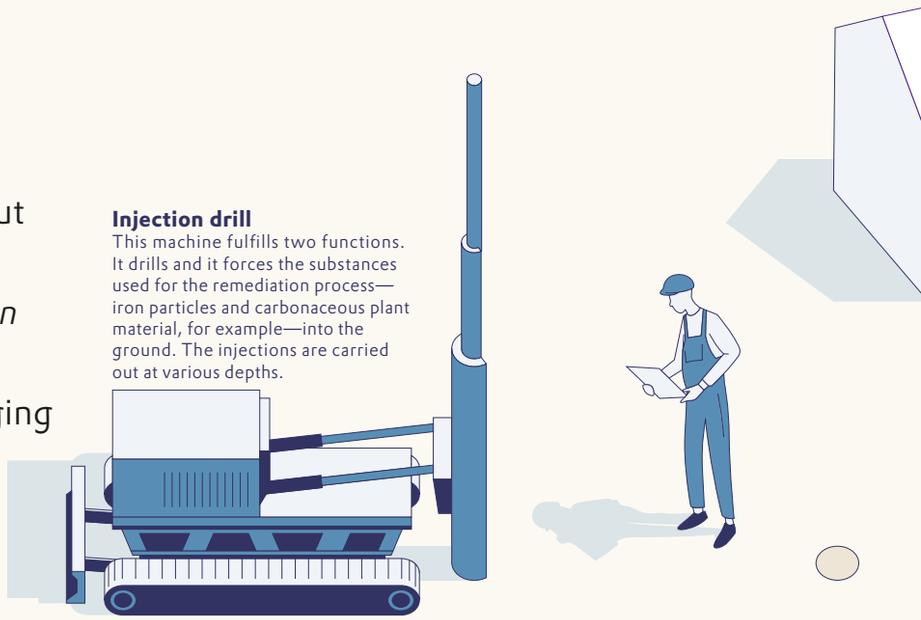
Others also seem to see the Pioneer Park project as a complete success. In 2024, it was honored with Germany’s most important award in the remediation industry, the Brownfield Award. The project was awarded third place in the “Particularly sustainable” category. —

Tim Schröder is a science journalist who lives in Oldenburg

Clean solution

It's not necessary to dig up or pump out pollutants from the ground— the contamination can be made harmless *in situ.* This is done by injecting into the ground substances that convert damaging chemical pollutants into harmless materials

INFOGRAPHIC **MAXIMILIAN NERTINGER**



Injection drill
This machine fulfills two functions. It drills and it forces the substances used for the remediation process—iron particles and carbonaceous plant material, for example—into the ground. The injections are carried out at various depths.

Drill channels
The drilling and injection take place in the same bore. Drilling is paused at intervals of about 50 to 75 centimeters in order to inject the material. The drilling is then restarted.

Aquicludes
These layers of ground are so dense that they are hardly permeable to water.

–5m

Injection
The emulsion is injected under pressure. It spreads out in the pore spaces of the ground and forms a reactive zone in which the pollutants are converted.

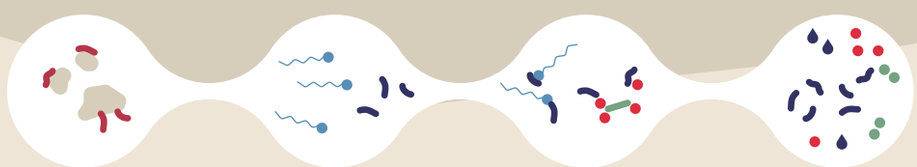
–10m

Aquifer
Aquifers consist of sand, gravel, and loose stone and are porous to water. They are often tapped for drinking water.

DECOMPOSITION PATHS FOR CHLORINE COMPOUNDS

The chlorine compounds are broken down in three ways, one of which uses a carbon source and two that use iron particles.

Decomposition using carbon

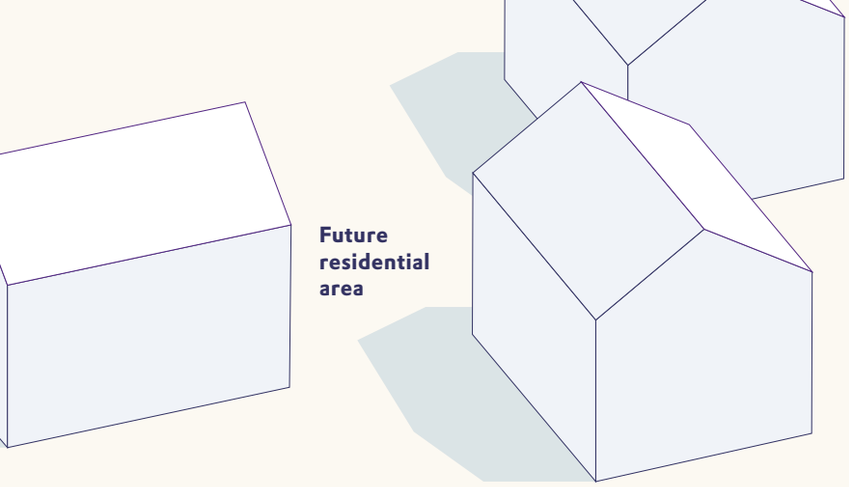


Heterotrophic **bacteria** break down **plant material**.

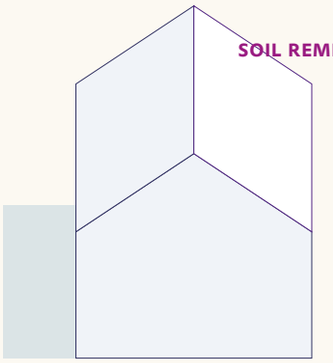
This decomposition process releases **fatty acids** that alter the soil chemistry and enable another sort of **bacteria** to thrive.

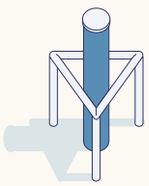
These **bacteria** feed on the **fatty acids** and break down the toxic **chlorine compounds** by splitting off the chlorine.

They leave behind a carbon skeleton that reacts in the ground to form small **carbon compounds** and **water**.



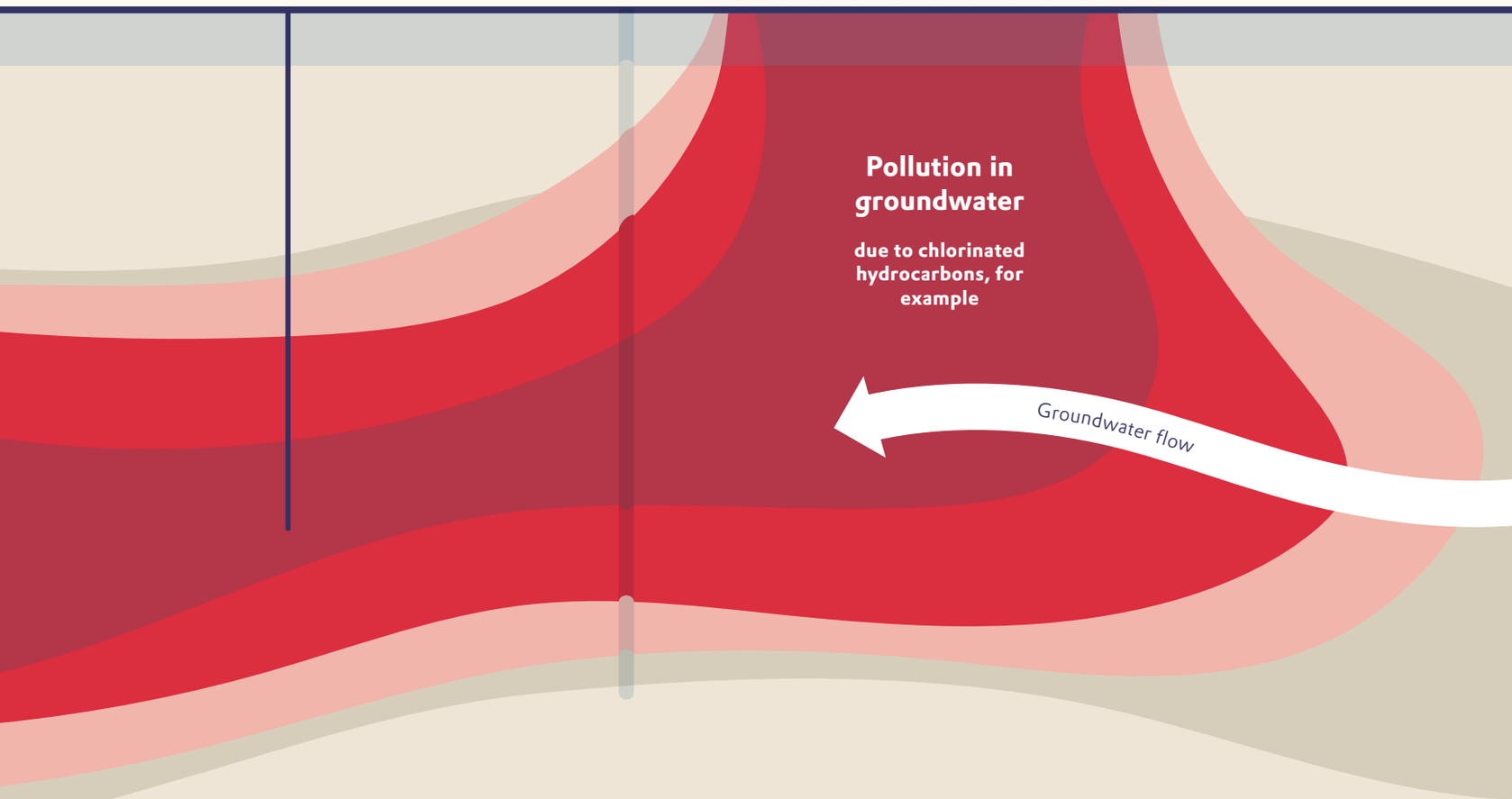
Future residential area





Groundwater sampling points
Two to four times a year groundwater samples are drawn via pipes from depths of several meters in order to check for contaminants.

Source of pollution

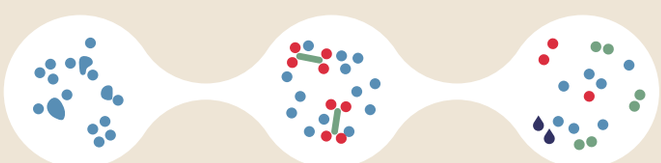


Direct chemical reaction with iron

Iron particles react directly with toxic **chlorine compounds** and split off the chlorine.

They leave behind a carbon skeleton that reacts in the ground to form small **carbon compounds** and **water**. The **chlorine** reacts in the ground to form non-toxic hydrochloric acid molecules.

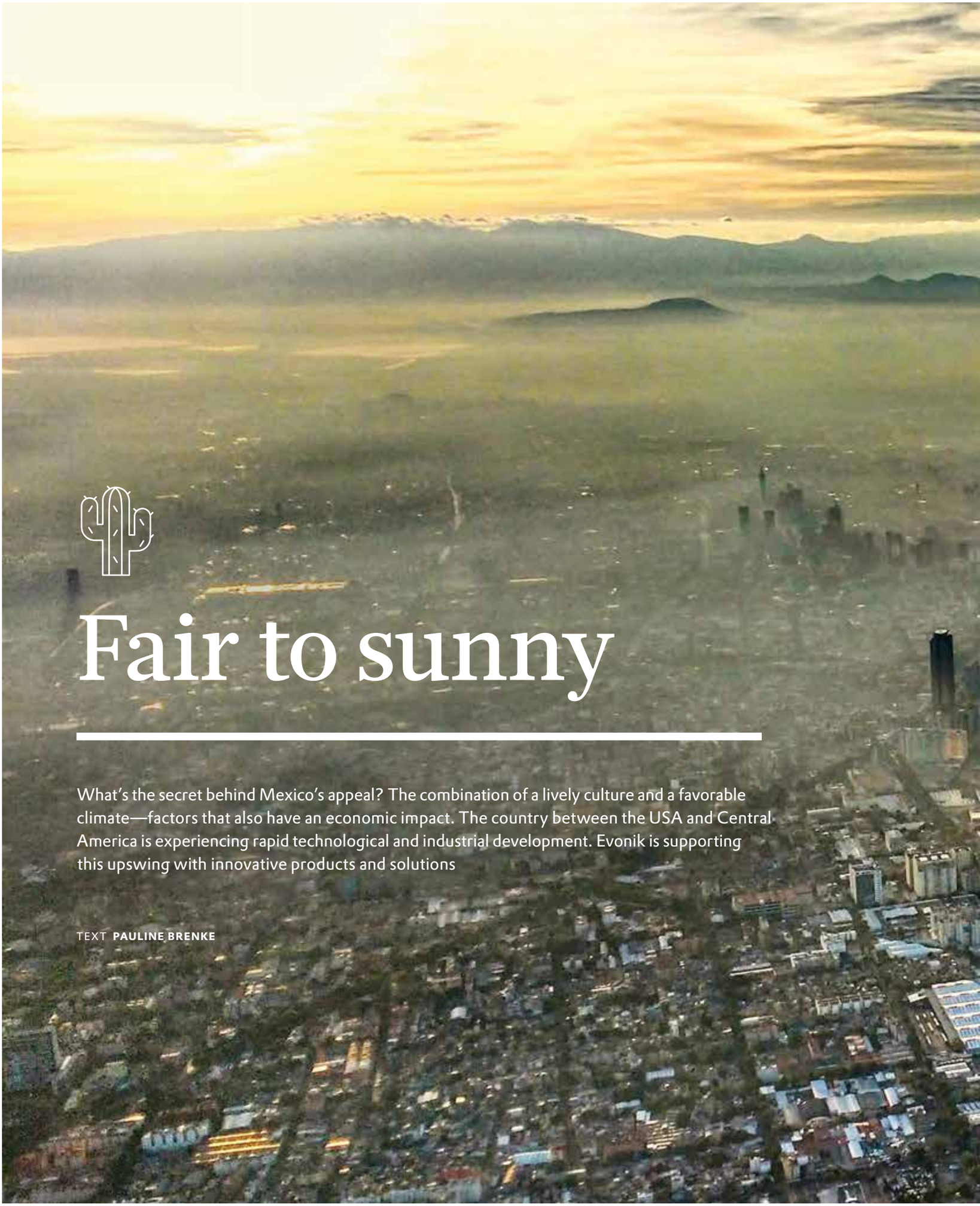
Indirect chemical reaction with iron



Iron particles in the ground are transformed into dissolved iron.

The dissolved **iron** reacts with the toxic **chlorine compounds** and splits off the chlorine.

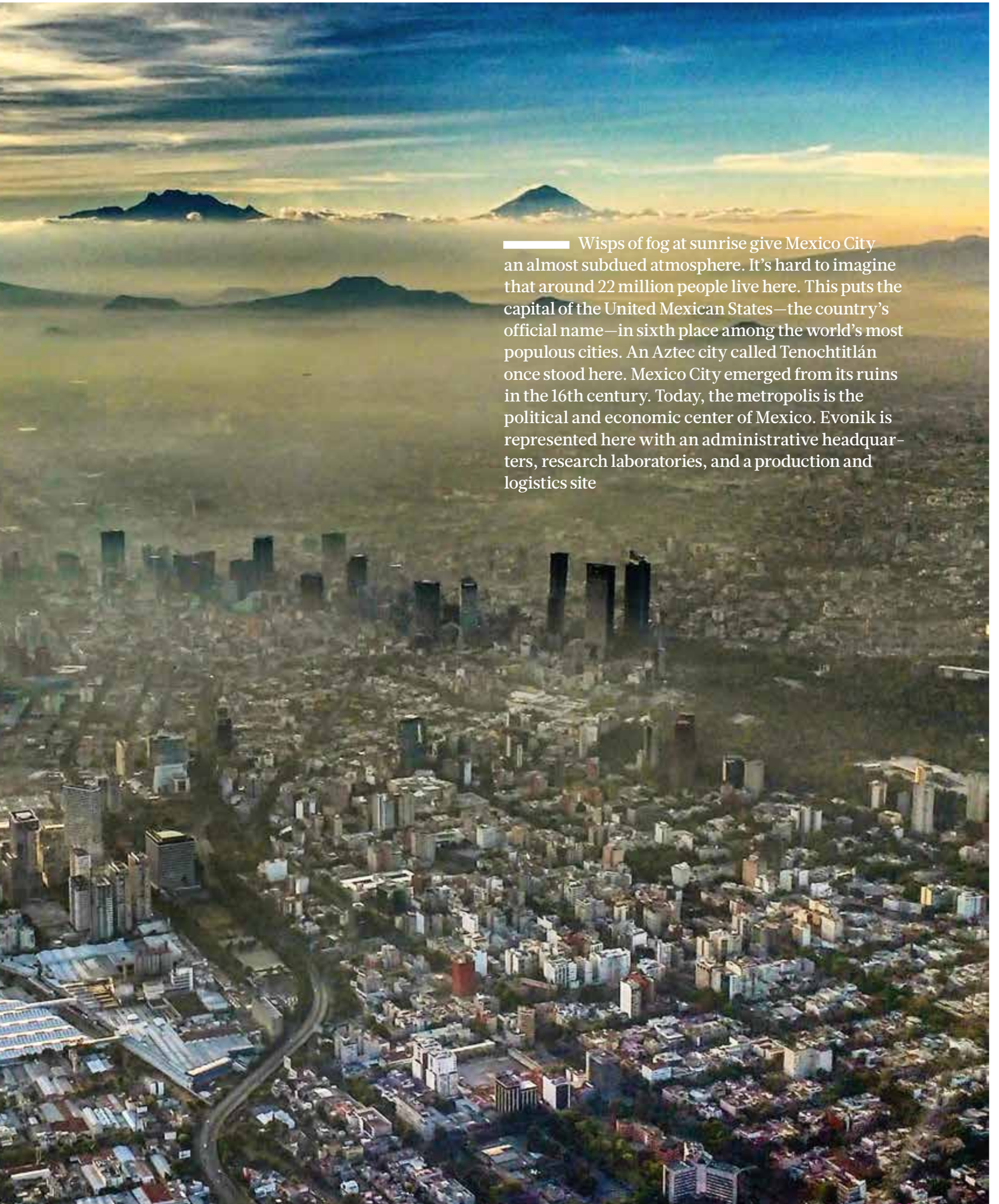
In the end, this reaction path also leads to the formation of small **carbon compounds** and **water** along with hydrochloric acid molecules.



Fair to sunny

What's the secret behind Mexico's appeal? The combination of a lively culture and a favorable climate—factors that also have an economic impact. The country between the USA and Central America is experiencing rapid technological and industrial development. Evonik is supporting this upswing with innovative products and solutions

TEXT **PAULINE BRENKE**

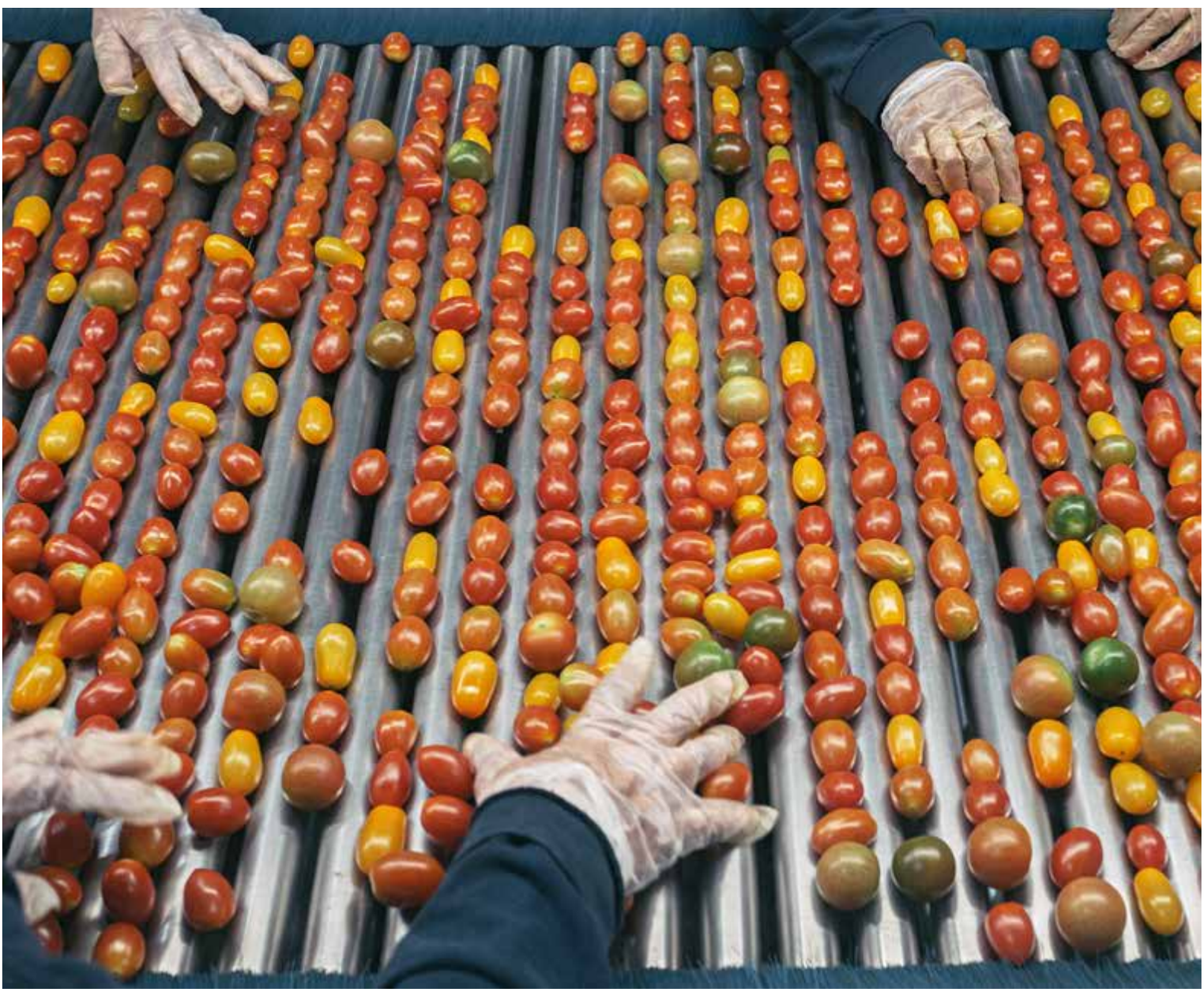


Wisps of fog at sunrise give Mexico City an almost subdued atmosphere. It's hard to imagine that around 22 million people live here. This puts the capital of the United Mexican States—the country's official name—in sixth place among the world's most populous cities. An Aztec city called Tenochtitlán once stood here. Mexico City emerged from its ruins in the 16th century. Today, the metropolis is the political and economic center of Mexico. Evonik is represented here with an administrative headquarters, research laboratories, and a production and logistics site

Mariachi is an important part of the country's culture and was added to UNESCO's Lists of Intangible Cultural Heritage in 2011. Contrary to popular belief, mariachi is not a musical genre, but a band with a broad repertoire of styles. These include polkas, waltzes, and typical Mexican *corridos*—ballads that tell of battles, heroic deeds, and love. The typical mariachi sound is created by an interplay of trumpet, guitar, violin, *vihuela*—a small, five-stringed instrument—and *guitarrón*—a bass guitar. Evonik supplies the high-performance polymer VESTAMID® for the strings, which ensures a good feel when playing and a clear, powerful sound.

A visit from the beyond: On the Day of the Dead, or *Día de los Muertos* in Spanish, people in Mexico celebrate the temporary return of the souls of their deceased loved ones. The festivities take place every year from October 31 to November 2 and show the special way Mexicans deal with the subject of death: Instead of mourning, there are processions, dancing, singing, and elaborate altars with lavish offerings for the dead. For many, dressing up as a skeleton is also part of the tradition. The artistic painting of one's face as a skull is particularly important. Silica from Evonik stabilizes color pigments in decorative cosmetics, improving their structure, and promoting the even distribution of color.

Moderate to tropical temperatures and plenty of sunshine—good conditions for a vacation and even better conditions for growing tomatoes. Tomatoes are in season 365 days a year in Mexico; no other country in the world exports more of the nightshade plant. Workers like these in San Juan del Rio carefully select the best tomatoes for domestic and foreign markets. Around 20 percent of Mexico's entire fruit and vegetable production is exported. In addition to tomatoes, oranges and avocados are also very popular. Evonik's Active Oxygens business unit helps ensure that the harvest stays fresh longer: Fruit and vegetables are cleaned in an environmentally friendly way in washing water containing peracetic acid and hydrogen peroxide.



An employee reaches up to his shoulders into the wing of a Boeing jet to conduct maintenance work. In addition to the US manufacturer, other major players such as Airbus and Safran are also established in Mexico. They are among a total of 370 companies in the aviation industry in the country—and this number is rising. A key location for the industry is the city of Querétaro in central Mexico. Evonik is also represented here with a logistics center and the company's largest rail terminal. Evonik provides important know-how for the aerospace industry. For example, it produces heat- and corrosion-resistant high performance polymers for aircraft.

CONNECTED BY RAIL

Evonik is represented twice in the metropolitan area of Mexico City: by an administrative headquarters and two laboratories for the Coating Additives and Care Solution business units in the south of the city, and by a warehouse and logistics center for the Active Oxygens business unit in Santa Clara. Another location with a large rail terminal is in Querétaro. A warehouse and distribution center for all business units is located in Monterrey, close to the US border.

Evonik locations
1 Mexico City
2 Santiago de Querétaro
3 Monterrey
4 Santa Clara del Cobre

Evonik has around

125

employees at

4

locations

CULTIVATING RELATIONSHIPS

Abolis founder and CEO Cyrille Pauthenier wants to support the chemical industry in becoming more sustainable by using micro-organisms to produce biobased ingredients

Cosmetics don't just make us look and feel good, they are increasingly eco-friendly too. Through innovation, partnerships and acquisitions, Evonik is reinforcing its focus on biobased ingredients and sustainable production. Now, with beauty giant L'Oréal, the company has invested in the French startup Abolis, which uses biotechnology to produces molecules for care products

TEXT **SINA HORSTHEMKE**

As you head southward from Paris on a regional train, it takes you just under one hour to reach the small station "Le Bras de Fer." When you get off the train here, you are greeted by billboard-sized photos of laboratory scenes announcing the Genopole biotechnology park, which is within walking distance. Sixty-five companies are based there, one of which is Abolis. Founders Valérie Brunel and Cyrille Pauthenier receive visitors in their office. "It's still quite sparse here," apologizes Pauthenier, "We only rented this wing a few weeks ago."

Fifty-five employees currently work at Abolis, and this number is set to double over the course of the year. The biologists, software engineers, experts in robotics and fermentation, bioinformaticians, and IT professionals that work here all have one goal: They want to help the chemical industry become more sustainable with biobased ingredients. They do this by inducing microorganisms to produce substances that would otherwise have to be extracted in a much more complex way. "Abolis aims to help satisfy the needs of our society without jeopardizing its future," says Pauthenier, summarizing his company's vision. →

“Thanks to its bio-based products, Abolis was a perfect fit”

DR. THOMAS SATZINGER, VICE PRESIDENT STRATEGY
EVONIK CARE SOLUTIONS

Evonik will scale up the production processes and enable manufacturing on an industrial scale, for example at the Slovenská Ľupča site in Slovakia

To come a step closer to this vision, the company has entered into a strategic partnership with Evonik and the cosmetics manufacturer L’Oréal. Thomas Satzinger, the industrial engineer who is responsible for the strategic orientation of Evonik’s business with care products and ingredients for cosmetics, played a key role in driving the project forward. “We have ambitious goals for the transformation of our portfolio. On the one hand, we want to increase the proportion of our specialties and on the other we want to become more sustainable. Biosourced raw materials that require less agricultural land, for example, play a decisive role here. Thanks to its biobased products, Abolis was a perfect fit.”

Abolis can accelerate the research and development of innovative biomanufacturing and microbiome solutions thanks to the investment of an international consortium last July that includes, among others, BOLD, L’Oréal’s Corporate venture capital fund, the DeepTech & Climate Fund, and Evonik Venture Capital.

STRICTER REQUIREMENTS, MORE DEMAND

Sustainability in the cosmetics sector is about much more than just CO_2 emissions. In order to make shampoo, make-up, and skincare products more resource-efficient and environmentally friendly, manufacturers need to consider the selection of raw materials and the way the products are formulated as well as how they are used in the consumer’s bathroom. The cosmetics industry is committed to improving its entire value chain by addressing multiple key areas. These include issues such as the conversion of environmentally valuable land, the type of cultivation, and fair working conditions in agriculture.

The efficient use of raw materials in the production of cosmetics is just as important as the biodegradability of the cosmetic products themselves. Through innovative eco-design principles, manufacturers are striving to optimize product usage by consumers, reducing packaging material and energy consumption.

The sustainability of cosmetic products plays an important role for more and more consumers. The analysis company Straits Research estimated the volume of the market for biobased cosmetic and personal care

In strain development, Abolis experts identify yeasts that are suitable for industrial production

ingredients at more than 5.2 billion US dollars in 2023. It is expected to rise to more than 8.6 billion US dollars by 2032. “The legal requirements have become stricter and our customers are also increasingly selecting ingredients based on environmental criteria,” confirms Satzinger. “For several years, Evonik has been using targeted enzymes to produce cosmetic oils in order to make a significant contribution to reducing emissions from cosmetics. At first, only a few customers wanted them. Today, they are in high demand.” Most of the ingredients for cosmetics that Evonik produces are now biodegradable, says Satzinger. “New products must meet this criterion from the outset.”

However, responsible handling of valuable plant resources and their environmentally friendly processing are not enough by themselves, he emphasizes: “The performance of a product must also be right.” The best example of this is glycolipids, which also include rhamnolipids. These biosurfactants are both skin-friendly and powerful cleaners as well as being extremely biodegradable. In 2024, rhamnolipid production started at a new plant in Slovakia, making Evonik the world’s first company to produce biosurfactants on an industrial scale—a milestone on the road to greater sustainability. →

From Plant-Based Cholesterol to Alternative Preservatives

How Evonik strengthens its expertise in biocosmetics through company purchases. A selection of key acquisitions:

2017: DR. STRAETMANS—NORTHERN GERMAN PRESERVATION IDEAS

Preservatives in cosmetics protect the formulation and reduce the risk of microorganisms multiplying in creams or lotions. The Hamburg-based company Dr. Straetmans, founded in 1984, which Evonik acquired over seven years ago to strengthen its position in the cosmetics industry, is an expert in alternative preservation systems. The site is set to be developed into a globally recognized center of competence for alternative preservatives. Unlike conventional preservatives, these alternatives not only maintain the quality of a product but also serve additional functions, such as providing moisture to the skin. The use of these alternative preservation systems is complex; accordingly, Dr. Straetmans’ experience has also enhanced formulation expertise at Evonik.

The various candidates for producing the desired substances are tested in the lab

2020: WILSHIRE TECHNOLOGIES —PHYTOCHEMISTRY FROM THE USA

The research and development conducted at Wilshire Technologies significantly expands Evonik's range of natural ingredients. Phytochemicals, such as plant-based cholesterol and essential oils, are the specialty of this biotechnology firm, which was founded in 1997 in Princeton, New Jersey. Wilshire Technologies has made a name for itself in green chemistry, producing bioactive ingredients for the pharmaceutical and food industries. Founder Joe San Filippo was previously a chemistry professor at Rutgers University in New Jersey.

INVESTMENT IN EXPERT KNOWLEDGE

Evonik does not develop every process on its own. Where it makes sense, Evonik invests in companies that have acquired expert knowledge in their respective fields. Around a dozen companies are thus expanding the portfolio of solutions (see boxes): Dr. Straetmans from Hamburg, for example, contributes expertise in preservation, while Botanica from Switzerland and Novachem from Argentina contribute plant extracts.

Further progress might now be achieved by a collaboration between Abolis, Evonik, and L'Oréal. The three partners want to produce ingredients using biotechnology in the future. Satzinger explains how this cooperation will work: "If L'Oréal needs an ingredient for a product, Abolis will develop its biotechnological solution in the laboratory. If the process works on a small scale, Evonik will take it over and transfer it to larger systems for industrial production."

The founders of Abolis are well-versed in the biobased production of molecules: Valérie Brunel, 54, is a chemist and expert in innovation management, while Cyrille Pauthenier, 36, is a chemist and biologist. "We met in 2013, when Cyrille was an ambitious young researcher with an entrepreneurial spirit and Abolis was nothing more than a PowerPoint presentation," says Brunel. The fact that Abolis joined the Genopole research campus made the start easier: "In the beginning, we only had a workbench, an office, and a set of pipettes. We were able to borrow a lot of the super-expensive equipment we needed here," says Brunel.

In the first ten years, says Brunel, they only raised one million euros, "which is not much for a biotech-company." The State, which supports young French companies, provided startup assistance in the form of grants. "But we had sales right from the start and managed to run the company with as few expenses as possible." The fact that they could lease equipment also helped. The first collaborations with large companies, such as pharma group Servier, cheese manufacturer Bel, food group Lesaffre and, in 2019, L'Oréal, were established after just a few years. Abolis now has its own equipment. And that, says Pauthenier, is one of his company's four treasures, "along-

In the beginning, Abolis had to borrow the analytical equipment—now, they work with their own robots to screen the strains

“Together with L’Oréal and Abolis, we can cover the entire value chain”

VALÉRIE BRUNEL, CO-FOUNDER & GENERAL MANAGER ABOLIS

side the data, the employees, and our yeast strains.” The yeast strains’ genome is modified by Abolis so that they produce a desired product from simple starting materials such as sugar. The process is similar to brewing beer, in which yeast converts malt sugar into alcohol through fermentation—except that the yeast fungi at Abolis are programmed to produce other substances.

The genetic engineering of yeasts is Abolis’ core competence, say the founders. However, they emphasize that they are not discovering new active ingredients but merely finding new ways to produce already known molecules in a more resource-efficient way, or molecules that could only be produced by biotechnology. “Sometimes, for example, the cosmetics industry is interested in a substance that is only found in minute quantities in a particular plant,” says Pauthenier. “Growing millions of tons of it for industry and extracting the molecule from it makes no ecological sense and is often impossible in practice. However, using our yeasts, we can develop a method to do it with a smaller footprint. In this way, we also bring to life active ingredients that could not otherwise have been produced on a large scale.” Biotechnological production can replace chemical production, conserve fossil sources or rare resources and, according to Pauthenier, is more stable and more easily scalable than natural plant growth.

But there is a long way to go before the yeasts produce what they are supposed to. It begins in the computer science and modeling department at Abolis. Here, engineers develop sequencing software, maintain the databases, control the robots in the laboratory and back up the genome data. The experts have to keep an eye on all kinds of imponderables, such as ensuring that the yeasts do not poison themselves with the product they are making. If Abolis considers the production of a substance by a strain to be feasible, employees in the laboratory implement what the IT experts have previously worked out.

THE TRICK IS IN THE PROGRAMMING

Flasks with blue lids and clear yellowish liquid circle in shaking incubators, centrifuge tubes are arranged in an orderly fashion on the workbenches, and plates with →

2021: BOTANICA—SWISS PLANT EXPERTISE

For over three years, Botanica has been part of Evonik. Like the other specialized companies mentioned, Botanica is integrated into the Care Solutions business line. Since 1998, the Swiss company has specialized in extracting ingredients for the personal care industry from flowers, leaves, buds, fruits, roots, or bark—available as extracts, tinctures, concentrates, or distillates, depending on the need. Botanica is considered the market leader in its segment across Europe. The company, based in Sins in the Aargau canton, offers a portfolio of more than 1,000 plant raw materials, ranging from apple mint to cedar, enriching Evonik's active ingredient portfolio.

The analyses from the high-throughput mass spectrometers show whether a yeast strain is good enough for the next step—the fermentation

culture media are stacked next to them. An employee in a white coat and gloves carefully pipettes a clear liquid into small reaction vessels with plastic lids. It looks like a classical biotechnology laboratory. "The difference is in these tubes," says Abolis co-founder Pauthenier, pointing to the liquid in the reaction vessels.

Next comes a room kept at a constant temperature of 19 degrees Celsius. Several high-throughput mass spectrometers analyze samples simultaneously, and an automatic pipetting and sample processing station does its work. "This is where it's decided whether a yeast strain created in the laboratory is good enough to be taken further in our fermentation process," explains Pauthenier.

One floor down, three robots stand in a light-flooded room: One of these robots can completely automatically dilute up to 96 samples simultaneously—much faster and more precisely than a human. A second one isolates and purifies DNA. It can handle up to 600 samples in one working day and uses very little disposable material such as pipette tips. Finally, the third robot is specialized in distributing reagents onto plates, among other things. "You can buy a few robots quickly," says Pauthenier. "But programming them so that they run as they should takes years." It's a task that the IT experts at Abolis are taking on.

One of these experts is working on his laptop next to the latest device: Behind a glass pane, a gripper arm moves reagent vials back and forth. The device costs around 350,000 euros and is intended to categorize yeast strains in the future. Pauthenier sees robotics and artificial intelligence as a valuable addition to his team's skills, no more and no less. "They cannot replace human creativity and intuition," he says.

MORE THAN THE SUM OF ITS PARTS

The recently concluded industrial partnership offers Abolis a huge opportunity. The biotechnology specialists from south of Paris have been working with the Beauty giant L'Oréal's R&I for five years. However, the three-way constellation with Evonik offers new

Abolis' industrial solutions stand out particularly because they are based on yeast rather than bacteria

opportunities: "The three of us can cover the entire value chain," says Abolis co-founder Brunel enthusiastically. There was always this gap before: "We talked to L'Oréal about new ingredients, but we can't produce them in large quantities. So we brought Evonik on board as a third partner."

Brunel and Pauthenier also see Evonik as a pioneer in microbiome research, particularly for animal health. "The animal microbiome is an area in which we are also developing expertise that could complement Evonik's work."

Guillaume Climeau, Head of Business Development and Alliance Management at L'Oréal R&I, also has high hopes for the cooperation: "Abolis has the biotechnological expertise, we are familiar with the formulation and the consumers, and Evonik has unique expertise in the industrialization of the processes developed by Abolis."

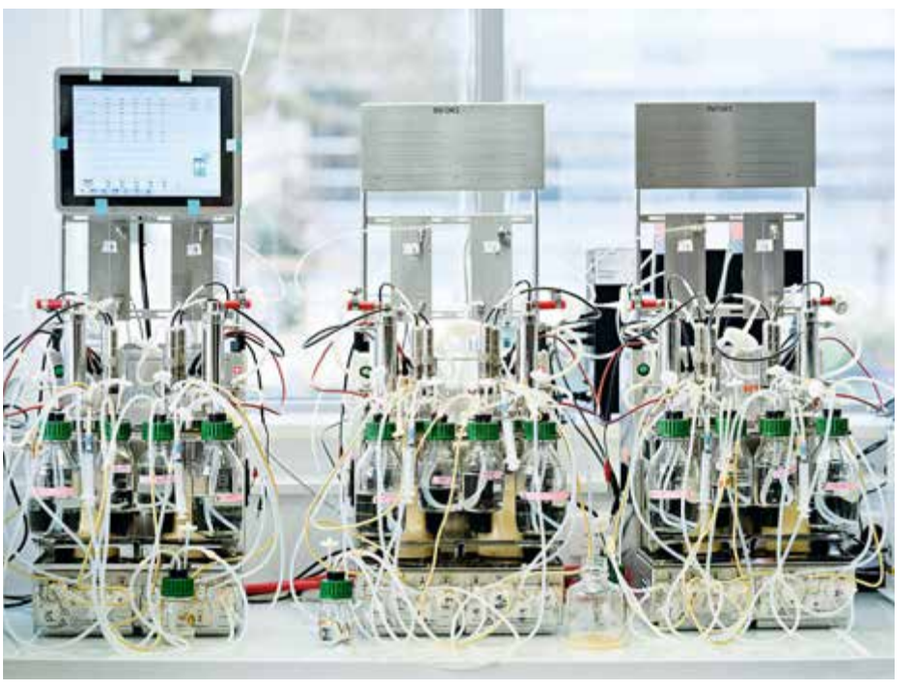
The Beauty group is expanding its portfolio with biobased ingredients (see also the interview on page 55) and is confident of achieving results more quickly through →

2021: INFINITEC ACTIVOS—SPANISH ACTIVE INGREDIENT CARRIER SYSTEMS

To ensure that cosmetic active ingredients reach their target, such as deeper skin layers, carriers can be used as transport systems. The Spanish company Infinitec Activos, which Evonik acquired in 2021, is a specialist in their development and production. The company expands Evonik's active ingredient carrier business with seven systems and several natural active ingredients. Infinitec Activos is headquartered at the Barcelona Science Park, complemented by a production facility in Montornès del Vallès and Naturethic, a producer of natural raw materials

2023: NOVACHEM—PLANT EXTRACTS FROM SOUTH AMERICA

In the summer of 2023, Evonik acquired Novachem to expand its portfolio of plant-based ingredients for cosmetics. The Argentine company, based in Buenos Aires, was founded in 2007 and develops biotechnological, natural, and sustainable active ingredients for skin and hair care products for Evonik. It uses raw materials from Latin America, one of the most biodiverse regions in the world. Novachem develops environmentally friendly technologies and processes, combined with field projects that protect regional biodiversity.



Fermentation is the final step at Abolis. Models are used to test whether the developed product can also be produced on an industrial scale

new forms of collaboration. "Whenever we jointly build something in a creative encounter, one plus one plus one equals more than three," says Climeau.

At the last station, the fermentation laboratory, Abolis co-founder Pauthenier shows what this means for collaboration at the Genopole research campus. Here, the yeasts prove that they can handle production volumes of up to 20 liters.

Evonik then takes over the process and starts production on a larger scale with the yeasts from France. To ensure that the scaling up is successful, the experts from Evonik have already been closely involved in the development process. "Simply throwing the results over the fence when one side is finished doesn't work. We are in contact with Abolis from the outset in order to identify at an early stage which steps need to be taken to optimize the manufacturing process," explains Thomas Satzinger. At Evonik, the choice of manufacturing location depends on the desired product—but one important location is certainly the biotech hub in Slovenská Ľupča, Slovakia, with its decades of experience in fermentation and the downstream purification process.

It won't be long before the first L'Oréal products containing biotechnologically produced molecules from Abolis and Evonik will be on the shelves of retailers worldwide. "I would expect to see the first successes of our collaboration in a few years," says Satzinger. Abolis founder Cyrille Pauthenier is looking forward to this: "It's very meaningful to do something that is scientifically exciting and challenging, that is economically and socially useful, and that also helps the environment. From a global perspective, we may only be a small stone, but even small stones can set big things in motion." —

Sina Horsthemke is a science journalist based in Munich. She has a degree in biology and writes primarily about health-related topics

"We share the same vision"

L'Oréal is the world's leading cosmetics manufacturer. Guillaume Climeau, the company's Head of Business Development and Alliance Management for R&I Open Innovation, explains what sustainability and the tripartite collaboration with Abolis and Evonik mean for L'Oréal

Mr. Climeau, along with price and quality, sustainability is playing an ever-greater role in customers' purchasing decisions. How do you react to these requirements?
L'Oréal has been a pioneer of sustainability in the beauty sector for more than 30 years. As the market leader, we have a responsibility to positively influence the standards of the entire industry in the interest of the environment, and to do so worldwide.

Where do you actually start?
We started long time ago in the distribution centers and factories. We also committed ourselves to foregoing tests on animals as early as 1989, long before they were forbidden in Europe. Because we are convinced that we have to follow a scientific approach to be ever more respectful of the environment, we established dedicated laboratories as early as 1995 and set environmental targets in 2009. Four years later we launched a global sustainability program. In 2015, we first had our sustainability strategy validated by the Science Based Targets Initiative—a climate action organization that enables companies and financial institutions worldwide to play their part in combating the climate crisis. We do not see sustainability as an extra but rather as a fundamental requirement and a central point of our activities. This is also reflected in the "L'Oréal for the Future" transformation program with which we are aiming at strongly reducing our effects on the climate, water, resources, and biodiversity since 2020.

How do you integrate suppliers and partners in this strategy?
The changes affect the entire value chain, starting with the agricultural sector, the raw material, and finished product production and extending to the supply chain to our clients and the end customers' use of the product. For example, we are working with Carbios, a company that is forging ahead with the enzymatic recycling of plastics. Shower heads from Gjosa, a water technology start-up acquired by L'Oréal, help to reduce water consumption in hairdressers' salons.

What role do biotechnologically produced ingredients such as those from Abolis play here?
Manufacturing raw materials by means of biotechnology is a powerful lever for innovation and at the same time helps to further reduce our environmental impact. Biotechnology is an important component of our green sciences toolbox along with green extraction, green chemistry and sustainable cultivation, to provide more sustainable, high-performance ingredients.

Is it also a matter of getting products to market faster?
Of course, we hope that cooperations such as those with Abolis and Evonik can help us cut the time to market launch, simply because we bring together more brains and capabilities. Evonik takes account of aspects that are decisive for processing on an industrial scale at a very early stage. But above all, we share the same vision. I remember meetings with Evonik employees in which we discussed respective ideas and plans for greater sustainability, and we could have almost exchanged the slides because the mindset and approach were so aligned. Of course, a vision on slides isn't enough; what matters is following up with concrete steps. We can use our respective expertise and our combined research, innovation, and production capacities to establish a value chain that has the potential to be a gamechanger for biologically based ingredients in the cosmetics industry. That's also something that Evonik sees exactly as we do—and makes them an ideal partner.

Guillaume Climeau As Head of Business Development and Alliance Management at L'Oréal R&I, Guillaume Climeau, 53, is responsible for strategic business development and the establishment and management of partnerships at L'Oréal. He brings experience from the pharmaceutical sector and has worked at Unilever, the pharmaceutical group Sanofi, and dermatology specialist Galderma in Tokyo and Paris

FLYING FREE

A gift from on high: The low-altitude economy may make airborne deliveries a reality

In just a few years, drones could complement delivery vans, cargo planes, and helicopters. Tests for unmanned aerial transport solutions are in full swing

TEXT **BJÖRN THEIS**

Look, up in the sky! It's a bird! It's a plane! No, it's a pizza taxi! This scene could soon become reality because governments and companies are in the process of developing low-altitude airspace economically. The emergence of a low-altitude economy is in full swing. The term refers to airspace activities up to an altitude of 1,000 meters for logistics, tourism, and agricultural purposes. Most of these activities involve electrically powered, unmanned aerial vehicles (UAVs).

The development of this economic space is being made possible by innovative batteries with a very high energy density, inexpensive and powerful sensors, and robust lightweight materials. China's government sees the low-altitude economy as a previously untapped economic sector that needs to be exploited quickly—after all, the country's expertise in electric mobility gives it a head start over the rest of the world.

Premier Li Qiang recently described the low-altitude economy as one of the most important growth drivers for the Chinese economy. Beijing supports the research and development of the new industry both financially and in terms of regulation. Demonstration zones where the new type of air transportation is being tested have been set up in many provinces of the country. Shenzen province, for example, is planning to set up more than 600 new take-off and landing sites for electrically powered vertical take-off aircraft and other unmanned aerial vehicles in 2025.

The projects are ambitious: The Chinese startup Air White Whale, for example, recently unveiled the world's largest cargo drone. The W5000 model, which resembles an aircraft, can transport a load of up to five tons over a distance of more than 2,000 kilometers without a pilot. The company is now hoping to obtain approval for the drone so that it can take off in 2026.

REMOTE CONTROL JOBS

Other nations have also recognized the sector's potential: It is estimated that the global market volume for commercial UAVs could rise from around 35 billion US dollars in 2024 to around 58 billion US dollars in 2030.

The low-altitude economy could create numerous new jobs. There is already a shortage of drone pilots in China, while thousands of people in the USA are being retrained to pilot the aircraft remotely. The United States does not want to be left behind by China when it comes to tapping into the booming market. The national space agency NASA has already been commissioned to develop a system for controlling low-altitude air traffic (Advanced Air Mobility/AAM).

Europe is also following suit: The world's first fully functional vertiport, an airport for vertical take-offs, was opened in Coventry, England, in 2022. In Germany, a drone airport began test operations in Hamburg in mid-2024. Until 2026, the EU project BLU-Space will be testing how the aircraft can be integrated into urban transportation. However, some commercial providers are currently struggling because they relied on faster commercial expansion or have encountered technical hurdles.

A great deal of innovation and new materials are still needed to make this completely new sector of the economy a reality. That's a good reason for the Creavis Foresight team to analyze these needs in more detail as part of the GameChangers 2035 project. After all, it may not be long before we have pizza or sushi delivered directly to our windows instead of our doors. —

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

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Gallium

"Gallium melts on your hand"

LOG **MARKUS SARIOGLU**
PHOTOGRAPHY **ROBERT EIKELPOTH**

Marcel Häfele launched the YouTube channel *Techtastisch,* on which he regularly publishes videos of scientific experiments and DIY projects, in 2014. The channel now has more than 577,000 subscribers

My career began in the field of technology, but I felt myself insufficiently challenged. So in my leisure time I began to focus my attention more on metals and their properties. In the process, I learned that the melting point of gallium is below body temperature. I wanted to see this with my own eyes. That's when I started to carry out experiments. Among other things, I created an alloy of gallium and aluminum in order to lower the melting point of my material below room temperature.

The alloy reacted on contact with water and formed bubbles of a flammable gas: hydrogen! That made me curious about chemistry, and formed the starting point for my YouTube channel *Techtastisch* (Techtastic), on which I demonstrate experiments that you can do at home.

One of my first videos was about gallium. On contact with the skin, it melts into an extremely thick liquid. So I could literally let it melt in my hand. Of all the elements, gallium remains liquid over the largest range of temperatures. It also forms very nice crystals.

Today, people can access good information via channels such as *Techtastisch,* and so expand their knowledge in an entertaining way. Many viewers report that my channel was the reason they chose to get an education in science, technology or mathematics. The ideas for my videos frequently come from my community. I often fulfill the requests within the same week.

It's great, getting other people enthusiastic about your own passion. My inspiration came from the YouTube videos by the science journalist Christoph Krachten. They encouraged me to set up my own channel. As a child, I loved the science series *Forscherexpress* or *Wow – die Entdeckerzone* (Researcher Express or Wow—the Discoverer Zone). I really like my job as a YouTuber. It gives me creative freedom and variety. And I can keep on educating myself in mathematics, IT, science, technology, and video production. It's thanks in part to my encounter with gallium that my career has turned out so well.

Masthead

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“There’s a better way…

…to do it—Find it.” The quote is attributed to Thomas Alva Edison (1847–1931). The American inventor, electrical engineer, and entrepreneur came up with more than 2,000 inventions in the course of his life and had a decisive influence on the electrification of everyday life.

The mobility transformation also requires improvements to the existing technology—especially for storing electricity. Vehicle batteries need to be capable of fast charging, to offer a long range, and to be as economical as possible to manufacture. Evonik’s know-how in the field of polymers contributes to improving battery performance and speeding up the general acceptance of electric cars on the road.