CREATING TOMORROW'S SOLUTIONS

WACKER Magazine 01 22

WWW.WACKER.COM/MAGAZINE

WACKER

K SPECIAL

All WACKER innovations being presented at the world's largest plastics and rubber tradeshow

WACKER DIGITAL

WACKER offers a wide range of print and digital media that provide you with information about the company, its innovative products and exciting application possibilities.

SOCIAL MEDIA

Learn more about WACKER by following us on Twitter, viewing our YouTube videos or networking with us via LinkedIn.

www.twitter.com/wackerchemie

www.linkedin.com/company/wacker-chemie-ag

www.youtube.com/wackerchemie

WACKER **SQUARE APP**

Another way to immediately access both this current WACKER Magazine and an archive of all back issues over the last 10 years is our WACKER Square media app. Add personal comments (including handwritten ones) to individual articles and send them via the app's integrated share function. The app is available offline which means you can access the whole edition or individual articles even when you don't have an internet connection. For more information, go to www.wacker.com/square-app or install the app by scanning the QR code above.

Download the WACKER Square app here
www.wacker.com/square-app

Laden im App Store

JETZT BEI Google Play

THE WACKER MAGAZINE ON WWW.WACKER.COM/MAGAZINE

In the spirit of "online first," most WACKER Magazine articles will appear on our website. Our website is responsive, which means that all the articles adapt to the mobile device on which you're viewing the webpage. So whether you use your cellphone, tablet or notebook to access www.wacker.com/magazine – you'll find all WWW articles from recent years there. These articles feature not only an inspirational design but also additional content relevant to each topic covered.

WACKER PODCASTS

"Radio to go" – At the WACKER website's Podcast Center, you'll find many audio articles to listen to immediately or to download for later use.
www.wacker.com/podcast

WACKER Magazine – The company magazine; publisher: Wacker Chemie AG; project manager: Jörg Hettmann; editor: Michael Kuhli; EDITORIAL ADDRESS: Wacker Chemie AG, **WACKER** Magazine, Hanns-Seidel-Platz 4, 81737 Munich, Germany; Phone +49 89 6279-1176; Fax +49 89 6279-2830; magazine@wacker.com; www.wacker.com. Design and production: plan p. GmbH, Hamburg; Translation: WACKER's Language Services. PHOTO CREDITS: Adobe Stock/Strandperle 20, 22, 46, 81, 82, 85, 86, 88/89, 90, 97, 108/109, 113, 115, 117, back cover; Uli Benz/TUM 17; Fountain House GmbH 18/19, 20/21, 22, 22/23, 24/25; Gettyimages/Strandperle 58, 77, 78, 111, 112, 113; Jarvin, Wikimedia 6; Jean Luc Thomas, 2021, 38; all other photos from WACKER. Date of publication: October 2022.

Driving Innovation for 75 Years

The growth strategy we presented to the capital market this spring is our clear and consistent response to burgeoning demand from our customers, which has once more risen sharply, especially in the past two years, despite the setbacks caused by the coronavirus pandemic, supply chain difficulties, and surging raw-material and energy prices. Our sales are expected to climb to over €10 billion by 2030.

We aim to achieve this accelerated growth with measures such as extensive investment in the active expansion of our biotechnology division and of our capacities for high-quality silicone specialties.

Sustainable solutions, which have already been factored in to over two thirds of our product portfolio, are key to this growth strategy. We are convinced that the high demand for innovative solutions that contribute toward energy savings, resource conservation, and climate protection will develop into a major sales and earnings driver for WACKER.

This is why electromobility and sustainability are the main focus of our booth at K 2022, the world's largest plastics and rubber tradeshow, which is about to take place in Düsseldorf. Silicones are advanced materials that are indispensable to most industries. They enable a wide range of innovative technologies that help to reduce emissions of climate-damaging greenhouse gases, for example. One of many such examples is modern electric cars: they contain up to four times more silicone than conventional vehicles with combustion engines. Thermally conductive silicone encapsulants ensure that the heat generated by the battery and power control unit can dissipate easily, increasing the performance of such components considerably and extending their service life – something that organic plastics are often unable to deliver. This is precisely why demand for our silicones has increased so dramatically in recent years. As a result, WACKER will continue to invest significant sums in the global expansion of its silicone production capacities.

Seventy-five years ago, WACKER was the first European company to begin research into silicones, a materials class that was a complete novelty back then. Today we rank among the global market and technology leaders in this sector. Our mission is to provide our customers with innovative and customized solutions, making us their development partner of choice. Silicones are drivers for innovative development in many industries when it comes to climate protection and energy saving. This is shown by the articles in this issue of our company magazine. Let us inspire you!

Dr. Christian Hartel
President & CEO of Wacker Chemie AG

Dr. Christian Hartel, President & CEO of Wacker Chemie AG

"Silicones are advanced materials that are indispensable to most industries."

K SPECIAL

A HYBRID FIBER-COAXIAL CABLE MADE FROM SILICONE

The automotive industry needs extrudable materials that will reliably retain their electrical insulation properties over a broad range of temperatures and over long periods of time. The rapid-curing, two-part silicone rubber compound ELASTOSIL® R *plus* 4305 is an ideal fit for applications in automotive construction, such as this hybrid fiber-coaxial. WACKER will present this and other new products at the International Trade Fair for Plastics and Rubber in Düsseldorf from October 19 to 26 – and across 42 dedicated pages in this issue.

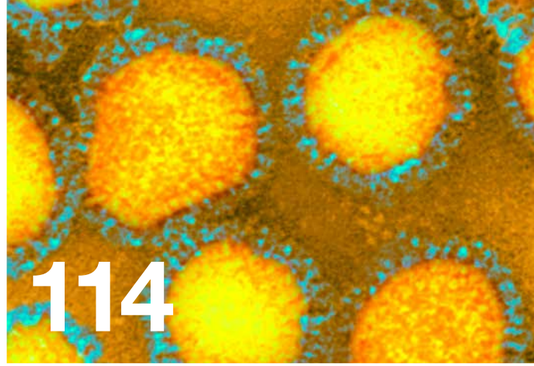
Starting on page 44

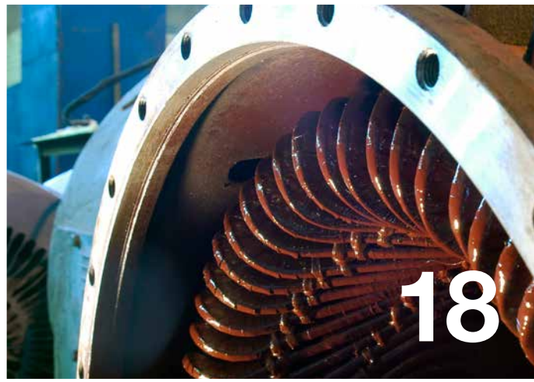
44

CONTENTS

WACKER Magazine 1.22

Here you'll find all of this issue's articles at a glance.





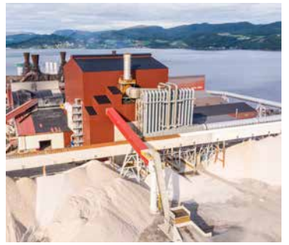
1.22 ▸ GLOBAL ▸ **WACKER WORLDWIDE**

WACKER WORLDWIDE

WACKER has production sites, application technology centers, subsidiaries and sales offices on every continent. Here is a selection of news and interesting topics from the Group's four business divisions.

1 ABERDEEN

Instead of being anchored to the sea floor, wind turbines float on the waves off the coast of the Scottish port. As only a fraction of the world's oceans are flat enough for conventional offshore plants, researchers worldwide are developing solutions for floating wind turbines, allowing energy to be generated on the open seas. In fall 2017, the first floating wind farm, Hywind Scotland, went on line off the coast of Aberdeen. Its five wind turbines provide a total of 30 megawatts of power. At the end of 2021, another floating wind farm went into operation in the region. With a capacity of 50 megawatts, Kincardine is currently one of the largest power generators floating on the world's oceans. WACKER delivers future-oriented technical solutions for power and electrical engineering, including impact modifiers which extend the service life of the rotor blades on wind turbines.



2 HOLLA

In the future, around 40 percent of WACKER's energy requirements at the Norwegian silicon site will be covered by green energy from hydroelectric power. The Norwegian electricity producer Statkraft plans to deliver a total of 2.35 terawatt-hours of hydroelectric power for the Holla site by December 2027. WACKER wants to meet the electricity needs of its sites with more energy from renewable sources and to expand its green power portfolio in the medium term with more purchases from Norway and elsewhere in Europe.

3 COLOGNE

At the start of the year, WACKER POLYMERS filled its dispersions into 1,000-liter-capacity IBC storage tanks made of recycled plastic at the production sites in Burghausen and Cologne for the first time. The switch to these champagne-colored containers made from used plastic saves more than 200 metric tons of CO_2 each year. The sustainable IBC tanks consist of two layers of high-density polyethylene (HDPE). Their external layer is manufactured from old tanks which have been shredded and melted down, the inner layer is, as before, made from new HDPE. The recycled tanks' properties, such as stability and purity, are identical, the only difference to the conventional IBC tanks is the color.

4 BURGHAUSEN

Water plays a key role in the chemical industry. Clean, cold water is crucial for operations at the Burghausen site – without it, the power supply, cooling and production would be compromised. Responsibly handling this resource is one of WACKER's sustainable development goals. The Group is currently developing a strategy that is oriented toward the standards of the international Water Stewardship Initiative. On this basis, WACKER has set two ambitious targets, namely to introduce a sustainable water management policy at all production sites from 2022 and to reduce water withdrawal across the Group by 15 percent by 2030.

5 DUBAI

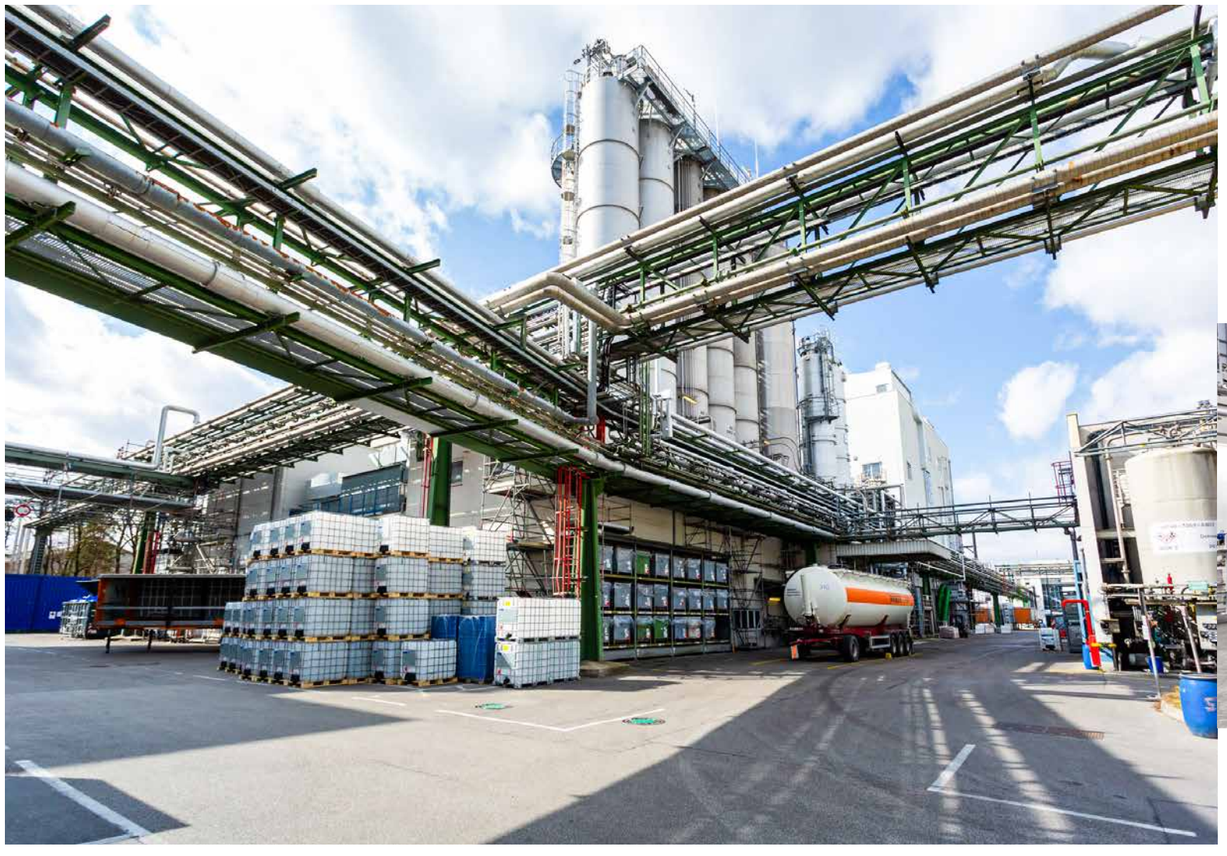
In the United Arab Emirates alone, around 25 million silicone cartridges are consumed each year. In this region, WACKER sells its own-brand joint sealants, which are distributed via the Bosco Group. Until now, it was not possible to recycle the empty cartridges. WACKER Chemicals Middle East wants to change that and provided Bosco with three cartridge-recycling containers in late 2021. The plan is to have installed around 20 containers for recycling silicone cartridges across the whole United Arab Emirates by the end of 2022.

1.22 ▸ NEWS ▸ **UPDATES**

GROUP UPDATE

SILICONE PRODUCTION EXPANDED WORLDWIDE

WACKER responds to rising demand for silicone specialties with growth campaign



To meet growing demand for silicone rubber, WACKER is accelerating the expansion of its production capacities. To this end, investment projects are either in the planning phase or will be concluded shortly. Additional volumes of liquid silicone rubber (LSR) will already be available in the second half of 2022 or at the beginning of next year. Planning is also underway to increase production of high consistency rubber (HCR). Some €100 million has been earmarked for this capacity boost.

"WACKER returned to a growth trajectory last year. We finished 2021 with record sales and strong earnings – despite headwinds from raw material and energy prices. We want to maintain this momentum and are charting our course for accelerated growth with higher investments," says WACKER's CEO Dr. Christian Hartel.

A new vinyl polymer reactor and a silicone-base facility (small photo), where silicone polymers and pyrogenic silica are processed in kneading chambers, are under construction in Burghausen's liquid silicone rubber plant (large photo). The project is one of the WACKER SILICONES division's growth initiatives.

High-quality silicone rubber is one of the products that are central to the new growth strategy. Demand for silicone elastomers has surged in recent years since they offer product and processing advantages not available to other materials. "As the world's second largest silicone manufacturer, silicones have strategic significance for us," noted Dr. Robert Gnann, president of WACKER SILICONES. "This is why we will do all it takes to better support the dynamic growth of the silicone market."

WACKER expects additional LSR capacities in the second half of this year due to several capacity expansions at its production site in Burghausen, Germany, which will reach full production capacity by the end of the year. Production is also being expanded in Adrian, USA.

First in line with high-temperature-vulcanizing solid silicone rubber is the new production site in Panagarh, India (see article on page 13). Additional production capacities will be available at the beginning of next year at the company's sites in the Czech Republic (Pilsen), where ready-to-use SILMIX® silicone compounds are manufactured, and in Japan (Tsukuba).

Owing to its good mechanics and unique physical, chemical and electrical properties, HTV solid silicone rubber often offers advantages over other rubber grades. Especially in food, pharmaceutical or medical applications, pure, sterilizable, and bio-compatible medical silicones have become indispensable. In order to better meet this demand in the long term, WACKER is considering additional expansion measures at its sites in Zhangjiagang (China), Charleston (Tennessee, USA) and in Burghausen (Germany).

The Group also intends to expand its pyrogenic silica production in Zhangjiagang. Pyrogenic silica enhances the mechanical properties of silicone rubber and is therefore a key ingredient. WACKER produces the filler at its sites in Burghausen, Nünchritz, Charleston and Zhangjiagang, making the company one of the few backward-integrated silicone manufacturers that produces pyrogenic silica in large quantities for direct sale as well as for captive use.

WACKER BEGINS GROUNDWORK ON SILICONE PRODUCTION FACILITY IN CHARLESTON

Feasibility study underway for site in the USA; investment amounts to over US$200 million

WACKER is preparing to erect a new production complex for silicones at its US site in Charleston, Tennessee. The Group has already begun a feasibility study to this effect. Initially, there are plans to erect facilities for manufacturing high consistency rubber and silicone sealants used in construction applications, among others. Moreover, additional plants for manufacturing intermediate products are to be erected. Later phases envisage the construction of production plants for other product groups, such as silane-terminated polymers used as binders for formulating high-quality adhesives and sealants, liquid waterproofing systems and environmentally friendly wood-flooring adhesives.

An investment sum estimated at around US$200 million has been earmarked for the entire expansion project, which is to last several years, thereby creating more than 200 new jobs at the Charleston site.

WACKER has been producing high-purity polysilicon for the semiconductor and solar industries in Charleston since 2015. It started to produce HDK® brand pyrogenic silica there in 2019.

"The planned expansion measures in Charleston are a further step toward making it a fully integrated site with closed production loops, and an important prerequisite for accelerating our growth as planned," said CEO Dr. Christian Hartel, explaining the strategic background of this investment. WACKER is aiming for sales of over €10 billion by 2030, with an EBITDA margin of over 20%.

"WACKER is the world's second-largest silicone producer, and this business is of strategic importance to us. Demand for high-performance specialty silicones is showing particularly strong growth. Such specialties enable innovative, tailor-made solutions in key industries such as automotive engineering, construction, electronics and medical technology. By expanding our capacities, we aim to support our customers to the best of our ability," emphasized Hartel.

"In the USA, demand for silicones has risen exponentially in recent years," noted David Wilhoit, CEO of Wacker Chemical Corporation, a US subsidiary. "This comprehensive investment offensive sees us further expanding our position in the world's second largest chemical market."

Distillation columns for manufacturing trichlorosilane at the site in Charleston, Tennessee, where WACKER has manufactured highly pure polysilicon since 2015 and HDK® pyrogenic silica since 2019.

1.22 ▸ NEWS ▸ **UPDATES**

1.22 ▸ NEWS ▸ **UPDATES**

Puja ceremony at the opening of the new silicone site in Panagarh: During this traditional Hindu ritual, food and other offerings are made.

NEW SILICONE SITE OPENS IN PANAGARH, INDIA

WACKER strengthens its position as a leading manufacturer in India

WACKER opened a new production plant for silicone rubber and ready-to-use silicone compounds in Panagarh, 160 kilometers north west of Kolkata, India, at the beginning of July. A subsequent expansion stage at the site is to include the production of silicone fluids and silicone emulsions in the medium term. The company will invest a mid-double-digit million-euro amount in Panagarh in the next few years. The first expansion phase will create around 100 new jobs.

Wacker Metroark Chemicals (WMC) is a joint venture in India. It is fully consolidated in the WACKER Group and has operated a production plant for silicones in Amtala, a suburb of Kolkata, since 1999. The new 165,000-square-meter plant in Panagarh is three times the size of the existing site in Amtala, where silicone fluids and silicone emulsions will continue to be produced for the cosmetics and personal-care industries.

"Panagarh offers excellent infrastructure and very good connections to the Indian road and rail networks. The site also offers plenty of space which we will use to significantly expand our production capacity in India and our market position on the Indian subcontinent," said WACKER Executive Board member Auguste Willems at the opening. "This additional production capacity will double the amount of silicone we produce in India in the medium term."

WACKER will expand production at the new site in stages. Currently, heat-curing and room-temperature-curing solid silicone rubber, liquid silicone rubber and SILMIX® ready-to-use silicone compounds are manufactured in Panagarh. These products are used particularly in electromobility, medical technology and electric energy transmission. Production of silicone fluids and silicone emulsions for cosmetics, textile and personal-care applications is planned in the next stage. "This way we can supply our customers in India even better and more quickly with our specialty silicones," said Willems. "We will expand this site step by step and thus continue to strengthen our leading position as the largest silicone manufacturer in India."

Soumitra Mukherjee, president and managing director of WMC, considered the new site to be an important milestone in the cooperation between the two companies. "When WACKER and Metroark formed a joint venture almost a quarter of a century ago, the foundation for a successful partnership was laid. The new Panagarh site will continue this German-Indian success story."

Wacker Chemicals Norway AS produces silicon metal at its Holla site for the manufacture of silicones and hyperpure polysilicon.

MORE SILICON METAL FROM NORWAY

Feasibility study launched: Holla site's capacity to increase by 50 percent

WACKER is preparing to expand its production capacity for silicon metal at Holla, Norway. There are plans to construct a new furnace, which will increase current capacity in Holla by around 50 percent. A study is underway to determine how the infrastructure in Holla can be developed in order to accommodate potential further expansion measures. Talks in this regard are being held with local authorities and energy suppliers. If the preparations are completed as planned and the expansion measures are approved by the authorities, the decision to build the new furnace could be taken toward the end of the year. It would then be scheduled for completion in 2025.

Silicon metal, one of WACKER's most important raw materials, is needed for producing silicones and hyperpure polysilicon. Currently, the silicon metal produced in Holla covers around one-third of demand at WACKER's sites in Germany.

"The planned expansion measures in Holla are an important prerequisite for accelerating our growth as planned," says CEO Dr. Christian Hartel, explaining the strategic background of this investment. The Munich-based chemical group is aiming for sales of over €10 billion by 2030, with an EBITDA margin of over 20 percent.

"In order to meet the high customer demand for our silicone specialties and our high-quality polysilicon, we need to ensure that we have sufficient amounts of silicon metal available at all times. By expanding our captive production, we will become more independent of price fluctuations on raw-material markets and enhance our supply security, both during times of peak demand and if problems arise in relation to restrictions in global supply chains," emphasized Hartel.

At the same time, capacity expansion and the enhancement and modernization of infrastructure are essential building blocks in WACKER's plans to halve its greenhouse gas emissions by 2030. The Holla site will play a key role in achieving this target. "The production of silicon metal is very energy-intensive," explains Robert Gnann, president of the WACKER SILICONES division. "In order to significantly reduce greenhouse gas emissions in such production, the plants must be state-of-the-art. That is exactly what we are aiming for with the capacity expansion and planned infrastructure measures in Holla."

An additional lever for reducing emissions is the use of electricity from renewable sources. WACKER and the Norwegian electricity producer Statkraft recently signed a supply agreement for green electricity from hydropower (see article on page 7).

NEW RESEARCH CAMPUS OPENED IN THE USA

The Innovation Center in Ann Arbor is also Wacker Chemical Corporation's new headquarters

WACKER opened a regional innovation center in Ann Arbor, Michigan, USA, in mid-May. The research building, which will develop high-margin biotech and silicone specialties for high-tech applications in key industries, also serves as the headquarters of Wacker Chemical Corporation (WCC). The subsidiary is responsible for the Group's business activities in North and Central America.

The 70,000-square-meter new campus in Ann Arbor houses 20 development and analysis laboratories spanning 13,000 square meters. WACKER invested a total of some 40 million euros in the campus.

"After China, the USA is the largest market for chemical and silicone products," said Robert Gnann, president of WACKER SILICONES, at the opening. "Our new Innovation Center is an essential prerequisite for serving customers in North America with tailor-made silicone specialties, which are used in a wide range of fields of application."

WACKER will thus become the preferred point of contact for customers who are looking for sustainable and forward-looking solutions for tomorrow's products and technologies. With the decision to pool and expand its regional research and development expertise in Ann Arbor, the company is fully committed to growth. "Over the next few years, we will systematically expand our market position as a manufacturer of silicone specialties in this important region," stressed Gnann.

The new Innovation Center also houses the administrative headquarters of Wacker Chemical Corporation. In mid-April, management, sales and administration – a total of over 200 employees – moved to Ann Arbor from the previous company headquarters at the Adrian production site. The Adrian site, where WACKER has been producing silicones for more than 50 years, continues to manufacture silicone fluids, silicone emulsions and silicone rubbers.

"With its many research facilities and educational institutions, Ann Arbor is Michigan's leading R&D hub," said WCC President David Wilhoit. "Our presence in this attractive university city with its high quality of life will also have a positive impact on our search for highly qualified young people."

Ribbon cutting at the new Innovation Center in Ann Arbor: WACKER intends to benefit from the center's proximity to the prestigious University of Michigan to recruit highly qualified young people.

Inside WACKER's Biotechnology Center: The Group has conducted research in biotechnology at its "Consortium" in Munich since the 1980s.

WACKER RESEARCH ERECTS BIOTECHNOLOGY CENTER IN MUNICH

Center staffed by 90 scientists to increase growth in Life Sciences

The WACKER Group is investing a double-digit million-euro sum in the construction of a Biotech Center in Munich, which is scheduled to be operational in 2024. "The WACKER Biotech Center will allow us to concentrate and intensify our biotech research activities. The additional capacity we are creating here will accelerate the growth of our Life Sciences activities," said CEO Dr. Christian Hartel, explaining the reasons for the construction project.

As part of its strategy for growth, the company is planning to significantly increase investment in the biotechnology sector in the coming years. The product portfolio is to expand through innovation, partnerships and acquisitions. By 2030, WACKER BIOSOLUTIONS plans to contribute around €1 billion to Group sales. The construction of the Biotechnology Center supports this strategy.

The WACKER Biotechnology Center will be erected at the existing site of its "Consortium" in Munich, where the company has consolidated its basic research for over 100 years and its biotech research since the 1980s. The growth of biotech business has stretched the capacity available for research activities to its limits. The WACKER Biotechnology Center, with space for around 90 employees, is intended to alleviate this. Ground was broken in late June on the building, which is expected to open in 2024.

The plans include laboratory and pilot plant areas across approximately 2,000 square meters, spread over three floors. The research here will mainly concentrate on the manufacturing process of biopharmaceuticals, especially in the area of advanced medicines, as well as the fermentation-based manufacture of ingredients for foods and food supplements.

WACKER AND TECHNICAL UNIVERSITY OF MUNICH FOUND INSTITUTE FOR INDUSTRIAL BIOTECHNOLOGY

Institute strengthens basic research as the foundation for sustainable business management

WACKER and the Technical University of Munich (TUM) have deepened their partnership with the founding of the TUM WACKER Institute for Industrial Biotechnology. The goal of the new institute is to further develop research in the field of industrial biotechnology in Germany at the highest international level. The two partners will bring their combined forces to bear on researching new approaches for the production of specialty chemicals and active ingredients from renewable resources as a basis for sustainable business management. WACKER is funding research at the institute with more than €6 million over the contractually agreed term of six years. The new institute will commence its work in the 2022/2023 winter semester.

"Industrial biotechnology is key to achieving a sustainable economy," says Thomas F. Hofmann, president of the TUM. "We will be linking the disciplines of molecular research, chemical engineering and process engineering with each other and, through closely collaborating with WACKER, accelerating the effective transfer of the knowledge gained thereby to industrial practice."

TUM and WACKER have been collaborating in different areas for many years, actively driving knowledge transfer between scientific research and industry. "With the foundation of the Institute for Industrial Biotechnology, we are now jointly focusing on a particularly promising field," noted Dr. Christian Hartel, president & CEO of Wacker Chemie AG.

A key focus of the institute's research in the field of biotechnological production systems will be the production of nucleic acids, which are used, among other things, to treat illnesses such as cancer. Further research areas will target the production of low-molecular compounds and the development of new process concepts.

Head of the TUM WACKER Institute is Prof. Sonja Berensmeier, a high-profile expert in the field of new biofunctional materials and process development for the separation of biotechologically produced high- and low-molecular biomolecules. Over the next six years, 20 doctoral candidates will be doing research work at the institute.

Dr. Christian Hartel, CEO of Wacker Chemie AG (left), and Prof. Thomas F. Hofmann, TUM president (right), signing the agreement.

1.22 ▸ SOLUTIONS ▸ **SILICONE RESINS**

OPERATIONAL RELIABILITY THANKS TO **SILICONE RESINS**

Stator windings of electric motors are often impregnated with resin to increase the motor's high temperature resistance and ensure a long service life. Now, WACKER has launched SILRES® H60, which – by curing extremely rapidly – is suitable for mass automotive production, among other applications.

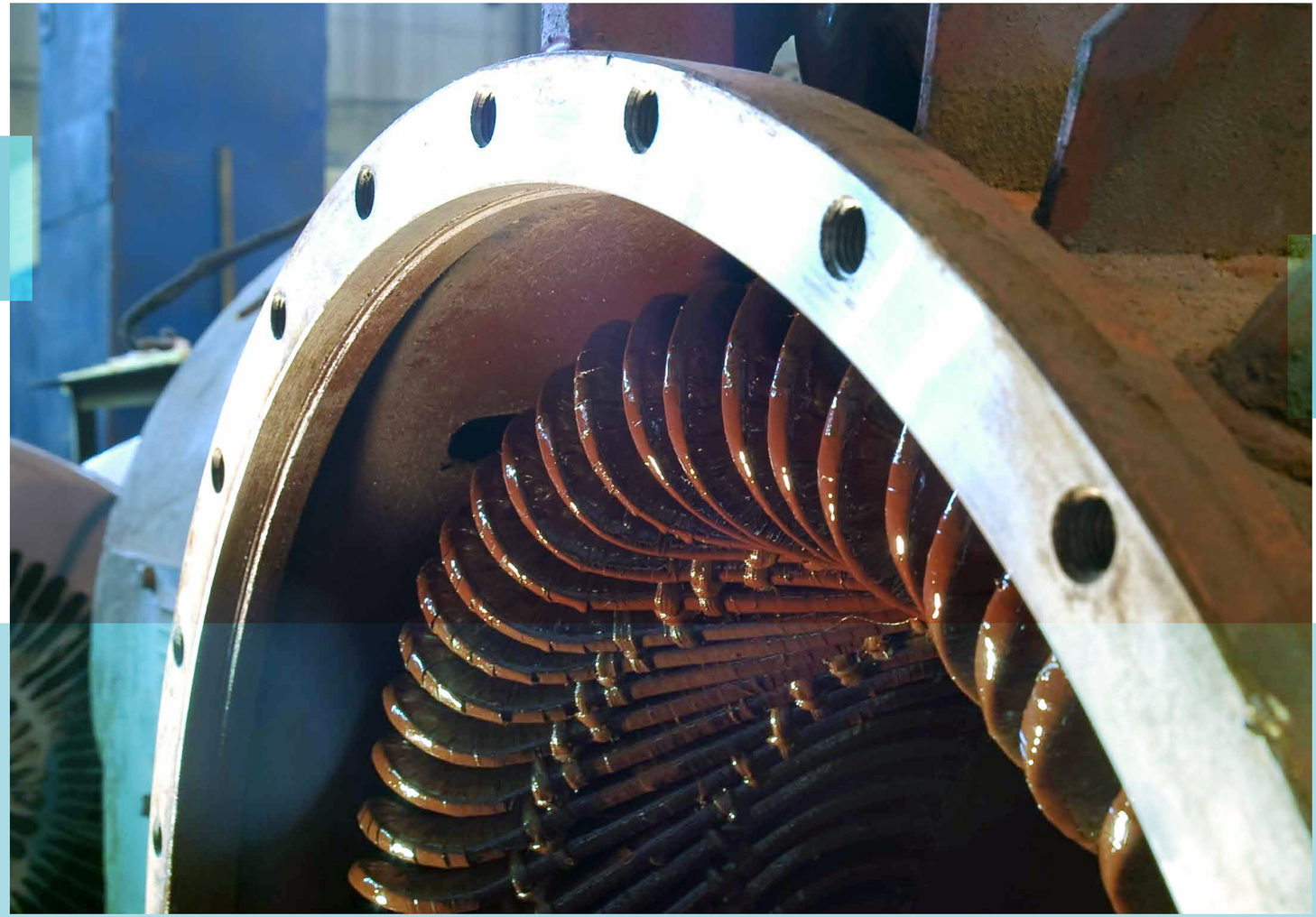
Testing the flexural strength of the new SILRES® H60 silicone resin in the lab.

CONTACT

For more information on this topic, please contact:

Dr. Christian Ochs
Head of Technical Marketing
Performance Silicones
Tel.: +49 8677 83-7358
christian.ochs@wacker.com

Stators are the non-moving parts in electric motors. Their copper wires can be impregnated with liquid silicone resins of the SILRES® H series. As below in the case of a stator, wound with round wire, for a fairly small electric motor.



Preformed coils for electric motors of railway vehicles: such large stators are impregnated with SILRES® H62 C by vacuum-pressure impregnation.

The market for electric cars has been picking up speed for about two years. The industry report of the German Center of Automotive Management states that 13 percent of all the new cars registered in Germany in 2021 already featured an electric drive. China, the biggest market for battery-powered cars by far, shows similar market shares.

If confidence in electric cars is to keep growing, they must be just as reliable, robust and long-lasting as their combustion-driven counterparts. The conditions for this are promising, since an electric motor comprises only 250 parts – compared with the 2,500 components of a combustion engine. Electric cars are therefore considered low-maintenance.

But these components are of course subject to strict requirements – for example on the wire-wound stators that are often used in electric motors. Impregnation of the windings, which consist of lacquer-insulated round copper wires, is the last step in stator manufacturing. For impregnation, a resin is used that cures to form an electrically insulating thermoset. The impregnation resin, which is liquid during application, penetrates into the gaps between the individual windings and into the interstices of the winding. Once the resin has cured, the windings are coated with solid resin.

"It is well known that silicone-based winding impregnations provide the electric motor with exceptionally high thermal resistance and a long lifetime," explained Dr. Klaus Angermeier, head of WACKER SILICONES' Industrial Solutions business team for the European and Latin American markets. Impregnation with a solvent-free phenyl silicone resin is considered particularly effective. Such impregnation resins were only available as one-component products until now, since they were time consuming and laborious to process.

A solution is provided by the new phenyl silicone resin SILRES® H60, which has been in WACKER's portfolio since early 2021. "This two-component product is characterized by a high curing rate," explained Dr. Christian Ochs, head of an applications laboratory at WACKER and responsible for developing this silicone resin. "SILRES® H60 was specially developed for

"Silicone-based impregnation provides an electric motor with extremely high temperature resistance and a long lifetime."

Dr. Klaus Angermaier,
Head of WACKER SILICONES' Industrial Solutions business team

Ready for production: SILRES® H60 permits rapid and automated impregnation.

trickle impregnation. It allows fast, automated impregnation processes to be set up, which can be easily integrated into a mass production line for electric motors," adds Dr. Ochs.

IMPREGNATION IMPROVES THE PROPERTIES OF THE STATOR IN VARIOUS WAYS:

1. It optimizes the electrical insulation.

2. It mechanically reinforces the entire winding as the resin bonds the individual windings and wire layers together. Fixed in this way, the windings can no longer move with respect to one another, thus eliminating vibrations and abrasion. This prevents damage to the primary insulation of the copper wire windings. The primary insulation generally consists of a very thin lacquer coat.

3. The impregnation promotes heat dissipation from the copper winding to the stator laminations, thereby improving thermal management and increasing the heat resistance of the stator – an important effect, since overheating is one of main causes of motor failure.

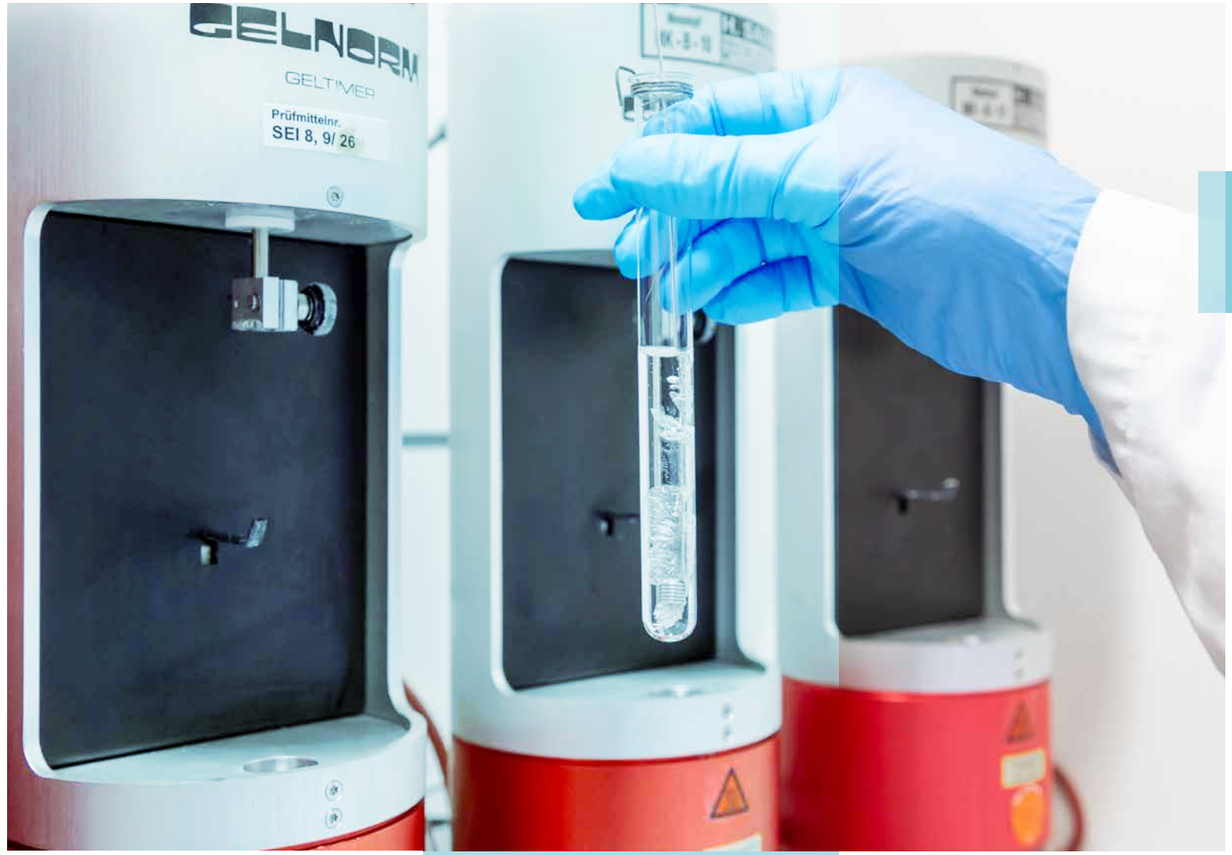
4. The resin protects the winding against moisture, salt spray and other external media.

Manufacturers of electric motors can adjust the properties of the impregnation to their needs by choosing a suitable resin. "With many electric motors, it is quite sufficient to impregnate the windings with an organic resin, such as an unsaturated polyester or epoxy resin," added WACKER's Christian Ochs, a chemist by training. However, for motors expected to face considerable stress from heat or media, optimum protection can be achieved with a phenyl silicone resin.

Cured phenyl silicone resins are thermally and chemically resistant. They age more slowly than organic resins under the effects of temperature and weathering. Their high durability is especially salient in the impregnation of windings particularly of motors that are subject to strong electrical currents during operation and are compact in size without active cooling. As a result, silicone resin impregnation imparts high operational reliability to the motors even under overload conditions.

SOLVENT-FREE CLASSIC

Renowned for its good impregnation, the one-component phenyl silicone resin SILRES® H62 C from Wacker Chemie AG has a proven record of over 35 years in traction motors of electric rail vehicles. As far back as the 1970s, this resin system was being used by the Swiss manufacturer Brown, Boveri & Cie (now ABB) for electric locomotives, and from the 1980s



Measuring gel time: the reactivity of WACKER silicone resins is measured in a lab. Measurement curves can be found on page 24.

Smoke extractor fans in a road tunnel. In a fire, the fan motors are subject to severe thermal stress. Impregnation with SILRES® H60 provides ideal thermal protection.

SUCCESSFUL FLAME-PROOFING

SILRES® H60 is already successfully used in smoke extractor fans that form an important component of fire-protection measures in tunnels. The heat-stable silicone impregnation resin ensures that the fan motors perform reliably in a fire for at least 2 hours, even at ambient temperatures up to 400 °C, in order to rapidly dissipate toxic fumes and give the rescue services as long as possible to secure and evacuate the hazard area. This corresponds to classification F400 – 120 as per EN 12101-3 and EN 13501-4

for the high-speed trains that were a new technology at the time. Since 2007, this system has also been used in drive motors for hybrid and electric cars. Unlike many organic impregnating resins, this product does not contain either solvents or reactive diluents. The liquid formulation is usually applied at temperatures between 60 and 80 °C and cured at temperatures between 170 and 200 °C, with the material being crosslinked by a platinum-catalyzed addition reaction.

"Despite having notched up an exceptionally long track record, SILRES® H62 C is by no means an outmoded product but continues to be state of the art," explains Dr. Ochs. For example, new-generation subway trains are being introduced in various cities around the world, with electric motors impregnated with SILRES® H62 C from WACKER.

As a one-component formulation, SILRES® H62 C contains an inhibitor which slows down the curing reaction. This is advantageous if the resin is applied to the windings by traditional dip coating or vacuum-pressure impregnation (VPI). These processes are mainly used for large machines, for example for impregnating railroad, streetcar and subway traction motors, and for traction motors of diesel-electric haul trucks for open-cast mining. For this, the liquid resin must remain in a processable state during impregnation of the winding, i.e. it must not gel or cure too fast. In the automotive industry, on the other hand, the low curing rate of the one-component silicone proves to be a disadvantage – the slow curing thwarts the goal of impregnating large quantities of stator windings in a short time.

"Our customers from the automotive industry prompted us to develop a ready-to-use phenyl silicone resin formulation that would permit a rapid and automated impregnation process, similar to the established one-component product as far as

the impregnation effect is concerned," said Dr. Klaus Angermaier, a WACKER manager. This became possible thanks to SILRES® H60 This impregnation resin is a two-component formulation based on the same silicone resin prepolymers used in the one-component product.

Since the new SILRES® H60 grade is a two-component product, developers were able to keep the curing time short. For example, an inhibitor as required for one-component silicone impregnation resins is no longer necessary. This eliminated a factor that limits the curing rate. Moreover, besides the platinum catalyst, the experts at WACKER introduced another accelerator for the hydrosilylation reaction. The additional accelerator chiefly becomes active during the initial stage of thermal curing, i.e. it significantly speeds up gelling.

TURBO SWITCHED ON

This allowed a silicone impregnation resin to be developed with a curing rate comparable to that of organic impregnation resins. The curing time depends greatly on the temperature (see chart, top left). Gel time at 150 °C is thus about 15 minutes. At this temperature, the material is fully cured after 6 hours. At 180 °C, the gel time is reduced to seven minutes and curing takes just two and a half hours.

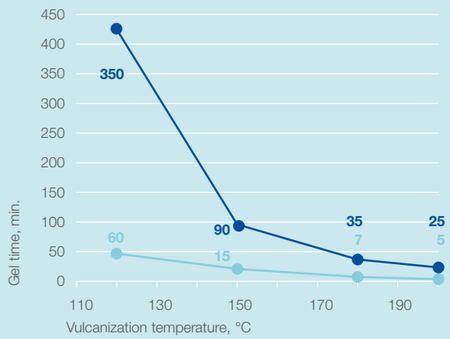
The two components are mixed in a ratio of 10:1 for processing. The viscosity of the mixture depends greatly on temperature (see chart, bottom left): at 25°C, the kinematic viscosity is about 1,000 mm²/s, and drops by a factor of 10 when heated to 80 °C. This effect is used in the impregnation process. Both the resin and the winding are preheated to minimize the resin's viscosity and ensure it penetrates rapidly into the winding during impregnation. In practice, the temperature is usually maintained at 60 °C.

Like the traditional, tried-and-tested product, the new two-component silicone resin is also free of solvents and reactive crosslinkers, and cures in a platinum-catalyzed addition reaction to form a thermoset of 65 Shore D hardness.

The cured transparent resin has a non-tacky, hydrophobic surface. With a dielectric strength of 27 kV/mm, measured as per IEC 60243-1 (23 °C, 50 Hz, air as ambient medium), the resin is a very good electrical insulator. The material is largely chemically inert and resists aging and long-term thermal loads. It permanently withstands temperatures up to 200 °C, such that a winding impregnation with SILRES® H60 corresponds to thermal insulation class H and higher according to EN 60085. For short periods, the resin also resists temperature spikes significantly above those of the determined continuous service temperature.

GEL-TIME DEPENDENT ON TEMPERATURE

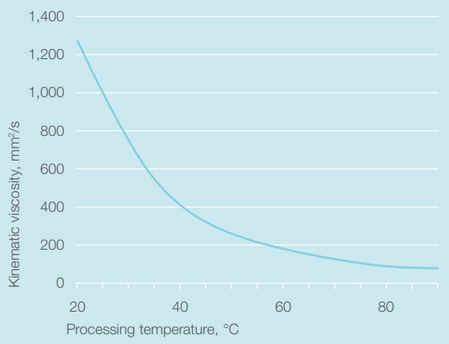
COMPARISON OF SILRES® H62 C and SILRES® H60



Temperature dependence of gel time of SILRES® H60 (light line) and the one-component silicone impregnation resin SILRES® H62 C (dark line). The new two-component formulation cures much faster than the one-component. At 150 °C, SILRES® H60 cures within 15 minutes; the one-component impregnation resin takes 91 minutes. The gel time is 7 minutes at 180 °C and 5 minutes at 200 °C.

TEMPERATURE DEPENDENCE OF VISCOSITY OF SILRES® H60

A and B mixed in a ratio of 10:1



For impregnation, the two components of SILRES® H60 are mixed in a ratio of 10:1. The kinematic viscosity of the freshly prepared mixture decreases strongly with increasing temperature. It is 180 mm²/s at 60 °C and about 90 mm²/s at 80 °C.

Silicones play an important role in electromobility. Parts of electric motors are impregnated with silicone resins, for example, to cushion mechanical and thermomechanical stresses.

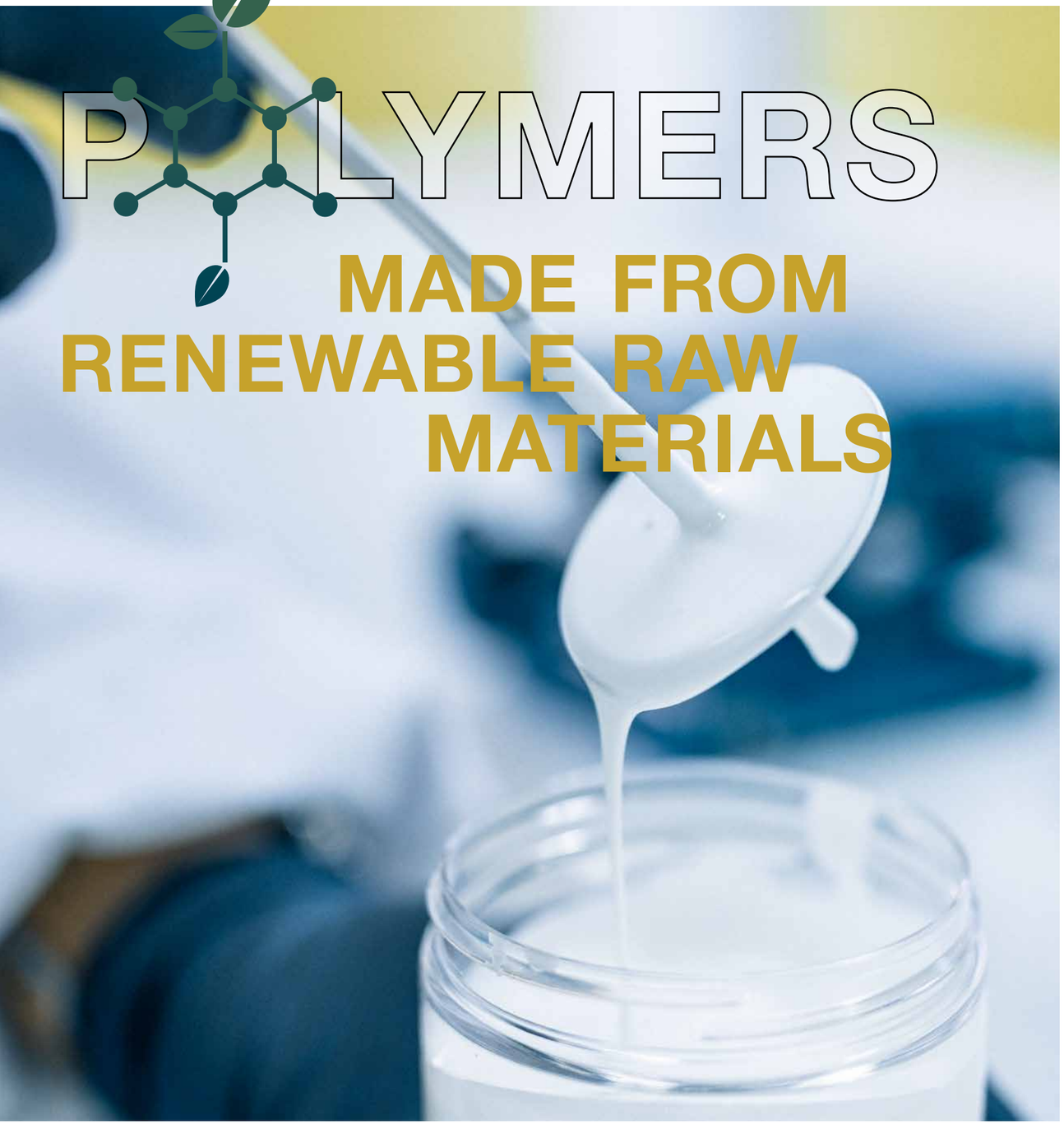
TRICKLE IMPREGNATION

Thanks to its rapid curing, SILRES® H60 is ideal for trickle impregnation of copper round-wire windings. The new resin, because of its short gel time, is not suitable for dip coating or VPI.

For trickle impregnation, the stator is clamped on a mandrel at a slight angle and rotated around its own longitudinal axis. The impregnation resin is continually dripped through multiple dispensing nozzles onto the winding head of the continuously rotating stator. Gravity and capillary forces draw the liquid into the winding and, together with the rotational movement, ensure that the resin is evenly distributed in the stator. At the same time, the rotation keeps the liquid resin in the coil, preventing the impregnation resin from flowing unused out of the stator. After trickle application, the still-rotating stator passes through a heating zone, where the resin is gelled and cured.

This offers a fast, economical and neat process for achieving a high impregnation quality with low resin-application rates. Trickle impregnation is performed in fully automated systems. The art of the resin processor consists in correctly setting all the process parameters of the trickle impregnation unit – from the application rate of the resin, through the tilt angle of the winding and the rotational speed, to the temperature and timing programs for curing. Modern trickle impregnation units can be easily integrated into electric-motor manufacturing lines.

"SILRES® H60, for the first time, offers electric motor manufacturers a phenyl silicone resin for winding impregnation that can be processed and cured as rapidly as an organic resin," said Dr. Angermaier, summing up the advantages of the new product. "It will open the door to rapid large-scale production of highly reliable and durable drive motors."



POLYMERS MADE FROM RENEWABLE RAW MATERIALS

By launching adhesives based on renewable feedstock, Kiilto is helping paper and packaging industries to reach their environmental goals.

Finnish chemical company Kiilto aims to be net zero by as early as 2028. So, it showed a great deal of interest when WACKER experts introduced Kiilto to binders that, mathematically, had 100 percent of the fossil raw materials replaced by certified renewable raw materials like biomass during production.

Kiilto was established over 100 years ago and is managed by the fourth-generation Solja family. When such a family-owned company steeped in history makes a "promise to the environment" – as Kiilto did in 2018 – it's a matter of honor to its almost 1,000 employees to fulfill this.

"We want to be a leader in environmental protection in our sector, which is reflected in all our activities – from raw materials selection to packaging, energy, logistics and services," explains Kiilto's Maija Kulla-Pelonen, who is an R&D and innovation manager. "That's why we choose renewable resources whenever possible and are continuously reducing the use of fossil raw materials," she adds.

Kiilto has four areas of business, one of which produces and markets industrial adhesives. VINNAPAS® brand vinyl acetate-ethylene (VAE) polymers have proven their worth in many of these adhesives. WACKER's polymer binders ensure that the adhesive layers provide good bonding between the surfaces to be joined. This especially applies to surfaces made of paper – both uncoated and coated – cardboard and plastic film.

WACKER uses ethylene and acetic acid to first make vinyl acetate monomer, which is then copolymerized – once more in combination with ethylene – to obtain VAE. Up until a few years ago, these polymers were exclusively produced from fossil raw materials.

At the European Coatings Show in Nuremberg in 2019, WACKER then presented VAE-based polymer binders that, in accordance with a certified mass balance approach, are mathematically based entirely on renewable raw materials. Since then, an alternative to con-

A view inside Kiilto's production halls (left) and laboratories (above): Constant development of greener products is natural for the Finnish company, as it is guided by its goals, including its "Promise to the Environment."

The environmental aspect of Kiilto Pro Pack Eco adhesives, which are manufactured in Finland, is taken into account throughout the whole supply chain.

1919

Kiilto, established 103 years ago, produces and sells chemical industry solutions in four business areas: construction, industrial adhesives and fireproofing, professional hygiene, and consumer goods. The family-owned company with more than 1,000 employees operates in 11 countries in Eastern Europe and the Baltic region.

ventionally produced VAE polymers – one that saves on fossil resources – has been available to customers like Kiilto.

The tradeshow team had the challenging task of explaining to interested parties what certification in accordance with the mass balance approach actually meant. In particular, the team had to dispel any potential reservations about this just being a marketing ploy intended to give conventionally made industrial products a greener look.

CERTIFIED RAW MATERIALS

Currently, bio-based acetic acid is used in the production of the VAE polymers that WACKER now markets under its VINNAPAS® eco brand. The bio-based acetic acid used is certified in line with international PEFC (Programme for the Endorsement of Forest Certification Schemes) standards and is a byproduct of the woodworking industry, for example from pulp production. The wood itself stems from woodland that is sustainably managed.

Since the market does not yet offer a renewable version of ethylene – the second basic raw material required for VAE – in the required quantities and under cost-effective conditions, WACKER mathematically accounts for this fossil component by increasing its use of bio-based acetic acid. The petrochemical raw-material source is thus effectively compensated for. This follows the specifications of the REDcert² standard, which certifies the material use of biomass or other renewable feedstock in the chemical industry. An inspector accredited by the TÜV Nord technical inspectorate audits and certifies that everything is correct and that WACKER adheres to REDcert² specifications.

WACKER processes bio-based acetic acid in its existing plants together with acetic acid of fossil origin. This yields VAE polymers whose atoms stem partly from renewable and partly from fossil raw materials. WACKER then uses the mass balance approach to mathematically separate the manufactured quantity of VAE polymers into two parts. In the laboratory, the end product that stems from bio-based acetic acid is indistinguishable from the polymer based on fossil raw materials – the quality is absolutely identical. Only the raw materials used in the supply chain are different.

ACCURATELY REFLECTED

"We select the fraction which we designate as VINNAPAS® eco so that it does not exceed the amount of renewable raw material originally used," says Lena Kläger, sustainability manager at WACKER POLYMERS.

Kiilto was won over by this certified mass balance approach. "We believe that this process is an important first step toward fully bio-based production," says Kulla-Pelonen, R&D manager at the Finnish chemical company. "In many

"Our customers have the same environmental objectives as we do – promoting a circular economy, lowering our carbon footprint and supporting biodiversity."

Tomi Takala, Business Area Director, Industrial Adhesives and Fireproofing, Kiilto

Maija Kulla-Pelonen, R&D and innovation manager at Kiilto, is responsible for developing a portfolio of adhesives based on VINNAPAS® eco.

cases, the mass balance approach is a more sustainable alternative right now than operating stand-alone bio-based production, because existing production lines can be used rather than having to build new facilities that are currently less efficient."

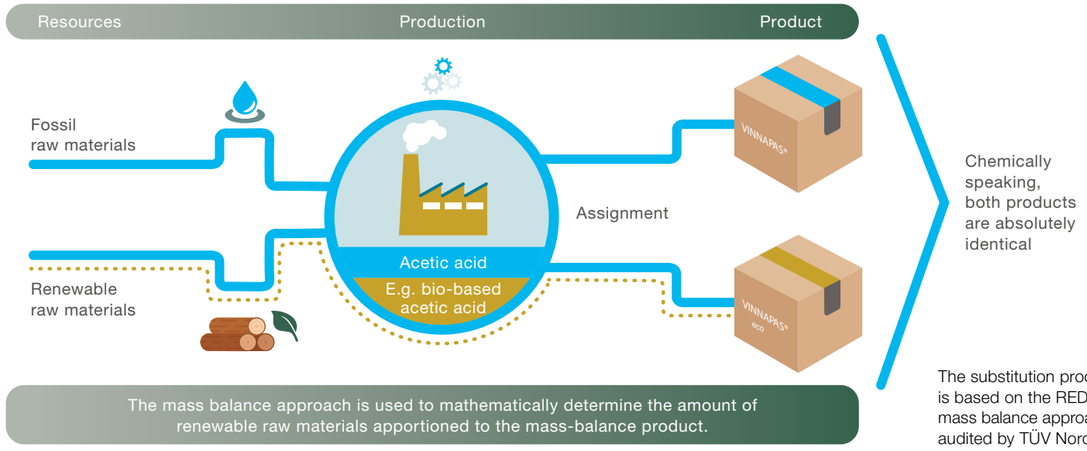
"We believe that this process is an important first step toward fully bio-based production."

Maija Kulla-Pelonen, R&D and Innovation Manager, Kiilto

So Kiilto decided to launch a portfolio of adhesives based on VINNAPAS® eco. Called Kiilto Pro Pack Eco, it comprises 16 different products for the paper and packaging industries. Tomi Takala, director of this business field at Kiilto, says: "Our customers have the same environmental objectives as we do – promoting a circular economy, lowering our carbon footprint and supporting biodiversity. We can now offer them adhesives based on renewable raw materials that provide as much high value as our established products." VINNAPAS® eco can indeed replace VINNAPAS® binders based on petrochemical feedstocks one to one in formulations – quality and properties are completely identical.

ONE PLANT FOR TWO FEEDSTOCKS

One and the same plant manufactures not only VINNAPAS® but also VINNAPAS® eco products. VINNAPAS® eco 8620 E is a product that saves on fossil resources. Whenever this product is bought, 100% of the fossil-based raw materials required for manufacturing this product are replaced by sustainably certified renewable raw materials like biomass.



COMMITTED TO SUSTAINABILTY

According to Takala, the decision to launch the Kiilto Pro Pack Eco portfolio was guided by the company's promise to the environment. He added that ecological rather than economic considerations had therefore been the deciding factor. "We are nevertheless confident that the course we have taken is also sustainable from a business point of view," he emphasizes.

Johan Bülow, polymers sales manager for Scandinavian and Baltic countries, welcomes the sustainability initiatives of his Finnish customer: "Together with Kiilto, we succeeded in expanding our VINNAPAS® eco business for adhesives applications last year, despite a very challenging economic climate marked by a difficult logistics situation and raw-material scarcity due to the pandemic."

Bülow and his team hope to intensify collaboration with Kiilto in the future, especially on the marketing front. "We are thinking of joint workshops for industry in order to bring home the advantages of mass-balance products," he says.

After all, any customer who chooses VINNAPAS® eco or a product based on it already helps not only to increase the proportion of renewable resources, but also to reduce the amount of fossil raw materials in WACKER's production lines.

CONTACT

For more information on this topic please contact

Lena Kläger
Sustainability Manager
WACKER POLYMERS
Tel.: +49 89 6279-1230
lena.klaeger@wacker.com

Taking a look at production: silicones are the secret to the success enjoyed by Newteam Medical's attractive breast prostheses.

PERSONALIZED PROSTHESES

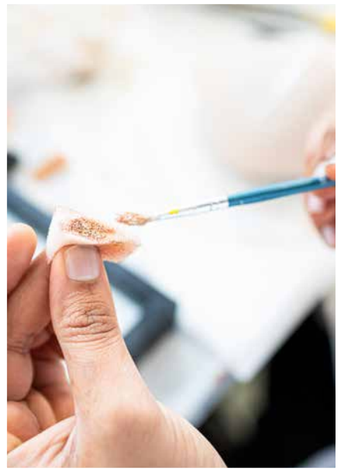
The startup Newteam Medical from Toulouse in the South of France manufactures breast prostheses from silicone rubber that can be individually adapted to the patient's anatomy. They are amazingly life-like and give cancer patients back some of their quality of life.

Whereto? Newteam Medical? Down at the end, the second to last door on your left!" The caretaker behind the high railing fence holds the gate open and points the way through several austere-looking office buildings and warehouses. The Saint-Jory industrial estate, roughly half an hour's drive from the southern French city of Toulouse, is the epitome of functionality, though you soon forget your surroundings when the head of Newteam Medical, Leonarda Sanchez, opens the door. Sanchez exudes South American warmth, energy and zest for life: she vivaciously greets her visitors and straight after the first "bonjour" apologizes for the startup's humble abode. "We're a very small team, a real startup," she says, all smiles.

TEN YEARS IN DEVELOPMENT

The premises are indeed limited. So much so that the few employees work shifts as there is not enough space for them all to be there at the same time. The functionality found outside is mirrored here indoors on a smaller scale: a polished metal table is the focal point of the first room. On the table are scales and a few amazingly life-like breast prostheses laid here to dry as the temperature-controlled drying cabinet next door is already full. Under the large table there is a stack of trash cans to mix silicone in, on the shelf opposite are metal molds, all carefully arranged according to size. The next room is somewhat cozier where two employees are sat concentrating on their work.

The primer is dabbed onto the slightly translucent prosthesis.

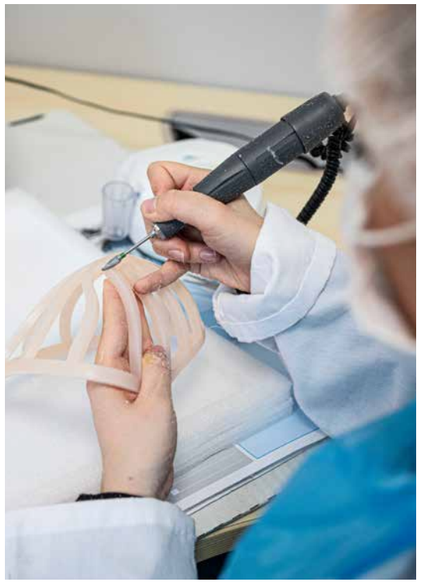


Leonarda Sanchez excitedly gives us a tour of her small realm, alternating between being communicative and remaining reserved for fear of inadvertently disclosing company secrets. This is because these products, which have only been on the market since 2021, are the result of a decade of research and several patents. The three product groups offered by Newteam Medical are called Airavanti, Meavanti and Suitavanti and they differ in many respects from the standard prosthetics on the market. “Our prostheses are personalized and always state-of-the-art. We have patents in France, the EU and even one in the USA. Three unique aspects have been acknowledged,” she explains with great pride and joy with regard to what has been achieved. It all began with a personal stroke of fate.

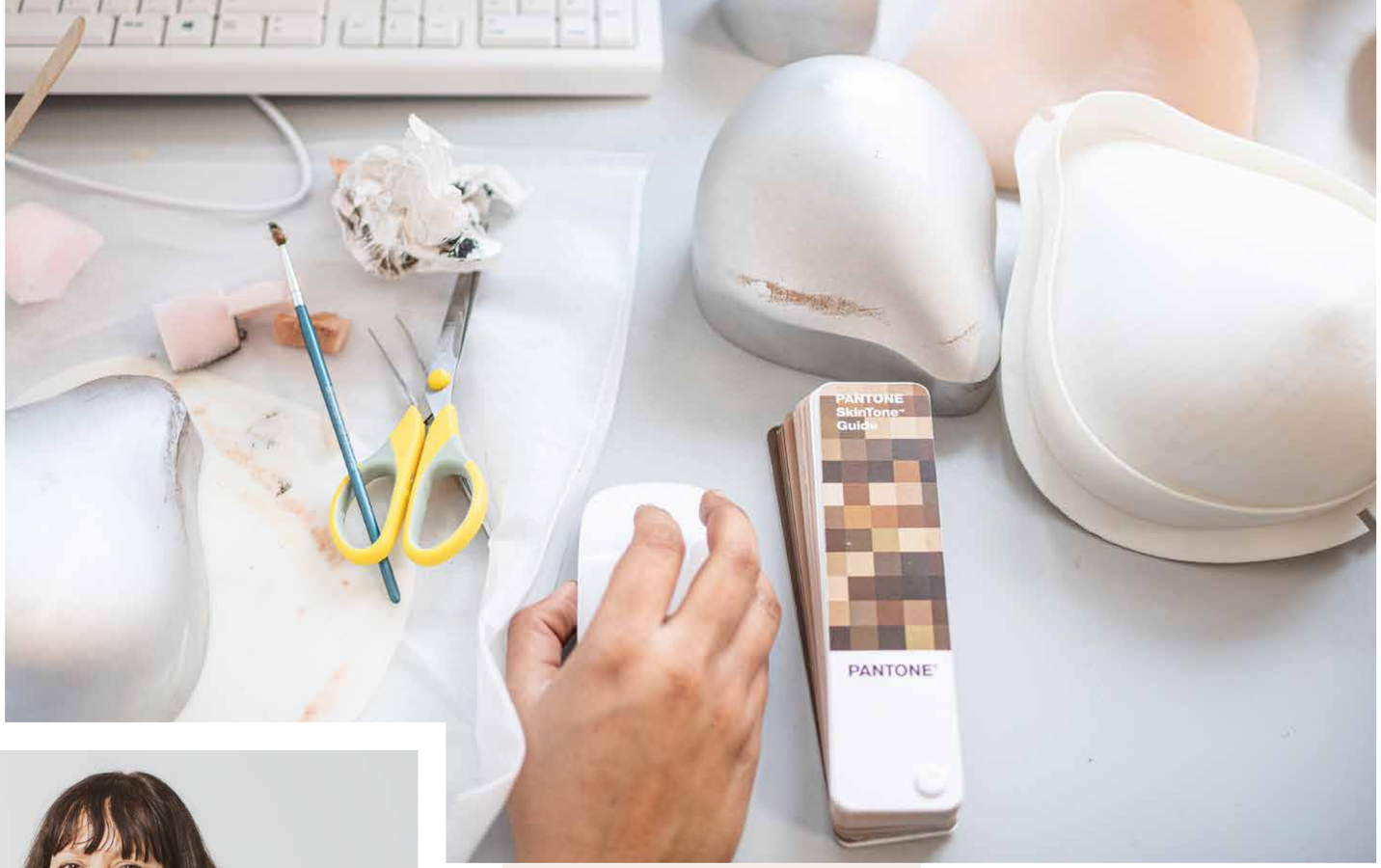
PROTHESES IN DAYS PAST: HEAVY AND UNCOMFORTABLE

Sanchez got thyroid cancer in 2010, while her friend came down with breast cancer. Confronting the illness completely changed the life of this mother of three. While she beat the cancer, her friend had to undergo a mastectomy, i.e., have her breast removed. “She was not the only one in my circle of friends. To lose such an intimate part of the body is unbearable.” Sanchez experienced the difficulties women face afterwards, both psychologically and on a practical level with conventional prostheses. “Standard prostheses were very heavy back then and caused acute back problems for most women due to the imbalance of the two breasts, not to mention the volumes that were often wrong and failed to produce visual harmony.”

The prostheses shown are called AIR’AVANTI. They are being cleaned in the tunnel on the right. Quality control is the next stage.



An AIR'AVANTI prosthesis is sanded by hand.



Customization takes parameters such as skin tone and individual pigmentation into consideration.

WEARING COMFORT AND AESTHETICS

Leonarda Sanchez told herself that there had to be a better way of doing things and set to work without any prior knowledge of medicine, chemistry or materials science. "I am a tinkerer and my mathematical background during my early career has always helped me. When I come across a problem, I look for a solution and keep going until I have found one." For three years, the 51-year-old experimented in her kitchen. She carried out the first tests with natural materials such as plants or corn and finally came across silicone. "Our products have to meet stringent health standards and regulations, which have become stricter since 2017. Only silicone is able to fulfill these requirements."

But on this point, she was not satisfied with commercially available products either.

"Our products have to meet stringent health standards. Only silicone is able to fulfill these requirements."

Leonarda Sanchez

Sanchez quickly realized that she needed her own formula. "I first contacted chemists because I didn't even know that you have to mix the A and B components when working with silicone," she smiles in retrospect. She regularly exchanges information with experts and works closely with clinics, but over the last ten years she has acquired a vast amount of knowledge herself. At the outset, the goal was only to make the prostheses lighter and fit in terms of volume. Nowadays, Meavanti and Suitavanti prostheses take that much further by trying to imitate the amputated breast as regards weight, volume, shape, skin color and nipple, down to the smallest blemishes such as moles, visible veins and blood vessels. The prostheses are also adapted to the thorax or rib cage to ensure maximum comfort.

PROPRIETARY SOFTWARE

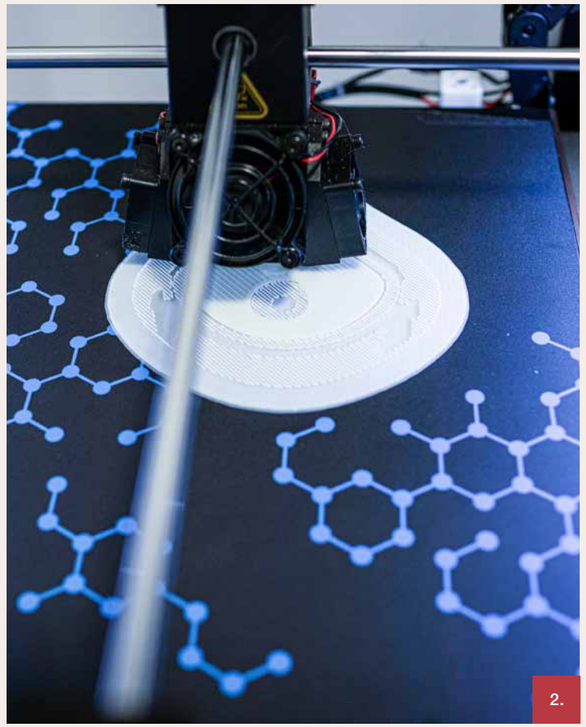
Several individual steps are required to achieve this. "Each breast has its own weight. Regardless of cup size or volume." Newteam Medical uses its own program based on AI, a scanner and its own algorithm to measure the weight of the breast. The margin of error is minimal with discrepancies of 10 grams at most. Initial data is collected by trained contractors who use performance specifications to gather information from customers regarding weight, shape, volume and skin color. Once the data has been anonymously transferred to the headquarters in Toulouse, production can begin.

A Meavanti prosthesis consists of several individual parts which are pieced together in the course of production. Newteam Medical uses WACKER's room-temperature-vulcanizing

10

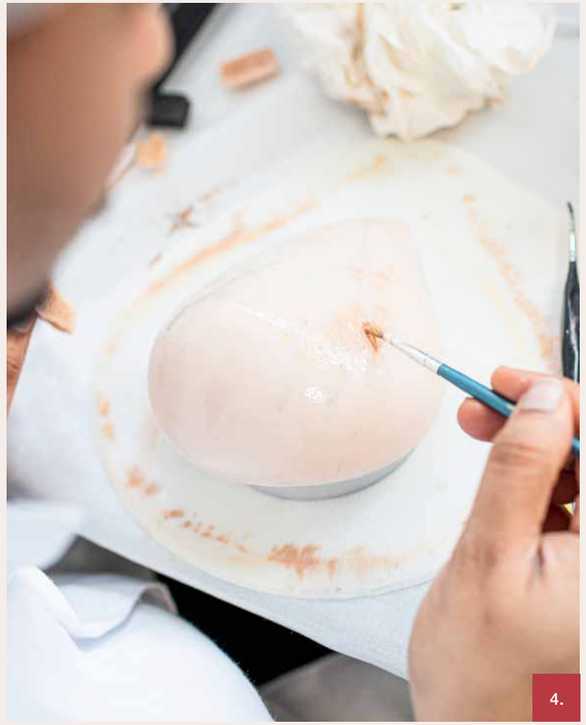
minutes is the time it takes for the WACKER silicones used in the MEAVANTI prostheses to cure in the drying oven.

1.



2.

3.



4.

The individual parts of the prosthesis vulcanize in the drying oven.

1 Weighing: The silicones selected are of high-grade quality and meet the stringent demands of the health-care industry.

2 3D printing: Each prosthesis involves several parts. In this particular case, the back is printed from biocompatible material.

3 Antislip: The surface of each prosthesis is individually coated, which enhances the antislip quality on the patient's torso.

4 Adding color: After the prosthesis has been primed, silicone-based paints are used to paint on tiny blood vessels, veins, moles and nipples.

silicone rubber compounds from the ELASTOSIL® and SILPURAN® ranges.

THE KEY TO SUCCESS? SILICONE!

"I have been experimenting for a long time to find the perfect formula. Each type of silicone has different properties. Both the WACKER silicones I use today have properties other manufacturers are unable to supply," Sanchez explains without going into any more detail so as to protect intellectual property.

Few operators have been working on the painstaking job of painting silicones. Newteam Medical has invested many years of R&D in developing customized painting procedures.

The first step is mixing the matching skin color from silicone paints. Due to their low surface tension, silicones can only be painted using special paints, which are likewise based on silicone. In order to ensure biocompatibility and the patients' comfort, Newteam Medical has selected only the very best silicone paints available on the market.

What is more, Newteam Medical employs art college trained students specialized in realistic painting, such as Laurent Cartier. The painting techniques developed by Newteam Medical allow Cartier to dab on the silicone paint with a cloth and then carefully paint on small blood vessels, veins, freckles, moles and the nipple with a brush.

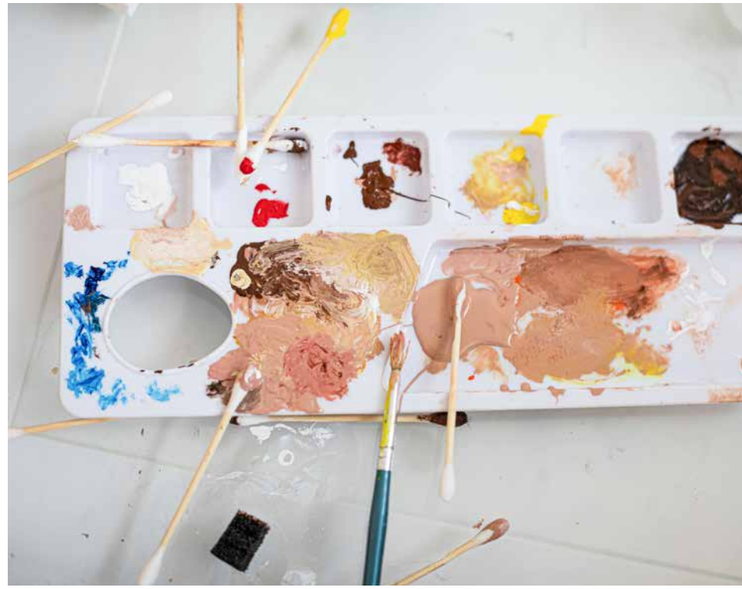
The result reproduces a real breast very closely. As Laurent Cartier says, "Painting on silicone is completely different from painting on canvas. You have to be very quick as the paint dries fast. Thanks to our technique, customization lasts two years."

Once the prosthesis has been painted, the appropriate weight is inserted and the rear side is sealed with a silicone backing.

INNOVATIONS FOR HIGHLY SENSITIVE SKIN

External prostheses may be supplied as padding in a special bra or as prostheses which adhere to the skin. In this case, another layer of

Leonarda Sanchez founded Newteam Medical, a company dedicated to the highest quality and the needs of women affected by breast cancer.



To give the skin a natural look, the silicone-based paints are mixed individually.

CONTACT

For more information on this topic, please contact:

Jacky Fromont
Wacker Chimie S.A.S.
11, bis quai Perrache
69002 Lyon, France
Tel.: +33-478-1760-44
jacky.fromont@wacker.com

silicone is applied. "We also use a product from WACKER for this. It is fantastic. It adheres to the skin and is not painful at all when you remove the prosthesis," she enthuses.

Newteam Medical has also come up with a solution for women with particularly sensitive skin or for those who have been recently operated on where the scar tissue has not yet formed. The Airavanti model is also made of silicone but has a mesh structure which allows the skin to breathe and does not touch the scar at all. This is a real breakthrough as women are not normally able to wear silicone prostheses directly after having had a mastectomy. For patients who are unable to wear any kind of standard prosthesis, for instance because their rib cage is uneven, there are even customized designs: Sanchez calls this range of custom-designed prosthetics Suitavanti.

"The feedback we get from women shows that our effort is all worthwhile. Some women write telling us that they have been back to the beach for the first time or that they finally have the confidence to be photographed again." Several women sent unsolicited photos of their breast. Although the products cost almost three times as much as standard prostheses and there is up to one month's wait for a prosthesis, demand is continuously increasing.

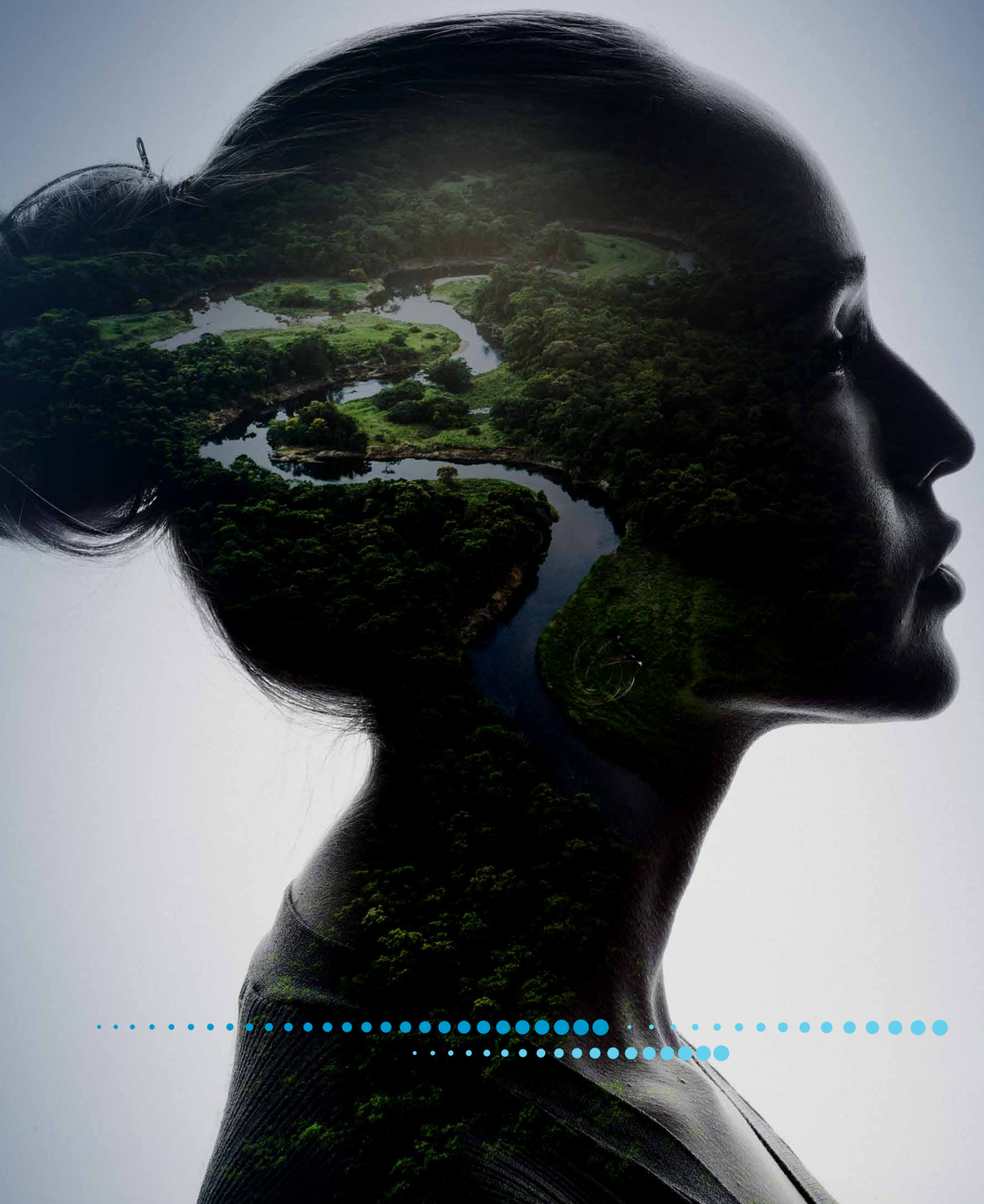
> "But what really counts for me are women and the quality of life that we give back to those affected by breast cancer."
>
> **Leonarda Sanchez**

POSITIVE ACTION

To date, there have been virtually no complaints. There is a two-year warranty on Newteam Medical's products. These prosthetics are not yet subsidized by French health insurers. However, Leonarda Sanchez is hopeful that this will change. She is conducting a long-term study with IUCT Oncopole Toulouse, a university cancer institute, to prove the positive impact personalized prosthetics have on the psyche, as well as wearing comfort and health aspects.

The small company is growing more quickly than expected. Two new employees have been hired and the company also plans to move to newer and larger premises. "But what really counts for me are women and the quality of life that we give back to those affected by breast cancer," Leonarda Sanchez emphasizes. "I know every woman I have sent a prosthesis to, every single one. Everything else can wait." ■

1.22 ▸ K SPECIAL



THINKING BEYOND

WACKER is bringing a host of product innovations to K 2022, the International Trade Fair for Plastics and Rubber, taking place in Düsseldorf from October 19 to 26. Its offerings center on silicones and silicone-based applications that pave the way for sustainable solutions in the fields of electromobility, energy generation, medical technology, and plastics processing.

1 ELECTRO-MOBILITY

2 IATF CERTIFICATION

3 ELASTOSIL® ECO

4 VINNEX®

5 GENIOPLAST® PE50S08

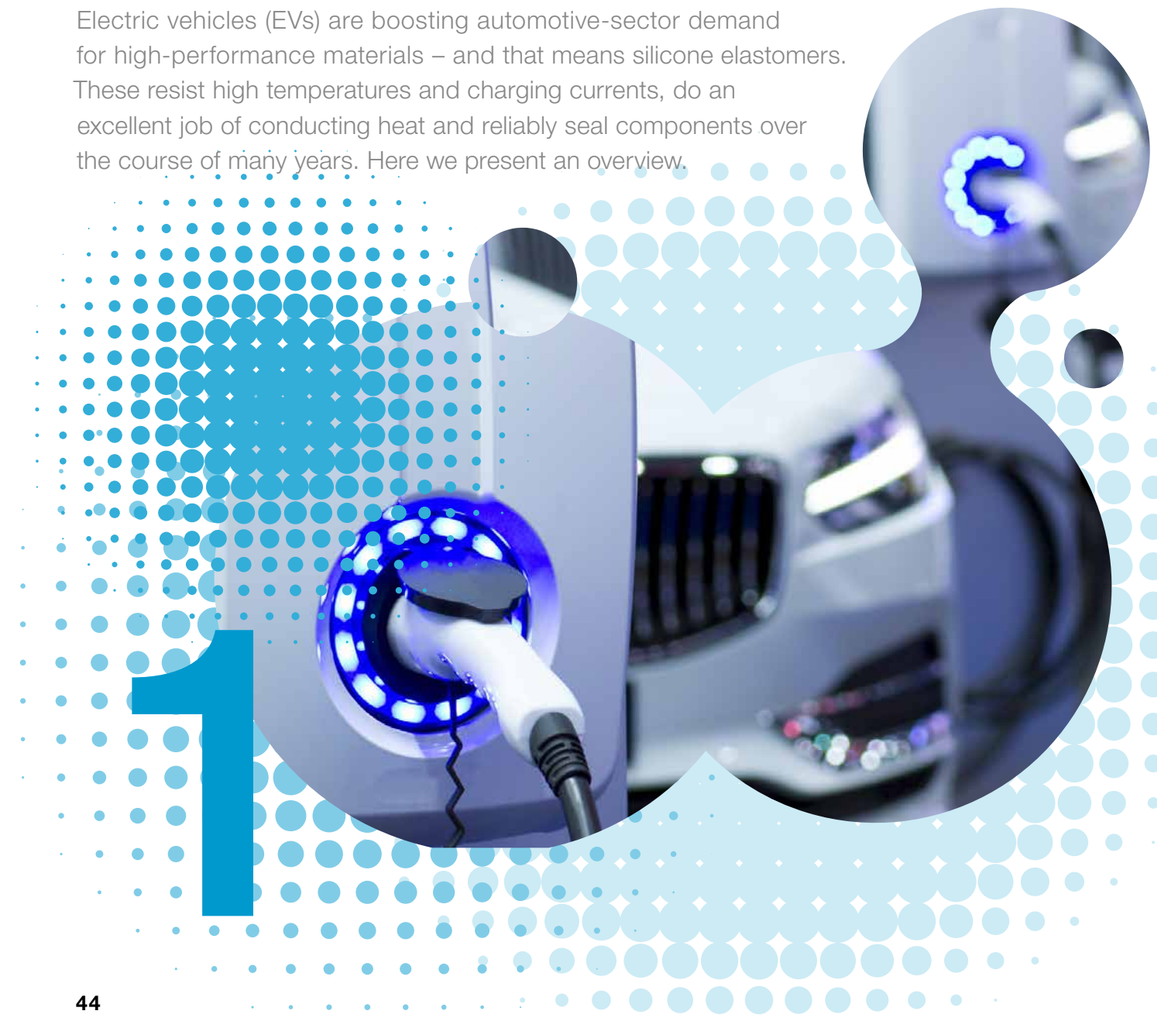
6 ELASTOSIL® LR 3078

7 POWERSIL® RESINS

8 INTERVIEW

MATERIALS SIMPLY MADE FOR EVS

Electric vehicles (EVs) are boosting automotive-sector demand for high-performance materials – and that means silicone elastomers. These resist high temperatures and charging currents, do an excellent job of conducting heat and reliably seal components over the course of many years. Here we present an overview.



1

1.22 ▸ K SPECIAL ▸ **ELECTROMOBILITY**

n 1964, a typical car made do with 180 meters of cables and a couple of connectors. By contrast, today's models, whether hybrid or fully electric, contain 3,000 meters of the former and up to 200 of the latter.

With the growing electrification of vehicles, it is not just the number of cables, on-board electrical systems and electronic control elements that is growing, but also the demands imposed on these components and their constituent materials.

Through its portfolio of ELASTOSIL®, SEMICOSIL® and WACKER SilGel® silicone rubber compounds, WACKER offers a wide range of solutions for meeting the challenges facing the automotive industry as it transitions to electromobility. The fact that its Burghausen (Germany) and Zhangjiagang (China) production sites are IATF 16949 certified (see the next K Special article) for certain parts of the company puts WACKER in a position to supply automobile manufacturers with silicone products directly.

"The unique properties of silicones have an important role to play in electromobility and, it follows, in sustainable transportation for the future," says Dr. Martin Bortenschlager, head of the WACKER SILICONES Engineering Silicones business team and responsible for the regions of Europe, Middle East, Africa and Latin America. "Silicone rubber compounds do more than just make electric vehicles more reliable – they make them last longer too. They also reduce the need for repairs and replacement parts, which helps prevent waste. And on top of that, their ease of processing supports automated mass production." ■

ELECTRICAL CONNECTORS

Electrical lines have to be connected and disconnected during assembly and maintenance work. The fastest and most reliable way to do this is with electrical connectors. These frequently have a silicone seal to prevent ingress of moisture, dust and de-icing salt. The most common seals are single-wire, radial and mat types.

For applications like these, WACKER offers both liquid and solid silicone rubber products that continuously bleed silicone fluid after they have cured. Also available are products with oil-free yet lubricating surfaces. These are perfect for electric vehicles.

The products in the ELASTOSIL® LR 38xx line are of the oil-bleeding type and can be used to reliably seal connectors. These liquid silicone rubber products can be processed by injection molding. Just shortly after curing, the rubber starts exuding a thin fluid film, yielding lubricating properties that make it easier for the connector to slide into the desired mounting fixture. ELASTOSIL® LR 38xx products offer low-temperature flexibility and heat resistance and can be used in the range from -55 to +210 °C. These liquid silicones also contain very little in the way of volatiles, an achievement made possible by the ultramodern processing technologies used by WACKER during production.

Alternatively, automakers that do not wish to use oil-bleeding elastomers, yet are keen to mount their connectors efficiently in a fully automated process can make use of silicone products with low coefficients of dynamic friction, such as ELASTOSIL® LR 3065. Another option for connectors is ELASTOSIL® LR 3005. This is the ideal product whenever a low coefficient of friction is not absolutely necessary. All the aforementioned products have low compression set at high service temperatures, even when non-postcured. Postcuring is therefore superfluous.

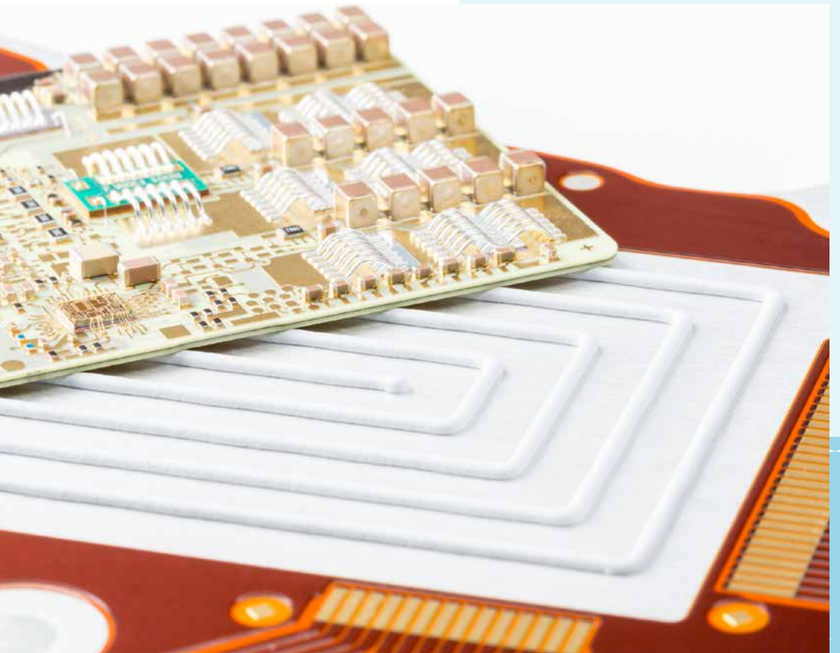
THERMAL INTERFACE MATERIALS

Efficient heat management of components is a pressing issue in electric vehicles. One reason for this is the increasing level of miniaturization and the resulting higher energy densities. Among the important roles that they play, thermal interface materials fill the gaps between heat-generating assemblies and the heat sink, taking the place of air, which is a poor heat conductor. Silicones filled with inorganic heat-conducting materials are ideal for this task, as their properties remain virtually unchanged at temperatures ranging from -45 to +180 °C. They also resist aging and act as flame retardants.

The SEMICOSIL® 96xx TC line of room-temperature-curing silicone rubber products, for instance, is suitable for the thermal coupling of printed-circuit boards to a heat sink. They are easy to dispense and can be applied in no time to large surface areas – and without any flaws. This renders them perfect for coupling battery modules to a heat-dissipation system, even in a mass-production scenario. Depending on the specific design involved, thermal gap fillers such as SEMICOSIL® Paste 40 TC are suitable for fixing and cooling components, while thermally conductive adhesives such as the SEMICOSIL® 97xx TC line create a thermal coupling between components and the heat sink in question.

The power control units in EVs, in particular, are becoming increasingly compact and energy-dense, and are generating more heat. This needs to be removed efficiently if the components are to stay at the desired operating temperature. Thermally conductive compounds such as ELASTOSIL® RT 76xx TC are a new class of materials for encapsulating or immersing printed-circuit boards fitted with discrete devices, such as transformers, chokes, coils and other electronic components.

Thermally conductive silicone gels make ideal gap fillers, taking the waste heat produced by electronic components and dissipating it efficiently to a heat sink.



BATTERIES – NEW APPROACHES TO PERFORMANCE AND SAFETY

With the growing adoption of electric vehicles, battery makers face numerous challenges when it comes to improving battery performance and safety. The focus of attention here is on the following fundamental aspects:

- The batteries must be compatible with high-volume, cost-efficient assembly and mass-production processes.
- For efficient thermal management, innovative approaches have to be found. Keeping the cells at their ideal temperature is central to the safety and durability of a vehicle battery. And is the only way to ensure optimum performance.
- Safe operation must be ensured even if extreme events occurred. This includes thermal runaway in the battery.

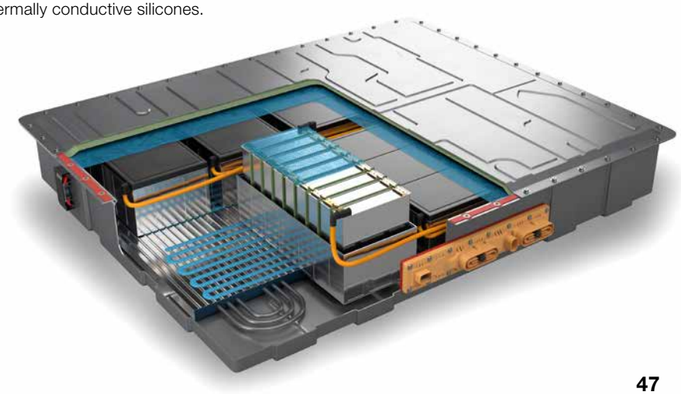
WACKER offers various silicone solutions for keeping the battery temperature within the optimum range, for boosting battery safety generally, and especially for preventing thermal runaway.

GAP FILLERS PREVENT PREMATURE BATTERY FAILURE

Electric vehicles frequently employ lithium-ion batteries as their power source. These are usually installed below the passenger compartment, where they occupy most of the floor space. A thermally conductive gap filler is needed to provide thermal coupling between the battery modules and the heat-dissipation system. It must be aging-resistant to prevent premature battery failure and must lend itself to rapid application to large surfaces.

One particular challenge consists in ensuring that the bottom of the battery cell fits tightly to the heat sink. The resulting narrow gap of a

When in use, the lithium-ion batteries in EVs generate vast quantities of heat that has to be dissipated by means of thermally conductive silicones.



CONTACT

For more information on this topic, please contact:

Claudia Berghammer
Senior Marketing Manager
Engineering Silicones
Tel.: +49 8677 83-86745
claudia.berghammer@
wacker.com

Silicone encapsulants reliably protect sensors and sensitive electronic components in vehicles against vibration, dirt and moisture.

few hundred micrometers has to be completely bubble-free in order that the heat may dissipate unhindered. For this, WACKER has developed a flowable gap filler that can be injected quickly and yields perfect results even on large areas, thereby facilitating high-speed industrial production.

HIGH OUTLAY ON FIRE SAFETY

Automakers go to great lengths to ensure the safety of their electric vehicles, especially of their batteries. They install flame-resistant fire-protection mats and coatings to prevent heat and flames from raging through the vehicle in the event of a battery fire. However, current safety strategies have advantages and disadvantages. Fire-protection mats, for instance, take up more space than intumescent coatings. These, for their part, are designed to swell up extensively in the event of a fire, and that could cause damage to individual cells.

WACKER is currently contributing to battery safety by developing an innovative coating that meets all the technical and safety aspects of fire protection, efficient use of space and process-automation needs. The coating is a novel silicone rubber blend that is applied to the internal face of the battery housing and ceramifies completely when exposed to heat. Although it is is just a few millimeters thick, the ceramic layer can withstand temperatures higher than 1,000 °C. Should thermal runaway occur, a coating like this protects the housing and so boosts vehicle safety substantially. ■

CABLES

Voltage, charging currents and the resulting waste heat of battery-operated vehicles are constantly on the rise, with voltages of up to 800 V and charging currents of up to 350 A no longer uncommon. To make cables, the automotive industry therefore needs extrudable materials that will reliably retain their electrical insulation properties over a very broad range of temperatures and over long periods of time. It applies very high standards: the only cables that may be installed are those that can be used for at least 3,000 hours at temperatures between 180 and 200 °C.

Silicones such as ELASTOSIL® R *plus* 4305, a rapid-curing, two-part, solid silicone rubber compound, are an ideal fit for applications such as these. When formulated with a corresponding heat stabilizer, the product can withstand temperatures of up to 200 °C, without substantial changes in either the mechanical properties or the electrical characteristics of the elastomer. ■

SEALS IN FUEL CELLS

The debate surrounding sustainable drive trains is currently focused on battery-powered electric vehicles. But there are other drive designs that may equally serve the purpose of electromobility in the future. One such example is fuel cells. These are attractive because they make it possible to achieve a long range. They are already the preferred sustainable alternative to ICE trucks, because they enable drivers to transport loads over long distances, which is not the case for battery-powered vehicles.

Such a system consists of single fuel cells connected together through what are known as bipolar plates. WACKER supplies specially developed silicone rubber grades for sealing these plates: ELASTOSIL® LR 3025 for injection molding and room-temperature-curing ELASTOSIL® RT 624 for dispensing. Both silicone rubber compounds are characterized by extremely low compression set – even when in contact with coolants.

Die-cut seals made from ELASTOSIL® Film 624 represent an additional option. Consisting of ELASTOSIL® RT 624, these silicone rubber films are produced with incredible precision to thicknesses between 150 µm and 400 µm. Deviations from target thicknesses amount to less than 5% across the entire range. This, along with the typical silicone properties of the film, makes the product very attractive to fuel-cell manufacturers. ■

TWO-COMPONENT PARTS

Thermoplastics such as polyamide and polyester can be combined in an injection-molding machine with liquid silicone rubber for an efficient method of producing multicomponent parts in which the silicone performs a sealing or protective function. For this to work, however, the liquid silicone has to adhere perfectly to the thermoplastic.

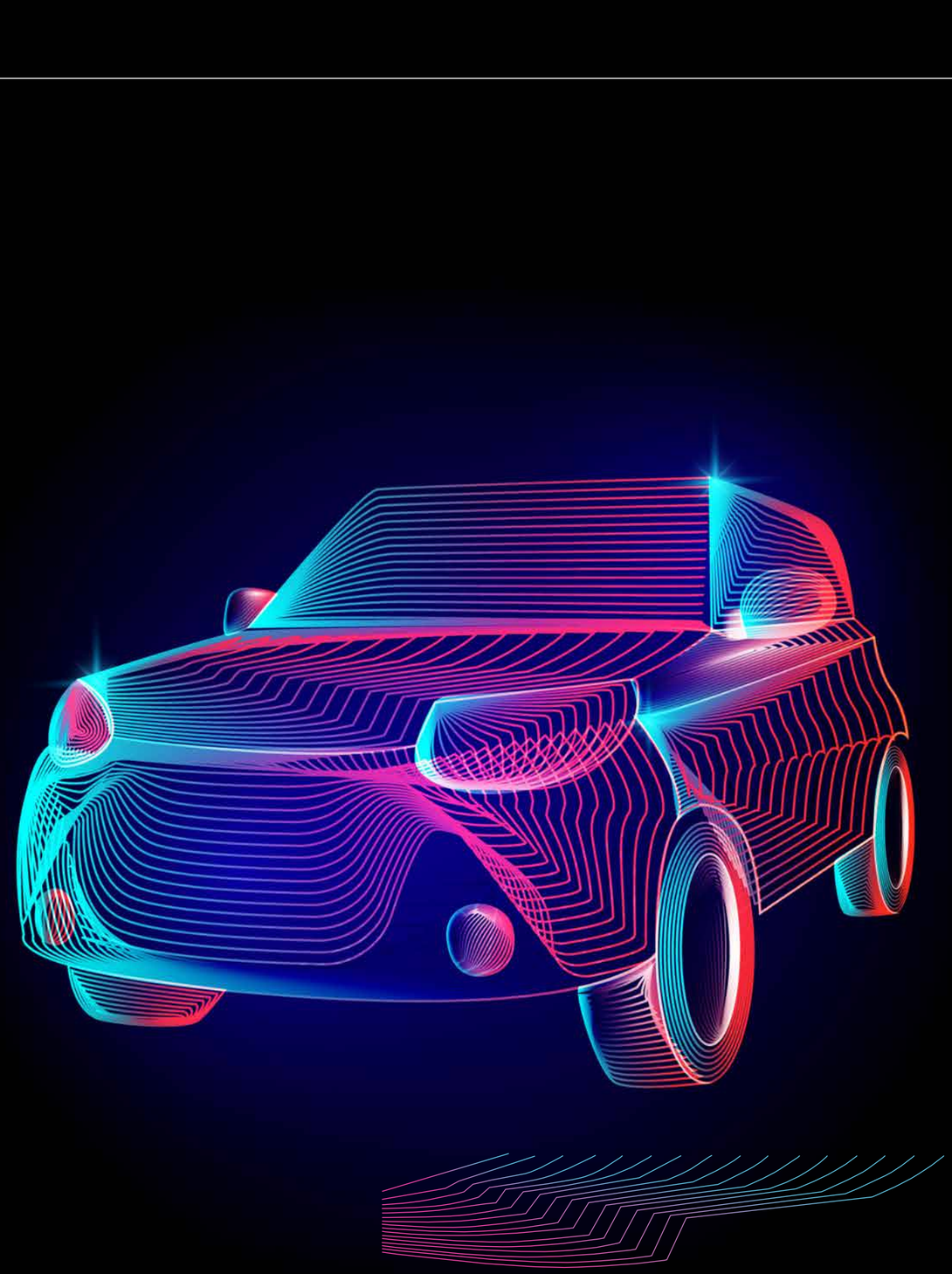
ELASTOSIL® LR 3070 and its oil-bleeding counterpart ELASTOSIL® LR 3072 are ideal for this application. Because they adhere well to many metals, they open the door to cost-effective production of metal-silicone-elastomer components, even on a large scale.

“2 ZERO ERRORS: THE NEW NORM

WACKER has had part of its silicone production certified to the IATF 16949 standard – thus opening the door to new automotive-sector markets. After all, today’s cars wouldn’t work without silicone rubber – regardless of whether they have a conventional or electric drive.

In 2016, the International Automotive Task Force – a group of major automotive manufacturers and international automotive associations – published the IATF 16949 automotive standard. The automotive industry uses this standard to summarize the requirements that have to be met by suppliers’ organizational structures and quality management systems. WACKER, too, has now had part of its silicone business at its sites in Burghausen (Germany) and Zhangjiagang (China) certified to IATF 16949. Two-component silicone rubber formulations that are cured at room temperature by an addition reaction to form silicone elastomers are produced in the certified plants. Under the brand names SEMICOSIL®, ELASTOSIL® and WACKER SilGel®, they are used as thermally conductive gap fillers, silicone adhesives, potting compounds, and more.

The editorial team discussed this project with Dr. Thorsten Schneppensieper, head of Global Customer Service, and Dr. Sebastian Rommel, Global Segment Manager – Automotive, who jointly promoted the certification.



1.22 ▸ K SPECIAL ▸ AUTOMOTIVE INDUSTRY

WACKER Magazine: What are the automotive industry’s goals with IATF 16949?

Dr. Sebastian Rommel: With this standard, the automotive industry wants to minimize all risks that might threaten production, and to ensure that suppliers operate reliably. The industry is aiming for continuous, absolutely smooth automotive production. To achieve these goals, the automotive industry uses the IATF standard to impose strict requirements on the organizational structures and the quality and risk management of its suppliers.

Customers know WACKER for the consistently high quality of its products. Why does the automotive industry have to get this specially certified?

Dr. Thorsten Schneppensieper: The automotive industry has exceptionally high requirements that relate to the sector’s typical supply chain. Suppliers are responsible for at least three-quarters of the entire value creation inherent in the production of a vehicle. Carmakers process the supplied parts and materials using fast and highly automated manufacturing processes. Assembly lines standing idle because of faulty components or materials, or a delivery delay, would result in high costs. If you consider the costs in the event of a product recall, not to mention the damage to their image, it is understandable that a special standard for a highly engineered and

complex entity like a car was implemented. To ensure value creation, automotive manufacturers expect a zero-error strategy from their suppliers. The IATF 16949 standard is intended to ensure zero errors throughout the entire value creation chain. A supplier not certified to this standard has almost no chance of working directly with the car industry.

What are the main requirements of IATF 16949?

Schneppensieper: Error avoidance, risk management and reliability are at the core of IATF 16949. The notion of error avoidance is particularly important: instead of reacting to malfunctions and correcting errors, such errors should not even arise. This minimizes the failure risk for automotive manufacturers and the liability risk for suppliers. The standard not only states what needs to be done, but also specifies how this should be achieved, i.e. which specific quality-assurance measures need to be taken. It also entails meeting every single customer-specific requirement in full. In addition, IATF 16949 requires suppliers to continually improve their processes.

> “The electromobility revolution is proceeding apace, so that demand for silicone specialties is growing rapidly.”
>
> **Dr. Sebastian Rommel**

The automotive standard formulates requirements regarding processes, workflows and management methods for those parts of the company that develop and manufacture products for the automotive industry.

WACKER SILICONES has allowed itself several years for the certification. Why is the business division performing the certification just now?

Rommel: Until recently, material manufacturers hardly ever supplied the automotive producers directly. In the past, our silicone products for automotive applications were supplied almost exclusively to part and component manufacturers, and thereby to companies operating in upstream stages of the value creation pyramid. However, with the transformation to electromobility, the supply chain has changed: some automotive manufacturers now manufacture key systems for electric vehicles – such as drive batteries or on-board charging units – themselves or in joint ventures with suppliers. Suitable materials – including silicone products from our portfolio – are increasingly needed directly at the automotive manufacturers’ production lines. The electromobility revolution is proceeding apace, so that demand for silicone specialties is growing rapidly. We – WACKER – want to participate in this growth market. That’s why this was the perfect time for us to obtain certification.

Are there silicone products that have become indispensable for electric vehicles?

Rommel: We are seeing extraordinarily high demand for silicone-based thermally conductive materials from the automotive manufacturers – for example for our thermally conductive gap fillers and thermally conductive potting compounds. Such materials are used in electric vehicles, for example for thermal management of the drive batteries and the charging unit. Both components get very hot during use, particularly during fast charging, which can lead to severe damage unless adequate cooling is provided. Thermally conductive materials help to effectively dissipate the generated heat to the heat sinks or the cooling system and thereby ensure reliable operation and a long lifetime. Thermally conductive potting compounds can additionally perform yet another function: they protect the surface of the power control units against environmental effects. Both types of silicone-based thermally conductive materials have become indispensable in the manufacture of electric vehicles, because silicones are not only electrically insulating but also heat and aging resistant, and therefore have superior properties to other classes of materials.

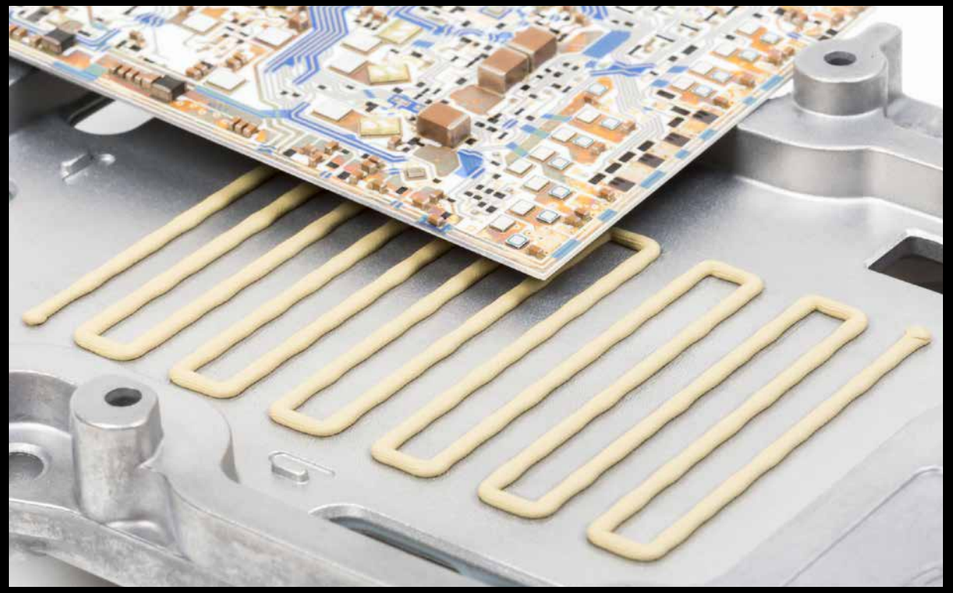
Dr. Sebastian Rommel is Global Segment Manager – Automotive at WACKER SILICONES.

Which parts of the company has WACKER had certified to IATF 16949?

Schneppensieper: Of course, it primarily involved the manufacture of thermally conductive silicone products. They include addition-curing RTV-2 compounds. These are two-component silicone-rubber formulations that are cured by an addition reaction to form a silicone elastomer. We have therefore certified those parts of the company that manufacture these RTV-2 silicones – specifically, certain areas of the silicone plants at our sites in Burghausen (Germany) and Zhangjiagang (China) – together with all the supporting functions such as product development, strategic planning, HR, procurement, marketing and sales.

Dr. Thorsten Schneppensieper is in charge of Global Customer Service at WACKER SILICONES' Regulatory Affairs and Quality Performance unit.

Thermally conductive silicone-based gap fillers optimize heat transfer between an electronic circuit that heats up during operation and the heat sink.



What test organization conducted the certification and what was the procedure like?

Schneppensieper: We commissioned TÜV Nord to do the certification. As specified in the standard, we first had to submit a detailed plan for the quality management system of the part of the company involved to the test organization, and show with suitable documentation that we had already been working for a year according to the stipulations of IATF 16949. We had already identified and eliminated weaknesses, adapted our workflows and processes to the requirements of the standard and installed additional systems for error avoidance. For example, as part of our continuous improvement efforts, we pursued the long-term goal of building up our automation to almost entirely eliminate manual errors by our operators. After examining the submitted documents, TÜV Nord conducted an initial audit with us, the phase 1 audit, and assessed us as ready for certification. Some weeks later, two auditors then spent several days with us to put our quality management system through its paces in the phase 2 audit. Having passed the audit, we received the certificates in January 2022.

Does that mean that WACKER now offers its entire portfolio of addition-curing RTV-2 silicones with IATF certification?

Rommel: No, not at all. An IATF-compliant quality management system and production setup involves far too much work – and is just not needed in many cases. Although we manufacture all our addition-curing RTV-2 silicones in the plants with certified parts of the company, we only selectively offer certain silicone compounds to the automotive industry within the scope of the certification. Our business partners can identify this selection by its name, WACKER SILICONES Automotive Solutions or WACKER SAS for short, which we use in our sales brochures and other documentation. Besides the silicone-based thermally conductive materials, this portfolio includes special automotive silicone adhesives, as well as a steadily growing number of other, non-thermally conductive RTV-2 compounds.

How does WACKER benefit from the certification?

Rommel: By fulfilling the IATF standard, we have created robust – that is failure-proof – transparent and traceable processes and workflows for our RTV-2 silicone plants. Certification allows us to prove to the automotive industry that we are a reliable business partner. This opens doors for us to new markets in the world of the automotive manufacturers. ■

"To achieve value creation, automotive manufacturers expect a zero-error strategy from their suppliers."

Dr. Thorsten Schneppensieper

CONTACT

For more information on this topic, please contact:

Dr. Thorsten Schneppensieper
Global Customer Service
Regulatory Affairs and
Quality Performance
WACKER SILICONES
Tel.: +49 8677 83-86345
thorsten.schneppensieper@wacker.com

EIGHT NEW ADDITIONS

WACKER's eco silicones are considered particularly resource-efficient since they use biomethanol from waste vegetable matter in the production process. The silicone rubber brands ELASTOSIL® and SILMIX® are now also available as eco products.

The chemical industry is committed to continuously reducing its use of fossil raw materials. One strategy here is to replace these with identical materials from renewable resources – an option best implemented using the mass balance approach. This method allows manufacturers to process raw materials from fossil-based and renewable sources at the same time, later assigning them to specific products according to the proportions in which they were used. The mass balance approach ensures that the "bio-based" label is applied only to those products that can be verified as being based on renewable raw materials.

The most important raw materials for silicone manufacturing are silicon and methanol. Methanol is first converted to methyl chloride and then reacted with elemental silicon via the Müller-Rochow process to form a mixture of various methylchlorosilanes – intermediates that play an important role in the production process.

In 2018, WACKER began producing methyl chloride from methanol it had generated from both petrochemical and plant-based resources, always applying the mass balance approach to the amount of biomethanol used. The method that WACKER employs for its mass-balanced products is certified at regular intervals by TÜV Nord in accordance with the REDcert² standard, ensuring that the amount of eco product sold always corresponds to the amount of biomethanol that goes into the process.

The mass balance approach is suitable for ready-to-use silicone products containing pigments or other organic additives. Such additives can be similarly offset by incorporating corresponding amounts of biomethanol. The REDcert² standard stipulates the exclusive use of raw materials obtained from renewable sources. The biomethanol in these processes is derived exclusively from plant residues suitable neither for food production nor as animal feed.

The first biomethanol-based silicones to be launched by WACKER in 2018 were silicone fluids and defoaming agents. Silicone sealants followed in 2020. Now, the ELASTOSIL® eco family, too, can announce new members.

THE NEW "ECO" SILICONES

Some eight silicone rubber alternatives based on biomethanol have been available since the fall. The first liquid silicone rubber to leave the starting gate is ELASTOSIL® LR 5040. The eco version (ELASTOSIL® eco LR 5040) of this extremely tear-resistant, non-post-curing grade will be available for order in six different hardness values. Customers wanting to conserve resources can choose between two lines of solid silicone rubber as well: peroxide-curing, general-purpose ELASTOSIL® R 401 (ELASTOSIL® eco R 401, hardness Shore A 40) and addition-curing, exceptionally tear-resistant solid silicone ELASTOSIL® R *plus* 4020 (ELASTOSIL® eco R *plus* 4020 with hardness Shore A 40). WACKER also offers biomethanol-based solid silicone compounds on request; these are ready-to-use mixtures marketed under the SILMIX® eco brand name. Throughout the K 2022 international tradeshow, the processing of the SILMIX® eco R *plus* TS 40002 solid

AT THE TRADESHOW

You can find us at the K 2022 international tradeshow in

Hall 6, Booth A10

Tradeshow management
Alexandra Wensauer
Tel.: +49 1520 9352490
alexandra.wensauer@wacker.com

1.22 ▸ K SPECIAL ▸ **RENEWABLE RAW MATERIALS**

"We can convert other products over to biomethanol at any time upon request."

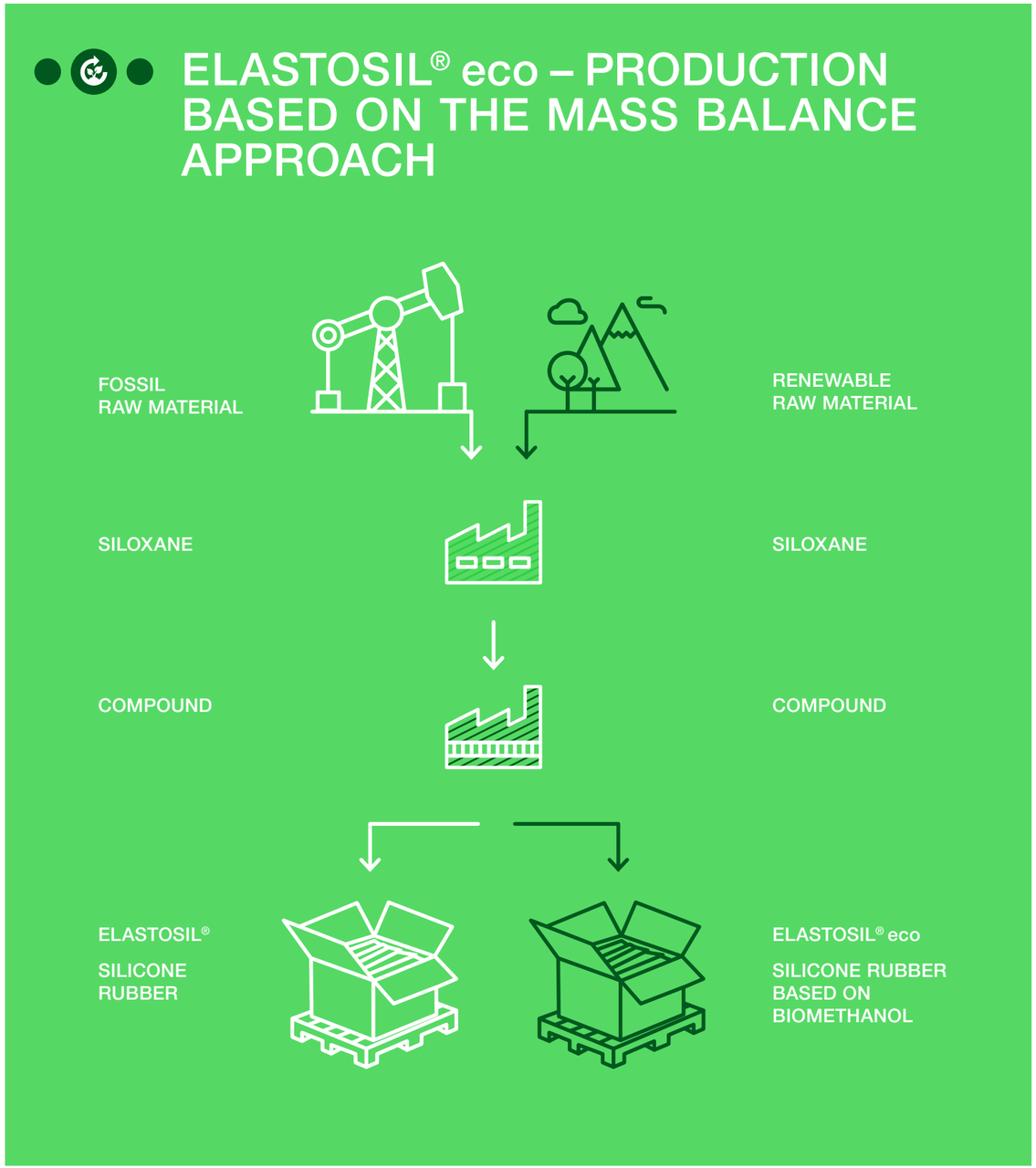
Dr. Martin Bortenschlager,
Engineering Silicones

rubber compound will be demonstrated live at the WACKER booth from 9 a.m. to 6 p.m. on an Engel injection molding machine (mold: Nexus; part design: Lékué).

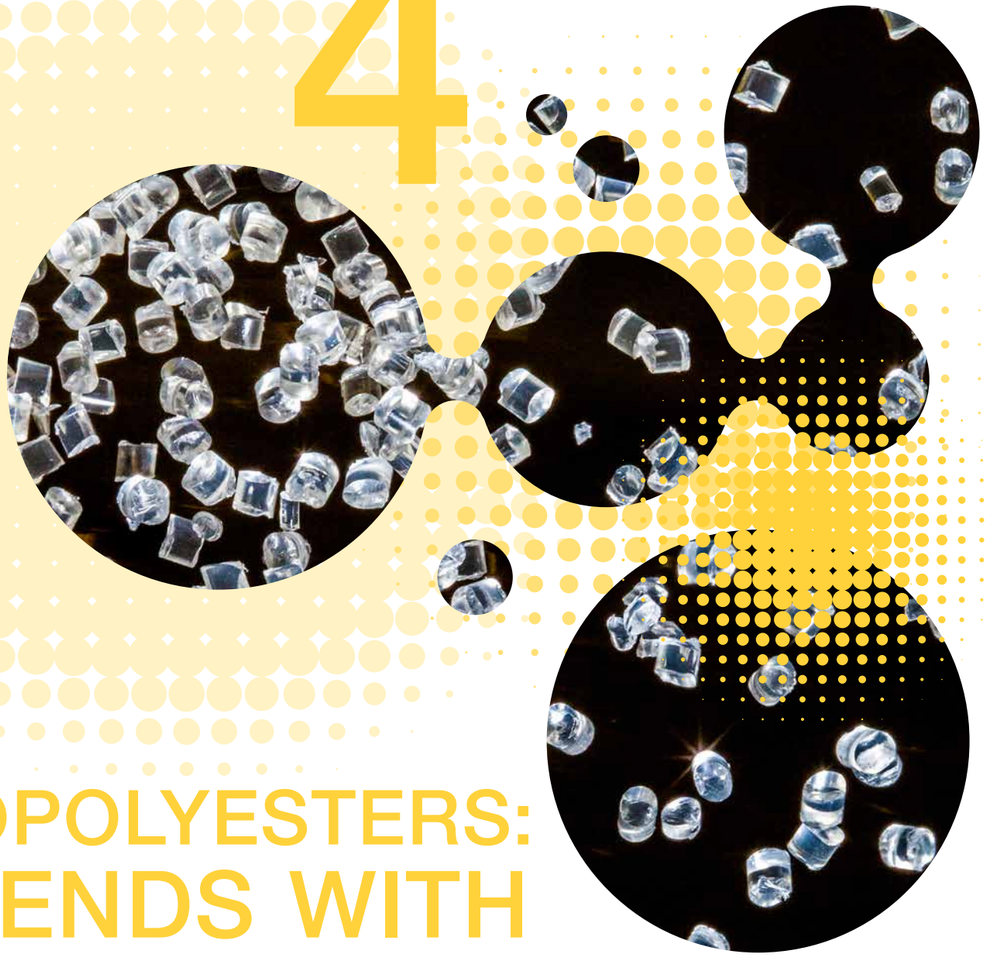
"We can now offer our customers eco versions of two multipurpose solid silicone rubber grades and one non-postcuring liquid silicone rubber grade for exceptionally sensitive applications," explains Dr. Martin Bortenschlager, director of WACKER's Engineering Silicones business team. He has been aware of the increasing interest in resource-efficient, and hence more sustainably manufactured, products for some time and can therefore readily imagine an expansion of the eco portfolio. "Our first step was to demonstrate that we're capable of offering resource-efficient versions of rubber products and of silicone compounds formulated to customer specifications. But that's just the beginning. We can also convert other products over to biomethanol at any time upon request."

Making the switch to the new eco product line is straightforward, incidentally. Because methanol and biomethanol are chemically identical, the silicone expert points out, there is no difference between ELASTOSIL® and ELASTOSIL® eco products. "You can test out ELASTOSIL® eco whenever you want without having to run a complex, expensive series of tests. The properties of our biomethanol-based silicones are the same as those of fossil-based products, which means the processing techniques involved are identical too." ■

WACKER will use this Engel injection-molding machine at the K 2022 tradeshow to produce lemon presses from a biomethanol-based, food-grade silicone rubber.



4



BIOPOLYESTERS: BLENDS WITH A BOOST

VINNEX® additives based on polyvinyl acetate make biodegradable plastics easier to process and improve their material properties – especially when combined with silicone-based additives. Four VINNEX® grades are now available as resource-efficient eco products.

1.22 ▸ K SPECIAL ▸ **DEGRADABLE POLYMERS**

Products made from disposable plastics– including plastic cutlery and straws, stirrers, carry-out containers and to-go cups that one would previously have thrown away after using – have been banned within European Union territory since July 2021. Government efforts to reduce the volume of plastic waste accumulating around the world have been accompanied by a parallel increase in interest in degradable plastics. The European Bioplastics industry association expects global production capacity for polymers like these, especially for biodegradable polyesters, to expand markedly over the next several years.

"Unfortunately, potential applications for these plastics are limited at this point, because they often lack the property profile that compounders, plastics processors and end users expect from traditional thermoplastics," explains Dr. Ingo Jeschke, the Resins business development manager at WACKER POLYMERS. They're difficult to process too. "Both of those weaknesses need to be offset during the compounding process," Jeschke stresses.

Polymeric organic additives based on polyvinyl acetate have a proven track record when it comes to modifying biodegradable polyesters. Available commercially under the brand name VINNEX®, these products include homo-, co- and terpolymers with polarities that make them perfectly compatible with biopolyesters and starches.

"Our VINNEX® additives make biodegradable polymers easier to process, improve their material properties and enhance their compatibility," says Dominique Nely, head of the Resins global business team at WACKER POLYMERS. This opens up the door to manufacturing compounds from a variety of biopolyesters and starches – in combination with fillers as well.

The VINNEX® portfolio is divided into polymer powders and polymer resins. Because powder-form grades regulate the crystallization behavior of semi-crystalline biopolyesters, they ensure end properties that are stable over time, while also improving the impact strength and flexibility of the biopolyester. The primary role of VINNEX® resins is to serve as a processing aid that can raise properties such as the melt strength of the biopolyester to make it easier to handle.

WACKER will be at the K 2022 Trade Fair for Plastics and Rubber presenting four additives from its VINNEX® product portfolio that are produced from polyvinyl acetate using resource-efficient manufacturing methods:

"Biodegradable polyesters often fail to deliver the property profile that processors and consumers expect."

Dr. Ingo Jeschke, WACKER POLYMERS

CONTACT

For more information on this topic, please contact:

Dr. Ingo Jeschke
Senior Business Development Manager, Resins
WACKER POLYMERS
Tel.: +49 8677 83-86906
ingo.jeschke@wacker.com

1.22 ▸ K SPECIAL ▸ **DEGRADABLE POLYMERS**

"VINNEX® makes biopolyesters easier to process and improves their material properties."

Dominique Nely, WACKER POLYMERS

VINNEX® eco 2522, VINNEX® eco 2525, VINNEX® eco 2504 and VINNEX® eco 2505. The VINNEX® eco product line is manufactured from renewable resources based on the mass balance approach, in which both fossil and renewable raw materials are introduced at the beginning of the production cycle. The mass balance approach is then used to mathematically determine the percentage of solid resins made from renewable raw materials. VINNEX® eco products possess the same chemical and physical properties as the standard products, but they have a lower carbon footprint. All VINNEX® eco grades are certified to the REDcert² standard.

Additives in the VINNEX® or VINNEX® eco product lines can also be combined with silicone-based additives (see article starting on p. 64), which WACKER sells under the brand name GENIOPLAST® Pellet. Universally suitable for compounding any type of thermoplastic, GENIOPLAST® Pellet products reduce the effects of friction to make processing easier and improve the end properties of the plastic.

WACKER chemists selected two biodegradable plastics for a screening study on the combined use of VINNEX® and GENIOPLAST® additives: polylactic acid and polybutylene succinate. While these biopolyesters are, in principle, considered alternatives to conventional thermoplastics, they are difficult to process and require suitable additives to achieve the property profile of traditional thermoplastics.

Because it is extremely permeable to water vapor and highly transparent, a film made from polylactic acid (PLA) and VINNEX® is ideal for packaging items such as fresh vegetables.

38.3%

Percentage by which the melt volume-flow rate – an indicator of workability – of filled polybutylene succinate (PBS) increases when 10 percent VINNEX® 2504 and 1 percent GENIOPLAST® Pellet S are added to the formulation.

Preliminary stage for the production of blown or cast film: transparent pellet stock is made from a bioplastic and VINNEX® 2526. During this process, the strands pass through a water bath.

MORE THAN THE SUM OF ITS PARTS

The key finding of the screening study is the observation that the effects of VINNEX® and GENIOPLAST® complement each other – in both filled and unfilled bioplastic systems. A closer look at the advantages:

- Using VINNEX® and GENIOPLAST® together allows manufacturers to optimize the processing and performance properties of bioplastics to meet specific requirements. The additives are more effective in combination than when used separately.
- Depending on the grade used, VINNEX® has a positive influence either on the behavior of the polymer melt or on the mechanical properties. The additive also ensures that bioplastics can be processed without difficulty.
- When mixed with VINNEX®, GENIOPLAST® primarily improves the surface properties of the plastic product, especially in filled systems.
- In the bioplastics studied, GENIOPLAST® acts as a booster when added to VINNEX®, enhancing the effects achieved with the latter. In some cases, it also improves properties over which VINNEX® has no influence. It is the addition of GENIOPLAST® that reduces surface friction, thus increasing the bioplastics' scratch and abrasion resistance. This is verified by examination of the depth and roughness of scratches with a confocal microscope.
- This combination of additives also improves the mechanical properties of the final product: when used together, VINNEX® and GENIOPLAST® make bioplastics more flexible and impact resistant and increase elongation at break in filled systems without sacrificing thermostability. Plastics modified in this way are thus suitable for applications previously reserved for conventional thermoplastics.
- When added in the usual amounts and depending on the individual system, VINNEX® and and GENIOPLAST® additives do not compromise the degradability of thermoplastic starches, of biopolyesters such as polybutylene succinate or polylactic acid or of combinations of these biodegradable polymers. ■

SILICONE ADDITIVES – ONE TO THREE PERCENT SUFFICE

Even small amounts of silicone gum masterbatches can improve the distribution of filler in plastic molding compounds as well as their flowability and abrasion resistance. WACKER has developed GENIOPLAST® PE50S08, an additive specifically designed for polyethylene, giving compounders a greater range of formulation opportunities.

1.22 ▸ K SPECIAL ▸ **PLASTICS TECHNOLOGY**

The market for polyethylene, the most used thermoplastic globally, is highly competitive, with the industry under increasing pressure and facing additional challenges regarding the recycling of polyethylene waste. "Compounders and plastics processors can only stand out in this economically and technically demanding environment by offering superior quality, specialization and cost-savings," explained Martin Schmid, who manages a business team in WACKER SILICONES' Performance Solutions business unit. One way to do this, according to Schmid, involves using additives with which the product properties of the plastic can be improved or which can improve the efficiency of manufacturing and processing – both for virgin material and recyclates.

The plastics industry has long been using silicone additives in polyethylenes and other thermoplastics. The added silicones act as processing aids by reducing friction effects and improving the flowability of the polymer melt. They also influence the quality of the plastic article by reducing surface friction.

"One advantage compared to organic additives is the very low surface energy of the silicones, which is responsible for high activity at the phase interfaces – and therefore for the thermal resistance and low-temperature flexibility," explained Oliver Fuhrmann, who manages an applications laboratory for silicone additives at WACKER in Burghausen.

Standard silicone additives do have some disadvantages: low-viscosity silicone fluids have a tendency to migrate out of the plastic. The exuded silicone hinders downstream processing steps. Highly viscous silicones – non-reactive ultra-high-molecular linear polydimethylsiloxanes, known as silicone gums – practically never migrate out of the plastic, but are difficult to incorporate in thermoplastics.

"Our silicone gum masterbatches resolve this problem," stated Fuhrmann. "A thermoplastic polymer, compatible with the thermoplastic being modified, is used as a carrier for the silicone gum in these formulations." The masterbatches, in the form of solid pellets, can then be easily processed.

SILICONE GUM WITH VERY HIGH MOLECULAR WEIGHT

WACKER has produced GENIOPLAST® PE50S08, a silicone gum masterbatch specially developed for compounding polyethylenes. The active ingredient in GENIOPLAST® PE50S08 is a silicone gum with an extremely high molecular weight, dispersed in a low-density polyethylene. The active ingredient content is 50%.

Due to the carrier matrix used, this additive can only be used in polyethylenes and other polymers compatible with polyethylene. GENIOPLAST® PE50S08 can also be used for plastic articles that come into contact with foodstuffs.

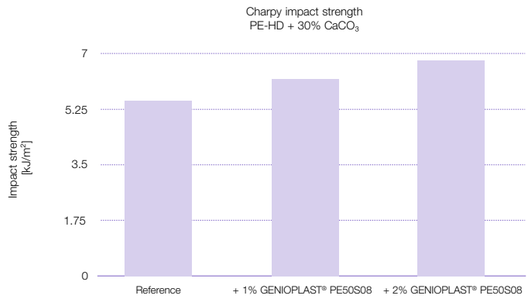
The new additive is available in the form of pellets which the compounder can easily incorporate, together with mineral fillers, into the polyethylene base polymer using standard equipment such as twin-screw extruders or co-kneaders. The silicone active ingredient improves the dispersion of the fillers and increases the

CONTACT

For more information on this topic, please contact:

Oliver Fuhrmann
Head of Technical Marketing
Performance Solutions
WACKER SILICONES
Tel.: +49 8677 83-5877
oliver.fuhrmann@wacker.com

CHARPY IMPACT TEST
GENIOPLAST® PE50S08



The addition of 2% GENIOPLAST® PE50S08 to chalk-filled high-density polyethylene increased the impact strength measured during Charpy impact tests by a good 20%.

Silicone additives – here as ready-to-use pellets – facilitate the production of workable polyethylene molding compounds and improve the surface properties of the resulting plastic articles.

flowability of the polymer melt. This gives compounders greater formulation freedom.

The friction-reducing properties mean that this active silicone ingredient facilitates the production of the compound, i.e. the ready-to-use pelletized molding compound. Less energy is therefore required for compounding when this silicone additive is added. The compounder can also achieve a higher throughput. GENIOPLAST® PE50S08 therefore saves costs during compounding. Because of the high efficacy of the silicone gum, the addition of just 1 to 3 percent is sufficient.

GENIOPLAST® GUARANTEES A HOMOGENEOUS PROCESS

The use of this silicone additive is also advantageous in the reprocessing of recycled polyethylene: such polyethylene waste is usually a mixture of several polyethylene grades which differ significantly in their melt behavior and flow properties. If such mixtures are re-compounded, i.e. reprocessed to become ready-to-use molding compounds, considerable torque and temperature fluctuations occur in the compounding extruder, causing it to run unevenly. This is where GENIOPLAST® PE50S08 ensures the process is more homogeneous.

The process-improving properties of the additive are also clear when we look at the compound-molding process – irrespective of whether the plastics processor is injection-molding parts or passing the molding compound through an extruder to produce profiles, hoses, cable sheaths or films.

These process-improving properties are just one aspect of the versatility demonstrated by GENIOPLAST® PE50S08. The silicone additive also improves the surface properties of the resulting plastic articles without the processor seeing any unwanted side effects. The main properties of the polyethylene base polymer, such as tensile strength, hardness and thermostability remain unchanged, while impact strength is increased.

Like a typical silicone additive, GENIOPLAST® PE50S08 increases the smoothness of products based on virgin and recycled polyethylene. The smoother surface in turn increases the scratch and abrasion resistance of the plastic.

Adding just 2% of this silicone additive reduces the coefficient of dynamic friction – regardless of which polyethylene base polymer is used – to values below 0.25, even for recyclates. Such low coefficients of dynamic friction are desired by film manufacturers and the packaging industry because the film can be more easily unrolled. Without such countermeasures, adjacent film layers on a roll would stick together more strongly, making it more difficult to unroll the film. Significantly reducing the coefficient of dynamic friction would tangibly speed up film packing and product packaging. Film manufacturers and users will save time and money with this new additive.

“GENIOPLAST® PE50S08 contributes to the sustainable use of thermoplastics such as polyethylene.”

Martin Schmid, Performance Solutions, WACKER SILICONES

The improved surface properties of polyethylene that has been compounded with GENIOPLAST® PE50S08 are ideal for applications where the material is subjected to strong mechanical loads, such as these running shoe soles.

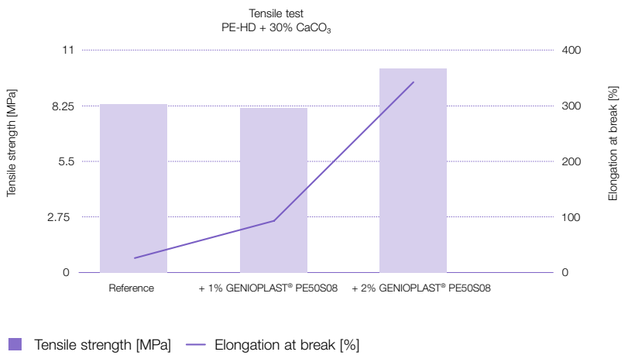
LABORATORY TESTS PROVE BETTER SCRATCH AND ABRASION RESISTANCE

Evidence of improved scratch and abrasion resistance was shown by tests carried out in WACKER applications laboratories. The focus here was on the Erichsen scratch test and the crockmeter test.

In the Erichsen scratch test, a scratch hardness tester produces defined scratches in the plastic surface, which are then examined in detail. In the crockmeter test, as per EN ISO 105-X12, a test head covered with a cotton cloth is rubbed over the plastic surface, leaving behind more or less visible friction marks which are then evaluated visually.

A confocal microscope examination showed that the scratches made by the scratch hardness tester in the GENIOPLAST® PE50S08-modified polyethylene were not as deep as those seen in unmodified polyethylene and also that these scratches were significantly less rough. Such

EVALUATION OF MECHANICAL PROPERTIES (TENSILE TEST) AFTER ADDITION OF GENIOPLAST® PE50S08



The addition of GENIOPLAST® PE50S08 was positively evaluated in the tensile test. Chalk-filled HDPE evidenced greater tensile strength and a higher elongation at break.

FURTHER ADDITIVES FOR THE COMPOUNDING OF THERMOPLASTICS

WACKER has expanded its portfolio of silicone-based compounding additives with a product – GENIOPLAST® PE50S08 – that has been specially developed for use in polyethylene molding compounds. This portfolio also includes the following products for the compounding of thermoplastic materials:

GENIOPLAST® Pellet S is universally suitable for the compounding of all thermoplastics. The active ingredient in this additive is a non-crosslinked ultra-high-molecular silicone polymer mounted on pyrogenic silica. The main application area is for flame-resistant cable sheathing.

GENIOPLAST® PP50S12, a silicone additive masterbatch, improves the scratch resistance of polypropylene articles. The main applications are packaging film, garden furniture and components for vehicle interiors.

GENIOPLAST® Pellet 345 is a silicone-based additive for thermoplastic polyurethanes. It bestows a pleasant feel on smartphone covers, wearable wristbands and other articles made with these plastics, and increases their dirt resistance.

scratches therefore scatter incoming light to a lesser extent, so they appear less bright. Measuring the brightness confirms this effect: brightness differences between the scratched and unscratched areas are smaller in the modified plastic and so the scratches are less visible.

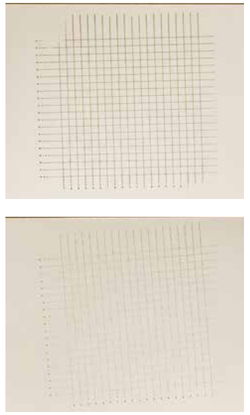
GENIOPLAST® PE50S08 also reduces abrasion as proven by the crockmeter test: like the scratches, friction marks are much less visible to the observer compared to unmodified polyethylene.

Ethylene-vinyl acetate copolymers are some of the polymers that are compatible with polyethylene and which can therefore also be modified using GENIOPLAST® PE50S08. This plastic, also known as EVA, is frequently used to produce shoe soles and cable sheathing. The effect of the silicone additive here is greatly dependent on how high the vinyl acetate percentage is in the EVA. The compounder can balance the coefficient of dynamic friction and material abrasion and tailor it to the application by selecting a suitable EVA base polymer and optimal additive percentage. This means that shoe soles will last longer due to reduced abrasion without increasing the risk of slipping.

Thanks to its process- and surface-enhancing effects, GENIOPLAST® PE50S08 is an efficient aid in the compounding of polyethylenes. Some of the main application options include the production of blown film, recycling of polyethylene waste and the extrusion of highly filled polyethylene molding compounds – such as the extrusion of sheaths for low-voltage cables. This latter application is possible if the cable does not have to meet any specific flame-retardant requirements.

When reprocessing polyethylene waste, the compounder can use the silicone additive to produce recyclates with properties almost identical to those of virgin material. WACKER manager Martin Schmid emphasized, “GENIOPLAST® PE50S08 therefore contributes to the sustainable use of a thermoplastic such as polyethylene, and supports industry in setting up a circular economy.”

Just these few examples have shown that GENIOPLAST® PE50S08 has flung open the door to cost-effective compounding and further processing of polyethylenes. Martin Schmid is convinced: “Compounders and processors will gain saving potentials and achieve better product quality with our new silicone gum masterbatches. These are real competitive advantages.” ■



An unmodified polyethylene panel evidences significant scratches after the scratch test (see top image). Scratch resistance was significantly improved through the addition of GENIOPLAST® PE50S08 (bottom image).

In the Erichsen scratch test, a needle moves at a specific force and speed across the plastic being tested, creating a grid pattern of scratches. The scratches are then examined closely and the color differences determined with a colorimeter.

1.22 ▸ K SPECIAL ▸ **PLASTICS TECHNOLOGY**

A STRONG BOND – WITHOUT ANY PRETREATMENT

Before now, polycarbonate was a particularly tough nut to crack when it came to creating a hard/soft combination with silicone. But thanks to ELASTOSIL® LR 3078, neither priming nor, for example, plasma treatment is necessary. This liquid silicone rubber offers excellent adhesion to polycarbonate and is a cinch to process on two-component injection-molding machines.

Most molded plastic parts very commonly consist of two components: one hard, and the other soft and elastic. The hard component for such hard/soft combinations is usually a rigid thermoplastic and provides the strength. By contrast, the soft component functions as a seal, absorbs vibrations or sounds or improves the tactile properties of the molded article.

Product designers tend to choose a polycarbonate if the hard component is not only expected to exhibit high impact strength, heat resistance and transparency, but should also lend itself to medical products. For the soft component, they are increasingly turning to silicone elastomers, especially where the property set offered by silicones is needed: chemical and biological inertness, flexibility at low temperatures and resistance to heat and aging.

Good adhesion is essential for creating hard/soft combinations that function reliably and for manufacturing such articles cost-effectively on a large scale. “Adhesion between the polycarbonate and the silicone is particularly challenging in this regard,” says Dr. Florian Liesener, head of an applications laboratory for liquid silicone rubber at WACKER in Burghausen. “With conventional silicones, the only way to achieve reliable adhesion is to either treat the surface of the polycarbonate with a primer or activate it with a plasma treatment.” For the parts manufacturer, this represents an additional, costly step, he adds.

“Our patented, self-adhesion technology has been specially developed for polycarbonate/silicone combinations.”

Dagmar Rische, Marketing Manager, Engineering Silicones

FULLY AUTOMATED PROCESSING

The new line of ELASTOSIL® LR 3078 silicone rubber products developed by WACKER forms a strong bond to polycarbonate and obviates the need for pretreating the thermoplastic substrate. “These self-adhesive silicones are capable of being used on fully automated two-part injection-molding machines,” says Dagmar Rische, marketing manager in WACKER’s Engineering Silicones department. “This capability stems from a novel, patented self-adhesive technology that has been specially developed for the polycarbonate/silicone combination.

As a result of this technology, which is deployed in the ELASTOSIL® LR 3078 series, the adhesion builds up rapidly – reaching high levels even as the part is still inside the mold. However, the silicone does not stick to the metal mold and the multicomponent part is easy to demold. And, as no secondary finishing is needed, the part can undergo further processing straight away.

The hardness values of these product grades cover the range (20 to 70 Shore A) specified by parts designers for the soft component of the polycarbonate/silicone combination.

VERY GOOD PEEL-FORCE VALUES

The bond strength of the new product range has been thoroughly tested in WACKER’s applications labs where WACKER engineers conducted 90° peel tests based on the ISO 813 standard. This involves preparing test strips of the material and determining the force needed to peel off the silicone layer at an angle of 90° to the polycarbonate substrate. The peel force needed to separate the two serves as a measure of adhesion. The tests showed that a peel force of at least 10 newtons per millimeter, and in many cases much higher, was needed. These are generally accepted to be very good peel-force values.

COMPRESSION SET

If deformed over a long period of time, an elastomer seal will not return to its exact shape after release, and instead will stay more or less deformed. The extent of this sustained deformity depends on how greatly the elastic recovery of the material decreases under the prevailing storage conditions – deforming forces, the medium that is impacting the material, and the temperature. This information is provided by compression set, a parameter that is determined in a standardized testing procedure.

To determine the compression set, an elastomer test specimen (whose shape and dimensions are defined in testing standards) is placed in a compression mechanism, where it is compressed to a pre-defined extent and stored in this state for a specific period of time under the testing conditions. Once the test specimen is released, it will not return to its original thickness. The thickness of the test specimen is measured before and after compression as well as after relaxation. Expressed as a percentage, the compression set is the ratio of the reduction in thickness following relaxation to the thickness to which the test specimen was compressed. A low compression set is favorable – this shows that the material has high elastic recovery.

Dr. Liesener's team also studied the failure mode in those samples which failed the peel tests. They wanted to identify the weak point in the bond: did the tear occur in the interface of the hard and soft components or did it form inside the soft component? It transpired that the silicone had suffered cohesive failure – in other words, the soft components had torn during peeling, but the bond between the hard and soft components had remained intact. This result, together with the high peel-force values, serves as proof of the excellent adhesive strength.

"The lab tests and injection-molding trials also show that the ELASTOSIL® LR 3078 range scores points for ease of processing," marketing manager Rische is keen to stress. The liquid silicone rubbers cure very quickly and the injection-molding cycle times are short, even at relatively low processing temperatures. "This means that converters can adapt their processes to the limited heat-deflection temperature of the hard component and still achieve high productivity," she says, further emphasizing her point.

Another plus point for ELASTOSIL® LR 3078 when it comes to injection molding is that the silicone rubber formulations have a very low tendency to form deposits in the mold. When these build up, the molds have to be dismantled and cleaned. The use of ELASTOSIL® LR 3078 more or less rules out such production interruptions altogether, with the result that fully automated processes are possible.

CONTACT

For more information on this topic, please contact:

Dr. Florian Liesener
Head of Technical Marketing
Engineering Silicones
WACKER SILICONES
Tel. +49 8677 83-3566
florian.liesener@wacker.com

1.22 ▸ K SPECIAL ▸ **PLASTICS TECHNOLOGY**

"Even in the non-postcured state, ELASTOSIL® LR 3078 materials possess very good mechanical properties."

Dr. Florian Liesener,
Technical Manager,
WACKER SILICONES

MINIATURIZATION OF PARTS ON TREND

ELASTOSIL® LR 3078 can also be used to produce intricate designs and will reproduce the finest of details with great accuracy. The new product series thus goes some way toward meeting the trend to miniaturize parts.

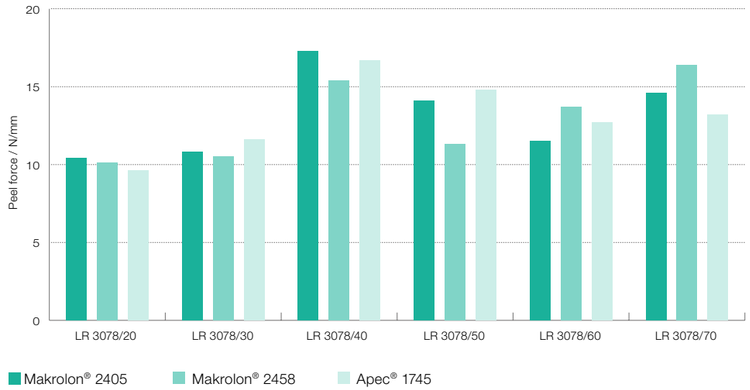
Given the limited heat-deflection temperature of the thermoplastic hard component, polycarbonate/silicone combinations are not postcured before use, i.e. they are not heat-treated, as the polycarbonate would not withstand the thermal stress. "We have formulated our materials in the ELASTOSIL® LR 3078 series in such a way that they already possess very good mechanical properties without the need for postcuring," underscores Dr. Liesener, a WACKER developer.

Thus, the new silicone grades are notable for having low compression set values in their non-postcured state. Elastomers that have low compression set feature high elastic recovery. Non-postcured ELASTOSIL® LR 3078 grades have compression set values far below 20 percent, as determined by 22-hour compression at 125 °C. These are very low values. Their significance is that sealing elements made from the new silicones will function reliably for long periods of time.

Cured rubber made from ELASTOSIL® LR 3078 is biocompatible, as demonstrated by various tests meeting ISO 10993 and United States Pharmacopeia (USP) Class VI standards. The materials have been tested in accordance with ISO 10993 for their cytotoxicity, pyrogenicity and sensitizing properties. And their acute systemic toxicity, intracutaneous toxicity, and short-term implantation have been assessed under USP Chapter <88> Class VI. Plus, the new self-adhesive technology does not contain any bisphenol A structures at all. WACKER's decision to dispense with this class of substance is helping to boost the occupational safety aspects of the production and processing of the silicone rubbers while also serving to protect consumers.

What is more, polycarbonate/silicone combinations made with ELASTOSIL® LR 3078 and the right polycarbonate grades can be steam-sterilized, because the mechanical properties of silicone remain virtually unchanged

ELASTOSIL® LR 3078 — PEEL-FORCE VALUES FOLLOWING INJECTION MOLDING ONTO A VARIETY OF POLYCARBONATE GRADES



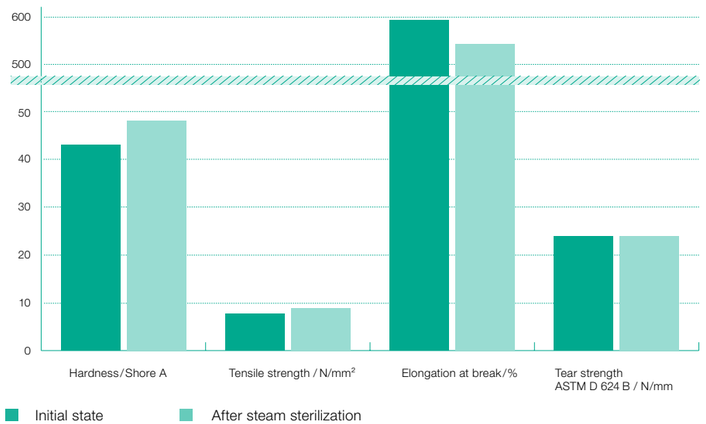
Adhesion was tested by conducting 90° peel tests on multicomponent specimens made from all the grades in the ELASTOSIL® LR 3078 series and three commercial polycarbonate grades. Peel-force values higher than 10 newtons per millimeter signify excellent adhesion.

Peel testing stresses samples of multicomponent materials to their breaking point. In samples made of ELASTOSIL® LR 3078 and polycarbonate, it was the soft silicone component which consistently tore. The bond between the hard and soft components remained intact.

even after one hundred sterilization cycles involving exposure to steam heated to 134 °C. They also continue to adhere well to Apec® 1745 after one hundred cycles (5 minutes at 134 °C). Thus, ELASTOSIL® LR 3078/40, for instance, only exhibits a slight reduction in peel-force values after more than ten sterilization cycles. And, although the failure mode switches to adhesive failure once fifty cycles have been exceeded, the peel forces after 50 and 100 cycles, respectively, are still high, at 10 newtons per millimeter.

"A chemical bond created by ELASTOSIL® LR 3078 to polycarbonate offers product developers considerably more design freedom than traditional mechanical joining techniques involving interlocking openings and undercuts," says Liesener, adding that the chemical bond prevented gaps from forming between the hard and the soft components, where dirt could collect, or bacteria and mildew could form colonies.

ELASTOSIL® LR 3078/40 – MECHANICAL PROPERTIES BEFORE AND AFTER STEAM STERILIZATION (100 CYCLES)



Not even 100 steam sterilization cycles in the lab were able to reduce the mechanical properties of test specimens made with ELASTOSIL® LR 3078. They remain at a consistently high level (ISO 17665 – Aging test as per EN 868-8; 134 °C, 5 min).

Because it is a biocompatible and steam-sterilizable material, ELASTOSIL® LR 3078 is perfect for medical applications. The cushion in a respirator or anesthesia mask, for example, can be made with a soft grade from the ELASTOSIL® LR 3078 series. This kind of cushion molds perfectly to the facial contours, creating a reliable seal. Possible applications lie in automated drug-delivery systems that deliver active ingredients in the required dosage, or in devices for minimally invasive examinations and surgery.

But other industries, too, such as the automotive industry, stand to benefit from injection-molded combinations made of polycarbonate and silicone. Possible automotive applications are transparent covers with integrated sealing lips and transparent components for ambient interior lighting.

"No matter where our new self-adhesive silicones are used, they can serve to turn product ideas that were previously unthinkable into reality," sums up marketing manager Dagmar Rische.

Respirator masks made with ELASTOSIL® LR 3078 fit snugly over the face thanks to the soft silicone component. What is more, the silicone creates a perfect seal.

1.22 ▸ K SPECIAL ▸ **POWERSIL®**

7

HEAT-RESISTANT UP TO 220 DEGREES CELSIUS

Innovative silicone resin binders from WACKER open up the door to mechanically and thermally stable molded plastic parts manufactured using injection molding – truly uncharted waters for the company.

"The previous process produced a lot of scrap, a lot of waste."

Dr. Jens Lambrecht, electrical engineer, WACKER Technical Service

You can hear a touch of pride in the voice of Dr. Jens Lambrecht from WACKER Technical Service: "Our new material solution is taking us into truly uncharted waters," the engineer says. It is true, of course, that not only industrial manufacturers, but also self-employed builders and decorators already use silicone resins to make molded parts that are stable and mechanically robust even at extremely high temperatures, while also exhibiting electrically insulating properties. Sophisticated molded parts like these are needed in electrically insulating technology for future innovative applications currently under development – in order to protect hub motors in electric vehicles, for instance.

Up to now, processors would first produce semi-finished parts by laminating starting products with silicone resin binders and would then finish them later to create the final shape. "Preparing laminates from a silicone resin and glass or carbon fiber, pressing them and then processing them mechanically – that's quite a labor-intensive process and it produces a lot of scrap, a lot of waste," as Lambert knows.

Up to now, direct, less complex processes such as injection molding have failed, both for lack of suitable binders and because the mechanical properties of the cured silicone resin compound are unsatisfactory. And competing materials in a similar heat-resistance class – such as PTFE (polytetrafluoroethylene), otherwise known as Teflon™, and PEEK (polyether ether ketone) – either make processing complicated or lack the thermoset properties needed.

SILRES® LR 700 and POWERSIL® Resin 700 now put efficient, cost-effective processing within reach, even for molded parts that remain stable at high temperatures. "Introducing these two silicone resins will put materials on the market that are as easy to process as, say, polyurethane or epoxy resins – plastics that are very commonly used in the production of components subject to much lower thermal stresses," Lambrecht points out.

Dr. Frank Sandmeyer, a WACKER chemist responsible for developing the underlying silicone resin, discovered an ingenious way of incorporating phenyl groups into the polysiloxane backbone, thus making the cured silicone components significantly less brittle. "What we needed was an easy-to-handle liquid silicone resin that would be both exceptionally heat resistant as well as relatively reactive," says Sandmeyer, recalling the specifications he was given during the development phase.

Appropriate fillers provide considerable mechanical strength. Dr. Lambrecht worked with technology manager Dr. Markus Winterer on numerous series of experiments with pyrogenic silica, quartz and glass fibers to develop an initial optimized filler blend. The liquid silicone resin, this filler blend and a peroxide as crosslinker are the ingredients that make up compounded POWERSIL® Resin 710 – a product for customers who would prefer a ready-to-use material solution.

The new silicone resin technology is an advantageous alternative to high-temperature-resistant polymers like PTFE and PEEK. Injection molding cannot be applied with PTFE, for instance, which has to be compressed or sintered at temperatures of over 360 °C. Temperatures are similarly high for PEEK injection molding. The silicone resin in

Glass circulating reactor: WACKER has developed a continuous manufacturing process for resin binders at a technical service lab at its Burghausen production site.

POWERSIL® Resin 710, by contrast, crosslinks at only about 160 °C.

"This innovation is our answer to rising industry demand for polymers that resist high temperatures," Lambrecht explains. Because technical systems are growing increasingly powerful even as they become smaller, they now release more heat per unit volume. Again, motors in electric vehicles are a good example of this trend. Electrically insulating polymer components located in or near sources of heat like these need to work perfectly for many years, retaining their properties at the resulting high temperatures.

"We've incorporated a phenyl group into the polysiloxane backbone of the silicone resin, which makes the cured silicone components significantly less brittle."

Dr. Frank Sandmeyer, chemist specializing in WACKER silicone resins

TESTS DEMONSTRATE THERMAL RESISTANCE OF THE SILICONE RESIN

Samples of molded parts made from POWERSIL® Resin 710 were stored at a variety of temperatures in order to determine their thermal resistance. WACKER technicians then measured the percentage change in the binder mass over time as a function of storage temperature. Using a standardized mathematical method, they then extrapolated the insulation class as a measure of the long-term service temperature. The result of this accelerated thermal aging process is that the molded parts made from these silicone resins met the criteria for insulation class R, which means they will withstand temperatures of up to 220 °C.

WACKER also tested the behavior of POWERSIL® Resin 710 samples that underwent frequent deformation. Each of these samples – strips eight centimeters long, one centimeter wide and four millimeters thick – were affixed only by their ends. The mandrel of a test instrument then repeatedly pressed down on the middle of the strips with a defined force. The result: the material withstood several hundred cycles of severe deformation and tens of thousands of cycles of modest deformation.

The new binders contain reactive double bonds that form crosslinking ethylene bridges in the presence of a catalyst. Some customers may want to use the new liquid silicone resin binders to establish their own in-house technology for making molded parts. Alongside peroxide curing, these users may also wish to consider what is known as an addition-curing process, which is typically used for liquid silicone rubber.

As Lambrecht notes, "That kind of processing technology offers two advantages," which the WACKER developer then goes on to name: "It can be applied at relatively low temperatures, and the curing speed of the resin can be adjusted by varying the temperature."

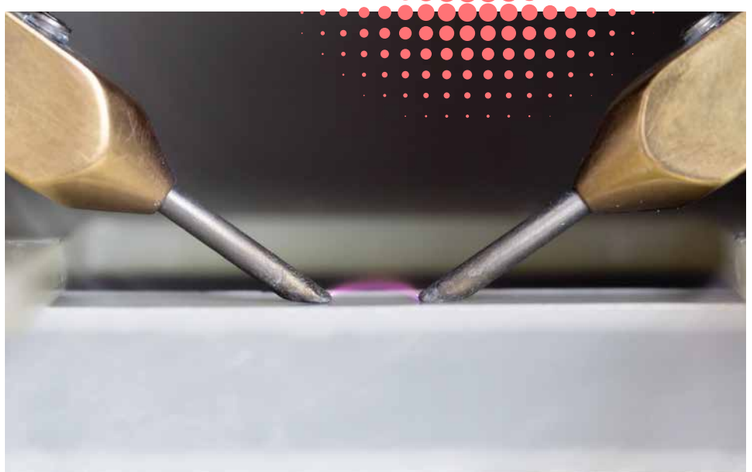
As is always the case with product developments like this, chemists and engineers begin with batch production on a laboratory scale in order to create initial samples for internal tests and for potential customers. Given the highly positive feedback, both internal and external, that the developers received for the outstanding property profiles of the two silicone resin binders, the challenge now was to develop a continuous production process as quickly as possible.

At WACKER SILICONES, this job, i.e. scaling up the process, is the responsibility of Technology Management, and in this particular case the challenge is being taken on by the Alkoxy/P-Resins Laboratory managed by Dr. Georg Lössel. The focus of this development stage is now on a continuous process – both for phase separation and product washing – that will enable efficient production. Measured in kilograms produced per hour, mass throughput of a continuous process is far greater – by a factor of five to ten – than that of batch production, which means that future customers likewise stand to benefit from this kind of neatly scaled-up process. "What we've done is create a foundation that will allow us to scale up the current process for manufacturing these silicone resins in three stages – from the lab through to our WACKER SILICONES pilot plant and the industrial-scale process," says Lössel.

"This innovation is our answer to rising demand for polymers that resist high temperatures."

Dr. Jens Lambrecht, electrical engineer, WACKER Technical Service

Making a good impression, even at high temperatures: plastic molded parts made from WACKER's new silicone resin undergoing IEC 61621 testing.



“SILICONES ARE ENABLERS”

Dr. Robert Gnann, head of WACKER’s silicones business, talks about the planned capacity expansions and the indispensable role of silicones in mitigating climate change.

1.22 ▸ K SPECIAL ▸ **STRATEGY**

WACKER Magazine: For about two years now, demand for silicones has outstripped supply – on markets all around the world. Naturally, this is a highly unsatisfactory situation for those customers that rely on these materials. How is WACKER, the world’s second-largest silicones manufacturer, responding to the shortage of installed capacity?

Dr. Robert Gnann: By accelerating growth. The WACKER Group, and especially its silicones business, has performed very positively in recent years. The company is on a sound financial footing and has plans to turbo-charge growth all over the world. A number of expansion measures have been launched in the recent past. For example, over the next several years, we will be investing 100 million euros alone in expanding our solid and liquid silicone rubbers production capability. By the end of the decade we intend to have installed enough new capacity to have doubled our divisional sales.

> “By the end of the decade, we intend to have doubled our divisional sales.”
>
> **Dr. Robert Gnann,** President of WACKER SILICONES

The 100-million-euros program is essentially aimed at downstream capacity. What is the situation with upstream production, where precursors are involved, i.e. silanes and siloxane?

We are drawing up plans for the long-term construction of a new fully integrated site in Charleston, Tennessee, in response to the equally strong demand growth we are seeing for silicones in the USA. This is initially likely to take the form of midstream and downstream investments in the order of 200 million dollars. Some of that will be earmarked for high-performance rubber compounds and silicone sealants. We already have a production facility for polysilicon and HDK® pyrogenic silica in Charleston and so the prerequisites for an efficient silicones production setup are already in place.

Which silicone products are in particularly short supply on the market at the moment?

There is a particular shortage of liquid silicone rubber and high-consistency, i.e. solid, silicone rubber compounds in the Americas and Europe as well as in parts of Asia. Our expansion plans are designed to address precisely this need. Additional capacity has now become available at our production site in Burghausen and, from next year, expansion measures at our Adrian site in Michigan, USA, will come into play as well.

What about high-consistency rubber?

Availability will improve here, too. We will still need a little more time for major capacity expansions in solid rubber. But we have introduced measures at short notice to eliminate bottlenecks. Our new production site in Panagarh in India set the ball rolling on the expansion of capacity for high-temperature-curing (HTV) silicone rubber in July. Additional quantities will come on stream early next year at our sites in the Czech Republic and Japan. And our big integrated site in Zhangjiagang, China, will be in a position to deliver even more HTV from 2024 on. Taken all together, this 100-million-euro investment will enable us to match the growth of our elastomer customers and to achieve double-digit growth for several years to come.

Where will WACKER rank in the silicones market when these expansion stages are complete?

By carrying out these measures, we are consolidating our position as the global number two in the silicones business and investing more particularly in the production of high-quality silicone specialties that are tailored to the specific needs of our customers. Our goal is also to be the number one in high-consistency silicone rubber. While some of our competitors are disengaging more and more from this market, we are resolved to keep investing in quality and new capacity. Our products are formulated to contain up to 35 percent by weight HDK® pyrogenic silica. That is what makes our HTV products among the best in their class. WACKER is the only major silicones supplier to have its own vertical integration and a strong proprietary technology for pyrogenic silica in this area. For HDK®, we can call on capacity in Europe, China, and the USA.

Dr. Robert Gnann, a chemist, has been been president of WACKER SILICONES, the company's largest division, since 2016.

Is WACKER SILICONES investing primarily in the elastomers business?
In general, our plans for expansion extend much further than elastomers. Specialty silicones are being rigorously expanded across all areas and in all regions. We will be the ones supplying the requisite raw materials and precursors. The acquisition of SICO in China, which produces organofunctional silanes, has also strengthened many areas of our specialty additives portfolio, e.g. our specialty adhesives business.

What supply chain challenges is WACKER currently facing?
In principle, the same ones as our customers and competitors. We are struggling with rising energy and raw-material prices, reduced transport capacity, unreliability and longer transport times. However, we are fortunate in having our own plant in Holla, Norway, which covers a substantial amount – roughly one third – of the silicon metal we need for producing silicones and polycrystalline silicon. This makes us less vulnerable to supply problems and rising prices for this key raw material. And, we are even planning to expand capacity there as well – right at the start of our supply chain.

By how much?
We have commissioned a feasibility study for a new furnace in Holla that will boost the site's capacity for metallurgical-grade silicon by about 50 percent, relative to its current level. We are also looking into ways of replacing the coal used as a reducing agent in the manufacture of silicon metal with renewable materials, such as charcoal or pellets. The goal here is to save up to 430,000 metric tons of CO_2 a year in Holla. So, our Norwegian site, too, has quite a key role to play in helping WACKER reach its sustainability goals. Ultimately, we intend to have halved the entire company's greenhouse-gas emissions in absolute terms by 2030.

Sustainable processes in production are one aspect. What about the product aspect and the contribution which silicones make to sustainability and to mitigating climate change?
Silicones rank among the most important enablers of climate-change mitigation. I would even venture that, without silicones, we would find it hard to reach our climate goals. Silicones are employed in many key industries and are simply irreplaceable when it comes to the development of innovative, sustainable technologies. This applies as much to wind power and photovoltaics, where silicones seal and protect parts and components, as it does to electromobility, consumer electronics and areas such as the insulation of buildings and windows. The European Silicones Centre, CES, has calculated that the greenhouse-gas savings arising from the use of silicones outweigh the carbon emissions generated during the production and disposal of silicone products by a multiple.

> "I would even venture that, without silicones, we would find it hard to reach our climate goals."
>
> **Dr. Robert Gnann**

What makes silicones such enablers of climate-change mitigation?
There are a number of reasons. Because of its heat resistance and its insulation properties, silicone rubber is essential for electromobility. Only silicones can deliver the high standards of performance needed for the insulation of high-voltage cables, applications in battery safety, and heat-conducting bonded joints. Our ultra-thin precision silicone film and the NEXIPAL® laminates that we make from it will be used for fuel cells and novel, electrically active actuators and generators in the future. These can also be used to generate electricity. The list of applications could go on and on. Silicone rubbers, then, are highly versatile materials that offer extreme performance and adaptability and have any amount of development potential. They are therefore just what processors and product developers need for developing the innovative and sustainable products and technologies of tomorrow. So, we are not over-promising when we say that, by 2030, our entire product portfolio will be geared toward supporting defined sustainability criteria.

Dr. Robert Gnann (on right) at a preview event where WACKER unveiled its innovations for the K 2022 plastics and rubber tradeshow to journalists.

1.22 ▸ APPLICATIONS ▸ **CYCLODEXTRINS**

SMUGGLING CURCUMIN INTO THE BODY

Dr. Natalie Vladi uses curcumin in her range of Foondiert® food supplements because she greatly appreciates its antioxidant and anti-inflammatory properties. This turmeric extract is not water-soluble, however, which hampers its bioavailability. WACKER BIOSOLUTIONS has come up with a solution that “smuggles” curcumin, so to speak, into the human body.

Curcuma, also known as tumeric, is a member of the ginger family. The intensely yellow rhizome is used as a spice and in alternative medicine.

For centuries , turmeric, which is also referred to as yellow ginger, and saffron, a type of crocus, have been much valued in the Orient in stressful situations – turmeric especially due to its antioxidant and anti-inflammatory properties and saffron because of its mood-enhancing and nervine effects. Dr. Natalie Vladi spent 20 years working in the research-driven pharmaceuticals sector. So, when she decided to start her own food supplements company – Fountain House GmbH – she wanted to ensure that her products' ingredients, including saffron and curcumin, the bioactive component of turmeric, would meet the most stringent quality standards.

"Standardized dosage is particularly important for plant compounds used in food supplements in order to ensure clinical effectiveness," emphasizes the Hamburg-based registered pharmacist with Persian-Canadian roots. "The body should receive both the same quantity and quality every day. Many manufacturers cannot guarantee this, however."

"Standardized dosage is important for plant compounds used in food supplements in order to ensure effectiveness."

Dr. Natalie Vladi, Fountain House GmbH

The mixture of turmeric and saffron has been known for centuries and is also used in Ayurvedic nutrition, as the two plant compounds create synergistic effects when combined. Natalie Vladi is convinced that "essentially everyone can benefit from curcumin's antioxidant effect." Ozone, UV radiation or air pollution, for example, can cause oxidative stress for cells. "People who suffer from musculoskeletal inflammatory diseases such as osteoarthritis greatly value the anti-inflammatory effect of curcumin."

1.22 ▸ APPLICATIONS ▸ **CYCLODEXTRINS**

FONDIERT

is the name Natalie Vladi has given to her trademark for food supplements, which pays tribute to the German word "fundiert" – meaning well-founded and substantiated.

PATENTED PROCESS

Natalie Vladi wanted to convert this traditional knowledge from the Middle East and Asia into a modern, standardized and quality-assured formulation. So, for saffron, she uses Affron® – the most clinically studied of the products composed of this medicinal and spice plant. For the active ingredient curcumin – a bioactive component of the turmeric plant – she sought a manufacturer who could offer a patented, standardized production process. Moreover, one who could provide a solution to a problem that all users of conventional curcumin products encounter: this plant compound is not

1.22 ▸ APPLICATIONS ▸ **CYCLODEXTRINS**

The eight formulations in the Foondiert® product line – four in capsule form and four as direct sprays – complement one another with the aim of increasing emotional and physical well-being.

The curcumin in the support complex is formulated to be gentle on the stomach. This complex contains neither piperine nor polysorbates, micelles or synthetic emulsifiers of any kind whatsoever.

water-soluble, which hinders absorption in the human body.

The brand name – Foondiert® – a tribute to the German word "fundiert," which means well-founded or substantiated, reflects Vladi's high standards for her products' effectiveness. In Germany, quantities specified on food-supplement packaging can deviate by up to 50 percent from the actual amount in the product, while for medicinal products, only 5 percent is allowed. "It was important to me that the products be made using pharmaceutical-grade manufacturing," explains the pharmacist and founder, adding that her company is a member of the German Pharmaceutical Industry Association (BPI). In this way, Vladi can guarantee that her Curcumin Support Complex contains exactly

40

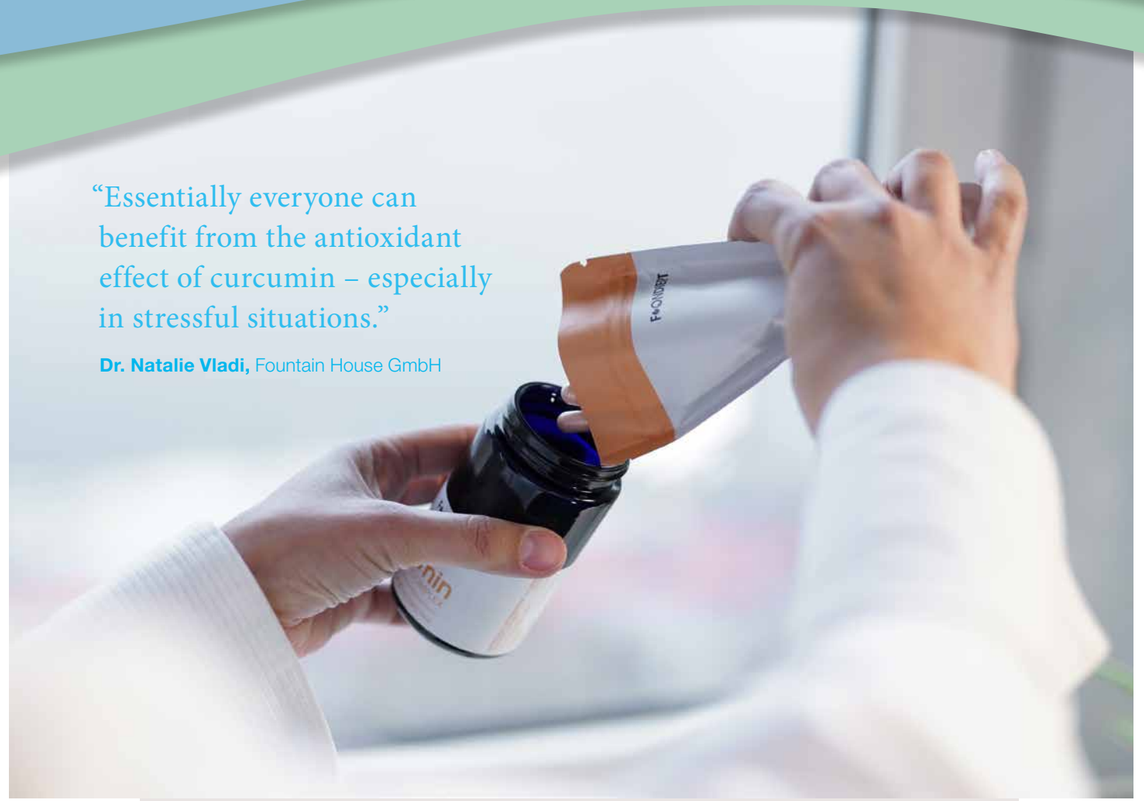
times higher – that is the bioavailability of curcumin in CAVACURMIN® compared with conventional curcuma extract.

880 milligrams of curcumin in the daily dose of two capsules.

Even a precisely measured daily dose is, however, of no use if it cannot be absorbed by the body. The crux of the water-insoluble curcumin is its poor bioavailability. That's why piperine or polysorbates are sometimes added to the turmeric active to help absorption in the body. Vladi does not recommend the use of these additives, because they can irritate the stomach's sensitive mucous membrane or adversely impact digestion. She also wanted to exclude micelles and synthetic emulsifiers of any sort in her product line.

For Vladi, the challenge was formulating her curcumin products to ensure optimum bioavailability for consumers despite the hydrophobic nature of the active ingredient. That's

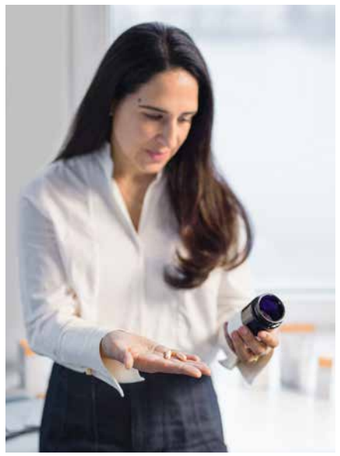
1.22 ▸ APPLICATIONS ▸ **CYCLODEXTRINS**



“Essentially everyone can benefit from the antioxidant effect of curcumin – especially in stressful situations.”

Dr. Natalie Vladi, Fountain House GmbH

The use of patented ingredients in Foondiert® brand products ensures a standardized dosage and quality.



why she chose CAVACURMIN® from WACKER BIOSOLUTIONS, in which curcumin is complexed with gamma-cyclodextrin. Cyclodextrins are ring-shaped oligosaccharides that are water-soluble. They can reversibly encapsulate other molecules – even ones that are not water-soluble themselves – in their cavity as a kind of “guest.” This way, they significantly boost the bioavailability of certain water-insoluble compounds – in the case of curcumin by a factor of 40, compared with conventional turmeric extract. This was shown in two clinical studies commissioned by WACKER and published in 2018 and 2021, respectively (see box).

“CAVACURMIN® is the only formulation on the market that has been shown to increase the bioavailability of both curcumin and tetrahydrocurcumin, into which supplemented curcumin is largely converted in the body,” explains Dr. Nicolle Mirie, head of Sales & Marketing for Bioingredients at WACKER BIOSOLUTIONS.

DERIVED FROM CORNSTARCH

Cyclodextrins are produced via enzymatic degradation of cornstarch in a fermentation process. WACKER was thus able to provide Vladi with the patented and standardized production process that she wanted for the cyclodextrin as a “carrier.”

As a free-flowing powder, the gamma-cyclodextrin-based raw material is perfect for use in tablets, capsules and granules. Vladi obtains CAVACURMIN® as a bulk product from WACKER for her Foondiert® range of products that are made in northern Germany by a GMP-certified pharmaceutical-grade manufacturer.

Since the powder readily disperses in water, it is also ideal for use in liquid food supplements. CAVACURMIN® allows Vladi, for instance, to offer her Foondiert® product line as oral sprays and not solely as capsules. In order to avoid the use of artificial preservatives, this oral spray is formulated with organic ethanol. “It is ideal for when you are on the move, and the active ingredients are also absorbed through the oral mucosa,” she states. “This innovative technology would not have been possible without complexation of curcumin with gamma-cyclodextrin.” ■

STUDIES ON THE BIOAVAILABILITY OF CURCUMIN-CYCLODEXTRIN COMPLEXES

A study published in 2021 in the Journal of Functional Foods shows that ingestion of the curcumin-cyclodextrin complex CAVACURMIN® leads to an increased metabolic bioavailability of tetrahydrocurcumin. A large portion of supplemented curcumin is converted into tetrahydrocurcumin in the body.

As it is not water-soluble, curcumin is not readily absorbed in the human bloodstream. Its bioavailability can be boosted significantly with the aid of gamma-cyclodextrin. A study published in the European Journal of Nutrition in 2018 already showed that the curcuminoids of WACKER’s cyclodextrin complex CAVACURMIN® are absorbed around 40 times more efficiently in the body than those of a standard curcumin extract (Purpura et al. 2018).

As part of a randomized double-blind study, it has now been shown that the metabolic bioavailability of tetrahydrocurcumin is also around 40 times higher following ingestion of CAVACURMIN® compared to a standard curcumin extract (Hundshammer et al. 2021).

Tetrahydrocurcumin is a curcumin metabolite credited with additional health-promoting properties. The metabolic bioavailability gives the ratio of the in-vivo production of tetrahydrocurcumin to the absorbed amount of curcumin. Another finding of the long-term study is that after only four weeks, daily ingestion of CAVACURMIN® (approx. 340 milligrams curcumin each time) leads to a consistently high blood concentration of curcumin and tetrahydrocurcumin. This effect can be measured after 12 weeks as well. The long-term study furthermore confirmed very high tolerability of CAVACURMIN®.

1 Purpura, Martin, et al. „Analysis of different innovative formulations of curcumin for improved relative oral bioavailability in human subjects.“ European journal of nutrition 57.3 (2018): 929-938.

2 Hundshammer et al., Enhanced metabolic bioavailability of tetrahydrocurcumin after oral supplementation of a γ-cyclodextrin curcumin complex. Journal of Functional Foods, 79 (2021), 104410

CONTACT

For more information on this topic, please contact

Dr. Nicolle Mirie
Head of Sales & Marketing
Bioingredients
WACKER BIOSOLUTIONS
Tel.: +49 89 6279-1342
nicolle.mirie@wacker.com

1.22 ▸ CORPORATE ▸ **75 YEARS OF SILICONES**

75 YEARS OF SILICONES

A PLASTIC FOR A MODERN WORLD

In 1947, WACKER became the first European company to start working on silicones. Today, the Group is the world's second-largest manufacturer of these high-performance plastics, which are now ubiquitous in our everyday lives. Here, we look back at the time when the future was taking shape in the most modest of circumstances – in a wooden barracks in Burghausen.

In this furnace, we are producing at least 1,000 kilograms [of silanes] a month, and soon, when we have a further reactor, it will be two to three tons." "Try to make 200 to 300 tons as soon as you can." That was the advice given in late 1950 to one Dr. Siegfried Nitzsche by the former managing director, Dr. Johannes Hess, shortly before his death on February 3, 1951. And Dr. Nitzsche, despite all the naysayers, took the advice – and in so doing earned the right to be called the "father of WACKER silicones." For, according to Nitzsche's own recollections, even the board of management back then took the view that "we'll be happy if we can generate a million marks in sales."

That WACKER has long since left such modest goals behind is due in no small part to the tireless efforts of Dr. Nitzsche and his unstinting perseverance. Today, WACKER SILICONES is the largest business division of Wacker Chemie AG, notching up sales approaching three billion euros.

The most important of the silanes mentioned in that exchange between Director Hess and Dr. Nitzsche, namely dimethyldichlorosilane, is the precursor to about 2,800 silane and silicone-containing products at WACKER and is produced at Burghausen, Nünchritz and Zhangjiagang. WACKER is thus the undisputed number-two player in the global market for silicones.


Dr. Johannes Hess


Dr. Siegfried Nitzsche

The circumstances in which Dr. Nitzsche began his work on silanes and silicones at the Burghausen site in 1947 are worth examining, as they reveal why WACKER countenanced the idea of engaging with this new business area in the first place and the resistance which Dr. Nitzsche initially faced.

IT ALL BEGAN WITH A MISTAKE

The route followed by Dr. Nitzsche to obtain silicones also proceeded via dimethyldichlo-

1947 – **GETTING STARTED** Work began on silanes and silicones

1949 – **PRODUCTION** Silane production began in Burghausen

1951 – **COOPERATION** Licensing agreement with Dow Corning

1.22 ▸ CORPORATE ▸ **75 YEARS OF SILICONES**

THE BASIC SILANE SYNTHESIS OF MÜLLER AND ROCHOW

The gates to industrial-scale chemistry had already been opened up to silanes and silicones in 1942. In the middle of the Second World War, an American, Eugene Rochow, and a German, Richard Müller, working completely independently of one another, developed a way to produce liquid dimethyldichlorosilane direct from solid, powdery silicon and gaseous chloromethane. Figuratively speaking, this silane can be understood as a basic LEGO® building block from which thousands of organosilicon compounds can be systematically synthesized.

Back then, Eugene Rochow was working for General Electric in Schenectady, New York, while Richard Müller, affectionately named "Silicon Richard" by his co-workers, was employed at the *Chemische Fabrik von Heyden* in Radebeul, Saxony. By the way, this factory also included the Weißig plant, which commenced production of silicones for the German Democratic Republic in 1953 to a design by Müller and his team. Today, it is known as the Nünchritz plant and, since 1998, has been one of the largest silicone plants operated by Wacker Chemie AG.

Even today, after more than 80 years, Müller-Rochow or direct synthesis is the only method in the world that is capable of producing dimethyldichlorosilane and hence silicones in commercially viable quantities. When one considers how much our lives are influenced by silicones, whose unique properties render them indispensable in countless everyday applications, it is surprising that the two inventors were never awarded the Nobel Prize in Chemistry. A late honor was forthcoming in 1992, though. On the occasion of the 50th anniversary of their synthesis, they were presented with the WACKER Silicone Award in Burghausen by Dr. Stroh, the then head of the Silicones division. Rochow was 83 years old at the time and Müller was 89.

The Burghausen plant at the time of Dr. Nitzsche

Dr. Stroh (center) presented the WACKER Silicone Award to Prof. Müller (left) and Prof. Rochow (right) in 1992.

WACKER's Chief Chemist, Dr. Wolfgang Gruber, had his memoirs published (in German only).

rosilane. In the early 1940s, the Chemical Institute in Jena, where he was preparing for his postdoctoral qualification, had received an order from the German Army for the "siliconization of iron pipes." It is not hard to fathom that these were intended for use as heavy artillery. While working on this task, Dr. Nitzsche's laboratory assistant suffered a mishap: water came into contact with the sensitive dimethyldichlorosilane, hydrolysis occurred, and Dr. Nitzsche was unable to distill off the resulting oily product – not even at 360 °C. Upon cooling, a rubber-elastic product was obtained, which remained stable even when heated to red-hot temperatures. Without knowing it, Dr. Nitzsche had just made his first silicone rubber. Other, less-talented chemists would have dismissed the incident and returned to the task at hand. But Dr. Nitzsche was fascinated and had now found the subject area for his postdoctoral thesis: "Heat-resistant, silicon-containing plastics."

Later, in spring 1947, when Dr. Nitzsche was released from an American internment camp for German scientists, he received an invitation from the German Chemical Society. He was asked to deliver a plenary lecture on his thesis subject at its first post-war conference in Heidelberg. Among the audience were two representatives from Wacker Chemie: Chief Chemist Dr. Wolfgang Gruber and Director and Senior Engineer Dr. Eduard Kalb. Dr. Gruber would later describe the event in his memoirs, which were published under the title "Gratwanderungen (Balancing Acts)."

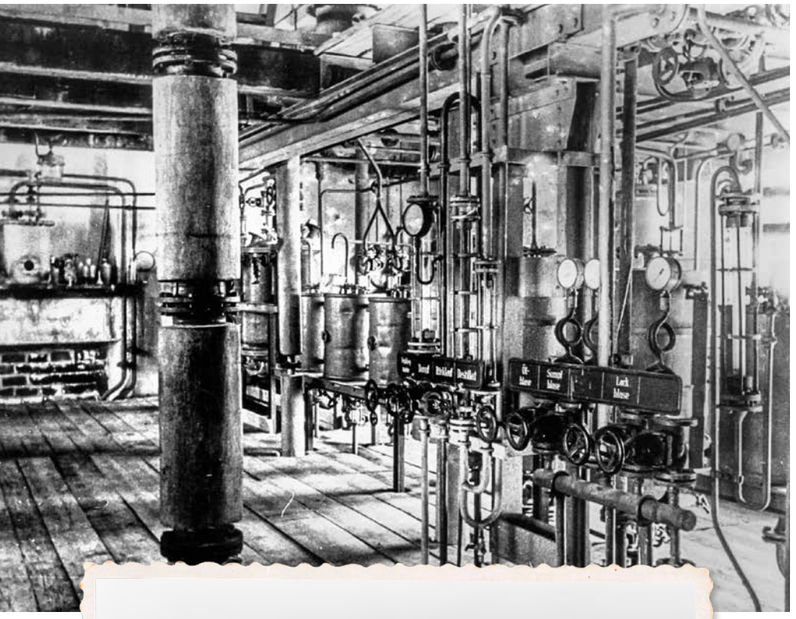
"Here I managed to do the company a great service by recruiting Dr. Siegfried Nitzsche, who gave a very good lecture on silicones, for the Burghausen plant. I had already suggested to Director Hess that we study the field of silicones, because the raw materials fall within our sphere of activity and we could easily get our hands on them (copper-silicon alloys, methyl chloride,

1953 — **NEW PRODUCTS**
Room-temperature-curing and heat-curing silicones (RTV & HTV)

1954 — **FIRST EXPANSION**
Expansion of the silicone facilities in the old plant

1959 — **PORTFOLIO**
100 different silicone products were being developed

1.22 ▸ CORPORATE ▸ **75 YEARS OF SILICONES**



This is how post-war silane distillation started in the "Salettl" summerhouse.

possibly silicon tetrachloride). Nitzsche had previously had a job application turned down by the WACKER board in Munich, but this decision was quickly reversed. In just a few years, annual sales of silicones soared into the millions of deutschmarks and the number of articles rose to 100 and beyond!"

Dr. Nitzsche joined WACKER in Burghausen on August 2, 1947, and immediately set about working on WACKER silicones.

What were the raw materials that Dr. Gruber was referring to? Back in 1947, silicon, a semi-metal, was already a long-standing "old familiar" at WACKER. In fact, Elektrobosna, a predecessor company established by Alexander Wacker, had owned a patent for the production of elemental silicon. And before the war, WACKER's portfolio included numerous alloys for the processing of steels, including calcium silicon, ferrosilicon and calcium aluminum silicon. In the 1930s, WACKER's plants accounted for two-thirds of German demand for ferrochrome alloy. So, in 1947, the company had access to silicon and was experienced at handling both it and, of course, the hydrogen chloride needed for the production of methyl chloride from methanol.

In terms of raw materials, then, Dr. Nitzsche was off to a fairly good start. But in the immediate aftermath of the war, there were still shortages on all fronts elsewhere. Dr. Nitzsche found it hard to get his hands on

The company that would become WACKER started to make elemental silicon in 1914.

personnel, equipment, the requisite laboratory and production rooms and even specialist literature. For example, it was from an article in the popular science magazine Reader's Digest that he learned about the progress being made in the field of silicones in the US. Another difficulty was the patent situation. General Electric (GE) held the important patents for the production of silanes, and another US company, Dow Corning Corporation (DC), had secured the rights to the key steps for processing these into silicones.

Fortunately, both companies were interested in working with European companies on the production and marketing of silicone products. Aside from with WACKER, they concluded contracts with Rhône-Poulenc and Bayer AG. The key licensing agreements with DC were signed in 1951 and those with GE in 1953. And so it came about that the first brochures marketing WACKER's own silicones were published in 1951, in parallel with a catalog in which WACKER acted as the general agent for DC silicones.

OVERSHADOWED BY OTHER PRODUCTS

All the while, Dr. Nitzsche had not been idle. In the face of great adversity and resistance, he had managed to develop and build up his own silane production. This was being done in the "Salettl" – a Bavarian word for summerhouse – in Burghausen. At the time, Wacker Chemie's focus was entirely on expanding its emerging PVC activities, which Dr. Berg, the later managing director and inventor of PVC suspension polymerization, had commenced back in the 1930s. The lion's share of the investment budget was therefore flowing into "VINNOL," WACKER's brand of PVC, and Dr. Nitzsche had to keep fighting to secure his modest funding.

In his own chronicle celebrating 25 years of WACKER silicones, he wrote: "Until about 1965, when managing director Dr. Maurer began to show an interest in them, silicones – as people said back then – were the whipping boys."

The fact that PVC would disappear from the Group's product range in 2000 and that WACKER SILICONES is now the company's strongest business segment by far would undoubtedly have given Dr. Nitzsche enormous satisfaction. Unfortunately, this brilliant chemist, to whom WACKER owes so much, succumbed to a serious illness in 1974. He was just 59 years old.

25 YEARS OF FURIOUS EXPANSION

Further developments in silanes took a leap forward from 1950 on, with the recruitment of two new key employees, Dr. Ewald Pirson and Dr. Manfred Wick. As of 1949, the following products were already available: silicone fluids, oil emulsions, antifoam agents, impregnating agents, pastes and release agents. 1952 saw the appearance of the first silicone rubber grades, followed in 1953 by masonry

> "Until about 1965, silicones were the whipping boys."
>
> Dr. Siegfried Nitzsche


VORLÄUFIGE MITTEILUNG ÜBER

WACKER SILICONE

WACKER SILICONPASTEN

Wacker Siliconpaste P

Wacker Siliconpaste PH

Dr. Alexander Wacker
Gesellschaft für elektrochemische Industrie
G.m.b.H.
MÜNCHEN 22, Prinzregentenstraße 22

An early example of marketing silicones: the very first product brochures from 1951

EXPANSION
Production lines in the West Plant expanded

1963

HIGH-RANKING VISIT
German Chancellor Ludwig Erhard visited Burghausen

1965

USA
Stake acquired in SWS Silicones Corporation (Adrian)

1969

Dr. Ewald Pirson

Dr. Manfred Wick

protection agents – applications which were basic back then but which can still be found in WACKER SILICONES' product portfolio today in a much more advanced and sophisticated form. By 1959, more than 100 different silicone products were under development.

As demand for silicones rose, the plant in Burghausen expanded. The first production facility had long been too small and was pulled down. Significant sums were invested from the mid-1960s to gradually expand silicone production. The plant was extended in the west and north to create an integrated production system. The idea is to waste nothing and make use of everything. WACKER was thus able to run low-waste and efficient production lines even then."On June 26, 1972, the new North Plant started up production of silane." This report in the plant magazine was something of an understatement. In reality, it was a much more spectacular affair that in subsequent years would be systematically expanded with further facilities to form what is now Burghausen's integrated

WACKER silicones were a big success at the 1952 Hannover Trade Fair.

Silane distillation in the new North Plant heralded the start of integrated siloxane production 50 years ago.

INVESTMENTS
The new silane distillation facility went on stream in the North Plant

1972

INTEGRATED PRODUCTION
The first HDK® facility in Burghausen to make use of byproducts

1978

INNOVATION
Development of liquid silicone rubber (LSR)

1980

DEVELOPMENT PRODUCTS FROM THE FIRST 25 YEARS OF WACKER SILICONES

1949—1954

Development of electrical insulating materials with silicone resin binders
- Construction of the first electric motor in Europe to feature silicone insulation (with Loher & Söhne, Ruhstorf)
- Production of the first European dry transformer to feature silicone insulation (with Siemens AG, Nuremberg)
- Silicone fluids as an ointment base in medical and cosmetics applications
- Textile finishing and impregnation
- Development and testing of masonry protection agents
- Cable insulation with silicone rubber
- Silicone-insulated high-voltage motors (3000 V) for the oil fields of Venezuela
- Antifoam agents in the food industry

1955—1957

Silicones for the paper and leather industries
- Room-temperature-vulcanizing silicone rubber as molding material for artistic and technical purposes and as encapsulant for electrical equipment
- Diffusion pump oils for high-vacuum technology

1958—1966

Combination resins (as they were then called) and copolymer oils for the coatings industry
- Silicone pastes for high-voltage technology
- Enhanced release agents for rubber and plastics processing
- Laminating resins and molding compounds for electrical engineering and electronics
- Joint sealants for construction
- Heat-resistant greases for high-stress ball bearings
- Silicone rubber applications in the automotive industry
- Silicone rubber as a prosthetic material and as a depot material for drug formulations in the medical sector
- Alkali-resistant antifoam agents

1967—1972

Enhanced masonry protection agents and their application
- Agents for cleaning up oil spills
- Conductive silicone rubber for panel heaters
- Functional silanes as adhesion promoters, e.g. for processing glass fabric and fibers
- Foam stabilizers for polyurethane foams
- Enhanced paper-coating agents
- Solvent-free casting resins for electronics
- Easy-to-process silicone rubber pellets

siloxane production plant. The plant featured a revolutionary, unenclosed reinforced-concrete design and the first vestiges of automated control in the guise of a control room.

At 51.1 meters, the silane distillation columns erected in 1972 were the tallest of their kind in Burghausen. Recently, after 50 years' service, they were replaced by a new silane column, which, at more than 70 meters, towers above them.

A BLOCKBUSTER MADE UP OF BYPRODUCTS

Around about the same time, in the early 1970s, Dr. Günter Kratel at the Kempten plant of WACKER's subsidiary ESK developed a filler: HDK® pyrogenic silica, which also turned 50 in 2022. This extremely versatile material can be found in a swath of wholly disparate applications and, among its many uses, has more or less become the default reinforcing filler for WACKER's silicone rubber.

As early as 1978, a separate HDK® plant was built in Burghausen and hooked up to the integrated silicon production network. What makes this so interesting is that HDK® is itself obtained from byproducts from silane synthesis and is thus part of the integrated production network operated by the WACKER SILICONES and WACKER POLYSILICON divisions. The "silane byproducts" from silane synthesis are pyrolyzed at over 1,000 °C in a hydrogen-oxygen flame, and cool to form flocs that have

A new silane distillation column went into operation in 2022. It is not only higher than its 1972 counterpart, but also more effective and energy-efficient.

Considerable size, low weight, high demand – pyrogenic silica is made from silane-manufacturing byproducts.

the basic structure of silicon dioxide (SiO_2). In other words, a substance with the same composition as sand. Unlike sand, HDK® from WACKER has a massive surface area that serves as the source of its unique properties. A large bag of HDK® weighs just ten kilograms.

There are very few chemical reactions that give a 100-percent yield of the intended product. This fact underlies one of the key advantages of integrated production at WACKER. Over the decades, chemists and engineers have succeeded in taking a great many byproducts generated in various processes and using them, for example, as starting materials for other products.

Today, demand for WACKER HDK® is so great that it is produced not only in Burghausen, but also in Nünchritz, Zhangjiagang and Charleston. HDK® is therefore a prime example of how, at WACKER, one little cogwheel meshes with another. Waste from silicone production is thus transformed into a new sales product which may not be visible in our living environment, but is nevertheless omnipresent.

WACKER SILICONES CONQUER THE WORLD

However, it was not just the range of silicone products that expanded over the decades. The

Dr. Günter Kratel

APPLICATIONS OF HDK®

- Hydrophilic or hydrophobic reinforcing filler for plastics
- Thickening agent for paints and coatings
- Insulation material for thermally insulating parts
- Flow enhancer for, e.g., fire-extinguishing powder, toner for laser printers or tomato powder for ketchup
- Grinding agent for planarizing silicon wafers
- Pseudoplastic additive for emulsions, dispersions or toothpaste

1983 — **GROWTH IN ASIA**
Wacker Chemicals East Asia founded

1986 — **CLOSE TO CUSTOMERS**
Construction started on the silicone manufacturing facility in Japan

1987 — **AWARD-WINNING**
Presentation of the first WACKER Silicone Award

1992 — **PATRONAGE**
of the first "Silicone Days," now a major industry gathering

1998 — **NEW SITES**
Nünchritz site purchased and a site in India founded

1999 — **FOCUS ON ASIA**
Wacker Asahikasei Silicone Ltd. joint venture (Japan)

3,000

products are made by WACKER today, including silanes, siloxanes, silicone fluids, silicone emulsions, silicone elastomers and silicone resins.

customer base also grew steadily and became more and more international. And that is why, in the late 1960s, it proved necessary to build up production capacity beyond the confines of Burghausen. Wacker Chemie took an initial 33.3-percent stake in SWS Silicones Corporation (Stauffer-Wacker Silicones) in Adrian, Michigan, gradually increasing it to 100 percent by 1987. The name was changed to Wacker Silicones Corporation (WSC).

In early 1978, Wacker Química do Brasil Ltda. began manufacturing and selling silicone products in Jandira near São Paolo, and, with the 1983 founding of Wacker Chemicals East Asia (WCEA) in Daito-cho, Japan, WACKER silicones made the leap into Asia. 1998 brought another important cornerstone in the Asian market, with the founding of the joint venture Wacker Metroark Chemicals Pvt. Ltd. in Kolkata, India.

It would go beyond the bounds of this article to list all the other WACKER silicone sites that emerged worldwide in the decades that followed. However, two fully integrated sites deserve a mention, because they have something in common with Burghausen: they each boast a complex that produces silanes by the Müller-Rochow method.

The first is Nünchritz, which has already been mentioned briefly. Founded in 1900 as the Weißig plant of *Chemische Fabrik von Heyden*, it operated in former East Germany first as *VEB Schwefelsäure und Ätznatronwerk* and then, following the work of Richard Müller, as *VEB Chemiewerk Nünchritz*. After the fall of the Berlin Wall, the plant was initially taken over by Hüls AG in 1990, which sold it to Wacker Chemie a few years later in 1998. Since then, as a result of continuous investment in its expansion, Nünchritz is now the largest WACKER site in Germany after Burghausen.

Unlike Burghausen, Nünchritz does not have its own chlorine production. This highly reactive gas is needed for the production of chlorosilanes – which serve as intermediates in the production of silicones. This process re-generates the chlorine, which is then removed and reused. Every chlorine atom passes through the production loop a great many times. In Burghausen, chlorine is produced by electrolyzing rock salt sourced from the Group's own salt mine in Stetten. Nünchritz, without its own supply of salt and therefore of chlorine, obtains chlorine-containing intermediates from Burghausen to replace the losses that inevitably arise even in an excellently designed integrated production system.

Another important step toward expanding silicone activities was the construction

The photos show clearly that the Nünchritz site has flourished since it was taken over by WACKER in 1998.

2004
PREMIERE IN CHINA
A silicone emulsions plant went on stream in Shanghai – the first time WACKER had produced silicones in China

2006
JOINT VENTURE
Ground-breaking ceremony for a joint WACKER/Dow Corning site in China

2008
EASTERN EUROPE
Production plant for ready-compounded SILMIX® silicones in Czechia

1.22 ▸ CORPORATE ▸ **75 YEARS OF SILICONES**

1.22 ▸ CORPORATE ▸ **75 YEARS OF SILICONES**

WACKER has been producing silicon in Holla, Norway, since 2010 – from quartz and coal at 2,000 °C.

of the Zhangjiagang plant in China, where the first facility went on stream in 2005. WACKER entered into a joint venture there with competitor Dow Corning in 2006 to build one of the world's largest integrated production sites for polydimethylsiloxane and pyrogenic silica, which was inaugurated on November 18, 2010. Upstream production of precursors – silanes and siloxane, as well as the pyrogenic silica byproduct – is conducted there in a joint operation by the two partners. WACKER and Dow Corning are each responsible for manufacturing their own end products – silicones – downstream.

The plants in Burghausen, Nünchritz and Zhangjiagang, working together in a harmonious triad, produce dimethyldichlorosilane as a basis for all silicones, and they are still using the Müller-Rochow method, which is 80 years old by now. At a symposium for organosilicon chemistry in Poznan, Poland, in the mid-1990s, a smiling Prof. Eugene Rochow asked the young chemists there to finally come up with something better than his ancient Müller-Rochow synthesis. To this day, nobody has managed it.

WHY DOES WACKER MELT SAND?

Wacker Chemie AG also worked to ensure that it was vertically integrated. Silicon is not just a vital raw material for WACKER SILICONES, but is also an essential semi-metal needed by WACKER POLYSILICON in particular. In total, products containing silicon account for some 80 percent of WACKER's current sales. So, the company's decision to secure its own raw-material base by acquiring a captive production facility was certainly taken with an eye to the future.

To this end, in 2010, WACKER acquired a site in Holla, Norway, where quartz and coal are converted into silicon metal in huge furnaces. Silicon is the most abundant element in the earth's crust after oxygen. Due to its very affinity for oxygen, however, it does not occur in elemental form anywhere, but primarily as silicon dioxide (SiO_2), i.e. quartz or quartz sand. From the outset, Holla was able to cover about one third of WACKER's raw silicon requirements, with work ongoing to expand this capacity even further.

Possessing unique properties and unrivaled in their diversity by any other polymer, silicone fluids, resins and rubbers can be found in all kinds of applications, from lipsticks and baby pacifiers through to high-quality potting compounds for electric-vehicle batteries. Silicones serve as insulators in high-voltage technology and as the optical lenses of LEDs. In bathrooms and kitchens, they have long been the sealing material of choice for preventing water ingress behind tiles. Hardly any industry can do without silicones today. The end products that were first developed in a barracks in Burghausen 75 years ago are indispensable in our modern world. Consequently, WACKER's current statement of purpose was relevant to silicones even then: our solutions make a better world for generations. Dr. Siegfried Nitzsche would have liked that.

16

Production sites for silicones ensure that we are close to our customers

2010
KEY INVESTMENTS
A silicon-metal production plant was purchased in Norway and Lucky Silicones was bought in South Korea

2017
R&D
Lab complex for developing innovative silicones (Ann Arbor, USA)

2022
EFFICIENCY
New distillation column added to Burghausen's integrated siloxane production system

1.22 ▸ CORPORATE ▸ **ALEXANDER WACKER**

A LATE-19TH-CENTURY START-UP ENTREPRENEUR

Alexander Wacker wasn't a chemist or an engineer. He was a qualified textile merchant. And yet on his death one hundred years ago on April 6, 1922, he had become a pioneer of German industry – first in electrical engineering, and then in electrochemicals. He began his life's greatest achievement in 1914, when he was 68 years old. Today, his creation, Wacker Chemie, is among the leading suppliers on the world market for all its main areas of business.

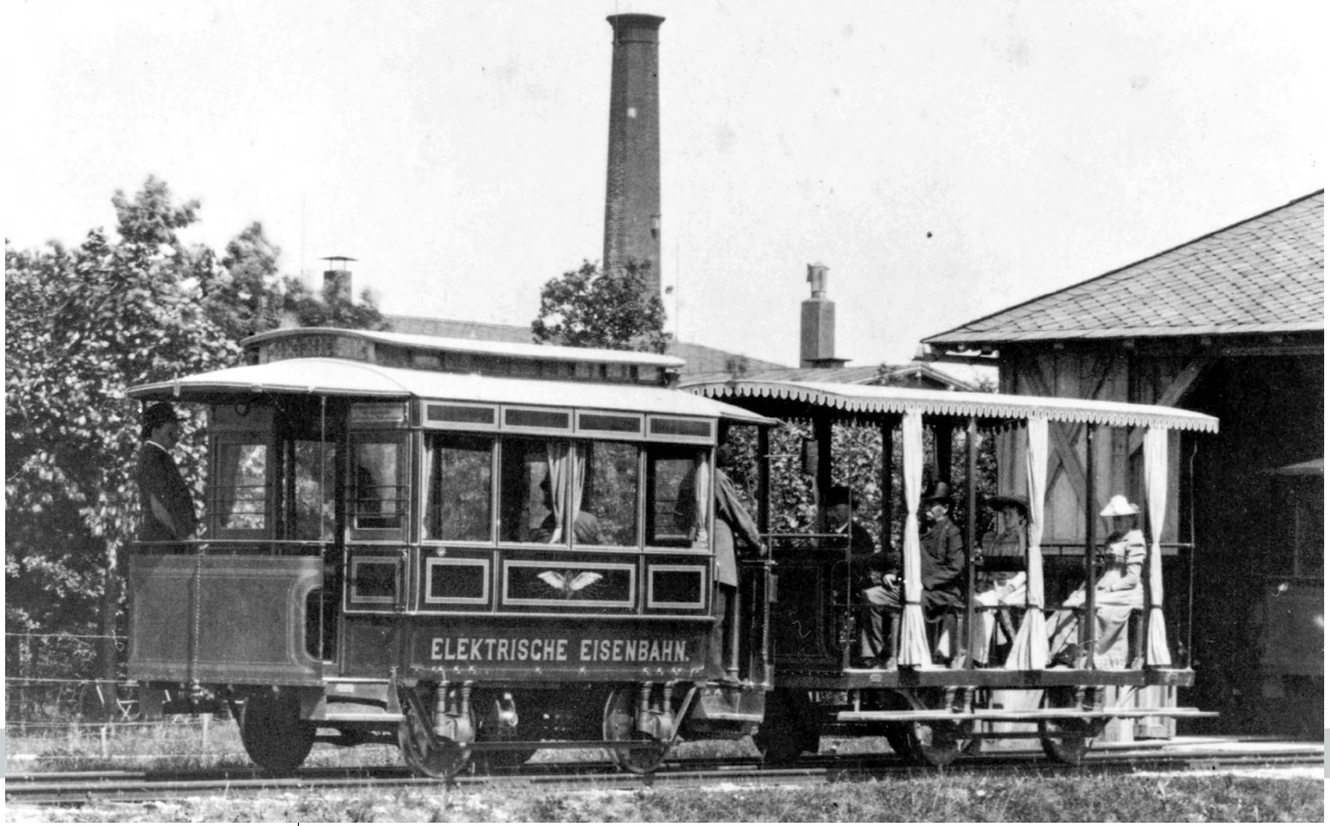
When Alexander Wacker registered Wacker Chemie in the Traunstein Commercial Register on October 13, 1914, he was 68 years old – an age at which most people have already retired, not only today but back then, too. In addition, he had just suffered a great loss: his son Franz Alexander, a chemist he had wanted to establish as his successor, died. He was just 31 years old. Plus, World War I had just broken out in Europe – hardly an ideal time to open a business.

Nevertheless, Alexander Wacker, who already looked back on a long career, in his own company and others, staunchly persevered with his plans. What motivated him to rise to new

1901

Alexander Wacker during his time as general director of Elektrizitäts-AG in Nuremberg.

Alexander Wacker as a commercial apprentice in Schwerin in 1863, as a young textile specialist in Kassel in 1874, and in old age.



1886

The Schuckert factory supplied the city of Munich with an electric streetcar, which started running in 1886.

holder of his company, one of the pioneers of electrification in Europe in the late 19th century, much like Siemens and AEG.

He set up sales offices across Europe for Schuckert: he must have been a talented salesman. "Wacker was unbeatable in acquisition," said Georg Wilhelm from the large rival company Siemens.

HIGHLY DYNAMIC INDUSTRY

The period of economic growth during which Alexander Wacker became great and wealthy was an extraordinary, dynamic, breathtakingly fast-paced time, comparable to today. Between 1871 and 1914, a rapidly expanding industry radically changed the world – with dynamos and fertilizers, automobiles and telephones, synthetically produced pharmaceuticals and, sometime later, the first plastics. Electrical engineering, mechanical engineering and the chemical industry created completely new markets, laying the foundations of a new world – just as information technology, the internet and biotechnology are doing today.

1884

Meeting Sigmund Schuckert, a precision engineer, would change the course of Alexander Wacker's life. Initially, he became commercial head of the Schuckert factory in Nuremberg in 1884, before becoming joint partner in the company four years later.

entrepreneurial heights at the end of his life, and found a company that has passed the 100-year milestone? As is often the case: the clue lies in his childhood.

HALF-ORPHANED AT BIRTH

Eight months before Alexander Wacker was born, his father died of tuberculosis. His mother remarried. The young Alexander was raised by his maternal grandmother and aunts, but maintained regular contact with his mother. He would gladly have gone to university, but money was tight and the family took him out of school at the age of 15. In 1862, in distant Schwerin, he began a commercial apprenticeship as a textile merchant – a trade that neither suited nor fulfilled him.

Presumably, these early experiences, not uncommon at that time, spurred on his entrepreneurial ambition. The honors bestowed on him in the latter part of his life, including honorary doctorates from the universities of Heidelberg and Göttingen and an aristocratic title, must have given him satisfaction.

Alexander Wacker's entrepreneurial years also began during a period of economic growth in Germany. He established a silk manufacturing company in Kassel in 1872. Three years later, in 1875, he took over a machine trading company in Leipzig. And in 1877, he met Sigmund Schuckert, a precision engineer. This meeting changed the course of his life. From then on, Wacker sold the dynamo machines and electrical equipment his new partner manufactured in a small workshop in Nuremberg with just 28 employees.

Then Alexander Wacker's career really took off. In 1884 he became commercial head of the Schuckert factory and moved to Nuremberg. Four years later, Schuckert made him a share-

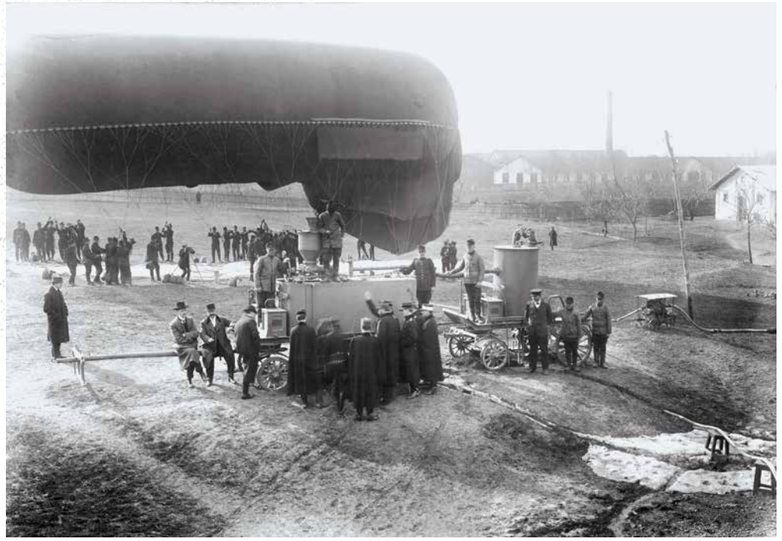
1893

The largest searchlight of its day was made by Schuckert and went on display at the 1893 World's Fair in Chicago.

EAG share certificate. The owners turned what had been a limited partnership in a stock corporation on April 1, 1893. Alexander Wacker was made general director.

1908

Alexander Wacker founded the Consortium für elektrochemische Industrie in Nuremberg. This was where mobile generators were invented that could be used to inflate airships with hydrogen at their mooring point.



At the turn of the last century, people like Werner von Siemens or Andrew Carnegie, or, for that matter, Alexander Wacker, were the Jack Ma, Elon Musk or Steve Jobs of modern times. Like a start-up entrepreneur of the imperial age, his career path took him from city to city and company to company at a rapid pace. Eagerly he embraced innovations and experimented with a number of sectors. He and Schuckert benefited from the speed at which worldwide economic networks grew at the end of the 19th century – another parallel to our times. This pace was only reached again a century later with the surge in globalization following the opening of the Eastern Bloc between 1989 and 1991.

Under the commercial management of Alexander Wacker, Schuckert built the first electric tram line for the city of Munich in 1886, and the first electric power plant for the city of Lübeck in 1887. In 1892, Sigmund Schuckert retired from the company he had founded due to a nervous condition. The partners then transformed Schuckert-Werke into Elektrizitäts-AG, or EAG, also based in Nuremberg. The general director was Alexander Wacker. By the turn of the century, the company's workforce numbered 8,500. Earnings skyrocketed – from 56,000 German mark in 1880 to 46.5 million in 1898.

SETBACK WITH CARBIDE

The electrical and chemical industries initially went separate ways. As time went on, they increasingly moved in tandem, and each benefited from the other's progress. Gifted with astute business acumen, Alexander Wacker foresaw this development. Directly or indirectly, he acquired various carbide factories in places such as Bosnia, Switzerland and Norway, where calcium carbide was produced using large amounts of cheap hydro-electric power. Alexander Wacker's initial idea was to process this carbide into acetylene and then sell it as illuminating gas for city lighting. However, this did not pan out. The electric light bulb outrivaled the gas light and soon became the default in the private sector, quashing the market for acetylene.

This setback – possibly the biggest in his career – left Alexander Wacker undeterred. He retained the carbide factories and the laboratory – later to become the Consortium – when he sold EAG to Siemens & Halske in 1902. Even before the sale, he had resigned as general manager and moved to the company's supervisory board – a position he never warmed to.

1917

During the years of construction, the site in Burghausen consisted of the acetone factory, the mercury oxide electrolysis facility, the main building, workshops and the boiler house.

1918

On July 8, 1918, Alexander Wacker (2nd from left) received King Ludwig III of Bavaria (5th from left) at the new plant in Burghausen. Alexander Wacker was granted an aristocratic title by Ludwig III for his achievement in the construction of a strategic factory.


Burghauser Anzeiger
und Salzach-Zeitung
Gruß unserem König Ludwig III.

1922

Constructing the Alzwerke hydroelectric power station in Burghausen: Alexander Wacker's vision of chemical production based on hydroelectric power was implemented effectively in his own plants.

LOOKING FOR NEW APPLICATIONS

What to do with the stockpile of carbide? When he founded the Consortium for the electrochemical industry in 1903, Alexander Wacker's instruction to his chemists was along the lines of "Get rid of the carbide!"

Around a dozen of the Consortium's chemists, technicians and assistants spent this interim period lasting over ten years working on finding commercially viable uses for carbide and acetylene. Alexander Wacker wasn't a chemist, but he was a patient man. He understood that systematic research is a prerequisite for commercial success – a principle that he also applied in the company that later became Wacker Chemie. He was able to afford this long phase of groundwork in the Consortium because, despite surplus production, his carbide factories had a stable economic basis: they also produced ferro and silicon alloys, which were needed for welding and steel production, among other things.

Between 1903 and 1914, the Consortium became the scientific hub of the future Wacker Chemie. Its chemists filed dozens of patents, some of which were licensed to other companies, while others, such as chlorinated hydrocarbons, remained pillars of WACKER's business until the 1990s. The mainstay was the 1st WACKER Process for manufacturing acetylaldehyde, which was further processed to synthetic acetic acid and later to vinyl acetate – basically the "big bang" for the WACKER POLYMERS business division's highly successful VINNAPAS® range.

> The Consortium has, since 1903, been a scientific hub of what would eventually become Wacker Chemie. Consortium chemists registered dozens of patents.

What Alexander Wacker still needed in his adopted home in southern Bavaria was a large electrochemical plant to turn theory into practice and the Consortium's patents into operational production. In 1913, Burghausen, a remote fairly rural town at the time, was selected, because the elevation gradient of around 70 meters between the Alz and Salzach rivers would enable the construction of a hydroelectric power plant by means of a canal. And chemical production in those days needed vast amounts of electricity.

BEING MADE AN ARISTOCRAT

But the onset of the First World War in 1914 put a stop to the construction work on the Alz canal and the WACKER plant until the attention of the War Ministry in Berlin was drawn to a process developed at the Consortium for the production of acetone from acetic acid. Acetone was the base material used by Bayer in Leverkusen to manufacture artificial rubber for sealing the accumulators of submarines. Suddenly, the WACKER plant was considered important for the war effort, and everything had to be ready very quickly. On December 7, 1916, the first industrial production of synthetic acetone in the world went into operation. To mark this milestone, King Ludwig III of Bavaria conferred an aristocratic title on Alexander Wacker in 1918.

A few months later, the war was lost, and the Kingdom of Bavaria was history, along with the German Empire. And after 1918, no one in Germany needed acetone for submarine construction – 60 percent of sales were lost in one fell swoop.

Geheimrat Dr. Alexander Ritter von Wacker, as he was then allowed to call himself, once again faced an enormous challenge in the last four years of his life. He had to bring about what we'd term a transformation today: the transition from military to civilian production. By then 72 years of age, Alexander Wacker tackled the task with great resolve and also set about settling his affairs. In 1920, he transferred his Wacker Chemie shares to a family holding company – an arrangement still in place today, giving the company continuity and stability.

In 1921, the family sold half their shares to Hoechst. Alexander Wacker urgently needed capital to cover the rapidly rising costs of the Alz Canal construction. This old-school "joint venture" was a successful partnership for many decades. In 2005 and 2006, shortly before Wacker Chemie AG's IPO, the family led by Dr. Peter-Alexander Wacker, a great-grandson of Alexander Wacker, bought back the Hoechst shares.

PUTTING HIS LIFE'S WORK IN ORDER

When Alexander Wacker died on April 6, 1922, just before his 76th birthday, he secured his last and most enduring company by establishing the new family-owned holding company. And in Burghausen, a remote town in southeastern Bavaria, he created a groundbreaking full-scale chemical production plant that now ranks among the top three global suppliers in all its main business areas and operates large integrated production sites in Germany, the USA, China and South Korea. Alexander Wacker's aptitude for innovation and developing new technologies and business fields is still very much alive and well a hundred years later in the company he founded.

This industrial pioneer's "start-up" gene dating back to the far-off imperial age is part of Wacker Chemie AG's DNA. The entrepreneurial tradition that Alexander Wacker established lives on unabated as the founder's family continues to cultivate this heritage going forward. ■

1.22 ▸ SOLUTIONS ▸ **BIOTECHNOLOGY**

WITH mRNA AGAINST CANCER

Vaccines based on mRNA protected humanity against a worst-case scenario during the Covid-19 pandemic. The mRNA therapeutics not only protect against virus infections, they also have great potential for tumor therapy. WACKER is now building a new mRNA competence center in Halle to complement its three existing sites in Germany, the Netherlands and the USA (California).

Bacteria at Wacker Biotech in Halle produce pharmaceutical proteins in stainless steel tanks known as fermenters. The site is being expanded into an mRNA competence center, scheduled to start up in 2024 and featuring a new technology.

The production capacity will more than triple thanks to the future mRNA competence center in Halle – proposed design shown here.

Until just a few years ago, mRNA therapeutics were only familiar to specialists. Today, most people are at least familiar with the term. The reason? Coronavirus. “The high demand for new and, above all, rapidly available vaccines has shown the potential of this technology. The biopharmaceutical sector has experienced a major boost,” said Dr. Guido Seidel, managing director at Wacker Biotech. He compared the situation with the amazing rise of antibodies just a few decades ago: “There were a lot of skeptics in the 1980s who dismissed any potential for this technology. Today, highly specific antibodies are used in standard therapies for numerous diseases.”

The same point, he explained, had now been reached for mRNA technology: “Proof of concept” has been achieved. Whether this technology works in other indications still has to be demonstrated. Seidel is confident: “We will be able to treat or even prevent numerous diseases in 20, 30 years with mRNA-based medication.”

More research, more demand, more business – WACKER is moving with the current rise in demand and has decided to expand the Wacker Biotech GmbH site in Halle to become an mRNA competence center. The WACKER Group focuses all its biopharmaceutical activities within its Wacker Biotech subsidiary. Ground was broken at the beginning of July 2022. The new production building at the Halle site in Saxony-Anhalt will be up and running within two years, with some 200 people working there. Plans are for four production lines which will exclusively manufacture mRNA biopharmaceuticals. This means that Wacker Biotech will greatly increase its production capacity based on its current site capacities in Jena and Halle (Germany), and in Amsterdam (NL) and San Diego (USA). “It is no longer possible to conceive of medical biotechnology not being used in patient treatment. Almost half of all newly approved medicines are now biopharmaceuticals,” Seidel underlined. According to experts, the percentage of mRNA therapeutics will continue to rise.

1.22 ▸ SOLUTIONS ▸ **BIOTECHNOLOGY**

“It is no longer possible to conceive of medical biotechnology not being used in patient treatment.”

Dr. Guido Seidel, managing director of Wacker Biotech

NEW COMPETENCE CENTER FOR mRNA ACTIVE INGREDIENTS IN HALLE

The start of the Weinberg campus expansion was marked with a symbolic groundbreaking ceremony. Over the coming months, a competence center for active ingredients based on messenger ribonucleic acid (mRNA) will take shape here. Numerous guests from politics and business attended the ceremony: (from left) Michael Zorn from Saxony-Anhalt’s State Administration Office; Egbert Geier, Mayor of Halle; Melanie Käsmarker, co-managing director of Wacker Biotech GmbH; Sven Schulze, Saxony-Anhalt’s Minister of Economic Affairs; Christian Hartel, president & CEO of Wacker Chemie AG; Armin Willingmann, Saxony-Anhalt’s Minister of Science, Energy, Climate Protection and Environment; Wolfgang Büchele, CEO of Exyte; Guido Seidel, co-managing director of Wacker Biotech GmbH; Ulf-Marten Schmieder, managing director of the Weinberg Campus technology park; and Joachim Bug, deputy director of ZEPAI (Center for Pandemic Vaccines and Therapeutics).

mRNA-based vaccines require special handling and may only be thawed shortly before being administered.

DETAILED BLUEPRINT

The foundation stone was laid by vaccine development during the current pandemic. In just a few months, numerous biotechnology companies developed vaccines against the SARS-CoV-2 virus. The main constituent is mRNA. The abbreviation stands for messenger ribonucleic acid (RNA). While previous vaccines usually consist of virus particles or fragments of such particles, mRNA vaccines take a slightly different path: they consist of a detailed blueprint of the special proteins in the pathogen, also known as antigens. In the coronavirus, for instance, this is the spike protein that protrudes from the surface of the virus, providing it with a striking appearance. Packed in a lipid envelope, the genetic message is delivered into the muscle cells at the injection point. The cells then build the corona protein, present it to the immune system, which recognizes the antigen as an intruder and starts producing antibodies against it. Should the body one day be infected with the actual pathogen, it is then suitably equipped and can effectively combat the intruder.

In order to understand what is so unusual about mRNA, you need to look inside the cell nucleus. This is where the DNA, containing the human genetic information, is stored. It holds the complete information for the blueprint of the human body. Each gene codes for a protein. These genes determine the characteristics of every life form. It has been 60 years since it became clear that cells produce a copy of the genes in order to translate the information in a protein. Whenever the body requires a specific protein, the required gene is translated in an mRNA. The mRNA transfers the blueprint for the protein from the cell nucleus to the ribosomes. The ribosomes in the cells then produce the required protein. The DNA remains protected in the cell nucleus.

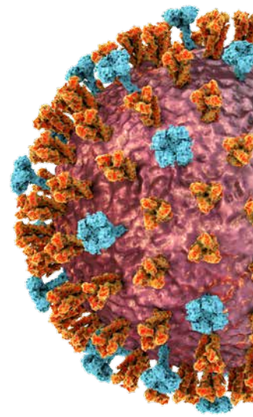
LARGE VOLUMES, RAPID PRODUCTION

It has now become possible for the first time to use these mRNA vaccines to create therapeutic agents based on mRNA on a large scale. Over 12 billion vaccinations worldwide up until June 2022 have shown that mRNA vaccines work effectively, are well tolerated and can be efficiently produced. Many were astounded at how rapidly the appropriate vaccinations became available in such huge volumes. This rapid development was made possible because many building blocks for mRNA vaccine had already been created, emphasized Seidel. He is himself a biochemist and has been familiar with the research and production of biopharmaceuticals for more than 20 years: “That production ramped up so fast is because the spike sequence mRNA could be conceived, designed and synthesized so rapidly, relatively speaking, compared to cancer therapeutics that companies have been researching so intensively to date.”

That this experience has resulted in numerous ideas for further vaccines based on the same principle is a logical conclusion: The US biotech company Moderna is working, among other things, on a quadruple vaccine against the influenza virus. The company even intends to create a form of “autumn vaccine” that combines different vaccines against various respiratory diseases such as Covid-19, influenza and respiratory syncytial virus (RSV).

There is a lot to suggest that mRNA therapeutics will also find a use in the future for other indications. Biontech founder Ugur Sahin, for example, believes that his company will introduce multiple products to combat cancer and infectious diseases over the next three to five years. “You can use mRNA anywhere in the body where proteins are functioning incorrectly or where proteins are needed to activate the immune system, for instance, the vaccination against the coronavirus – but also against cancer,” said Seidel. Possible application areas for mRNA therapeutics could be autoimmune diseases, cardiovascular diseases and in regenerative medicine.

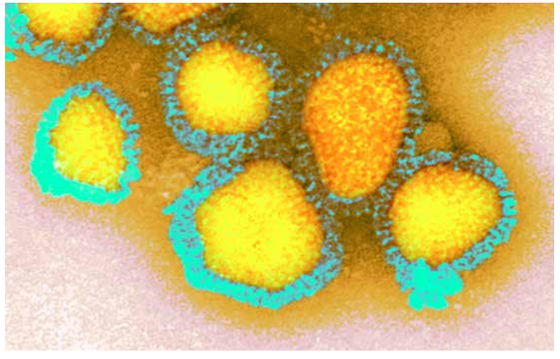
Developers are placing a lot of hope in cancer treatment in particular. The challenge for a cancer vaccination is that cancer cells often hide and therefore avoid being destroyed by the immune system. The mRNA vaccine is intended to induce the immune system to recognize tumor cells as “foreign” again and effectively fight them. The mRNA vaccine therefore contains the blueprints of important components of individual tumors, for instance a surface protein. The resulting protein or peptide then activates the immune system which combats the cancer cells. “The key step here is to rapidly



“mRNA can be used anywhere where proteins are malfunctioning in the body.”

Dr. Guido Seidel, managing director of Wacker Biotech

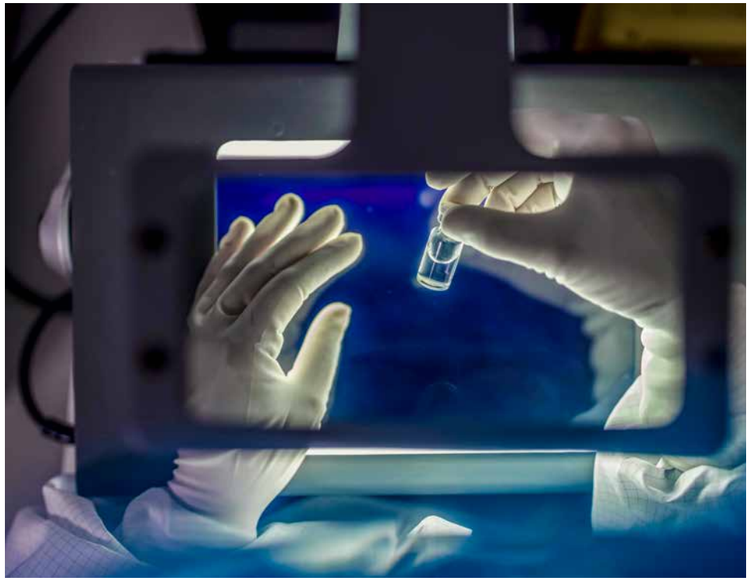
The H3N2 subtype of the influenza A virus was responsible for the Hong Kong flu at the end of the 1960s – a pandemic that was variously estimated to be responsible for between one and four million deaths.



CONTACT

For more information on this topic, please contact:

Manuela Dollinger
Manager, Media Relations & Information
Tel.: +49 89 6279-1629
manuela.dollinger@wacker.com



From development to dispensing: at Wacker Biotech's Amsterdam site, active ingredients can be dispensed into their final packaging for shipment to customers. The vials then undergo one last quality control step.

produce a suitable active ingredient from the tumor data," said Seidel, adding that mRNA was predestined for this as it can be relatively rapidly designed and produced.

As is often the case during the development of new medicines, numerous actors are essential: while pharmaceutical companies drive research forward, contract manufacturing organizations such as Wacker Biotech ensure that the new active ingredients can be produced in large quantities. As a contract development and manufacturing organization (CDMO), the company produces active ingredients for the market and clinical testing on behalf of pharmaceutical and biotech companies. "The rapid success in vaccine production would hardly be possible without companies like us," said Seidel. As a full service producer of biologics, Wacker Biotech has 20 years of experience in the sector of microbial systems. Core competencies include the production of pharmaceutical active ingredients, live bacteria and vaccines – lately also based on mRNA. Wacker Biotech has built up an international portfolio of customers over the years. Business is growing steadily.

POTENTIAL RECOGNIZED EARLY ON

The biotech company recognized the potential in mRNA therapeutics early on: "We have been intensively expanding our expertise and production capacities for mRNA therapeutics since 2018," said Seidel. The various sites cover different specialist areas of the manufacturing processes: in Amsterdam for example, they know how to package the highly sensitive molecules into tiny lipid spheres. Plasmid DNA is produced in San Diego as the raw material for mRNA therapeutics.

WACKER eventually decided to focus all these mRNA competencies at one site: "Together with our partner, CordenPharma, our Halle site will, going forward, cover the complete manufacturing process for mRNA active ingredients," said Seidel. While Wacker Biotech takes over the production of mRNA derived from plasmid DNA and the preparation of the mRNA active ingredient with lipid nanoparticles (LNPs), CordenPharma is to produce the lipids for the LNP preparation and take over the sterile filling and packaging of the mRNA vaccine.

Four new production lines will be set up in Halle for this purpose. Approximately half of the production capacity will be reserved for the German Government within the framework of its pandemic preparedness plan contracts. Seidel explained that the concept of a 'warm facility' would be followed here: "Systems will be operational and be maintained in a state of full readiness. If we receive the order from the German Government to produce mRNA vaccine, we can start production within a very short time." The aim is to be optimally

1.22 ▸ SOLUTIONS ▸ **BIOTECHNOLOGY**

"The rapid success in vaccine production would hardly be possible without companies like us."

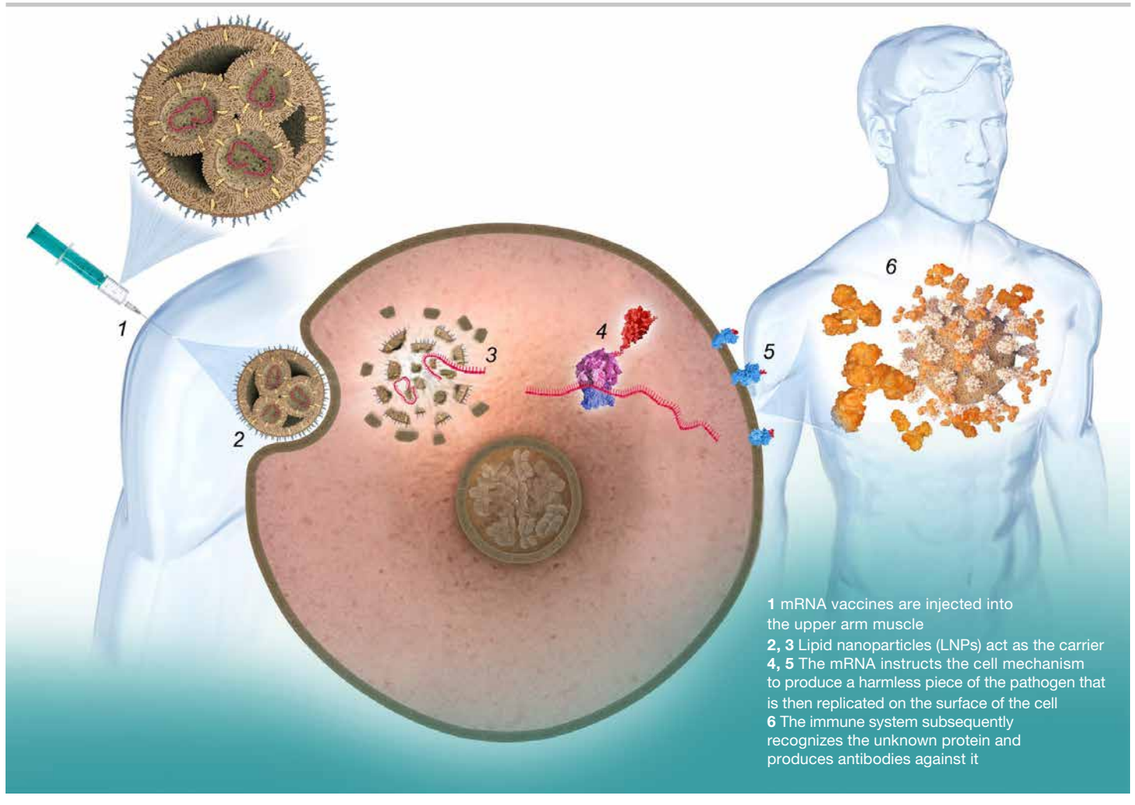
Dr. Guido Seidel, managing director of Wacker Biotech

As a contract manufacturer, Wacker Biotech US Inc. in San Diego operates a specialized fermentation line for manufacturing and purifying plasmid DNA.

prepared for a future pandemic and thus avoid any supply bottlenecks like those that occurred at the start of the coronavirus pandemic. Seidel is very proud that WACKER will be producing mRNA vaccines for the German Government if needed: "We are very happy that we have invested in this technology over the years – and are now playing in the front row."

If necessary, Wacker Biotech and CordenPharma can supply Germany with 80 million vaccine doses per year. The plan is to use the remaining production capacity in Halle to contract-manufacture mRNA therapeutics. The first products will emerge from the Halle plant from mid-2024. Wacker Biotech is already putting out feelers to customers who could in the future produce in Halle. Seidel's dream? To be present when the new technology will also be able to heal cancers in the future. "It is so exciting to imagine that we will one day be able to contribute towards improving the fight against tumors in a truly wide range of cancer indications, and to heal patients in a highly specific manner." ■

mRNA VACCINE WITH LIPID NANOPARTICLES (LNPs)



Executive Board member Angela Wörl (far left) and Dr. Christoph Kowitz (far right), head of Corporate R&D, presented the award to Dr. Mario Arcos Rodriguez (2nd from left), Dr. Johanna Koch (3rd from left), Dr. Rupert Pfaller (4th from left), and Annemarie Reutter-Maier (5th from left).

NOVEL PROCESS FOR MANUFACTURING CYSTEINE WINS AWARD

Spanish-German project team wins Alexander Wacker Innovation Award

WACKER presented its 2022 Alexander Wacker Innovation Award to a Spanish-German project team. Johanna Koch, Annemarie Reutter-Maier, Rupert Pfaller and Mario Arcos Rodriguez won the award for developing and launching a novel and far more efficient fermentation process for producing L-cysteine. The team managed to intensify the natural fermentation power of the E. coli bacteria strains used in the process and to set new standards for glucose conversion and productivity.

"Thanks to this pioneering approach, our BIOSOLUTIONS division is able to strengthen its technological leadership as a manufacturer of high-quality cysteine," said Angela Wörl, member of Wacker Chemie AG's Executive Board and its personnel director, in her laudatory speech.

By developing new E. coli strains with unique metabolic pathways and skillfully selecting process conditions, including a novel system to optimize glucose feed, the team improved the overall process efficiency beyond previously known limits. At the same time, the sustainability of the production process has risen markedly. "The winners of the Alexander Wacker Innovation Award have once again shown that outstanding biotechnology know-how coupled with interdisciplinary cooperation between product development, engineering departments and production are the key success factors for efficiently developing and implementing sustainable production processes," emphasized Wörl.

The Spanish-German project group's innovative approach to improving the fermentation of cysteine prevailed against strong competition. 25 development teams from Brazil, China, Germany, South Korea, and the United States submitted applications for this year's €10,000 Alexander Wacker Innovation Award, which was conferred for the 18th time.

WACKER IN FIGURES

WACKER has set new, ambitious sustainable development goals as its own contribution toward limiting the global rise in temperature to a maximum of 1.5 degrees Celsius, as called for in the Paris Agreement. As part of the UN's "Race to Zero" initiative, WACKER is voluntarily committing to comply with this limit. It is focusing on two fields of action: first, by further reducing not only greenhouse gas emissions caused by its own products and processes, but also consumption of resources; second, by empowering customers to market climate-friendly solutions that minimize resource consumption.

More than

450

MILLION METRIC TONS OF CO_2

are avoided as a result of WACKER's annual production of solar silicon, which is then used in photovoltaic modules. This is equivalent to offsetting the annual emissions of a city the size of Hamburg for 30 years.

By

2030

the Group's entire product portfolio is expected to meet defined sustainability criteria.

50%

fewer greenhouse gas emissions – that's what WACKER aims to achieve in absolute terms by 2030 compared to 2020.

A 25%

drop in greenhouse gas emissions relating to upstream products used by WACKER is expected.

Roughly

60%

of production processes at WACKER are already electrified – substantially more than in similar chemical companies – and these processes can therefore be run without emissions when enough electricity from renewable sources is available at a competitive price.

By

2045

WACKER strives to have reached net zero.

IN TOP FORM

Eyebrows have always been an ideal of beauty. In ancient Egypt and Greece, they had to be striking and dark. Raised eyebrows were extremely important for facial expressions in silent films. 100 years ago, actors plucked their eyebrows into extremely thin strips, coloring them black to make them very long and give more expression to their eyes. Their eyebrows were also dabbed with oil to make them shine. These days, people like to shape eyebrows in particular with eyebrow soap. Products that are formulated with BELSIL® PF 100 silicone fluid do not stick, dry quickly and give eyebrows structure, volume, hold and shine.

WACKER

BELSIL® PF 100 is a polyfunctional phenyl silicone fluid for use in hair-care and color cosmetic products, and is a highly effective gloss agent thanks to its high refractive index.