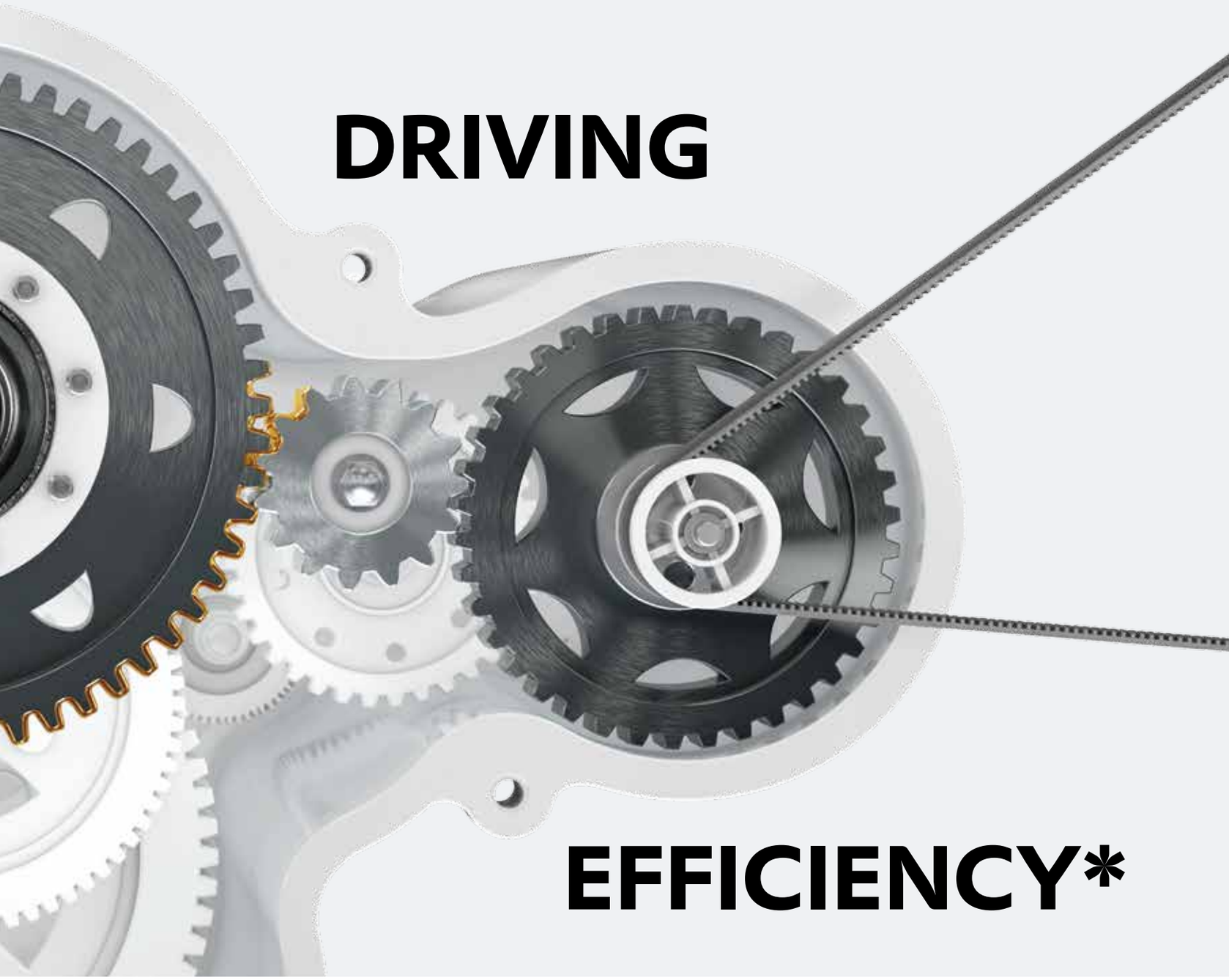
INTERVIEW: ENJOYING RESEARCH

THERMAL INSULATION: WHY SKINNY IS BETTER

ELEMENTS

DECEMBER 2016

57



DRIVING EFFICIENCY*

THE INNOVATION MAGAZINE

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POWER TO CREATE

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EDITORIAL

Relying on know-how instead of raw materials

Dr. Ulrich Küsthardt
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Would you drive a car that needs 40 liters of fuel for 100 kilometers? Probably not. But it's different when it comes to housing: The German Federal Environmental Agency estimates that the primary energy requirements of a building could be cut by up to 90 percent through energy conservation measures. About 28 percent of worldwide energy consumption is caused by buildings; in the Western world it is even 45 percent.

Such inefficient use of resources hurts both the ecology and the economy. For Evonik with its large flows of materials and energy, maximum value creation with minimum use of raw materials is therefore an obligation. And what's more, our Resource Efficiency Segment not only produces in a resource-efficient way, it also sells resource efficiency. Its products help to conserve energy and raw materials and to extend the service life of consumer goods.

How the segment plans to continue making such contributions was the topic of our scientific forum Evonik Meets Science. The agenda for more resource efficiency through Evonik technologies included, among other things, continued developments in the area of mobility. Even today, fuel consumption can be reduced by up to eight percent through the silica/silane system for green tires, and up to four per cent through innovative additives for high-performance lubricants. Prof. Matthias Beller presented numerous examples to demonstrate that resource efficiency is hardly possible without catalysts. Prof. Beller is one of the world's leading catalyst researchers, whom we have now honored with our Friedrich Bergius Lecture.

Just like Evonik Meets Science, this edition also deals with resource efficiency. As varied as the projects are that we present here, they all have one thing in common: They rely on the lavish use of know-how, not raw materials.

Feedback
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INSOLES FROM THE 3D PRINTER

The Canadian start-up Wiivv Wearables, in which Evonik holds a stake via its venture capital unit, uses 3D printing for individualized mass production of biomechanically optimized insoles.

Photography: shutterstock | Graphic: C3 Visual Lab

Polyamides (PAs) are versatile and popular as structural materials or in coatings. And there's more to them than that: Experts in the High Performance Polymer Business Line are developing special PA powders for tool-less 3D printing processes that allow series production of complex and individualized products.

MASS-PRODUCED SUCCESS

Attractive growth

The 3D printing market is forecast to grow by about 25 percent annually. Growth is driven by technologies based on polymer powders, such as selective laser sintering, and on metal.

Source: A.T. Kearney

Wolfgang Diekmann, Thomas Große-Puppendahl, and Sylvia Monsheimer

A paradigm change is underway in industrial fabrication facilities. Normally, plastic material must be fused and cast or pressed into predefined molds to produce the corresponding element. Where these forming processes meet their limitations, additive processes pick up the slack: On the basis of a digital three-dimensional blueprint, material is applied in layers on a base surface. After each application the surface is lowered by a fraction of a millimeter and another layer is added. Very soon a three-dimensional structure is produced that corresponds exactly to the digital specification—with no need for special molds or extensive post-processing.

Additive processes—usually referred to as 3D printing—have so far been used mainly for prototypes and models. The advantages are obvious: If the result is not optimal, the data set is simply changed and the printing is repeated. In addition, when products are required only in small production runs conventional fabrication is usually too labor-intensive and costly; examples are components for vehicles with optional extras, housings for specialty machines, and even grippers for robots transporting and packing sensitive and constantly changing objects.

Aviation and medical technology as drivers of 3D printing

Over the last few years this new forming process has also been establishing itself in series production, the most important application drivers being aviation and medical technology. Aviation components must be light, extremely compact, and highly functional, but also heat-resistant. Both Boeing and Airbus are already using printed components: According to consultant Terry Wohlers, more than 30 components of Boeing's 787 Dreamliner are produced by selective laser sintering. Airbus has already produced a bionically designed cabin bracket in a 3D printing process. It is used to secure the rest area of the crew aboard the new long-haul aircraft A350 XWB and has been used since 2014.

In medical technology another factor plays a role: No two people are alike, and prostheses, medical aids, and even surgical devices must therefore be individually dimensioned and adapted. 3D printing is used to produce, for example, hearing aids or small drilling and sawing aids for knee operations.

For plastics, additive manufacturing is a highly promising market. Plastics are durable, easily fusible, and almost infinitely variable in their properties, and are therefore ideally suited for this cutting-edge ➜

➜ technology. With polyamide 12 (PA12) Evonik is among the leading global suppliers of powders for 3D printing; with VESTAKEEP® AM 9000 the Group even offers a PEEK material (polyether ether ketone) for use in high-temperature applications.

In 2015 Evonik gained access to the highly innovative market sector of wearables, electronic devices worn on the body: Through its venture capital unit, Evonik acquired a stake in the Canadian startup Wiivv Wearables Inc. Wiivv produces biomechanically optimized insoles from PA12 and is among the first to use additive processes for individualized mass production. For these insoles the software first produces a 3D mold of the foot with the help of photographs. The mold is then translated into data that a suitable printer can immediately process. In the future electronic sensors will also be integrated into the insoles, allowing recording and improvement of motion sequences, such as in professional sport.

Quick market penetration expected

Digital layer manufacturing is clean, fast, and innovative—and therefore ideally suited to an industrial world where every cent and every second count. And for a number of years now expectations regarding the development of tool-less production have been correspondingly high. Market researchers estimate that the global market will grow by about 25 percent annually in the period 2015–2020.

One factor favoring rapid market penetration is that 3D printers are more powerful than they were a few years ago: The recording, storing, and processing of enormous quantities of data is no longer an obstacle. The range of suitable materials is also expanding. Many firms are therefore currently investigating where the limits of profitability lie for conventional methods, and for which products it will pay to switch to additive manufacture.

In the excitement over this entirely new route to high-functionality components, however, it is easy to overlook the fact that time is not the only consideration here. If additive processes are to be competitive and cost-effective other factors must also be taken into account. How reproducible are the properties of a product made by additive manufacturing? In which areas are standards needed for materials and machines? And which are the methods and materials that will eventually prevail?

For polyamide components powder-based methods (powder bed fusion) are now established on the market, and are currently being used to produce certain series products as well as test components and a number of functional prototypes. In these processes the structure grows in a powder bed of polymer particles in which an energy source fuses the powder to generate the three-dimensional profile, layer by layer. The thickness of each individual layer is generally 0.10 to 0.12 mm, and the rate of growth 2 to 4 cm per hour.

These methods include selective laser sintering, in which a laser produces the component. Selective heat sintering (SHS) uses a thermal printhead instead of the laser. A relatively new technique is high-speed sintering (HSS), in which the powder is printed with an energy-absorbing ink and heated by infrared radiation. The advantage of these sintering processes is that external support structures are not required even with projecting segments. Instead, the surrounding powder gives the component, growing in the vertical direction, sufficient support and is treated and reused after production.

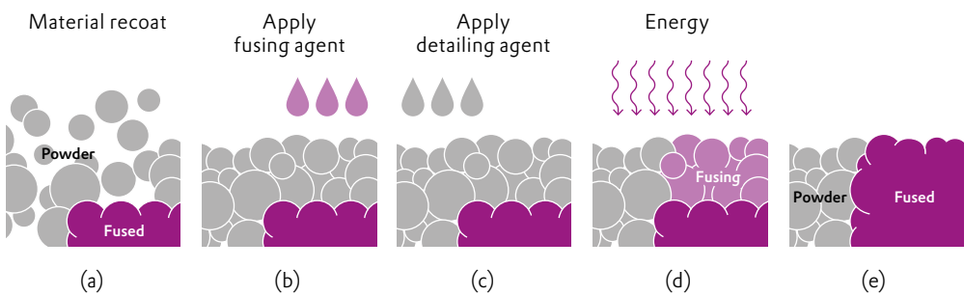
New polyamides for advanced sintering processes

Polyamide 12 is also the material of choice for a new process from the US IT group HP Inc. that is marketed by HP's Open Platform Program. This Multi-Jet-Fusion™ technology works similarly to the more familiar ink jet printing. On an ultrathin powder layer, a

HP's Multi-Jet-Fusion™ technology

Two liquids or agents (b, c) of different thermal conductivities are printed on to the powder bed in the build space (a). The thermally conducting liquid causes the printed powder to fuse under infrared radiation and form the respective layer (d). The second liquid (e) functions as what is known as a detailing agent, ensuring sharp edges and good surface quality.

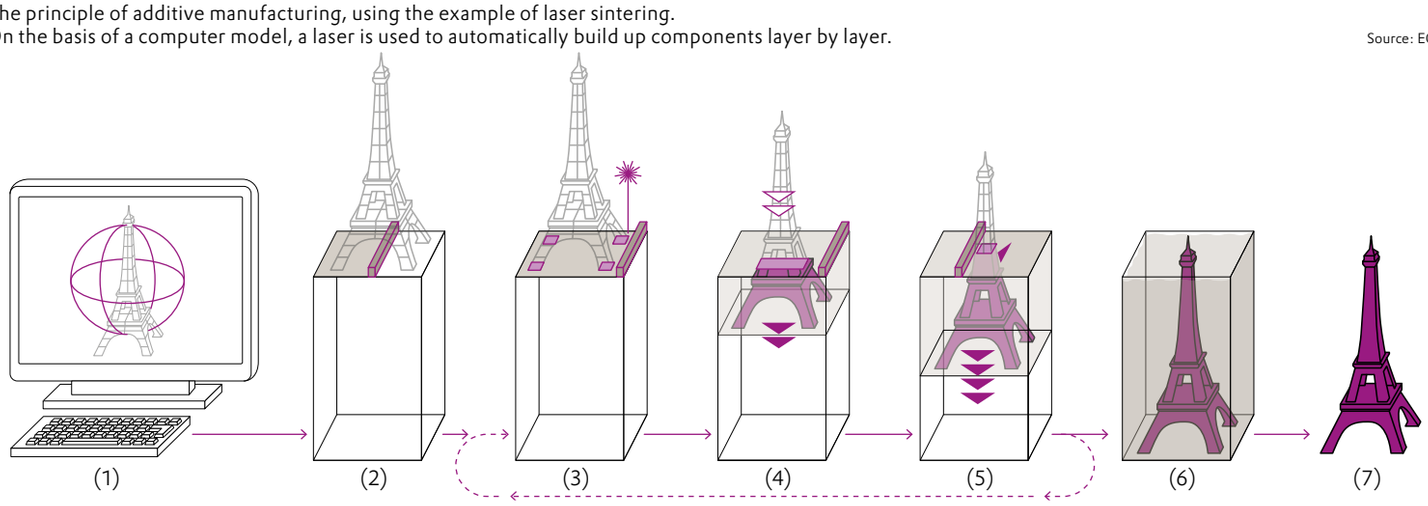
Source: HP Inc.



Digital layering

The principle of additive manufacturing, using the example of laser sintering.
On the basis of a computer model, a laser is used to automatically build up components layer by layer.

Source: EOS

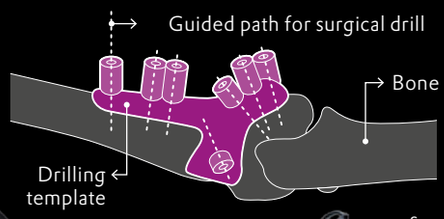


(1) 3D geometry model (2) Application of a layer of powdered material (3) Powdered material is solidified into a cross-section of the model (4) Building platform is lowered (5) The next layer of powder is applied (6) The process repeats itself until the part is complete (7) Complete part after removal of loose powder.

Graphic: C3 Visual Lab

CUSTOMIZED DRILLING AIDS

Drilling aids that are produced with 3D printing can be adapted individually to the anatomy of the patient and facilitate operations on the knee, for example.



Source: Materialise

large number of nozzles apply two different agents: The fusing agent sketches out very accurately the desired shape of the component, while a second agent determines the physical outline of the layer being created. The entire surface is then heated by an infrared lamp. Only the fusing agent absorbs the heat and transmits it to the powder particles. These fuse into the prescribed structure while the surrounding material remains unaffected.

The advantages are twofold: The process works about ten times as fast as other additive processes, and the indirect fusion protects the polymer chains so that the defined properties of the material are retained. Evonik will participate in HP's Open Platform Program and provide additional powder materials for Multi-Jet-Fusion™ technology.

Evonik's portfolio includes a number of polymers and additives for various 3D printing processes; however, the High Performance Polymers Business Line focuses particularly on further development of the polyamide powders. Due to their mechanical properties, chemical resistance, and high fusion point, they are ideal for currently available sintering processes and will become more important on the market. For this reason the Group is currently expanding its capacities: A new production line in Marl is expected to increase annual capacity for specialty VESTOSINT® powders by 50 percent from the end of 2017.

Experts at High Performance Polymers are also investigating the potential of other polyamides for tool-less manufacturing. An example of a new development is polyamide 613, whose relatively high fusion point ensures particularly good heat resistance; in addition, the material has excellent rigidity combined with optimal elongation at break. As a result, products made from PA613 are extremely strong but not brittle and are therefore ideal for all mobility applica- ➜

Photography: Getty Images | Graphic: C3 Visual Lab

MORE FREEDOM IN DESIGN

Additive manufacturing allows complex, three-dimensional shapes to be produced in a single piece without the need for tools.

Test passed
A ventilation duct with an integrated heat shield constructed from the new 3D polymer PA613 and installed in a Lotus racing car proved that the material could be used under the engine hood without any problem.

➜ tions, where parts need to be light and accurate but at the same time highly durable and break-resistant. Samples of the new 3D material are now being supplied to customers. PA613 has already been successfully tested in motor sport: A ventilation duct with an integrated heat shield in a Lotus racing car withstood several races with no problem.

Making tool-less manufacturing ready for series production isn't merely a matter of using the right material and a fast process: It's also vital that quality and reliability be ensured over the entire value chain. Stable processes, consistently high quality of material, and reproducible properties in the finished components are the top priorities for the user.

For this reason the German company EOS, a market leader in laser sintering systems and a long-standing partner of Evonik, started a quality initiative in July 2016. This covers all the technical factors in the material, process, and supply chain that directly affect product quality. Evonik is participating in this initiative and will contribute its comprehensive expertise and proven quality management for raw materials and powder technology.

Quality and standards in demand for series production

It is often overlooked that quality, norms, and standards are not merely requirements of an old and outdated industry but also crucial factors in a digitized and highly dynamic sector. The development of norms, particularly in the international context, needs time. Over the last two years, important specifications have been developed and the number of standards already approved or under development has grown to about two dozen. Even so, only a few standards currently exist for the use of polymers in 3D printing, particularly in the area of test procedures.

There are also other challenges to be mastered on the way to tool-less series manufacturing. The cost efficiency of the process must be significantly increased, for example by higher recycling rates for the material and consistently short manufacturing times. The range of available and tested materials must be widened. And even apparently elementary experience is lacking: Are upstream and downstream processing necessary for 3D components, for instance, and if so what form do these take?

> **"Collaborations open the door to one of the most exciting future markets for high performance polymers."**
>
> *Sylvia Monsheimer*

Even if additive manufacturing will take longer to establish itself than had been predicted a few years ago, Evonik's polymer experts are determined to systematically master every new application. This means observing the dynamics of the market, promoting innovations, and applying their own expertise systematically and sufficiently early. Evonik views collaboration between equipment manufacturers and 3D users as critical in opening the door to one of the most exciting markets of the future for industrial plastics and high-performance polymers.

This effort is worthwhile because the way forward is clear: Mass production that is individualized and at the same time resource-conserving is possible only by way of extremely flexible and highly networked digital manufacturing systems. It helps here that young researchers and employees in the industry are well acquainted with the laws of the virtual world and have a firm faith, instilled from the cradle, in digital data. The establishment of tool-less manufacturing in the long term is therefore not merely possible but inevitable.

The experts

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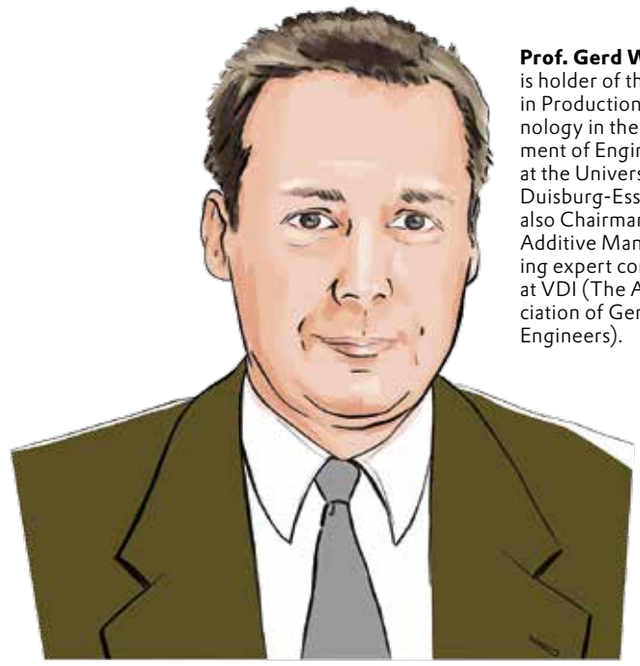
Photography: Evonik

Guest commentary

A supplement, not a replacement!

Prof. Gerd Witt



Prof. Gerd Witt is holder of the Chair in Production Technology in the Department of Engineering at the University of Duisburg-Essen. He is also Chairman of the Additive Manufacturing expert committee at VDI (The Association of German Engineers).

Public awareness of the 3D printing technique, also called additive manufacturing, has risen significantly in the past few years. New, innovative developments and the potential of this manufacturing process created media hype that incited some unrealistic expectations. And time and again in the recent past, a number of rating and consulting companies have discovered the potential of additive manufacturing processes to increase competitiveness and innovative capacity. The market research company IDC, for example, recently predicted that the additive manufacturing industry will double its turnover in the next four years.

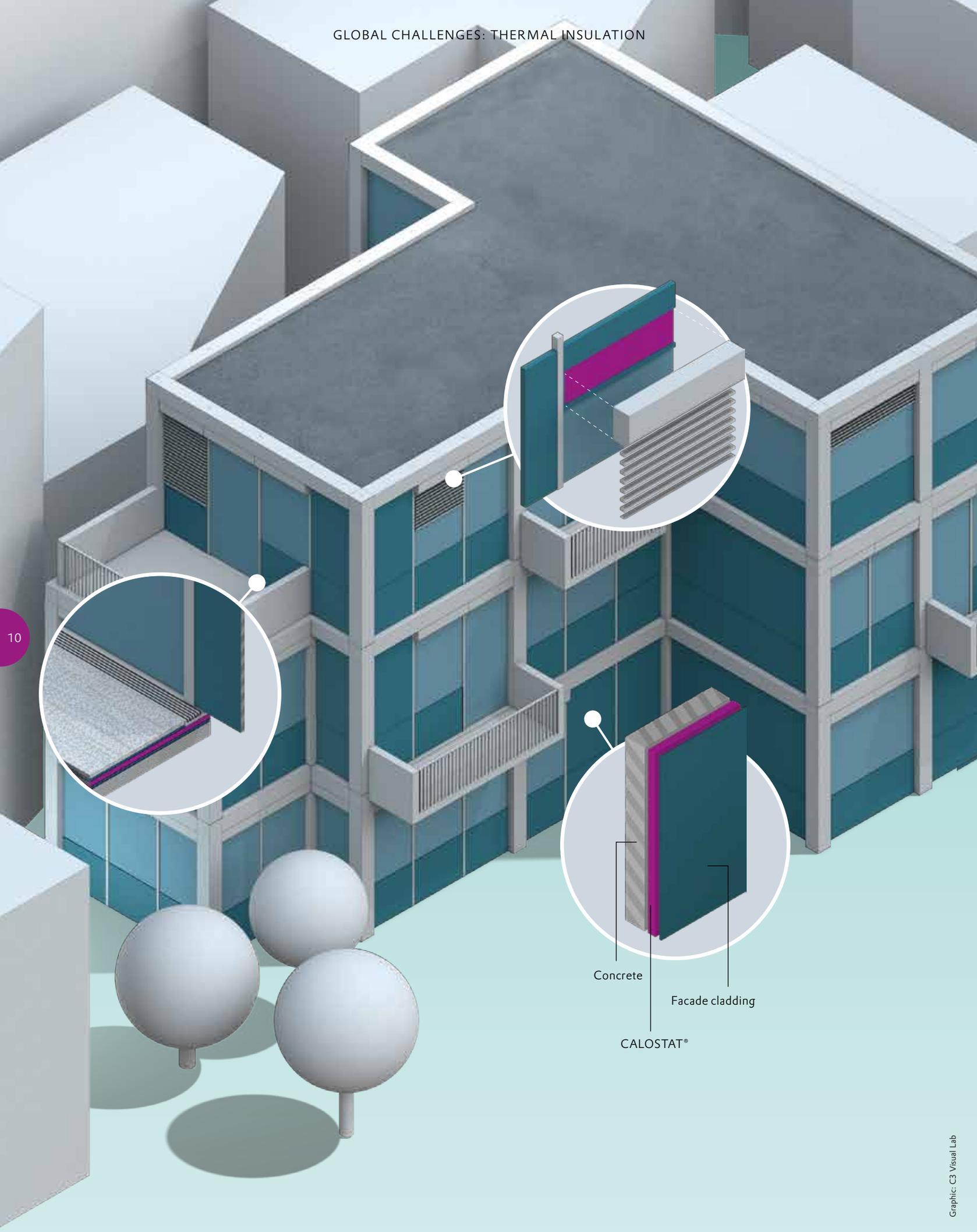
But several measures need to be implemented to fulfill the great development potential of this industry and also benefit from the high level of public interest. The technological maturity of the process must be improved, for one thing. But basic conditions for using the additive manufacturing process must also be developed. This includes sensitizing designers, managers, and engineers to the strengths and weaknesses of this technology as part of their training and development.

Within product development, especially construction, there has to be a paradigm shift towards the functional and production-ready design of component geometry. Additive manufacturing opens up new options in part geometry—for example, by allowing undercuts or complex bionic forms. It also offers the opportunity to integrate functionalities. This means that several parts can be combined into one, components such as cooling channels can be produced directly, and lightweight structures can be realized for the purpose of weight reduction. The important thing is that, unlike conventional production, a part can be made more complex without also being made more expensive. Nevertheless, certain conditions must also be met here, such as optimal orientation within the installation space or the use of rectangular cooling channels. In additive manufacturing, rectangular cooling channels are easier to realize than conventional round channels and provide the same benefit. The main challenge is in breaking loose from traditional thought patterns and methods.

"The main challenge of additive manufacturing is in breaking loose from traditional thought patterns and methods."

For most industrial applications, conventional manufacturing methods will continue to be the logical choice, whether for economic or qualitative reasons. Additive manufacturing is more a supplement to the existing production portfolio than, as it is often portrayed in the media, a technology that will replace conventional manufacturing techniques.

Illustration: C3 Visual Lab



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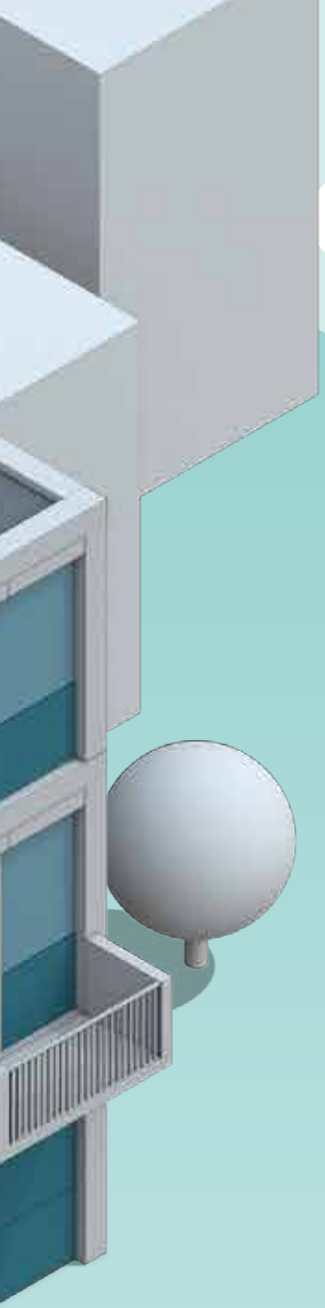


SKINNY INSULATION

Excellent thermal insulation with fire-retardant properties or an excellent fire retardant with thermal insulation properties? With CALOSTAT®, a rather new product of Evonik, those lines become blurred—it does both equally well, after all, yet remains very slim. And in the medium term, that could even be of benefit in paints and coatings.

Dr. Gabriele Gärtner

When it comes to unused potential for saving energy, buildings can't be beat: They are responsible for 28 percent of the world's energy consumption, a figure that rises to 45 percent when only Western countries are taken into consideration. According to the German Environmental Agency (UBA), an energy retrofit can reduce a building's primary energy demand by up to 90 percent. The EU has responded by strengthening its directives for the overall energy efficiency of buildings: Starting in 2021, for instance, all new buildings in the EU are to be constructed to meet virtually the same standards as zero-energy buildings. These buildings produce electricity and/or energy in an amount corresponding to their energy consumption.

While good thermal insulation is key for making buildings more efficient, growing building efficiency demands are resulting in thicker and thicker insulating materials. However, space is particularly limited and expensive in city centers, and fire-safety standards here are high. For this reason, architects are on the lookout for lean solutions that can meet both of these demands while leaving as much room as possible for creative design.

Recognizing this trend, Evonik launched a silicon-based heat insulation panel almost three years ago—a semifinished product sold under the name CALOSTAT® which is made of synthetic, amorphous silica. Its thermal conductivity (λ) of just 0.019 W/mK makes CALOSTAT® by definition a superinsulator, performing even better than air at rest, which has a λ value of roughly 0.025 W/mK. This means that CALOSTAT® can be up to 50 percent thinner than conventional mineral insulating materials yet achieve the same effect.

In addition to having superinsulating properties, CALOSTAT® is also categorized as a Class A building material (non-flammable)—an unbeatable combination. What makes this possible are the mineral nature and the fine porous structure of silica. We have long known that AEROSIL®, a synthetic, amorphous silica from Evonik, is an established first-class insulating material for radiant heaters, where the temperature of the heating coils can reach several hundred degrees Celsius. A layer of AEROSIL® up to a maximum of only about 2 cm thick below the stovetop absorbs the heat to the point where electric cables can be placed nearby.

The high-tech insulating material is hydrophilic, however. If it comes into contact with water its inner adhesive forces become so powerful that they can destroy the fine porous structure. When this happens, the material not only changes its macroscopic form—it also loses its excellent insulating properties. That's why the construction industry has long resisted its use as an insulating material. ➜

A superinsulator

0.019

W/mK is the thermal conductivity of CALOSTAT®, which is considerably lower than that of other established insulating materials.

20

millimeters: At thicknesses as low as this, CALOSTAT® can be used flexibly.

50

percent of the thickness with no loss of efficiency: That's what CALOSTAT® offers over conventional mineral insulators.

CALOSTAT® allows highly efficient and space-saving insulation of facade systems, window frames, barrier-free roof terraces, balconies, roller shutter casings, and many other building elements.

➜ The breakthrough came in the form of a new technology from Evonik known as core hydrophobization, which makes the entire pore structure—not just the surface—water-repellent. As a result, water vapor can diffuse through the material without destroying the structure or condensing inside it. And that paved the way for its use in the construction industry.

Plus, thanks to core hydrophobization, CALOSTAT® is not susceptible to mold, which eliminates the need for fungicides and biocides. The fact that it is based on mineral raw materials not only explains its outstanding fire-retardant properties. It also means that, unlike other types of insulation, CALOSTAT® is recyclable. If preferred, it can also be easily disposed of as part of normal construction waste—a cost benefit in the construction industry, which always has its eye on the bottom line.

Effectively suppresses heat transfer

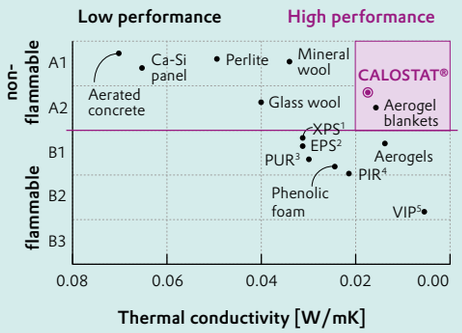
There are three ways that undesirable heat conductivity can arise in insulation: solid-state thermal conductivity, heat transfer via gases (which is inhibited, for instance, by the vacuum in multiglazed windows), and heat transfer via infrared radiation.

CALOSTAT® effectively limits thermal conductivity and heat transfer. The solid-state matrix of the silica used is specially treated in such a way that the contact surface—and thus the transfer paths between individual solid particles—is kept as small as possible, minimizing thermal conductivity. In addition, the very tiny pore spaces limit the energy transferred by gaseous conduction. Thermal radiation doesn't stand a chance with CALOSTAT® panels either.

The material and its fine pore structure also confer a second advantage: Its thermal conductivity, unlike that of traditional insulating materials, is almost not temperature-dependent. As a result, CALOSTAT® not only prevents the interior from cooling during the winter—it also keeps it from heating up in the summer, when building exteriors can easily reach temperatures of up to 80 °C. This pays off especially in buildings made of lightweight panels. Here, rooms easily become overheated, because the shade from blinds alone is not enough.

Top marks for high performance

Its combination of fire resistance and low thermal conductivity makes CALOSTAT® superior to established insulating materials.

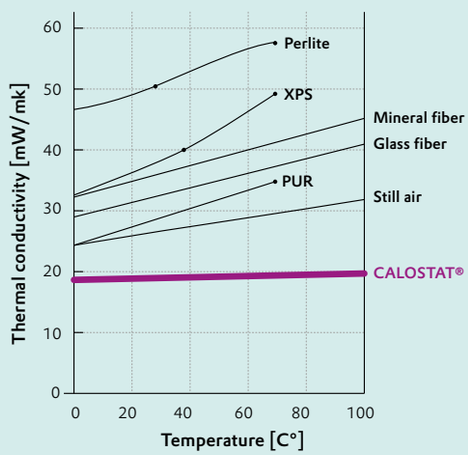


Legend

[1] XPS: Extruded polystyrene
[2] EPS: Expanded polystyrene
[3] PUR: Polyurethane
[4] PIR: Polyisocyanurate rigid foam
[5] VIP: Vacuum insulation panel

Cool in the summer

Unlike that of other insulating materials, the thermal conductivity of CALOSTAT® is virtually independent of temperature, allowing it to provide protection from summer temperatures as well.



Strength in indoor environments and fire protection

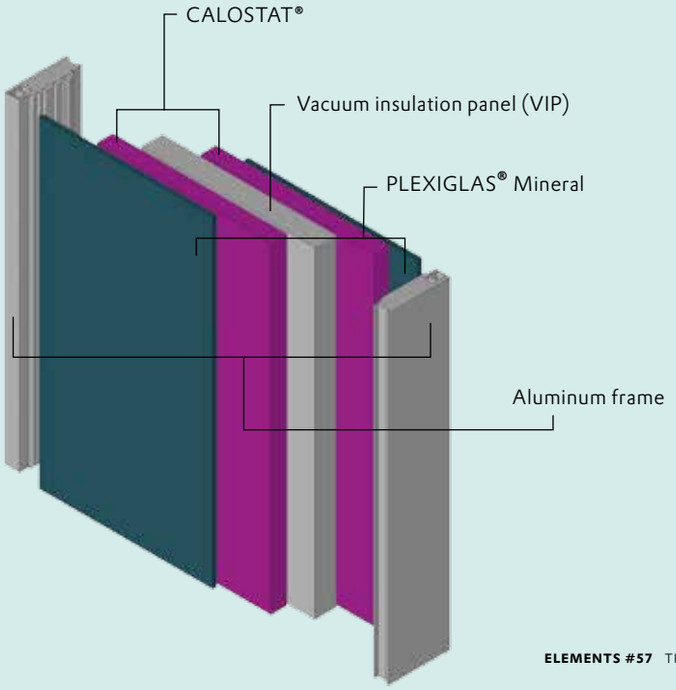
The reason why the thermal conductivity of CALOSTAT® is almost not temperature-dependent is its favorable temperature-amplitude ratio—a complex interplay of specific storage capacity, density, and thermal conductivity. The ratio describes the phase shift in the temperature maxima observed when heat is transferred through an external wall. Studies conducted by the Bavarian Center for Applied Energy Research (ZAE) in Würzburg (Germany) have shown that, in walls insulated with CALOSTAT®, heat takes eight to twelve hours to reach the interior wall—in other words, not until nighttime, at which point the air outside has cooled and ventilation from windows provides a pleasant ambient temperature.

In the time since the company introduced the CALOSTAT® brand in 2013, the team of developers has taken an intense look at the needs of customers and end consumers. Using numerous reference objects, they have been able to demonstrate the performance of the thermal insulation panels.

The most recent example can be found in the historic center of Düsseldorf, where the team insulated the ceilings of the basement and underground parking garage of a historic landmark building to which a modern extension had been added. The structure of the underground garage and the sprinkler system of the historic building were to be preserved to keep costs down, even though they left little space for thermal insulation or fire protection. The structure of the modern annex needed to be updated accordingly. The project played to the strengths of CALOSTAT®, which offers excellent fire-retardant and thermal insulation properties for the basement ceiling while protecting the sprinkler system from freezing temperatures—all in very little space. The insulating layer is only 40 mm thick, whereas traditional insulation would have required a much thicker layer.

Suitable for inside and outside the building envelope

CALOSTAT® is suitable for cavity insulation for load-bearing external walls, for interior insulation, for insulating rainscreen cladding, and for concrete sandwich elements. Within the facade itself, the insulation can be combined with ceramic tiles and with elements made of glass, metal or concrete—even with PLEXIGLAS®. Evonik has

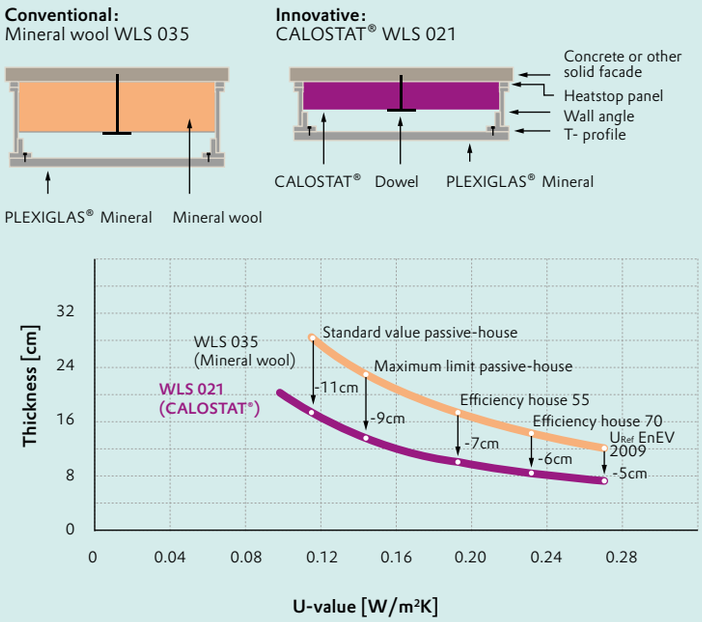


Setting new standards: The insulation paneling developed by Evonik is **just 12 cm thick.** This can, for example, positively impact statics in the energy restoration of old buildings.

Graphic: C3 Visual Lab

Saving space: Slim insulation that meets passive-house standards

When used for insulating a solid exterior wall, CALOSTAT® can achieve passive building standards with a layer 11 cm thinner than would be the case with mineral wool.



been included in KlimaExpo.NRW—a climate-protection exhibition and idea laboratory sponsored by the German state of North Rhine-Westphalia—for its development of an insulating panel made of CALOSTAT® and PLEXIGLAS® Mineral for building exteriors. Thanks to its heat transfer coefficient of 0.15 W/m²K, the panel only has to be 12 cm thick to achieve passive building standards, using 90 percent less heating energy than a traditional building.

Despite having developed this product for building exteriors, Evonik sees itself as a manufacturer of semifinished products, whose customers produce thermal insulation systems. Not surprisingly, the company offers extensive applied technology services up to and including joint development projects.

One example here is a material composite consisting of CALOSTAT® and calcium silicate for interior insulation. Covered by an Evonik patent, the composite drains capillary water from the interface with the wall, thus preventing mold from forming at this boundary layer. The development work that Evonik conducts with its partners has also yielded a sandwich panel with CALOSTAT® that is mechanically bonded with a mineral fleece or even just with mineral wool—despite being exceptionally thin, the panel possesses outstanding handling and thermal insulation properties.

More freedom for component geometry

But research work on CALOSTAT® hasn't stopped there. In order to free up more options for component geometry, there are plans to offer the material in granulate form. Their ability to fill cavities means that granulates can be used for insulating reactors or boilers, for example.

For this to work, the granulate must be mechanically stable and it must be possible to control its pore structure, as this has a critical impact on its thermal insulation properties—if this structure is destroyed by stirring or shaking, the insulating properties will be lost. The team of developers is currently working on adjusting the granulation process for silica in order to optimize density, pore size, and mechanical stability, while maximizing cost-effectiveness.

Overcoming this hurdle would also clear the way for its use as a highly insulating filler for mineral-based construction products and coatings. This, in turn, would open up the possibility of manufacturing safe-touch and thermal insulation coatings, which differ in terms of thickness. For safe-touch coatings, just a few millimeters is all it takes to prevent a hot surface from damaging skin on contact. Industrial occupational safety would be one potential application.

Thermal insulation coatings take this a step further. Unlike safe-touch coatings, they prevent energy from being lost in the form of heat transferred to the surrounding air. This, however, requires thicker coatings of several centimeters.

While these developments are far from being ready for the market, the CALOSTAT® team has already sent granulate samples to an initial group of customers. The move marks a return to familiar work habits: looking to the needs of the market, even at an early stage in the process, and incorporating customer feedback into the ongoing development process.

The expert

Dr. Gabriele Gärtner works in Evonik's Resource Efficiency Segment, where she is responsible for applied technology, research, and development of CALOSTAT®.

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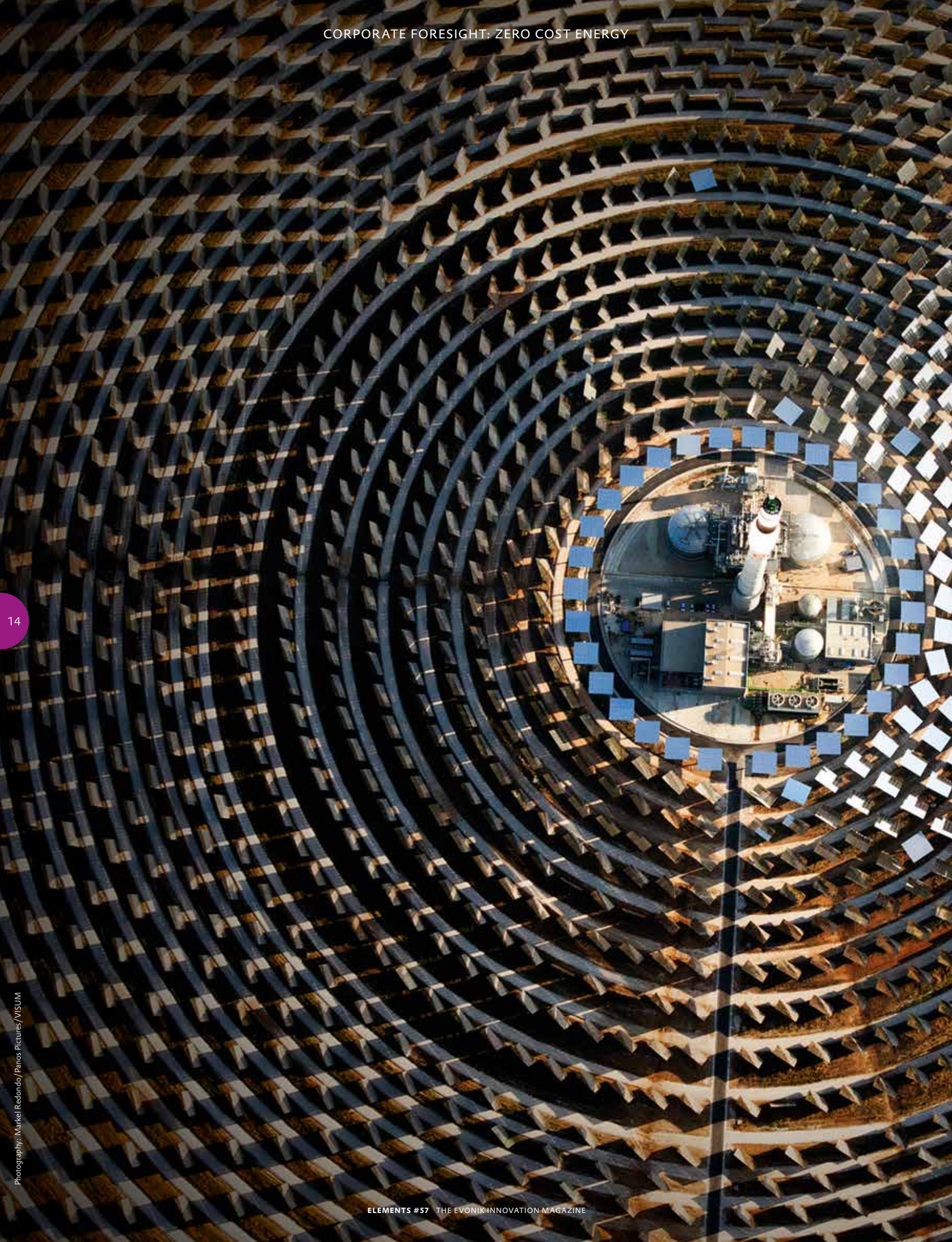
Photography: Evonik | Graphic: C3 Visual Lab



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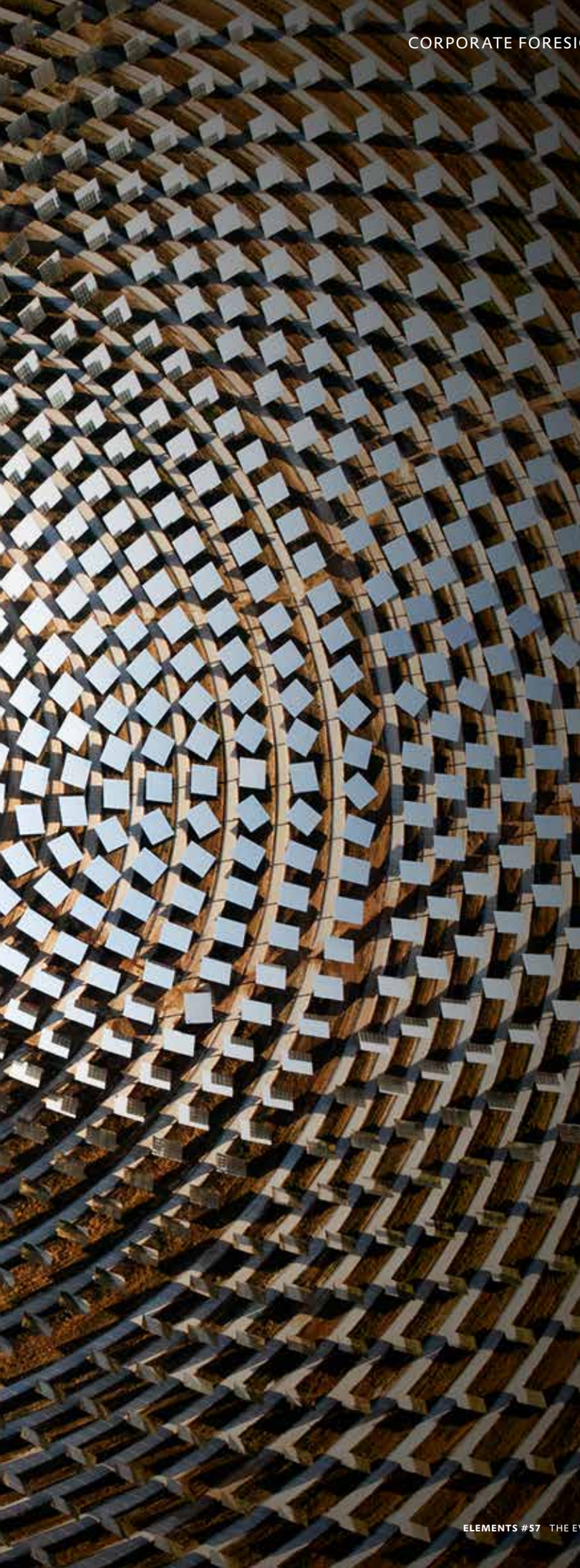


ENERGY AS AN ECONOMIC FACTOR

Electricity aplenty

Energy is one of the chief cost factors of any manufacturing industry. But that could quickly change if electricity prices head towards zero. One driver of falling prices is the incredible advances in solar energy technology: In many regions of the world, the production and use of solar energy will soon become the cheapest form of power. Moreover, new technologies such as flexible solar films or the use of new materials like perovskite ($CaTiO_3$) promise additional increases in efficiency and lower costs. According to estimates, the price of electricity from solar energy could be about 2 cents per kilowatt hour by 2050.

Enormous advances are also occurring in other forward-looking technologies, especially nuclear fusion. In 2014, Lockheed Martin announced that, in ten years, it intended to bring to market a 100 MW fusion reactor the size of a sea container. The market maturity of this technology would herald an age of unlimited and affordable energy—with a dramatic impact: It would significantly reduce the cost of e-mobility and energy-intensive processes such as aluminum production and the desalinization of sea water while rendering energy generation from fossil fuels obsolete.

But while the technologies for energy production are forging ahead boldly, network expansion is lagging behind. Even now, networks in many places are reaching the limits of their capacities at main feed-in times. To reduce their burden, the excess energy has to be consumed—if necessary, at a charge to the consumer. So it is not unusual to hear nowadays that you can "use electricity and earn money doing it."

The Corporate Foresight Team evaluates the impact of these changes on Evonik as part of its GameChanger focus topic. Because one thing is clear: For the specialty chemicals industry in particular, falling energy prices, or even zero cost energy, will be a real game changer.

"PUT GOOD PEOPLE IN A GOOD PROJECT, AND WATCH IT TAKE OFF"

Dr. Gerd Löhden heads the Innovation Management unit at Evonik's Resource Efficiency Segment. In this interview he talks about enjoying research, the ongoing trend toward resource efficiency, and his strategy for doubling the segment´s output of new products and technologies by the year 2020.

Dr. Löhden, what do you expect of good researchers?
The desire to create and a willingness to fight for their ideas and projects. That they know what to do with the freedom we provide, and therefore enjoy their work. Resource efficiency is an exciting area. A lot can be achieved there.

When it comes to new products, isn't resource efficiency a given—because of economic reasons alone?
What makes us unique is that our products are not only manufactured in a resource-efficient way, but they also help the customer save resources—for example, by protecting against corrosion and wear. That extends the life of commodities. Or by lowering the consumption of energy and materials.

In which markets do you see the greatest leverage for resource efficiency for your segment?
One key driver is resource-efficient mobility. We offer a number of solutions for lowering a car's fuel consumption: silica-silane technology for green car tires; oil additives that, as part of lubricants, reduce friction losses in the drive train; lightweight high-performance polymers that can also be installed in the hot engine compartment; and thermoplastic and thermosetting lightweight construction materials developed by Creavis in the Composites Project House for more economical lightweight construction in cars—a solution that we have now taken over since the conclusion of the project house. With all of these products we are knocking on open doors, because we help our customers not only to save resources, but also to comply with the increasingly stringent requirements for climate and environmental protection. The coatings market, too, is extremely important for us. Longevity is the name of the game here, because coatings make consumer goods more durable, so they don't have to be replaced so often. At the same time, the environmental requirements for coatings are increasing.

If your products are right on trend, then what is the challenge for research and development?
We want to continue offering our customers high-quality products over the years and decades to come. And we want innovations to make a significant contribution to the growth of our segment. For this reason, we are pursuing the extremely ambitious goal of doubling the output of our research into new products and technologies by 2020.

Twice as many new products and technologies within four years—how are

"With our products we are knocking on open doors. We help our customers comply with increasingly stringent requirements."

“Defined growth fields, synergies, internationalization—this is our leverage for additional growth through innovation.”

Dr. Gerd Löhden

Dr. Gerd Löhden, a chemist by training, has been Head of Innovation Management at Resource Efficiency since the establishment of the Segment in 2015. He was previously in charge of Innovation Management in the former Coatings & Additives Business Unit.

you going to achieve that?
We are already good at maintaining the competitiveness of our core business with new products. But if we want to grow, we have to do more in R&D. We are focusing on new fields of growth, exploiting synergies, and increasing our international presence. Specifically, this means we want to use our wide-ranging technology expertise to work promising growth fields for our segment—namely, everywhere in the world where the relevant market is seeing the strongest growth.

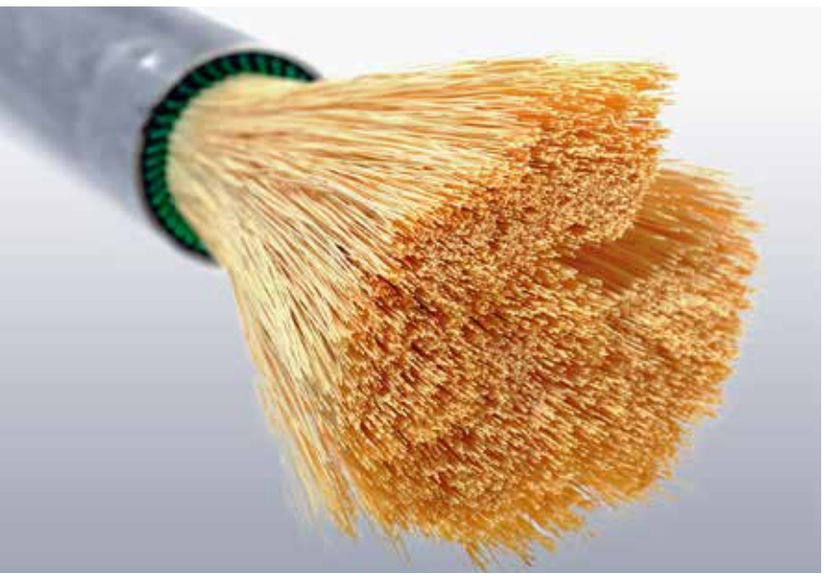
In which fields does the Resource Efficiency Segment want to grow through innovation?
We have defined six topics into which we are putting more resources for faster growth: thermal insulation, membranes, tires, electronic solutions, 3D printing, and surface solutions. Resource efficiency is the driver for all six topics. To take just one example, the idea behind Surface Solutions is, among others, protection against fouling and icing—phenomena that cause enormous economic damage, because they drastically increase the fuel consumption of ships and aircraft and reduce the performance of wind turbines.

700
employees work in research and development in the Resource Efficiency Segment. About 600 additional employees work in applied technology.

You plan to exploit synergies in your technology expertise. How will you do that?
By combining our expertise on a specific topic. Take, for example, friction between moving parts, such as in a car engine or in industrial machines. We have extensive ➜

Photography: Lina Nikelowski

“About four percent of our revenue in the Resource Efficiency segment goes on innovation.”



Membranes is one of six growth fields at Resource Efficiency. It includes SEPURAN® membrane technology for efficient gas separation in biogas upgrading, helium recovery, and nitrogen generation.

➜ know-how in polymers, coating and bonding, interfacial chemistry, particle technology, and oil additives. And through the Oil Additives Business Line we have both market access and application expertise—we have engine test stands for testing our developments. This combination makes us unique. We intend to leverage that now and are building a Friction & Motion Competence Center in Darmstadt (page 19). Above and beyond our oil additives business activities, this is where we want to investigate ways we can further reduce friction with new materials and technologies.

You’re building the new Friction & Motion Competence Center in Germany. How is this “international”?
Without doubt, we will strengthen our R&D internationally and in close proximity to our markets. This is particularly true of North America and Asia. In Europe, we are already very well positioned. In North America, we will benefit from the acquisition of APD Performance Materials*, the Specialty Additives division of Air Products, with its excellent R&D employees and strong innovation pipeline. APD Performance Materials generates between 15 and 20 percent of its sales with new products and has R&D centers worldwide.

**The acquisition is subject to the approval of the relevant antitrust authorities.*

Which growth field will see the most benefit from the new specialty additives business?
Surface Solutions without doubt—epoxy systems, for example. Evonik is a leader in amine-based epoxy hardeners, and APD Performance Materials is a leader in epoxy hardener formulations that are used in applications such as ship coatings. Out of US$1.1 billion in sales in 2015, APD Performance Materials generated about 40 percent with epoxy hardeners and resins. Other strengths of the unit also include additives for water-based coatings. So our areas of expertise complement each other very well, and we can exploit a lot of synergies here.

And what is your experience in Asia?
We have already gained a lot of good experience with our Coating Additives Laboratory in Singapore. Here, our employees develop additives and binders for coatings that get particular impetus from the Asian market. The laboratory is extremely successful. In the last few years, it has developed ten completely new products and filed one patent application. Two patent applications are in preparation. We give our colleagues in Singapore a lot of freedom to tackle ideas in an uncomplicated way at an early stage.

Do you plan to expand your activities in Asia?
We intend to significantly increase our presence in the growth regions and make ourselves more attractive for talented people in our field. Based on the very positive experience we’ve had, we are currently working on plans to significantly expand our R&D commitment in Asia. We’re working out the details for that now.

More resources for growth fields, more R&D in Asia, a new competence center—how do you finance all that?
We have a comparatively high R&D budget. In the Resource Efficiency Segment we spend about four percent of our revenue on innovation—that amounted to about €180 million in 2015, and we aren’t planning to change that. We’ve also taken a critical look at our existing project portfolio and given it a stronger focus. This has freed up funds for new activities.

How do you assess whether a new project fulfills your economic and substantive criteria?
We have processes and key figures that we use to manage our projects. However, we don’t expect a hard and fast net present value and sophisticated Excel tables on the very first day. At the beginning of a project, there has to be persuasive story and a committed employee who fights for it, because when the story is right, that can be far more convincing than a KPI. This is why we give our employees a lot of room for creativity. If they want to make a difference, they can do that with us. In my experience, when you put good people in a good project, you can watch it take off.

The name says it all
The Resource Efficiency Segment offers high-performance materials for environmentally friendly and energy-efficient system solutions, especially for the automotive industry and the paints, coatings, plastics, and construction industries. With 8,662 employees, it generated sales of €4.3 billion in 2015; the ROCE (Return on Capital Employed) was 24.8 percent.

Photography: Evonik

LOWER FRICTION, HIGHER EFFICIENCY

At the end of 2015, the Resource Efficiency Segment started planning a Friction & Motion Competence Center dedicated to the task of developing new solutions that further reduce friction and wear and their associated economic costs.

Dr. Günter Schmitt

Friction is an energy guzzler, and the savings potential in this area is huge: Experts estimate that improvements of between 10 and 20 percent could be realized in transport and industry by new tribological system solutions. Up to 20 million terajoules of energy could be saved in this way worldwide, because 100 million terajoules per year are currently lost due to friction after all.

Consumers would also benefit: The annual "friction costs" for the average passenger car would be reduced by €250 with tribological optimization of just five percent. And lower friction means less wear and therefore longer component life, leading to significantly higher resource efficiency in mobility as well as the industrial environment.

This is where the Friction & Motion Competence Center comes in. It will identify improvement and savings potential in various application fields and develop system solutions for the efficient use of operating power. Its 15 or so employees will also work on such new fields as e-mobility, robotics, and drone technology.

The starting point here is the wide-ranging technological and marketing expertise of the Oil Additives Business Line in lubricants and lubricant additives. But the Competence Center will also benefit from the comprehensive skills of the Resource Efficiency Segment in coatings and high-performance polymers. The Center's work will focus on three main areas. Fluid Solutions will investigate novel additives for lubricants targeted at reducing friction and wear between surfaces moving against each other. New high-performance polymers can be expected to bring lightweight construction into the powertrain—for example, to replace materials of higher density. This is also relevant in other areas of long-term interest such as robotics and drones. Finally, new coatings will counteract friction and wear directly without the need for large quantities of liquid lubricants.

The Competence Center is aiming at a holistic view because these three fields are closely interlinked. New high-performance polymers for the powertrain, for example, require specially adapted lubricant additives in order to realize their full performance potential. Ever since its inception, the Center has been closely aligned to market needs and the specifications of OEMs and customers as well as to the latest results from research institutions.

To enable employees to perform all their tasks professionally, the Competence Center is also professionally equipped. In addition to chemical and technological expertise, it is currently developing a series of new test and analytical methods to comprehensively investigate, understand, and counteract the causes and effects of friction.

The networker

Dr. Günter Schmitt is Head of the new Friction & Motion Competence Center, which operates within the Oil Additives Business Line.

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Main focuses Friction & Motion

Fluid Solutions: Novel additives for lubricants

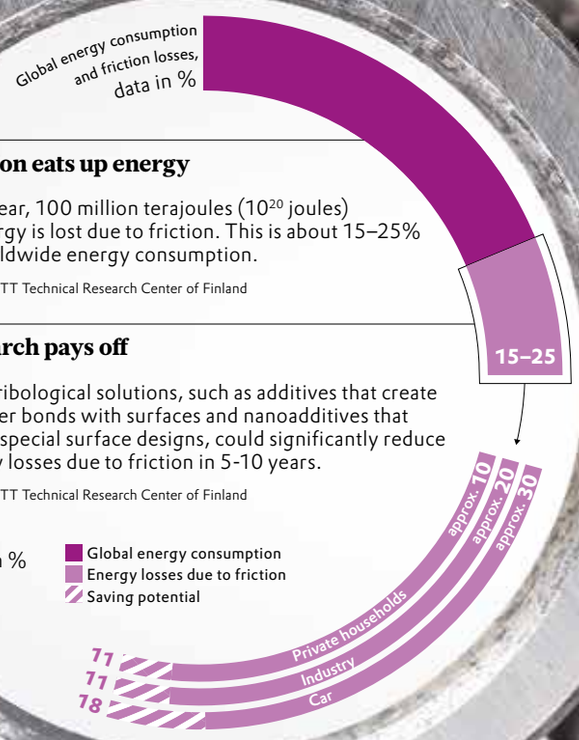
High-performance Polymers: Replacement of high-density materials in the powertrain

Coatings: Direct counteraction of friction and wear

Photography: shutterstock, Evonik | Graphik: C3 Visual Lab

All-rounder

Lubricants take on a wide range of tasks. They…



Friction eats up energy

Each year, 100 million terajoules (10^{20} joules) of energy is lost due to friction. This is about 15–25% of worldwide energy consumption.

Source: VTT Technical Research Center of Finland

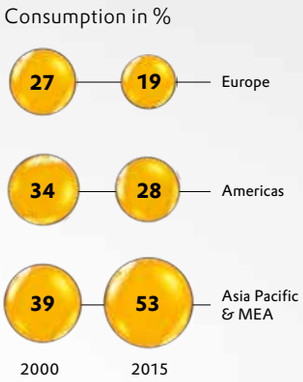
Research pays off

New tribological solutions, such as additives that create stronger bonds with surfaces and nanoadditives that create special surface designs, could significantly reduce energy losses due to friction in 5-10 years.

Source: VTT Technical Research Center of Finland

Data in %

- Global energy consumption
- Energy losses due to friction
- Saving potential



Growing demand in Asia

From 2000 to 2015, the worldwide lubricants* market grew relatively slowly, due to improved lubricant quality mainly through additives and longer oil-change intervals. But regional demand has changed dramatically.

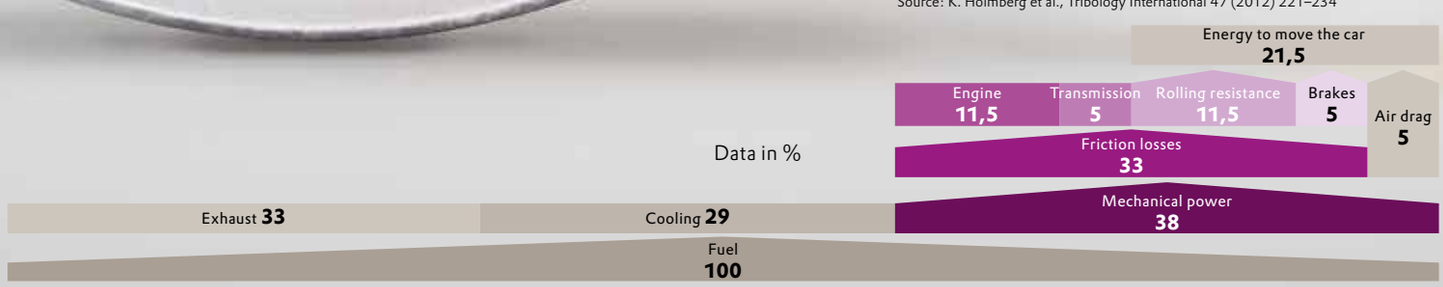
*not including marine lubricants
Source: Fuchs Petrolub

Friction costs fuel

Only 21.5% of the fuel in a car is used to move the car* forward—rolling and air resistance and friction is overcome by braking. Thirty-three % of fuel consumption is caused by friction (engine, transmission, rolling resistance, braking).

*Global average car, 4 cylinder, 75 kW, 1,500 kg, 8l/100 km, average speed 60 km/h, manufactured in 2000

Source: K. Holmberg et al., Tribology International 47 (2012) 221–234



Photography: shutterstock | Graphik: C3 Visual Lab

DATA MINING

Running smoothly

Wherever there is friction, there's also energy loss and wear and tear. The science of friction and its reduction by means of lubricants and optimized surfaces is called tribology. At Evonik, experts are doing research in this field at the new Friction & Motion Competence Center. Wherever friction losses diminish, lucrative markets await.

Less friction through lubricants

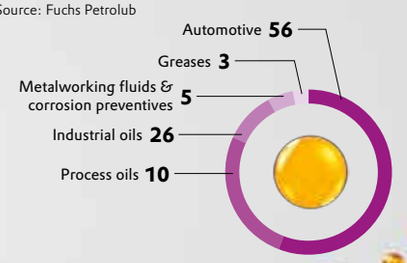
Whenever two surfaces move relative to each other, there is friction. Possible effects: distortion, welding, shearing, energy loss. Lubricants counteract this. Ideally, only their internal friction results in losses, which depends on their viscosity. This is why the trend is towards lubricants with lower, temperature-independent viscosity and optimal wear protection through new additives.

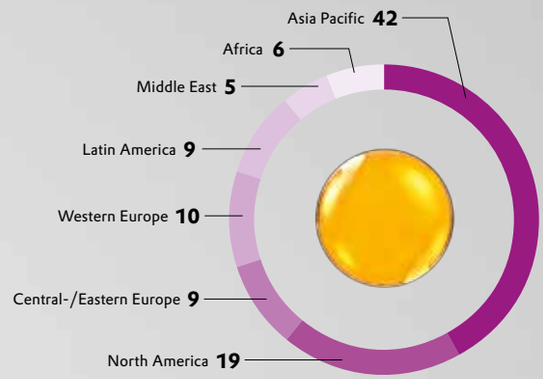
Motor vehicles dominate

More than half of all lubricants are used in automobiles (engine, transmission, hydraulics).

Data in %, 2015

Source: Fuchs Petrolub





Regional consumption

In 2015, the Asia-Pacific region accounted for 42% of worldwide demand for lubricants*.

*not including marine lubricants

Total: 35.6 million metric tons, data in %, 2015

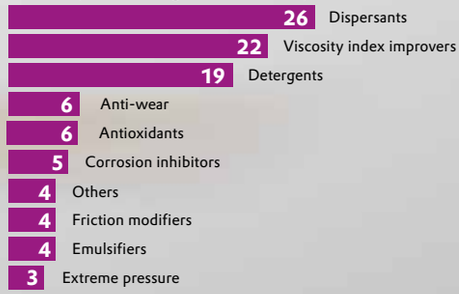
Source: Fuchs Petrolub

Additive consumption by function (in %, all figures rounded)

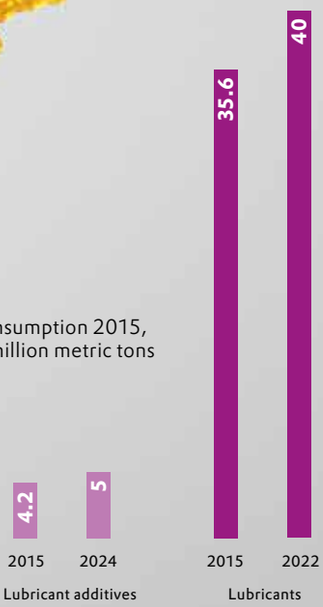
Indispensable additives

Additives determine lubricants' properties. They can be up to 30% of a lubricant's volume. The most-used additives are dispersants, VI improvers, and detergents.

Source: Kline&Co.



Consumption 2015, in million metric tons



Worldwide consumption of lubricants and lubricant additives

In 2015, 35.6 million metric tons of lubricants* (valued at about US$90 billion) and 4.2 million metric tons additives were used.

*not including marine lubricants

Source: Fuchs Petrolub, Lubes´n´Greases

Infographic: C3 Visual Lab

INDUSTRY MEETS ACADEMIA

Innovation requires openness. Every two years, Evonik puts this into practice with its scientific forum Evonik Meets Science. There experts from the company can join university researchers in an intensive exchange of information on new research projects.

"Corrosion is a highly complex process."
Prof. Günter Schmitt, CEO, IFINKOR Institute for Maintenance and Corrosion Protection Technologies n.f.p. Ltd., at the South-Westphalia University of Applied Sciences

"In addition to improved protection against corrosion for offshore wind turbines, other applications can also profit from our technology."
Jan Berger, Head of Oil Exploration in the High Performance Polymers Business Line

The ocean can be both a living space and a harsh environment at the same time: living space for maritime creatures, harsh for the steel structures used to anchor offshore wind turbines to the sea floor. In the current situation, mechanical stresses from wind and waves, fouling by organisms, and a corrosive milieu mean that extensive maintenance work at operative offshore wind turbines can become necessary after just a few years. That this need not remain so was just one of the topics of the scientific forum Evonik Meets Science, which took place in September in Bonn.

For the eighth time already, more than 200 scientists from universities came together at the event with researchers from Evonik. This time the experts came together under the motto "New materials for sustainable innovation." Every two years the scientific forum serves as a joint platform for dialogue—in the form of presentations, posters, a podium discussion, and plenty of time for networking.

Evonik Meets Science takes place not only in Germany but also in China, Japan, and the USA. "We cannot solve the complex problems specialty chemistry is facing on

The former plenary hall of the German Bundestag in Bonn formed the scenery of Evonik Meets Science 2016.

Illustration: C3 Visual Lab

"Infrared spectroscopy is a powerful tool for a better understanding of silica/silane systems."

Prof. Frédéric Thibault-Starzyk, Research Director at the Centre National de la Recherche Scientifique (CNRS)

"The rolling resistance of car tires causes 20 per cent of fuel consumption."

Prof. Anke Blume, IP Manager in the Silica Business Line

our own," said Dr. Ulrich Küsthardt, Chief Innovation Officer at Evonik, at the opening. "We therefore want to work together with universities over the long term in an innovation ecosystem, within an international framework."

These cooperative efforts are already a component today in making Evonik—as is our stated goal—"one of the most innovative companies in the world," as Dr. Küsthardt put it. In the mid-term, the company wants to achieve 16 percent of its sales with products and applications that are less than five years old. At the event in Bonn, researchers from universities and Evonik came together to present the results of projects that could meet this goal.

"Innovations are levers for opening up new markets, driving growth forward, and creating high-quality jobs," said Klaus Engel, Chairman of the Executive Board of Evonik, on the occasion of his laudation for the Bergius Lecture (see page 24), which was presented in the context of the scientific forum. "Resource efficiency is one of the central challenges of the future," continued Dr. Engel. "With its innovative products, Evonik is making a contribution to sustainable development." In this way, resource efficiency is becoming a driver of research and development, thus securing the competitiveness of Germany as an industrial location.

More protection against corrosion for wind turbines

The fact that resource efficiency is also important for renewable energies is shown by the example of the maintenance-intensive offshore structures mentioned at the beginning. One might think that such problems had already been solved after decades of offshore oil production. "A drilling platform is manned and produces two million dollars a day; in contrast, a wind turbine operates autonomously and has to be much cheaper," as Dipl.-Ing. Jan Berger explained the problem. He heads the Oil Exploration Subsegment in the High Performance Polymers Business Line at Evonik.

Concepts from oil production cannot be transferred one to one. For Evonik this meant that although solutions based on high-performance polymers have already been in production for more than a decade for the oil and gas industry, there was still no material available that could be used for mass production of structural tubing for jacket grounding structures for offshore wind turbines.

Berger explained the search for a solution to the problem in the KOWIND research project sponsored by the BMBF (German Federal Ministry for Education and Research). The goal was to develop precoated pipes and joints for the framework structure of the grounding elements as well as a field coating system for weld seams based on polyamide 12.

The IFINKOR Institute for Maintenance and Corrosion Protection Technologies n.f.p. Ltd., an institute associated with the South-Westphalia University of Applied Sciences, and a partner in the KOWIND project, was responsible for corrosion testing and for the preparations for official approval. "For this purpose, we first had to find appropriate testing procedures," reported Prof. Günter Schmitt. Active infrared thermography and magnetic resonance tomography (MRT) proved suitable.

"Thermography not only enabled us to track the timing of the delamination," said Schmitt. "It also helped in developing appropriate primers, because it enabled us to get quantitative results." In turn, MRT makes it possible to measure the aging of the coating. Even though there is still a way to go before the new material system is approved, the test results have convinced Berger that it is "far superior to the current market offerings."

Less rolling resistance for tires

The role played by modern measurement technology in the development of new materials was also shown in the joint presentation by Prof. Anke Blume, IP Manager ➜

Illustration: C3 Visual Lab

RETHINKING CATALYSIS

At this year's Evonik Meets Science scientific forum, Evonik awarded the Bergius Lecture to Prof. Matthias Beller. The specialty chemicals company chose Beller in recognition of his many years of outstanding service to catalysis research.

Matthias Beller has spent a substantial portion of his career grappling with a single subject area, without which many products would not exist in their current form. "Eight out of ten processes in the chemical and pharmaceutical industries benefit from catalytic reactions," he stressed as he began his lecture. As part of the Bergius Lecture, he described the opportunities new research work is opening up for future catalytic reactions. Beller is the executive director of the Leibniz Institute for Catalysis (LIKAT) and a professor at the University of Rostock. "Much of our work has been done in partnership with Evonik," he said. Indeed, LIKAT and its predecessor institute have worked with the specialty chemicals company on research projects for the last two decades.

"Despite systematic advances, chance still plays a role in catalysis research," Beller said. As an example, he described experiments at his institute that involved producing new catalyst materials based on metal-amine complexes. "Despite all of our efforts, the system initially turned out to be inactive," he said. "It became activated only after the employee involved, who was inspired by a colleague's work in a completely different area, pyrolized the complex." The resultant heterogeneous metallic nanoparticles are in contact with nitrogen-doped graphenes and then behave like a homogeneous system. While the activities are not yet as good as a comparable precious metal system, their selectivity is actually better[1].

Today, researchers know that "catalysis is more than the individual catalytic center," says Beller. This is why he views cooperative catalysis as an important line of development. "The combination of elements, control of the structure, and modification of the nearby environment of the catalytic centers all play a role."

In the past few years, this is the only way LIKAT researchers could show that it was possible, in principle, to replace rare and expensive precious metals like palladium, ruthenium, and rhodium with more economical and widely available metals in complex-based catalysts.

Honored for outstanding research: Prof. Matthias Beller (middle). Right: Klaus Engel, Chairman of the Executive Board of Evonik, left: Ulrich Küsthardt, Chief Innovation Officer.

"We have to go off the beaten path if we want to develop new, more resource-friendly catalysts."

Prof. Matthias Beller, LIKAT

For example, Beller and his team have achieved highly promising results in the area of hydrogenations and dehydrogenations with iron-based systems[2]. The LIKAT scientists have been successful even with manganese catalysts, which up to now have not been considered active in hydrogenation. Some examples of this work include their hydrogenations of ketones and nitriles[3]. "In the right microenvironment, it also works with aldehydes and alkynes," says Beller. But that is not all: Cobalt-based heterogeneous catalysts can also be obtained from waste products such as prawn shells. "We have to go off the beaten path if we want to develop new, more resource-friendly catalysts," Beller stresses.

[1] F. Westerhaus, R. Jagadeesh, G. Wienhöfer, M. Pohl, J. Radnik, H. Junge, K. Junge, A. Surkus, J. Rabeah, A. Brückner, M. Beller, Nature Chem. 2013, 5, 607-612.

[2] S. Werkmeister, K. Junge, B. Wendt, E. Alberico, H. Jiao, W. Baumann, H. Junge, F. Gallou, M. Beller, Angew. Chem. Int. Ed. 2014, 53, 8722-8726.

[3] S. Elangovan, C. Topf, S. Fischer, H. Jiao, A. Spannenberg, W. Baumann, R. Ludwig, K. Junge, M. Beller, J. Am. Chem. Soc. 2016, 138, 8809–8814.

Photography: Stefan Wildhirt

"Lubricants make a decisive contribution to lowering fuel consumption."

Dr. Thorsten Bartels, Head of the Performance Testing Laboratory of the Oil Additives Business Line

"Test bench measurements in the automotive industry are more complicated than one might first think."

Prof. Gerald Ruß, University of Darmstadt

➜ in the Silica Business Line at Evonik, and Prof. Frédéric Thibault-Starzyk, Research Director at the Centre National de la Recherche Scientifique (CNRS) and Professor at the École Nationale Supérieure d'Ingénieurs de Caen (ENSICAEN).

They presented the development of new silica/silane systems, which made "green tires" possible through lower rolling resistance and improved wet grip with quasi-constant wear. Using infrared spectroscopy, Thibault-Starzyk's team characterized what happens with the SiOH groups when a silica/silane system is added to a synthetic rubber. "Thanks to its polar and nonpolar sides, the silane, as a bonding agent, ensures that the chemical incompatibility of the rubber and the reinforcing filler silica can be overcome," he explained. How this takes effect during processing and later in the tires depends decisively on the accessibility of the SiOH groups. "Spectroscopically we see which SiOH groups are accessible for molecules of different sizes," continued Thibault-Starzyk. The coupling of the silane to the silica can be analyzed in the reactor in real time.

Based on these measurements and molecular modeling, Blume and her team were able to derive how existing silica/silane systems have to be modified in order to produce better tires. "We were searching for a silica with a high proportion of isolated silanol groups that simultaneously had just a small number of bridged silanol groups," said Blume.

In addition, silane would have to be adsorbed quickly to the surface of the free remaining SiOH groups during the entire coupling reaction. And, last but not least, effective shielding of the silica improves the processing. "With this knowledge we have now developed silica/silane systems for fuel-saving summer and winter car tires," said Blume.

Lower temperature dependence of motor oils

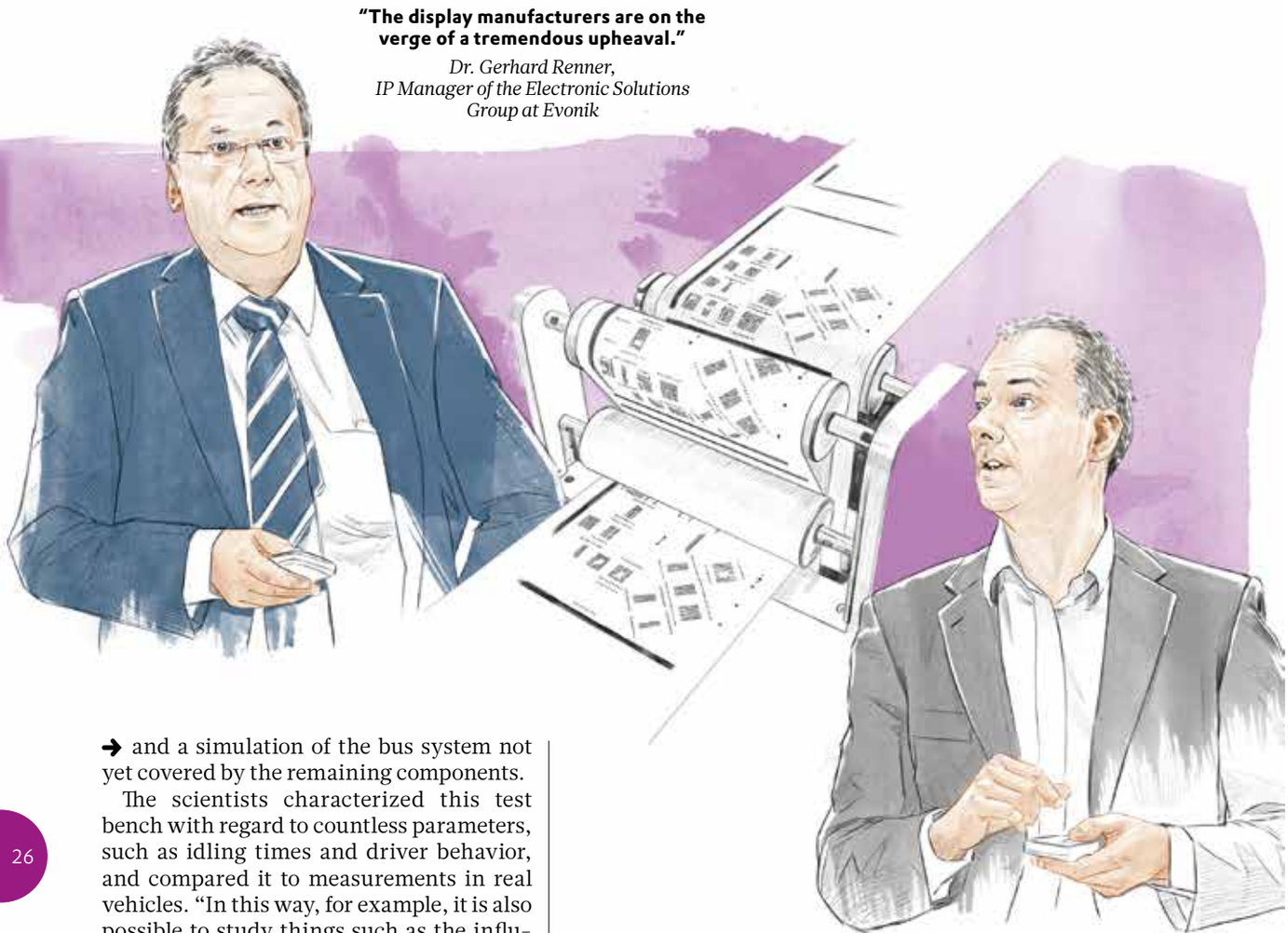
New materials for vehicles were also the subject of the joint presentation of Dr. Thorsten Bartels, Head of the Performance Testing Lab in the Oil Additives Business Line at Evonik, and Prof. Gerald Ruß of the University of Darmstadt. They presented new lubricant additives and the role complicated testing played in their development. "The ideal motor oil would have a temperature-independent viscosity," explained Bartels. "At low temperatures it has to be as low as possible in order to save fuel, and at high temperatures it has to be at least high enough to prevent wear, abrasion, or material fatigue."

While the requirements at high temperatures can already be met well today, there is still definitely potential for improvement at low temperatures. This is where Evonik stepped in with a further development of its existing additive technology based on comb polymers. These are long-chain molecules based on alkyl methacrylates with very long nonpolar side chains. In the lubricant, they take the form of a coil that is compact at low temperatures and hardly increases viscosity and then expands at high temperatures to thicken the lubricant.

"With the additives developed by us, fuel savings of three to four percent are possible; independent test labs have now confirmed this," said Bartels. "However, such certifications are extremely expensive, so that they only made sense after we had already demonstrated the effect of the additives"—meaning after the end of development.

This is where the University of Darmstadt, which had set up a suitable motor test bench, came into play. "Consumption measurements depend on very many parameters," explained Gerald Ruß. "On vehicle roller test benches, it is possible only through great effort to get the measurement uncertainty below one percent." Ruß and his team therefore work with a dynamic motor test bench: an original vehicle motor with a cable harness, control devices, ➜

Illustration: C3 Visual Lab



"The display manufacturers are on the verge of a tremendous upheaval."
Dr. Gerhard Renner, IP Manager of the Electronic Solutions Group at Evonik

"Printable electronics means resource-efficient electronics."
Prof. Gerwin Gelinck, TU Eindhoven and Holst Centre

➜ and a simulation of the bus system not yet covered by the remaining components.

The scientists characterized this test bench with regard to countless parameters, such as idling times and driver behavior, and compared it to measurements in real vehicles. "In this way, for example, it is also possible to study things such as the influence of moisture in the combustion air that is taken in," Ruß explained. When relative humidity rises by 24 percent, fuel consumption rises by one percent. In the end, this controlled measurement environment also enabled the Darmstadt researchers to characterize the effect of the new additives from Evonik so precisely that the subsequent certification in the test lab was economically feasible.

Simpler production of electronics

The closing presentation at Evonik Meets Science was dedicated to a future topic that researchers around the world are currently addressing: printable electronics. Dr. Gerhard Renner, IP Manager of the Electronic Solutions Group at Evonik, and Prof. Gerwin Gelinck, TU Eindhoven and Holst Centre, showed the potential of this completely new production process. "Printing is an additive process, which means little material is required; it does not require a vacuum, and it can produce functional layers of low thickness," said Gelinck to summarize the advantages.

While the cost per square meter for producing current electronics from amorphous silicon is already less than with crystalline silicon by a factor of 400, the price for printed electronics would drop further by the same factor. "The challenges are to achieve adequately high charge carrier mobility at low process temperatures along with uniform thickness and material composition over an iXscenic® surface area of several square meters," Gelinck continued.

With iXscenic®, Evonik has already developed a material that is suitable for coating and printing. It has a charge carrier mobility that is ten times greater than amorphous silicon. It is of interest, for example, for the production of thin-layer transistors for large displays of the next generation. "For industry, the transition from current semiconductor processes to additive processes is a tremendous change," explains Gerhard Renner. "For this reason Evonik is working together with the Holst Centre in Europe and the Industrial Technology Research Institute in Taiwan to adapt the iXscenic® materials to industrial processes." Preparations are currently under way for the market launch with key customers. This was made possible through cooperation among industry and research institutions.

Illustration: C3 Visual Lab

CompanyNews

SILANE RESEARCH INTENSIFIED

A new Competence Center in Rheinfelden offers space for research, applied technology, analytics, and quality management.

Evonik has constructed a new silanes competence center at its Rheinfelden site, continuing its expansion of research and development in the area of silane technology. About 100 employees work in the new 3,500 m^2 building. As well as R&D, the new competence center is also home to the Applied Technology, Analytics, and Quality Management departments. Short distances between the workplaces create optimum working conditions for collaboration and the exchange of ideas and experiences. "This will enable us to create customized solutions for our customers even faster and more efficiently," says Dr. Johannes Ohmer, a member of the Board of Management of Evonik Resource Efficiency GmbH.

Demand for innovative specialty silanes is high in all markets. For example, the silanes protect buildings, bridges, and monuments against corrosion, make smartphones more efficient, and enable fuel-saving tires and durable paints.

The new research center fits perfectly into Evonik's integrated silane production system. Silane research has been carried out at this site for more than 80 years. The first patent for a silane was granted here in 1934.

Photography: alamy

Lysine from Brazil ➜ Chair in Bochum ➜ Biopolyamides at K ➜

Low extractable fuel line

With the multilayer tubing system 4800, the world's leading provider of polyamide 12 for multilayer plastic tubing systems, Evonik, responds to new requirements in the automotive industry. The new system with an inner layer of low extractable VESTAMID® polyamide 612 offers significantly reduced levels of extractable substances.

Fuels that contain alcohol, for example biofuels containing ethanol, can lead to the extraction of substances from the inner walls of conventional gasoline lines. Under certain extreme conditions these substances can clog the nozzles in new, sensitive fuel systems, which use small-diameter nozzles to create an atomized spray of gasoline and air for fuel injection in order to decrease fuel consumption. To reliably counteract this, the automotive industry is looking for new fuel line materials with significantly reduced extraction.

Reduced level of extractable substances: The new multilayer tubing system 4800.

New plant for Biolys® in Brazil

In the Brazilian town of Castro, Evonik has commissioned a new plant for the biotechnological production of Biolys®. It will have annual production capacity of around 80,000 metric tons. This new plant will meet the rising demand over the past years for Biolys® in Latin America, and particularly in Brazil.

Evonik produces Biolys® on the site of the US-based company Cargill, from which it procures site and logistics services as well as locally produced raw materials. Agricultural products from the region are used as the main raw material for the fermentation. The plant will create around 100 jobs for highly skilled workers.

Biolys® is globally known as a highly efficient source of L-lysine for animal feed, which helps to sustainably reduce costs in both feed production and animal breeding.

Biolys® is used in the feed for poultry, among other things.

Chair for Organic Chemistry

Evonik will endow a chair in organic chemistry at Ruhr University Bochum (RUB). As holder of the chair, renowned chemist Prof. Lukas J. Gooßen will teach and conduct research at the university beginning in the winter semester. Gooßen, 46, will succeed Prof. Günter von Kiedrowski, who is retiring. The organic chemistry chair, including staff and resources, will receive €750,000 in funding for five years.

Lukas Gooßen studied chemistry at the universities of Bielefeld, Michigan, and Berkeley, and earned his doctorate at the Technical University of Munich in 1997. Following a postdoctorate position at the Scripps Research Institute in San Diego, California (USA) in the working group of Prof. K. Barry Sharpless, holder of the Nobel Prize in Chemistry, he worked for nearly two years in Central Research at Bayer AG. In 2004, he qualified as a lecturer at the Max Planck Institute for Coal Research in Mülheim an der Ruhr and continued his research work as a Heisenberg fellow at RWTH Aachen. He became a professor at the Technical University of Kaiserslautern in the Department of Organic Chemistry in 2005.

Defoamers for architectural coatings

The new TEGO® Foamex series 10 to 34 from Evonik makes it possible to develop innovative architectural coatings. The effective defoamers do not have an impact on volatile organic compounds (VOC), are ecolabel-compliant, and reduce production times with minimal investment. They also define filling capacity more precisely and improve the appearance and performance of architectural coatings. The new portfolio comprises ten defoamers with different performance profiles and cost structures.

Progress in life cycle analyses

Evonik has already conducted life cycle analyses (LCA) of around 70 percent of external sales generated by its three chemical segments as part of the sustainability analysis of its businesses. The aim is to extend this to 80 percent. Thomas Wessel, the member of Evonik's Executive Board responsible for sustainability, said, "These analyses take account of our customers' rising demands on the sustainability of our products. At the same time life cycle analyses are the basis for operational and decision-making processes at Evonik." Life cycle analyses make the environmental impact of products and processes more transparent.

Since 2009, the interdisciplinary Life Cycle Management team, which comprises scientists and engineers, has performed more than 100 life cycle analyses of products, processes, and entire sites. In addition, the experience of the LCM experts is used in the ongoing development of the methods used for such analyses, both nationally and internationally, in conjunction with sustainability institutions such as the World Business Council for Sustainable Development (WBCSD).

HD silica from Brazil

In Americana (São Paulo, Brazil), Evonik has put its first plant for easily dispersible silica (HD silica) into operation. This high-growth silica is used mainly for high-quality low rolling resistance tires. In addition, by building this new silica production plant, Evonik is also catering to the needs of the growing regional business in attractive specialty segments of South America's food, animal feed, and agricultural industries.

The tire industry in South America profits from the region´s growth in the automotive industry, which has recorded considerable increases in sales over the past years. The market for low rolling-resistance tires and, consequently, for HD silicas has been growing disproportionately. Evonik expects additional demand because of the planned labeling of the energy efficiency of tires in Brazil.

The use of silica in combi-

In combination with silanes, silica reduces the rolling resistance of tires.

Photography: Evonik, istockphoto (2)

nation with silanes means that tires can be produced with a much lower rolling resistance, which can reduce fuel consumption by up to eight percent (compared to conventional automobile tires). Evonik is the only manufacturer that offers both components.

High-quality building protection

TEGO® Phobe 1659 and TEGO® Phobe 1409—the new hydrophobing agents from Evonik—protect facades from weather, water, and dirt. The technology balances hardness and silicone characteristics while increasing efficiency and significantly reducing dirt pick-up. This results in a reduced silicone concentration on the surface, which makes

New hydrophobing agents protect facades from weather, water, and dirt.

extremely low dirt pick-up possible. Due to improved wetting characteristics and the interaction with pigments and fillers, better distribution of the silicone resin is achieved. The required dosage of TEGO® Phobe 1659 can be reduced without impairing water resistance.

The amino-functional polysiloxane TEGO® Phobe 1409 also generates a water repellency effect, which leads to significantly faster drying of the facade, thus reducing susceptibility to the growth of algae and moss.

Both hydrophobing agents can be used without restriction in formulations that must meet the stringent requirements of various eco-labels such as Ecolabel or Blue Angel.

Linen closets fresher for longer

With a new silicone derivative, Evonik enables the formulation of fabric softeners with better performance: softer linen and, above all, longer-lasting freshness. The product, which is called REWOCARE® GSM 42, is currently being launched.

Just a small amount of the product increases the softening effect and enhances the fresh smell of fabric softeners. With REWOCARE® GSM 42 in the fabric softener the laundry still has a pleasant freshness even two weeks later. The desired softening and freshness effect can also be achieved with less of this active softener ingredient. For manufacturers, this offers interesting options for improving their products. The silicone derivative is formulated as a microemulsion and can be added to all popular fabric softeners.

REWOCARE® GSM 42: Softer linen and longer-lasting freshness.

GARMENTS MADE OF BIOPOLYAMIDE

Evonik surprised visitors at the K 2016 plastics trade show by presenting women's fashion. The elegant garments are made 100 percent of new biopolyamide fibers based on VESTAMID® Terra, which is marketed by the Italian fiber manufacturer Fulgar under the name EVO®.

The high-tech textile fibers are extremely light, flexible, and breathable. They also have an odor-reducing effect thanks to their lasting natural bacteriostatic characteristics. In addition, they dry quickly, require no ironing, and can be processed in all textile applications, including an Italian designer fabric for evening gowns, functional sportswear, all the way to durable upholstery materials.

The fibers are produced from VESTAMID® Terra, a biopolyamide that is obtained 100 percent from the seeds of the castor bean plant. Since castor bean plants can also withstand long periods of drought, they are cultivated in dry areas that are not suitable for any other form of agriculture. The biopolymer therefore has no adverse effect on the human food chain.

Ladies' coat made from the biopolyamide fiber EVO®.

Investment in Vivasure Medical

Through its Venture Capital unit, Evonik has invested in Vivasure Medical Limited in Galway, Ireland. The product from the company's PerQseal™ technology platform is the only approved fully bioabsorbable, sutureless, and entirely synthetic option to close large-bore arteriotomies that result from percutaneous transcatheter procedures. These procedures are becoming prevalent in operations worldwide and are already established as standard in some areas, as minimally invasive procedures require only small incisions. The Vivasure closure device is designed to be easy to use, allowing the surgeon to provide a complete repair at the access site without leaving metal implants, sutures, or exogenous tissue behind.

Photography: Frank Preuss, Evonik, blend images/JGI/Jamie Grill

BRILLIANT PROSPECTS

In 2013, Evonik marketed a new building block for heat-curing clear coats that are particularly effective for protecting cars against microscratches. Now, thanks to developers who have "taught" the building block to cure at room temperature, it can also be used to maintain the beauty and shine of parquet, furniture, and plastic surfaces.

Photography: shutterstock

Markus Hallack and Dr. Hans Görlitzer

When the coating experts in the Resource Efficiency Segment started a new project in 2010, they called it Adamant. The name is derived not only from the German word Diamant ("diamond") but also from the Greek word ἀδάμας , which can be translated as "invincible." The project was just as ambitious as the name: The goal was to develop raw materials that would make coatings extraordinarily resistant to the abrasive effect of dust, dirt, and cleaning equipment, and even outshine traditional two-component polyurethane coatings.

Even razor-thin layers of coating can make an astonishing improvement in the strength of surfaces against external influences such as moisture, sunlight or cleaning products. For example, the outermost coating layer on cars is usually only about 40 thousandths of a millimeter thick, and yet it effectively protects the metallic bodywork of a car against the damaging impact of UV radiation and chemicals such as gasoline. The chemical industry has improved this aspect of the coatings many times over the decades.

"The Adamant project has become a success story, and many sequels are likely to come."

Markus Hallack

Other examples include wood floors and furniture. If they are coated with an advanced high-performance coating, even red wine from an overturned glass leaves no permanent traces. By default, the manufacturers of both coating raw materials and coatings use tests to demonstrate to their customers how their products cope with coffee, mustard, vinegar, and cleaning products. It is not surprising that kitchen manufacturers, for example, place greater value on high resistance to such substances than producers of bookcases or wardrobe closets. They are also prepared to pay more money for high-quality coatings.

Coatings for the most demanding applications are often made of polyurethanes—large molecules of repeating units that are linked by urethane groups (chemical formula: -NH-CO-O-). These urethane groups form when painters mix two components supplied to them by the coating manufacturer: polyisocyanates (characteristic group: -N=C=O) and polyols (characteristic group: -OH). In the industry, the polyisocyanates are called hardeners and the polyols binders. While there are also single- ➜

A new coating raw material prevents micro-scratches on coated plastic and wood surfaces, thereby ensuring a durable gloss.

➜ component coatings on the market that the coating technician does not have to mix, they usually do not attain the same favorable characteristics as two-component coatings.

Red wine and dust: High gloss has powerful enemies

But the glossy appearance of a surface has more enemies than gasoline, red wine, and cleaning products. For example, particles in cloths that are not completely clean or brushes at the car wash will leave fine scratches on a car's body. This is why the body "wears out" over the years. Closer to home, anyone who walks over parquet flooring with dusty street shoes leaves behind microscratches that cover the painted surface with a gray haze and make it dull. Even high-gloss kitchens lose their shine over time, because the use of cleaning sponges or rough cloths leaves their traces behind. Even modern microfiber cloths can bring high gloss to a fast end.

For years, suppliers of raw materials for coatings and the coating industry have devoted themselves to the question of how to improve the protective effect of their products against such aggressors. They have incorporated such substances as nanoparticles into their coating components to make the resultant coatings more scratch-resistant. But incorporating these particles takes enormous effort.

For this reason, the coating specialists from Evonik's Resource Efficiency Segment took a completely new approach. When a polyisocyanate and a polyol are mixed, the polyurethane molecules should not form immediately prior to coating. Instead, "finished" polyurethane molecules should react during coating via additional silane groups ($-Si(OH)_3$) that are present. The silicon-rich network that results can significantly improve the properties of coatings—a fact that has been published in the literature for many years.

Up to now, however, silane-modified polyurethanes have been extremely difficult and expensive to produce, and therefore were not marketable as coating raw materials. But here, and this is the point of departure for the coating specialists, Evonik has a decided advantage: The company can produce a key starting material—3-isocyanatopropyltrimethoxysilane (IPMS)—highly efficiently and, therefore, more cost-effectively.

The project team was actually able to produce industrially relevant quantities of competitive silane-modified polyurethane very quickly **(Fig. 1)**. They were presented to the coatings industry and car manufacturers for the first time in 2013. In the same year, because the automobile clearcoats based on this innovative substance class proved to be as scratch-resistant as they had hoped, the team received the Evonik Innovation Award 2013 in the New Products/New System Solutions category (see elements 46). Evonik markets the corresponding coating raw materials as VESTANAT® EP-M types. Given their comparatively high price, they will initially be used to protect cars in the luxury class—and not just against scratches. Because these clearcoats are just as effective as conventional two-component clearcoats, they can also protect against the influences of weather and chemicals.

There are two reasons why Evonik will initially market its silane-modified polyurethanes—which can also be called urethanized polyalkoxysilanes—for applications in the automobile industry. The first reason is that the industry has a particularly high demand for scratch-resistant coatings. The second is that coatings based on the VESTANAT® EP-M types that were originally made available harden quickly and effectively only at temperatures over 100°C. When a car receives its original paintwork, this is not a problem, because the coating layers are baked anyway. In this process,

Curing process over a broad range of temperatures

With two products from VESTANAT® EP-M- and the MF line, Evonik covers the central coating requirements in the automobile (EP-M), furniture, and plastics industries (EP-MF).

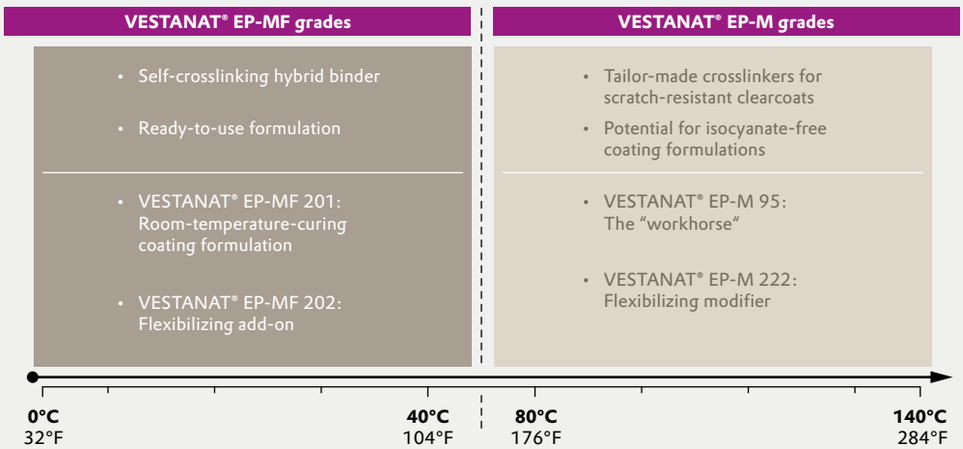
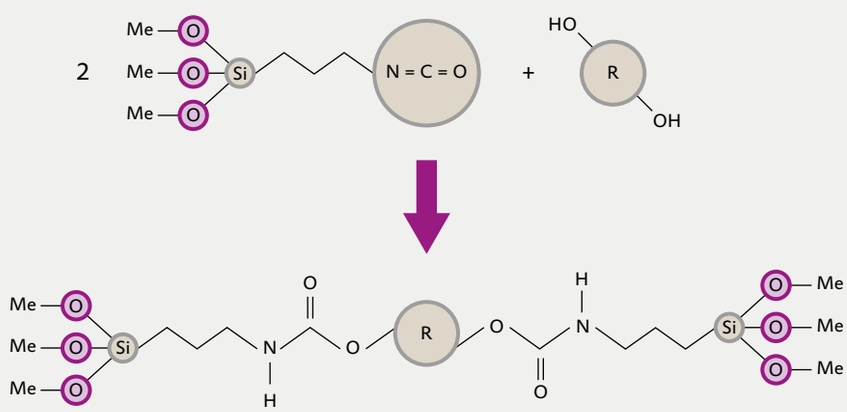
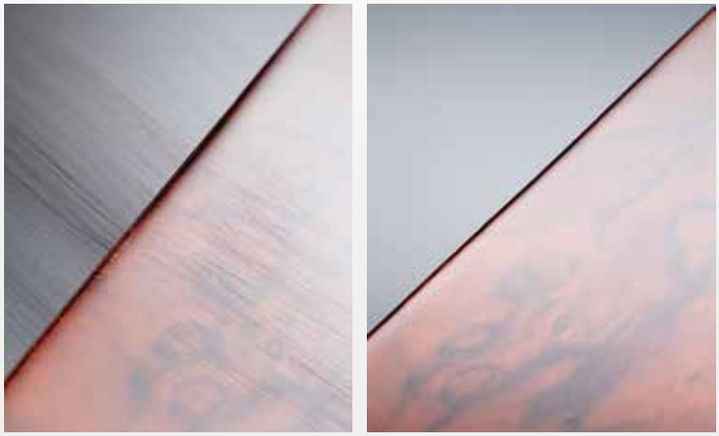


Figure 1. Versatile building block

The IPMS component reacts with diols, for example, to form silane-modified polyurethanes. The advantage: During coating, the "finished" polyurethanes crosslink, isocyanate-free, by means of the silane groups.



Graphic: C3 Visual Lab



Clearcoats on wood after a modified scratch test in the crockmeter. A conventional 2K PUR lacquer (left) shows significant scratch marks—unlike a formulation that contains 50% VESTANAT® EP-MF as a binder (right).

the car body with the freshly applied coating layer passes through an oven. But with temperature-sensitive materials such as wood and plastic, coatings that need high temperatures to cure cannot be used.

Fast crosslinking even at room temperature

So the developers faced a new challenge: To make the new scratch protection accessible to the wood and furniture industries, as well as the plastic processing industry, they had to make the silane-modified polyurethanes harden sufficiently quickly at room temperature.

The mechanism of this cold curing is different **(Fig. 2)**. With atmospheric humidity, the silane groups react with each other and form a siloxane network (Si-O-Si). So the molecules of the innovative substance family crosslink with themselves under these conditions. This means that coatings based on them must not consist of more than two components. The coating raw material can serve as a kind of binding agent and hardener in one.

But how do you get the raw material to bond rapidly at room temperature by this mechanism? For a chemist, the answer is easy: You need a catalyst. This is easily said, but in practice, it means hundreds of test series with potential material candidates that could serve as the catalyst. But the effort paid off, and the researchers found a suitable reaction accelerator. The silane-modified polyurethanes that contain it are classified as EP-MF types.

Wood and plastic coating manufacturers use VESTANAT® EP-MF either as a coating on its own or dilute it with a polyol component that is embedded in the siloxane network. In this way, they influence how flexible the resultant coating layers are and how well they adhere. Tests can provide impressive proof that such coatings are less sensitive to scratching than conventional polyurethane coatings.

Most begin with a measurement of how much light is reflected off the freshly coated surface. In the Crockmeter test, a probe covered with a rough cloth wipes this surface over and over again in the same spot. The test device, the Crockmeter, can be set to control how often the probe travels back and forth and how much force it applies. In another test, a hammer weighing 500 grams travels over the coating surface with a piece of scouring pad without applying any pressure. Then, another measurement is taken to determine how well the test coating reflects the light and, therefore, how much shine it has lost due to scratches.

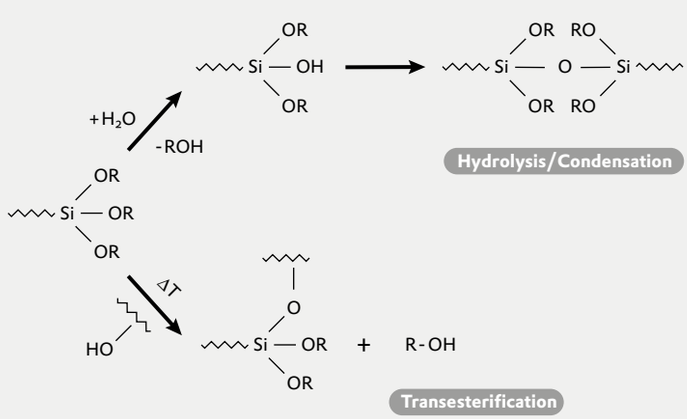
Easy handling because isocyanate-free

But VESTANAT® EP-MF not only makes coatings more resistant to mechanical and chemical attackers. As isocyanate-free coatings, they are also especially easy for coating technicians to handle, since there is nothing to mix and therefore no risk of errors or selecting the wrong mixing ratios. That can also be a financial advantage, as kitchen manufacturers and parquet producers can expect fewer complaints.

Even though Evonik's marketing has been extremely selective so far, the production plant for the silane-modified polyurethanes in Marl has plenty to keep it busy. The Adamant project has become an Evonik success story, and there are likely many sequels yet to come. In any case, the coating raw material specialists are full of ideas. One project on their agenda is to modify the chemical backbone of the silane-modified polyurethanes to provide coatings with additional unique capabilities.

Figure 2. One component, two reaction mechanisms, many applications

While silane-modified polyurethanes for clearcoats (VESTANAT® EP-M grades) are produced in a transesterification process, the products for wood and plastic coatings (VESTANAT® EP-MF grades) are obtained through a hydrolysis/condensation reaction.



The experts

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Photography: Evonik | Graphic: C3 Visual Lab

CAREERS IN CHEMISTRY

One doctoral degree, many career paths

A doctorate in chemistry doesn't necessarily lead to the laboratory: In the Resource Efficiency Segment chemistry Ph.D.s are also opening up new fields of activity for themselves. Six employees report on where their career paths have taken them so far.

Six chemists, six paths, one goal: To promote Evonik's Resource Efficiency Segment as a supplier of eco-friendly and energy-efficient solutions.

The Resource Efficiency Segment, with its nine business lines and 64 sites, offers chemistry graduates many options for building a career—not all of them obvious. "My position as controller of a business line developed step by step," says Dr. Arne Wigger, organic chemist. Other chemists work in research, process development, and marketing. In this article they describe what they find exciting about their current jobs.

1 Dr. Arne Wigger

Controlling, Essen, Coating Additives, organic chemistry, at Evonik since 2000

Because he always had been fascinated by the language and culture of Japan, Arne Wigger's aim was to get to that country. And so he was on the lookout for career opportunities abroad even as he pursued his doctoral degree. It was during a presentation that he got lucky. "Professor Kollmeier, a member of the Management Board of SKW Trostberg, talked about management positions for chemists in industry," recalls Wigger. "That piqued my interest in business management. And the company even had a site in Japan—what could be more perfect." Following a postdoctoral stint in Japan Wigger applied successfully to join a trainee program and worked in France and China. "In Paris I worked in controlling for the first time," he says. "What particularly excited me about the job was providing strategic support for a project." Even today it's this aspect of his work that he likes best: "Chemistry and controlling have much in common. In both, you're looking for solutions to problems." An added plus is that when discussion partners lapse into chemical jargon, Wigger more than holds his own. He is, after all, a chemist by training.

2 Dr. Dominik Maschke

Process Development, Wesseling, Silica, inorganic chemistry, at Evonik since 2011

"We had a clear goal before us," says Dominik Maschke, who, along with his colleagues in Production, was responsible for starting up the first silica plant in Brazil. Since mid-2016 the Americana plant has been producing highly dispersible silicas, which customers use mainly in tires to reduce rolling resistance. To ensure that the quality of the products is maintained also in Brazil, Maschke checks the machines at the site and trains new employees. "First I had to ensure that everything had been correctly installed," says Maschke, a member of the start-up team. This he did, for example, by means of test runs using water instead of raw materials. "Safety is our first priority. Only if the test run is successful can we make a start on production," he says. Maschke acquired the necessary expertise for the post by working in silica research at Evonik. His specialist field is precipitation, the first step in silica production, in which water glass is reacted with sulfuric acid. "It's exciting to now be passing on this knowledge to new employees in Brazil," says Maschke. "They are deeply committed to their work, and they looked forward to the opening of the plant as much as I did."

3 Dr. Stefan Hilf

Innovation Management, Singapore, Coating Additives, polymer chemistry, at Evonik since 2009

Localizing effects in molecules: That's what Stefan Hilf finds particularly fascinating about his work as the Head of Innovation Management for Coating Additives in Asia. Along with his 11-strong team he develops new products for the Asian market. Hilf's responsibility is to design the product portfolio for Asia, adapting the product palette to local conditions. And it isn't always smooth sailing: "You have to accept that projects don't always work out. That's the nature of research. Only one in a hundred molecules might make it to the market." But Hilf has never been able to envisage working in any other field. Having gained his doctorate during the global economic crisis—not the best time to embark on a professional career—he nevertheless decided to try his luck at Evonik, and landed a job. He started work in 2009 as a product developer, which is still the main thrust of his work. "I almost always work in the office," says Hilf, "but I'm happy to go into the lab and get my hands dirty with my colleagues there." The high points for him have been the moments when the team's products have made it to the market. In the last four years these have included ten new coating additives: "We put our heart and soul into every one of our products," Hilf says.

4 Dr. Björn Borup

Marketing, Hanau, Silanes, inorganic chemistry, at Evonik since 1998

Sheer staying power is what Björn Borup needs for his work in marketing. It's on his desk that customer queries for new products and application possibilities land. "I analyze whether we have sufficient raw materials and the necessary chemical and technical framework—and whether in the end the returns will be satisfactory," says Borup. If all the boxes are ticked, the project can go ahead: The customer and Evonik employees work together on implementation. It could

be years before a project finally comes to an end. "In one project for the automotive industry, the first discussions took place as far back as the 1990s," recalls Borup. "But we delivered the product only a couple of years ago." This could be due to, for example, changes on the customer's project team: "In that case I have to hang in there and convince the new contacts of our expertise." It is this aspect of the job that Borup finds particularly exciting: Even when he was starting out in Technical Service way back in 1998, he sought out contact with customers. "I always wanted to work directly with people, to negotiate and have discussions with them," says Borup, "so this is absolutely the right job for me."

5 Dr. Benjamin Souharce

Business Development, Marl, Crosslinkers, polymer chemistry, at Evonik since 2012

When is an idea a worthwhile business idea? That's the question French-born Benjamin Souharce of Business Development is constantly asking himself. A clutch of new ideas arrives on his desk every day; his job is to assess which of these have market potential and should be implemented. "In my book an idea is good if it has high novelty value, is closely aligned to our core competencies, fits in with our strategy, and brings business advantages," says Souharce. "But even the best suggestion is ultimately of no avail if the market has no interest in it." This is why he sets great store by close contact with the sales force. "The stimulus for an idea often comes from the outside," he says. "Our colleagues out in the field are close to the customer and know what he needs." Souharce also organizes internal workshops in which employees put themselves in the customer's situation and thus generate ideas for meeting his requirements. "My goal is to involve the entire structure," says Souharce. That's also the reason why he moved from research initially into marketing and then into business development: "Every day brings new perspectives and fresh ideas. There's never a dull moment."

6 Dr. Emmanouil Spyrou

Innovation Management, Marl, Crosslinkers, organic chemistry, at Evonik since 1995

"We must all make the most of our strengths, and my special interest is research," says Emmanouil Spyrou. The head of Product Development at Crosslinkers has been working in R&D for 21 years. "The environment has, of course, changed over the years," says Spyrou. "The Internet, for example, has strongly influenced my work. But the essentials have stayed the same." After gaining his doctorate and doing postdoctoral work in California, Spyrou started his professional career in research for coating raw materials at the former Hüls AG in 1995. He now leads a department of 25 employees. "In a large concern there are many interesting things to do, but for me chemistry has always held the most fascination," he says. Along with his colleagues, he develops high-quality eco-friendly raw materials for the coatings industry. He particularly values the variety in his job: In addition to the pure chemistry involved in research and the support of new products from initial idea to market launch, he also works in patent law, competition analysis, and idea generation. So what keeps him on the ball? "Enjoying my work, of course," says Spyrou. "Chemistry is my passion, and will always be."

Photographs: Dirk Bannert, Stefan Wildhirt

NOMINATED FOR THE EVONIK INNOVATION AWARD 2016

The Innovations of the year

Recognition is an important driver of creativity. This is why work on new ideas is particularly well honored at Evonik. The Group's annual Innovation Award honors outstanding research findings and the creative minds behind them. In 2016, three teams made the final cut in each of the two categories.

The award: motivating
Winning the Innovation Award means having done outstanding work. The winning team in each of the two categories can also look forward to a cash prize of €30,000.

The standards: sustainable
The selection criteria are economic importance, environmental advantages, and societal benefit. The team that accumulates enough points with its project in all criteria has an opportunity to reach the final round.

The jury: demanding
The members of the audience select the winners during Evonik's traditional Christmas Colloquium. The audience is made up of about 200 members of the Group's senior management, as well as researchers from all segments.

The teams: interdisciplinary
Innovation occurs at the interfaces between traditional disciplines such as chemistry, biology, and engineering. Accordingly, most of the teams that make it to the finals are interdisciplinary.

The final: conclusive
The finalists hold ten-minute presentations of their projects. The judges evaluate not only the projects' scientific depth but also their presentation. After all, innovations also need good marketing in order to be successful on the market.

The CIO Award: surprising
The Chief Innovation Officer (CIO) Award acknowledges an individual achievement. Last year the award went to Dr. Peter Murphy for his performance as a networker and initiator of fruitful discussions.

Graphics: C3 Visual Lab

New Products/System Solutions Category

A new generation of surfactants: Sophorolipids— the cleaning power of nature

Already available in the supermarket: household cleaners with REWOFERM®.

With sophorolipids, Evonik has entered the market with a new generation of surfactants based on a biotechnological production process. The new biosurfactant called REWOFERM® offers full, sometimes even superior, cleaning power, is particularly eco-friendly and well-tolerated by the skin, and is produced entirely from regionally sourced renewable raw materials. For this development, a team of biotechnologists, process engineers, and interfacial chemists was nominated for the Evonik Innovation Award 2016.

Surfactants provide the cleaning performance in shampoos, laundry detergents, and cleaning agents. The problem is that they are often produced from petrochemical raw materials or tropical oils, and their cleaning efficiency is still at odds with skin compatibility. Sophorolipids, which are produced naturally by microorganisms such as yeasts, manage the difficult balance between performance and mildness.

The nominated team has learned from nature and successfully transferred to the industrial scale what microorganisms have been doing for millions of years. In a fermentation process, yeast organisms produce sophorolipids that are then separated from cells and byproducts and brought into a form suitable for transport. This is a challenging task, as the demands for consistent product quality are high. "Many organisms aren't suitable for industrial-scale production. With surfactants, product purification is also particularly complex. This is why, up to now, sophorolipids have been available only in small quantities and at a high cost," explains Dr. Hans Henning Wenk, Head of Research for Biobased Materials at Evonik Nutrition & Care.

After five years of research, the team has succeeded in solving the problems and developing an industrial process to production scale. Evonik is now producing the sophorolipids in Slovenská Ľupča (Slovakia) in industrial quantities, and household cleaners with REWOFERM® sophorolipids are already available in the supermarket. "We have filed patent applications for even more applications," says Dr. Jens Peter Hildebrand, Head of Innovation Management in the Household Care Business Line. There are also plans to further improve the production process.

Dr. Hans Henning Wenk, spokesperson for the nominated Sophorolipids team.

New Products/System Solutions Category

Lower fuel consumption and CO_2 emissions through improved tire performance

POLYVEST® ST promises a further significant reduction of the rolling resistance of tires.

With POLYVEST® ST, Evonik wants to achieve a further distinct reduction of the rolling resistance of tires and thus reduce fuel consumption and CO_2 emissions. Tests with mixtures based on natural rubber have shown that the product, a liquid polybutadiene with terminal silane functionalities, allows significant reduction in terms of hysteresis loss, an indicator of reduced rolling resistance, compared to conventional silica/silane systems. This achievement has earned the development team from the Segment Resource Efficiency a nomination for the 2016 Evonik Innovation Award.

Up to 20 percent of a vehicle's fuel is used only to overcome the resistance of the tires. A reduction of rolling resistance by 30 to 40 percent can cut fuel consumption by about eight percent. For a passenger car, at an average consumption of 8 l/100 km and a travel distance of 25,000 km per year, this corresponds to savings of up to 160 l of fuel or 380 kg CO_2. However, the magic triangle, a basic principle of the tire industry, states that improving any of the core characteristics rolling resistance, wet road grip, and abrasion resistance is always achieved on the expense of at least one of the other characteristics.

This explains the triumph of the silica/silane system from Evonik over the past two decades. Through a combination of precipitated silica (ULTRASIL®) and rubber silanes, such as Si 69®, Si 266®, and Si 363™, it has already been possible to reduce rolling resistance by more than 30 percent, while simultaneously achieving a significant increase in wet road grip—without impairing the durability of the tire. Here, silica acts as an active, reinforcing filler, while the silane builds a chemical bridge between the non-polar rubber and the polar silica.

Combined with Si 69® or Si 266®, POLYVEST® ST allows the further improvement of the compatibility between silica and rubber. The result is an expansion of the magic triangle toward improved rolling resistance, while keeping abrasion resistance and wet road grip virtually unaffected. And the team is optimistic that additional improvements can be achieved through skillful formulation.

Numerous tire manufacturers have already subjected POLYVEST® ST to extensive tests, and the feedback from the market is very promising. A renowned manufacturer has already ordered goods on the double-digit metric-ton scale for final testing in multiple tire plants.

Dr. Kai-Steffen Krannig, spokesperson for the nominated POLYVEST® ST team.

Photography: Evonik (3), Fotolia

New Products/System Solutions Category

New base oil for gearboxes: More efficient wind turbines

VISCOBASE® 11-522 improves the energy efficiency of high-performance gear units.

Operators of wind energy farms place steep demands on the gear oil for their wind turbines: long oil drain intervals, sustained optimal viscosity of the oil over a wide temperature range, and maximum durability and long life for the gearbox. In VISCOBASE® 11-522, Evonik has developed a synthetic base oil that sets new standards in the field. As the critical key component of lubricants formulated to Evonik's NUFLUX™ technology standard, it has, in short order, received the essential "thumbs up" from the key industrial gearbox manufacturers. With these critical approvals, the way is now open for other high-performance gear applications. For this achievement, the development team from the Oil Additives Business Line has been nominated for the 2016 Evonik Innovation Award.

Wind turbines are tough testing grounds for gearboxes and gear oils: They need to perform as long as possible in a maintenance-free state despite constantly changing weather conditions and temperatures, humidity, and peak loads during storms. Until now, the gear oils of choice have been synthetic formulations based on polyalphaolefins. But with VISCOBASE® 11-522, based on polyalkyl methacrylates, this could now change.

FZG tests are regarded as the industry standard, and Evonik's VISCOBASE® 11-522 formulation has now passed the FZG bench test and earned a very important approval. More importantly, over the past two years the company has shown that gear oils formulated to NUFLUX™ technology standards with VISCOBASE® 11-522 have a particularly long service life between fewer drain intervals and improve energy efficiency by maintaining an optimal viscosity across an expanded range of operating temperatures.

The VISCOBASE® 11-522 base oil is one component of the novel NUFLUX™ technology with which Evonik is making its formulation expertise available to its customers. More precisely, NUFLUX™ technology is the collection of products, formulation concepts, and services that Evonik provides to customers in need of resource-efficient industrial lubricants. Now that both the base oil and the formulation technology have succeeded in the tests developed by the industry leaders in gearbox design and manufacturing, Evonik is well positioned for expansion into other applications, such as mining and steel production, which are, by far, two of the largest markets for industrial gear oils.

Sofia Sirak, spokesperson for the nominated VISCOBASE® team.

New Processes Category

Lightweight construction: Short cycle times for large runs

Sandwich profile component produced with PulPress.

In times of ever stricter CO_2 emission limit values and improved resource efficiency, reducing the weight of cars plays an increasingly decisive role. The weight can be reduced most effectively through sandwich composite materials with a foam core. Until now, however, their production has often failed, because the established methods were not cost-effective. Evonik has now closed this gap with the new PulPress process, which permits the production of complex shaped components in large numbers and at a suitable price. A team from the High Performance Polymers Business Line and the strategic innovation unit Creavis has now been nominated for the 2016 Evonik Innovation Award for their efforts.

The key element of the new process is the polymethacrylimide ROHACELL® from Evonik, a form-stable, temperature-resistant foam core that offers outstanding bonding behavior with minimal resin absorption. It is surrounded by woven fibers that are subsequently impregnated with resin. The overall system is then pressed at high pressure and high temperature. The new PulPress process is fast and continuous, produces almost no waste, and offers great freedom of design, so that even complex shapes can be produced.

Customers from the automotive industry are convinced by the new production method's freedom of design and cost efficiency, and by the crash behavior of components produced by this process. They are 75 percent lighter than conventional steel structures. In addition, the PulPress process offers cost savings of up to 60 percent in comparison to composite materials produced with established methods, such as resin injection.

Thanks to the fast, economical, and resource-saving production of composite components, the PulPress process permits technology transfer from high-end segments to mass production, making it possible to cost-effectively replace metal materials in the mobility sector.

Dr. Sivakumara Krishnamoorthy, spokesperson for the nominated PulPress team.

Photography: Evonik (3), istockphoto

New Processes Category

Methyl methacrylate: Fewer raw materials, more sustainability

PMMA is used for the production of rear lights, among other things.

Methyl methacrylate (MMA), a timeless classic of the Evonik product portfolio, is produced in a multi-step process in several plants at the Worms site in Germany. A team from the Methacrylates Business Line has now succeeded in reducing the amount of raw materials needed. It took a smart approach using innovative technology to optimize the process. For this effort, the team has been nominated for the 2016 Evonik Innovation Award.

MMA is a building block in many products of our daily lives such as coatings, paints, anti-corrosion coatings, print colors, adhesives, and textile auxiliaries. It is also a raw material for producing soft contact lenses and dental implants. The MMA polymer polymethyl methacrylate (PMMA) is just as versatile, marketed by Evonik under the PLEXIGLAS® or ACRYLITE® brand names and used, among others, in the automotive and lighting industry, medical technology, optics, and electronics.

In producing MMA, natural gas, ammonia, and oxygen react to form hydrogen cyanide, which reacts without prior storage directly with acetone to form acetone cyanohydrin (ACH). ACH is then processed in the next step with sulfuric acid and methanol, yielding MMA. The sulfuric acid serves as a solvent but is also needed to catalytically create the carbon double bond in the target molecule. After the reaction, it is recycled in a sulfuric acid splitting unit.

Optimization includes innovative control and online analysis technology and will enable Evonik, as one of the leading MMA manufacturers, to significantly improve its production. The six sigma project studies were successfully concluded at the end of 2015. The German MMA sites Worms and Wesseling are currently implementing the derived measures. There is also a plan for implementation at the US Fortier site. The optimization can increase MMA production, depending on the site, and reduce residue quantities and carbon dioxide emissions.

Dr. Hans-Gerhard Stadler, spokesperson of the nominated Methyl Methacrylate team.

New Processes Category

Polyesters for paints and adhesives: Production platform optimized

Polyesters from Evonik are used in such applications as interior coatings for food cans.

In view of the strong and growing demand for its specialty polyesters, the Coating & Adhesive Resins Business Line has launched the Polyester Process Technology Platform. The objective is to continuously and sustainably assess the strengths and weaknesses of the existing production technologies, work out optimization potentials and implementation strategies, and simultaneously coordinate them with market developments and the business strategy of the business line.

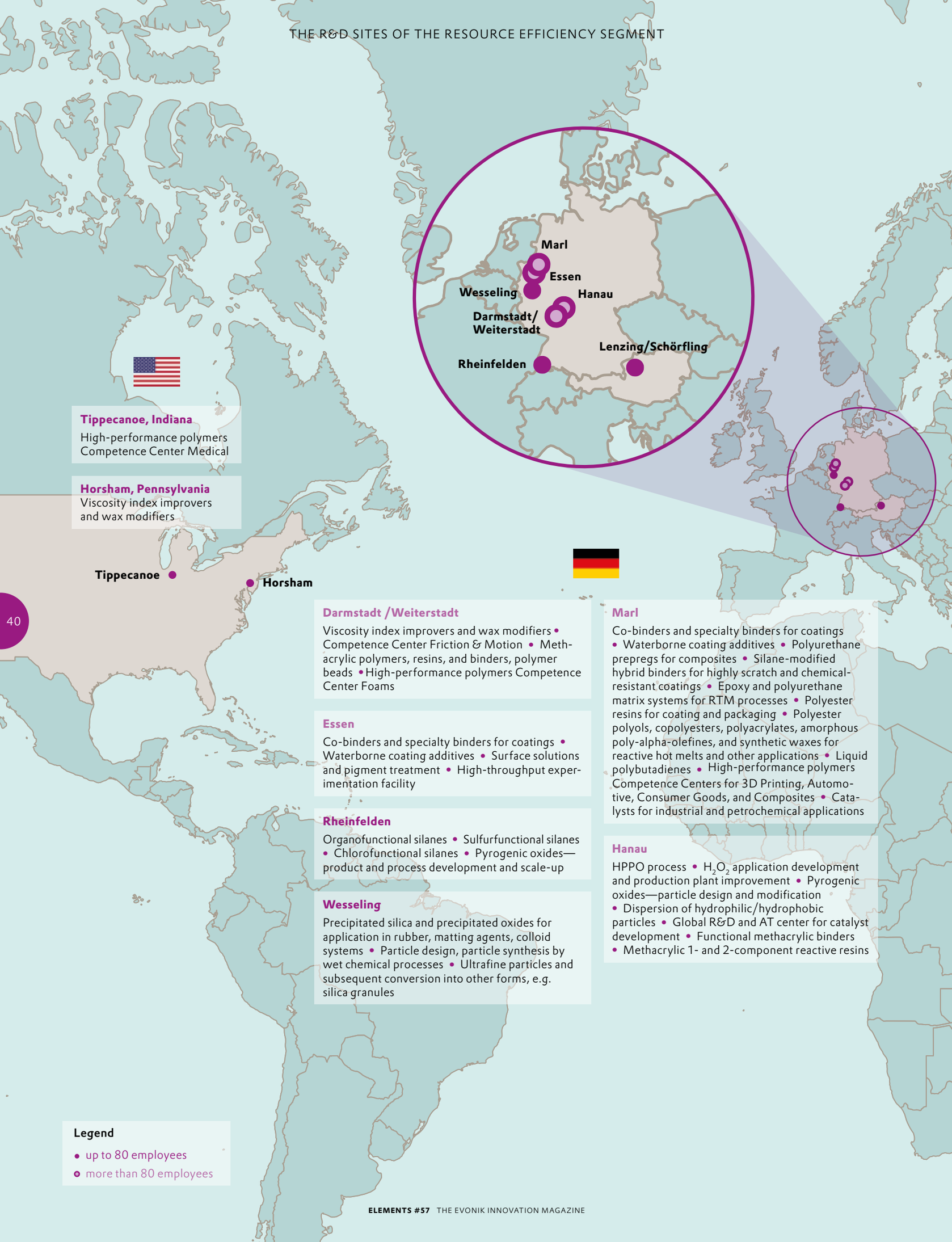
With this platform, Evonik is systematically pursuing its course of long-term process optimization in the production of polyesters for coating and adhesive applications. An interdisciplinary team made up of process engineering, production, the business line, and R&D has systematically analyzed the global production landscape of polyesters (technology assessment) and identified various means of optimization. The findings are being incorporated into the new plant for specialty copolyesters in Witten, which will come on stream in 2018, providing high efficiency and product quality. For the integrated approach of the Polyester Process Technology Platform, the team was nominated for the 2016 Evonik Innovation Award.

Evonik's product portfolio comprises over 120 different polyesters, which are produced in more than ten production plants worldwide. The products are used as binders in the coating of large-format metal coils and also, increasingly, for interior food can coatings. Additionally, they are used in reactive single-component and thermoplastic hot melts for technical joining applications. The special challenge in optimizing this production network is its high complexity, which is determined by the product variety and the differing plant designs.

With the help of process modeling and simulation, innovative online analytics, and analysis of thermodynamic and hydrodynamic effects, the team developed a whole range of measures that are already being used to optimize operation modes and increase capacities. The jointly developed expertise will also form the basis for maintaining the competitiveness of the processes in the future, and guide the evolution of the market within the framework of the business strategy.

Dr. Sabrina Mondrzyk, spokesperson for the Polyester Process Technology Platform team.

Photography: Evonik (3), Dirk Bannert



Tippecanoe, Indiana
High-performance polymers
Competence Center Medical

Horsham, Pennsylvania
Viscosity index improvers and wax modifiers

Darmstadt /Weiterstadt
Viscosity index improvers and wax modifiers • Competence Center Friction & Motion • Methacrylic polymers, resins, and binders, polymer beads • High-performance polymers Competence Center Foams

Essen
Co-binders and specialty binders for coatings • Waterborne coating additives • Surface solutions and pigment treatment • High-throughput experimentation facility

Rheinfelden
Organofunctional silanes • Sulfurfunctional silanes • Chlorofunctional silanes • Pyrogenic oxides—product and process development and scale-up

Wesseling
Precipitated silica and precipitated oxides for application in rubber, matting agents, colloid systems • Particle design, particle synthesis by wet chemical processes • Ultrafine particles and subsequent conversion into other forms, e.g. silica granules

Marl
Co-binders and specialty binders for coatings • Waterborne coating additives • Polyurethane prepregs for composites • Silane-modified hybrid binders for highly scratch and chemical-resistant coatings • Epoxy and polyurethane matrix systems for RTM processes • Polyester resins for coating and packaging • Polyester polyols, copolyesters, polyacrylates, amorphous poly-alpha-olefines, and synthetic waxes for reactive hot melts and other applications • Liquid polybutadienes • High-performance polymers Competence Centers for 3D Printing, Automotive, Consumer Goods, and Composites • Catalysts for industrial and petrochemical applications

Hanau
HPPO process • H_2O_2 application development and production plant improvement • Pyrogenic oxides—particle design and modification • Dispersion of hydrophilic/hydrophobic particles • Global R&D and AT center for catalyst development • Functional methacrylic binders • Methacrylic 1- and 2-component reactive resins

Legend
- • up to 80 employees
- o more than 80 employees

WHERE WE DO RESEARCH

The 700 researchers and 600 application technicians at Resource Efficiency work unceasingly to develop new products and technologies that fulfill a variety of regional needs. The map shows where they are located and what they are working on.

Graphic: Natural Earth, December 2013

Prof. Wolfgang M. Heckl (58), a biophysicist, is not just one of Germany's leading researchers in the field of nanoscience and an advisor to the European Commission and the German federal government. He also works as Director General of the Deutsches Museum in Munich, the largest science and technology museum in the world. In recognition of his services as an advocate for science and technology, he received a professorship from the Technical University of Munich, where he holds the Oskar von Miller Chair of Science Communication.

WHAT I HOPE FOR FROM SCIENCE

Wolfgang M. Heckl

MOLECULAR RECYCLING

My wish is for scientists and engineers to work together with society to develop the technical means to be able to recycle literally 100 percent of all the consumer products and devices we use so abundantly in our daily lives. Recycling right down to single molecules has its ubiquitous model in nature, where a plant not only uses the earth's natural resources such as water, minerals, and carbon to grow into a wonderful flower by means of self-assembly, but also recycles all its atoms and molecules at the end of its lifespan.

Nanoscience should guide us to directed bottom-up chemical and physical molecular manufacturing technologies that will not only enable our industries to produce better products perfectly suited to the future needs of a growing earth population, but also to take responsibility for reusing all our natural resources over and over again—provided solar energy input continues to come into our earth-economy system from outside for the next six billion years.

I believe that my wish will only come true if science and technology, production, and the use and distribution of goods are based on a process of negotiation between science, culture, and society.

NON-FICTION BOOKS

On the future of the EU, elites, and the information flood of the digital age.

Where is the EU going?

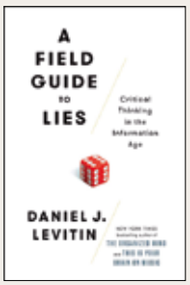
A national economist of international repute, Hans-Werner Sinn polarizes opinion. His criticism of EU economic and financial policy is hotly debated, and he's always good for constructive controversy. Now, in the midst of dramatic developments, he puts forward a concept for renewal that is a response to the current crises, from Brexit to the banks. He proposes, among other things, a renegotiation of the EU's 2009 Lisbon Treaty—"Europe must be redesigned from scratch!"—because only in this way can Europeans safeguard their freedom and prosperity.

Hans-Werner Sinn, Der Schwarze Juni. Brexit, Flüchtlingswelle, Euro-Disaster – wie die Neuordnung Europas gelingt
Herder Verlag, Freiburg 2016

Where top managers come from

The global market for top managers is a myth, claims German sociologist Michael Hartmann. The international superelite in multinational organizations that is assumed to be pulling the strings and controlling the world simply does not exist. Hartmann, who researches elites, studied the 1,000 largest companies in the world over 20 years and found that business elites prefer to recruit from within their countries. The reasons lie in language, cultural traditions, education systems, and, not least, tax policy. The business world that Hartmann describes is a multipolar one whose elites go their different ways.

Michael Hartmann, Die globale Wirtschaftselite. Eine Legende
Campus Verlag, Frankfurt 2016



How to handle information

Every day the world is flooded with a surfeit of information—including half-truths, superficialities, and misinformation. In this digital age, every recipient has also become a sender. So how do you separate the wheat from the chaff? Bestselling author Daniel J. Levitin, Professor of Cognitive Neurosciences at McGill University in Montreal, has written a book on information literacy—the ability to handle information and to recognize faulty data and misleading arguments. His arguments are based on scientific logic—but this is nonetheless a humorous and enjoyable book.

Daniel J. Levitin, A Field Guide to Lies. Critical Thinking in the Information Age
Dutton, New York 2016

THE COVER #57

The relative motion of two solids (e.g. cogs in engines or transmissions) creates friction that can lead to wear and tear. At its new Friction & Motion Competence Center, Evonik is developing solutions for reducing friction and making machines more efficient. The competence center is only one of many measures that Evonik is taking to help conserve resources. Additional measures are described in this issue, which is devoted entirely to resource efficiency.

Photography: Deutsches Museum, PR (3)

Masthead

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*** ...HOW EVONIK IS HELPING TO CONSERVE RESOURCES**