

# WWW 02 17

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**WACKER**



## A PLAY OF LIGHT

Alainpers is a Paris-based artist whose LED objects illuminate time. WACKER's silicone adhesives hold the individual parts together.

# WACKER DIGITAL

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# EVOLUTION AS A MODEL FOR SUCCESS

Dear Reader,

The evolutionary principle of natural selection means that a species successfully adapts to its environment. In business too, evolution can be a model for success. For decades, a company like WACKER has continually fine-tuned and developed its basic processes so as to reflect the altered needs of its customers and markets, while taking new technological trends into account.

Our basic production processes for silicones and vinyl-acetate-based polymers were established between the 1920s and 1960s. And today, we continue to constantly enhance our processes so that we can optimize productivity and maintain a competitive edge. At the same time, we are very successful in adapting our products to yield new applications. This includes our partnership with Royal Tech. We supply this Chinese solar thermal power specialist with WACKER silicone fluid, which increases the efficiency of solar power plants by enabling them to operate at temperatures significantly higher than is usually the case.

Technologies and business models that were regarded as niche applications not so long ago – take, for example, renewable energy sources such as solar thermal power – are now redefining the rules of the game in entire industries.

To a company like WACKER that supplies almost every industrial sector, such young technologies are of great interest as they are a stepping stone to acquiring new markets: our customers use WACKER products to optimize and enhance their own applications. Our silicones, polymers and biotech products increase the efficiency, effectiveness and performance of buildings, laser printers, detergents and food supplements – all these applications are featured in the current issue of our company magazine.

What is more, we can steadily enhance our products because two things rank highly at WACKER: innovation and being close to the customer. In mid-June, we opened a new research and development center for silicones in Michigan, USA, thereby strengthening both our presence in the second largest chemical market in the world and our global network of 19 innovative applications centers on four continents.

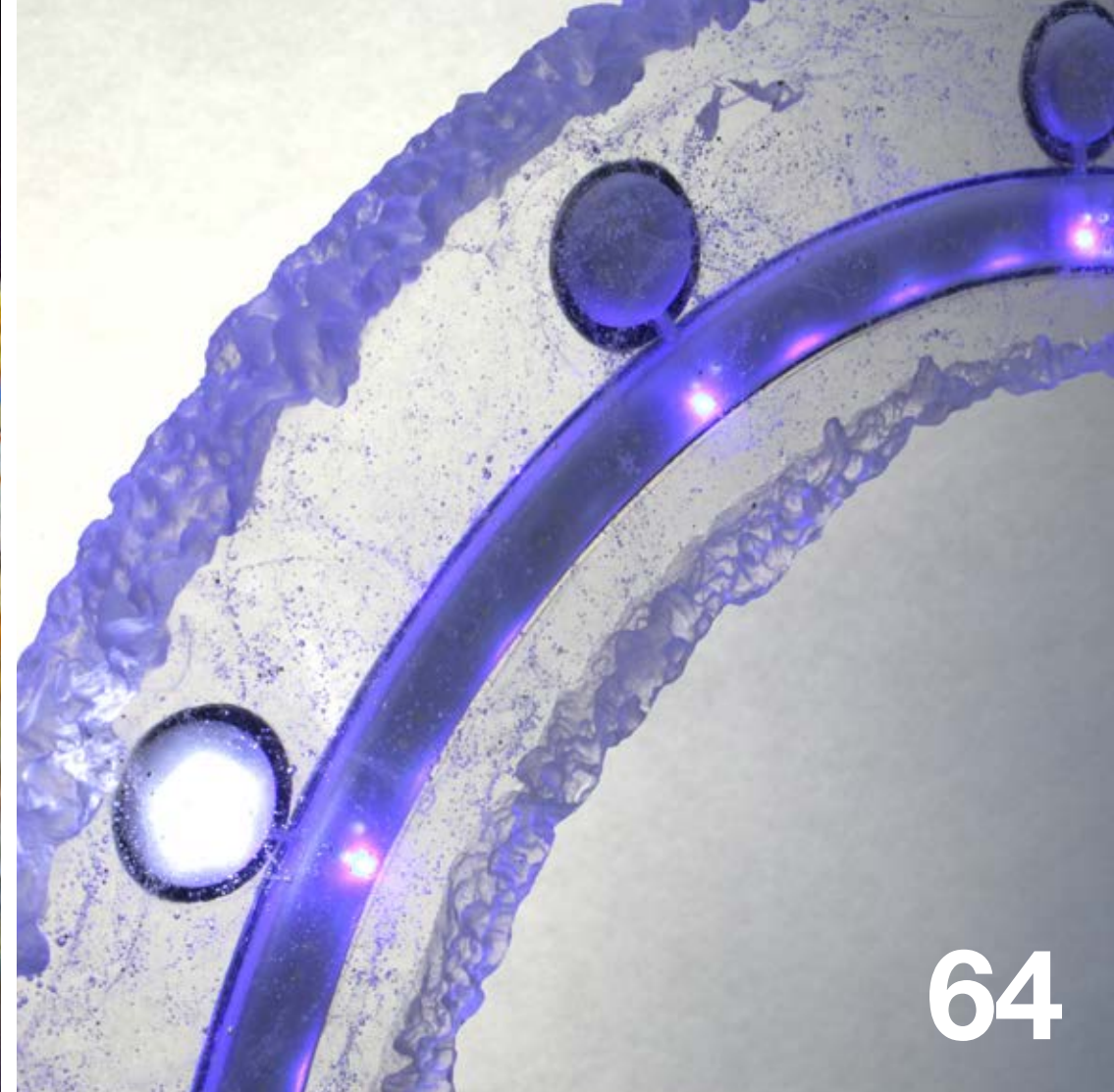
I hope you enjoy reading this issue.

Dr. Rudolf Staudigl  
 President and CEO of Wacker Chemie AG



Dr. Rudolf Staudigl,  
 President and CEO of  
 Wacker Chemie AG

“Two things rank highly at WACKER: innovation and being close to the customer.”



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# WACKERWORLDWIDE

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 ADRIAN

In mid-May, WACKER's US subsidiary in Michigan hosted the 20th Household Hazardous Waste Collection Day in partnership with the Anderson Development Corporation and the Stubnitz Environmental Education Center. Since 1997, residents of Lenawee County have taken advantage of this day to dispose of potentially hazardous waste properly and responsibly. Once again the offer was well received. 720 vehicles brought some 44 metric tons of hazardous waste to the collection site, including paint-related material, pesticides, aerosols cans, cleaners and solvents. While WACKER staff and Anderson residents supported the event by greeting visitors and answering questions, the Stubnitz Environmental Education Center gave adults and children alike an opportunity to explore indigenous local flora and fauna.



## 2 MUNICH

Nobel Laureate Prof. Fraser Stoddart from Northwestern University, Illinois, USA, recently attended the WACKER BIOSOLUTIONS annual meeting in Munich, where he spoke about cyclodextrins and their far-reaching applications in modern industrial processes. Prof. Stoddart conducts research in the fields of nanotechnology and supramolecular chemistry. In recent years, he discovered supramolecular structures of  $\alpha$ -cyclodextrins and metal ions, so-called CD-metal-organic frameworks (CD-MOFs). These CD-MOFs exhibit unique cavities, which are not attainable by way of individual cyclodextrins, and can be found in cosmetic and food applications, among others.



## 3 BURGHAUSEN

Export-control regulations help to prevent the distribution of weapons of mass destruction, fight international terrorism and safeguard the observance of human rights. WACKER is obligated by German, European and international law to guarantee compliance with embargoes, export restrictions and re-export regulations. Employees across the Group tasked with Export Control meet once a year to keep up to date – this time at Villa Sell. The external speaker was Karlheinz Schnägelberger, head of Export Control and Customs Regulations at the Merck Group and a renowned expert in the field. He concluded that WACKER is well positioned to ensure compliance with export-control regulations.



## 5 HONOLULU

Hawaii aims to meet its entire energy demand with renewables by 2045. By then, only cars powered by electricity should be on the road. The plan is to generate the electricity needed with solar and wind power plants, as well as a wave generator that has been yielding energy from the sea since 2015. When it comes to renewable energy, Hawaii leads the way in the USA. 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. The Group also ranks among the world's largest manufacturers of solar-grade polysilicon.

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## 4 RIEMERLING

Thirty years ago, WACKER founded DRAWIN, a fully owned subsidiary. In some segments of the silicone market, such as moldmaking compounds, the customer structure is small-scale and the product range is very fragmented, which necessitates special sales processes. The DRAWIN warehouse in Riemerling is set up to handle small quantities and a combination of various products. Unlike the warehouse in Burghausen, pallets and batches are divided up here so that partial quantities can be shipped. DRAWIN also hold items in stock for customers and acts as a temporary warehouse for distributors across the globe. The packaging units range from a few grams to 200-liter drums. On request, special filling demands can be met.

# GROUP UPDATE



A view of the state-of-the-art R&D labs in Ann Arbor, Michigan (USA).

## NEW SILICONE RESEARCH CENTER IN ANN ARBOR

R&D facility near high-tech co-work campus to boost growth on US market

WACKER officially opened its new US-based Silicones Research & Development Center in mid-June. The new center is located at the co-work campus of the Michigan Innovation Headquarters (MI-HQ) in Ann Arbor, not far from WACKER's silicone production site in Adrian. It houses research and analytics labs providing a state-of-the-art environment for developing new products dedicated to customers in the Americas.

Staffed with highly specialized experts in the field of silicone and polymer chemistry, the R&D center will be operated by Wacker Chemical Corporation (WCC), WACKER's Adrian-based subsidiary for North and Central America and the North Andean region of South America. Invest-

ments for building alterations and lab equipment fall within the single-digit million US dollar range. The silicone research in Ann Arbor will focus on developing innovative and forward-looking solutions and products that serve regional trends and can quickly be brought to market.

At the opening ceremony, David Wilhoit, Wacker Chemical Corporation President & CEO, pointed out the major significance of the new R&D center for the Group. "The installation work is finished and the R&D labs are fully equipped. Now we can forge ahead with projects in all key growth segments for silicones, such as health and medical technology, the paints and coatings industry, electronics or cosmetics and personal care products."



Practical training at WACKER ACADEMY: seminar participants at the Tsukuba training center can put what they have just learned into practice.

## TRAINING CENTER FOR SILICONES OPENED IN JAPAN

WACKER ACADEMY now offers workshops in Tsukuba

In spring, WACKER opened a new WACKER ACADEMY facility in Tsukuba, near Tokyo, Japan. At Tsukuba, WACKER produces silicone products through its joint venture, Wacker Asahikasei Silicone (AWS). It also operates a silicone-coatings competence center there. With the addition of WACKER ACADEMY, the site now combines under one roof not only production, R&D and application technology, but also a training center for WACKER silicones.

"Our new training center in Tsukuba is another milestone in our growth strategy for Asia, particularly for Japan," said Dr. Christian Hartel of WACKER's Executive Board. The center's seminar program is specifically tailored to market needs in Japan and Asia as a whole, he added. "Thanks to this facility, which is the only one of its kind in Japan, we generate high added value for our local customers and partners and are expanding our technical expertise in the region."

Hiroshi Yoshida, the joint venture partner Asahi Kasei Corporation's Lead Executive Officer, is convinced: "WACKER ACADEMY is a highly efficient tool that accommodates the sophisticated demands of Japanese customers. I anticipate that the facility will drive AWS's growth."

Specialty silicones from WACKER are used in products ranging from airbag coatings to skin creams. "WACKER ACADEMY workshops and seminars are ideal for showing how we tailor the versatile properties of our silicones to a customer's specific needs," explained the head of WACKER SILICONES, Dr. Robert Gnann. He added that the focus was on specialty silicones used, for example, for coating technical textiles and as optical lenses in LEDs. The center also offers seminars on personal-care products, release coatings, electronic applications and sealants.

BELSIL® EG 6000 is a transparent, colorless silicone elastomer gel. As an additive in moisturizing creams, mascaras and deodorants, the product imparts a very pleasant skin feel.



## SILICONE EMULSION FOR ESPECIALLY MILD SHAMPOOS

At the in-cosmetics 2017 trade fair in London, WACKER premiered several new products for the cosmetic industry

BELSIL® DM 5700 E emulsion was one of the highlights showcased by WACKER at in-cosmetics. This low-viscosity, milky-white liquid can be used to formulate shampoos that simultaneously clean and condition hair. Unlike conventional silicone emulsions, BELSIL® DM 5700 E contains an emulsifying system that consists of an alkyl polyglycoside and sorbitan laurate. These nonionic surfactants are based on renewable raw materials and make the new emulsion extraordinarily mild and gentle on the skin. A shampoo formulated with BELSIL® DM 5700 E generates a fine-pored foam that is pleasant to the touch, and so meets consumers' requirements. BELSIL® DM 5700 E makes hair smooth, supple and easier to comb, while also leaving it feeling pleasantly soft.

### BELSIL® EG 6000

WACKER also presented the silicone elastomer gel BELSIL® EG 6000. Used as an active agent in decorative and moisturizing cosmetics, the product leaves skin feeling extremely pleasant, something that cannot be achieved in this form with conventional silicone elastomer

gels. The gel also ensures that the preparations spread evenly on the skin. BELSIL® EG 6000 is based on a traditional addition-curing silicone elastomer and contains a linear volatile silicone fluid as its liquid component.

### BELSIL® ADM 8105 E

The amino silicone microemulsion BELSIL® ADM 8105 E was also presented to a wider specialist audience for the first time. BELSIL® ADM 8105 E is characterized by its excellent conditioning properties. Typical applications are conditioners, hair masks, and shampoos.

### BELSIL® PF 22

Similarly showcased for the first time at this year's in-cosmetics was BELSIL® PF 22. This colorless, low-viscosity fluid, which has a refractive index of 1.46, greater than that of polydimethylsiloxanes, can act as a gloss agent for various cosmetic formulations. The phenyl silicone fluid achieves water repellency while allowing the skin to breathe. It reduces the tackiness of sunscreen formulations and increases their water resistance.

## WACKER OPENS A NEW TECHNICAL CENTER IN INDONESIA

The Group is strengthening its presence in Southeast Asia and has recently opened a new technical center for construction and adhesive applications in Indonesia's capital Jakarta

Until now, WACKER's presence was limited to a sales office in Jakarta. The technical facility serves as a development and test laboratory for dispersible polymer powders and dispersions needed as binders in regional construction, paint, coatings and adhesives industries. The focus is on formulations with VINNAPAS® polymer powders and dispersions. These are used in dry-mix mortars for tile adhesives or grout mortar, in waterproofing membranes for bathrooms, kitchens and basements, or in environmentally friendly interior paints.

This increased commitment to the region is driven by continuous growth, particularly in the construction industry. "Southeast Asia and, in particular, Indonesia offer WACKER highly promising growth potential. Demand for specialty construction chemicals, especially our dispersible polymer powders and dispersions, has risen noticeably over recent years," said Executive board member Christian Hartel during the opening ceremony. To meet rising customer demands in Indonesia, the Group is constantly investing in its local service portfolio and has now set up a new competence center in Jakarta. "With our new Indonesian

technical center, we are further expanding our strong market position in the region. This will allow us to optimally support our local customers and partners," added Hartel.

The labs in the new technical center are all state-of-the-art and provide facilities for testing products under different environmental and climatic conditions using a variety of raw materials. The weathering behavior of polymer-modified exterior paints is analyzed in the purpose-built outdoor weathering station. For supplementary analyses, customers can also use services provided by other technical centers in WACKER's global network.

"Our aim is to support our customers in the construction industry by realizing their individual requirements directly on the spot. This enables us to develop and test innovative polymeric binder applications tailored to both modern construction trends and local raw materials," explained Patrick de Wolf, managing director of WACKER Southeast Asia. Our new lab is significantly contributing to the distribution of modern construction materials in Indonesia and Southeast Asia."



Technical service engineers test products and formulations for the Southeast Asian market in WACKER's new technical center in Jakarta. The new lab focuses on polymer binders used in construction applications such as tile adhesives, waterproofing membranes and indoor paints.

### WACKER AT TRADESHOWS


 **Compamed**  
Düsseldorf, Germany  
November 14-17, 2017  
[www.compamed.de](http://www.compamed.de)


 **ProSweets**  
Cologne, Germany  
January 28-31, 2018  
[www.prosweets.de](http://www.prosweets.de)


 **JEC**  
Paris, France  
March 6-8, 2018  
[www.jeccomposites.com/events/jec-world-2018](http://www.jeccomposites.com/events/jec-world-2018)

 **Paint India**  
Mumbai, India  
March 8-10, 2018  
[www.paintindia.in](http://www.paintindia.in)

 **Middle East Coatings Show**  
Dubai, UAE  
March 19-21, 2018  
[www.coatings-group.com/mecs/dubai](http://www.coatings-group.com/mecs/dubai)

 **Paint Istanbul**  
Istanbul, Turkey  
March 22-24, 2018  
[www.turkcoat-paintistanbul.com](http://www.turkcoat-paintistanbul.com)

 **Mosbuild**  
Moscow, Russia  
April 3-6, 2018  
[www.worldbuild-moscow.ru/en-GB](http://www.worldbuild-moscow.ru/en-GB)

 **in-cosmetics Global**  
Amsterdam, Netherlands  
April 17-19, 2018  
[www.in-cosmetics.com](http://www.in-cosmetics.com)



## SILICONE FLUID BOOSTS EFFICIENCY OF SOLAR THERMAL ENERGY PLANTS

**WACKER showcases new heat-transfer medium HELISOL® and agrees on a partnership with Royal Tech CSP**



The HELISOL® silicone fluid makes high efficiencies possible inside Royal Tech's solar thermal power pipe.

Wacker Chemie AG has strengthened its cooperation with Royal Tech CSP Limited by signing an agreement with this specialist Chinese company for highly efficient solar thermal power plants. Under the terms of this agreement, WACKER will supply its newly developed HELISOL® silicone fluid to Royal Tech, its exclusive partner in China. The silicone fluid is used as a heat-transfer medium in Royal Tech's CSP (Concentrated Solar Power) plants. HELISOL® can be heated up to 425 °C and its viscosity remains low even at -40 °C.

HELISOL® silicone fluid used in combination with Royal Tech's parabolic trough collectors yields far higher efficiency levels than conventional heat-transfer fluids. At present, Royal Tech is building a 50-megawatt solar power plant in the city of Yumen in western China.

WACKER Executive Board member Auguste Willems underscored the importance of the new partnership: "As a leading polysilicon manufacturer, we have become a key player in the global expansion of solar

power. With our newly developed silicone fluid for solar power plants, we are strengthening our portfolio in the renewable-energy field and, at the same time, are supporting initiatives to cut carbon dioxide emissions. Our partnership with Royal Tech will contribute to significantly enhancing the efficiency of solar power plants and, in turn, bolster the market position of our two companies in the highly promising market for high-performance CSP systems."

At the signing ceremony, Richard Yu, general manager of Royal Tech, noted: "Royal Tech has been involved in the research, development and industrial implementation of CSP technologies since 2009. Our comprehensive supply chain encompasses project development, technology research, component manufacturing and system integration, as well as commissioning and plant maintenance. Our well established partnership with WACKER, a leading global silicone manufacturer, will further strengthen the technological edge of CSP in the Chinese market for renewable energies. China is making a concerted effort to replace fossil fuels, such as coal, with electricity generated by cutting-edge solar plants. Our partnership will contribute to China's ambitious and resolute plans to promote renewable energies even faster and more effectively."

Royal Tech specializes in the development of components and solutions for highly efficient solar thermal power plants based on CSP technology. The systems use reflecting parabolic troughs to concentrate sunlight

CSP plants use the sunlight captured in parabolic trough collectors to heat the heat-transfer medium flowing through a vacuum pipe.



onto pipes (receivers) filled with heat-transfer medium. Heat exchangers and steam turbines then convert solar energy into electricity. In such systems, the level of efficiency primarily depends on keeping the heat-transfer medium at the highest possible temperature, and on storing part of the heat obtained during the day, so that the system continues to generate electricity after sunset and can operate around the clock.

As the key medium in CSP systems, WACKER's HELISOL® silicone fluid features very high heat resistance and durability. During testing at Royal Tech's CSP test facility in Inner Mongolia, which lasted over a year, this transparent and odorless heat-transfer medium was heated to 425 °C. At the same time, its freezing point of -55 °C is far lower than that of conventional heat-transfer media. This significantly reduces the energy needed to maintain operating temperatures in winter. As a result, HELISOL® is ideally suited to the harsh climates prevalent in the areas where

China is conducting its major CSP projects. Additionally, it forms much less hydrogen than conventional heat-transfer media, and no benzene.

### ABOUT ROYAL TECH

Royal Tech CSP Limited is headquartered in the Chinese city of Changzhou. Founded in 2009, the company specializes in developing components for highly efficient solar thermal plants based on CSP technologies. At the same time, it is one of China's major project developers for CSP systems. At present, Royal Tech is carrying out one solar thermal power project in Yumen, Gansu province, (50 megawatts) and another in Inner Mongolia (100 megawatts). As one of China's pioneers of this technology, Royal Tech additionally supplies components for various commercial CSP systems worldwide.



Many small automotive parts, such as exhaust hangers (pictured), are manufactured from specialty silicone rubber compounds like those produced by the Brazilian compounder STC Silicones.

## WACKER AND STC SILICONES AGREE ON CO-BRANDING OF SILICONE COMPOUNDS

WACKER and the Brazilian silicone compounder STC Silicones have signed an agreement on co-branding ready-to-use silicone rubber compounds. The formulator based in Ribeirão Pires (state of São Paulo) can now use the “Based on ELASTOSIL®” seal of approval for silicone compounds made with WACKER raw materials. ELASTOSIL® has been synonymous with high-quality silicone rubber products for over 60 years, and is now one of the Group’s most successful brands. WACKER has been supplying STC Silicones

with high-quality silicone raw materials and additives since 2003. The family-owned business uses them to produce ready-to-process silicone compounds for the automotive, medical, electrical and household-product sectors. “STC Silicones has been operating in the Brazilian market for over a decade and is now one of the country’s most successful compounders,” said Christian Gimber, Vice President of the Engineering Silicones Business Unit. “STC can supply its Brazil-based customers with high-quality and tailored silicone compounds

even more effectively and we will be able to further strengthen our competitive position in the region.”

STC Managing Director Joaquim Carlos Lopes da Silva said the agreement was an important milestone in positioning the company on the market as a supplier of high-quality compounds. “ELASTOSIL® represents superior quality in Brazil. Being able to extend the use of this brand to our compounds is a huge advantage and opens up completely new distribution and sales opportunities.”

## WACKER EXPANDS THE DUBAI TECHNICAL CENTER

WACKER has expanded its technical center in Dubai to include a laboratory for polymer dispersions used as binders in adhesives and carpet applications



The WACKER laboratory for silicone elastomers in Dubai: an employee performs a Shore hardness test.

The expansion was made necessary by the region’s strong economic growth, particularly in the fields of energy and carpet applications. “Our center is the first in the region to offer both technical support and testing services for carpet manufacturers in addition to an ISO-certified lab for high-quality silicones used in energy and mold-making applications. And this makes us proud,” said Cyril Cisinski, managing director of Wacker Chemicals Middle East. The new polymer lab primarily offers technical support for formulations with vinyl acetate-ethylene copolymer (VAE) dispersions to meet the rising demand from the regional carpet and adhesives industries. The expanded lab for silicone elastomers supports customers from the energy, mold-making and automotive sectors. Owing to their versatile properties, silicones can meet the increasingly sophisticated demands in these sectors better than other plastics. Both labs have state-of-the-art equipment and are ISO 17025 certified. They offer a number of testing methods customized to locally available raw materials as well as reflecting the region’s climate, environmental conditions and specific needs.

## EXPANSION OF INTEGRATED KETENE PRODUCTION

Burghausen site builds plant for isopropenyl acetate with an annual capacity of 2,500 metric tons

WACKER BIOSOLUTIONS is ramping up its integrated ketene production in Burghausen by erecting a new reactor for manufacturing isopropenyl acetate (IPA) with a capacity of 2,500 metric tons per annum. IPA is an important starting material for acetylacetone (AcAc), which is used in numerous applications, ranging from life sciences products through to construction and automotive applications.

Capital expenditures of almost €2 million are budgeted for the capacity increase. Completion of the plant is scheduled for the second half of 2017.

“The new IPA reactor is an important step toward strengthening our integrated ketene production system in Burghausen,” said WACKER Executive Board member Auguste Willems. “The expansion is part of our strategy of raising the proportion of specialties in our business as a whole to boost growth and profitability.”

The new plant is a key addition to the Burghausen site’s supply chain. In the integrated production system, acetic acid is converted first into ketene, then into isopropenyl acetate and finally to acetylacetone. Both IPA and AcAc serve as building blocks for syntheses in numerous branches of industry, from pharmaceutical active ingredients through to specialty automotive coatings. Additionally, AcAc is a starting material for further products in the WACKER portfolio.

To further strengthen the integrated production system and the degree of forward integration, WACKER took over distribution in April of calcium acetylacetonate (Ca-AcAc), a fine chemical made by Acetonate GmbH in Greiz, eastern Germany. Acetonate GmbH will continue to produce Ca-AcAc on behalf of WACKER, but with WACKER taking charge of sales and distribution of the entire annual production volume of around 900 metric tons.



The new IPA reactor is part of the integrated ketene production system at WACKER’s site in Burghausen, where acetic acid is converted into ketene, isopropenyl acetate and acetylacetone in various steps.

“This strategic cooperation will enable us to offer even greater security of supply, in addition to excellent product quality, for our customers, especially those in Europe, because we now cover the entire supply chain for calcium acetylacetonate,” said Gerhard Schmid, president of WACKER BIOSOLUTIONS, describing the collaboration.





Customer service tailored to local needs: at WACKER's technical center in Brazil, technical service engineers test products and formulations for the South American market – water-repellent silicone emulsions and low-emission interior paints, for example.

## 40 YEARS OF WACKER IN BRAZIL

On August 30, 2017, WACKER celebrated the 40th anniversary of its South American headquarters in São Paulo, Brazil. At the Jandira site near São Paulo, WACKER now manufactures silicone products used in the textile, construction, paper, agrochemical, personal-care and cosmetics industries.

“Our sales in the region have grown by an annual average of more than 9 percent over the past ten years, while local production volumes have increased five-fold,” stated Executive Board member Dr. Tobias Ohler, highlighting the importance of WACKER Brazil for the Group's future success in South America. WACKER Brazil is ideally positioned, he continued, thanks to our high product quality, excellent service and committed team of experts. “In the years ahead, we expect demand in South America to grow for our high-quality specialty chemicals – and see huge potential for our Jandira site.”

WACKER already ranks among the top silicone suppliers in South America and is the

Wacker Química do Brasil has been supplying the South American market with silicone products and polymer binders for 40 years. The 21,000-m<sup>2</sup> site houses administration and logistics, as well as its own silicone production facilities.



market leader for dispersible polymer powders for the construction industry. The region's main markets for WACKER products range from construction, paints/coatings, paper, electrical/electronics and textiles, through to the cosmetics, agrochemical, household and personal-care sectors.

Executive Board member Auguste Willems underscored the opportunities for innovative WACKER products in his speech. “Thanks to their virtually unlimited applications, silicones have become an integral part of daily life – whether in the electronics industry, the automotive sector, in cosmetics or medicine. Our polymer binders enable cutting-edge construction solutions, such as fire-protection coatings and water-saving sealing systems. As for our novel biotech products, we are building a bridge between chemistry and biotechnology,” he continued in his address to customers and business partners. “With the ongoing expansion of our silicone production in Jandira, we are well positioned to meet the growing needs of the South American market. As a result, WACKER Brazil can offer its customers even better local support in the development of new products and customized applications.”

A wholly owned subsidiary, Wacker Química do Brasil Ltda. supports customers and partners in Argentina, Brazil, Chile, Paraguay and Uruguay. Beside sales and marketing, the approx. 21,000-m<sup>2</sup> site houses



New silicone plant in Jandira, Brazil: with its new multifunctional facility for manufacturing antifoam agents and functional silicone fluids, WACKER is strengthening its position as one of the world's leading producers of high-quality silicones.

its own production plants, which make, for example, silicone fluids and emulsions, as well as silicone resins and rubber compounds. WACKER is currently expanding its existing silicone operations by building a multifunctional facility for manufacturing antifoam agents and functional silicone fluids for the paper, cosmetics and household industries. While the reactor for silicone fluids has already been completed, the plant for antifoam agents is expected to come on stream by the end

of the year. The investment needed for the pilot reactor amounts to around €7 million. In 2003, WACKER opened a technical center for silicone applications in Jandira, which was expanded in 2005 to include labs for dispersible polymer powders. In spring 2010, the Group established a branch of its international training center – WACKER ACADEMY – at the Jandira site. With over 100 employees, WACKER Brazil generated sales of around €90 million in 2016.



“We want  
between

Dr. Rudolf Staudigl,  
President and CEO of  
Wacker Chemie AG

## to promote the exchange of views startups and established companies”

WACKER is actively pursuing new market and technology trends by cooperating with Hightech-Gründerfonds (a German company founder fund). CEO Dr. Rudolf Staudigl views collaboration with startups as a source of new impulses for established fields of business and beyond.

**Dr. Staudigl, Hightech-Gründerfonds (HTGF) is Germany’s most active early-stage investor which invests in technology-based start-ups shortly after their founding. Why is WACKER now joining other large German chemical companies by investing in this fund?**

**Dr. Rudolf Staudigl:** Our strength and success includes further developing our processes and the resulting products to yield new applications. In both silicon chemistry and VAE technology, we rank among the leaders in technology and the world market. We have always been able to win new markets and will continue to do so. A company seeking to be successful in the long term must – especially in this day and age – increasingly focus on new developments in technology and the market place. We have to be open to new trends and look beyond our established business. Digitization and life science are cases in point. By cooperating with Hightech-Gründerfonds we want to intensify the exchange between young and established companies.

**Why can’t the company’s own research department pick up on these market and technology developments?**

They are already doing so. WACKER has a highly productive R&D department. They perform research for the business divisions, the consortium and the new businesses, and develop processes for Corporate Engineering.

We have also established the WACKER Institute for silicon chemistry at the Technical University of Munich and coordinate our external research activities with our university and funding management. However, even the most efficient research department can’t possibly cover all areas that may be of interest to us, given the major leaps in technology we are currently experiencing in the biotechnology sector or Industry 4.0.

### GERMANY’S HTGF III FUND

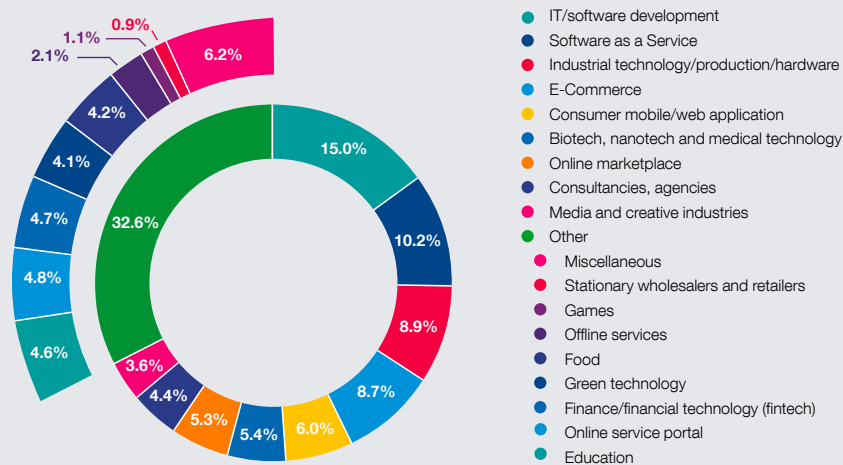
From fall 2017, Wacker Chemie AG will be taking part in HTGF III – stage three of Germany’s high-tech company founder fund. Set up in 2005, HTGF is Germany’s leading investment fund for technology-driven early-stage financing. Generating a volume of some €875 million across three funds, HTGF finances recent innovative technology-driven startups, actively supporting them in putting their business concept into practice. HTGF covers a wide range of topics – from robotics, energy and the Internet of Things, through to the medtech, biotech, chemical and software sectors. The Federal Ministry for Economic Affairs and Energy and the state-run KfW bank group are the main investors contributing to this third fund. WACKER joins other well-known private-sector companies in helping to finance company founders.

**Is WACKER's contact with startups intended as a means of developing totally new technologies and business fields or to find new applications for existing products?**

Both. For example, in the field of medical technology, we are working with the Danish startup company Leap Technologies, which uses our electrically active precision silicone films to manufacture intelligent textile sensors. Our contact with this young, promising high-tech company opens the door to potential new

markets. Linking production with the internet and IT is a highly complex topic that affects the entire chemical industry and requires action on numerous fronts. We are banking on startups which act as innovation drivers to provide new impetus. We already hire startups to carry out the end-application testing of our materials. We benefit from the startup's user expertise. Additionally, collaborating with startups can minimize the development risks that inevitably go hand-in-hand with research. Sometimes, a promising project turns out to be a dead end, technologically or financially.

**STARTUPS FOUNDED BY CATEGORY IN 2016**



Source: Deutscher Startup-Monitor 2016/KPMG

**Can you give a few examples of the Group's cooperation with startups in the past?**

With WACKER BIOSOLUTIONS we have been successfully exploring new avenues unrelated to silicon and VAE chemistry for over 20 years. Owing to its relatively small size and the large scope of this field, WACKER BIOSOLUTIONS is dependent on external impulses, which is why we began investing in biotech startups over ten years ago. We acquired two German startups to contract-manufacture therapeutic proteins – ProThera GmbH based in Jena in 2005 and Scil Proteins Production GmbH in Halle in 2014.

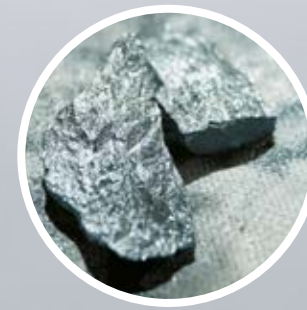
**Has WACKER invested in startups in other fields besides biotechnology?**

One important future-oriented field of research, which we have designated as a key Group project, is silicon-based anode materials for lithium-ion batteries. Silicon potentially is capable of storing far more lithium ions than the graphite previously used for anodes. This means the energy density of batteries used in electric cars or electricity storage can be increased significantly. In 2013, we invested in Nexeon Ltd., a startup that advances our expertise in this field. And last year, we invested US\$15 million in the American startup 1366 Technologies, which has developed a new process for manufacturing solar wafers. We see this as a strategic investment. At the same



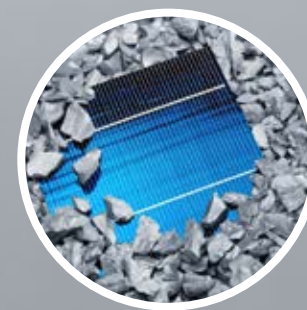
**BIOTECHNOLOGY**

WACKER acquired ProThera GmbH in Jena in 2005 and Scil Proteins Production GmbH in 2014. Both these German startups are dedicated to the contract manufacturing of therapeutic proteins.



**SILICON**

In 2013, WACKER invested in the British startup Nexeon Ltd., a company that advances the Group's own expertise in the field of silicon-based anodes for lithium-ion batteries.



**SOLAR WAFERS**

In 2016, WACKER invested in the US startup 1366 Technologies, which has developed a new process for manufacturing solar wafers.

time, we concluded a long-term supply contract for polysilicon with the Americans and collaborate with them on technical matters.

**How does our cooperation with Hightech-Gründerfonds differ from our previous activities?**

As I mentioned before, we have cooperated with startups in the past and have invested sporadically or acquired startups. For example, a few years ago we invested in T-Mat, a company that works with a technology for thinning silicon wafers. Our R&D department developed a silicone adhesive designed to thin wafers and selectively separate them for T-Mat. Actual screening of startups previously arose out of a particular need – with Hightech-Gründerfonds, however, the move is strategic and systematic.

**Do we stand to gain financially from these activities?**

Not in the short to medium term, but definitely over the long term. WACKER does not invest in risky ventures. We will not make venture capital generally available. But if we find a startup that suits us well strategically, we are prepared to invest, as we have done in the past.

**How does the company culture of a startup shape up with a company like WACKER that looks back on a long history?**

WACKER too began as a startup early in the 20th century and I am certain that we have not lost the essence of this founder culture: the courage to enter new territories. We have always moved on from existing business fields – think back to the PVC business, long the Group division with the highest sales – and have built up new ones, like WACKER BIOSOLUTIONS. By cooperating with HTGF, we hope to combine the speed and technology of startups with the market experience and large-scale production competence of a corporation. Of course there are differences in company culture and it is a learning curve for us.

**Will our contact with Hightech-Gründerfonds open the door to the international startup scene?**

HTGF operates solely in Germany, but the skills we plan to acquire with this fund are naturally intended for international business. Our most important markets outside Europe are China and the USA. We also want to build up more intensive contact with young high-tech companies in those countries. Our cooperation with HTGF is the first step in this direction.

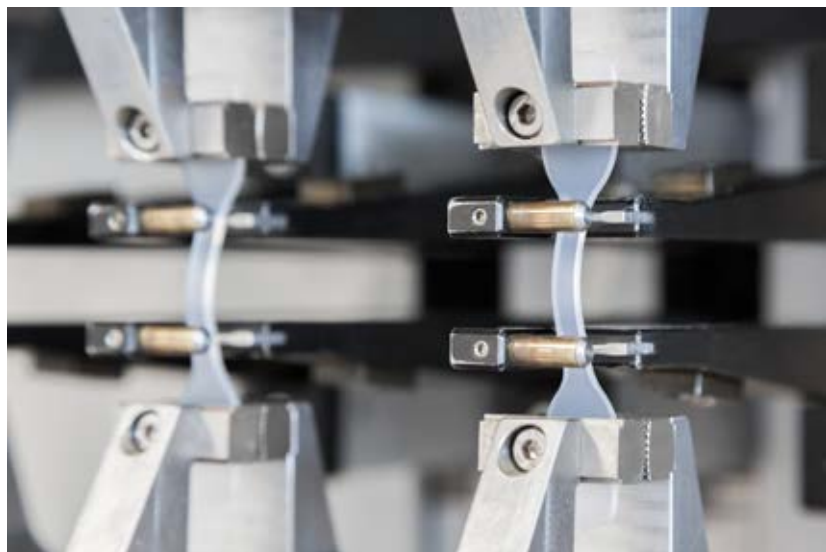
## SILICONE SETS THE STAGE

Israeli designer Ron Arad invented a gigantic 360° canvas for the Roundhouse Theatre in London. The curtain experiments with light and material in a revolutionary way and has been a crowd-pleaser around the world. The Curtain Call installation is made of WACKER silicone rubber.

Silex, a British manufacturer, chose a light-permeable silicone rubber for Curtain Call.



**T**he canvas is used from both sides. The audience can part the curtain at any point on either side and walk through it while the images projected on a cylinder-shaped area spanning 500 square meters fall into place around them. At the same time, the canvas reveals the real world behind the scenes. This kind of vast curtain had never been seen prior to its premiere in the summer of 2011. Consisting of 5,600 suspended ceiling-to-floor rods, Curtain Call, a 360° installation created by industrial designer and architect Ron Arad, enthralled the audience at London's Roundhouse Theatre, a former railway engine shed dating back to the 19th century. "I didn't tell the audience how to use the curtain. I wanted them to be curious and delighted," said the London-based Israeli in an interview.



The stability of the silicone rubber is checked in a WACKER laboratory in Burghausen using a tensile tester. The mechanical resistance is crucial so as to enable the audience to touch the curtain without causing any damage.

**VERSATILE MATERIAL**

Arad owes the resounding success of his idea, which has subsequently been installed at other locations, to his creativity and the versatile properties of the silicone rubber used to create Curtain Call. “The idea had us hooked right from the start. Ron had a totally new take on how to use our products,” said Nick Soudah, managing director of Silex Silicones Ltd. The British silicone manufacturer from Bordon, 30 kilometers north of

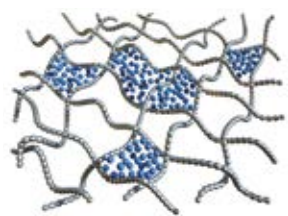
Portsmouth, immediately knew which material had the requisite properties: WACKER’s ELASTOSIL® solid silicone rubber.

This class of high-temperature vulcanizing silicone rubber has been tried and proven as a reliable material for a range of extremely varied applications for over 70 years. It is the standard material used for manufacturing hoses, seals, membranes and molded parts in the medical-technology, pharmaceutical and food industries. The properties can be varied

by using additives. For example, heat resistance is achieved with stabilizers and pigment pastes regulate light permeability. By adding a catalyst, the raw silicone rubber’s base materials bond during heating to form a three-dimensional network, which experts call curing. “That’s why WACKER’s solid rubber grades offers high elasticity and good mechanical properties,” explained Dr. Andreas Bacher, a chemist and head of technical marketing at WACKER SILICONES.

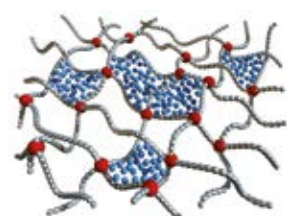
The audience can touch the curtain and even pull at it without causing any damage. “Its high translucency means it transmits light well and the audience can see the projected images from all sides – the perfect medium for the canvas project,” he added. The silicone rubber used for the curtain is cured during the manufacturing process – that is, it becomes an elastomer. Organic peroxides or platinum-catalyzed additives can be used for this purpose. Silex Silicones Ltd. used a platinum-curing system. Arad’s artwork required a few adjustments to the usual production process. “Our many years of experience stood us in good stead and we quickly came up with a solution to the problems,” said Soudah.

**COMPARISON OF UNCURED FILLED POLYMER AND CURED RUBBER**



Uncured polymer with filler

Curing  
→



Polymer with chemical crosslinks (red) forms a filled, elastic network

**VIEWING FROM BOTH SIDES**

First, the light permeability had to be ensured to allow the images to be viewed from both sides. Addition-curing systems produced the desired translucence of the silicone rods while protecting them from yellowing.

The length of the rods presented another challenge. The base material was heated at the beginning of the manufacturing process, and then pressed into shape by the extruder. “The usual procedure of reheating the tubes would have made them inflexible,” he noted. Once they had been cut to size, they were stored lying flat. And that’s how a base material resembling modeling clay was transformed into 5,600 rods measuring eight to ten meters with a diameter



5,600

tubes suspended from ceiling to floor enthralled the audience at London’s Roundhouse Theatre.



The backlit Curtain Call installation makes it possible to show different visual elements or even movies.

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of 1 centimeter. Arranged in a row, they span a distance of 37 kilometers. The quality of the material would have allowed for a length of 20 meters, “but no one has asked for this specification,” said Soudah.

### LONG, FLEXIBLE RODS

The impressive show drew other customers to Silex. Titled 720°, the curtain was set up in the Israel Museum in Jerusalem as a stage for several film and music events in 2012. Ford used the concept to stage its presence at the 2013 Frankfurt Motor Show. Its new models premiered by driving through the curtain in full view of the public. The Olympic Museum in Lausanne (Switzerland) purchased a similar curtain for its permanent exhibition. And British fashion label Top Shop has also discovered the principle of long, flexible tubes. Dyed in different colors, they were arranged across retail space to symbolize the strings of a harp. Roundhouse repeated its success with Curtain Call on the theater’s 50th anniversary in 2016.

For Silex’s managing director, the curtain demonstrated how imagination and creativity can reinvent commonplace materials to create something entirely new. Soudah was invited to the premiere in London in 2011; it was an unforgettable evening: “I was both proud and impressed to experience our product live in action. I got goose bumps.” ■



# 3D PRINTING FITS LIKE A GLOVE

A startup named Formhand has developed a robot gripper expected to revolutionize automation technology – with an elastic gripper made of silicone and manufactured using ACEO® 3D technology.

“A lot of designers and design engineers still think in terms of outdated paradigms. If you couldn’t make it with traditional tools or if it took a lot of time and investment, you just didn’t design it.”

Dr. Vera Seitz, mechanical engineer

The silence at WACKER’s ACEO® campus in Burghausen is almost total – the only sound is a buzz coming from a box the size of a photocopier. The buzzing box is the first industrial 3D printer for silicones, which was developed by WACKER engineers. Since its inception, it has been turning clever ideas into tangible objects – like the silicone cap designed by Holger Kunz, which had only existed on a USB drive until now.

**GETTING AN IDEA OVER A BEER**

This unremarkable-looking part is designed to be about the size of a thumb and shaped like a cylindrical pocket: closed at the top, open at the bottom and hollow inside. Yet as unspectacular as it may appear, it is the result of years of fine-tuning, hard work and no small amount of courage. That’s because the mechanical engineer and his team founded Formhand, a startup built around their idea.

“It all started seven years ago – the traditional way over a beer,” Kunz recalls. “That evening, I was telling my startup partner Christian Löchte about this problem that hadn’t been solved at the time: how to develop a robot gripper that can pick up really thin materials. At first, we were just joking

around, but then we came up with the idea of Formhand.”

It was an idea as simple as it was brilliant. “Any child understands the principle from home: if you suck up a ball with a vacuum cleaner, you can move the ball from point A to point B. The main idea behind Formhand is to add a granulate-filled pad in front of the ‘vacuum cleaner’: the vacuum changes the shape of the pad, molding it to any geometry you like,” Kunz explains.

This unique setup means that the pad has three different operating states, and the user

can move between these as desired: from conforming to any shape, to holding its current shape, to completely solid.

He added that, in production and logistics for the automotive industry, for example, manufacturers commonly use two different grippers for the left and right fenders. “The Formhand pad can be adapted to an extremely wide array of geometries and surfaces – which makes it a good bit more like the human hand.”

Left and right fenders, different-sized packages in the Logistics Center, thin textiles

– the technology can be applied anywhere objects need to be moved. This versatility ultimately saves the company a considerable amount of time and money on robot retrofits.

The Formhand engineer has come to WACKER today to expand his startup’s applications. The digital design drawing of the blue cap on his USB drive is a draft for a new, very small pad. The purpose of the newly developed shape is to allow the vacuum gripper to grasp one of eight different objects, each about the size of a ping-pong ball, and move it to a different location.



ACEO® 3D printers can even print silicone-based products with complicated geometries.



FACTS AND FIGURES:  
ACEO® 3D PRINTING AT WACKER



**2016**

WACKER puts the first industrial 3D printer for silicones into service and creates the ACEO® brand.



**700 m<sup>2</sup>**

is the size of the ACEO® campus near the WACKER site in Burghausen.



**700**

customer requests have been processed since the ACEO® brand was established.



A water-soluble support material makes it possible to print cavities and overhangs.



**\$3 billion**

The 3D printing industry generates billions of US dollars in annual sales.



## 1 PRINTER



- The printer dispenses individual droplets.
- The object cures upon exposure to UV light.

- The printer produces one layer at a time.
- No molds or additives are required.

## 2 SUPPORT MATERIAL



- The silicone and the support material are printed at the same time.

- This allows users to produce overhangs and cavities.
- The support material can then simply be washed out.

### PIONEERING WORK

“Welcome to the ACEO® campus,” says Dr. Vera Seitz, greeting the entrepreneur at the 3D printer. Up to now, the process had mainly been used for printing hard plastics, ceramics and metals. But the ACEO® Imagine Series 100 is now making WACKER the first company ever to print elastomers on an industrial scale.

“That’s why the production printers we have on site are a revolution all to themselves – the technology has only been on the market since last year. Even the way we work with the

technology is new,” explains Seitz, who holds a doctorate in mechanical engineering. “On the one hand, customers can simply go to the ACEO® website and import their design file. Then we print it and send them the product. That’s the classic way that 3D printing services are often provided.”

In addition to this webshop-based, digital business model, WACKER also offers what it calls an Open Print Lab, where customers receive individual training on site – nothing like this has ever been offered in the industry before now. “We go with customers to the

printer and work with them to figure out and test the best way of making their projects work,” she says, describing the process. “Projects like the component that Mr. Kunz would like to print.”

### EXPERIENCING PRODUCTION

#### FIRST HAND

The Formhand founder is in total agreement: “I thought the idea of the Open Print Lab was exciting, so I signed up. Where else do customers have an opportunity to witness production of their own part?”

Formhand, a startup based in Braunschweig, Germany, has developed a universal robot gripper featuring a pad made on the ACEO® 3D printer.



When it launched the technology on the market last year, WACKER was also embracing a new business model, creating the ACEO® brand for all 3D printing services involving elastomers. The company has built a 700 m² technology center for additive manufacturing near the WACKER site in Burghausen. The ACEO® campus, which is where Dr. Seitz and her 20 or so team members work, definitely has the feel of a startup. “Even as someone who set up their own company, I can still learn a few things there. Distances are short. The team works with an eye to solutions, flexibility and the needs of individual customers. Everyone is quite literally close to each other.”

### ONE DROP AT A TIME

In keeping with the hands-on spirit, production gets going right away: shortly after the Formhand file is uploaded, the printer head begins zipping back and forth. Known as drop on demand (DOD), the method was developed by WACKER experts over the course of

“The Formhand pad can be adapted to an extremely wide array of geometries and surfaces – which makes it a good bit more like the human hand.”

Holger Kunz, Formhand founder

roughly two years of research. Tiny droplets, or voxels (volume pixels), flow together on one level and are then permanently linked by briefly exposing them to UV radiation. The curing process results in a homogeneous layer upon which the next layer is printed. “Our blue cap is growing on a glass plate, one drop at a time, and getting to see that with my own eyes is just awesome,” says Kunz.

In addition to developing a novel silicone formulation, the experts also reimagined the hardware and software from the ground up –

which the ACEO® team is now continuously updating. “The only way to grasp how 3D printing works is to see it in person. That’s the only way you can see how to improve a design and understand what is even printable in the first place,” Seitz and Kunz agree. “A lot of designers still think in terms of outdated paradigms. If you couldn’t make it with traditional tools or if it took a lot of time and investment, you just didn’t design it,” Seitz adds.

Traditional injection molding involves first having to prepare the mold that will be

used for casting the liquid silicone rubber – an extremely complicated process that only pays off for large-scale projects. “Thanks to 3D printing, now we can make what we used to call ‘impossible products,’” she notes. “Examples of these include complex geometries, like components with a lot of cavities or lattice structures for varying the elasticity of the object. The sky is pretty much the limit.”

**OVERCOMING LIMITATIONS**

This revolution in additive manufacturing – another name for 3D printing – is made possible by a unique feature of ACEO®: when printing layers, a water-soluble support material can be printed along with the elastomer and then washed out at a later time.

The use of silicone generally results in highly elastic products, making the technology of interest to entirely new industries that have not yet been able to benefit from the development of 3D printing. Anything is possible, from conventional industrial applications, such as those in the automotive industry, up to and including lifestyle products. This broad applicability is due to the advantages that silicones confer relative to other materials, such as resistance

to chemicals, UV radiation, and extreme temperatures of -80 to +180 degrees Celsius.

**THE LOGICAL SOLUTION**

For Braunschweig-based Formhand, the most important property was elasticity. “Up to now, we’d been using textiles for our pads – fabric gloves, so to speak,” says Kunz. “But now we have a customer who’s ordered a very small Formhand that has to meet highly precise grasping specifications. What we need are basi-

cally gloves like the ones surgeons wear. Silicone is the logical solution.”

The first blue cap – the “glove” – has now been printed out. Kunz and the ACEO® team inspect the thin-walled piece from all sides and confer. While the objects from the printer are consistently homogeneous, the surface is slightly rough depending on the print direction. The settings are adjusted. Next attempt. “Here you can see another strength – and an important application –

Holger Kunz, founder of startup Formhand, takes the new, extra-small silicone cap made by the 3D printer and fits it on the robot.



Thanks to silicone 3D printers from ACEO®, additive manufacturing can now be used for making elastomer-based products.

of 3D printing in action: prototyping. The process allows hobbyists and startups like Formhand to create unique components quickly and, most importantly, at low cost,” says Seitz. She also notes, however, that customized products play an important role in medical technology as well. “This is an area where we see a lot of opportunity for the ACEO® 3D printing process. After all, silicone is perfect for this because it’s biocompatible – tolerated by the human body, in other words. One conceivable use would be for external applications such as custom breathing masks, prostheses or epitheses that we can tailor to the individual patient.”

“I think 3D printing is going to transform the industry. The relative ease with which you

can produce prototypes and individual parts is going to be an especially important driver of development throughout the industry,” says a confident Kunz. Dr. Seitz agrees: “The technology has so much potential. It’s going to become more and more established, and, in many areas, it’s going to be the standard.”

The arm of the ACEO® printer starts to move back and forth one more time, and then comes to rest. Where there had recently been just a plain piece of glass, there now stands another unassuming blue object: about as big as your thumb and shaped like an inverted hollow bag with the open end pointing down. Holger Kunz carefully removes the part from the box and smiles. “Now it’s perfect. Exactly how I’d pictured it.”

**CONTACT**

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A person is shown from the side, wearing a dark jacket, holding and interacting with a smartphone. The background is a blurred city street at night, filled with warm, glowing bokeh lights from street lamps or buildings. The overall mood is modern and urban.

## PROTECTIVE SHIELD FOR SCREENS

The touchscreens of smartphones and tablets are crucial human-machine interfaces, functioning as both displays and control elements. Their surfaces are shielded against damage by covering them with protective films that incorporate self-adhesive silicones from WACKER.

Natural color expression and retina displays along with low energy consumption: manufacturers don't spare the superlatives when extolling the screens of their smartphones, tablets and the like. The screen surfaces are the all-important human-machine interfaces, functioning as both displays and control elements. Phoning, taking high-res snaps, or gaming – everything you do pivots around the touchscreen. The screen's quality therefore plays a key role in the purchasing decision.

“Protecting high-quality screens against scratches and impacts is becoming ever more important in view of the high price of many smartphones,” explains Dr. Timo Hagemeister, until recently silicones development manager at WACKER in Shanghai (China) and now head of the Group's Consumer Care business team. “The equipment manufacturers protect them with thin films, which are permanently applied to the sur-

faces during production.” At the same time, consumers can do their touchscreens a favor by applying an additional self-adhesive protective film, which guards the display against minor accidents and extends its lifetime. Hardened plastic films or glass protectors are also commercially available. They can be made extremely thin, as well as robust and flexible and even defend the display against hot cigarette butts or violent shocks when the device is dropped, for example.

**RELEASE FORCE IS KEY**

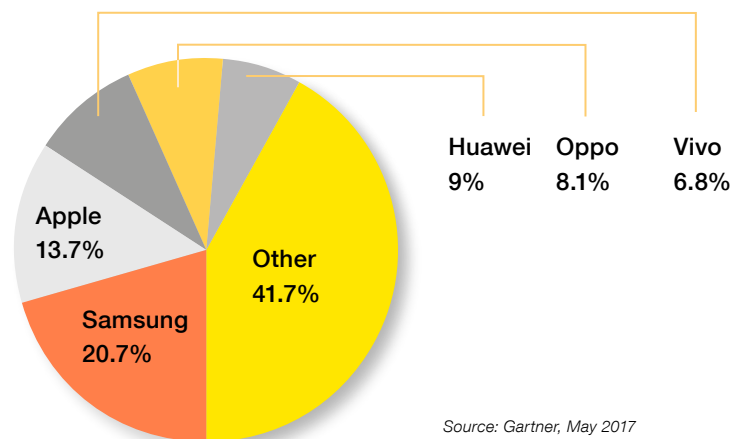
Whether the protective films are applied by manufacturers or consumers, or films are employed permanently or as temporary protection during transportation, it is essential to bond them effectively on the surface. For this purpose, the films are treated with pressure sensitive adhesives (PSA). These self-adhesive coatings only need to be pressed on gently. To enable the films to be easily peeled off completely as required, the

release force of the PSA film is adjusted precisely. The release force indicates how much force is required to peel a film off its backing.

**CUSTOMIZABLE**

“The manufacturers decide whether it has to be easy or difficult to peel off, depending on the specific requirements. The best systems should be capable of being individually tailored to the application. With our new silicone DEHESIVE® PSA 765, that is exactly what we have achieved,” explains Ki-Eon Kim of the Group's applications technology center in Seongnam-si, near Seoul in South Korea. Just as was the case for his colleague Timo Hagemeister in his previous job, Kim works in the beating heart of the electronics industry. East Asia is not only where many smartphone manufacturers have their production sites, but is also the home of their subcontractors – including protective-film manufacturers.

**MARKET SHARES FOR SMARTPHONES BY VENDOR (Q1 2017)**








“It is becoming increasingly important to protect high-quality smartphone screens against scratches and knocks, as these devices are often very expensive”

Dr. Timo Hagemeister, WACKER SILICONES



**CROSS-SECTION OF A PROTECTIVE DISPLAY FILM**

-  Hard-coated layer: obtained by UV-cured urethane
-  Substrate: urethane-coated PET film (polyethylene terephthalate)
-  Silicone-PSA coating
-  +
-  Liner: uncoated PET film

**SANDWICH STRUCTURE**

The exact properties of the self-adhesive films are determined by their structure and chemical composition. The protective films have a multilayer sandwich structure. A key role is played by the PSA layer, “It may be made of polyacrylic, polyurethane or rubber – or silicones, as in this case,” explains Hagemeister. The PSA layer is usually between 15 and 25 micrometers thick, and has to perform several different functions, such as anchoring firmly to the glass surface of the display. At the same time, the layer must remain bonded to the backing material usually a polyethylene terephthalate (PET) film. The adhesive film is thus the connecting element



The chemical and physical properties of the release coating can be tested in WACKER's technical center in South Korea.

between the PET layer of the film and the glass surface of the smartphone.

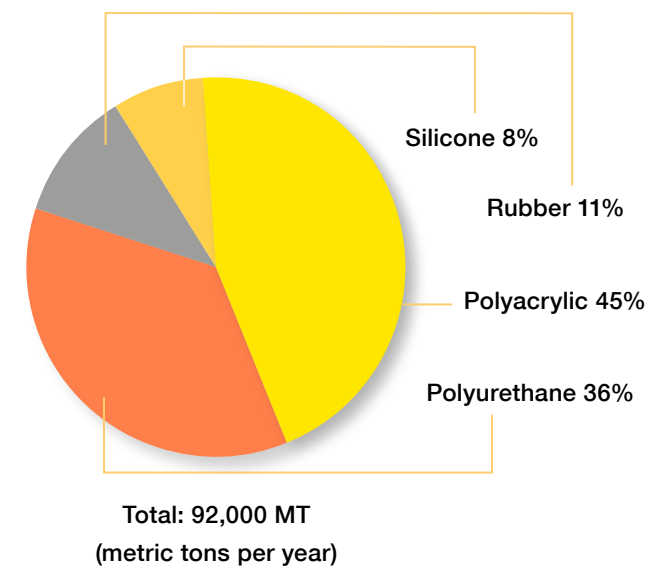
“However, the materials have very different chemical and physical properties,” says Hagemeister. “That is why it is a challenge to formulate the silicone PSAs such that they remain anchored to both materials – but with different adhesion strengths.” It should be possible to strip the adhesive film off the glass surface, though not off the PET layer. Manufacturers of protective film need a higher adhesion strength here.

This is the balancing act that the new product DEHESIVE® PSA 765 is required to perform. Its properties have convinced a South Korean protective-film manufacturer – which now uses the silicone PSAs from WACKER.

**OPTIMIZED PRODUCTION**

“Silicones are more expensive on the whole. That is why they only command some 8% of the market. Our customers therefore only use silicones where they offer a performance advantage,” says Kim, explaining the challenges facing developers. “In practical terms, our silicone PSAs show ideal behavior in the production process. To ensure rapid processing workflows, the viscosity and curing behavior must be precisely matched,” adds Hagemeister.

Other important criteria that the protective-film manufacturers use to choose their adhesive suppliers include storage stability, abrasion resistance and surface adhesion. In addition, the handling also plays an important role. “The adhesive layer must ensure that



**MARKET SHARE OF DIFFERENT PSA GRADES**  
(in the markets of Greater China and South Korea)

Estimate: WACKER

the protective film conforms to the display surface without troublesome air bubbles,” says Kim. The silicones achieve all that – as well as another advantage: they do not yellow and they retain their properties both at high and low temperatures.

Silicone PSAs are multicomponent systems, including high-adhesion and less high-adhesion silicones, various additives and a platinum catalyst. This catalyst triggers the crosslinking of the silicones to form a three-dimensional polymer structure. This step only takes place during manufacture of the protective films, after the silicone PSA has been applied to the backing material. “The platinum catalyst is thus sold as part of the product – and makes up a significant share of the total price. The less precious metal that is needed for the curing reaction, the better,” explains Hagemeister. “We managed to reduce the platinum content of DEHESIVE®

PSA 765 to the point where we have a competitive product that performs very well on various PET films, and which protective-film manufacturers can tailor to their requirements,” he adds.

**MOLECULAR CHAINS**

We exploit the special talents of silicones here, since, by artfully functionalizing them, that is to say introducing special chemical groups and combining different silicone grades, we can produce complementary properties, with low or high adhesion, and flexible or stiff characteristics. The reason lies in their chemical structure. Whereas silicone fluids consist of linear molecular chains, silicone resin chains are highly branched, and introduce a high degree of crosslinking into the adhesive layer. And that has an effect on the release force: where the degree of curing is higher, the film remains strongly bonded. Thus, the release force can be precisely adjusted by adding

silicone resins. This opens up a wide range of applications for DEHESIVE® PSA 765 coatings on protective films.

In display production as a whole, various protective films are used – for example to protect the components against damage during manufacture. “Our goal is to develop a product family that supplies the entire value chain with solutions for self-adhesive films,” explains Kim, summarizing his future development ambitions. ■

**CONTACT**

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Washing clothes by hand involves several rinse cycles to get rid of the foam – a time-consuming and exhausting process.



## JUST THE RIGHT AMOUNT OF FOAM

No matter where you are in the world, nothing says clean and hygienic like a thick, white foam. Detergents that foam too much, however, require an unnecessarily large amount of water to rinse them out. WACKER has now developed SILFOAM® SD 9019, a foam-control agent especially for hand washing that strikes the perfect balance between fluffy white bubbles and responsible use of resources.

**T**he washing machine has become an essential household appliance in industrialized countries; according to Germany's Federal Statistical Office, over 96% of German homes have one. It is much less common in emerging economies, however, and for reasons that are fairly obvious: in some cases, the technical infrastructure is

not available, and in others, it's simply a question of money. That's why roughly half of the world's population still performs the laborious process of washing clothes by hand. Maids and housewives soak the clothes, scrub them by hand, rinse out the suds and then wring out the laundry – a step that requires a great deal of strength.

### FOAM WITHOUT FUNCTION

And washing by hand does not exactly conserve resources: the method consumes roughly two to three times as much water as machine washing. This issue is particularly acute in those parts of the world where water is already a scarce resource. The amount of clean water used for rinsing out the suds at the end of the process is especially large. This is arduous and time-consuming work.

“The foam itself doesn't make laundry any cleaner – it's a by-product that consumers want. After all, we automatically associate soap suds with cleanliness,” notes Dr. Klaus Pohmer, director of business development for WACKER's Performance Silicones business unit. Studies have shown that soap with good foam-forming properties is automatically perceived as more effective by consumers, even

### BALANCING FOAM NEEDS

The SILFOAM® brand unites a broad portfolio of highly effective antifoams. SILFOAM® products control foam formation and ensure a smooth and therefore efficient production process. In modern detergents, they control foam formation to prevent washing machines from foaming over. In the textile industry, SILFOAM® foam-control systems must withstand temperatures of up to 130 °C, as well as acidic and alkaline environments.



The huge amount of water needed to get rid of foam from handwashed laundry is a major environmental problem.

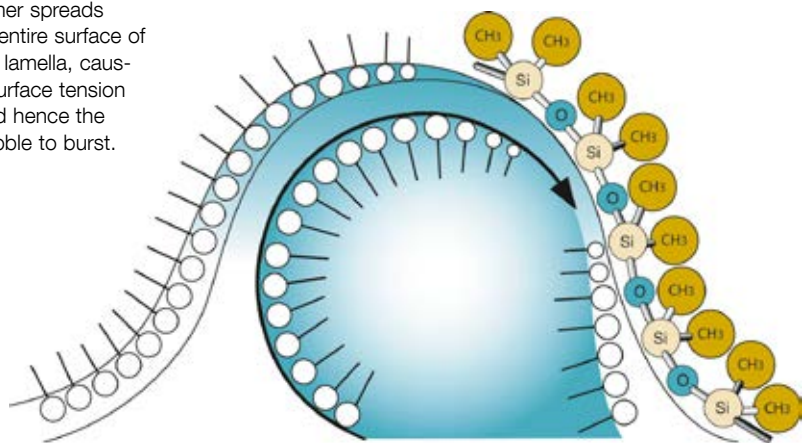
though the suds are nothing more than the air bubbles that form when a detergent containing a surfactant is mixed with water. Surfactants form a thin film on the surface of the water, which reduces the surface tension of the water. Whereas the hydrophilic ends of the surfactant molecules project into the water, the hydrophobic ends extend into the air, resulting in the formation of entrapped air. Within the water,

individual surfactant molecules arrange to form small, spherical aggregates – bubbles in other words – with the polar, hydrophilic end directed outward and the hydrophobic end on the inside. This is what we know as soap suds.

Even though the consumer generally associates foam with cleanliness, it does have a disadvantage: too many suds can cause a washing machine to overflow.

## HOW SILICONE DEFOAMERS WORK

A defoamer spreads over the entire surface of the foam lamella, causing the surface tension to fall and hence the foam bubble to burst.



In large parts of Africa and Asia, water does not come out of a tap in the kitchen, but has to be fetched in buckets from central wells or bodies of flowing water.



### PODCAST



Our podcast tells you all about the performance range of silicone fluid emulsions in fabric softeners:  
[www.wacker.com/podcast](http://www.wacker.com/podcast)



### ESSENTIAL ADDITIVE

As a result, foam-control agents are added to laundry detergents to prevent excessive foaming. Antifoam agents are an indispensable process aid in detergents for washing machines. In 2016, the sector for foam-control agents generated sales of three billion US dollars – with the upward trend intact. The largest gains were seen in emerging markets such as China and India, not to mention Japan and Latin America. Besides water- and oil-based products and polyethylene oxide and polypropylene oxide copolymers, silicones are among the key foam-control technologies with a market share of some 40%.

WACKER has now developed a foam-control agent that makes it a lot easier to rinse handwashed laundry and thus significantly reduce water consumption. SILFOAM® SD 9019 is an anhydrous, low-viscosity, silicone-based anti-foam agent that results in a fine dispersion in water or other highly polar systems. The remarkable feature of this new foam-control agent is its delayed defoamer technology, which does not immediately begin inhibiting foam formation. Unlike a machine wash, where the foam-control agent prevents the detergent from foaming over

Silicone defoamers are thoroughly tested at WACKER's laboratory in Burghausen: foam collapse is recorded and analyzed photoelectronically.

# 50%

of the world's population still washes its laundry by hand – a laborious task.

from the start, SILFOAM® SD 9019 only takes effect when the pH value of the detergent liquor drops. In hand washing, this is typically the case when the detergent is diluted, i.e. rinsed. Once the defoaming agent starts to work, the foam immediately collapses.

#### LESS LABOR-INTENSIVE

The result is amazing: instead of being rinsed three to four times, the wash now only needs one or two rinse cycles, thereby reducing water consumption by 50%. This can save up to 20 liters

of water per wash load. "That allows us to find a middle ground between the perception of cleanliness and behavior that protects the environment," explains Amit Paul, who developed the product for India-based Wacker Metroark Chemicals, a WACKER joint venture headquartered in Kolkata.

#### SILICONES COMBAT FOAM

Thanks to their good wetting properties, silicones are highly effective foam-control agents. Due to their extremely low surface tension – even lower than that of a surfactant molecule – they



#### SILICONE AS AN INTERNATIONALLY POPULAR DEFOAMER

Silicone defoamers are used in a diverse range of industrial applications such as in the household and personal-care sectors, pulp and textile manufacturing, agrochemicals, the life sciences, paints, surface coatings and printing inks, as well as in adhesives and construction materials, not to mention industrial and municipal wastewater treatment. The pharmaceutical industry also uses foam-control agents, for instance in the manufacture of drugs or as active ingredients (e.g. in antifoam agents). Some 40% of all silicone defoamers are sold in the Americas, followed by Europe, including the Middle East, and Asia-Pacific. WACKER has an extensive portfolio of defoamers to suit a wide variety of industrial applications. For example, PULPSIL® foam-control agents are tailored to the pulp industry. SILFAR® defoamers are especially pure and have no known harmful effects, and are thus ideal for the pharmaceutical industry and medical applications.





263

million people  
need over 30 minutes there and  
back to fetch water from a  
safe source of drinking water.



Source: WHO/UNICEF Joint Monitoring Programme for  
Water Supply, Sanitation and Hygiene (JMP) 2017

spread out at the interface between the liquid and air, thereby displacing the foam-stabilizing surfactant molecules. This results in a local weakening of the foam lamella – a chemist would call it a stabilizing, surfactant-containing liquid layer – which ultimately causes the lamella to rupture and the foam to collapse. SILFOAM® SD 9019 is chemically stable and can be combined with many non-silicone-based defoamers. Thanks to their high thermal stability, they are ideal for critical temperature profiles.

“Delayed defoamer technology is a true advancement in countries where people primarily wash by hand and water is a scarce resource,” emphasizes Pohmer. It makes hand washes easier and, at the same time, directly helps to conserve water, an increasingly important resource. Delayed defoamer hand-laundry detergents have been on the market in Africa since 2016 and are currently being rolled out successively in certain Asian countries. ■

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# FROM INSTANT COFFEE TO HIGH-TECH POWDER

WACKER's VINNAPAS® dispersible polymer powder has been setting benchmarks in the construction industry for 60 years. Over three million metric tons have been distributed globally to date, and new applications are still being found. This pioneering product has become a world-famous all-rounder.

VINNAPAS® is a German baby boomer. Amid the country's rebuilding and growing prosperity, the development of dry-mix mortars was particularly important for the construction industry. The overriding concern at that time was to build or renovate as fast as possible. Growing prosperity also raised quality expectations. In both cases, VINNAPAS® provided the answer, as dispersible polymer powders paved the way for faster, more efficient work tech-

niques, while enhancing the quality of construction. This holds true to this day and sales volumes of the powders have risen continuously. Over three million metric tons of VINNAPAS® have now been sold worldwide. That makes WACKER not just the pioneer, but also the world's biggest supplier of dispersible polymer powders used for modifying mortars.

At the start of the 1950s, WACKER embarked on initial tests in Burghausen to convert its liquid vinyl acetate dispersions into

powder that only redisperses when processed. This process was masterminded by WACKER chemist Dr. Max Ivanovits. The story goes that he got the idea from instant coffee. He would always take some Nescafé with him on his frequent visits to customers. While making his coffee one day, he had the brainwave of turning dispersions into powder, and simply reconstituting them on site as needed. Once the idea had taken root, it would not let him go. Previously, liquid dispersions had been delivered to construction



## PODCAST



To learn more about using VINNAPAS® in construction applications, listen to this article's podcast:  
[www.wacker.com/podcast](http://www.wacker.com/podcast)

sites in small drums, and construction workers performed the painstaking job of mixing them with other components (cement, sand and additives) in defined mixing ratios to prepare the finished mortar. If, however, the dispersion could be provided as a finished dry-mix mortar, it would need to be mixed with water on site – just like a cup of instant coffee. These ideas were quickly followed by actions.

**FROM IDEA TO GLOBAL PRODUCT**

An initial application patent was registered in 1953. However, much more development work was needed to obtain a usable product. After several attempts, so-called spray drying was successful. Here, the dispersion is sprayed into the spray tower as a fine mist; high temperatures then evaporate the liquid component, leaving behind powdery polymer particles. Following on from

the laboratory process, a small jet dryer successfully started producing initial quantities of powder at WACKER's Burghausen plant in 1957.

Customers were quickly won over by the new miracle powder. It boosts durability, tensile adhesive strength on many substrates, and resistance to abrasion, moisture and airborne pollution. What is more, modified mortar can be processed faster and more easily, because dispersible poly-

**BUILT WITH DISPERSIBLE POLYMER POWDERS**

1. Self-leveling flooring compounds

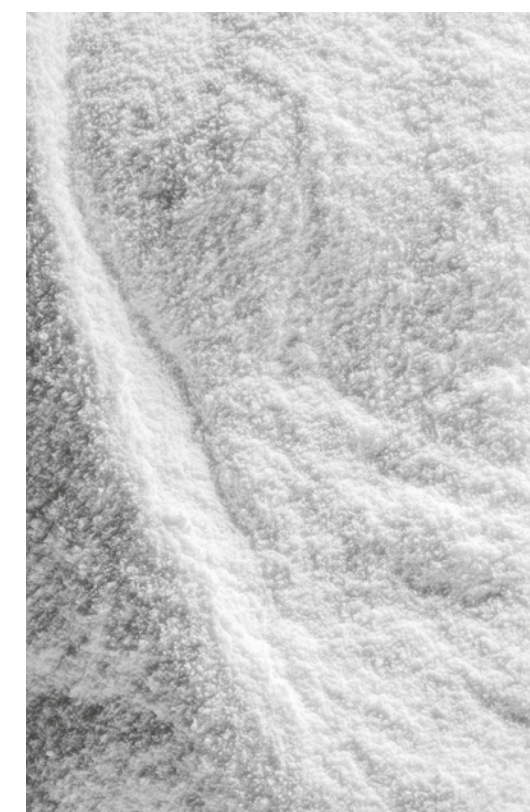
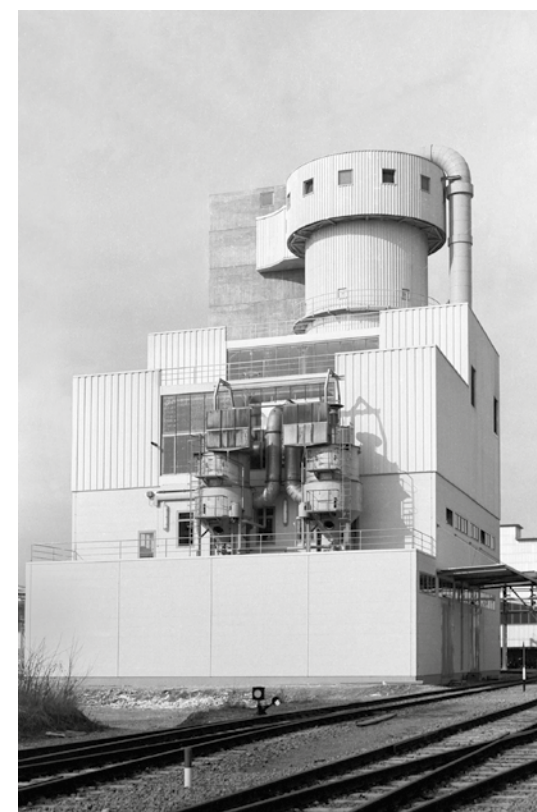
2. Grout mortar

3. Waterproofing membranes

4. Tile mortar

5. EIFS/ETICS

6. Render



In 1969, WACKER produced 1,490 metric tons of dispersible polymer powders. Ten years earlier, its output was just 19 metric tons.

Vinyl acetate dispersions in powder form – an idea that revolutionized the construction-material sector worldwide.

“Our range is so varied – its innovative potential has by no means been exhausted even after 60 years.”

Andreas Collignon, head of WACKER's polymer powder business

mer powders optimize such key parameters as non-slump properties and open time (i.e. how long the mortar can be worked).

With these advantages, WACKER's dispersible polymer powder quickly revolutionized the construction industry. Without these binders based on vinyl acetate and ethylene, many modern construction applications, such as EIFS/ETICS, thin-bed mortars and lightweight construction materials, would not be possible at all. The fine white powders also radically changed tile laying, for example. Thanks to dispersible polymer powders in the tile adhesive, nowadays only a very thin layer of mortar is needed, instead

of the thick mortar beds in which tiles used to be set. Builders thus achieve higher productivity, coupled with lower error rates and better quality. Furthermore, only one third to half as much material is required with the thin-bed technique, which is kinder on the environment and conserves resources.

**TAILOR-MADE QUALITY**

Since the 1970s, dispersible polymer powders have been tailored more and more to the specific requirements of customers around the globe. Softer and harder, hydrophobic and hydrophilic, as well as heat- and frost-resistant

grades were added to the range. Dispersible polymer powders and additives can also facilitate formulation of cementitious systems such as grout mortars and tile adhesives suited precisely to specific applications – indoors or outdoors, on smooth or uneven surfaces, and for stoneware tiles on plasterboard or porcelain tiles on wood.

To cater to cost-sensitive markets, WACKER has increasingly also been developing all-rounders in recent years, which are suitable for a wide range of dry-mix mortar applications, from cementitious tile adhesives and plasters to self-leveling flooring compounds and EIFS/ETICS.

“We are continuously working on adapting our construction chemicals to suit the industry's changing requirements,” confirmed Andreas Collignon, head of WACKER's Construction Polymers business unit. “WACKER's dispersible polymer powder has revolutionized the construction industry over the past 60 years and will continue to be an important building block – to

help conserve valuable resources on the one hand and increase quality and efficiency in construction on the other.”

#### SOLVING TOMORROW'S CHALLENGES

Today, VINNAPAS® is available in six product classes and used in over 3,000 specific application formulations. With its dispersible polymer powders, WACKER has always been an innovation driver in the construction sector. Product development is a key component of its corporate strategy. With annual R&D expenditures at some 3% of sales, the Munich-based chemical group ranks among the industry's most research-intensive companies. Over the past five years, this gave rise to around 90 to 100 new patent applications and inventions per year.

WACKER's dispersible polymer powders are also continuously being developed in order to support the construction sector's four megatrends: cost efficiency, saving energy, optimum space utilization and environmental awareness. “Gaining a lead over competitors means solving tomorrow's challenges today. Our aim is to develop convincing solutions with and for our customers early on,” said Collignon.

Whereas dispersible polymer powders have long been established as building additives in western industrialized countries, emerging-market economies in Asia, South America and eastern Europe, in particular, are registering an above-average rise in demand. WACKER is well prepared to meet this demand. At our technical centers around the world, technicians are working on new dispersible polymer powders, dry-mix mortars and standards for country-specific applications around the clock. This is because, along with the powder itself, the entire mortar formulation has to be tailored to specific requirements such as the regional climate and available raw materials. “Starting materials such as sand

and cement differ from country to country. That is why it is important for us to develop a customized solution that meets the local needs of each market and also delivers an attractive price/performance ratio,” explained Collignon.

Our global network also offers support for problems with construction chemicals and local technical service. “It puts us in a position to deal with our customers' needs and wishes directly, and to develop the perfect solution hand in hand with them,” he added.

To provide its locally based customers and partners with the required expertise in high-quality construction chemicals, WACKER has set up WACKER ACADEMY branches at many of its sites. This international training center is oriented specifically to the needs of the construction-chemicals industry, and along with theoretical training offers practical exercises in applications laboratories. “We now have training centers in Germany, the USA, China, India, Russia, Dubai, South Korea, Brazil, Mexico and

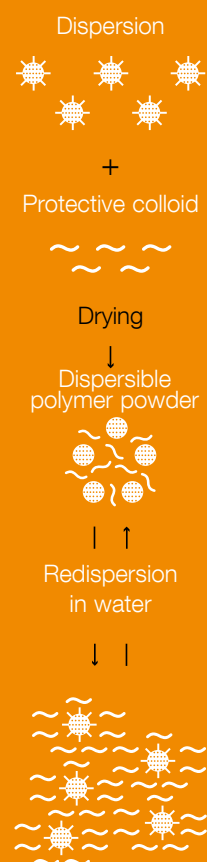
#### VINNAPAS® DISPERSIBLE POLYMER POWDERS

... are thermoplastics based on vinyl acetate and ethylene. As film binders, they find use in such wide-ranging applications as tile adhesives and joint fillers, mineral plasters, waterproofing membranes, plaster of Paris, repair mortars, self-leveling compounds and powder paints. They enhance important end-product properties, such as adhesion, cohesion, flexibility and flexural strength.

Dispersible polymer powders have positive effects on water retention and processing properties.

#### How They Work

The polymer film, which acts as a binder, is formed via fusion of individual polymer particles as the water partially evaporates. This film (acting as an organic binder) bonds the filler's particles, thus improving the mortar's intrinsic strength (cohesion).



# 60 Years of Dispersible Polymer Powder

## 1967

Ten years after the start-up of the first powder tower, dispersible-polymer-powder production reaches its capacity limit at 1,000 metric tons.

## 1968

WACKER starts operating its second powder spray dryer with a capacity of 2,400 metric tons per year.

## 1969

WACKER POLYMERS succeeds in copolymerizing vinyl acetate and ethylene and thus launches the monomer combination that continues to dominate the market to this day.

## 1976

WACKER develops the world's first non-sag dispersible polymer powder specifically for tile adhesives.

## 2015

WACKER opens the biggest, most efficient, state-of-the-art spray dryer worldwide with a capacity of 50,000 metric tons per year in Burghausen.

WACKER runs a global network of technical centers in which products and formulations can be tested and adapted to meet the needs of individual regions.

Singapore,” said Collignon with a touch of pride. “We can pass on sector-specific knowledge about construction trends from around the world to local experts and thus create definite added value for our customers.”

#### GLOBAL NETWORK

Even after 60 years in the business, there is no sign of VINNAPAS® polymer powders approaching retirement. On the contrary, global demand is still on the rise. Modifications which are tailored specifically to local needs are becoming increasingly important in all areas of application.

“In Mexico, we recently attended Latin America's largest construction tradeshow, where we successfully presented our solutions for self-leveling flooring compounds that meet local design preferences. Our Dubai team is working on local products that take account of the region's distinct climate. And in China, we are currently observing increased quality awareness in construction, making our dispersible polymer powders indispensable there,” said Collignon. That is why he is optimistic: “Our range is so varied – its innovative potential has by no means been exhausted even after 60 years.” ■

## FILM-COVERED FRUIT

Roses, flower bulbs, mangoes and papayas often go bad on the long journey from their tropical cultivation areas to Europe or North America. Dutch company Liquidseal has developed a coating, based on VAE dispersions, that stunts the metabolism of the crops, thus increasing their shelf life.



Mango plantations in Thailand: the thick skin of this tropical fruit make mangoes ideal for treatment with Liquidseal.

It was at a summer garden party, while barbecuing, that neighbors E.R. van den Berg and Victor Monster from Leiden, the Netherlands, came up with their business concept of using a polymer dispersion to extend the shelf life of fruit, vegetables, cut flowers and flower bulbs. “We repeatedly opened and closed the barbecue’s air vent to regulate the oxygen supply,” explained Van den Berg, CEO of Liquidseal. “When no oxygen reached the

charcoal, the flame went down,” added his colleague Monster. “The coal no longer burnt and thus did not decay.”

#### HOME OF TULIP BULBS

The two neighbors reckoned that the same principle would also apply to other organic substances. If the oxygen supply to fruit, vegetables or flowers is prevented or hindered after harvest, their metabolism slows down. Conse-

quently, the shelf life of the treated products ought to increase considerably.

Leiden is not just the home town of these two entrepreneurs, but was also where the great botanist Carolus Clusius devoted many years of study to his work. The Flemish scholar contributed greatly to the introduction of the potato and the tulip to western Europe in the second half of the 16th century. The region around Leiden and Utrecht – with its intensively farmed fields and greenhouse belts – is still one of the world’s largest producers of tulip and lily bulbs.

#### LILY BULBS AS TEST OBJECTS

It therefore made sense for Monster and Van den Berg to first test their business concept on flower bulbs, primarily lilies. “We looked for an application in our own backyard,” said Van den Berg. “However, lily bulbs are a very conservative market and, furthermore, a highly seasonal business,” added Monster. “Lily bulbs are harvested, treated and packaged in November, December and January – then nothing else happens for the rest of the year.”

# 30%

of mango fruit goes bad during transit, according to a rule of thumb.

#### FILMFORMING VAE DISPERSION

According to Monster, another reason why the Liquidseal managers particularly focused on bulbs and cut flowers at the start was that “this market is very clearly structured and easy to target, while the strict regulatory requirements associated with food do not apply.”

Nevertheless, the two company founders needed a business concept for a post-harvest product to extend over the whole course of the year. That’s why they decided to experiment with cut flowers and fruit and vegetables.

Only fruit and vegetables with a tough skin that is removed before consumption – mangoes, avocados, lemons, papayas, etc. – came into consideration. The Liquidseal laboratory assistants applied a thin, aqueous polymer dispersion to the fruit – vinyl acetate-ethylene dispersions from WACKER proved to be particularly suitable. This film-forming dispersion dries within a few minutes to leave a fine plastic layer on the skin or flower that largely inhibits the exchange of oxygen, atmospheric humidity and carbon dioxide, as well as the access of microorganisms to the harvested produce.

“The fruit is essentially wrapped in an ultrathin plastic film that can be washed off,” explained Van den Berg. The desired effect: the metabolism is stunted and the ripening process slows down. It takes considerably longer for the product to spoil as a result of rotting processes. The Liquidseal managers say that the shelf life of mangoes and papayas is extended by a minimum of five days; lemons and oranges can even be stored for two weeks longer, at the very least.

All links of the supply chain profit from this: wholesalers can store fruit and vegetables that have been treated with Liquidseal for longer, and retailers can offer them for sale for longer. Thanks to these advantages,

“The fruit is essentially wrapped in an ultrathin plastic film that can be washed off.”

E.R van den Berg, CEO, Liquidseal



At Liquidseal’s laboratory in Leiden, Netherlands, mangoes are dipped into the finished dispersion so as to slow down the ripening of the fruit.

the Dutch Chamber of Commerce presented Liquidseal with an award for the most innovative business concept in the agricultural and food sector in 2016.

**SHIPMENT BY MARITIME CONTAINER**

Produce that spoils quickly and that previously had to be transported as air freight can now be shipped to the end customer in maritime containers – thus lowering transport costs significantly. Consumers benefit from the later ripening time, because they obtain fresher goods that were harvested later and thus had time to develop more sugar. “This kind of fruit simply tastes better,” said Monster with a chuckle.

Cut flowers and bulbs enjoy similar advantages when treated with the Liquidseal dispersion. The produce remains fresh and looks

appetizing for longer, can be stored for extended periods and the formation of mildew – which rapidly thrives under moist conditions – is prevented. The VAE dispersion can be applied manually; workers use large sprayers to cover the freshly harvested flowers. However, in collaboration with an engineering partner, the company also leases out entire machines that carry out the process automatically.

In addition, some large-scale farms already have spray systems for treating cut flowers or bulbs with fungicides, for example. These kinds of fungicides are used to prevent mold rot caused by Botrytis fungi.

**DELAYED RELEASE**

According to Monster, if the crop is sprayed with the Liquidseal dispersion, farmers can

“After treatment with our dispersion, the amount of fungicides used to combat mold can be reduced, too.”

Victor Monster, Liquidseal



The founders of Liquidseal: Victor Monster (left) and E.R. van den Berg. Oranges are among the kinds of fruit that can be stored for longer using a post-harvest product.

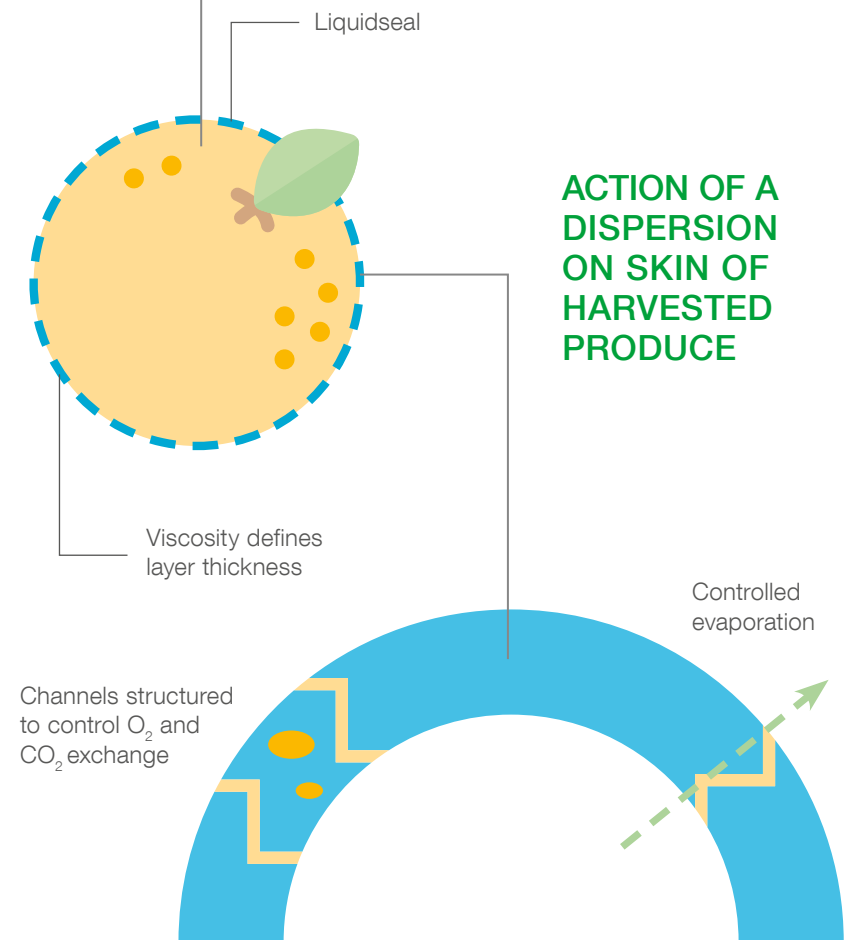


Growing roses in Debre Zeyit, Ethiopia. Cut flowers, too, last much longer if they are sprayed, post harvest, with a polymer dispersion.

also reduce the use of fungicides – by up to 80% for lily bulbs and up to 50% for roses. Wholesalers and growers in Spain, South America (Ecuador and Colombia), Mexico and Kenya are already using Liquidseal to treat their crops. Countries near the equator enjoy a certain priority in Liquidseal’s sales strategy. “Cut flowers, such as roses, thrive best at altitudes above 1,000 meters, where it is cool in the evenings, and where they can savor twelve hours of sunlight every day – this is guaranteed at the equator,” explained Monster. South American countries like Ecuador and Colombia primarily produce cut flowers for US retail chains such as Walmart, while African countries like Kenya work for European distributors such as Aldi or Lidl.

**BUSINESS CONCEPT EXPANDED**

Since the treatment of flower bulbs and cut flowers with Liquidseal yielded promising results, Van den Berg, Monster and their team



began expanding their business concept to include fruit and vegetables. This process took several years, because the startup company first had to obtain all European Union and US Food and Drug Administration approvals. Since the skin of mangoes or papayas is not consumed, no approval was needed for food additives, but for food-contact applications.

“Only a very limited number of substances are suitable for these kinds of applications – and our VAE dispersions basically match the requirements,” said Robert Tangelder, business development manager at WACKER in the Netherlands, who helped the Liquidseal managers find the right specification. “Of course, the dispersion had to be adapted to regulatory and application-specific requirements,” added Dr. Marcus Pfaadt, market segment head and business development manager at WACKER BIOSOLUTIONS in Burghausen.

“Only a very limited number of substances are suitable for these kinds of applications.”

Robert Tangelder, Business Development Manager, WACKER BENELUX

The Liquidseal managers are, of course, aware of the partially contradictory expectations of consumers, who would prefer their food to be entirely untreated – put on their table fresh from a small farm. On the other hand, modern-day consumers take it for granted that exotic topical fruits are available in, for example, German or Canadian supermarkets all year

round. This kind of fruit is treated regularly, for instance with fungicides or carnauba wax.

**SEARCHING FOR ALTERNATIVES**

“Some substances are meanwhile viewed somewhat critically, so that growers are looking for alternatives,” reported Van den Berg. “As such, we are introducing our product to



Loading up oranges on the Greek island of Crete. If the fruit is protected with a dispersion after being harvested, they can ripen longer beforehand – and taste sweeter as a result.



These avocados have been stored at room temperature for 17 days. The two examples on the right were pre-treated with Liquidseal.

Control group

Liquidseal

the market at a good time.” He also pointed out that existing equipment can be used to apply Liquidseal to fruit, which lowers market-entry barriers, as no large investments are needed. What is more, as was the case for cut flowers, treatment of fruit or vegetable skin with Liquidseal would allow growers to significantly reduce the amount of fungicides in the spray solution or do without them completely.

According to the two company founders, a general industry rule of thumb is that – in

the case of mangoes, for example – around 30% of fruit spoils during transport. “Just imagine,” explained Monster, getting agitated. “The fruit requires large volumes of water, large areas for cultivation, nutrients, labor, etc. – and then a third of the produce has to be discarded?” The Dutch startup entrepreneur emphasizes that a coating with Liquidseal could reduce the percentage of mangoes spoiled during transport to a definite single-digit figure. “If that’s not sustainable, what is?” ■

**CONTACT**

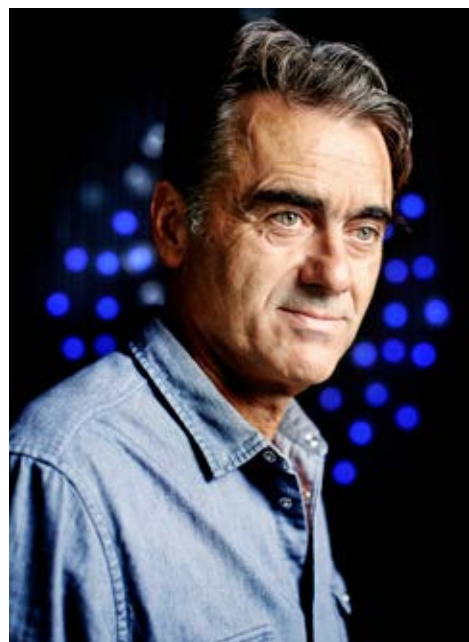
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## THE ENIGMATIC FACE OF TIME

The light effects associated with the LED objects created by Paris-based sculptor and industrial designer Alainpers entice the viewer into a world where time can be experienced. Silicone plays a hidden but indispensable role in his work.



Alain Persouyre in his studio: the 56-year-old light artist is actually an electrical engineer by training. It was his work in industrial design that introduced him to art.



**T**he half dozen clocks in Alain Persouyre's small studio are strangely silent: no familiar ticktock can be heard. Visitors don't immediately recognize the timepieces for what they are, as the clocks have no hands. Instead, points of light appear on the walls; sometimes they flash. Glass rings suspended from the ceiling gradually fill with blue lights. A ray of light suddenly flashes across one of four quadratic, monochrome images hanging on the wall. It disappears as rapidly and as abruptly as it appeared.

"That was one second. The images are part of a series. Together they create a clock on the wall," says the 56-year-old artist, whose artistic name is Alainpers, smiling as he looks around his office. "This here is my own little universe. Time has always fascinated me. My goal is to show time in a new and unfamiliar way."

And indeed, his clocks resemble sculptures, architectural installations or contemporary works of art. His very first major project broke with all conventional notions of clocks: Alainpers joined three glass spheres, mounted one above the other, and placed them in the center of a rotating stainless steel ring. Droplets of water dyed blue drip from the upper receptacle through to the lowest one – much like an ancient Greek water clock or clepsydra. When an hour has elapsed, the glass spheres automatically turn and the passage of time is measured anew. The whole structure is synchronized with an LED display worked into the built-in mount where the full hour is displayed. Over three meters tall, this time display graces the entrance of a high school in Rueil-Malmaison, a suburb south west of Paris.

#### USING THE SUN TO TELL THE TIME

Another work by this French artist is a clock called "Noon Somewhere" which can be viewed in the lobby of a Brazilian airline. Instead of showing local time, a bright red light appears on a four-meter-high map of the world made of

For over 20 years, Alain Persouyre has been using two of WACKER's liquid industrial adhesives: ELASTOSIL® E43 and E41. Both grades are one-component silicone adhesives that cure at room temperature and are therefore easy to use.

The Blue Ring clock: luminous symbols indicate the hours, minutes and seconds.





“My goal is to show time in a new and unfamiliar way.”

Alainpers, light artist



“60 Opalescent Minutes” with 12 glass disks at its center. These disks are successively illuminated to show time. Around them, the seconds and minutes are gradually filled with blue light.

It takes about 12 hours for the adhesive to dry completely. But then it lasts forever.



sand-blasted glass, indicating locations across the globe where the sun is currently at its zenith. A red light is also the protagonist in his time-play sculpture “12 Directions of Time.” It moves along twelve transparent resin poles which are suspended in the air on two steel wires spanning eleven meters. The resin rods contain diodes which display the minutes. The red light travels along one rod and then leaps up one level to the next rod. As the day progresses, it flashes at different places at various heights on this installation, which is mounted in the entrance hall of the Alcatel telecommunications offices in Paris.

Alainpers’ light effects are created exclusively with LEDs. “Ever since I visited an exhibition on the reaction kinetics of light when I was 17, I wanted to make objects come alive with light. LEDs are ideal for this purpose because they produce high-quality light, they’re easy to install and

have a long service life. A diode only lights up once a day in some of my clocks. Theoretically, the clock could work endlessly. “The LEDs are embedded in steel, metal, glass, crystal, synthetic resins and sometimes also in PVC. They are fixed into place with silicone. Alainpers doesn’t use nuts and bolts; he relies on adhesives. “I use silicone everywhere. It’s perfect for bonding glass, metal and the LEDs.” The two liquid industrial adhesives ELASTOSIL® E43 and E41, currently supplied by IMCD France, one of WACKER’s distributor in France, have served him well over the past 20 years or so. Both grades are one-component silicone adhesives that cure at room temperature and are therefore easy to use.

**NO DISTRACTIONS PLEASE**

Alainpers points to a clock made of 60 glass panes. A glass bead equipped with a diode has been



WACKER's silicone adhesive forms a completely transparent bond so that nothing detracts from the light effect.

glued onto each one. “Can you see anything?” he asks, only to answer the question himself: “No. The bond is completely transparent. That’s important to me. That way nothing detracts from the light effect.”

It takes about twelve hours for the adhesive to dry completely. But then it works forever. “Like the LEDs!” The mechanical resistance and the elasticity of the silicones do an excellent job. “The bonding also withstands sudden jolts well – should something fall down.” The structural properties of the adhesive, which automatically forms a compact round shape, practically eliminate the human error factor. “I use regular disposable syringes from the drugstore to apply the adhesive. If my work isn’t accurate, the consequences are minimized because the silicone is able to form the right shape by itself. The result almost always meets expectations and looks good,” says Alainpers, proving his point by picking up an abandoned syringe and pressing a drop of silicone onto a sheet of paper. Initially an unshapely blob, the droplet takes on a homogeneous round form a few minutes later.

The table the syringe lay on is a work in progress: several batteries cables, a soldering iron, random sheets of paper, rulers and adhesive tapes clutter the surface. Even though Alainpers’s most famous works are gigantic, the artist doesn’t need more than a small, modest studio for his designs. His office and studio are located in the drab 13th arrondissement of Paris, an eclectic architectural mix comprising modern high-rises, elegant, Haussmann-era apartment blocks and old low-rise buildings. On the ground floor of his studio, there are a few desks and a cast-iron spiral staircase leading to the basement whose ancient arches house countless shelves full of screws and tools. Generators and drills of various sizes are attached to the workbench over which cable trays are draped. There isn’t much room to move. But

“Silicone has the ability to form a round shape all by itself. That is one reason why the result is persuasive.”

Alainpers, light artist

this doesn’t seem to bother him: “I mostly work alone. Most of the objects are set up elsewhere in collaboration with other companies.”

#### FROM ATOMIC CLOCKS TO SUNDIALS

His studio functions mainly as a place for developing ideas and reflecting on time. “The subject is multi-faceted and has an inherent vitality. Time is ever changing and has a fascinating history – beginning with sundials right up to modern atomic clocks.” At the moment, he is working on a clock that reflects the position of the moon in relation to the sun. “It’s about where the moon is visible at a given time. I’m interested in the position of the earth, the sun and the moon in relation to one another – in terms of latitude and longitude.” It is evident that Alainpers has internalized time, his subject, and approaches it from a scientific perspective.

He has acquired the requisite knowledge over the years. Alainpers is actually an electrical engineer by profession. After completing his studies, he worked in aviation, which was followed by a career as an industrial designer. “This job change was a catalyst in my life. In the industrial sector, you work with narrow and rigid constraints. Design is freer.” But he still felt that the performance specifications in this sector placed too many restrictions on him. Originally from central France, the engineer then enrolled at an

art school and started his own business once he had qualified. “I have enjoyed creating objects ever since I was a child. Now the only boundaries are those set by technology and myself.

#### CONSIDERABLE LEEWAY FROM CLIENTS

From the beginning, his clients generally gave him a great deal of freedom. Many projects came to fruition, but many did not. “The 1980s were better when it came to installing large-scale works.” Now he works more on smaller sculptures for individuals, like the “Blue Ice Clock” LED clock made from a rough wheel of crystal. With its shimmering blue hues and white LEDs, this beautifully shaped object is representative of Alainpers’s design goals: “My work hinges on three points: the beauty of the object, the unlimited freedom in creating the form and the vitality of the time I wish to bring to life.

On the opposite wall, a ray of light illuminates the passage of a second in time traveling across the monochrome wall images. When, and in which of the four images the next ray will appear, is a mystery, even to the inventor himself. “In this piece, I have set the timer for the seconds at random,” explains the designer, laughing. Sometimes even time itself escapes from its stringent parameters and enjoys the freedom Alain Persouyre has sought for so long. ■

# BACK ON STREAM AFTER 58 DAYS

As a source of cooling water and hydroelectric power, the Alz Canal is the lifeline of WACKER's Burghausen site. The canal has now undergone its first full renovation in 100 years, and the canal bed now incorporates a WACKER innovation: self-filling concrete.

It was like open-heart surgery," recalls Michael Stauber, one of the engineers responsible for maintaining infrastructure at the WACKER site in Burghausen. He was describing the late-2016 renovation of the roughly 17-kilometer Alz Canal – the lifeline of the largest WACKER plant in the world. "We use the water for cooling our chemical plants, for example, which allows us to cover 70% of our cooling needs," the engineer explains. The canal also delivers 10% of the electrical energy consumed at the Burghausen plant: before plunging into the Salzach river some 60 meters below, the canal water passes through the Alzwerke hydroelectric power plant. The difference in height between the Alz and the Salzach – and thus the ability to generate hydroelectric power – was actually the reason why WACKER decided to build its chemical production facility in out-of-the-way Burghausen in 1916. The average annual output of the Alzwerke remains impressive to this day: this on-site hydroelectric power plant generates 266 million kilowatt hours of electricity each year – enough to power about 90,000 households, or a medium-sized city. If needed, the Alz Canal also provides the plant fire department with water for firefighting. The site's hydrants are supplied with water from the canal as well.

"After nearly 100 years in operation, however, the canal bed, the tunnels and the buildings were all showing extensive signs of age," Stauber explains. Algae had colonized the concrete walls over the decades, reducing the flow rate and hence the performance of the canal, but that was not the only issue: the building fabric had also suffered a great deal from the elements. "The structural components are nearly 100 years old, but repairs in recent decades have largely just been local," notes the WACKER engineer. "The



In 2016, the Alz Canal was completely drained for the first time since it first came into operation in 1922, and was closed down for 58 days.

The Alz Canal is an important lifeline in the region – not just as a source of energy and cooling water. For its shutdown, 3.8 metric tons of fish were fished out and relocated to the Alz river.

asphalt lining applied in 1984 only covered four kilometers of the channel. Large areas of spalling, defective coatings and rotten bits of old formwork made comprehensive renovation an absolute necessity.”

The 2016 Alz Canal renovation was a mammoth project, both for the maintenance team and for the WACKER Group as a whole – one that presented many challenges. During the construction phase, the canal would have to be drained and completely shut down, but industrial operations needed to continue unaffected. And, at just 10 weeks, the construction time frame was extremely tight, especially given that the canal was filled throughout the entire nearly four-year planning phase.

#### NEW TECHNOLOGY EMPLOYED

Whereas Stauber and his team had to keep their eyes on the big picture, WACKER applications engineer Klaus Bonin and his colleagues focused on a relatively small area to be renovated. “Last year’s comprehensive restoration of the Alz Canal gave us an opportunity to use a brand-new technology that we’d developed, and test it under real-life conditions,” Bonin recalls. As the chemical engineer explains, “We renovated an area of roughly two square meters with what is known as a self-filling concrete compound, or SFCC.” SFCCs can only be formulated with the aid of

dispersible polymer powders – the field in which Bonin and his laboratory assistants, Peter Raucher and Christine Köster, specialize.

“The idea of developing a self-filling concrete compound came from Indonesia. Researchers there were looking for a simple, quick-drying technology for making relatively small road repairs,” the engineer recalls. “The timeframe for blocking off roads and restoring the road surface is usually small.” Customized dry-mix mortars modified with dispersible polymer powders meet those constraints. Unlike traditional concrete, which is transported as a prepared, ready-to-pump mixture of cement, additives and aggregate stone, this product is handled somewhat differently: the desired filler aggregate (pebbles or crushed rock) is separate from the cementitious binder – in this case the dry-mix mortar. At the construction site, the stone is first spread out on the prepared section of roadway, after which the dry-mix mortar is then combined with water as directed and poured over the layer of gravel. “The compound then fills in all the gaps between the rocks and binds them into a solid layer of concrete. Depending on the formulation, the system sets very quickly – sometimes in even less than an hour if requested. We can adjust that to the customers’ precise specifications,” Köster explains. “Since the pieces of

crushed stone are packed close together, you end up with a strong bond after just a short period of time.”

The key issue is for the SFCC to have the right flow characteristics – the right rheology, in other words. Using VINNAPAS® 7016 F dispersible polymer powder from WACKER meets that requirement: “It gives us a really unique rheological profile – one you can’t get with conventional flow improvers,” Bonin explains. “After all, you

“We had estimated 70 days for the renovations, but we brought the canal back on stream on October 26, 2016 – after just 58 days.”

Michael Stauber, infrastructure repair engineer at WACKER



**7.5 million m<sup>3</sup>**

When the canal is completely filled, 7.5 million cubic meters of water flow through it each day, a figure corresponding to roughly three times the volume of the Pyramid of Cheops.

**1922**

Built between 1916 and 1922, the Alz Canal began operations in December 1922.

**400**

At peak times 400 people were working on the canal around the clock.

**58 days**

The Alz Canal had to be completely shut down for 58 days for the renovation work, although 70 days had been planned for the project.

**2012**

Planning for the restoration project began in June 2012.

**3.8 t**

80 people worked for 22 hours catching fish with a total weight of 3.8 metric tons, and transferring them to the Alz river.

**€41 million**

€45 million were budgeted for the restoration. The repairs actually cost only €41 million.

**2 days**

The work of draining the Alz Canal began on August 27, 2016, and lasted for two days.

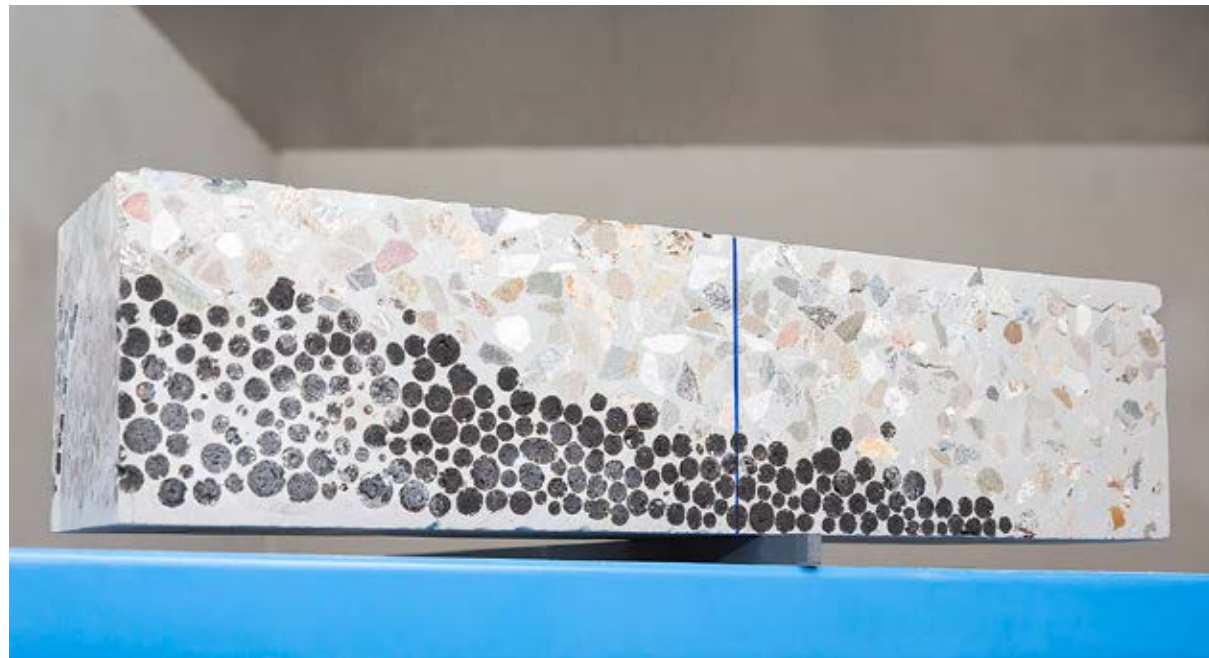
**6,000**

To renovate the two tunnels, workers drilled 6,000 holes and pressure-injected 1.6 million liters of a cement-bentonite suspension.

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Lab model made of functionally graded concrete. The dots on the test specimen describe the density of the particular element. SFCC allows a part with low (left) and high density (right) to be produced in one step.

don't want the liquid mixture to flow too slowly or too quickly through the pebble structure. If the formulation is not intrinsically stable, if it solidifies too early or forms air bubbles, then it won't work the way it's actually supposed to – and that will jeopardize the stability of the entire concrete structure.”

**RECYCLING WITH CONCRETE**

One advantage of the new WACKER development is that stones that have broken loose or

other solid recyclable materials can be crushed and then mixed with the SFCC, allowing old construction materials to be immediately incorporated into a project. “Since our modified dry-mix mortar can be mixed with water on site, using SFCC allows us to recycle materials right on the construction site. That reduces the amount of new construction materials that we have to transport,” says Köster.

The VINNAPAS® product line includes a large number of different polymer dispersions

and spray-dried powders. As co-binders in cementitious dry-mix mortars, these products improve adhesion, flexibility and workability – and, in the case of SFCC, deliver outstanding flow properties. “That means we can even apply concrete around a corner, which we hadn't been able to do before now,” says Bonin, pointing to a V-shaped Plexiglas tube. The hard, vinyl-acetate-based VINNAPAS® 7016F dispersible polymer powder used here offers ideal technical properties for this application due to its specific rheological profile. The WACKER experts have cleverly modified the SFCC formulation in order to keep friction between the cement particles very low, increasing their mobility and making the mixture extremely flowable.

Laboratory studies back that up: when SFCC is introduced into one end of a V-shaped tube filled with aggregate, the fine concrete particles slowly flow down one end of the tube to the bend and then rise up to the other end. As a result, the entire V-shaped element quickly fills with the self-filling concrete compound and then sets. What this means is that adding water causes the cement to harden, forming long, filamentous crystals, that interlock to form a stable



Self-filling concrete technology has the big advantage of being a low-cost solution for filling large areas.

“Last year's comprehensive restoration of the Alz Canal gave us an opportunity to use a brand-new technology that we'd developed, and test it under real-life conditions.”

**Klaus Bonin**, applications engineer, WACKER POLYMERS

network – a hardened cement that is no longer water soluble. This in turn binds all of the components, up to and including the largest pebbles, into a solid object.

The dispersible polymer powder also plays an important role in the curing process. “The cement first reacts with the protective colloid and deactivates it,” Köster explains. “Only then can the polymer particles form a waterproof film. The result is what are known as resin domains, which act as an additional binder reinforcing the cement,” says the WACKER expert. SFCC also offers another major advantage over traditional concrete: it is virtually shrinkage-free – the volume, in other words, does not change and the workpiece does not contract. “Concrete generally shrinks by roughly one to two percent. The longer the component, the greater the effect,” Bonin explains. “With this new system, the granulate stones are right up against each other. So in our sample application, the filled spaces in between are at most a centimeter long – and shrinkage is correspondingly low. It hardly enters into the equation at all.” This also prevents stress or cracks from arising in the component.

**TESTS ON NEW APPLICATIONS**

WACKER experts Bonin and Köster already have a number of ideas for their SFCC, one of which is in their lab: a home-made gabion. A gabion is a rock-filled cage used as reinforcement, visual screens and noise abatement in landscape architecture and in the construction of roads, paths and waterways. “Our application allows us to dispense with the wire cage without sacrificing the structure of the gravel. All we need is a mold, which we can just remove when we're done,” says Bonin. SFCC is also useful in the urban mining process, in which construction waste in densely populated cities is reused for building projects. Here SFCC is suitable for what is known as functionally graded concrete, in which lightweight elements such as expanded clay are integrated into the concrete to produce different densities and to allow for more sustainable construction practices. The two experts agree: “You could say SFCC is a diamond in the rough that we can use in many more innovative construction applications.”

The water from the Alz Canal has since begun flowing over the SFCC and putting its stability to the test. The mammoth Alz Canal restoration project is now finished – and much earlier than planned. “We had estimated 70 days for the renovations, but on October 26, 2016 – after just 58 days – we were able to bring the water back,” Stauber points out. “The internal and external employees on our team all did a great job of working together. We made the most of every minute and everyone involved was really committed.” The Alz Canal was filled with water within a day and the WACKER lifeline was fully restored – at least until the next renovation project somewhere in the distant future. ■




The SFCC technology was developed and tested in the WACKER lab.

**MORE**

During the construction phase, a journal with text, pictures and video clips was kept (German-language link only).

[https://www.wacker.com/cms/de/wacker\\_group/wacker\\_facts/sites/burghausen/alzkanal.jsp](https://www.wacker.com/cms/de/wacker_group/wacker_facts/sites/burghausen/alzkanal.jsp)



Nanoscale measurement of the Shore hardness of a non-postcured baby bottle nipple made of ELASTOSIL® LR 5040. The properties offered by the new liquid silicone can generally only be achieved by standard silicone rubber grades after thermal post-treatment.

## MORE PRODUCTIVE WITHOUT POSTCURING

When baby bottle nipples, pacifiers, ketchup bottle metering valves and seals for medical devices are made of conventional silicone rubber compounds, they need to undergo subsequent heat treatment before they can meet legal requirements. A new generation of liquid silicones eliminates this complicated process step for many injection-molded articles.

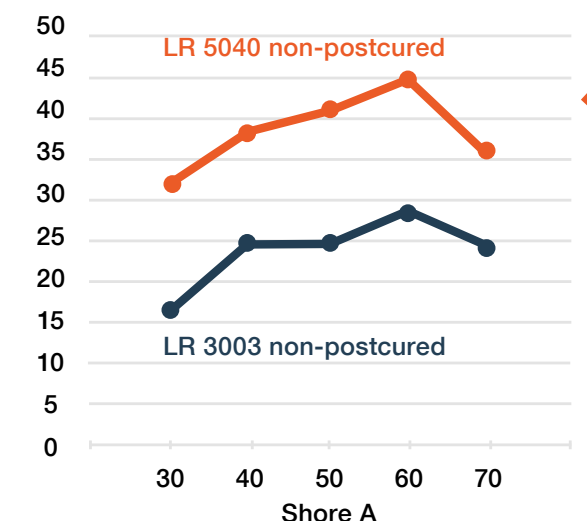


Baby bottle nipples must put up resistance even when toddlers bite on them vigorously with their milk teeth. It is precisely the act of biting that is simulated in the EN 14350-1 bite test: a bottle nipple into which a small incision has been made must be able to withstand a tensile force of 9.5 kilograms for ten seconds.



In a non-postcured state, ELASTOSIL® LR 5040 (orange curve) features significantly higher tear strength than standard liquid silicone rubber (blue curve). Injection-molded parts made of ELASTOSIL® LR 5040 thus do not require thermal post-treatment to improve their mechanical properties.

TEAR STRENGTH / N / mm<sup>[a]</sup>



One reason why the thermal post-treatment of cured rubber products is so complicated for silicone processors is that – unlike the injection molding and packaging of the articles – it is still performed mainly by hand. Filling and emptying the postcuring ovens is usually a manual task and baking out the silicone parts often takes several hours. Postcuring thus interrupts the process chain and limits production capacities.

applications. This is good news for processors. In many cases, the postcuring step that is currently necessary for certain applications will no longer be required (see box on p.84). “ELASTOSIL® LR 5040 not only makes considerable cost savings possible, but also continuous, fully automated production. And if need be, manufacturing can take place entirely in a cleanroom environment,” emphasized Frese.

**TESTED TO THE EXTREMES**

The WACKER developers extensively tested the various degrees of hardness offered by the new ELASTOSIL® LR 5040 line as regards their processing properties and those of the end part. The main question was whether the cured rubber products would achieve the ambitious goals.

“We put the new product line through its paces during injection molding and our internal results show that the liquid silicones can be processed superbly,” explained Klaus Wenzels, head of the WACKER SILICONES injection-molding pilot plant in Burghausen.

Liquid silicone rubber – still a relatively young class of materials – has become firmly established on the market. It is processed into molded parts via fully automated injection molding. In this way, silicone articles can be produced in large quantities – quickly, efficiently and with high precision.

In many cases, processors must postcure the injection-molded parts. That entails heating the molded parts at temperatures of up to 200 °C in a well-ventilated oven. This thermal post-treatment (see box) improves the

mechanical properties of the elastomer and ensures the removal of volatile silicone components that may arise as byproducts during the manufacture of silicone polymers.

European regulations stipulate postcuring particularly for silicone articles used in the baby-care, food and medical sectors. In the first two cases, the volatiles content must not exceed 0.5%. This limit is cited in Recommendation “XV. Silicones” of the German Federal Institute for Risk Assessment (BfR), the French decree of November 25, 1992, Swiss Ordi-

nance on Food-Contact Materials and Articles 817.023.21, and in standard EN 14350-2, applicable to infant and toddler drinking equipment, and EN 1400, which applies to pacifiers. As a measure of the volatiles content, the various regulations use the weight loss of silicone articles as a result of undergoing a specified heat treatment (4 hours at 200 °C in many cases). Dried samples of the molded parts must not lose more than 0.5% of their mass during this treatment. Only in their postcured state do the cured products

of conventional liquid silicone rubbers comply with these regulations.

**NO MORE COMPLEX POSTCURING**

“Although postcuring is a labor-intensive process step that costs time and money, it has so far been necessary in sensitive applications. If postcuring is left out, silicone processors can increase their productivity considerably,” explained Claudia Berghammer, marketing manager for silicone rubber compounds at WACKER SILICONES.

Hardness levels of between 30 and 70 Shore A are currently available, including a 45-Shore-A grade suitable for numerous applications in the baby care sector. Contrary to conventional silicone rubber, the specified hardness values refer to the non-postcured state here. For ELASTOSIL® LR 5040, they are achieved with a particularly narrow tolerance of 3 Shore A points. This allows processors to react to their customers' hardness requirements with high precision.

WACKER's technical service engineers initially checked the volatiles content via weight-loss measurements as per the method recommended by the BfR for food applications. Tests were carried out on non-postcured, two-millimeter-thick test plates. The weight loss was less than 0.4% for all grades and was thus clearly below the 0.5% limit.

Tests as per EN 14350-2, which applies to infant and toddler drinking equipment, also resulted in weight losses of less than 0.4%.

#### DEFINED UPPER LIMIT

For silicones used in sensitive applications, numerous laws and standards specify upper limits for extractable or migratable constituents as well. Specifications for this can be found, for example, in regulation CFR 21 § 177.2600 of the US Food and Drug Administration (FDA), in Section 3.1.9 of the European Pharmacopoeia, in BfR Recommendation "XV. Silicones" and in legislation issued by several EU member states. ELASTOSIL® LR 5040 in its non-postcured state complies with these requirements, too. Furthermore, the non-postcured rubber products of the new liquid silicones are biocompatible as per the

Dr. Thomas Frese, head of Technical Marketing in WACKER SILICONES' Rubber Solutions team, and Julia Demmelhuber show a baby bottle nipple made of ELASTOSIL® LR 5040.



# 9.5 kilograms

That is how much tensile force a baby bottle nipple must withstand for ten seconds during a simulated bite test.



specifications of United States Pharmacopeia (USP) Class VI and ISO 10993.

The new liquid silicones' claim of being especially pure is also underlined by their optical appearance: they are translucent and have a pale blue sheen. The molded parts made from them leave an impression of particularly high quality and purity. The unwanted yellowing that can sometimes be observed in conventional, postcured liquid silicone articles during storage was kept to a minimum in the case of the new range of grades.

In many sensitive applications, the demands are high with regard to not just purity, but also

the mechanical properties. For articles such as baby bottle nipples, pacifiers, teething rings and other baby care items, the silicone must be tough enough so that infants and toddlers cannot bite off small pieces.

#### EXCELLENT TEAR STRENGTH

Baby care articles can only achieve the necessary bite resistance if the material has sufficiently high tear strength. Small cracks must not get bigger whenever loads are applied to the rubber. "Our novel liquid silicone rubber grades perform well here, too," explains Frese, the chemist responsible for product

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development. Cured rubber products made of ELASTOSIL® LR 5040 already possess tear strengths of up to 45 newtons per millimeter in their non-postcured state (measured as per ASTM D 624 B). Conventional liquid silicones generally only achieve such values after post-curing. For example, a cured silicone made of ELASTOSIL® LR 3003 with a hardness of 50 Shore A has a tear strength of 24 newtons per millimeter in its non-postcured state. After four hours of postcuring at 200 °C, the value increases to 30 newtons per millimeter. The same silicone part made of ELASTOSIL® LR 5040 with the same hardness, on the other hand, achieves 40 newtons per millimeter without any thermal post-treatment.

#### HIGH-HEAR-STRENGTH GRADES

Nevertheless, this was not enough for Frese and his team. They also wanted to know how the new silicone behaves in selected baby care applications. To do so, they performed a simulated bite test as per EN 14350-1 with injection-molded ELASTOSIL® LR 5040 bottle nipples. First, they made a small, defined incision in the nipples and then stretched them lengthways. Here, the nipples must be able to withstand a tensile force of 9.5 kilograms for 10 seconds. In these WACKER-internal tests, non-postcured nipples made of the 45- and 50-Shore-A grades performed particularly well; none of the reference nipples failed in the bite tests conducted with the nipple geometry in use. On the contrary, in several cases, the new grades even achieved better results than standard high-tear-strength LSR market products that are subsequently postcured.

ELASTOSIL® LR 5040 has other impressive features as well. In their non-postcured state, the highly elastic, cured rubber products already exhibit “snap,” i.e. when the deformation load is removed, the deformed article returns to its original shape within a

**“ELASTOSIL® LR 5040 not only makes considerable cost savings possible, but also continuous, fully automated production. And if need be, manufacturing can take place entirely in a cleanroom environment.”**

**Dr. Thomas Frese**, Head of Technical Marketing, WACKER SILICONES

split second. ELASTOSIL® LR 5040 can also be used to manufacture slotted valves, which are needed, for example, in anti-colic valves for baby bottles. The slots remain open under standard conditions even when not post-cured. In contrast, the cut surfaces of cured

rubber products made of conventional liquid silicones tend to close up or heal in their non-postcured state, which impairs valve functioning. Experience has shown that this effect can be considerably lessened by using ELASTOSIL® LR 5040. ■

#### POSTCURING

In the materials sciences, the term “postcuring” generally refers to a heat treatment that provides a material with its end properties. This also applies to silicones.

The technical properties of postcured silicone parts are often superior to those of non-postcured articles. In the case of cured products of addition-curing silicone rubber compounds, which include liquid silicone rubber, postcuring degrades excess curing agent, improves the bonding of the fillers and removes low-molecular-weight residues. After postcuring, many silicones possess a slightly higher level of hardness, significantly enhanced tear strength and a lower compression set. The established standard method is four hours’ postcuring of silicone articles at 200 °C in an oven especially designed for this purpose with a correspondingly high air throughput. Since the entire volume of air that flows through the oven has to be heated to 200 °C, postcuring consumes a lot of energy, making it cost-intensive.

# “Fully Automated Processes”

WACKER Manager Christian Gimber talks about the trend toward liquid silicone rubber that can be processed without postcuring.

**Liquid silicone rubber compounds are indispensable in many applications nowadays. For what application fields are they particularly interesting?**

Liquid silicone rubber, or LSR for short, makes cost-effective, large-scale production of silicone articles possible, while very fine, intricate parts can be fabricated with high precision, too. LSR grades are available in any color; there are even highly transparent ones. All this makes liquid silicones particularly interesting for applications in medical technology and the automotive industry.

**What trends can you observe with regard to liquid silicones?**

LSR processors are under mounting pressure to increase their productivity and cost efficiency further. Hence, a streamlined and fully automated manufacturing process is at the top of their wish list. This is currently hindered by the postcuring process step, in particular. That’s why the future belongs to liquid silicones that can be processed without postcuring. What’s more, the demands placed on product quality are getting tougher. Processors increasingly expect product specifications to be met with extremely low tolerances, even from batch to batch. The trend toward tailor-made specialty products that meet specific requirements, for example in the automotive industry or in medical technology, likewise continues apace.

**As part of a product upgrade, WACKER will further lower the volatiles content of its LSR portfolio. Can you explain why WACKER is carrying out this upgrade?**



Christian Gimber is in charge of WACKER’s Engineering Silicones business unit.

The raw-materials sector has to meet ever tougher legal as well as industrial requirements. For instance, stricter and stricter regulations are being issued, especially as regards the amount of volatiles. This is a challenge for the entire chemical sector and affects liquid silicone rubber grades, too. In this respect, the trend is mainly being driven by the baby care and food markets, but it is also supported by the automotive industry. What’s more, the reduction in volatile components positively impacts the properties of injection-molded liquid silicone rubber

articles. That’s why we decided to optimize our LSR portfolio and reduce the amount of volatile substances significantly. Thanks to cutting-edge production technologies now in use, we are able to go well beyond legal stipulations. We are thus meeting tougher challenges, which immediately benefits our customers in a variety of ways.

**The new ELASTOSIL® LR 5040 product line is characterized by its lower content of volatile substances. What makes it different from other products? What was the reason for the new formulation?**

Particularly strict regulations apply to the materials used in the baby care and food sectors. Injection-molded parts made of our liquid silicone rubber already meet the limits, but require suitable postcuring to do so. Many customers, however, would like to do without this process step, as the thermal post-treatment is work- and cost-intensive and lowers the productivity of the entire manufacturing process. That’s why we developed ELASTOSIL® LR 5040. The product line represents a new generation of liquid silicone rubber grades that have been devolatilized particularly well and which no longer require thermal post-treatment, even when intended for use in sensitive areas. This makes streamlined processes and highly efficient, fully automated production possible, which is a big advantage for our customers.

ELASTOSIL® R plus 4350/55 combined with heat stabilizers offers long-term stability up to 300 °C and can even withstand temperatures of 400 °C for short periods, making it suitable for applications such as oven-door profile gaskets.

## IN GREAT SHAPE – AT 300 °C

Heat-resistant elastomers are increasingly part of our daily lives – especially in household appliances. WACKER has responded to rising demand with a new addition-curing solid silicone rubber that pushes heat resistance to the limits of what is feasible.



Dr. Christian Anger, head of an applications laboratory for silicone rubber at WACKER in Burghausen, makes a selection from a number of test pieces undergoing heat-resistance testing.

profiles and hoses made from ELASTOSIL® R plus 4350/55 even cope with several days' exposure to temperatures of up to 300 °C," explained Dr. Christian Anger, who is the technical marketing manager in charge of developing these silicone grades. "Their mechanical properties remain stable far longer than those of standard silicone elastomers," he noted. "They are less prone to becoming brittle and maintain their elasticity even at exposure to 300 °C over 150 hours."

#### FOOD-SAFE SILICONES

ELASTOSIL® R plus 4350/55 crosslinks by means of a platinum-catalyzed addition reaction and can be readily processed by extrusion into hoses or profiles. As crosslinking does not generate any by-products that could affect odor or taste, the industry is showing growing interest in these heat-resistant solid silicones, particularly in the case of food-sector applications – another area where ELASTOSIL® R plus 4350/55 postcured rubber grades are suitable for use. These products meet all of the relevant requirements of the German Federal Institute for Risk Assessment (BfR) and the US Federal Food and Drug Administration, and are therefore considered safe for use in foods.

**M**anufacturers of household appliances are experiencing an ever rising demand for ovens with more sophisticated features. Multi-functional appliances with an integrated microwave or steamer, or a self-cleaning function, for example, are gaining popularity. All these extras require more robust gaskets with extraordinarily high heat resistance, given that even standard ovens already heat up to 250 °C.

#### STABLE DESPITE HIGH TEMPERATURES

Consequently, materials must satisfy higher demands on their heat resistance. "Rubber-elas-

tic components, for instance, need to withstand temperatures of 300 °C much more frequently and for increasingly longer periods," said Dr. Martin Bortenschlager, senior marketing manager responsible for silicone elastomers at WACKER SILICONES. "Organic rubbers often throw in the towel at over 100 °C. They simply cannot cope with these kinds of conditions." Even conventional silicone elastomers reach their limits if they aren't designed to do so by the incorporation of suitable heat stabilizers.

For this reason, WACKER has developed a solid silicone rubber that, combined with the right heat stabilizers, can withstand high temperatures even for long periods. "Continuous



In addition to heat, oven-door gaskets are also exposed to other influences: they have to be resistant to splattered grease, as well as meat and fruit drippings, and the remains of food that has boiled over.

A specific design means that the oven doors and adjacent surfaces are largely protected from heat and food residues. Nevertheless, inevitably, dirt will accumulate on the profile gasket between the oven chamber and oven door

and the gasket will heat up during use. In some places, the gasket can temporarily reach temperatures up to 400 °C – much too high for traditional elastomers.

Up until now, oven manufacturers have generally used a tubular gasket made of woven fiberglass that is reinforced on the inside with wire mesh. The mesh supports the inside of the tube and gives the gasket the necessary resilience. In principle, the two materials can with-

stand the extremely high temperatures that may arise during use. However, such gaskets wear out quickly when used on a day-to-day basis. The repeated opening and closing of the oven door causes the wire mesh to lose its shape and therefore its ability to provide support.

#### AN ALTERNATIVE TO FIBERGLASS

During baking and cooking, the woven fiberglass absorbs grease-laden vapors, which condense,

become rancid and solidify over time. This causes the mesh to harden and the gasket becomes brittle. Because fiberglass gaskets are difficult to clean, they eventually become an eyesore.

A high-quality alternative to fiberglass gaskets are door profile gaskets made from ELASTOSIL® R plus 4350/55. “They withstand both heat and

greasy fumes,” added Bortenschlager. Tests also reveal that silicone profiles are better thermal insulators than fiberglass gaskets. “Oven owners enjoy double the benefits,” he explained. “The oven door doesn’t get as hot and the oven loses less heat, which reduces the energy required when cooking and thereby also the energy costs.”

Extrusion of a gasket profile made of the new ELASTOSIL® R plus 4350/55 solid silicone rubber: hoses and profiles made from the new silicone are extremely heat resistant, retaining their elastic properties for a long time even at high temperatures.



### INTEGRATED STEAMER

Consumers increasingly want ovens with an integrated steamer. These appliances combine the advantages of steam cooking – an especially gentle method for cooking vegetables, for instance – with the capabilities of traditional ovens. However, steam cooking is also challenging for silicone gaskets: the steam can split the polymer chains of the silicones, which causes the elastomer to lose elasticity and strength.

The new solid silicone improves performance here, too. During a series of tests, gaskets made from ELASTOSIL® R plus 4350/55 were exposed to steam heated to 250 °C. After 28 days, elongation at break for the silicone gaskets was over 100% and the Shore A hardness increased by less than 15%.

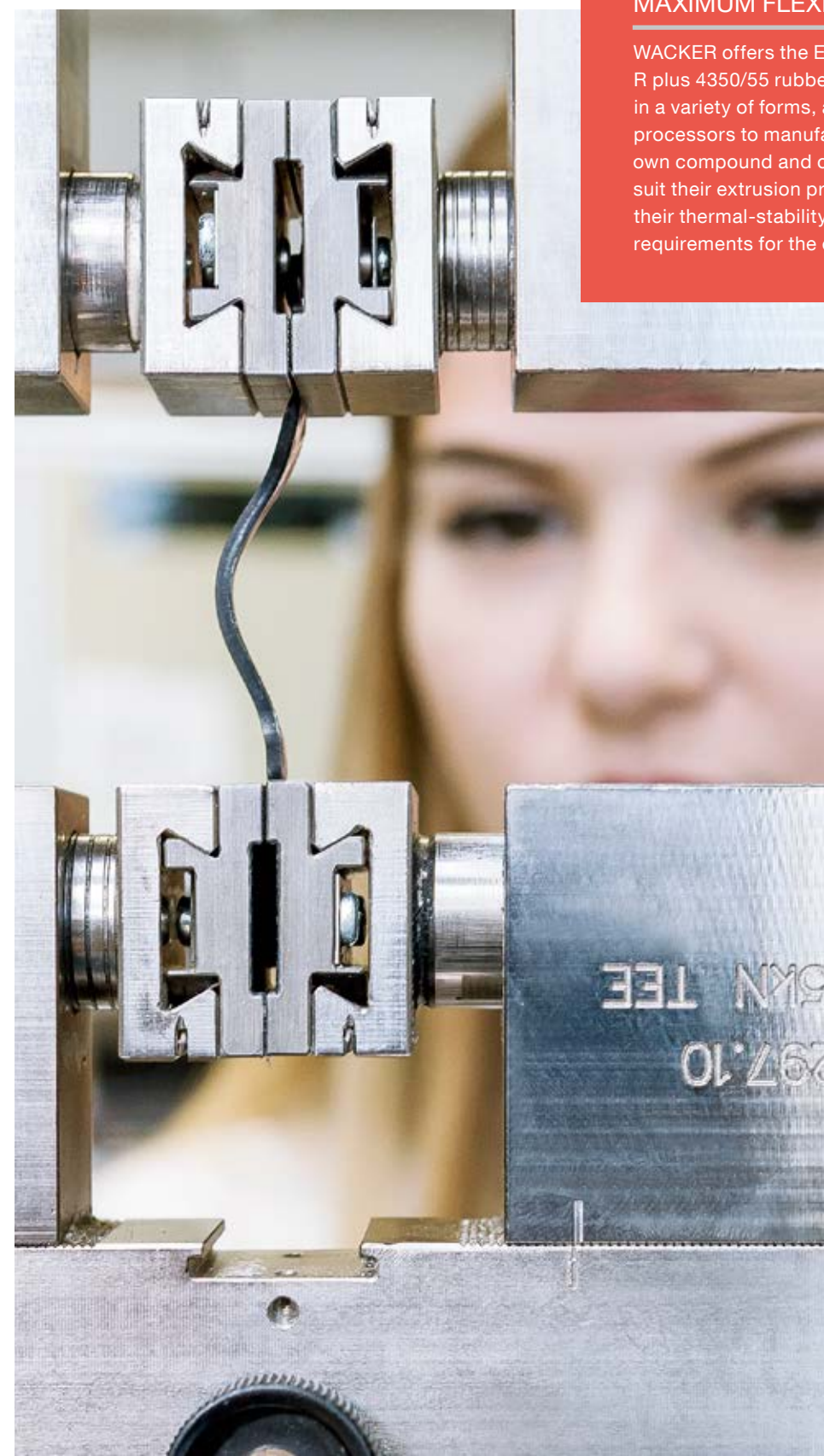
### HEAT STABILIZER NEEDED

To achieve maximum thermal stability, a suitable heat stabilizer needs to be added to the colorless, translucent base rubber compound. The type of heat stabilizer and the amount added dictate the maximum thermal stress that the silicone can withstand. The color of the cured rubber is also determined by the choice of additive. Incorporating the carbon black-based heat stabilizer ELASTOSIL® AUX H3, ELASTOSIL® R plus 4350/55 withstands temperatures of 300 °C, for instance, significantly better than standard heat-stabilized silicones. Even after several days of thermal stress, the new grade is superior to other silicones in terms of its mechanical properties.

“In regard to heat resistance, our new product pushes addition-curing solid silicones to the

### MAXIMUM FLEXIBILITY

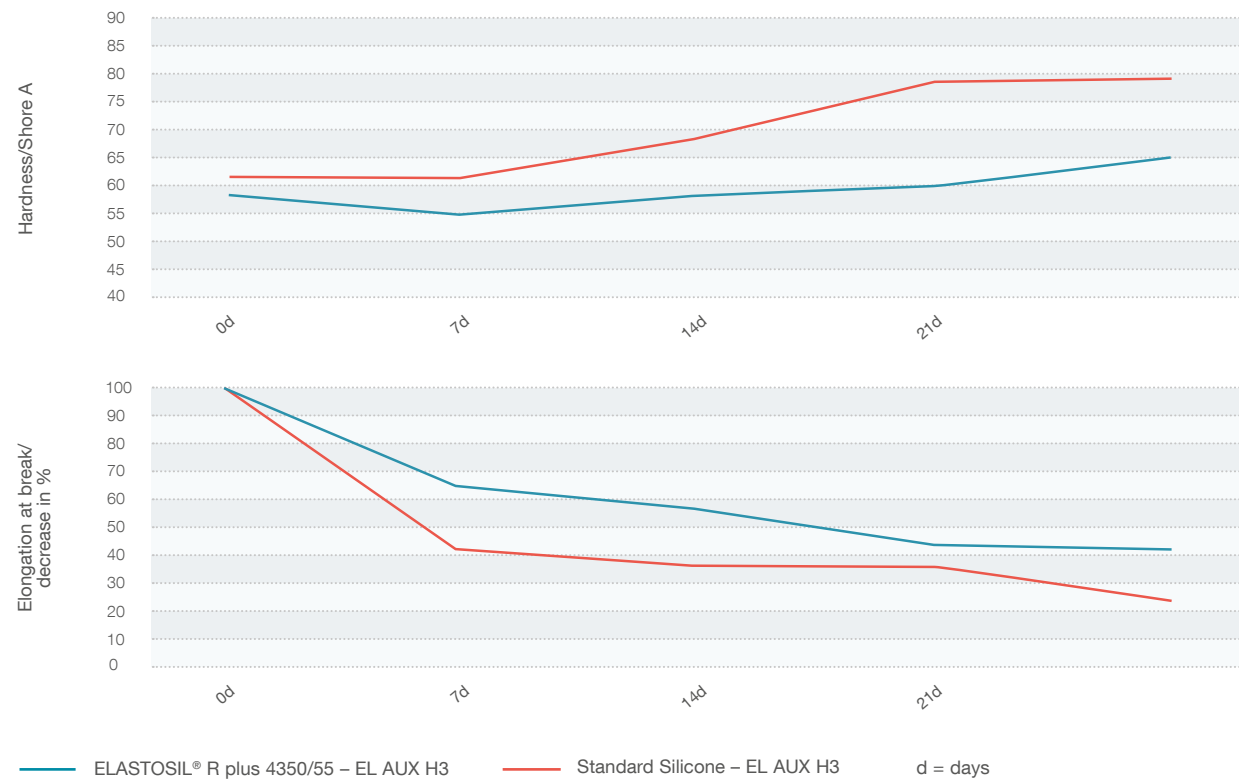
WACKER offers the ELASTOSIL® R plus 4350/55 rubber blend in a variety of forms, allowing processors to manufacture their own compound and optimize it to suit their extrusion processes and their thermal-stability and color requirements for the end product.



limits of what is technically feasible,” said Anger. “Measurements in our lab also show this.” Cured rubbers made from ELASTOSIL® R plus 4350/55 were exposed to temperatures above 220 °C for 2,000 hours with the temperature being gradually increased to 300 °C. The mechanical properties of the silicone were measured before and after heating: WACKER chemists simulated the temperature stress that an oven-door profile gasket is exposed to over a period of ten years.

The tensile test shows that ELASTOSIL® R plus 4350/55 is far superior to other silicones in terms of its mechanical properties and heat aging.

## MECHANICAL PROPERTIES AFTER CUMULATIVE THERMAL EXPOSURE FOR 650 HOURS AT DIFFERENT TEMPERATURES



Tests conducted at 275 °C over 650 hours showed an increase in hardness of 8 Shore A. By contrast, an addition-curing, heat-stabilized standard silicone exhibits a Shore A increase of 18. Heat-stabilized standard silicones also have a significantly lower elongation at break: the relative decrease for ELASTOSIL® R plus 4350/55 is around 55%, while the decrease for standard silicones is 75%.

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### LESS AGING

During these high-temperature conditioning tests, the hardness in the new solid silicone increased from an initial 55 to 75 Shore A. “This guarantees functionality,” explained Anger. “Standard heat-stabilized silicones harden at substantially lower thermal stress, and they harden much more.” The elongation at break, which allows researchers to make inferences about the gasket’s flexibility and durability, like-

wise barely changed in the new material, falling from an original value of 400% to 175%.

The standard heat-stabilized silicone, on the other hand, was so brittle after high-temperature conditioning that it could no longer be stretched. “ELASTOSIL® R plus 4350/55 offers processors an extrudable solid silicone rubber that combines the benefits of addition-curing with unprecedented thermal stability,” he concluded. ■

## IDENTIFYING DRUMS WITH BARCODES

WACKER and Austrian machine manufacturer ELMET maximize reliability in silicone injection-molding processes.

A systems supplier for all types of injection-molding processes involving liquid silicone rubber, the ELMET company – based in Oftring, Austria – has now taken another step toward perfecting the reliability of its operations. With support from WACKER, ELMET has developed a standardized barcode system for labeling and identifying drums – one that eliminates the risk of mixing up the A and B components when the similar-looking drums are being exchanged. Not only is this solution more reliable than any before it, but it is also unlike any other in the world. As simple as it is efficient, the innovative idea can provide the entire industry with a dependable way of putting an end to an error that, while uncommon, has extremely severe consequences.

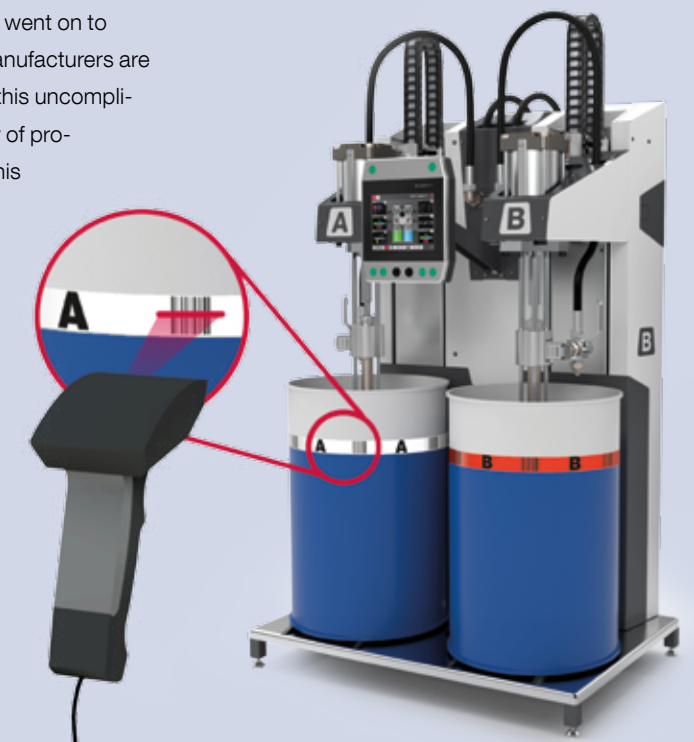
WACKER drums will now have wrap-around labels that, in addition to the traditional A or B designation, will also bear barcodes. And effective immediately, ELMET will be supplying its TOP 5000 P high-performance dosing system with the optional extra of a reader designed specifically for the new labels. The TOP 5000 P control unit will not release the pump to dip into the new drum until it recognizes the correct code. While the reader is currently designed as a hand scanner, it will be followed by a height-adjustable, built-in model as soon as this impressive error-prevention system has become widely accepted. Until that time, ELMET is offering a corresponding adhesive strip that can be applied in the incoming goods department as an alternative. “It’s

surprising how often less-than-ideal conditions lead employees to confuse drums of component A with those of component B, despite the fact that the drums are labeled,” explained Helmut Gaderer, sales manager at ELMET. “If operators then start up the machine, the system will have to be shut down and undergo extremely time-consuming cleaning procedures, potentially resulting in production downtime of up to 24 hours.” The resulting losses for the processor are immense. “The idea that we’ve now implemented with WACKER’s help prevents that from happening and is exceptionally reliable,” he said.

The ELMET manager then went on to observe how other silicone manufacturers are now being called on to adopt this uncomplicated coding system as a way of protecting their customers from this specific mistake. “We have intentionally refrained from patenting our solution in the hopes that our idea will quickly gain universal acceptance for the benefit of all of the liquid silicone processors on the market.”

The ELMET TOP 5000 P multicomponent dosing system equipped with the new scanner has been designed for the large-scale production of high-quality

parts. The system is suitable for shot weights ranging from less than 0.1 grams to up to several kilograms, for 200 L and 20 L drums, for material viscosities of 9,000 mPa s to 3,000,000 mPa s, and even for cases when the viscosities of the A and B components differ significantly. Its two control loops work independently from one another to empty 99% of the drum’s content and to control the volume of material fed into the process, making this system suitable even for tight process deadlines and difficult startup conditions.



# STILL STANDING TALL

Since the 11th century, Prunn Castle has perched majestically above Bavaria's Altmühltal valley. When cracks formed as moisture penetrated a limestone rock supporting the structure, injection mortar came to the rescue to repair the damage. With WACKER's dispersible polymer powder keeping moisture at bay, the castle can stand tall for another 1,000 years.







Pruhn Castle in Bavaria's Altmühltal valley is one of the oldest buildings managed by the Bavarian Palace Department. It underwent extensive renovation in 2007.

**P**ruhn Castle near Riedenburg in Altmühltal valley is an architectural masterpiece. Probably dating back to the 11th century, this is one of the oldest castles administered by the Bavarian Palace Department. The castle owes its fame to a manuscript of the Nibelungenlied (an epic poem) discovered in

1567 and now known as the Prunn Codex. It was built right at the edge of a steep limestone outcrop rising some 100 meters above the valley, a feat achieved before the advent of sophisticated construction techniques and building materials.

Binders were not unknown back in the 11th century. Alongside pure lime, the milk protein casein was used as well so that plasters and wall paint could adhere better to various surfaces. But these natural products, too, are exposed to the elements, so repairs to the castle were carried out periodically – most recently in 2007.

For two years, architects and construction workers collaborated with heritage conservationists in repairing and restoring the truss, masonry, foundation and facade – the total cost of the project was €2.7 million. Naturally, renovations were carried out with cutting-edge technology and the expertise of construction-material manufacturers' research and development staff.

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## DISPERSIBLE POLYMER POWDERS PROVIDE STABILITY

Dr. Wolfgang Hollweck, head of R&D at Rygol Sakret, a drywall construction-material manufacturer based in Painten, just a few kilometers away from the castle, was part of the team. He was the consultant when renovation work began on the stonework and facade in 2007. He was tasked with finding out how to fill the cracks in the limestone rock supporting the stair turret in the northern section of the fortress. As time passed, cracks formed in the rock, allowing water to penetrate it and if the water froze, sections of the rock could break off and put the houses at the foot of the mountain at risk. "Inspections on site and samples revealed that there were indeed safety concerns. Additionally, the stair turret could also have become unstable if large pieces of rock had broken off," recalled Hollweck, which is why they decided to treat the rock with an injection mortar. One way to



A limestone outcrop supporting the castle's stair turret was treated with injection mortar to protect it from the ingress of water.

close joints, cracks and cavities is to inject mortar into them using drill packers or adhesive packers. “We formulated RYGOL injection mortar IM 009 on the basis of semi-flexible VINNAPAS® 7220 E dispersible polymer powder from WACKER to guarantee the strongest possible adhesion,” he explained. The mortar had to rapidly create strong adhesion between the rock and the mortar; in other words, robust bond shear strength. Additionally, the filler’s adhesion properties ought to stand the test of time, regardless of weather conditions – frost,

thaw or severe rainfall. “The injection mortar had to seal the rock to preclude the ingress of water,” explained Hollweck. “We have many years of experience with WACKER’s polymer binders and quickly came to the conclusion that VINNAPAS® 7220 E combined with our cement was ideal for protecting such an exposed part of the rock from the effects of weathering.”

VINNAPAS® 7220 E, a dispersible polymer powder based on vinyl esters, ethylene and acrylate, features excellent tensile adhesive strength, especially after prolonged exposure

to water. “When VINNAPAS® 7220 E is added to injection mortar, elastic polymer bridges are formed between brittle mineral components as the mortar sets. These bridges significantly improve the adhesive properties on a variety of surfaces,” explains Dr. Hardy Herold, a senior technical service manager at WACKER’s Construction Polymers business unit.

#### HYDROPHOBIC OUTER SKIN

The drywall construction-materials manufacturer Rygol Sakret was also involved with the work on the facade. “We supplied the finishing plaster for the entire castle and decided on our HFS hydraulically setting plaster mortar, which reproduces the existing texture and appearance of the castle,” noted Hollweck. Here too, a WACKER VINNAPAS® grade based on different specialty monomers such as VERSA® 12 brand vinyl laurate played an important role.

It improves the adhesion and flexural strength of the mineral plaster on the substrate. The dispersible polymer powder enables the formulation of a particularly flexible plaster that neutralizes the tension between the different layer thicknesses. Since natural stones occasionally protrude from the plastered facade, which means that the plaster is applied quite thickly in the joints but in other areas where the substrate is uneven, the thickness falls short of the 15 mm minimum. Another challenge was the varying properties of the old plasters from previous renovation work in recent decades.

The VERSA® 12 brand vinyl laurate in the polymer powder combined with ethylene imparts a high level of elasticity to the plaster, making the coating particularly flexible, which is ideal for evening out the irregularities. “Especially in cases such as Prunn Castle where a high degree of elasticity is required,



The rock beneath the stair turret of Prunn Castle now withstands all weathering influences.



Dr. Wolfgang Hollweck from drywall construction-material manufacturer Rygol Sakret assessed the plaster in Prunn Castle 10 years after the renovation.

the quality of the binder comes into play,” says Herold.

Compounds modified with VINNAPAS® are also easier to process. Since it improves rheological properties, it can be applied with a machine – an invaluable advantage for vast surface areas such as a castle facade. The vinyl laurate in the dispersible polymer powder makes the plaster permanently water repellent, which in turn protects the masonry below from the ingress of water.

#### OLD YARDSTICKS, NEW MEANS

“Of course, we used state-of-the-art construction technologies for the renovation work to preserve the castle as far as possible with currently available means,” said Hollweck. “But we also made sure that the historical appearance remained authentic by using primarily regional raw materials.” Today, hundreds of years after it was built, the castle still dominates the landscape – its splendor restored, although a good ten years

have passed by since it was last renovated. One likely explanation lies in the recently introduced building materials: compared with many historic binders, polymers have the advantage of repelling water. As a result, moisture is unable to penetrate the masonry and damage it. Now WACKER’s innovative polymer binders provide lasting protection for Prunn Castle so that this architectural wonder can be enjoyed by many generations to come. ■



Finishing or filling plasters modified with water-repellent VINNAPAS® dispersible polymer powders improve weathering resistance and the longevity of buildings.



## SAY GOODBYE TO BITES

Summer is the season for mosquitoes. Mosquito repellents are one way of keeping the pests away from your skin, and cyclodextrins from WACKER make these products effective for much longer.

**W**ith single-minded determination, the mosquito buzzes its way to its next meal of blood.

Drawn magically to human perspiration and breath. “Insect antennae are extremely sensitive to lactic acid and carbon dioxide molecules, which is how they find the surface of our skin to bite us and suck our blood,” explains Dr. Ingo Jeschke, a chemist who heads up application technology for the pharmaceutical/agricultural business line at WACKER BIOSOLUTIONS. Whereas in temperate zones, mosquito bites are either just a nuisance or they cause an unpleasant itch, in regions near the equator, the pests represent a real threat, often transmitting life-threatening pathogens such as the Zika, dengue fever or yellow fever viruses, or the parasites that cause malaria. In order to keep the insects from coming near the skin in the first place, people who live in endemic regions rely on repellents. “The term encompasses any fragrant substances that are extremely unpleasant to mos-

quitoes,” says Jeschke. “If the creatures detect it through their sense of smell, it puts them off and will hopefully keep them from biting anymore.”

#### SPRAYS, EMULSIONS AND GELS

Available as sprays, emulsions and gels, anti-mosquito preparations range from natural repellents such as essential oils and plant

extracts – camphor and geraniol are two examples of these – to a variety of synthetic products such as highly effective diethyltoluamide (DEET). All of these active substances have one thing in common: in order to drive off insects, they have to be volatile and they have to evaporate off the skin. The odor molecules then accumulate in the surrounding air

**3,500**  
different species of mosquitoes  
can be found around the globe.

Cyclodextrins being tested in practice: to determine the release rates in a climatic chamber, a laboratory assistant at WACKER in Burghausen prepares each sample individually.



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#### MOLECULAR “DONUTS”

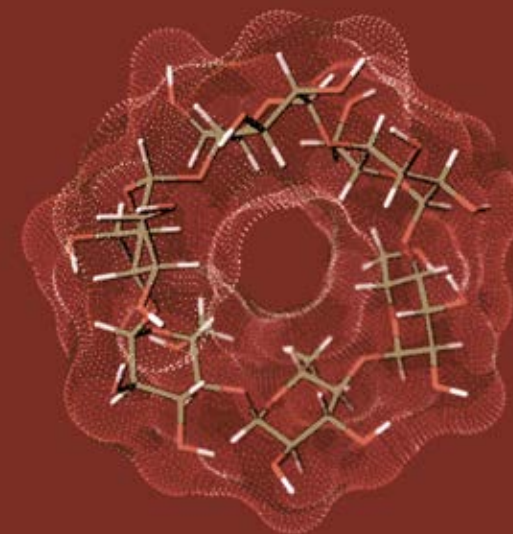
Cyclodextrins are composed of multiple glucose molecules linked together to form a ring. A distinction is drawn between alpha-, beta- and gamma-cyclodextrins depending on how many of these modules the compound contains (six, seven or eight units, respectively). The shape of cyclodextrins is reminiscent of a donut, with a central cavity that allows lipophilic, or fat-soluble, molecules to slip in and out as guests. That property makes cyclodextrins suitable for modifying or optimizing the properties of other substances, for instance by increasing solubility, improving stability and bioavailability, or reducing the volatility of chemical compounds. In addition to their use in the food sector, cyclodextrins are found in many other products and industries, such as household and personal-care products, pharmaceuticals, cosmetics, textiles and products for the construction industry. The sugar compounds are made using a biotech process in which starch, such as that found in corn or potatoes, is broken down enzymatically. Cyclodextrins are colorless, odorless and completely biodegradable.

to form an invisible envelope that protects the wearer from mosquitoes.

“The odor barrier only lasts for a certain amount of time, however,” says Jeschke. As the WACKER chemist explains, “Once the aromatic substance has evaporated, the repellent loses its effect and the bugs find their way back to human skin.” The duration of the effect depends on the insect repellent used and the actives it contains. “Today’s consumers have high standards for bug sprays: they should be highly effective, they shouldn’t have to be reapplied very often and they should provide protection for as long as possible,” says the WACKER expert, outlining the challenges that manufacturers face. To support them in their efforts, Jeschke and his team began looking into ways to solve the problem and found their answer in cyclodextrins. Cyclodextrins are oligosaccharides – sugar compounds, in other words – that are shaped something like donuts, with a molecular ring surrounding a cavity that can hold and then later release certain substances.

#### DELAYED RELEASE

“The idea came to us during a herbicide project,” Jeschke recalls. “In that case, our cyclodextrins slowed the release of the active substance, making the herbicide last longer.” The WACKER team attempted to extend that principle to repellents – and it worked: the researchers successfully made commercially available insect repellents effective for up to 80% longer. Their results were confirmed in laboratory tests conducted by the mosquito specialists at the Biogents company



When viewed under an electron microscope, a cyclodextrin molecule resembles a donut. The inside of this molecule can trap other substances, and the point at which they are re-released is staggered.



## The World's Deadliest Animals

The most inconspicuous animals in this list are usually the most dangerous – the various kinds of mosquito lead the way by a wide margin.

Source: WHO/Gatesnote

# 725,000

people die of mosquito-borne diseases each year, according to the World Health Organization.

Cyclodextrins are incorporated by being dissolved in the particular insect repellent formulation.



of Regensburg, Germany. These tests involved exposing the forearm of a human subject to up to 40 female mosquitoes of the species *Aedes aegypti* for two minutes (see photo on p.106). Prior to testing, the researchers treated one hundred square centimeters of skin surface with one hundred microliters of a mosquito repellent preparation. The Biogents specialists then documented the number of insects that landed on that area of skin and how long they stayed there, aborting the test after two mosquito bites.

### FOR ONCE, LESS IS MORE

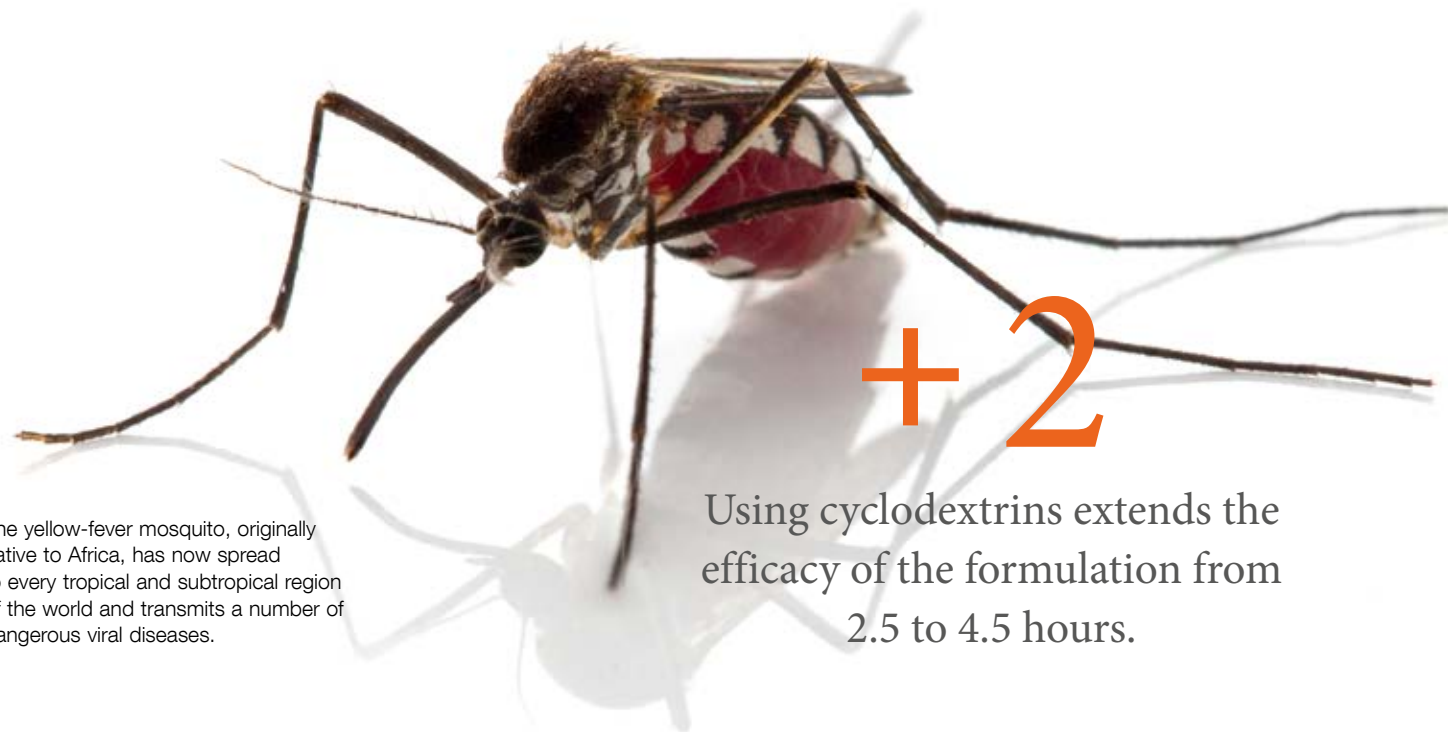
The team noted something else during the experiments: “Immediately after application, the amount of active agent that volatilizes is more than you need for driving away the mosquitoes – a waste, really,” Jeschke observes. This is where the WACKER experts were hoping to put their cyclodextrins to use. “From our many years of experience, we know that you ideally want to aim for an equimolar ratio of active substance to cyclodextrin – or you can even add the sugar compound in excess,” the chemist notes. When it came to insect repellents, however, that strategy was counterproductive, as it results in all of the fragrance molecules ending up bound to the surface of the skin and unable to evaporate. “But they have to evaporate for the repellent to begin protecting you from insects right away,” Jeschke points out. “We had to alter our thinking. We switched to a less-is-more approach and were surprisingly successful.”

The reason is because this leaves a portion of the active molecules in the mosquito repellent unbound so that they can evaporate and begin driving off insects immediately after application. Evaporation shifts the chemical equilibrium, so that the fragrance molecules still entrapped in the cyclodextrins can now leave the cavities. Jeschke and his team determined that the optimum ratio of active ingredient to cyclodextrin

is just 1:0.05. The effect is nevertheless large, extending the efficacy of a formulation from 2.5 to 4.5 hours.

### JUST STIR AND YOU'RE DONE

Another advantage is that the sugar compounds can simply be introduced into existing products as an additive – a method that works equally well with all common actives. “Just stir it in



The yellow-fever mosquito, originally native to Africa, has now spread to every tropical and subtropical region of the world and transmits a number of dangerous viral diseases.

Using cyclodextrins extends the efficacy of the formulation from 2.5 to 4.5 hours.

and you're done," is how the WACKER expert describes it. For manufacturers, the innovation represents an uncomplicated, fast, cost-effective way of making their products provide longer-lasting protection – a 400-milliliter solution of mosquito repellent requires less than 200

milligrams of cyclodextrin. In addition, manufacturers can achieve the same level of protection with less of the active ingredient than they usually use. "It's an interesting way of reducing costs, especially in cases where the active is expensive," Jeschke points out.

**LAB TEST SERIES**

WACKER experts are currently conducting a series of laboratory tests, analyzing the four most promising active substances at various concentrations and adding cyclodextrin in varying amounts. Their goal is to have an extensive data package that they can present to mosquito-repellent manufacturers and demonstrate the advantages and cost benefits of cyclodextrins. "We're also looking at other potential applications of cyclodextrins," says Jeschke. "Pheromone traps that attract specific agricultural pests are an interesting option, as are insect repellents for farm animals such as horses." ■



Insect repellents being tested at Biogents: the less often a mosquito bites a test person's arm, the greater the agent's efficacy.

## FIVE QUESTIONS ABOUT INSECT REPELLENTS

Ulla Gordon, research head at Biogents AG in Regensburg, talks about available active ingredients – and about possible ways to make them last longer.



Even as a student, Dr. Ulla Gordon was a member of the mosquito study group at the University of Regensburg's Zoological Institute and is now director of Contract R&D at Biogents AG.

**1 What legal regulations apply to insect repellents in Europe?**

Within the European Union, placing repellents on the market is governed by the Biocidal Products Regulation (BPR, Regulation (EU) 528/2012). Repellents are considered to be Product Group 19 biocides, which makes them subject to approval requirements. A review program of currently available actives is now underway; if an assessment result is positive, the corresponding active substance will be added to Annex I of the regulation.

**3 Do common active substances vary in terms of efficacy?**

Absolutely. Synthetic variants generally provide longer-lasting protection than plant-based essential oils or their constituents. While DEET provides very good broad protection against a variety of bloodsucking arthropods, it does, however, dissolve plastics. As a consequence, many consumers prefer DEET alternatives such as picaridin or IR3535, even if the protection these provide does not last as long.

**2 Which actives are approved for use in Europe?**

The following Product Group 19 actives have been approved to date: EBAAP (IR3535), Eucalyptus citriodora oil, geraniol, lavender oil, picaridin and DEET. Actives that are not yet in Annex I can still be approved, but this is a relatively time-consuming, costly process, which is why manufacturers of repellent formulations generally look to active substances that have already been approved.

**4 How long do repellents keep mosquitoes from biting?**

That depends on more than just the active substance – the formulation plays a decisive role in stabilizing the active and making it last longer. This effect has been observed, for instance, in various formulations containing PMD (para-menthane-3,8-diol obtained from the oil of Eucalyptus citriodora). Incorporating DEET in liposomes (LipoDEET) can make DEET last longer.

**5 Which actives represent a particularly good compromise between the protection they offer and their effects on human health?**

Another synthetic active is IR3535 (ethyl butyl-acetylaminopropionate, EBAAP), which is less effective than DEET or picaridin. IR3535 does, however, have an excellent safety profile and is considered to pose little physiological threat – properties that make it particularly interesting for use as a repellent. The use of cyclodextrin formulations could make the protection offered by IR3535 last longer, which, in turn, would make it significantly more attractive for consumer applications.



**“The formulation plays a decisive role in stabilizing the active and making it last longer.”**

Dr. Ulla Gordon, Research Director, Biogents AG

## HIGH-DEFINITION IMAGES

Pyrogenic silica is a key constituent of the dry toners used by laser printers and photocopiers. WACKER, together with its distributor Clariant, provides tailor-made solutions.





Investigating the chargeability and flowability of a dry toner in the lab.

“This extensive application-specific product portfolio and an understanding of the application area as well as the interaction of the individual toner constituents cultivated over many years have contributed enormously to the success of both companies in the toner industry,” said Maria-Anna Biebl, head of WACKER’s HDK® business team. Regional teams at Clariant work closely with Wacker Chemie AG. This ensures that market requirements are identified and innovations are implemented in a targeted manner.

#### LAB-SCALE PRODUCTION

“Our customers expect supply security and product innovation,” explains Dr. Ingmar Piglosiewicz, the chemist who manages the toner applications lab at WACKER in Burghausen. His team develops tailor-made silica specialties in close collaboration with Clariant and their end customers. The focus is always on customer requirements and long-term practical implementation. In Dr. Piglosiewicz’s experience, it is crucial to be able to produce silicas on a laboratory scale.

WACKER technicians also incorporate all the established analytical methods used in the toner industry to align the silica specialties to customers’ requests. “Key properties such as triboelectric chargeability, charge distribution, hydrophobicity and the mechanical strength of dry toners must be positively influenced by the silica products,” stresses Dr. Piglosiewicz. All these measurement parameters are important in electrophotography because the toner particles, which are just a few micrometers in size, must follow their predetermined path on the paper with utmost precision.

Dry toners are essentially composed of a resin, which binds the pigment, waxes and charge control agent. Initially neutral, it becomes triboelectrically charged upon contact with a magnetic powder. Mixing the two powders causes friction and a charge separation. A similar charge phenomenon can be observed when you rub a balloon against a rough surface.

The charged toner particles are first transferred in an electric field to a drum coated with a photo semiconductor. When the photo semiconductor is exposed to light, a latent image, in other words, areas of varying charge, is produced on the drum surface. To transfer the toner



Magnetic dry toner is metered onto a rotating roller, charged, and artificially aged to simulate a certain number of copies. The instrumentation determines the charge transferred to the toner.

**G**ood print quality depends on many factors. In the case of photocopiers and laser printers, it largely depends on the toner. This micro-fine powder produces letters and images on paper with razor-sharp definition. The underlying process is electrophotography, in which the dry toner, or rather the toner particles, are charged. For this purpose, a triboelectric effect can be used. This term denotes the charging of two materials when they come into contact with each other and are subsequently separated. The charged particles

are transported in electric fields and transferred to the paper.

Continuous improvements of dry toner enable higher print speeds and greater energy efficiency in the printing process – they also ensure flawless print quality. To achieve this, the dry toner needs to be perfectly adapted to the process, since not only the toner, but also the photocopiers and printers are continuously being optimized. Major manufacturers in the key markets of Japan and the USA develop not only toners, but also compatible equipment. By using WACKER’s HDK® pyrogenic silica, manufacturers can selectively adjust

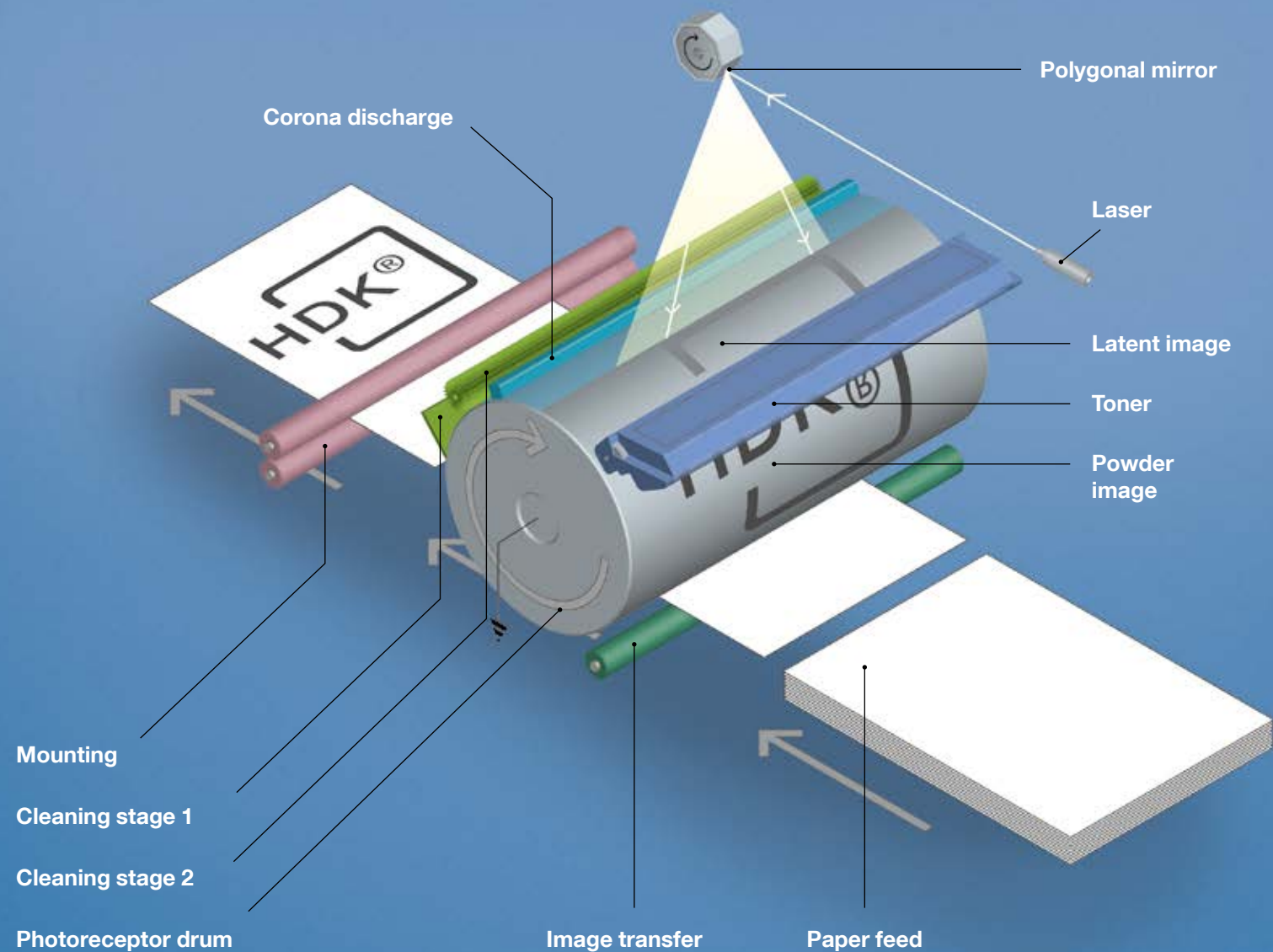
essential toner properties such as flowability, triboelectric chargeability and stability – in storage and in use. The highly innovative toner industry can draw on tailor-made products and services provided by WACKER and Clariant.

The success of HDK®, especially in Japan and the USA, is also the result of this long-standing partnership between WACKER and the Swiss chemical group that dates back to the 1980s. In addition to the HDK® produced by WACKER, Clariant also produces and markets other toner additives, such as waxes, pigments and charge control agents.



# How a Laser Printer Works

Electrophotography is used in photocopiers and printers: toner particles coated in silica are controlled by electrostatic forces and transferred to the paper.



particles to the drum, a magnetic brush is used to bring these particles as close as possible to the photo semiconductor. The toner particles of two-component toners are located on the larger particles of the magnetic powder sticking to the brush. The magnetic powder is not transferred. The process can be controlled in such a way that toner particles are conveyed exclusively either to the exposed or to the unexposed regions of the drum. This forms the visible powder image. The dry toner is then transferred to another, more highly charged drum – the transfer drum. The paper is guided between the two rollers such that the dry toner is deposited in a targeted

manner, and the powder on the paper is typically fixed at high temperature and pressure, once again using the rollers. The finished print-out is thus produced.

**POSITIVELY AND NEGATIVELY CHARGED**  
Positively and negatively charged dry toners are available on the market. The underlying application process is similar in both cases. The dry toner is transferred to the paper by a non-contact process using electrical fields. The procedure is called non-impact printing.

During use, the dry toner is subject to mechanical stresses, for example, when mix-

ing the toner and the magnetic powder in the charging process. Toners are also handled at different temperatures and air humidities. Throughout the application and under different ambient conditions, the dry toners and toner particles retain their clearly defined form, their outstanding flow properties and their triboelectric characteristics.

This enables the toner additives to perform a range of functions. Silica as an “external additive” influences several properties, as lab manager Piglosiewicz explains: “hydrophobic silicas significantly reduce the moisture absorption of the toners. This enables the powder to remain



Laser printer in use: the advantages of this technology include high-speed printing and low costs.

“We are able to customize the properties for the application by treating the surface with a wide range of silanes and siloxanes.”

**Dr. Ingmar Piglosiewicz**, Technical Marketing Manager for HDK®



free-flowing at any humidity and to retain its triboelectric chargeability. The printing process must function irrespective of the printing duration, temperature and air humidity.”

Silicas for toner applications have to be well distributed over the surface of the toner particles. On an industrial scale, this is called the additive blending step. This step, which takes place after the raw toner has been produced, is when the silica is admixed. The silicas have to be broken down into smaller entities using as little energy as possible, and homogeneously envelop the toner particles. Only in this way will the desired property profile be achieved. To ensure the process runs smoothly, Piglosiewicz and his team are working on the dispersibility of the silica. It is a measure of how easily the additive can be transferred to the carrier particles. “And we can influence more than the dispersibility,” stresses Piglosiewicz. “We are able to customize the properties for the application by treating the surface with a wide range of silanes and siloxanes. It is also important to select precisely the right particle size and to adjust the particle size distribution.”

“You need to follow the market trend,” says Takayoshi Miyatani. He is the sales director at Clariant Japan and, together with his team,



Paying a visit to Burghausen: Takayoshi Miyatani (left; sales director at Clariant Japan) and Daisuke Harada (right; technical sales manager at Clariant Japan), alongside Dr. Ingmar Piglosiewicz (head of WACKER's technical marketing for HDK®).

## CONTACT

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markets WACKER's pyrogenic silica as well as other toner additives. The Japanese market continually demands new solutions to support manufacturers in meeting requirements for higher print speeds, increased image resolution and even cost and sustainability issues. Producers increasingly rely on toners with low glass transition points and smaller, more defined particle sizes and shapes. These powders can be fixed to the paper using less energy. The process is faster, and increasingly higher image resolutions can be achieved. If the composition of the toner changes, it may also be necessary to adapt the silica product. Piglosiewicz's team in Burghausen needs to respond accordingly – in close consultation with Clariant and the toner producer.

## ESTABLISHING TRUST

“Regular site visits are extremely important in Japanese business culture,” explains Clariant manager Takayoshi Miyatani. “Face-to-face communication is the only way to build up trust. Only with trust can we jointly address the needs of our established customers and take their requirements into account.”

An understanding of the market, Clariant's presence in the regions, and WACKER's longstanding experience in the field of silica specialties creates synergies valued by end customers. Or as Takayoshi Miyatani puts it: “Our decades of collaboration and the trust-based relationship with our partner WACKER have proven extremely successful.”

# STRONGER TOGETHER

Curcumin is a highly effective antioxidant that is not readily absorbed by the human body. That's why Dr. Wolz, a German manufacturer of food supplements, is relying on CAVACURMIN® from WACKER – a cyclodextrin-encapsulated curcumin extract with increased bioavailability.



## PODCAST



The action of cyclodextrins in food supplements is explained in a podcast: [www.wacker.com/podcast](http://www.wacker.com/podcast)

**M**any home cooks know curcumin from Indian cuisine, where, in curry powders and pastes, it is responsible for the dishes' rich yellow color. Curcumin and its derivatives, which all belong to the curcuminoids, are the biologically active constituents of the spice plant *Curcuma longa*, or turmeric.

The substance is not just a spice and colorant – it is also a well-known active, used in the Ayurvedic diet and traditional Asian medicine. Its bioactivity arises from interaction with numerous cellular processes and from the scavenging of free radicals. “Curcumin is a powerful antioxidant,” explains Rachela Mohr, business development manager at WACKER BIOSOLUTIONS. “It has been proven to support the immune system and also has an anti-inflammatory effect.”

At Dr. Wolz, a medium-sized manufacturer of food supplements from Geisenheim am Rhein (Germany), the many therapeutic and preventive opportunities offered by curcumin were well-known – but so was the fact that curcumin is not readily absorbed by the human bloodstream.

“It had previously not been possible to fully exploit the therapeutic benefits of curcumin, because the fat-soluble substance only has very limited bioavailability,” said Dr. Georg Wolz, owner and managing director of the company that bears his name. He explained that reasons included poor water solubility, limited absorption, fast metabolism and rapid excretion. “90% of natural turmeric, or curcumin,

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that is taken orally is excreted again,” stated Dr. Wolz regretfully.

**CYCLODEXTRINS INCREASE BIOAVAILABILITY**

As a manufacturer of functional food supplements, Dr. Wolz therefore rose to the challenge and set itself the aim of formulating its curcumin product so as to ensure optimum bioavailability for consumers despite the hydrophobic nature of the active ingredient.

“One method of increasing the bioavailability of hydrophobic substances, such as curcumin,

is complexation with our cyclodextrins,” explains Dana Elgeti, marketing manager for nutrition at WACKER BIOSOLUTIONS. WACKER bioengineers these ring-shaped sugar molecules via enzymatic degradation from the starch-containing raw material corn.

The characteristic feature of cyclodextrins is their three-dimensional structure: it forms a ring with a hydrophobic interior cavity that is capable of receiving a lipophilic “guest” molecule – such as curcumin – provided its size and shape are compatible. The cyclodextrin’s hydrophilic shell can increase the bioavail-

ability of curcumin, i.e. the amount that can be taken up by the human body.

**STUDIES VERIFY BENEFITS**

Several scientific studies have confirmed the positive effect attained by complexation with cyclodextrins. In 2013, a human clinical trial compared the relative absorption of the curcumin-gamma-cyclodextrin complex – marketed by WACKER as CAVACURMIN® – with a conven-

tional curcumin extract (95%) and two further leading curcumin products said to have superior bioavailability (a curcumin-phytosome formulation and a formulation of curcumin oil from the *Curcuma longa* rhizome).

Over the course of the clinical study, 12 healthy participants, aged between 20 and 35, each took one of the three different bioavailable curcumin formulations or the conventional curcumin extract (95%) on an empty stomach. All test samples were administered as capsules with water only. After four and eight hours, respectively, the participants received a standardized, low-fat meal, so that any other influence on the absorption of the curcuminoids – for example due to fat – could be ruled out. Following ingestion of the products, blood samples were taken from the participants at regular intervals over a twelve-hour period and analyzed. Earlier studies had suggested that absorption and metabolization would be largely completed within this time frame.

**CONSIDERABLY IMPROVED UPTAKE**

The results of the study, which was published, for example, in the European Journal of Nutrition at the start of 2017, showed that absorption of the curcuminoids was around 40 times more efficient with the cyclodextrin formulation than with the conventional curcumin

“The considerably improved uptake of CAVACURMIN® revealed itself in the curcuminoid content of the participants’ blood, which was around 5 times higher than for the best of the two curcumin reference products.”

Dana Elgeti, Marketing Manager at WACKER BIOSOLUTIONS

extract (95%). Bioavailability was also greatly enhanced compared to the other two curcumin products. “The considerably improved uptake of CAVACURMIN® revealed itself in the curcuminoid content of the participants’ blood, which was around 5 times higher than for the best of the two curcumin reference products,”

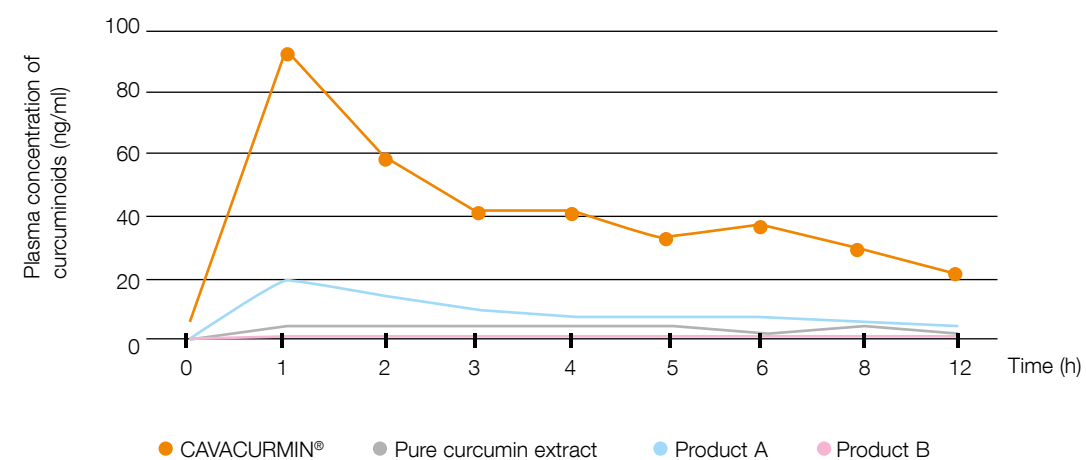
“90% of natural turmeric, or curcumin, that is taken orally is excreted again.”

Dr. Georg Wolz

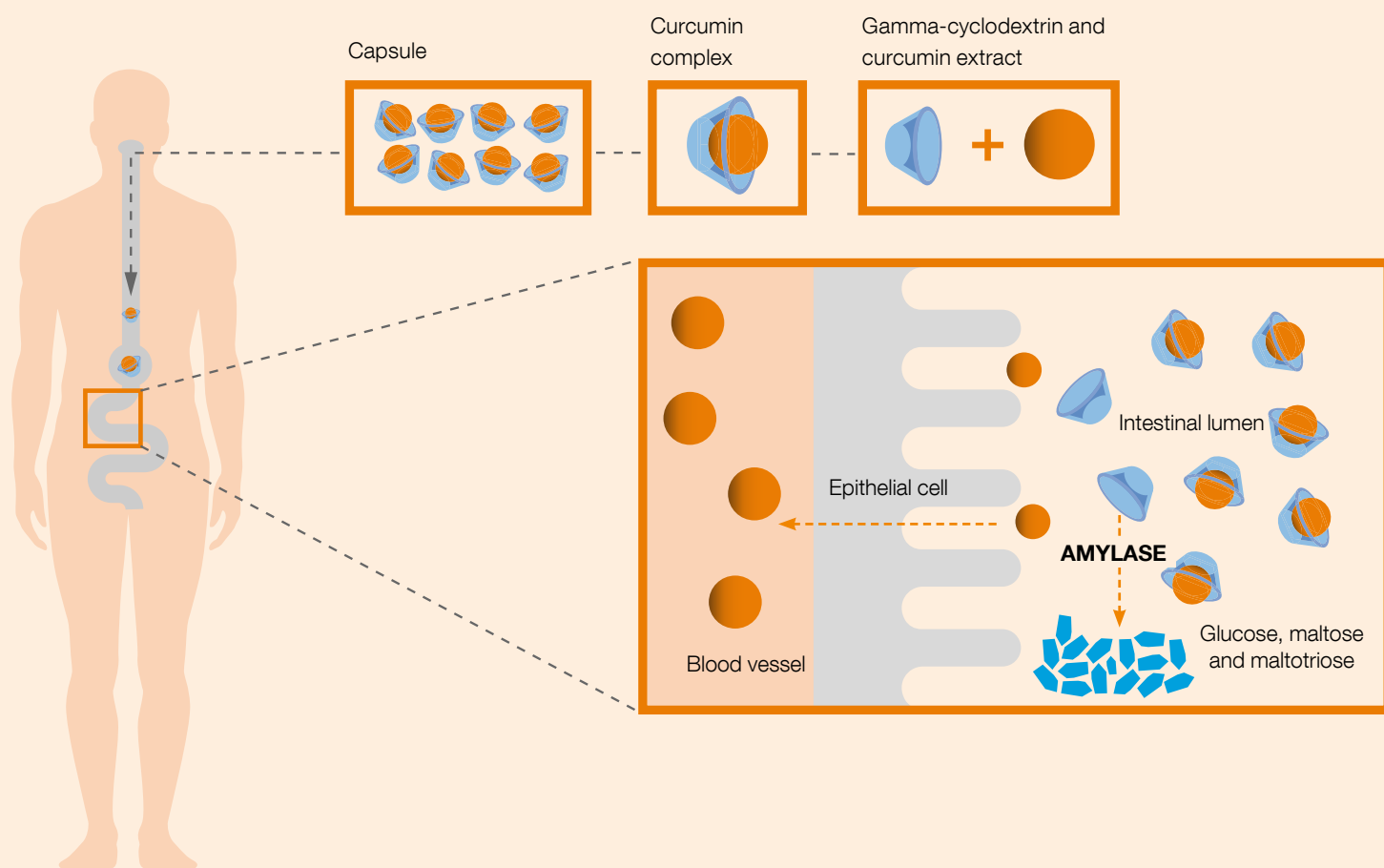


With the aid of CAVACURMIN® from WACKER, food supplement manufacturer Dr. Wolz has formulated a product containing a curcumin extract that is absorbed considerably better by the body than conventional supplements.

**HIGHEST CONCENTRATION OF CURCUMINOIDS IN THE BLOOD WITH CAVACURMIN®**



The study, which was published, for example, in the European Journal of Nutrition at the start of 2017, confirms the positive effect of CAVACURMIN®. With CAVACURMIN®, the concentration of curcuminoids in the participants’ blood was already significantly higher in the initial hours after ingestion than with pure curcumin extract or conventional curcumin products (A and B).



## MECHANISM FOR ABSORPTION OF CURCUMIN-GAMMADEXTRIN COMPLEX

Based on current knowledge, absorption of complexed curcumin involves the following individual steps:

1. After ingestion of the food supplement – for example in the form of a capsule as is the case with the Dr. Wolz product – the curcumin-cyclodextrin complex is transported unchanged through the stomach to the upper intestinal tract.
2. This is where a chemical equilibrium reaction releases the curcumin molecules, so that they can be absorbed by the body through the epithelial cell membrane.
3. During further digestion, gamma-cyclodextrin is degraded enzymatically into ever-smaller fragments down to glucose, which can ultimately be absorbed into the blood stream.
4. As a result, a considerably larger amount of curcumin is absorbed directly into the blood compared to conventional curcumin extract and other curcumin products.

emphasizes Elgeti. As a free-flowing powder, the gamma-cyclodextrin-based raw material is perfect for use in tablets, capsules, granules and energy bars. Since the powder readily disperses in water, it is also ideal for liquid food supplements.

“Based on available studies to date, WACKER’s CAVACURMIN® is the best solution for increasing the bioavailability of curcumin,” summed up Dr. Wolz. His long-established business has been marketing the curcumin-cyclodextrin complex as Curcumin Extrakt 45

since 2014 – and straight away created one of its most successful products. Bioengineered from renewable, plant-based raw materials, cyclodextrins also fully address the current trend of avoiding animal-derived products. Furthermore, gamma-cyclodextrin is hypoallergenic, kosher and halal in accordance with 2003/89/EC and 2006/142/EC, and approved for use in food by the authorities in the USA, Canada, Europe and most Asian and Latin American countries. “This makes cyclodextrin formulations an ideal alternative – free of allergens and

cholesterol, based on plant-derived renewable raw materials – for functional food applications to enhance the bioavailability of substances, such as curcumin, that are otherwise absorbed poorly,” said Mohr.

The German Reformhaus® chain of health-food stores has also recognized that the combination of cyclodextrins and curcumin is a highly innovative approach to dietary supplements. It honored Dr. Wolz’s Curcumin Extrakt 45 as the “2015 Health-Store Product of the Year.”

### α-, β- AND γ-CYCLODEXTRIN

Depending on the number of glucose units, a distinction is made between α-, β- and γ-cyclodextrin: α-cyclodextrin consists of six, β-cyclodextrin of seven and γ-cyclodextrin of eight glucose units.

Cyclodextrins are bioengineered via enzymatic degradation of starch-containing raw materials, made from corn or potatoes, for example. The enzymes used here are known as cyclodextrin glycosyl transferases, or CGTases. When acting on starch, the CGTase cleaves individual sections out of the carbohydrate’s helical structure and combines them to form a ring-shaped oligosaccharide or cyclodextrin. The sugar molecules are colorless, odorless, non-hygroscopic, very stable in alkaline solutions and are only hydrolyzed in acidic media when the pH falls below two. They have no fixed melting points and can withstand temperatures of around 200 °C. An important benefit for the food industry is that these molecules are non-allergenic, vegetarian-grade and produced from renewable raw materials.





## “WIDE RANGE OF EFFECTS”

Dr. Georg Wolz is a general practitioner and specialist in nutritional medicine. He founded the food-supplement manufacturing company that bears his name: Dr. Wolz. Here, he talks about the health-promoting effects of curcumin – and the challenges of enhancing its bioavailability.

**Curcumin has been known for its health benefits for centuries. When was it “rediscovered” by manufacturers of nutritional supplements?**

Dr. Georg Wolz: In the late 1990s, there was a real “vitamin boom” – the additional intake of vitamins, sometimes at very high dosages, was promoted. However, the hopes placed in vitamins did not come to fruition. Today, it is widely known that what makes fruit, vegetables and herbs so healthy are the secondary metabolites – whether lycopene from tomatoes, anthocyanins from red berries, catechins

from green tea, resveratrol from grapes, glucoraphanin from broccoli, or curcumin from the turmeric root.

**What health-promoting effects does curcumin offer?**

Numerous studies – over 3,000 since 2010 alone – have shown that curcumin is a highly pleiotropic molecule, i.e. it has a variety of different effects. It is attributed with properties that are cholagogic (i.e. promote the flow of bile), antioxidant, antiseptic, pain-relieving,

antithrombotic, antiproliferative, cytotoxic, antitumor, immunomodulating, antiviral and especially anti-inflammatory. Its main application fields thus include all types of inflammation, such as arthritis.

**Manufacturers of dietary supplements are faced with the challenge of increasing the poor bioavailability of curcumin time and again. What convinced Dr. Wolz to opt for CAVACURMIN® from WACKER rather than alternative technologies?**

To improve its bioavailability, curcumin had previously mainly been combined with the alkaloid piperine. While this raises the blood concentration, the effect only lasts for an hour and it then quickly returns to the original value. Moreover, piperine is a so-called



“Its anti-inflammatory and antioxidant effects play a key role, which helps curcumin keep silent inflammations in check.”

Dr. Georg Wolz, Managing Director

“bio-enhancer” that, through inhibition or stimulation, can also influence the effect of medication. It also irritates the stomach lining. Increasing the bioavailability of curcumin with the aid of so-called “polysorbates” is likewise viewed critically by many, because it caused nausea and other side effects in more than half of study participants. Against this backdrop and based on available studies to date, WACKER’s CAVACURMIN® is the best solution for increasing bioavailability.

**Should it be taken long term as a preventive measure or for a limited time due to acute illness?**

Both. Anyone who shows one of the indications listed above (e.g. an inflammatory illness) should consider taking curcumin as a supplement. However, it also offers many

positive effects in terms of prevention. For instance, there are many studies that confirm neuroprotective effects. So, taking curcumin regularly may help reduce the risk of dementia, for example. Due to curcumin’s effect on all stages of carcinogenesis, this natural product can contribute to cancer prevention, too. Its anti-inflammatory and antioxidant effects play a key role, which helps curcumin keep malicious silent inflammations in check. These are hidden inflammatory processes in the body that we only notice when they manifest themselves as an illness.

**What must be kept in mind when taking curcumin?**

Curcumin is very easy to digest. Only certain sensitive people may experience slight nausea

or diarrhea. No serious side effects could be detected even after a one-time administration of high doses. However, extremely high doses should not be taken over prolonged periods to avoid liver damage. Nor should curcumin be used by pregnant women or by people suffering from biliary obstruction or gallstones. Due to the effect on thrombocytes, it should only be taken together with blood thinners (such as acetylsalicylic acid) after consultation with a doctor. On the other hand, curcumin has been shown to generate positive synergy effects with other plant secondary metabolites such as catechins (known, for example, from green tea), quercetin, genistein and resveratrol (known, for instance, from red wine).

# A FAMILY COMMITMENT

David Wilhoit, head of Wacker Chemical Corporation, WACKER's US subsidiary, performs volunteer work in Cambodia

**D**avid Wilhoit is President & CEO of Wacker Chemical Corporation, the Group's US subsidiary, based in Adrian, Michigan. Together with his wife Anne, daughter Amanda and various friends, he recently traveled to Siem Reap, Cambodia, to perform volunteer work in a country that has survived decades of conflict, civil war and brutal regimes. Over the years, the Wilhoit family has dedicated their time and resources toward supporting programs in conjunction with providing education for school children in this Southeast Asian country.

Wilhoit and his family first became involved with the organization Caring for Cambodia (CFC) when he took up a managerial posting with Siltronic in Singapore, which was the WACKER Group's semiconductor arm

at the time. "We have been active for 10 years now with CFC, Anne has made seven visits, Amanda four; Katie, Amanda's sister, has been twice, and this year was my third visit," Wilhoit explained. "Each visit is more rewarding than the previous. We come away with a deeper understanding that helping the children of Cambodia through CFC is a life-long family commitment."

## FUNDRAISING AT HIGH SCHOOL

David Wilhoit's daughter Amanda started the CFC club at Skyline High School in her home town of Ann Arbor, and has enlisted the backing of her classmates to support the organization through numerous fundraisers and donations. Funds raised went directly into the painting of desks and stools and the

Young girls on a rural road in Cambodia: having endured many years of conflict, civil war and brutal regimes, the country is among the poorest in Asia, with health and education remaining important challenges. The country has been enjoying economic growth for two decades.



## CARING FOR CAMBODIA

Caring for Cambodia is a non-governmental charitable organization that provides a free education for over 6,400 impoverished children in 21 schools spanning pre-school to high school. CFC professionally trains its Cambodian teachers, and provides everything a child needs to succeed, including food, water, uniforms, school supplies, computers, transportation and basic healthcare. CFC is run entirely on volunteer support, which ensures that every dollar raised directly supports the education of a child.

[www.caringforcambodia.org](http://www.caringforcambodia.org)

“Every time we visit Cambodia, we get back more than we put in.”

David Wilhoit, CEO,  
Wacker Chemical Corporation

construction of a new school study hut for the children. Funds were also directed toward maintenance of a water filtration system which provides clean and safe drinking water to the school and surrounding community.

**ENGLISH TUTORING**

Anne Wilhoit said that on this most recent trip, the family all worked in English as a Second Language (ESL) class rooms and served meals provided through CFC's Food for Thought (FFT) program. “Amanda and other members of the Skyline High School Club have packed meals in Michigan for Feed My Starving Children (FMSC), an organization that provides meals for malnourished children worldwide,” she commented. “A number of rice packs recently arrived in Siem Reap and are currently being used to prepare meals through the Caring for Cambo-

dia Food for Thought Program. Seeing the rice that arrived in Siem Reap being used in the meals really brought things full circle.”

Amanda Wilhoit, who is very passionate about the volunteer work and the progress that is coming from CFC, remarked that even though it was her fourth trip, she feels there is always something new to discover, or that another opportunity always presents itself. “When you see the smiles on children’s faces and the look of appreciation from their teachers and families and friends, it puts everything into perspective,” she said. “We take a lot of things for granted. They show such gratitude that someone really cares about them. I come away each and every visit with a greater sense of pride and accomplishment that we are able in some small way to make a difference in their quality of life.” ■

Helping paint a bright future:  
Dave Wilson and David Wilhoit (right).



Students eating a breakfast provided by  
Caring for Cambodia.



# WACKER IN FIGURES

The chemical industry is one of the most energy-intensive sectors there is. WACKER is continuously improving the energy efficiency of its processes in order to remain competitive in the global market while simultaneously contributing to climate protection.

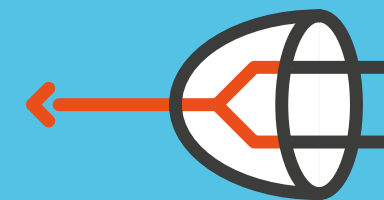
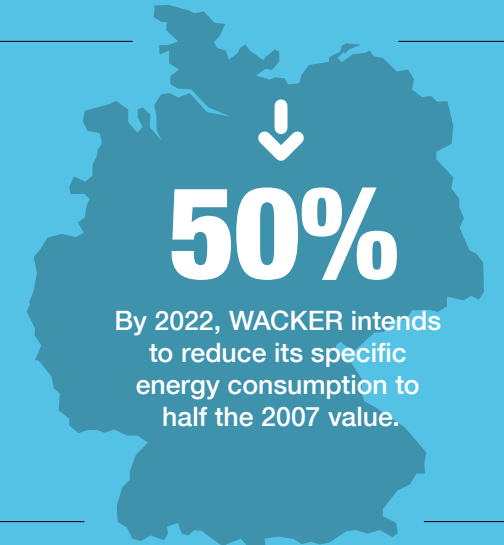
**15%**

of the natural gas consumed by the Nünchritz site was saved as a result of optimizing the hydrogen plant there.



**50%**

By 2022, WACKER intends to reduce its specific energy consumption to half the 2007 value.

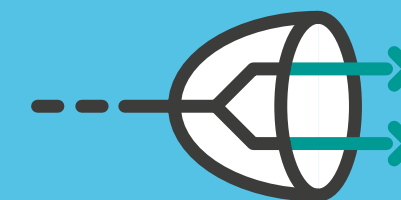


**4,103 GWh**

(gigawatt hours) of electricity were consumed by WACKER in Germany in 2016.

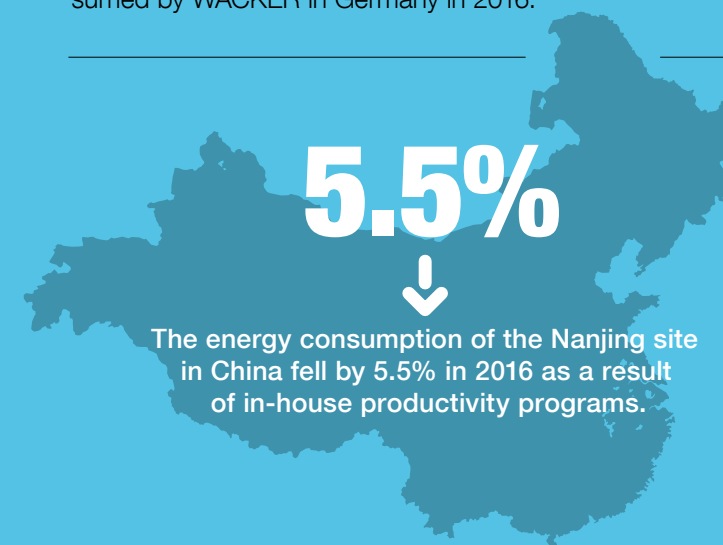
**1,416 GWh**

of electricity was generated in 2016 by WACKER's combined heat and power plant and the hydroelectric power plant at its Burghausen site, so that the company met around 25% of its total annual electricity demand itself.



**5.5%**

The energy consumption of the Nanjing site in China fell by 5.5% in 2016 as a result of in-house productivity programs.



**17 GWh**



of heating oil was consumed worldwide by the Group in 2016; 3 GWh less than in 2015.



## PERFECT BONDING

Wood flooring has been regarded as a premium floor covering since the Middle Ages. Over the centuries, flooring-installation methods remained virtually unchanged: nailing wooden slats and boards to a wooden subfloor was standard practice. Since the 1950s, floors have predominantly been cast from concrete and screed. Builders initially used hot-melt adhesives to install wooden floors, before later using solvent-based cold adhesives – either technique not entirely free from health risks. Today, modern and clean adhesives based on silane-terminated polymers are available. WACKER's GENIOSIL® XM 20 binder, an alpha-silane-terminated polyether, enables the production of safe, plasticizer-free adhesives with an exceptional bonding profile – ensuring perfect bonding, even on difficult substrates.



**WACKER**

GENIOSIL® XM 20 enables the formulation of plasticizer-free elastic adhesives with extremely high elongation. The product adheres well to concrete, wood, aluminum and glass, as well as to low-energy surfaces such as polyvinyl chloride (PVC), polystyrene (PS) and ethylene-propylene terpolymer (EPT).