Total cost of a painted component made from composite material

* ...HOW COMPOSITES ARE MAKING IT INTO AUTOMOTIVE MASS PRODUCTION

INTERVIEW:
DIGITAL IS BECOMING NORMAL

CHINA:
RESEARCH: FULL SPEED AHEAD

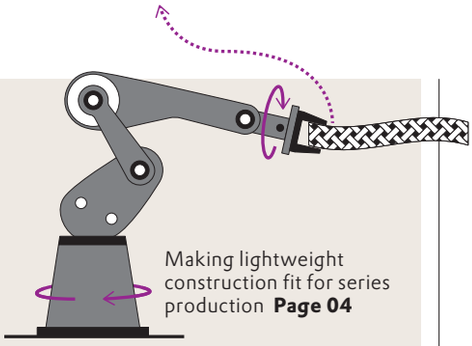
ELEMENTS

APRIL 2016
54

LIGHTWEIGHT DESIGN FOR SERIES PRODUCTION*

THE INNOVATION MAGAZINE

EVONIK INDUSTRIES



Making lightweight construction fit for series production **Page 04**

CONTENTS

Enjoying her leadership role: Dr. Marion Hax. **Page 32**

Cover and back cover: C3 Visual Lab Photography p. 3: Stefan Wildhirt (2) Graphics: C3 Visual Lab

EDITORIAL

Valuable networks

Dr. Ulrich Küsthardt
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Airbags, ESP, navigation, assistance systems, heated seats, air conditioning: Greater safety and comfort in a car mean added weight, which must be reduced elsewhere. Otherwise, the industry will fall short of the EU's CO_2 targets, which aim to reduce CO_2 emissions in all new cars from the current 130 grams to 95 grams per kilometer by 2020. This is where lightweight construction comes into play. In a gasoline car, 100 kilograms less weight reduces CO_2 emissions by up to 12 grams per kilometer. But because there are no fully automated production processes and much of the work has to be done by hand, at present less than three percent of a car is made from lightweight composites. This drives up costs.

At Evonik, composites are a strategic growth market, which is why we bundled our expertise in the Composites Project House. There, 20 researchers had three years to develop new materials and processes for more economical lightweight construction. Together with more than 80 partners from science and industry, they have successfully concluded nine projects. The new developments are currently being presented to potential customers.

The Crosslinkers Business Line has taken us another step forward with VESTANAT® PP, a new product which also simplifies the production of composites. Crosslinkers is already working on development projects with several car manufacturers who wish to use the product in future models. For this product, we presented the team of developers with our 2015 Innovation Award. Here, too, collaborating with partners—prepreg manufacturers and automotive suppliers—was a key to success, and it demonstrates how valuable networks are. To sharpen this awareness in the Group, our Special Innovation Award went to Dr. Peter Murphy, a dedicated and passionate networker.

Feedback
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elements@evonik.com

LIGHTWEIGHT DESIGN MADE FAST

A perfect example of innovative lightweight construction: the BMW i8. The high-strength, extremely lightweight passenger compartment, for example, is made from carbon fiber-reinforced plastics.

Photography: BMW

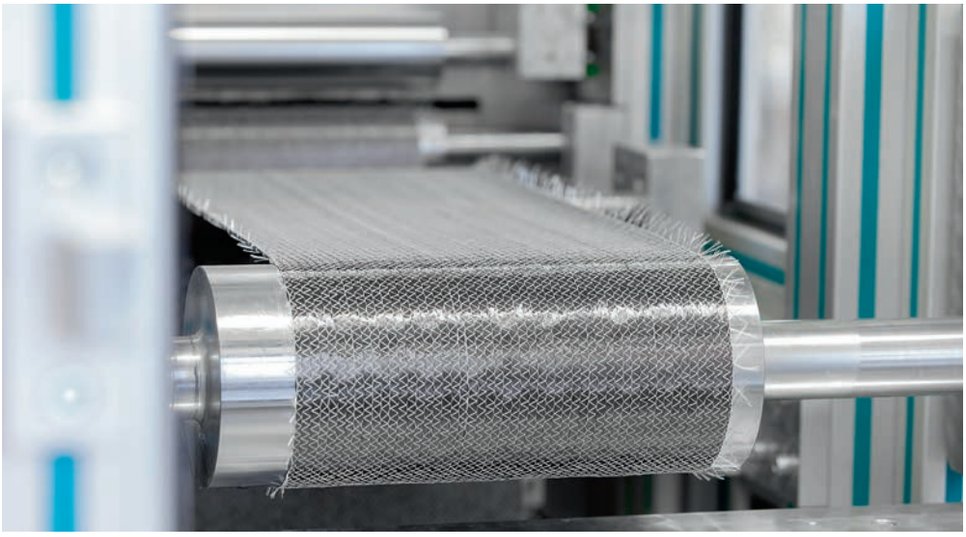
Without fiber-reinforced plastics, energy-saving aircraft, lightweight electric cars, and high-performance wind turbines would not be possible. A team from the Crosslinkers Business Line has developed VESTANAT® PP, an innovative polyurethane-based composite that makes the production of the components faster, easier, and more cost-efficiently. For this system, the developers received the 2015 Evonik Innovation Award.

Eike Langkabel, Dr. Guido Streukens

Wherever decreased weight and high performance are required, plastics and fiber-reinforced polymers in particular are the means of choice. Composites made of lightweight plastic matrix and fine glass or carbon fibers allow the fabrication of thin-walled yet highly durable components. As a construction principle, therefore, lightweight construction makes an important contribution to resource conservation and the reduction of emissions.

Although fiber-reinforced composites have been used for a number of years in a variety of industries, lightweight construction is still associated with intense manual labor. As yet, there is still no fully automated production process. This drives up costs, decreases production figures, and makes production time-consuming and relatively slow. At the same time, the demand for lightweight components, along with the standards for their durability and size, keep rising, which means that conventional fiber-reinforced compounds are reaching their performance limits.

When it comes to wind energy, for example, the dilemma is clear. Rotor blades ➜



Non-impregnated uni-directional fiber in the Marl testing facility.

➜ longer than 90 meters made of relatively inexpensive glass fiber-reinforced plastics (GFRP) are simply too heavy. In order to build even larger and more powerful plants for such purposes as offshore wind parks, manufacturers must switch to fiber-reinforced compounds with carbon (CFRP). But the production of extremely thin high-performance carbon fibers is expensive and time-consuming, as they are formed from spun polyacrylonitrile, which is converted into pure carbon at high temperatures in special air-sealed pyrolytic furnaces.

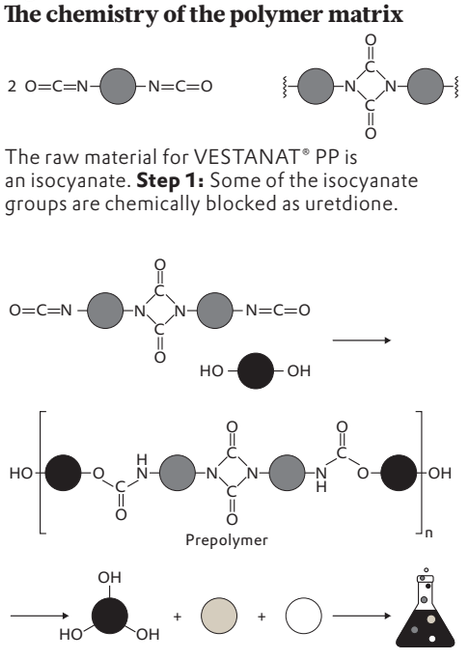
Established methods with drawbacks

Thermosets are the classic plastics of lightweight construction. They consist of two chemical components that react on the fiber to form a stable molecular network. The polymer matrix takes the external forces and feeds them into the fibers.

Two techniques have become established for the production of fiber-reinforced components. With the RTM (resin transfer molding) process, either woven or multilayered fabrics are placed in a hot mold. Resin and curing agents are then injected into the closed mold. The two components of the polymer harden under high temperature to form a thermoset matrix. RTM is standard in car manufacturing. To shorten production time, the fibers are normally preformed to near-net shape. The drawbacks are that handling up to four components—binder, resin, curing agent, and fibers—complicates the process. The process also requires expensive plants and plant components, including a high-performance press, injection plant, and dosing plant.

Prepregs (preimpregnated fibers) are an alternative to RTM. In these semi-finished products, endless fibers are coated with the reactants of the thermoset and pre-crosslinked. This technique would seem to simplify production, because the customer (in aircraft construction or the Formula 1 industry) must work with just one single component made of fiber, resin, and a curing agent. But even prepregs have significant disadvantages. The crosslinking continues at room temperature. So within just a few days, the viscosity and specifications change. This is why the transport and storage of conventional prepregs require a costly cold chain. They are also limp and sticky and unsuitable for automated handling with the help of robots.

Figure 1:
The chemistry of the polymer matrix



The raw material for VESTANAT® PP is an isocyanate. **Step 1:** Some of the isocyanate groups are chemically blocked as uretdione.

Step 2: The remaining isocyanate groups are polymerized to the prepolymer by adding alcohols. When more polyols and catalysts are added, VESTANAT® PP is produced and is used to impregnate the fibers. Heating the material to over 130 °C causes the uretdione groups to open and the material begins curing to the crosslinked polyurethane.

No need for extensive cooling

A team of developers from the Crosslinkers Business Line of the Resource Efficiency Segment has tackled these problems. The team has developed an innovative fiber composite that eliminates many of the difficulties of conventional production processes. A prepreg with VESTANAT® PP is solid and dry and easy for robots to handle and lay into molds. It is not reactive at room temperature. That saves cooling costs during transport and storage. Production is accelerated and process costs are reduced.

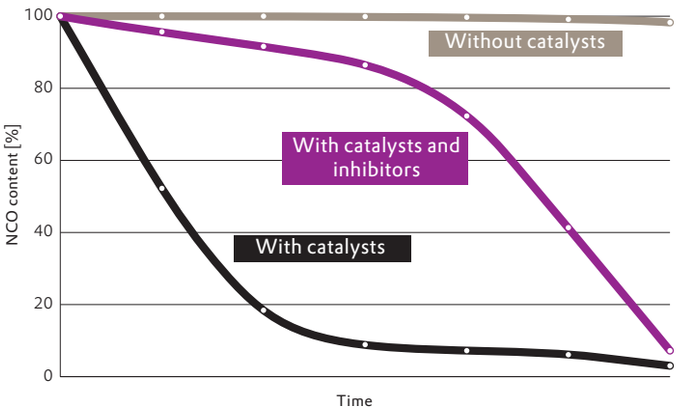
To achieve all these advantages, the chemistry of the polymer matrix was completely changed. Ordinary thermoset materials for fiber composites are epoxy resin formulations that are cured with amines. In contrast, VESTANAT® PP is based on polyurethane. Its starting material is an aliphatic isocyanate. What makes it special is that about half of its functional groups are reacted to urethane with alcohol, and the other half are chemically blocked in that every two isocyanates form a stable ring-shaped group (uretdione). Additional polyols and an organic catalyst are mixed with this dissolved prepolymer **(Fig. 1)**.

The fibers are impregnated with this formulation and the wet semi-finished product is dried at about 100 °C. When using carbon fibers, the end product is dry, dark black mats, while glass fibers result in a transparent material. For production, the mats are cut to size on the customer's premises and warmed to about 70 °C. The prepreg becomes supple again at this temperature. After that it is placed in a cold mold; it cools again and solidifies to a preformed component, which can be stored temporarily or finished immediately. To obtain the end product, the component is placed in the final mold, heated to 140 to 180 °C and pressed. The polymer will undergo final crosslinking only at these temperatures, because the uretdione rings open and polymerize by reacting with the polyols **(Fig. 2)**.

Two different reaction mechanisms separating pre-crosslinking and final crosslinking and the associated stabilization of the intermediate product are new for fiber composites but a proven formula at Evon-

Figure 2: Controlled curing

The speed of the final crosslinking of VESTANAT® PP, displayed in terms of the quantity of isocyanate groups (NCO content), can be adapted to the desires of the customer through the use of catalysts and inhibitors.

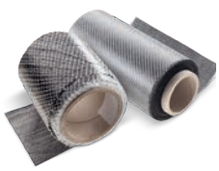


ik. The method is used in such products as powder coatings. In the development of VESTANAT® PP, this principle was adapted and optimized for the highly promising lightweight construction sector. The speed of the final crosslinking can be adapted to customer needs by adjusting the quantity of the catalyst added, and by varying the temperature: the hotter the curing process, the faster the final crosslinking.

This way, the system can be adapted to the existing fleet of equipment and the desired application. Existing facilities can be used with no problem. For new investments, expensive components such as dosing and injection plants are unnecessary, and the required press needs less power.

A car roof is one third cheaper

Calculations show that the roof of a car, for example, can be produced one third faster. The investment costs for a new plant are only half as high as for conventional production technology, and as much as 35 percent less expensive than RTM. In the laboratory, the team of developers tested all the production steps, as well as a variety of glass and carbon fibers, defined the influence of the catalyst quantity, and experimented with various formulas for the liquid resin.



Prepreg rolls of uni-directional multi-layer (left) and woven fabrics.

VESTANAT® PP is the first storable prepreg that can be reshaped by heating, and it cures by thermosetting. This means that it combines the advantages of both types of polymer—of thermoplastics and thermosets **(Fig. 3)**.

Market launch planned for 2016

The result is a new manufacturing process with advantages over conventional methods, because the RTM process, which is suitable for series production, is simplified by a one-component prepreg. The new lightweight material also displays extreme impact strength with high surface quality. In cooperation with a prepreg manufacturer, the material will be launched on the market in 2016.

Experience over several years of development work clearly shows that, when adapted to the challenges of a new product, expertise from other fields of business can result in excellent alternatives no one had previously thought of and help solve practical problems. Close cooperation with prepreg manufacturers and customers was a particularly important key to success.

The Crosslinkers team took on not only the role of the raw material developer but also that of the formulator, prepreg manufacturer, and direct supplier. Thus knowledge of the entire value chain resulted in a highly promising innovation for one of the most dynamic markets in the world. ■

The Experts

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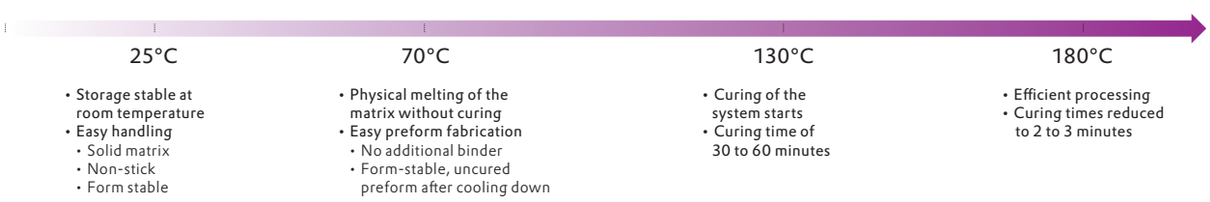
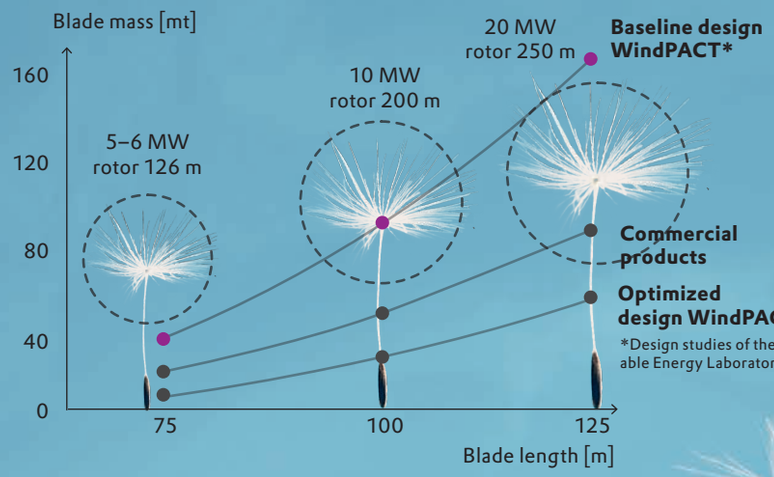
Evonik Innovation Award 2015 in the New Products/System Solutions category

Figure 3: Temperature behavior of the prepregs

Since the prepregs melt at a temperature as low as 70 °C and cure only at 130 °C, they can be processed just as quickly and easily as thermoplastics.



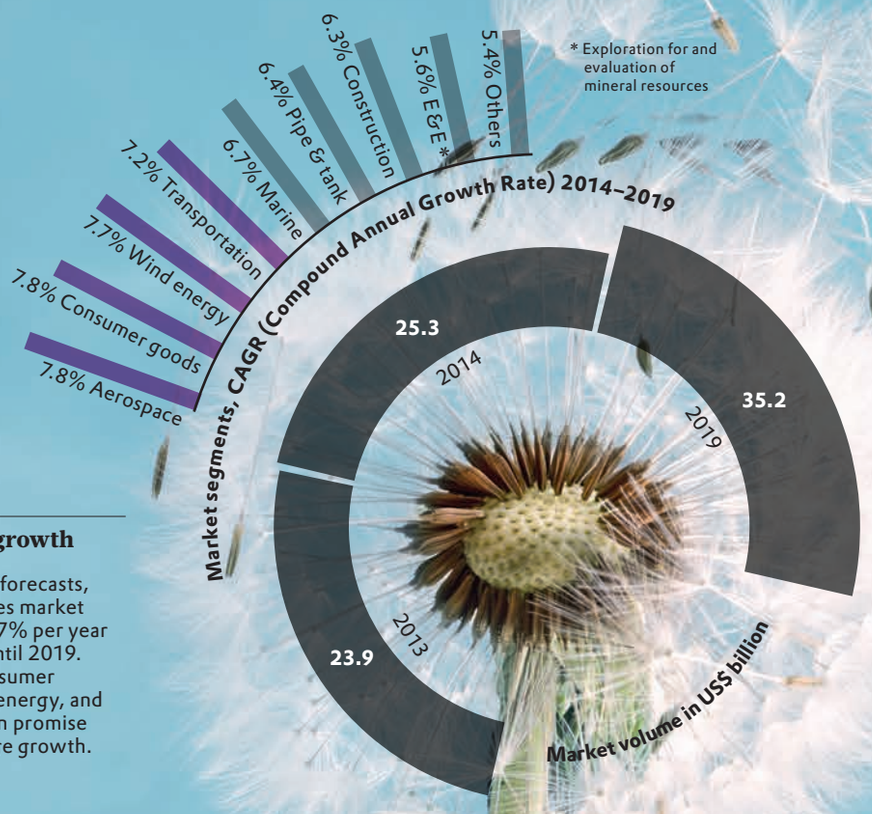
Infographic: C3 Visual Lab Photography: Evonik (4)



Source:
Lucintel

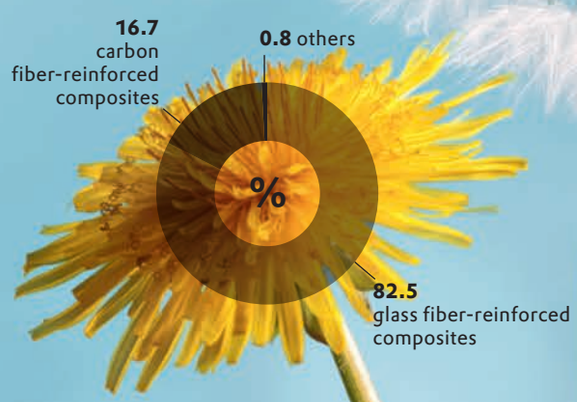
More wind energy through composites

The longer the rotor blades of wind turbines are, the more energy the wind turbine supplies. Their weight can be kept in check only through composites. The WindPACT studies show how optimizing the design can further reduce weight—for example, by using carbon fibers instead of glass fibers.



Attractive growth

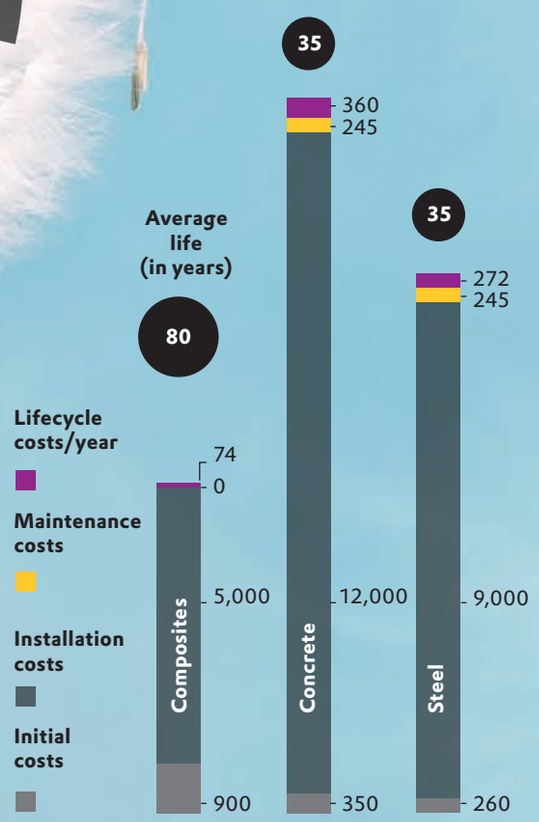
According to forecasts, the composites market will grow by 7% per year on average until 2019. Aviation, consumer goods, wind energy, and transportation promise above-average growth.



Glass fiber reigns

(Data in %, 2013)

The market for fiber-reinforced composites—comprising US$23.9 billion in 2013—is dominated by glass fiber.



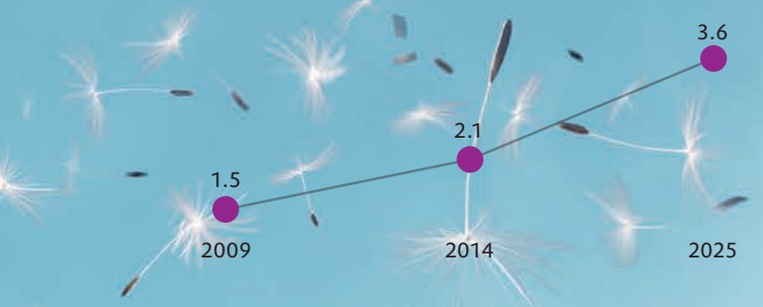
Lower costs

(Figures in US$)

Cost comparison for a pole made from composites, concrete or steel. With composites, the annual costs are significantly lower over the entire service life.

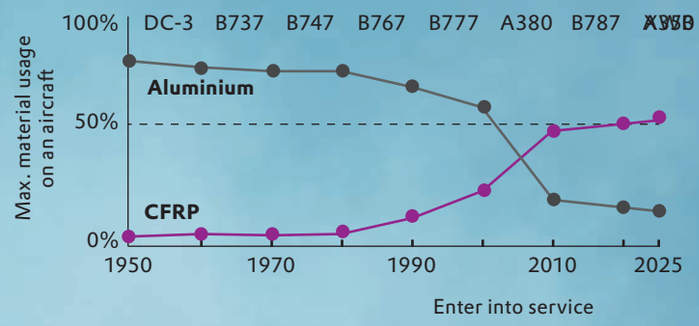
Composites making up a greater share of cars
(Data in million metric tons)

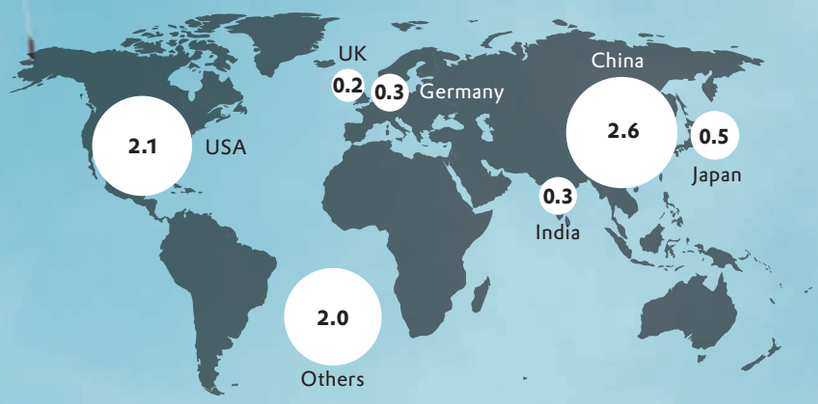
In 2014, the share of fiber-reinforced composites in automotive materials (131 mil. mt) was 1.6%; by 2025, it is expected to grow to 2.2% (3.6 mt).



Market driver: Aviation
(Structural weight of aircraft: Share of aluminum and CFRP in %)

Today's aircraft contain more carbon fiber-reinforced composites (CFRP) than aluminum; this is helping to drive market growth.





China is the largest market
(Data in million metric tons, 2013)

Six countries account for 75% of the worldwide composites market, which comprised approximately 8 million metric tons in 2013.

Infographics: C3 Visual Lab Photography: shutterstock

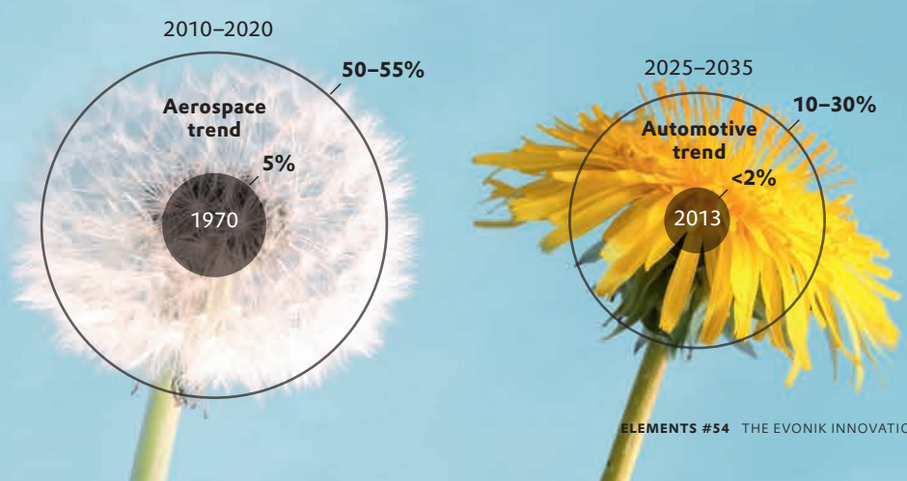
DATA MINING

Composites on the rise

Fiber-reinforced plastics are a versatile lightweight construction material. They not only save weight and energy but also allow freedom of design and integration of function, and they can absorb a lot of energy in a crash. A look at the markets, trends, and potential of fiber-reinforced plastics.

Aircraft: The trailblazers
(Composites content of structural weight in %)

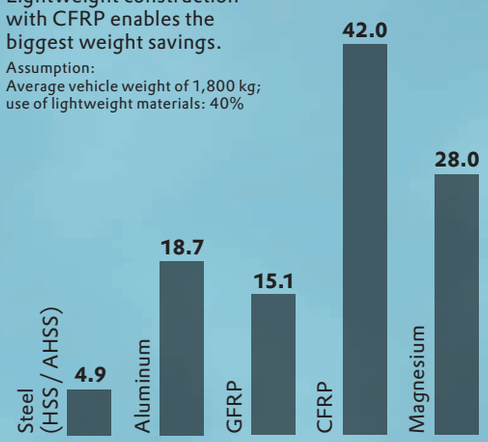
Measured by the percentage of composites in the structural weight, today's mass-produced cars are at the stage where aircraft were about 40 years ago.



Weighty arguments
(Weight reduction in cars as in % of total weight)

Lightweight construction with CFRP enables the biggest weight savings.

Assumption:
Average vehicle weight of 1,800 kg;
use of lightweight materials: 40%



TARGETING GREATER EFFICIENCY

Is there a simpler, more economical way of manufacturing fiber-reinforced composite materials for lightweight construction? The Composites Project House at Creavis, Evonik's strategic innovation unit, has found persuasive answers in the form of new materials, processes, and system solutions. Examples include the PulPress process, UD Tapes, and hybrid polymers on the following pages.

Dr. Sandra Reemers, Dr.-Ing. Leif Ickert

Lightweight construction is considered an important step on the road to sustainable mobility. Even though it has already become indispensable in the aviation and aerospace industries, the use of lightweight construction technology is still in its infancy in the automotive sector—just as it is in many other industries as well. Significant progress has been critically dependent on fiber-reinforced composites, a class of materials consisting of two components: a matrix system (thermoset or thermoplastic polymers) and high-performance fibers (glass or carbon fibers) that provide reinforcement.

Even though composites such as these are not fundamentally new, major hurdles continue to impede their use in industrial applications. High manufacturing costs are one example. Production processes account for roughly 70 percent of the total cost of fiber-reinforced composites. In addition, many of these processes are difficult to scale up if component complexity grows or output increases. The project house at Creavis responded to these problems by spending the past three years focusing on developing materials and processes that will lower the cost of composite manufacturing processes.

This company research was embedded within a broad area of competence that Evonik already possessed, including expertise in polymers, crosslinkers, additives, and high-performance structural foams. Close, trusting cooperation between developers at the project house and colleagues from the various business lines was one of the key factors in the project's success. In addition, business lines also provided significant financial support.

Other important contributions to the success of the project house came from industry and universities—the resulting network now includes over 100 partners. And last but not least, the work at the project house has allowed Evonik to strengthen its position within the composites community, as evidenced by considerable interest within the community, as well as the collaboration with external partners and three innovation awards. The project house has also sponsored nine student internships and produced a total of eight bachelor's, master's, and Ph.D. theses.

Up to 75 percent of today's market for fiber-reinforced composite materials is dominated by thermoset materials, with market researchers identifying considerable potential for growth in thermoplastic materials. Both classes of materials were developed further at the project house and even combined into a new material class. Of the nine research projects at the project house, two were dedicated to process development, while the remaining seven focused on material and process development alike. The projects can be divided into five subject areas: pre-impregnated semifinished products based on hybrid polymer systems, structural foams for sandwich systems, thermoplastic semifinished products, flame-resistant matrix systems, and high-quality composite surfaces. As the project house comes to a close, these projects are now being transferred to Evonik's business lines, which will move forward with the market launch. The company is aiming for sales in its composite materials business to range in the lower hundreds of millions of euros over the medium term. ■

The project house at a glance:

20
employees

3
Years' duration: April 2013 to March 2016

Awards
- The 2015 Innovation Award from the CFK Valley network for thermoreversible polymer networks
- The 2015 Innovation Award from the JEC industrial association for the CAMISMA project (40% lighter car seat backrest)
- The 2015 Innovation Award from the AVK association for the PulPress process

100+
external partners

40+
publications

8
business lines and the innovation management of the segments were involved in the various projects

The Experts

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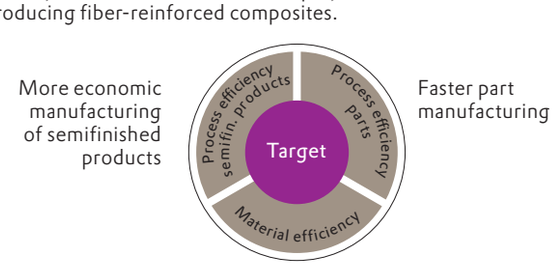
Dr.-Ing. Leif Ickert, business and application manager at the Composites Project House.
leif.ickert@evonik.com

Greater efficiency in processes and materials

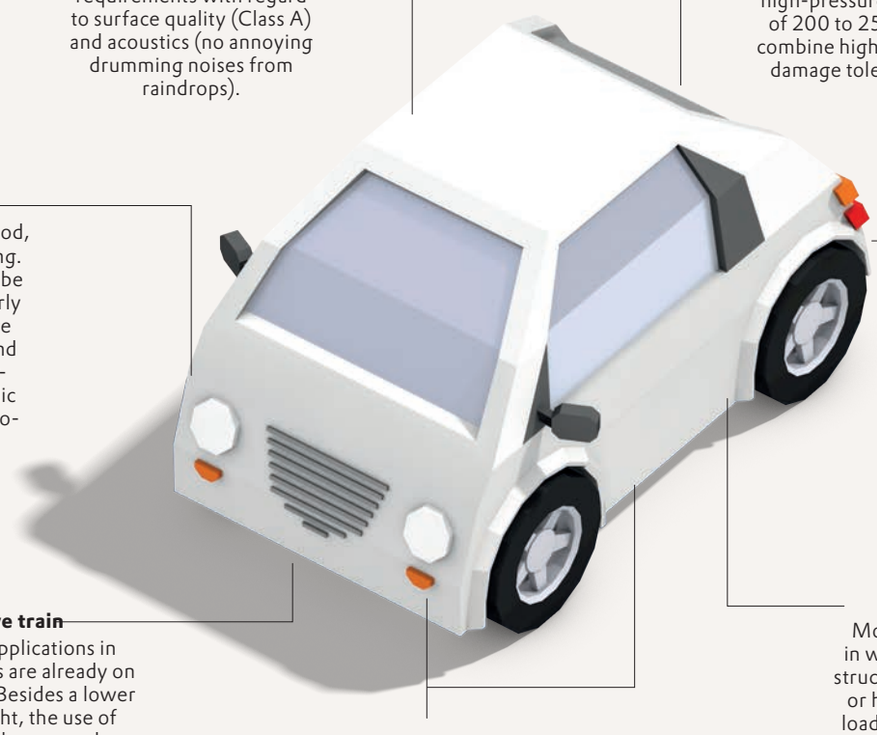
The objective of all the work in the project house was to lower the cost of producing fiber-reinforced composites.



Infographic: C3 Visual Lab Photography: Evonik (2)

Fiber-reinforced composites in cars

Fiber-reinforced composites currently account for only about two percent of a car's mix of materials. The graphic shows areas where such composites are currently used.



Roof
In addition to high strength, roofs have special requirements with regard to surface quality (Class A) and acoustics (no annoying drumming noises from raindrops).

Pressure tanks
Used to store compressed natural gas (CNG) as fuel. CNG is contained in high-pressure containers at pressures of 200 to 250 bar. Composite tanks combine high pressure resistance with damage tolerance and light weight.

Hang-on parts
Examples include the hood, the tailgate, and paneling. These components can be made of composites fairly easily, because they are attached to the body and don't have to be incorporated into the metallic structure of today's automobiles.

Chassis
A leaf spring that cushions the effect of bumpy surfaces is already in series production. Moreover, concepts for suspension arms are in development. The chassis accounts for about 20% of a vehicle's total weight. Crack resistance and protection against fracture are especially important here.

Drive train
The first applications in cardan shafts are already on the market. Besides a lower dead weight, the use of composites has secondary weight effects because cardan shafts no longer need any intermediate bearings.

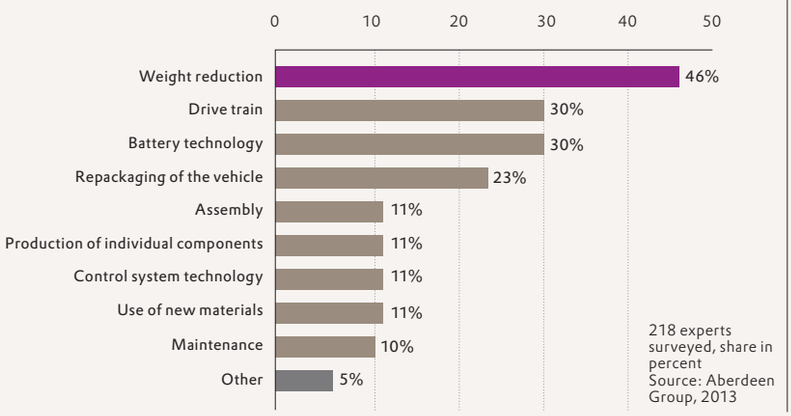
Body structure
Monocoque concepts, in which the entire body structure is made of CFRP, or hybrids, in which the load-bearing parts of the body are made of metal with reinforcement elements made of fiber-reinforced composites in areas such as the B-pillars.

Crash elements
Examples include crash boxes and side-impact bars. Here the good energy-absorption properties of fiber-reinforced composites come into play.

Source: Evonik

Cutting weight is the most effective means of reducing emissions

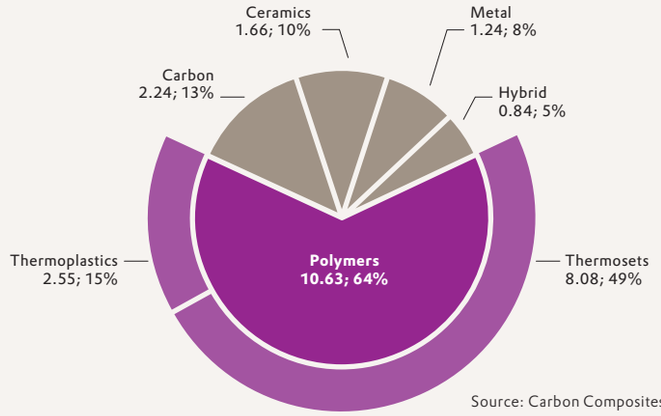
Which measures hold the most potential for reducing emissions? According to a survey of experts, reducing the vehicle's weight is the best way forward.



The market for carbon composites: The matrix

(Sales in billions of US$)

Carbon-fiber reinforced composites are particularly lightweight. In 2014 they generated sales of $16.6 billion. Thermosets are preferred as matrix material.



Source: Carbon Composites e.V.

Developed in the Project House

PULPRESS

Large volumes at reasonable prices—often, that goal is a contradiction in terms when producing fiber-reinforced composites. A pilot plant developed by Evonik and Secar Technologies demonstrates how it could be achieved by using a novel continuous process to make sandwich profile components from composites.

Dr.-Ing. Sivakumara Krishnamoorthy

A number of technologies are available for manufacturing complex molded parts from fiber-reinforced composites, but they all have one thing in common: Cost-effectiveness does not necessarily go hand in hand with the desired level of component complexity. The best example of this is lamination by hand—the oldest method for making composite components. While this method can be used for producing complex geometries, by definition it cannot be automated, which eliminates it as an economical option for mass production.

A greater degree of automation can be achieved with what is known as resin transfer molding, a process that has attracted some attention lately, not least as a result of the bodies of BMW's i3 and i8 electric cars, which were made from carbon fiber-reinforced plastic. Current cycle times are still relatively long, however—much longer than typical times for a BIW (body in white) cell in large-scale automobile production. One alternative is to make elements such as fiber-reinforced plastic profiles via the pultrusion method, even though for a long time manufacturers could only use this process to produce straight profiles.

It was against this backdrop that the Composites Project House developed a new, highly automated, continuous process for manufacturing components with complex geometries from fiber-reinforced composite materials. The development partner for the project was Secar Technologie GmbH, a company located near Vienna specializing in the production of components from a variety of fiber-reinforced composites.

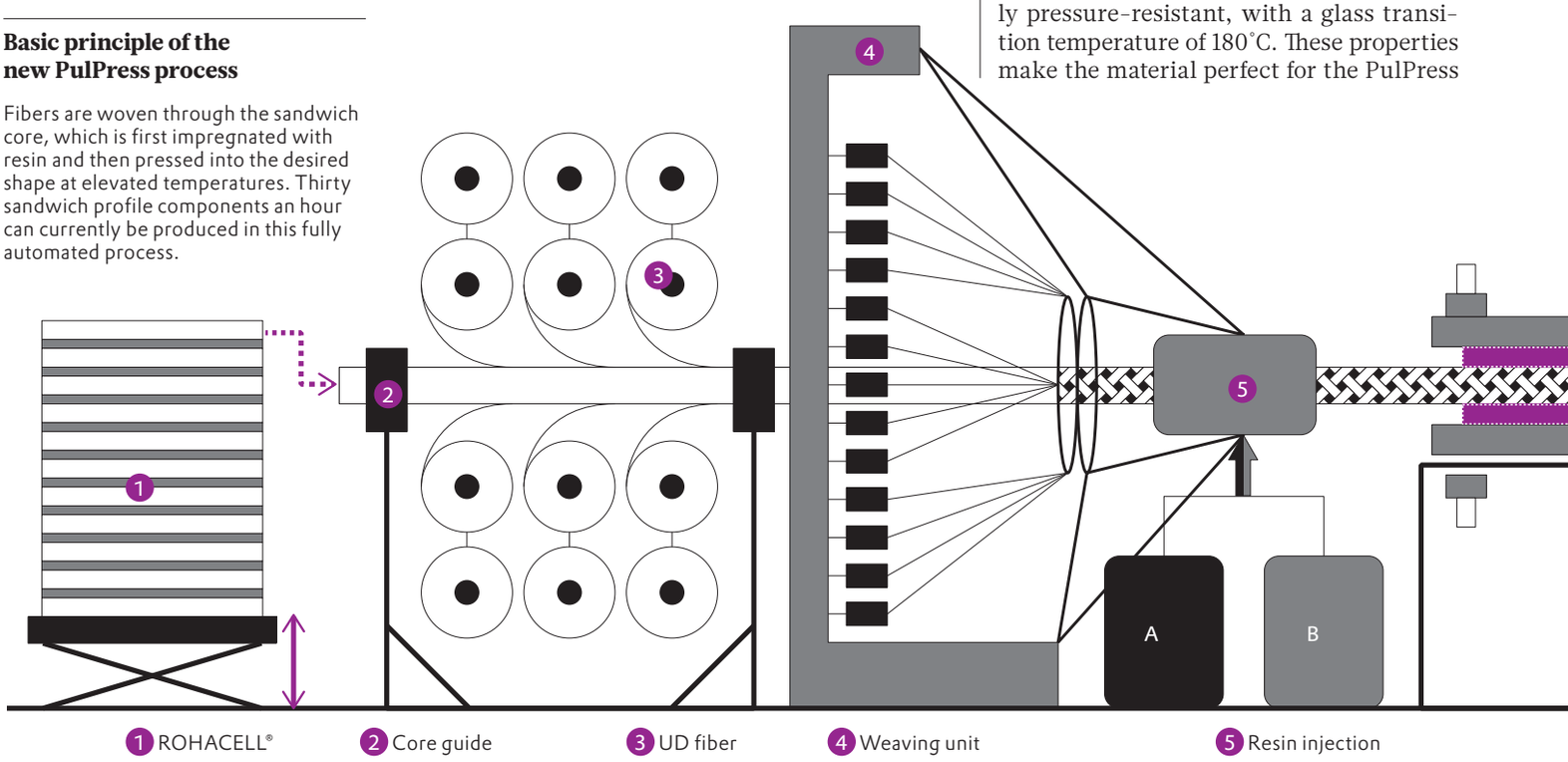
Established processes newly combined

Known as PulPress, the new method represents a novel combination of pultrusion and molding processes. In terms of the materials used, development began with Evonik's ROHACELL®, a closed-pore, high-performance structural foam that serves as the core material in sandwich components. This polymethacrylimide (PMI) foam has proven to be a lightweight yet strong material in composites such as those used in auto racing, aviation, and athletic equipment (hockey sticks, skis, etc.).

In addition to its low specific weight, the PMI foam is also thermoformable and highly pressure-resistant, with a glass transition temperature of 180 °C. These properties make the material perfect for the PulPress

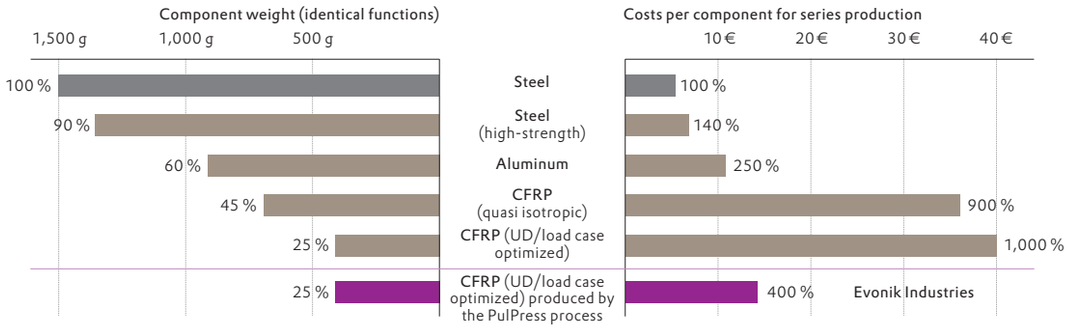
Basic principle of the new PulPress process

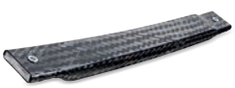
Fibers are woven through the sandwich core, which is first impregnated with resin and then pressed into the desired shape at elevated temperatures. Thirty sandwich profile components an hour can currently be produced in this fully automated process.



High efficiency

Using the new PulPress method cuts costs by 30 to 60 percent per component compared to other production methods. The resulting components weigh 75 percent less than their steel counterparts.





The pilot plant supplies sandwich profile structural components up to 1.2 meters in length.

method—the Composites Project House, in other words, has demonstrated yet another application for ROHACELL®.

In the PulPress process, the structural foam serves as the core around which reinforcing fibers are woven. Afterwards the resin is introduced for fiber impregnation. Once prepared in this way, the material is fed into a press system, which processes the continuous material at elevated pressure and temperature to create a 3D profile with defined dimensions. The pilot plant can currently produce sandwich profile components up to 1.20 meters in length in a continuous process. Components up to that size can already be made in the plant as well.

In these components ROHACELL® serves as the shaping core material; metal or polymer inserts can be used as well. Evonik and Secar worked together to build the pilot plant, which is capable of a fully automated throughput of 30 components an hour, or one component every two minutes. That rate could be increased still further, for instance by using a resin system that cures faster.

The structural foam core of fiber-reinforced plastic parts ensures that the resulting component will withstand the desired application of energy and force. Measurements taken at the project house on a component produced using the PulPress method show that the component strength is similar to that of a comparable aluminum part produced using conventional methods—even though the component made of composite material is nearly three times lighter.

Unlike today's processes, in which a structural foam core with fibers is processed into a composite material, the PulPress process involves almost no waste—of either the foam core or the fiber. The process will benefit customers in the athletic equipment sector, the automotive industry, and other markets. ■

The Expert

Dr.-Ing. Sivakumara Krishnamoorthy, head of the Complex Profiles project at the Composites Project House.

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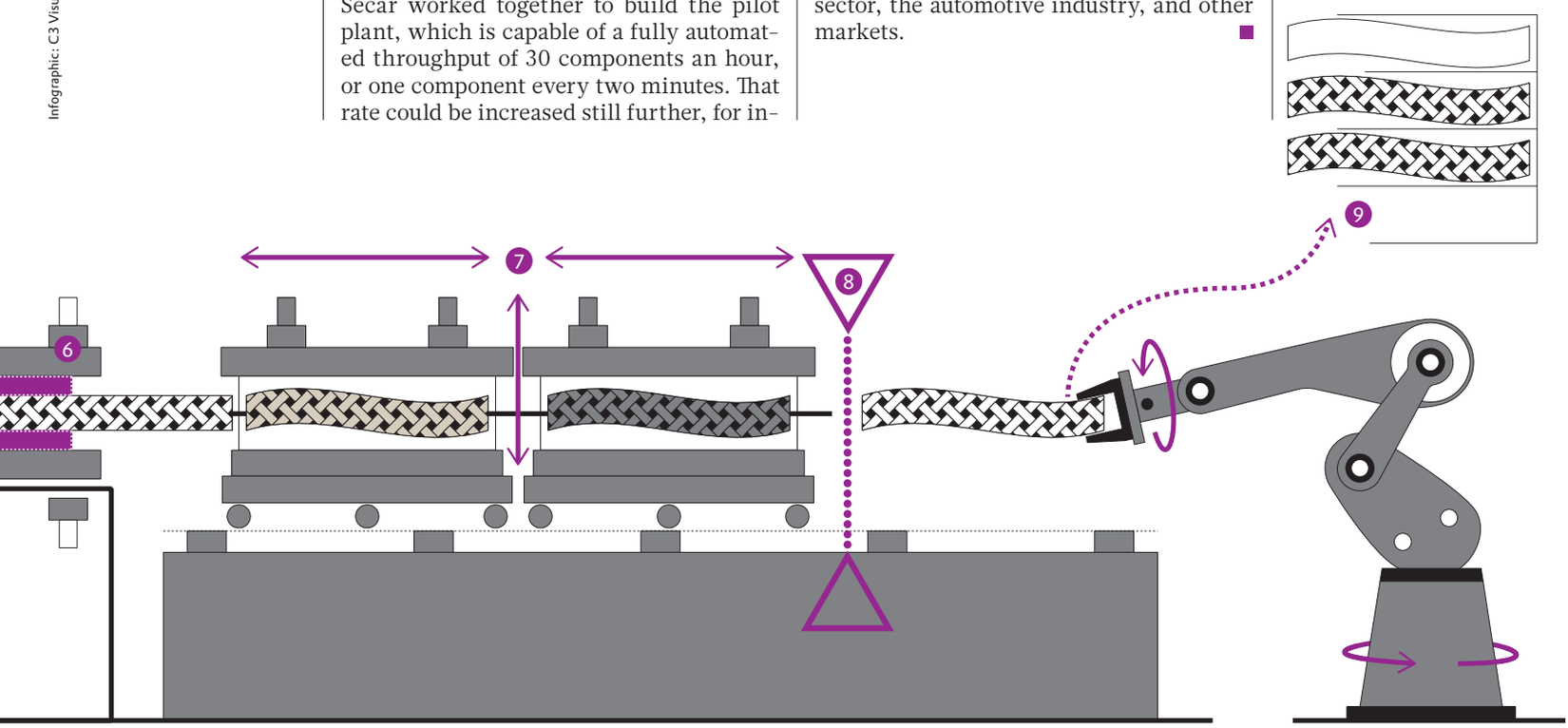
Infographic: C3 Visual Lab Photography: Evonik (2)



6 Preform 7 Movable press systems 8 Separation 9 Storage

Developed in the Project House

UD TAPES

Lightweight, stable, and extremely resistant to tensile forces: unidirectional tapes. Made of parallel continuous fibers embedded in a plastic strip, these tapes can now be produced more easily, thanks to a new process developed by the Composites Project House. Interesting applications for the tapes include oil and gas extraction.

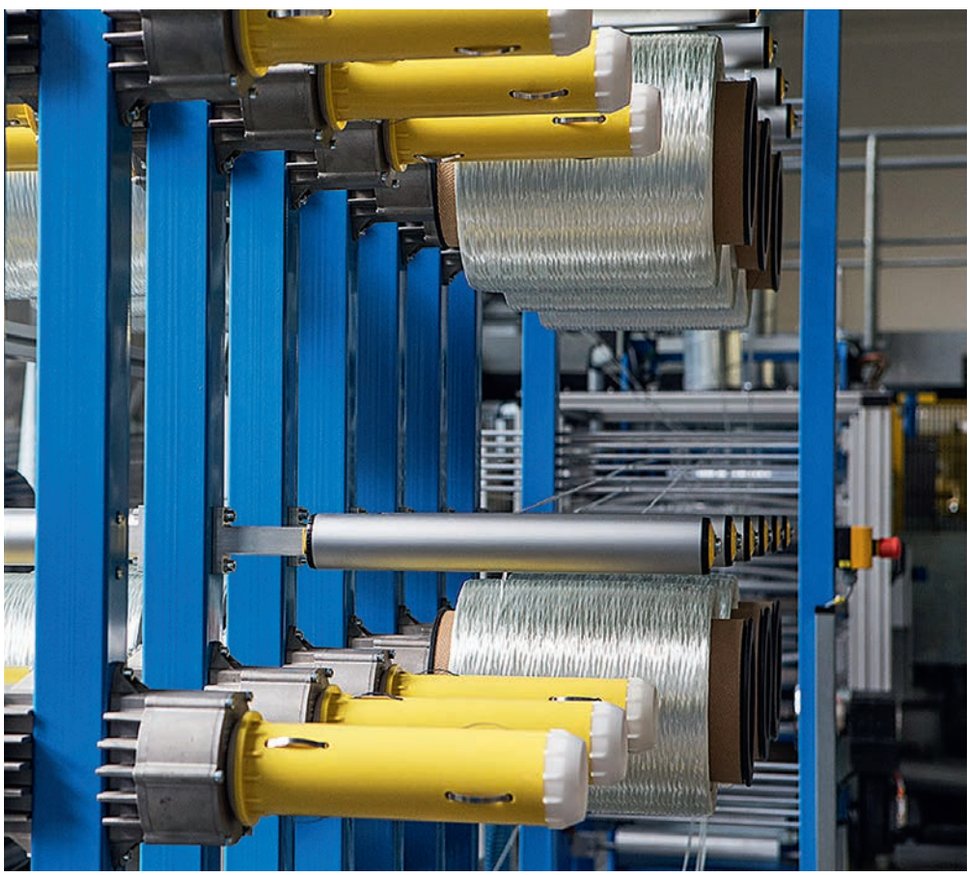
Dr.-Ing. Andreas Szentivanyi, Martin Risthaus

The oil and gas industries have a problem: While increasingly sensitive exploration methods allow them to detect new sources deep below the sea floor, traditional extraction equipment is gradually reaching its limits. When oil and gas are withdrawn from tremendous water depths, pipelines must be capable of withstanding extreme external pressures. For this reason, the flexible pipes currently in use contain stronger metal casings that give the piping the rigidity it needs, but also increase the weight significantly.

The oil and gas industry now drills to such tremendous depths that pipes need increasing amounts of reinforcement, making them heavier and heavier. This not only makes the pipes more difficult to handle but also requires additional buoys. However, water depths of more than 2,500 meters are a great challenge.

The situation can be improved by switching materials and using plastic pipes reinforced with fiber composite materials known as unidirectional (UD) tapes. Besides having a length-to-weight ratio that is far superior to that of pipes with steel reinforcements, these plastic pipes are also resistant to corrosion. They typically consist of several layers, and using the same polymer for all layers optimizes the material bond.

Unidirectional tapes are bands of fiber-reinforced polymer composites in which individual continuous fibers are arranged in parallel. The Composites Project House has developed a process for producing these unidirectional tapes directly from the melt. The advantage: Directly impregnating the fibers with the polymer during the melt phase eliminates the need for grinding the polymer to a powder and preparing it as a suspension, as is the case with traditional methods. The granulate is instead extruded onto the fibers directly, saving time, money, and energy.



Almost ready for mass production: Built for the purpose of manufacturing unidirectional (UD) tapes, the pilot plant constructed by the Composites Project House is currently producing tapes 160 mm in width.

Scalable pilot plant

The process has been running for nearly a year at a pilot plant that the project house team has optimized in terms of fiber feed and impregnation. The plant can handle 20 to 40 fiber bundles at a time. Known as rovings, these bundles consist of a few thousand to ten thousand filaments; glass fiber and carbon fiber have been the materials of choice to date.

To make sure that the fibers are distributed homogeneously in the final tape, they are first separated into individual strands. The strands and the polymer melt are then fed into a press with a heated die to produce a unidirectional tape 160 mm wide, which cools in a calender and is drawn over multiple rollers. The pilot plant can be scaled up, and the next step is to retool the plant for tapes with a width of 300 mm.

Whereas unidimensional tapes have been used successfully in the aviation industry for years now, Evonik is now working on specific inquiries from customers in the oil and gas industry. The automotive industry is interested in unidirectional tapes as well, as a way of reducing weight in vehicles. Experts expect a 100 kg reduction in vehicle weight to reduce fuel consumption by 0.3 to 0.5 liters per 100 km. This market is still in

Also attractive to the oil and gas industry: Polymer solutions based on UD tapes make it easier to deliver highly corrosive oil.

its infancy, but the industry is clearly moving in that direction. The Composites Project House, for instance, has been working with multiple partners from research and industry on the CAMISMA research project (sponsored by the BMBF, Germany's Federal Ministry of Education and Research), producing a 40 percent lighter backrest for automobile seats. The anchor points of the new backrests are just as strong and stable as those of current metal backrests.

Injection molding another plastic component on the backrest posed no difficulties either. This allows for much-needed system integration and a cost-effective workflow that compares well with solutions based exclusively on metal.

New opportunities for car body design

It is becoming apparent that composite materials do not represent a one-to-one replacement for welded metal components in cars—if for no other reason than production costs. Instead, composite materials open up opportunities for completely rethinking car body design and implementing such concepts as reinforcing metal structural components and drastically reducing the number of assemblies. In addition, components made of composite materials can be produced with much more flexibility than metal components.

This is becoming an increasingly important consideration as the variety of drive systems increases—combustion engines vs. hybrid drives vs. electric motors—and forces the automotive industry to adapt to smaller production lot sizes with greater variability. Used in this way, unidirectional tapes made in a direct melt impregnation process pave the way for new components and competitive applications. ■

The Experts

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Developed in the Project House

HYBRID POLYMERS

A new class of materials is expected to speed up the production of fiber-reinforced composites for lightweight design: thermally reversible hybrid polymers that are easy to process and that produce excellent mechanical properties in finished components.

Dr. Friedrich Georg Schmidt

As today's material of choice for the polymer component of fiber-reinforced composites, thermoset matrix systems possess a number of highly desirable properties. Their polymer chains are irreversibly crosslinked together in the finished composite, lending thermoset polymers considerable mechanical, thermal, and chemical stability. They also receive high marks during the first step in manufacturing composite materials: fiber impregnation. At this point in the process, they still consist of small molecules that have not been crosslinked, which means that they flow well and, as a result, do a good job of impregnating the fibers.

The structure of thermosets does, however, come with a disadvantage: processing times for the curing stage—and thus for manufacturing a component—are relatively long. And while thermoplastic polymers, on the other hand, can be processed and molded quickly, they do not achieve the favorable mechanical properties of thermosets. The reason for this is that thermoplastics do not crosslink, which can result in creep in structures under constant strain. And because their melt phase is highly viscous, they also require a more complex fiber impregnation process.

The ideal solution would be a single material that combines the best of both worlds: the excellent stability of a thermoset and the short processing times of a thermoplastic. Researchers at the Composites Project House have developed just such a material, launching it as "Thermoreversible Crosslinkable Thermoplast-Thermoset Hybrid." The crosslinking that occurs in these novel polymer networks is entirely reversible—no catalyst required. Because the crosslinks dissociate, the material system can be reshaped quickly; the polymer network then reforms upon cooling, stabilizing the shape.

The force behind this is a chemical reaction. Researchers were looking for a mechanism that would allow crosslinking or "de-crosslinking," as the case may be, to take place within a temperature range of interest for manufacturing fiber-reinforced composite materials. They found what they wanted in a special type of Diels-Alder reaction that acts as a thermal switch. The chemists who discovered the reaction—Otto Diels and Kurt Alder—received the 1950 Nobel Prize in Chemistry for their work. ➜

Photography: Evonik (3), fotolia

➜ The hybrid polymer system principle can be applied to a variety of different polymers. One example involves the use of an acrylate copolymer as the polymer matrix, in which the thermoplastic polymer chains undergo a Diels-Alder reaction to form covalent bonds with one another via a bifunctional dienophile. This results in the establishment of a diene-dienophile equilibrium that can be adjusted by altering the temperature.

A straightforward process

Producing a corresponding fiber-reinforced composite is astonishingly easy. Project house developers have designed their own plant to show how that works, and have already produced samples for potential customers. The plant processes semifinished glass-fiber and carbon-fiber products (fabric, non-crimp fabric), which are first impregnated by moving them through a dispersion of the hybrid polymers, and then briefly heated and cooled. The results of this continuous process are known as prepregs—semifinished products that have already been impregnated—that can then be molded into the desired components at temperatures above 170 °C.

Because these prepregs are not sticky, they do not have to be separated by films during storage and transport. Any waste produced during processing can be reused or even recycled, since crosslinking is thermally reversible in the hybrid polymer.

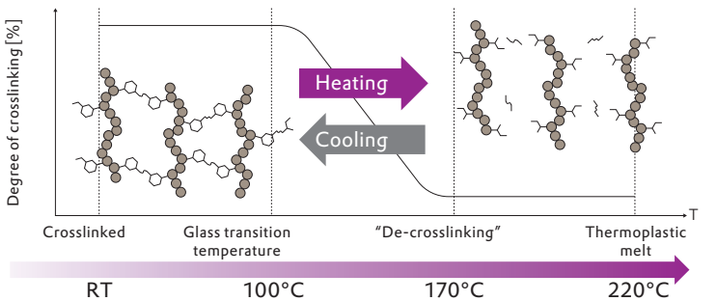
Consolidated semifinished products known as laminates are made from multiple layers of prepregs—these perform consistently at temperatures of up to 100 °C. Their elasticity and tensile strength over a broad range of temperatures are just as good as those of an epoxy resin laminate, and greatly superior even to those of semifinished products with thermoplastic polyamide 6. Water absorption is likewise very low and comparable to that of an epoxy resin.

Not surprisingly, the response from potential customers has been very positive. For applications in the automotive industry, Evonik is working closely with machine manufacturers, processing companies, and research institutes to explore pre-impregnated semifinished products in production cells.

Prepregs based on hybrid polymer systems are also attracting major attention in the athletic equipment and medical technology industries. And the good news for users? Working with hybrid polymers does not require any major modifications of existing thermoplastics production lines. ■

Switchable material behavior without a catalyst

When heated, the polymer network dissolves and the system can be reshaped. When cooled, the network reforms to yield a stable form.



The project house already produces samples for potential customers.

The Expert

Dr. Friedrich Georg Schmidt, head of the Thermoreversible Crosslinkable Thermoplast-Thermoset Hybrid project at the Composites Project House.
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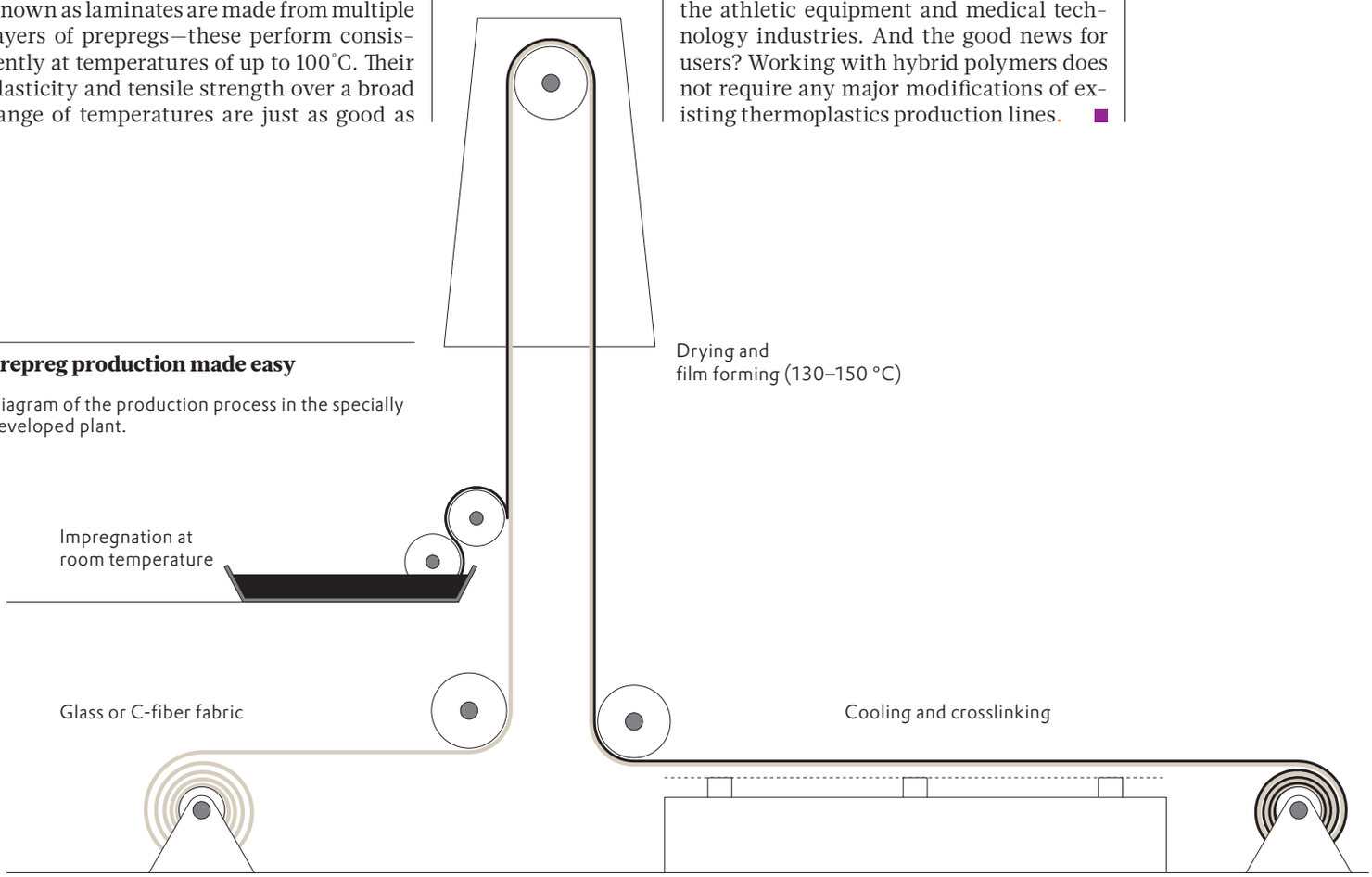
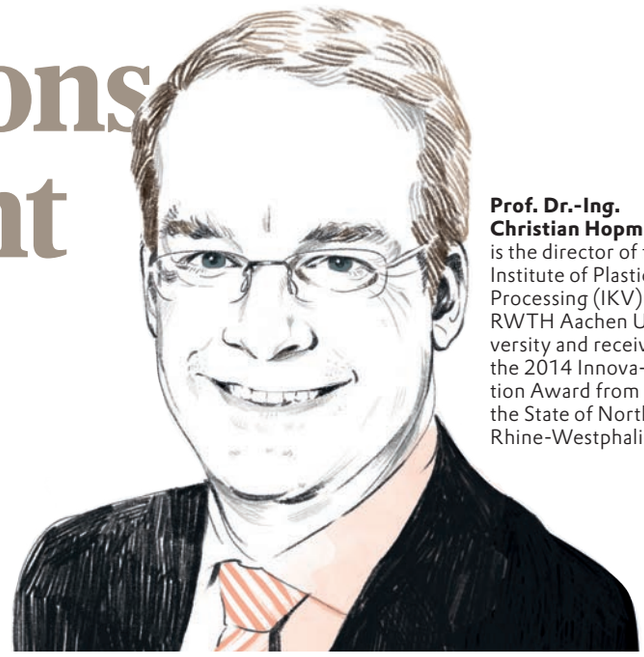
Prepreg production made easy

Diagram of the production process in the specially developed plant.



Guest commentary

Weighty reasons for lightweight construction



Prof. Dr.-Ing. Christian Hopmann is the director of the Institute of Plastics Processing (IKV) at RWTH Aachen University and received the 2014 Innovation Award from the State of North Rhine-Westphalia.

Prof. Dr.-Ing. Christian Hopmann

Leightweight construction is the heavyweight champion of modern production. Whether the product in question is a building, a vehicle, packaging, or any of the many things we use every day, the goal of delivering complex functionality with as little material as possible is common to virtually every industry. Besides saving money and materials in the manufacturing process, lightweight materials also save energy and resources when products are later put to use, thereby meeting demands for efficiency and sustainability.

Plastics are the stars of modern lightweight construction, especially when it comes to fiber-reinforced composites. Germany is the global leader in this area—our researchers and material developers among the best in their fields anywhere in the world. We have an efficient network linking academia and industry—who else has that? But our competitors aren't sleeping. We have to make sure that we will be able to keep our position as the front runner going forward. A number of issues are crucial if we are to succeed. New functionality means having to enhance existing materials and combine different materials, and the competition for materials opens up opportunities for new approaches. Hybrid solutions combining metal and fiber-reinforced plastics, for instance, do an excellent job of carrying tensile and compression forces. The variety of matrix systems is new as well, with thermoplastics on the rise along with thermosets. We have to put the full spectrum of lightweight materials to the test—in the case of carbon fiber-reinforced plastics, for example, the cost of manufacturing the fibers is a limitation. In order to reduce system costs, we need to develop cost-effective manufacturing processes that can be automated.

"Researchers need space and time. Immediately asking about the market applications of a research proposal is counterproductive."

As climate change becomes more and more pressing throughout the world, lightweight construction will play an increasingly important role in our technical toolbox. Continuing our success in lightweight construction in the future will mean making changes, and awarding development funds more strategically will play no small role in this. Germany is home to an increasing number of centers for lightweight construction research, but not all of these are viable. Instead of fueling hype with short-term megaprojects that are frequently motivated by local politics, we need to encourage long-term financing for interdisciplinary centers that can walk the line between research and industrial applications. Concentrating on sites that foster excellence is extremely important in this regard.

Researchers also need space and time. Immediately asking about the market applications of a research proposal is counterproductive. We need to give ourselves the freedom to pursue unconventional approaches. Lightweight construction research needs more diversity and competition. We need to approach the field from the bottom up—not from the top down! That's how extraordinarily exciting materials have come into being in the past, forming the basis of our current affluence. Lightweight construction is too important and too valuable to dismiss as a mere fad.

Infographic: C3 Visual Lab Photography: Evonik

ELECTRONICS ON THE BODY

Prêt-à-porter computing!

The computers are drawing nearer! Gone are the days when computers filled entire warehouses; now, having a smartphone on you is for many people just as normal as having a wallet in your pocket. In the year 2016, around one third of all humans will own a smartphone.

And the next step of the evolution is already in full swing.Microchips have become so small and affordable that they can be integrated into everyday objects such as motorbike helmets, items of clothing or toothbrushes. It is the beginning of the age of wearables—an age in which formerly "dumb" objects are transformed into intelligent data loggers and transmitters. Among the forerunners of this technology are smartwatches, like the Apple Watch. These technical devices help us live our lives more mindfully, healthily,

and safely. An intelligent contact lens, for example, could measure the sugar content in lacrimal fluid in the eyes of patients with diabetes and warn them as soon as their blood sugar levels go outside of the normal range.

Currently, however, there are still a few challenges to overcome. How, for instance, can you make the computer in a smart T-shirt able to survive a washing machine cycle? Or how can you integrate chips and conductor tracks into medical dressings without impeding wear comfort? The Corporate Foresight Team is looking into these questions and also potential growth opportunities for Evonik in the field of wearables as part of its Digital Futures focus topic. And, who knows—maybe in a few years' time we'll be deciding whether we want to buy our next smartphone as a jacket, pants or glasses.

The T-shirt as charging station: 120 thin-film solar cells from the Holst Centre in the Netherlands have been incorporated into the Solar Shirt by designer Pauline van Dongen. Under direct sunlight, they generate one watt of electrical power—enough to charge a cell phone in just a few hours.

Additional information:
bit.ly/1bqpfpg

Photography: Liselotte Fleur

DIGITAL IS BECOMING NORMAL

Interview with Dr. Henrik Hahn, head of Evonik's digitization strategy, and Dr. Zhong Hong, head of IT strategy and IT architecture.

"I anticipate that in five to ten years we will be able to control plants from across entire continents."

Dr. Zhong Hong

An **IT strategy expert at Evonik,** he has gathered extensive experience in the operational business as the Senior Vice President of the former Coatings & Additives Business Unit in Asia.

Digital is normal—at least in our daily lives. But what does digitization mean for chemical companies, business processes, technical processes, employees, and customers? "Digitization is an evolutionary process—not a radical upheaval, as it is often portrayed," says Dr. Zhong Hong. "We want to promote the digital transformation, together with the segments and all corporate units," adds Dr. Henrik Hahn. Together, they explain how Evonik will sustainably anchor a digital agenda in the Group in a close collaboration between IT and Corporate Strategy.

Digitization has completely permeated our everyday lives. Is it a blessing or a curse?

Henrik Hahn: It's certainly not a curse. Information has been stored, processed, and transferred digitally for a long time now—locally, globally, privately, and via public networks. But digitization has been advancing and generating developments that were unimaginable a few years ago. Think about household appliances that are connected with online retailers. At the push of a button they can reorder consumables such as detergents by themselves. There's no doubt that this simplicity benefits customers, even if we have to get used to it first.

Do you understand the fears people have when it comes to the rapid pace of development of digitization?

Zhong Hong: People have long been accustomed to digital information. To find out the weather forecast, most people prefer to consult their weather app rather than look at the sky. Of course every new technology has its own dynamics and can't be stopped once it starts to catch on. That can fuel anxiety. But experience tells us that in the IT field reservations about new technologies largely ease off when people recognize their benefits.

You describe digitization as an evolutionary process. What do you mean by that?
Zhong Hong: Let's take the smartphone. In the past, a cell phone was a cordless telephone. Today it's a mobile computer and, for a lot of people, indispensable. This development occurred gradually, which allowed people to get used to it little by little. Something similar is happening with the digital transformation in companies. It is a continuing process in which changes occur step by step. That affects all corporate units—from procurement, R&D, and production to sales and marketing, and ultimately the entire organization, including business processes.

Who determines the speed and the individual steps?
Henrik Hahn: Chemical companies like Evonik are facing a choice between allowing themselves to be passively carried along by digitization or actively promoting it. Both choices harbor a risk for business development. Companies that are driven by the ever-present digitization rhetoric and just start running with it are at the risk of taking the wrong path. Those who are too hesitant run the risk of having their path blocked—for example, when new players attack established value chains. For Evonik, we have decided to take an active approach. Over the next three years, an interdisciplinary team within the Corporate Strategy unit will study the impact digitization will have on Evonik. We will then convert the results into a digital agenda. Our goal is to make use of the opportunities that present themselves to increase our competitiveness. Conversely, of course, we also want to detect at an early stage any potential risks to our business interests that arise from digitization.

What does that mean in concrete terms?
Zhong Hong: Normally we offer a customer a specific product based on a defined formula in a particular field of application. He either buys it or he doesn't. In the digital sales process, the exchange between us as the seller and our customer is much faster and more flexible. For example, we can formulate a coating to precisely match the material the customer wants to coat. To do this, we use our own expertise and databases, as well as all the external digital data that we have at our disposal. We can use 3D imaging or virtual reality to make the color, grain, and coating properties of the formula vivid. Thus we are close to the customer and what that customer wants.

Does this make access to new markets easier?
Henrik Hahn: New digital business models are possible, at any rate, when they allow us to make a larger contribution to the customer's value. And with regard to the innovation process, we will also be able to introduce new developments more quickly to the market thanks to digitization. The timeframe for developing and launching a product is becoming shorter. One reason for this is that laboratory tests have to be done only once. The results of the test are stored and are available for new customer inquiries. Digital simulation might actually make experiments obsolete, even if the experts can barely imagine that. The same applies to established products. The first company to use digital processes internally or adds digital service components will secure for itself a competitive advantage.

Chemistry thrives on its methods and processes. What will digitization change in this area?
Zhong Hong: Digital process control is faster and more precise than manual control. But we have to think further ahead. Internet performance is increasingly better and faster. Today it doesn't matter how great the physical distance is between the user and the server, and where a server stands or an application runs. I anticipate that in five to ten years we will be able to control plants across entire continents—provided that we have components capable of communication by then, and that data transfer becomes even more efficient and secure.

Industrie 4.0 promises flexible production on demand. Can the chemical industry look forward to this as well?
Henrik Hahn: Yes. Digitization allows production to be made flexible. It would certainly be too simplistic to say that we will be able to just increase or decrease production volumes on request. The fact is, though, that production is now oriented not only to reactor size but also to the customer. But we need flexible and adaptable processes for this individualized production, smaller plants, different methods, and smart logistics that, for example, analyze data and processes by computer and find their optimal combination. Naturally, that should be discussed case by case in cost-benefit terms and will take another couple of years. But one thing is certain: If you can react faster to what the customer wants, you will get the customer. Digitization will change competitive dynamics and market structures.

In the past year, Evonik discussed specific digitization-oriented projects under the working title "D4P." What's D4P all about?
Zhong Hong: The four Ps stand for products, production, process, and people. The name signifies our intention to harness the potential of digital technologies and the abundance of digital data across all departments. This also includes sharpening our in-house expertise in big data analytics and IT. The impetus for this came from completely different areas of the company—from in- ➔

"Digital simulation might actually make experiments obsolete, even if the experts can hardly imagine that today."

Dr. Henrik Hahn

Head of Evonik´s digitization strategy and member of VCI's Task Force Industrie 4.0. Previously he headed a project house and was the chairman of Evonik Litarion GmbH, among other things.

Photography: Stefan Wildhirt, Frank Preuß/Evonik

➔ novation, production and engineering, marketing, HR, IT, and corporate strategy. That's an evolution that concerns everyone, and affects the entire value chain.

What's the next step?
Henrik Hahn: Our starting point is the development of a digitization strategy. But we won't stop at just a description of what to do. Digitization should already be an everyday reality in practice. A current example of what that means can be found in the Performance Intermediates Business Line, which already collects, analyzes, and visualizes all data about certain parts and aggregates of individual production processes. This data gives real-time information about the operating conditions and errors of a device, which tells us precisely when it needs to be serviced or replaced. This kind of proactive maintenance makes processes safer and more efficient.

Do you have other examples?
Zhong Hong: For example, the company has a team that was formed to foster innovation partnerships with other companies. With the help of data from professional databases, the Internet, and social networks, we want to find out whether in other companies new research projects or ideas for new products are emerging that also fit us. A third example is AMINOInsights. Up to now, customers could have their animal feed analyzed at Evonik and get recommendations for the optimal composition and dosing of certain amino acids from our portfolio. There are plans to digitize this service via an open platform. Customers, the sales department, and the analytical laboratory will have access to this platform and be able to find the best solution interactively.

What does the new data world mean for employees?
Henrik Hahn: In the working world, round-the-clock mobility and networking are becoming the norm. The smartphone, for example, is increasingly becoming a platform for everyone. In the future we will be able to access the data we have stored "in the cloud" via a terminal. Our employees will obviously have to receive the proper training and equipment for this. So digitization doesn't just mean increasing efficiency, or even streamlining. With open-minded employees and the right strategy, the company can actually realize growth opportunities through digitization. The human being, and not the machine, is at the center of the digital transformation.

The exchange of data also harbors risks...
Zhong Hong: Yes, of course. As soon as data comes into existence it can be siphoned off by third parties or copied without our being aware of it immediately. Obviously, we have to protect ourselves against that. One possibility is product platforms, which can be accessed by customers and enable fast communication with our employees, but which also ensure that our data stays in house. We can also use such platforms to digitize our logistics services—an important factor for staying in business.

Where do the challenges lie in the next few years?
Henrik Hahn: Chemical companies must lay the foundation now for dealing with the opportunities and challenges of big data. The first thing we're going to do right now is to develop a coherent digitization strategy for Evonik. That means that we are already operating digitally in certain areas and are integrating digital business processes in the company. At the same time, we're preparing ourselves for upcoming issues—future business models, for example. IT and business strategy go hand in hand in this work. By observing the IT industry, we get a feel for the speed. And we also observe end industries and the consumer goods market, because what happens today in other industries can be relevant for the process industry tomorrow. One thing we're planning to do is to open a big data lab this year.

A research lab for data?
Zhong Hong: Yes, a research lab for analyzing big data—the type of data that's too big or too complex to evaluate with conventional data processing methods. Current analytical methods and technologies quickly reach their limits. We want to use new analytical methods to make this kind of analysis economically viable for Evonik. ■

"In our new big data lab, we will use new analytical methods to make complex data economically viable."
Dr. Zhong Hong

Technical drivers of digitization

Cloud Computing
Thanks to high-speed Internet, servers can be anywhere; cloud computing is replacing hardware and software. Because of investments in data security, acceptance of cloud services has risen sharply.

Big data analytics
The processing power of computers has increased dramatically; the cost-benefit relationship is continually improving. This is making big data analytics attractive for companies.

Digitization of data
More and more information is available online; it is multiplied by search engines. This results in big data, from which additional information is generated through intelligent analysis.

Computing everywhere
The performance of the mobile network (WiFi) has substantially improved; data and IT services have become mobile, independently of the mobile device. Data can be digitized, stored, called up, and processed anywhere.

"The human being, and not the machine, is at the center of the digital transformation."
Dr. Henrik Hahn

Infographic: C3 Visual Lab

CompanyNews

METHIONINE FOR DAIRY COWS

Evonik has started up Mepron® production at its Mobile (Alabama) site in the USA. Mepron® is a rumen-protected methionine developed specially for dairy cows by the Animal Nutrition Business Line.

The USA has the world's largest stock of high-yielding dairy cows and is the most important sales market for Mepron®. About 12.5 percent of the world's milk is produced in the USA.

High-yielding dairy cows have particularly high methionine requirements. In conventional animal nutrition, these requirements are covered by protein-containing feeds. The use of Mepron® in dairy cow rations, however, allows manufacturers to reduce the amount of crude protein in feeds without sacrificing output. This, in turn, reduces feed costs, eases metabolism in the animals, and reduces nitrogen excretion.

Methionine is what is known as an essential amino acid, which higher organisms must ingest with their food. Without adequate methionine dairy cows cannot optimally metabolize the protein in their feeds. Unlike pigs and chickens, however, ruminants need methionine to be specially "packaged" so that it reaches the small intestine of the cow, where it can be absorbed. Without this type of protective coating, methionine would be broken down too early by microorganisms in the first stomach.

Mepron® was specially developed for dairy cows.

Photography: shutterstock

Venture capital in China ➜ Increased safety in cars ➜ High tech in bones ➜

Expanded capacity for PEEK polymers

Due to increasing global demand for high-performance polymers, Evonik's Resource Efficiency Segment is significantly expanding its production capacity for polyetheretherketone (PEEK) at the Changchun (China) site.

Business in Evonik's VESTAKEEP® brand of PEEK polymers has experienced consistent and strong growth over the last five years across

High thermal and chemical resistance: PEEK polymers.

all relevant industry segments, such as oil and gas, aviation, and automotive.

Thanks to their high thermal and chemical resistance, specialty polymers can replace metal components for use in demanding lightweight structural applications.

The new molding compound VESTAKEEP® Easy Slide I, for example, stands out by offering excellent abrasion resistance and low sliding friction, thereby allowing the production of ever smaller and more powerful structural elements such as vacuum pumps. The recently introduced VESTAKEEP® 5000 HCM (hot compression molding) grade increases the production efficiency of customized PEEK seals, delivering superior mechanical properties and performance for the oil and gas industry.

Expanded specialty silica production facilities

Evonik has expanded its facilities in Ako (Japan), where the company will produce its SIPERNAT® and CARPLEX® lines of specialty silicas. The investment represents a roughly 50 percent increase in Evonik's Japanese production capacity, which the company maintains through DSL Japan Co., Ltd. (DSL). Evonik maintains a 51 percent share in DSL, a joint venture with Shionogi & Co., Ltd. in Japan.

"The expansion will enable us to support the growth of our customers in sectors such as the food, cosmetics, and pharmaceuticals industries," explained Andreas Fischer, head of the Silica Business Line.

Applications for SIPERNAT® and CARPLEX® include their use in beer filtration and toothpastes, as drug carriers in pharmaceuticals, and as flow aids in powdered foods.

Evonik is expanding its global silica production capacities. Following expansion projects in Europe and Asia, Evonik is now constructing a facility in Americana (Brazil). This will be the first plant in South America for highly dispersible silica, a product used primarily in tires with low rolling resistance. In the spring of 2015, the company began the initial planning

Specialty silicas as drug carriers in pharmaceuticals.

stages of a new world-scale production plant for precipitated silica in the United States. The company hopes to finish construction by the end of 2017.

New specialty copolyester plant

At its Witten site in Germany, Evonik is building a new production plant for specialty copolyesters. The company is investing a mid-double-digit million-euro sum in the plant, which will have an annual production capacity of several thousand metric tons. It is scheduled to be completed in 2018. The investment will create around ten new jobs in Witten, where the group currently has around 250 employees. As

Special copolyesters are used to coat metal strip.

binders for paints, specialty copolyesters are used in coil coatings and, increasingly, in food can coatings. They enable the production of coatings with sufficient flexibility to process the metal into a food can, as well as adequate rigidity and protection.

Surface-modified AEROSIL® in Japan

NIPPON AEROSIL CO., LTD. (NAC), a joint venture between Evonik Industries and Mitsubishi Materials, has opened a new plant for surface-modified AEROSIL® in Yokkaichi (Japan). NAC is a key component of Evonik's global silica production network.

The new plant increases the production capacities for surface-modified AEOROSIL® in Asia. Customers will benefit from improved product availability and shorter lead times for the product supply.

In addition to the new plant, a new office building was also built and structural improvements were made to several

Hydrophilic (left) and hydrophobic pyrogenic silicas.

production buildings, thereby increasing safety at the site.

The production plant in Yokkaichi is Evonik Industries' largest fumed silica plant in Asia and one of the largest specialty fumed silica plants in the world.

Second methionine plant planned in Singapore

Evonik plans to construct an additional world-scale plant complex for the production of the amino acid DL-methionine in Singapore. The facility will have an annual production capacity of 150,000 metric tons and is expected to start operations in 2019.

The specialty chemicals company wants to contribute to meeting the increasing global demand for this product, which is indispensable for efficient and sustainable animal

Methionine is added to the feed of chickens and pigs.

nutrition worldwide. Evonik sells DL-methionine under the brand name MetAMINO®.

Evonik's most recent methionine plant took up its operations on Jurong Island in Singapore in the fourth quarter of 2014 after a two-year construction period—precisely on schedule—and operations are proceeding according to plan. The new complex will be built directly adjacent to the existing plant and will likewise produce all of its strategically relevant precursors on site. The location in Singapore enables Evonik to serve especially Asian growth markets well.

The specialty chemicals company produces DL-methionine at world-scale plants in Antwerp (Belgium), Wesseling/

Cologne (Germany), Mobile (Alabama, USA), and Singapore.

DL-methionine is an essential amino acid and must therefore be supplied in the diet. As a feed additive, it contributes to the efficient, healthy, and environmentally friendly nutrition of livestock, particularly poultry and pigs, thereby also helping to provide the growing world population with animal protein on a sustainable basis.

New membrane electrolysis

Evonik and AkzoNobel have started building a new membrane electrolysis facility in Ibbenbüren (Germany).

The new facility is due to come on stream by the fourth quarter of 2017, with an annual nameplate capacity of around 130,000 metric tons of potassium hydroxide solution and approximately 82,000 metric tons of chlorine. The two chemical companies established a production joint venture in June 2015 for the efficient and sustainable production of chlorine and potassium hydroxide solution at the AkzoNobel site in Ibbenbüren.

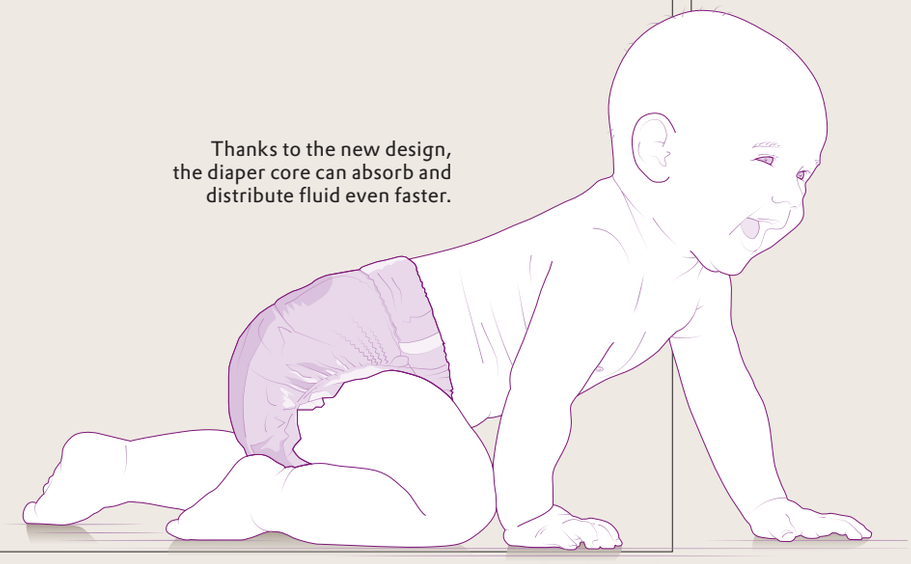
The new state-of-the-art plant consumes less energy and emits less CO_2 than conventional production plants. It will improve the ecological footprint of every ton of chlorine by 25 to 30 percent. The caustic potash produced by membrane electrolysis will be processed into potassium carbonate (potash), among other products, at Evonik's Lülsdorf site in Germany. AkzoNobel will commercialize the chlorine and hydrogen produced as a result of electrolysis, or will process these products directly at the Ibbenbüren site.

Dr. Ralph Sven Kaufmann (left), a member of the Executive Board of Evonik, and Werner Fuhrmann, a member of the Executive Board of AkzoNobel, during the groundbreaking ceremony for the membrane electrolysis facility in Ibbenbüren.

NEW DIAPER DESIGN

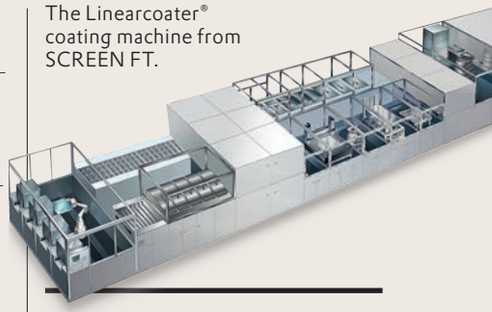
As one of the world's leading suppliers of superabsorbents, Evonik intends to offer a new absorbent core technology for ultrathin diapers on the market in the form of a licensing procedure. In this technology, the superabsorbent particles are found in small pockets that are formed by laminated nonwovens which allow the diaper core to absorb fluid even faster and distribute it.

In addition, the absorbent core technology gives the diaper core a high level of stability, because the superabsorbent particles always remain at the place where they are needed. This special design, combined with an enhanced FAVOR® superabsorbent polymer, enables the diaper to be worn longer. Rewetting is significantly reduced, while wearing comfort is enhanced considerably. The companies using the technology also benefit from lower raw material and logistic costs.



Thanks to the new design, the diaper core can absorb and distribute fluid even faster.

The Linearcoater® coating machine from SCREEN FT.



Strategic partnership with SCREEN FT

Japanese FPD production equipment manufacturer SCREEN Finetech Solutions Co., Ltd. and Evonik have concluded a strategic partnership in order to offer optimal performance of the perfectly matched iXsenic® semiconductor material, equipment, and process.

iXsenic® is a solution-processable inorganic metal oxide semiconductor that is applied under ambient conditions. No vacuum environment is needed. This results in process simplifications, high yield, and cost advantages. iXsenic® is best applied via slot-die coating.

SCREEN Finetech Solutions Co., Ltd. provides a wide range of equipment and services for the FPD industry, including high-quality coating machines such as the slot-die/slit coater (Linearcoater®). In the FPD industry SCREEN FT is the global technology and market leader for such equipment.

Evonik and SCREEN FT have been running application tests with iXsenic® on the Linearcoater® for years. The two companies hope that their strategic partnership will accelerate the introduction of iXsenic® on the market.

In today's electronics industry, material layers such as photoresists are already coated, but semiconductive layers are normally applied via vapor deposition (CVD or PVD). With the solution-processable iXsenic® material it is now possible to coat the semiconductor.

Further information:
www.iXsenic.com

Infographic: C3 Visual Lab Photography: Evonik (7)

Investment in Chinese venture capital fund

By investing in the Chinese venture capital fund GRC SinoGreen Fund III (GRC III), Evonik has expanded its venture capital activities into Asia. As a result, the company is now represented in the most important venture capital regions: North America, Europe, and Asia.

GRC invests in private green technology companies with unique strengths and substantial growth potential in Greater China. Target areas include energy and resource efficiency, cleaner transportation, sustainability, and climate change mitigation and adaptation. GRC III has offices in Beijing and Taipei.

In recent years Asia has evolved into the world's third-most important venture capital region. China accounts for around two thirds of these activities.

Aside from Evonik, the investor base of GRC III includes the World Bank subsidiary International Finance Corporation, the development bank Netherlands Development Finance Company (FMO), and Shell Technology Ventures, the venture capital arm of Shell.

Investments in funds are an important element of Evonik's venture capital activities. Previously Evonik had invested in the European and North American venture capital funds Pangaea Ventures Fund III, Emerald Cleantech Fund III, and High-Tech Gründerfonds II.

Safe driving with VESTAMID®

Valeo Schalter und Sensoren GmbH, with headquarters in Bietigheim-Bissingen (Germany), has opted for VESTAMID® L1930 polyamide 12 from the Resource Efficiency Segment of Evonik as the material for the gear drive of its steering angle sensor. The steering angle sensor measures

VESTAMID® L1930 gear wheels ensure the measurement accuracy that is vital for dynamic stability control.

the steering angle of the steering wheel and continuously indicates to the dynamic stability control system—also known as electronic stability control (ESC)—the direction in which the driver wants to go. The ESC compares the driver's intended course with the vehicle's actual direction and makes the necessary adjustments through the targeted braking of individual wheels. This should prevent acceleration of the vehicle on bends, for example, and ensure control of the vehicle.

The sensor is mounted in the steering column. A rotor consisting of a large gear wheel is actuated by the steering column and drives two smaller gear wheels with different numbers of teeth (on the Nonius principle). The magnets embedded in the gear wheels enable detection of the rotational position of the gear wheels by means of Hall or MR angle sensors. The electrical information provided by the angle sensors thus allows calculation of the absolute steering angle.

Investment in medical technology startup

Via its venture capital arm Evonik has invested in the startup company Synoste Oy and now holds a minority share in this medical technology company, which is based in Düsseldorf (Germany) and Helsinki (Finland).

The investment was made as part of a Series A round, together with High-Tech Gründerfonds, the Finnish venture capital funds Finnvera and Lifeline Ventures, as well as Finnish business angels. The overall volume of the financing round lies in the single-digit million-euro range.

Synoste, founded in 2012, is a spinoff of Aalto University in Espoo (Finland). Together with Orton, a hospital specializing in orthopedics and located in Helsinki, Synoste developed a high-tech implant for a minimally invasive treatment of leg length discrepancy, which can lead to chronic back pain and osteoarthritis in the long term. The bone of the shorter leg is lengthened in a gentle way over the period of several months.

The startup is expected to launch the implant on the market in 2017 with the name Nitinail™. Currently the product is heading to the CE approval procedure that is a prerequisite for the sale of medical technology applications in Europe.

VESTAKEEP® PEEK, a high-performance polymer from Evonik, will also be used in the implant. Due to its excellent mechanical properties and biocompatibility, VESTAKEEP® PEEK is well established in implant, dental, and medical technologies.

During the treatment, which lasts several months, the implant expands under the influence of electromagnetic radiation. In small steps of 0.5 mm, it expands like a telescope.

RSPO certification implemented worldwide

Evonik's two new production facilities for cosmetics ingredients in Shanghai (China) and Americana (Brazil) were recently certified in accordance with the Roundtable on Sustainable Palm Oil (RSPO) standard. This fulfills an important prerequisite for offering additional certified products to cosmetics manufacturers.

Evonik is one of the leading suppliers of raw materials for

Palm kernel oil is an important raw material in the cosmetics industry.

the cosmetics industry and processes derivatives of palm oil and palm kernel oil, among other substances. The company strives to use the largest possible share of RSPO-certified fatty acids and fatty alcohols from palm oil in its products for cosmetics, detergents, and cleaning agents. Evonik has introduced a corresponding supply chain system for this purpose.

Today more than 90 percent of the production locations of the Personal Care Business Line at Evonik are RSPO-certified.

The assortment of products made from sustainably produced palm oil derivatives is steadily growing as well. In addition to a range of emulsifiers, consistency enhancers for creams, and rinse ingredients that meet the RSPO mass balance standard, Evonik recently launched an RSPO-certified surfactant for shower gels and shampoos: TEGO® Betain P 50 C (cocamidopropyl betaine). In addition to RSPO certification (SG certification), the product offers a number of application benefits.

Photography: Evonik (2), Synoste

MURPHY'S NETWORK

One person cannot be as creative and effective as a whole group of people. Evonik employee Dr. Peter Murphy is convinced of this. It makes him an extraordinary networker, who stimulates discussion, brings colleagues together (in the virtual realm), and links knowledge. For these achievements, Chief Innovation Officer Dr. Ulrich Küsthardt has honored him with Evonik's own CIO Award 2015.

Dr. Ulrich Küsthardt (left) and Dr. Peter Murphy at the presentation of the CIO Award.

Dr. Peter Murphy likes to tell the story of the penguins on Middle Island, a small piece of land off the southern coast of Australia. On a regular basis, foxes would come over from the mainland at low tide and prey on the penguins, which were at risk of being wiped out. The residents of the island finally found an amazingly simple and inexpensive way of protecting their beloved penguins: Oddball the guard dog. The foxes feared the dog and stayed away. The penguins flourished.

"You just need a big dog," says Murphy. What he means is that for many problems and challenges there is a simple solution that someone somewhere already knows. But occasionally it can be so unusual, so surprising or simply so obvious that it gets overlooked. "The secret is in finding that dog," says Murphy. This is where networks and teams display their strengths—if they play by the rules. "Teams and networks work best when they are driven by team spirit," says Murphy. "When there are no stars, everyone pulls together and pursues the same goal without vanity."

He sets a good example. With a Ph.D. in physics, he has spent the last two years working as Senior Business Coach in Evonik's Marketing & Sales Excellence (MSE) unit and is a regular presence on Connections, an online platform on the Evonik intranet where employees in more than 4,100 communities share their knowledge about all kinds of problems, challenges, and ideas that arise from their daily activities.

"Teams work best when there are no stars."
Dr. Peter Murphy

A team player with passion

Whether it's an idea competition like the Ideation Jam or the innovation forum Operation Columbus, which is concerned with entrepreneurs, incubators, and fuzzy front-end innovation, Murphy gladly shares his knowledge, provides the company with food for thought, brings colleagues together, and even taps the network himself when he needs a clever idea. "This allows me to reach a lot of colleagues at one time—even those I don't know personally. I can't do that with any other means of communication," says Murphy. At peak times, such as during an idea competition, more than 2,000 employees can visit the platform in a single day.

As Senior Business Coach at MSE, Peter Murphy is a team player by profession. The name Marketing & Sales Excellence says it all: The task of the MSE is to promote excellence in marketing and sales at Evonik. The tools of the roughly 70 MSE employees are in-depth analysis, advanced methods tailored specifically to the Group, and the transfer of skills through training. Their fields of activity include pricing, management of sales channels, understanding markets and customers, growth strategies, and business model innovation. As a coach, Murphy assists the operative units not ➔

Photography: Frank Preuß/Evonik

“In rugby, team effort is the only thing that counts. Alone, you’re nothing.”
Dr. Peter Murphy

A team player also in his private life: Peter Murphy has played rugby for 30 years.

➜ only in their marketing and sales projects but in their team development. He picked up the background knowledge for this from a variety of professional development courses. “Good teams are more efficient and reach their goals faster,” he observed. “You can recognize them partly by their tone: It may be harsh on occasion, but it’s always objective, never personal.”

Tolerance, openness, constructive criticism, and a distinct error management culture—for Murphy, these are the ingredients of a successful team. “When you are afraid to make a mistake, you stand in your own way,” says Murphy. “You eliminate any potential solutions that may be uncomfortable or difficult to implement from the outset.”

And the team members have to find the optimal role for themselves. “The ‘innovator’ type, someone inclined to throw everything overboard once a day because he has a new idea, would have a problem with project coordination or even Excel tables—and vice versa,” explains Murphy. “I teach that all roles have equal value in a project. Because there are good reasons why the goalkeeper stands in goal—he is probably better at catching the ball than the others. This doesn’t mean he’s more important or less important.”

Murphy’s tasks also include ideation workshops, where he presents creativity techniques. “There is hardly any area in the world of work where people don’t constantly need new ideas for solving problems,” he says.

All in all, Peter Murphy is able to look back on more than 20 years of professional experience. Murphy was born in England. After studying physics, he began his career at Shell in plastics research. Later, he worked in the New Ventures unit, where a focus of his activities was on building new production plants together with partners. This work took him around the world—he has lived and worked in five European countries, as well as in Thailand and Iran. His knowledge of languages was a great help to him then; he has also learned to speak German, French, Italian, and Dutch. Five years ago he joined Evonik, where he initially worked in Business Development in the Oil Additives Business Line before going to MSE and specializing in team development, among other areas.

Murphy is just as much of a team player in his private life, having played rugby for the last 30 years. “In this sport, team effort is the only thing that counts,” he says. “It’s almost impossible for one person to dominate the game. The rules prevent it. Alone, you’re nothing.” ■

MSE, where Peter Murphy currently works, is the global center of expertise for marketing and sales at Evonik. The unit supports the profitable and sustainable growth of all of our business operations by teaching and establishing global standards, tools, processes, and skills for Marketing and Sales employees.

Presented with the Evonik CIO Award.

Infographic: C3 Visual Lab Photography: Stefan Wildhirt/Evonik

ON THE ROAD TO THE 2-IN-1 REACTOR

In collaboration with partners from research and industry, in the ROMEO* project Evonik is working to develop a new reactor concept for catalytic reactions with the aim of reducing processing steps and energy consumption.

Prof. Dr. Robert Franke, Dr. Frank Stenger

In the ROMEO research project, which started up in fall 2015, Evonik will be working with eight partners in pursuit of an ambitious goal. The aim of ROMEO is to reduce energy consumption by up to 80 percent and emissions by up to 90 percent in industrially important catalytic gas-phase reactions. ROMEO revolves around a new reactor concept that utilizes membranes in order to carry out chemical synthesis and processing in a single step—something of a 2-in-1 reactor, in which the product is continuously removed from the reaction mixture as soon as it is formed. The EU is providing €6 million in funding for the research program as part of its Horizon 2020 project.

Over the course of the next four years, the nine partners intend to demonstrate the technical feasibility of the reactor concept by using systems for two industrial gas-phase processes—hydroformylation and the water-gas shift reaction. "If we succeed, it will be a small revolution for chemical process engineering and a huge step toward more sustainable processes," says Professor Robert Franke, who works in the Performance Materials Segment of Evonik, where he leads innovation management for the hydroformylation process. "Not surprisingly, the project immediately landed in the top 15 percent of all the projects submitted," notes Dr. Frank Stenger of Evonik's Process Engineering Business Line, which will be carrying out Evonik's end of the project.

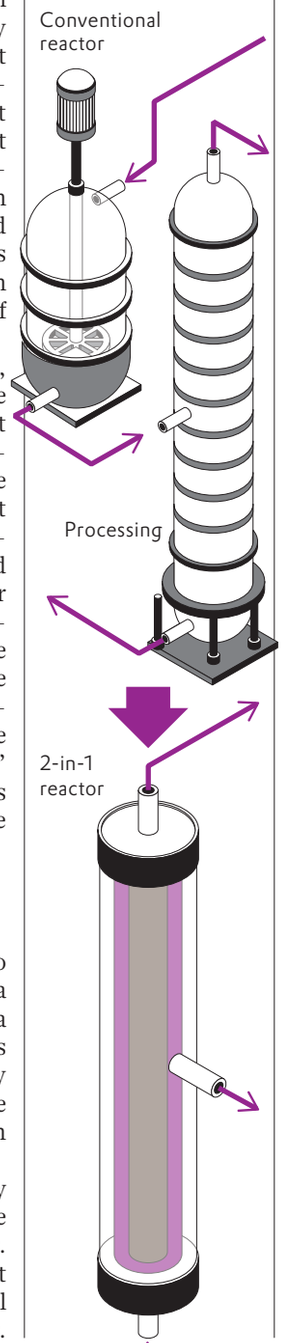
Proving suitability for broad industrial application

Chemicals are typically produced in two steps. Once a product is synthesized in a reactor, it is then processed further in a system such as a distillation column. This step tends to be very energy-intensive. By eliminating it, a 2-in-1 reactor can achieve drastic reductions in energy consumption and the resulting emissions.

The partners intend to use two very different model reactions to show that the reactor concept has broad applications. Evonik will be constructing a demo plant for hydroformylation. This facility will convert olefins and syngas to aldehydes.

The idea

A membrane enables synthesis and processing in a single step.



Among other applications, aldehydes are used as precursors for plasticizer alcohols. Evonik is a leading manufacturer of C9/C10 plasticizer alcohols in Europe. Linde, on the other hand, intends to demonstrate the feasibility of the concept for the water-gas shift reaction, in which carbon monoxide (CO) and water react to form hydrogen. If the new reactor concept is successful using CO or CO-containing syngas derived from biomass, researchers will have found a way of generating hydrogen from sources such as wood waste.

At the heart of the new concept is a reactor based on bundles of tubes. A homogeneous catalyst is fixed onto a special carrier material and a membrane is applied onto the outside of this. Depending on the properties of the membrane, either the product or the byproduct will then pass through the membrane once the reaction has taken place at the catalyst surface.

Expertise along the entire process chain

While the process is astonishingly simple in principle, it holds numerous technical challenges, beginning with the properties of the carrier, catalyst, and membrane, up to and including the modular construction of the reactor intended to simplify later scale-up. The expertise that the research partners bring to the table covers every key point along the entire process chain for implementing the process.

In addition to Evonik, partners include Friedrich-Alexander-Universität Erlangen-Nürnberg (Germany), RWTH Aachen University (Germany), the Technical University of Denmark, BioEnergy2020+ GmbH (Austria), LiqTech International A/S (Denmark), the European Membrane House (Belgium), the Agencia Estatal Consejo Superior de Investigaciones Científicas (Spain), and Linde AG (Germany). ■

More information:
http://www.romeo-h2020.eu/

The Experts

Prof. Dr. Robert Franke is head of innovation management for hydroformylation in the Performance Materials Segment.
robert.franke@evonik.com

Dr. Frank Stenger works at Process Technology, where he manages an expert group for reaction technology that deals with modular systems, innovative reaction concepts, reactor design, process development, and operational support.
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***ROMEO** stands for Reactor Optimization by Membrane Enhanced Operation.

Infographic: C3 Visual Lab Photography: Evonik (2)

LESS EFFORT FOR MORE SAFETY

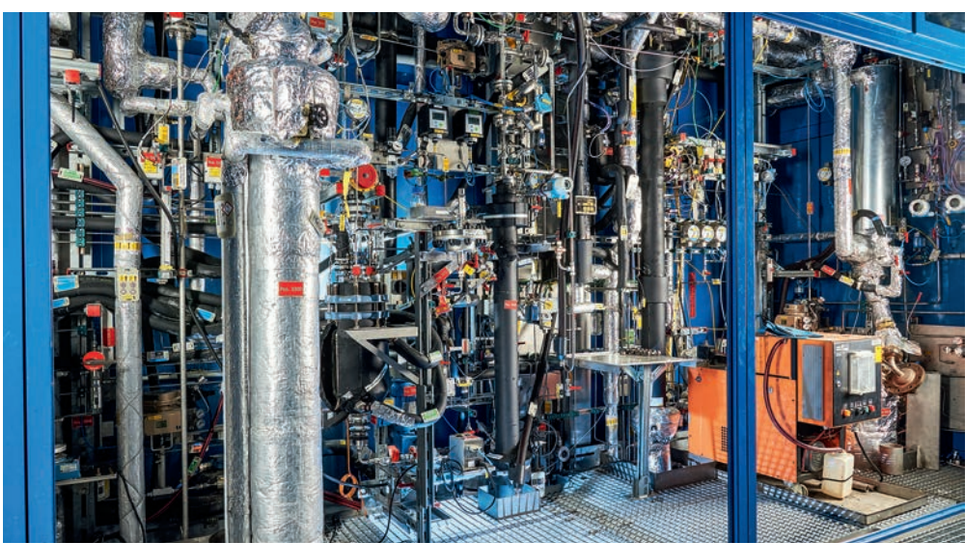
Once again Evonik has brought its chemical and process technology know-how to bear in improving an established process. The amino acid methionine can now be produced more simply and, more importantly, inherently more safely, as can be seen in the company's newest methionine plant in Singapore. The team of 11 developers won the 2015 Evonik Innovation Award for their efforts.

Martin Steurenthaler, Stephan Kretz, Martin Körfer

Amino acids play a key role in animal nutrition. Healthy growth can be ensured only when these protein building blocks are available to animals in an adequate amount and in the right ratio. The animals themselves can produce many of the necessary amino acids. However, some amino acids—the so-called essential amino acids—cannot be produced by the animals and must be taken in with their feed. These include methionine. However, feed sources such as grain in particular do contain these amino acids but in amounts that are much too low to cover the animals' needs. For this reason, large amounts of soy meal or—the more efficient and sustainable solution—small amounts of methionine are added.

Where methionine is concerned, Evonik has been not just the market leader but also the technology leader for many years. For nearly 50 years, the company has been producing this amino acid and thus can rely upon comprehensive process know-how. This knowledge enables researchers in the Animal Nutrition Business Line to continuously improve the production process for methionine. After all, this is the only way to maintain Evonik's technological edge in this area.

And the methionine experts in Singapore have succeeded in doing so. On Jurong Island, Evonik started up a new "world scale" methionine production facility in October 2014. With an annual capacity of 150,000 metric tons, the plant is an important link for supplying feed manufacturers and integrators in the rapidly growing Asian market. The plant utilizes an optimized process that was first implemented on an industrial scale there. The focus is on the stability and safety of the process. In the end, that results in a further increase in the reliability of methionine production and gives the customer additional security regarding the availability of the amino acid.



Above: A glimpse of the pilot plant in Hanau, in which the new MMP-CN process was developed.

Left: Working with the latest technology: Evonik's methionine complex in Singapore.

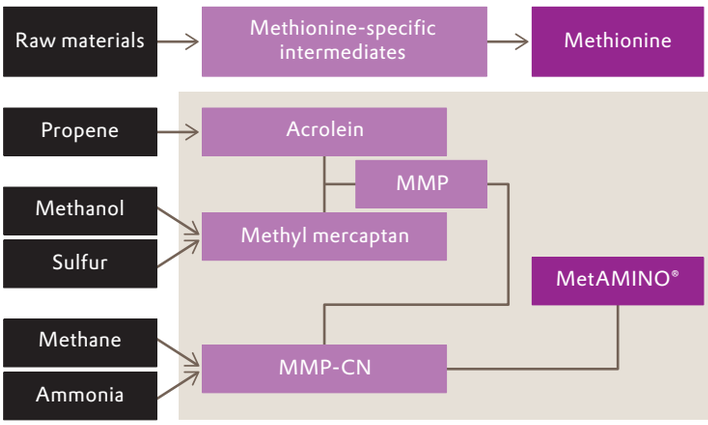
The amino acid methionine is ultimately a harmless crystalline powder, but on the way to producing it a number of chemicals, in particular hydrogen cyanide (HCN), acrolein, and methyl mercaptan, must be handled and reacted safely. Evonik produces these starting materials—and thus pursues the strategy of complete backward integration. This offers great reliability of supply, because the company can act independently of suppliers of these intermediates.

New location, new technology

In the process, which was newly established in Singapore, hydrogen cyanide is no longer liquefied but is instead absorbed directly from the gas phase into a solution, where it reacts with methylmercaptopropionaldehyde, or MMP, which is first produced through the reaction of methyl mercaptan and acrolein. Hydrogen cyanide and MMP then form a new, distinctly less critical intermediate product, which is stored instead of hydrogen cyanide: MMP-CN, or methylmercaptopropion-

The optimized methionine process

The new intermediate is MMP-CN (methylmercaptopropionaldehyde cyanhydrin), which then reacts further to form methionine.



aldehyde-cyanohydrin. This then reacts further to form methionine in the downstream process.

A particular advantage of the process is this: Whereas existing plants apply rigorous process safety measures to liquefy and store hydrogen cyanide in a controlled process, conversion into the distinctly less dangerous material MMP-CN makes it possible to achieve an even higher level of safety (inherent safety) by minimizing the inventory of hazardous materials in the plant. Another advantage of MMP-CN is that, in contrast to hydrogen cyanide, it has no propensity at all toward polymerization. Of course hydrogen cyanide polymerization is kept safely under control at all the other existing methionine sites, but in rare cases it can lead to undesired shutdowns due to plugging of equipment.

A trial run with 40 metric tons of MMP

The new methionine production process has proven to be extremely reliable and easy to control in Singapore. Above all, the researchers had the extensive testing in the pilot plant in Hanau to thank for this. Test operations were conducted there in three different phases over a period of several months. Numerous process parameters were varied, measurement data was collected and analyzed, and the product itself was analyzed with the widest range of methods in order to identify undesirable byproducts. Furthermore, in parallel with the experiments, the thermodynamic model of the process was refined. On the basis of these results, the members of the Column Competence Center of Evonik's Process Technology designed the industrial-scale absorption column.

The pilot plant processed about 40 metric tons of MMP from the Antwerp plant during this period. It quickly became clear that the process could be implemented in this way. The entire new process step, including the hydrogen cyanide synthesis, was set up and trialed in the testing facility of the Animal Nutrition Business Line in Hanau in a very short amount of time. At the start of 2009, the decision was made to build a pilot plant; in August 2010, after a short initial trial campaign, Evonik made the decision to set up the process in Singapore. Just four years later, the plant started methionine production on Jurong Island.

A pool of expertise

While the pilot plant would have needed more than half a year to fill a tank truck with MMP-CN, the plant in Singapore does so in just one hour. That is an impressive scale-up. Furthermore, in Singapore not only was a new process put into operation—the intermediate hydrogen cyanide has been replaced completely by MMP-CN. In addition, the methionine process now uses a new starting material, MMP-CN, rather than the MMP and HCN that were previously used.

Such courageous steps can be justified only on the basis of many years of technological experience and competence. Experts from Evonik's Animal Nutrition Business Line and from Process Technology participated in the project. All the necessary disciplines, such as fluid process technology, online analytics, and reaction and simulation technology, as well as the specialists in the areas of analytical and safety systems at the Evonik subsidiary AQura made substantial contributions to the success of the project.

Another aspect that facilitated the implementation of the new technology in Singapore was the fact that the equipment for online process analytics had already been calibrated in the pilot plant in Hanau, enabling it to be put into operation directly in Singapore. In addition, the shift team leaders of the Singapore plant were trained in the new process at the pilot plant in Hanau.

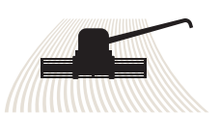
The new MMP-CN process shows that even established processes still have potential for innovation. And the project is a showcase example of the fact that increased safety does not necessarily mean less efficiency. In the end a plant was created that does completely without liquid hydrocyanic acid. The safety concept of the new technology will be implemented at all Evonik methionine sites from 2016 on.

The basic chemistry behind methionine production has long been known. However, behind the scenes of the new plant, high-tech processes and pooled expertise in process technology are at work—a specialty of Evonik. ■

Methionine in animal nutrition

For 2015 the FAO predicted a rise in worldwide meat production to 318.8 million metric tons.

One kilogram of DL-methionine and two kilograms of L-lysine can replace the methionine and lysine from 54 kilograms of fish meal and 34 kilograms of soy meal in poultry feed.



750,000 metric tons of methionine save 15 million hectares of agricultural area annually.

The experts

Martin Steurenthaler managed the pilot project in Hanau and is now working as a technology manager in the Animal Nutrition Business Line at the new methionine site in Singapore.
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Stephan Kretz heads the Animal Nutrition pilot plant facility in Hanau-Wolfgang, where new chemical processes and products of the business line are developed to production maturity.
stephan.kretz@evonik.com

Martin Körfer is responsible for technology development and process optimization in the Animal Nutrition Business Line.
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Presented with the Evonik Innovation Award 2015 in the New Processes category.

Infographic: C3 Visual Lab Photography: Evonik (5)

DR. MARION HAX

A Woman of Action

As head of the Fluid Process Engineering Technical Center in Hanau, Dr. Marion Hax has worked on the development of many important processes for almost all of the Business Lines. Her winning cards are her fascination with the industrial implementation of chemical knowledge and her expertise in dealing with employees and customers.

As is so often the case, you can trace it all back to a teacher. "My high-school chemistry teacher was a fun guy and his class was exciting, so I was always enthusiastic about chemistry in school." Hax has never had any reservations when it comes to engineering or the natural sciences.

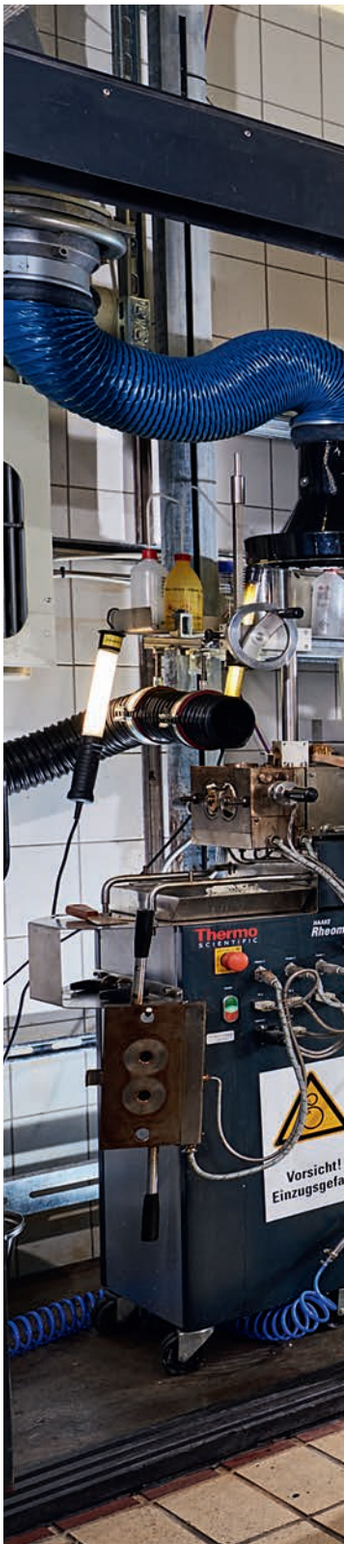
The same holds true for an increasing number of girls, as more and more women are working as lab technicians, chemical engineering technicians, and engineers than ever before. "Gender is not the deciding factor any more; industry has changed a lot," says Hax from personal experience. She and her colleagues are the proof. The Ph.D.-qualified chemist has been in charge of the roughly 15 employees of the Fluid Processing Pilot Plant in Hanau since April 2015. Every third member of the team is female, and the assistant plant director is also a woman. When Dr. Hax says she comes to work every morning in a good mood and highly motivated, it's easy to believe—this highly articulate 35-year-old likes to laugh and has an open look on her face.

The road that led Hax to the chemical industry did not have any detours: she went from a lab tech job to a chemistry degree with an emphasis on chemical engineering technology and a Ph.D. at the Technische Universität Darmstadt. Immediately after earning her doctorate, the young chemist joined Evonik's Fluid Processing Department, where she spent her first five years working primarily on research and development in polymer technology. Although Fluid Process Engineering focuses on separation techniques, it also works with the segments to develop and optimize processes. Methionine and hydrogen peroxide are examples of products manufactured using processes that the department studies. In short, much of what industrial chemistry is all about requires an understanding of fluid process engineering. That makes the Fluid Processing Pilot Plant an important partner when it comes to developing and improving processes in nearly all of Evonik's business lines.

Solving technical problems for the operational units

Hax maintains a functional, but not spartan, office. She has photos of her family on her desk and a heart-shaped mousepad next to her computer keyboard. The many systems, columns, pipelines, and control cabinets of the pilot plant are directly on the other side of her office wall, and Hax and her team are there to help resolve technical issues that arise in operational areas. How can we use a newly developed absorbent for a clean, reproducible method of separating CO_2 from gas streams? How can we selectively improve the properties of a plastic by modifying production conditions? Can the results of laboratory experiments be transferred to large-scale plants while remaining cost-effective?

Most of the members of her team are older than she is and have been working in the profession or at the plant for longer. But that doesn't bother her. It's much more important that team members know what to do, that their work corresponds to their respective areas of expertise, and that they work well in a team. So how do things if you're the boss at only 35? "Your skills are what count,



She worked as a chemical lab assistant, received a degree in chemistry and a doctorate, then started working in the field of fluid process engineering at Evonik. Marion Hax took the direct route into the chemical industry.

"Gender is not the deciding factor any more; industry has changed a lot."

Dr. Marion Hax

not how old you are," says Hax. Communication skills are a key part of that—for communicating with team members and supervisors, colleagues from other departments, and even external customers. To have what it takes to be a leader, you have to be open, direct, and self-assured when interacting with others. Just as important, however, is a broad range of interests, not just in the theoretical chemistry taught in schools, but—most importantly—in the industrial applications of chemistry.

Each new project raises new questions—a welcome challenge for Hax. "I've always been interested in using what I know to find solutions for completely different problems." The way she sees it, laboratory results are only meaningful if they can be adapted to large-scale applications while remaining as cost-effective, innovative, and sustainable as possible.

Strategic planning and reliable teamwork are the keys to success, Hax feels, and not just at the pilot plant—the chemist is also the mother of 3-year-old twins. She is well aware of the common assumption that motherhood does not mix well with management work. But it isn't impossible. While on parental leave, she and her husband, himself an electrical engineer, took turns managing their responsibilities. He has since gone back to work part time. And when push comes to shove, there are always the grandparents, who can for example pitch in when daycare is unavailable for weeks at a time due to strikes.

Hax enjoys having responsibilities and leading a team. "But," she says, laughing, "it certainly isn't a 37.5 hour workweek." Today's modern IT, she stresses, makes it much easier to bring a career and private life into balance, sometimes even by addressing urgent issues from home. And if she ever just needs to get away from chemistry entirely? "All I have to do is to look at my kids. That immediately transports me to another world." ■

Photography: Stefan Wildhirt/Evonik

RESEARCH: FULL SPEED AHEAD

"Made in China" is taking on a new meaning. Whereas in the 1990s this label was largely seen on cheap shirts and toys, today you can find it more and more often on inventions and innovations. Chemistry and materials research in China is conducted primarily at universities—institutions that do quite well when compared to elite universities in the West. This means that if Evonik is to make its research more international in scope, China has to be part of the equation.

Innovation on display: The Patent Wall of Huawei Technologies in an exhibition hall on the company's campus in Shenzhen (China). Huawei is China's largest producer of smartphones.

When Evonik built its R&D center in Shanghai's Xinzhuang Industrial Park in 2003, this move made sense. The country's standard of living was on the rise and, as a result, so was consumption. The buying power of a rapidly growing middle class was also producing more sophisticated demands. That meant having to develop and adapt products to meet Chinese tastes, and the best place to do that was China.

That's truer now than ever before. China's gross domestic product has nearly quadrupled since 2006, from US$2.7 trillion to US$10.3 trillion in 2014. This economic growth has been driven largely by infrastructure investment and urbanization. One result, according to the Global Wealth Report prepared by the Allianz company in the fall of 2015, is that almost 600 million Chinese now belong to the global middle class, which itself encompasses just one billion people. As early as 2010, China's consumer goods market was estimated to be worth US$1.7 trillion, and Credit Suisse predicted that this figure would grow to nearly US$16 trillion within a decade.

Evonik responded to this development in 2003 by significantly expanding its R&D center in Shanghai, investing a total of €45 million. The 32 laboratories in this 12,000-square-meter facility now house nearly 250 researchers working on ingredients for coatings, lubricants, cosmetics, household cleansers, and plastics, among other things. Each segment is represented by its own laboratories.

Demand for personal care products is especially high, making China one of the most valuable markets for cosmetics and hygiene products. The generally higher personal hygiene standards and rising awareness of personal grooming have led to a healthy acceleration of sales, with double-digit value growth seen in baby and child-specific products and strong value growth in men's grooming, color cosmetics, and skin care products in 2014.

For this reason the Nutrition & Care Segment, for example, started R&D activities in Shanghai, aiming to support local production, be able to react quickly to the market, and adapt to local market trends and needs in the area of personal care. The R&D group has already made a lot of progress. Besides its successful production transfers and evaluation of local raw materials, the team also works closely with various functions such as sales and marketing, application technology labs, production, EHS, controlling, and procurement to launch many new products on the local market.

"Research in China is moving full speed ahead. We're harnessing that momentum to propel our own innovation activities in China forward."

Dr. Claas Klasen, Regional President Greater China, Evonik Industries

"Our goal is to gear our innovation activities toward local needs and to strengthen our customers' competitiveness here in China," says Evonik's Chief Innovation Officer, Dr. Ulrich Küsthardt, in summary. "And of course we also hope to harness China's growing R&D expertise as a way of making our own research even more international."

Turning yeasts into a cellular factory

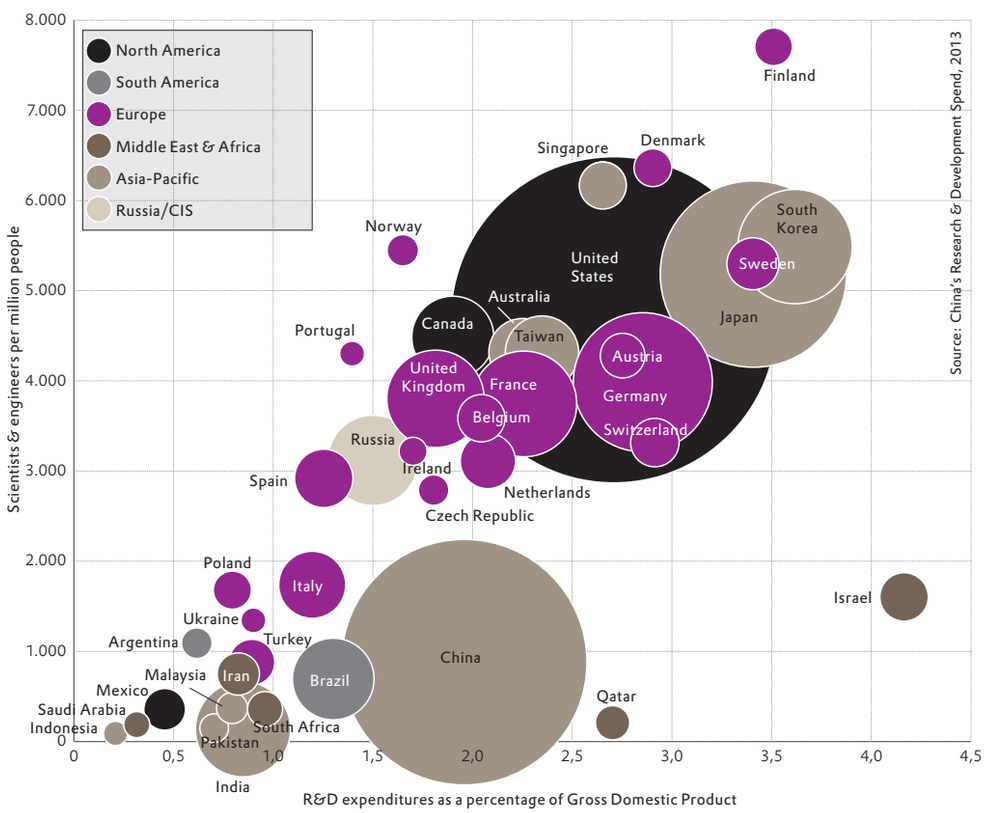
The research conducted for nearly three years at the yeast laboratory in Shanghai offers one example of what that means. Here scientists at Evonik's strategic innovation unit, Creavis, have been working with Chinese universities on new methods and products aimed at turning yeasts into microbiological cellular factories. "China leads the world in research on yeast-based fermentation processes," notes Laboratory Director Dr. Markus Pötter to explain why the company chose to establish a strategic research project in Shanghai. The yeast laboratory is expected to give rise to a new technology platform for the Group.

The yeast laboratory is a logical step, given the extraordinarily fast development of academic research in China. In recent years the Chinese government has made massive investments in R&D with the aim of accelerating the country's transition from a production-driven to a science-based economy. China, in other words, intends to transform itself from a low-wage market to an innovation infrastructure that will allow the development of sophisticated products or even technological breakthroughs to flourish.

The government has also defined which up-and-coming industries are to play the most critical strategic roles in the development of science and technology. These include industries that are geared toward sustainable growth, such as energy ef- ➜

Research and development in 2013

Scientists and engineers per million people, as well as R&D expenditures as a percentage of the gross domestic product; the size of the circles shows the level of R&D expenditures in each country.



Infographic: C3 Visual Lab Photography: Bloomberg Finance LP/Getty Images

Venture capital in China

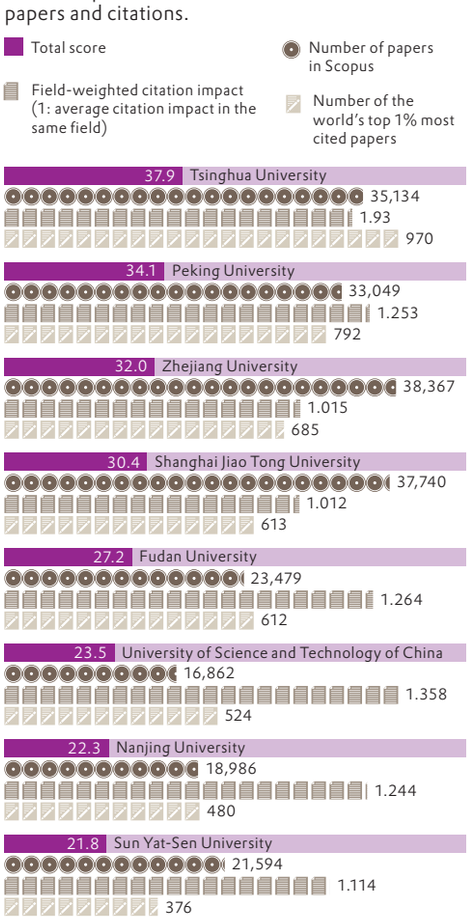
With roughly 1,000 transactions, Asia was the third-largest venture-capital (VC) region in 2014 after North America and Europe, having more than doubled its VC activities over the previous five years. China and India were the most active players in the region, with two thirds of all VC investment in Asia occurring in China. The focus of these investments was on new materials, while India concentrated more on IT and communications technologies.

VC investments of US$20.8 billion in 2014 enabled Asia to surpass Europe, even though the investments were connected with fewer companies. The reason for this is that China in particular has concentrated on late-stage deals, which involve larger-scale financing rounds.

Although China lags behind Europe and the United States in terms of the number of transactions, efforts on the part of the state to mitigate climate change have begun to have a significant impact on the number of startups.

The best research universities in China

Research performance based on the number of papers and citations.



Source: Academic Ranking of World Universities 2015

➔ ficiency, environmental protection, renewable energies, and electromobility, as well as industries that will allow the country to work its way up the value-added chain, such as biotech, new materials, information technology, and high-tech production.

The country is pulling out all the stops in its efforts to implement the plan. In terms of R&D expenditure, China has now captured second place after the United States. Whereas research investments in 2006 came to roughly ¥300 billion, by 2014 that figure had already risen to ¥1,331 billion (nearly €200 billion according to today´s exchange rate).

Systematic support for elite programs

Research in China is primarily conducted at universities. The country is home to some 3,000 universities, 1,025 of which are under the direct control of ministries or local governments. Of these, 116 are part of the "Project 211" program, through which they enjoy the best-equipped facilities and receive special subsidies so that they can achieve world-class status.

These universities oversee one fifth of the country's doctoral candidates, two thirds of its students in advanced degree programs, half of its foreign students, and one third of its undergraduates. In addition, 39 of these universities are recognized as elite universities.

The idea has already borne fruit. According to U.S. News & World Report, which annually ranks universities all over the world according to their academic research and reputation, five Chinese universities were among the top 20 in the fields of materials science and chemistry. In the field of materials science, key areas of research in China include ceramics, textiles, biomaterials, metals and alloys, and superconductors and semiconductors.

The impact of the systematic support for R&D is also reflected in the patent record. In 2013, China registered more patents than any other country in the world; the majority of these, however, do not (yet) have commercial applications. Nevertheless, the commercialization of technologies is a growing trend at the many universities and institutes that are in the process of establishing official technology transfer centers. The government also expressly requires universities to cooperate with industry in order to put research results to practical use.

For Evonik, these developments are both a challenge and an incentive when it comes to taking its innovation activities to a more international level. Expertise at China's universities continues to grow, and each year these institutions turn out numerous outstandingly trained scientists and engineers. For example, according to one McKinsey study, 1.2 million engineers graduate each year from Chinese universities. Evonik's network in Europe is already highly advanced, and study results like these make the idea of expanding that network to include Chinese universities very attractive. The aim here would be for corporate research to stop viewing China as an extended lab bench and instead to take a strategic look at the country to see where China offers favorable opportunities for advancing our own innovation activities.

"Cultural and language barriers limit companies' ability to conduct research remotely. That's why we need a powerful local team."

Dr. Ulrich Küsthardt,
Chief Innovation Officer, Evonik Industries

This is where Dr. Jing Feng, Head of Corporate Innovation in Greater China, and his colleagues come into play. This diverse team consists of 16 Chinese and four Germans, all of whom have university degrees. From its base in Shanghai, the team is tasked with driving Evonik's innovation activities and expanding its networks in the Greater China region (China, Hong Kong, and Taiwan). Their assignments include developing contacts with leading research institutions, setting the stage for joint ventures, and studying new technologies from China to assess their potential for Evonik. In all of these areas, the team always works closely with the segments.

Cultural understanding opens up doors

Feng's background makes him ideally suited to the task. A Chinese national, he studied chemistry in Berlin, and in addition to his native language he speaks German and English fluently and is familiar with both cultures. "Getting the chemistry right isn't the only thing that matters," says Feng. "A lot of doors open faster if you knock in the local language." Previous experience has shown that cultural barriers, especially language barriers, limit companies' ability to conduct research remotely. "Communication is incredibly important," echoes Küsthardt. "And not just here on site. That goes for the operating units and for Creavis too. After all, all of our work in Greater China has to fit in with Evonik's innovation strategy."

Even though the Corporate Innovation team in China is mainly spread out over Shanghai, and Beijing, its base of operations is Shanghai. "Shanghai offers an outstanding pool of talent right in the middle of real market demands," observes Dr. Baoshu Chen, describing the advantages of the city. Chen is responsible for Regional Develop-

ment Greater China. “In addition, the local government is making an intense effort to develop Shanghai into an innovation center for science and technology—one with a global outlook. That makes the city interesting for a lot of foreign companies, which have responded by setting up R&D centers. That includes Evonik’s customers.”

Joint laboratory for intelligent materials

Shanghai Jiao Tong University (SJTU), one of Evonik’s strategic university partners, is one place where the work of Corporate Innovation is making itself felt. Among other initiatives, the two partners operate a joint laboratory here for intelligent materials.

Their collaboration also encompasses research projects on other topics, an innovation forum for sharing ideas of interest to both parties, an assistance fund for Ph.D. candidates, and an Evonik stipend program aimed at advancing young scientists. Dr. Peter Nagler, the head of International Innovation at Evonik, also taught at the university as a visiting professor. “Students and professors alike are showing tremendous interest in our activities and in the career opportunities that Evonik offers,” Nagler comments.

Evonik has had production facilities in Greater China (China, Hong Kong, and Taiwan) ever since the late 1970s. The company has roughly 3,000 employees in the region, where it earns more than €1 billion in sales per year.

According to Küsthardt, the partnership benefits both sides. “We provide SJTU with important information about the market relevance of research topics, so that the research results can be transferred to society quickly,” Küsthardt observes. “At the same time, we learn more about research trends and projects in China and can react more quickly to them. Another important advantage is that the partnership helps us find gifted young scientists.”

Fostering an open innovation culture

In order to foster contact with Chinese universities, Evonik is also providing internal financial incentives in Shanghai. Corporate Innovation maintains an open innovation fund that it uses for supporting research projects in the operating units when these projects involve close collaboration with universities. “We hope to use this as a tool for fostering an open culture of innovation,” says Feng, “just as we do with our Evonik Meets Science symposium, where we facilitate the sharing of ideas between Evonik researchers and Chinese scientists.”

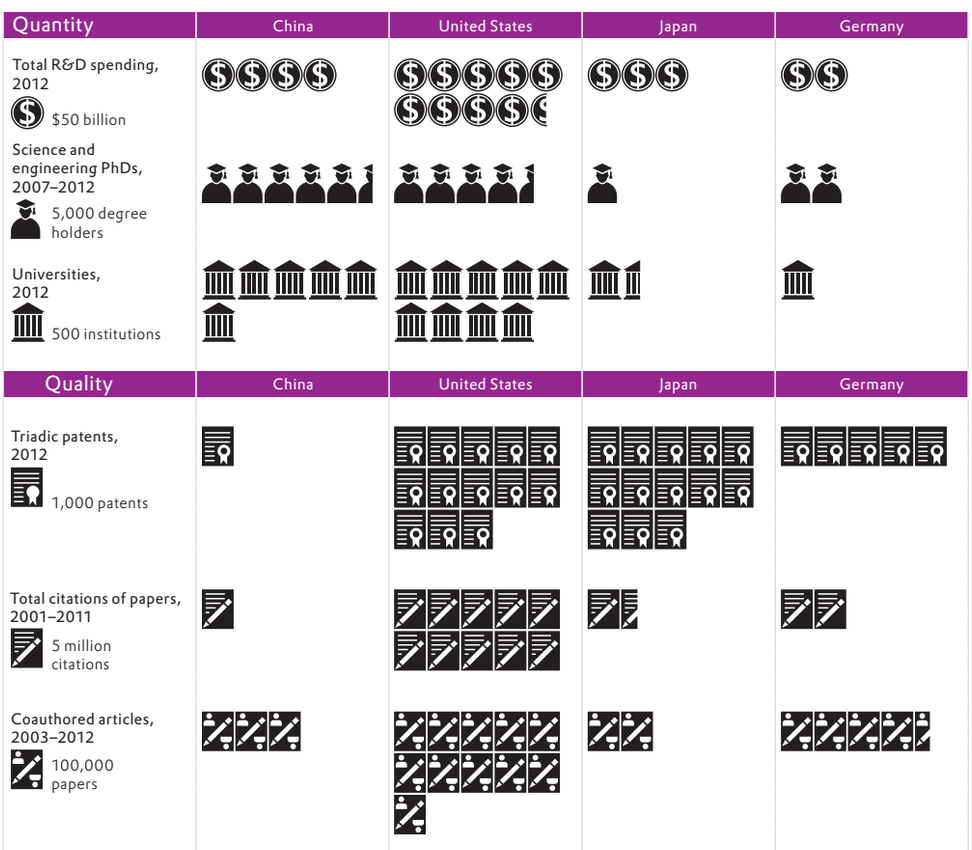
Evonik is also turning to the next generation in its search for new ideas. The company has held the Evonik China Idea Contest for two years now, calling on students to develop solutions to specific problems. The theme of the first competition was environmental problems in China; the second competition, which ended in October 2015, focused on intelligent materials for green buildings. The first competition was a huge success right from the start, with nearly 600 students from over 60 universities participating.

All of these initiatives are helping Evonik to anchor its position as an interesting player in Chinese academia and an attractive employer for young scientists. Skeptics still claim that, while invention may be one of China’s strengths, innovation—translating inventions into marketable products—is one of its weaknesses. Dr. Claas Klasen, who oversees the Greater China region for Evonik, disagrees with that assertion. “China’s political leadership regards research and innovation as a cornerstone of economic growth. And developments up to now show that research in China is moving full speed ahead. That’s why I’m confident that China will manage to transform itself into a science-based economy,” he says.

The venture-capital scene, at any rate, supports his claim: More venture capital was invested in China in 2014 than in any other country outside of the United States. ■

University research by country

Based on R&D spending, China has outperformed Japan and Germany and holds second place worldwide behind the United States.



Source: The China Effect on Global Innovation, July 2015, McKinsey Global Institute

Infographic: C3 Visual Lab Photography: Evonik

Dr. Mark Lorch works as associate dean for Engagement at the Faculty of Science and Engineering at the University of Hull, where he is responsible for international partnerships.

Dr. Lorch, who holds a degree in biochemistry, is also the director of the Hull Science Festival and a member of the University Senate and Council, and is actively involved in science communication. He hosts the Beverly Science Café, holds regular family-learning science workshops, and blogs on Chemistry Blog and also for *The Guardian* and *The Conversation*. His articles have been published in *The Hindu Times*, *Scientific American*, and *Ars Technica*.

WHAT I HOPE FOR FROM SCIENCE

Mark Lorch

PLAIN LANGUAGE

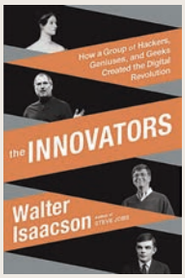
Open-access publishing is a wonderful thing. Paywalls are being torn down, liberating the science behind them. As a result, it is increasingly easy for anyone and everyone to read about the latest and greatest research. If only it were that easy.

The reality is that papers are easier to access—the paywalls are tumbling—but most new science is still trapped behind towering comprehension walls fortified with undefined jargon and defended with scholarly prose. So when a lay person, or even another scientist from a different field, reads the paper it's a real battle for them to understand it.

Instead I wish scientific papers were written in plain language. It's totally doable. My all-time favorite paper was written by primary school children and published in *Biology Letters*. "The Blackawton Bees" (the title is taken from the name of the school) is a model of clarity and is packed with naïve enthusiasm, which makes the paper an absolute joy to read. I'm a biochemist and know nothing about bee behavior, yet I understand the children's work perfectly. And for an added bonus, the diagrams are drawn in crayon!

NONFICTION BOOKS

On geniuses and geeks, on morality and the lack of distance



Ingenious teams

Walter Isaacson, the author of Steve Jobs' biography, sheds light on who is behind the milestones of the digital era—who invented programming languages, transistors, PCs, and the Internet—and explains why these inventions were successful in the first place. Almost incidentally, he explains how innovation takes place. Many things were created as a result of teamwork, says Isaacson. However, because the myths surrounding invention call for the lone genius, this aspect often went unnoticed. Along with the accomplishments of women, that is: In 1946, when the US Army presented the first universal computer, the female programmers were not even invited.

Walter Isaacson:
The Innovators. *How a Group of Hackers, Geniuses, and Geeks Created the Digital Revolution.*
Simon &Schuster, New York 2014

Ethical innovation

Adam Smith, theorist of the classic national economy, was one of the first to address the ethical responsibilities of a free market. When discussing his plea for a free market economy, people often forget that Smith was also a moral philosopher and did not regard economic action as being free of moral responsibility. Today, globalization and disruption represent entirely new challenges for ethical behavior in the economy. How can morals strengthen the innovative power of companies? That is the key question the book deals with. It demands different strategies for poor and rich countries, to enable sustainability as well as equity.

Edited by Georges Enderle, John T. Ryan Jr., Patrick E. Murphy: ***Ethical Innovation in Business and the Economy.***
Studies in Transatlantic Business Ethics series. Edward Elgar, Cheltenham/ Northampton 2015

Respect at a distance

Has respect become a foreign concept in business? Reinhard K. Sprenger, a motivation expert, psychologist, and philosopher from Essen (Germany), is convinced that this is the case. He identifies a lack of distance between the company and its employees as one of the basic problems. Freedoms are lost, limits are exceeded, and differences are leveled out, thereby impeding successful work. Expanding freedom, allowing employees to take on responsibilities, and acting respectfully toward them gets companies on the right path, according to Sprenger: showing respect by keeping a distance.

Reinhard K. Sprenger:
Das anständige Unternehmen.
Was richtige Führung ausmacht - und was sie weglässt. DVA, Munich 2015

THE COVER #54

Lightweight construction requires a lot of manual work and this translates into higher costs. Using fiber-reinforced composites in large-scale production in the automotive industry was not successful, mainly due to the high material and production costs. Evonik developed materials and processes that make lightweight construction with fiber-reinforced composites more cost-effective. This represents a large step toward utilization in large-scale production.

Illustration: C3 Visual Lab Photography: Karl Andre Photography Ltd., PR (3)

Masthead

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