THE INTERNET OF CHICKENS*

*THE INNOVATION MAGAZINE
We know what the future will bring. Because we deliver the goods.

Evonik is the creative industrial group from Germany. Drawing on our wealth of ideas, our specialty chemicals expertise and our strategic innovation unit, Creavis, we deliver solutions that will shape the world of tomorrow—from cosmetics to 3D printing. Our know-how coupled with our clear vision of the future make us a reliable partner to industry and investors alike. And happily also to you. Visit the future at [www.creavis.com](http://www.creavis.com).
Big Data on the chicken farm

75 percent of the Germans can make nothing of the term Big Data; only nine percent have an idea of what it is about. This is the result of a survey conducted by TNS Infratest in Germany in January 2016. Yet data mountains are growing inexorably to unimaginable heights: The volume of data generated in the year 2016 amounted to $1.6 \times 10^{21}$ bytes. Every click on a Web page, every business transaction, and an increasing number of devices and machines leave a data trail, as ever more areas of our lives become digitized.

These data, often unstructured, are of value only if they help us discern relationships or answer previously defined questions. In this issue we offer two examples of how this might be possible. The first example concerns simulation of chemical networks; here we assemble all the available data on value chains and examine them using system dynamics to generate realistic scenarios for the future. We expect that this will bring us insights into how our businesses, with their currently established chemical processes, might develop in different situations.

The second example is digitalization on the chicken farm to monitor the growth and well-being of the animals. We plan to link data from the farm with our own knowledge of animal nutrition and digital technologies to derive recommendations for action in poultry farming. The animals, the farmer, and the consumer all benefit, because to provide the growing world population with safe and high-quality food, despite limited resources in terms of fertile soil and water, we need highly productive farming processes. Evonik plans to contribute here with the digital chicken farm.
Evonik pursues a holistic, data and knowledge-based approach to optimizing health, animal well-being, and productivity in the poultry farm. To this end the company is now linking its competency in animal nutrition with modern digital technologies.
The chicken farm of the future is fully digitalized. It uses intelligent sensors and integrated systems to generate optimal climate conditions. Animal health is continuously monitored: What does the clucking say about the mood in the barn? Is the flock’s body temperature at a normal level? Are the animals eating and drinking enough? Sensors and microphones provide information, while specialized software analyzes the collected data. In the event of questions and problems, a support system comprising self-learning artificial intelligence components can help. Consumers get access to data as well. A wealth of important information creates transparency about animal farming, breeding, and slaughtering.

It will most likely take some more time to establish these conditions, but the researchers and developers of Evonik have already started to work on the Precision Livestock Farming (PLF) system for poultry. The term stands for the use of digital technologies to gather knowledge and data in order to develop effective recommendations with verifiable benefits. Based on its analytical services for amino acids, Evonik already has many years of experience with digital business models in agriculture.

“We are now linking our competency and innovation capacity in animal nutrition with modern digital technologies to create added value for customers and consumers,” says Prof. Stefan Pelzer, the head of the Gut Health & Diagnostics innovation unit at Evonik. To this end, the company plans to dig deep into data of its own, those of scientific studies, and those of customers.

Detecting changes in real time

The vision is this: The Evonik PLF system will give meat producers precise information about the current condition of the animals in a flock and their development. The necessary data will be recorded and evaluated automatically, with results conveniently available via an app on a smartphone, tablet or laptop. The system detects changes in important parameters in real time. The program provides daily recommendations for feeding and livestock management, with a primary focus on improving meat quality.

The combination of digital technologies and product innovations enables increased productivity. At the same time, it substantially reduces the use of antibiotic growth promoters, which still are frequently being mixed into the feed, says Pelzer. “Our goal is to keep animals healthy and raise them without any unnecessary drugs.”

Animal health is a top priority for Evonik in product innovations. The Evonik scientists consider the chicken gut a decisive element. This is the location where feed is digested and where important immune functions are situated—many infectious diseases have their origin in the gut. To better understand the complex processes in the digestive system, Evonik has been working to develop a gut simulation model since late 2015 within the scope of the “Good Bacteria and Bioactives in Industry” innovation alliance, which is funded by the German Federal Ministry of Education and Research (GOBI, Industrial bioeconomics, funding category, funding reference number 031B0074 A – C). The model is intended to reflect the interactions between feed, the immune system, and the intestinal flora and will enable the testing of feed additives such as probiotics (see also elements 58).

Probiotics are living natural microorganisms that unfold their effect in the intestines. Their metabolic products have a positive impact on the composition of bacteria in the digestive system, strengthen the immune system, and boost the resilience and health of animals. The Evonik portfolio already includes a number of probiotics for animals such as GutCare®, which was specifically developed for use with poultry.

In feeding studies involving GutCare® in chicken farms, it was possible to confirm the performance of the product. That could make our probiotic an alternative to the prophylactic use of feed antibiotics, says Pelzer. This is an important point, since the World Health Organization sees a link between antibiotic growth promoters and the occurrence of increasingly resistant pathogens in humans.

Evonik researchers are also working to develop quick and simple test systems, which will allow chicken-farm managers to make assessments of the health of poultry livestock. Evonik’s goal is to warn poultry producers when an infection is about to arise based on these new tests so they can take suitable countermeasures at an early stage.

“*Our goal is to keep animals healthy and raise them without any unnecessary drugs.*”

Prof. Stefan Pelzer, head of the Gut Health & Diagnostics innovation unit
MEASURING THE FUTURE

What will businesses look like in 20 years if they continue to use current established chemical processes? How do global production networks react to external influences? To consider possible future scenarios, Evonik examines chemical networks via system dynamics. While this does not provide a prediction of the future, it helps us to understand the behavior of complex systems over time.

ELEMENTS OF THE NETWORK:

Raw materials
Raw materials like oil, gas, and coal are the basis for many chemical products. The importance of renewable raw materials is growing, as is the development of new fossil resources. Raw materials can also be produced from the processing of waste.

Value chains
After going through multiple stages, raw materials are often turned into chemical products and ultimately consumer goods. Nearly all production processes generate several products that in turn are used to manufacture other products. The value chains that arise are all connected and create a worldwide network.

Supply and demand
The value of all materials produced is created by supply and demand: Rare products for which demand is high are traded at high prices, and vice versa. In extreme cases, a negative price may even arise. Carbon tax is one such example.

Global trade
Raw materials, intermediates, and consumer products are not always available in the places where they are needed. The regional deficits or surpluses that arise as a result of this situation are balanced by global trade in all of the processing stages.

Value chains of the chemical industry: The model logic
The model portrays the global value chains of the chemical industry. This network becomes disorderly due to permanent external influences. Compensating movements brought about by, for example, innovations bring it back into equilibrium. Evonik collects the conceivable influencing factors of the future into scenarios, which ultimately allow a differentiated view of business options in these newly generated networks.
Steve Jobs began a success story when he first presented the iPod to the general public in October 2001: Despite its considerable price, the MP3 player conquered the market, not least because Apple delivered the associated software with iTunes, which made the device extremely easy to use.

The next coup came in 2007 with the iPhone: The normal cell phones that were in use at that time were replaced by a pocket computer with touchscreen and Internet access, which you could also use as a phone. Having integrated an MP3 player, Apple put pressure on its own successful product—in fiscal 2006, iPods were still responsible for a good 40 percent of total sales revenue. Measured against the success of the iPhone, in retrospect this proved to be a clever move.

The situation with Kodak and digital photography was completely different:
As one of the most important producers of photographic equipment, the company stubbornly stuck with analog photography because this promised more profit—even though Kodak engineer Steve Sasson, of all people, had built the first digital camera in 1975. However, there was no stopping the rise of digital photography and Kodak had to file for bankruptcy. The one-time technology leader was a victim of its own success because it ignored the coming technological trend so as not to endanger its existing business.

Recognizing opportunities for a company’s own business
Both examples show that companies are fit for the future only when they examine it closely. When they recognize challenges and opportunities for their own business at an early stage and incorporate them into the development of strategies, innovations, and new business models now—and not only in the future.

Substances and processes form a network
At Evonik as well as in the entire chemical industry, products and raw materials are linked with each other via chemical processes to form a large network. This chemical network does not end at the factory gates but also involves suppliers and customers because they deliver raw materials and buy or process the products. But suppliers and customers are not only part of the Evonik network; they also have their own networks. Ultimately, every individual network is just a segment of an enormous web of production processes and substances.

Regardless of the size of the chemical network, it can be described quantitatively because the individual chemical conversion processes can be characterized by data—reaction equations, yields, energy balances. Evonik’s ECNS team aggregates all available data into a computer program and maps the chemical network throughout the entire supply chain.

In the following methodical step, underlying market mechanisms that determine key market variables are examined and taken into account. For example, in many cases the price determines demand for a substance: If there are less expensive alternatives, only small quantities of a substance are purchased and it plays only a subordinate role in the system. Consequently, the computer model contains chemical and process technology aspects as well as market data, such as costs, prices, quantities produced, and demand.

External factors unbalance the network
Up until this point, the model reflects the present. When the ECNS scientists use the model to look into the future, they assume that external factors could substantially impact a network when, for example, the packaging industry switches from oil-based to renewable raw materials?

The model simulation provides possible answers.
Due to the interdependency of chemical products, sudden changes in demand can affect entire value chains.
strict climate protection standards are actually implemented worldwide reducing the importance of natural gas for the global economy. The individual scenarios must be consistent and plausible, but may and should contradict each other.

Using system dynamics, within just a few minutes the ECNS team can calculate how the anticipated developments affect the computer-simulated network and the associated economic data. The result is a view of Evonik’s business in different futures.

But what good is this view if it is not certain which of these futures describes the actual future in 20 or 30 years? Quite a lot actually, because there are parts of the chemical network that promise business success in all scenarios, regardless of how different the scenarios are. Other parts of the system would generate sales revenue only if certain disruptions actually occurred. Otherwise, they would always lead to losses.

Decision-making aid for innovation managers

The aim of the ECNS team is to give scientists, managers, and the Executive Board an overview of the economic risks and opportunities harbored by certain production processes and business areas. That applies not only to processes that are already established at Evonik but also to new production concepts and innovations that are still in the pipeline. The innovation researchers can also investigate the effects of different behavior among competitors or start-ups.

The results of the simulations cannot decide which future someone should believe in or which business risks they are willing to take. But combined with other methods used at Evonik, they form a solid basis to support decisions that concern the strategic direction, long-term expansion of production capacities, or research investments. System dynamics expands the normal way of looking at markets and needs: If external or internal factors bring the system out of equilibrium and force it to change, this creates room for innovation. This is an additional starting point for Evonik’s innovation managers to discover new possibilities for discovering innovation potential.

The quality of the computer model is important

The quality of the simulation is very dependent on how comprehensively and correctly the chemical network and the interaction between the components within the network were captured in the computer model. The ECNS team continuously expands the model based on specific threads in the Evonik network. They are also working towards gaining a better understanding of the market mechanisms.

Although the scientific approach pursued by the ECNS is completely new, and it will certainly take more time for the methods to be full-fledged and verified, it has already been shown, using certain Evonik products, that the model delivers good and interesting results even in the current development stage. While the future can be researched but not predicted by simulating chemical networks, Evonik is developing additional methodological competence in order to create better decision-making bases for a successful future.

System dynamics simulation offers a new possibility for discovering innovation potentials.

The expert

Dr. Uwe Dingerdissen is a chemist and process engineer and heads the Evonik Chemical Network Simulation Team at Corporate Innovation.

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Artificial Intelligence (AI for short) has now been part of computer science for more than 60 years. Thanks to technologically leading platform companies such as Amazon and Alibaba it is now a hot topic, and the spiraling use of the buzzword is predominantly fueling the existing hype around AI. Nevertheless, there is sometimes major incomprehension within the business environment as to what AIs are and how they can be used in the business context.

AI research can be divided into three areas: narrow AI, general AI, and strong AI. While strong AIs as an all-encompassing superintelligence with their own emotions and values are best confined to the realm of science fiction, narrow AIs and general AIs are already being used in research and business.

Narrow AI algorithms are very suitable for solving a problem considered in isolation for the purpose of increasing efficiency. Within closely defined process limits, an existing structure that reflects or is based on current understanding is used to process large volumes of data with a view to, for example, recognizing patterns or making predictions. At the core of this data-based machine learning are classic statistical methods. Narrow AI algorithms are already used in, for example, advanced speech, text, and traffic–sign recognition as well as in medicine, for analysis of pathologies.

General AIs are considerably more far-reaching but also more complex, and therefore harder to find in the business world. As the name implies, they are broadly applicable and not restricted to the solution of a particular problem; general AIs can therefore be regarded as general problem solvers. A general AI consists essentially of a logic-driven argumentation structure that allows even unstructured data to be processed and combined across tasks to solve complex problems. The implementation of a general AI allows expert knowledge to be anchored in the company and employee experience to be scaled. At the same time employees are freed from routine duties and can apply themselves to more creative tasks.

Over the long term the limits of a general AI are bounded only by the company’s imagination. Integration of such AIs into business activities is therefore no longer a calculated risk, but rather a prerequisite for enabling the company to play a relevant role in the market in the future.

The future of business:
Anything that is a process can and will be run by an AI.

Chris Boos, CEO arago GmbH
Companies are not only finding more opportunities for using Big Data: They’re also using a wider variety of data sources.

**Advantages of Big Data**

Companies that already rely on Big Data analyses report significant advantages. Right at the top of the list are:

- Better understanding of customers / Improved customer experiences: 52%
- Better control of operational processes: 54%
- Better strategic decisions: 69%

**The great unknown**

In a survey in Germany in 2016, 75 percent of about 1,000 respondents replied that they did not know what Big Data means.

Source: TNS Infratest/Statista

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**Where the data come from**

Companies are not only finding more opportunities for using Big Data: They’re also using a wider variety of data sources.

Source: BARC

**The growing data mountain**

In 2016, 16.1 zettabytes (\(10^{21}\) bytes) of data were generated globally. The volume could increase tenfold by 2025.

Source: IDC/Statista

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**Internet traffic is increasing**

In 2016, global IP traffic was about 96 exabytes (\(10^{18}\) bytes) per month. More than 80 percent of this was generated by private users.

Source: Cisco Systems/Statista

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**Internet traffic is increasing**

In 2016, 17.8 exabyte, in 2021, 232.7 exabyte.

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DATA MINING

Creating value with data

Data are seen as the raw material of the 21st century. Evonik uses them, for example, to simulate the future with the aid of realistic scenarios, or to improve animal health on the chicken farm in the future. Big Data stands for, on the one hand, the rapidly growing data mountains and, on the other, IT solutions that help to create value from data. Unstructured data, such as those from social networks, make up the greater part of Big Data. Here’s a glimpse into the data deluge and how companies deal with it.

Sales of Big Data solutions

As data volume increases, so too does the need for tools to utilize this data correctly. Sales of Big Data solutions are growing accordingly.

Data in million US$

Source: Wikibon/Statista

The big players in the sector

In 2015 IBM generated sales of about US$ 2 billion with Big Data solutions. The ten leading suppliers together generated sales of just under US$ 7.6 billion.

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IBM 2,104

Oracle 745

SAP 890

HP 680

Palantir 672

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Data in million US$

Source: Wikibon/Statista

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Oracle 745

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HP 680

Palantir 672

According to a survey by BARC (Business Application Research Center) of 550 companies from various sectors, Big Data has now arrived in the corporate practice of more than 40 percent of the companies.

Big Data as pilot project 23%

Big Data already part of corporate processes 18%

No Big Data, but possibly in the future 42%

No Big Data, and not conceivable either 17%
Solutions: Corrosion Protection

Whether on utility poles, expressways, bridges, buildings, water lines, or pipelines, corrosion is all around us.

NO CHANCE FOR RUST

Specialists of Evonik’s Resource Efficiency Segment have developed novel silane-based corrosion inhibitors that are particularly eco-friendly, easily applied, and extraordinarily efficient.
Corrosion gnaws its way stealthily through bridges, machines, and buildings, whether of metal, concrete, glass, or plastic; in all of these materials it is a serious problem. As long as six years ago, DEHEMA, the Society for Chemical Engineering and Biotechnology, estimated annual global losses due to corrosion at an astounding US$ 3.3 trillion. So corrosion is a drain on the wallet as well as on the surfaces of materials. Industrialized countries lose about three percent of their gross domestic product to corrosion each year. But according to DEHEMA, appropriate protective measures could save up to 30 percent of these costs, amounting to approximately US$ 1 trillion every year.

These figures clearly indicate that today corrosion protection is an issue that cannot be ignored. Nonetheless, established methods of surface treatment, including chromating and phosphating, are increasingly coming up against limitations and are seen ever more critically, mainly for reasons of environmental protection. Application techniques for substances containing chromium (VI) are particularly problematic. The use of these substances is being banned in Europe in an increasing number of applications, through such provisions as the second RoHS Directive (Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment), which came into force in 2013. The US, Japan, China, and South Korea have adopted similar regulations.

Alternative methods for protecting metal surfaces against corrosion are therefore urgently needed, and these methods must be eco-friendly as well as reliable. Evonik’s developers rely here on hydrolyzed and condensed silanes that form a binder: The formulation of such binders results in eco-friendly corrosion protection systems. During the curing process a protective film with a thickness in the nanometer to micrometer range is formed; although thin, the film is highly impervious and protects the underlying metal against water and corrosive substances. It can be formulated using other binders and fillers to form thicker corrosion protection systems. In recent years, Evonik’s specialists have developed, under the Dynasylan SIVO brand name, a series of binders that have proved their worth in a very wide range of materials and application methods.

Environmentally friendly zinc dust paints
Paints with an underlying zinc dust primer are the means of choice when long-term corrosion protection is called for and other coatings have reached the limits of their capabilities. Typical application areas include transmission towers, industrial plants, bridges, and shipbuilding. The zinc dust in the paint is deposited as a fine film on the surface of the materials, the particle density being so high that the individual metal particles are in contact with one another. The electrically conducting film so formed then serves as anodic corrosion protection.

The current difficulty is that zinc dust paints have often used inorganic binders with high solvent content, which re-
lease volatile organic compounds while curing. This is seen increasingly critically on the grounds of health and safety. Water-based zinc dust paints, on the other hand, are normally formulated with epoxy or alkyd resins, which do not tolerate excessive heat or UV radiation.

The water-based Dynasylan SIVO 140 binder developed by Evonik’s researchers combines the best of both worlds. Like the solvent-based inorganic binders, it is powerful and thermally stable. But it releases almost no volatile organic substances and is therefore as environmentally friendly as the water-based zinc dust paints.

Dynasylan SIVO 140 was designed especially for use in two-pack zinc dust paints. It is formulated with the zinc dust as the second component and then cures at normal ambient temperatures. The organic–inorganic binder can easily be diluted with water without the generation of undesired ethanol; in addition, the active silanol groups are stabilized, ensuring optimal miscibility with fillers and pigments. Formulations can be adjusted for high or low dry film thicknesses, depending on the area of application.

When passivation alone isn’t enough
When metals rust, an oxide film forms on the surface. This familiar iron oxide (rust) film is porous. As a result, corrosion eats ever deeper into the metal. Many other metallic materials such as aluminum, zinc, and magnesium behave differently, interacting with air on the surface to spontaneously form an oxide film that, although thin, is impermeable to air. This passivation protects the underlying material from contact with oxygen and thus from further degradation. It may nevertheless be necessary to provide even these metals with additional corrosion protection if, for example, they come into contact with chloride.

Corrosion inhibition primers based on Dynasylan SIVO 160 are particularly suitable for protecting materials like aluminum, magnesium, and zinc–galvanized iron or steel against corrosion. In contrast to the current solutions employed in this area, the binder contains neither heavy metals nor fluorides, which are highly objectionable from an environmental viewpoint.

These additives are also not required in the formulation of the actual rust inhibition primer. A film thickness of just 100 to 200 nanometers of this water-based silane system is all that is needed to protect aluminum from further corrosion. For use in exterior applications, the system is formulated with additional additives and stabilizers. Thanks to the high reactivity of the organofunctional silanol groups, curing can take place at temperatures as low as 60°C.

Longer service life of structures and installations
Dynasylan-based corrosion-control coatings have been tried and tested over many years in Basel’s Picasso Center, for example, and London’s ‘Gherkin’ office tower, as well as in protective paints on innumerable bridges and ships all over the world. In all these areas Dynasylan SIVO offers a double benefit for the environment: directly, by releasing fewer volatile organic compounds, and also by increasing the service life of structures and installations as a result of its corrosion-inhibiting action. This prevents waste and represents a genuine contribution to sustainability.

The expert
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Now part of the Personal Care Business Line, Evonik Advanced Botanicals was created in 2016 when Evonik acquired experts in the biotechnological production of plant-based active ingredients—the French start-up Alkion Biopharma SAS. As a result, Evonik now boasts one of the world’s leading technologies for plant-based cosmetic active ingredients.

Evonik plans to develop the site into a center for plant-based active ingredients. The Tours region is located in what's known as Cosmetic Valley, the world’s largest cluster of cosmetic companies. This closeness to customers, along with the possibilities for scientific collaboration with the University of Tours with its plant biotechnology department, will help to promote future growth.

“This very attractive technology adds to our already impressive portfolio of cosmetic active ingredient specialties,” says Dr. Tammo Boinowitz, head of Evonik’s Personal Care Business Line. Now, with this addition, Evonik can offer customers tailored, plant-based, high-performance active ingredients in highly concentrated and reproducible forms, all manufactured in a resource-efficient process.

The new site in Tours is designed to produce commercial quantities of these plant extracts, and many customer projects for tailored products are already at an advanced stage. Evonik also plans to offer its own products, which will be developed and created at its new facility in Tours from 2018.

Evonik Advanced Botanicals has developed a process for cultivating plant biomass under laboratory conditions and recovering beneficial extracts, thus achieving an extraordinarily high yield of complex ingredients. The technology itself is based on the plants’ ability to produce a broad spectrum of secondary metabolites when required. Evonik knows how to utilize this potential without modifying the plant genome.
**CompanyNews**

**Kullmann elected to VCI Executive Board**

At the general meeting of the VCI (German Chemical Industry Association), Christian Kullmann, Chairman of the Executive Board of Evonik Industries AG, Essen, was elected Vice President. The Executive Board of the VCI thus consists of VCI President Dr. Kurt Bock (BASF SE) and the three Vice Presidents Werner Baumann (Bayer AG), Christian Kullmann, and Hans Van Bylen (Henkel AG & Co. KGaA).

**High-concentration omega-3 powder**

Evonik has launched an entirely new omega-3 product in the USA. AvailOm® is a high-concentration omega-3 lysine complex that exhibits excellent bioavailability and stability. As one of the highest-load omega-3 powders with a minimum of 45 percent EPA and DHA by weight, it is designed to reduce the number of daily dosage forms. With AvailOm®, EPA and DHA are absorbed as free fatty acids; there is no need for enzymatic conversion. The product's bioavailability is therefore three to five times higher than with traditional fish oil capsules containing liquid omega-3 ethyl esters.

A single small tablet made from AvailOm® is equivalent to the same omega-3 fatty acid uptake as from two large fish oil capsules. As a result, it is a convenient way to meet health organizations' recommendations of several hundred milligrams of EPA and DHA per day.

**Innovation drives growth**

Evonik plans to leverage additional growth potential with innovations. New products, solutions, and business models will make a significant contribution to the growth and profitability of Evonik. That is an essential part of our strategic agenda, noted Dr. Harald Schwager, Deputy Chairman of the Evonik Industries Executive Board, who is responsible for innovation, at the company's R&D press conference. Evonik's innovation pipeline is well filled. The overall value of pipeline projects with detailed business plans has increased by a third over the past five years. Schwager intends to quickly implement these business plans to generate additional sales from the value of the project pipeline.

In the intermediate term, Evonik's goal is to increase the sales share from products and applications developed in the past five years to sixteen percent. This portion is currently ten percent. Research & development expenses will remain at a high level with over €400 million per year. Some ninety percent of funds are invested in the research efforts of the operative segments, specifically in businesses with particularly high growth potential. The revenue share of R&D expenses (R&D ratio) in these businesses is already between four and six percent. Throughout the Group, the R&D ratio exceeds three percent.

**Modularly constructed pilot plant**

The Animal Nutrition Business Line has expanded its pilot plant for feed additives at the Hanau site. The new building will provide space for the development and optimization of production processes. In addition, it will serve as a launch platform for new products. The complex is built in a way that allows modularly constructed plant components to be installed in a simple step. For this purpose, the roof can be lifted to exchange modules using a crane. The modular structure offers flexibility, saves time, and allows faster optimization of chemical processes.

**Patent for membrane process**

The European Patent Office has granted Evonik Fibres GmbH, based in Schmallenberg (Germany) a patent for a three-stage process for membrane-based purification of biogas and natural gas. In the gas separation process, which has been developed by Evonik, binary gas mixtures such as raw biogas, which consists primarily of biomethane and carbon dioxide, can be separated very efficiently and cost-effectively. The enriched gas can be fed directly into the natural gas network without further purification.

At the core of the separation process are the innovative hollow fiber membranes of Evonik's SEPURAN® Green brand. With the purchase of the SEPURAN® Green membranes, plant engineers receive a license to use this three-stage separation process. Buyers of a biogas processing plant with SEPURAN® Green membranes that has been constructed by Evonik's contract partners can operate the plant using the patented SEPURAN® brand.

**Full speed down the slope**

For demanding applications in professional sports, Evonik has developed a new high-performance plastic: VESTAMID® CW1401. The impact-modified polyamide 12 combines extreme robustness with good elasticity and stability at temperatures as low as -40°C. This property combination makes VESTAMID® CW1401 the material of choice for the new ski and snowboard boots of the Austrian professional brand UPZ. In downhill ski and snowboard races, the pressure applied to the boot is several times greater than in the case with the average amateur skier or boarder.

UPZ therefore manufactures those boot parts that are subject to the greatest pressure from Evonik's high-performance plastic using an injection-molding process. They ensure optimal power transfer during the race while providing the greatest possible flexibility and maximum comfort.

**Christiane Kullmann, Chairman of the Executive Board of Evonik**

**Omega-3 fatty acids in powder form for dietary supplements**
for peptides are also becoming realistic for the first time. Currently, peptides are used above all as pharmaceutical or cosmetic active ingredients. Initially, Numaferm plans to use the fresh capital to drive forward technological development and develop the first products to market maturity.

Top grades for sustainability

Evonik has once again been included in the well-known Dow Jones Sustainability Index (DJSI) Europe and DJSI World. The specialty chemicals group received the maximum ratings in the categories Innovation Management, Climate Strategy, and Customer Relationship Management. Investors are increasingly basing investment decisions on ecological and social, as well as financial, criteria. In this they are guided by leading sustainability indices such as the DJSI, in which about 2,500 companies are invited annually to participate. The best of the participating companies in each sector are placed on the DJSI. The ratings are assigned by the Swiss rating agency RobecoSAM.

Investment in Numaferm

Through its Venture Capital unit, Evonik has invested in the start-up Numaferm and now holds a minority share in the biotechnology company, which is located in Düsseldorf. Numaferm has developed a technology platform that enables the plannable biotechnological production of peptides at higher yields and at lower costs. The technology can be used for almost all peptides, and production on an industrial scale becomes possible. As a result, new technical applications in, for example, polyurethane, paints, and coatings applications as well as in a variety of industrial applications.

Thanks to the new plant, Evonik will be able to support customers in the Asia region with even more speed and flexibility and simplify its own supply chains. Many specialty silicones will no longer be shipped from Europe or North America to Asia but will be produced locally.

The new plant is part of a global integrated production platform that is the backbone for the manufacture of about 3,000 different products.

New materials for 3D printing

As an industry representative and a materials expert, Evonik will be participating in the New Materials for Laser-Based Additive Manufacturing (SPP 2122) program run by the German Research Foundation (DFG). The aim of the project is to identify and develop new cost-efficient materials for additive manufacturing.

Sponsorship is to be provided from 2018 to 2024. In the first phase, which will run to 2020, new metal and polymer powders will be synthesized for efficient laser-based 3D printing. This will involve formulating, chemically modifying, and manufacturing new and cost-efficient powders.

FOR GREATER EFFICIENCY IN THE LABORATORY

In a pilot project Evonik is testing the electronic laboratory notebook of Dassault Systems Biovia GmbH. The new software allows research results to be more efficiently and easily documented and retrieved. In collaborative projects this facilitates exchange between the units involved and allows the integration of a variety of laboratory instruments.

This state-of-the-art solution from Biovia helps Evonik secure its expertise for the long term. It steps up the pace of innovation and reduces administrative effort for the scientists. At the same time the electronic workflow reduces paper volume.

FOR GREATER EFFICIENCY IN THE LABORATORY

Evonik has started up a new plant in Shanghai (China) for production of a wide range of organically modified specialty silicones. The products, which are manufactured in batch processes, are used, for example, in polyurethane, paints, and coatings applications as well as in a variety of industrial applications.

Thanks to the new plant, Evonik will be able to support customers in the Asia region with even more speed and flexibility and simplify its own supply chains. Many specialty silicones will no longer be shipped from Europe or North America to Asia but will be produced locally.

The new plant is part of a global integrated production platform that is the backbone for the manufacture of about 3,000 different products.

New materials for 3D printing

As an industry representative and a materials expert, Evonik will be participating in the New Materials for Laser-Based Additive Manufacturing (SPP 2122) program run by the German Research Foundation (DFG). The aim of the project is to identify and develop new cost-efficient materials for additive manufacturing.

Sponsorship is to be provided from 2018 to 2024. In the first phase, which will run to 2020, new metal and polymer powders will be synthesized for efficient laser-based 3D printing. This will involve formulating, chemically modifying, and manufacturing new and cost-efficient powders.

Investment in Numaferm

Through its Venture Capital unit, Evonik has invested in the start-up Numaferm and now holds a minority share in the biotechnology company, which is located in Düsseldorf. Numaferm has developed a technology platform that enables the plannable biotechnological production of peptides at higher yields and at lower costs. The technology can be used for almost all peptides, and production on an industrial scale becomes possible. As a result, new technical applications for peptides are also becoming realistic for the first time.

Currently, peptides are used above all as pharmaceutical or cosmetic active ingredients. Initially, Numaferm plans to use the fresh capital to drive forward technological development and develop the first products to market maturity.

FOR GREATER EFFICIENCY IN THE LABORATORY

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CONVINCING LOOKS AND PERFORMANCE
Lower component costs

With high-gloss non-transparent PMMA, A-pillar trims can be manufactured at up to 40 percent less cost than from coated steel or acrylonitrile-butadiene styrene (ABS).

Since 2001 BMW has been using high-gloss black plastic trims of non-transparent PLEXIGLAS® for the A-pillars framing the windshield of the MINI. This was the first use of the material in series production in the automotive sector.

Colored non-transparent PLEXIGLAS® is an indispensable element of modern vehicles. The past 15 years have seen a growing demand for high-gloss applications in particular, and their importance is set to grow further still in response to new design and mobility requirements.

Tony Häßler and Sven Schröbel

The automotive industry has been using transparent PLEXIGLAS® (polymethyl methacrylate, PMMA) for decades, mainly for taillights, light guides, and cluster lenses. The trend toward high-gloss automotive surfaces that began in the late 1990s offered further opportunities for the glass-like material. In 2001, the MINI (back then already a cult car with an unmistakable design) was the first car that used colored non-transparent PLEXIGLAS® for high-gloss black A-pillar covers.

The MINI’s large windshield is one of its characteristic features, as are the round headlights that look like big wide eyes, and the chrome-plated radiator grille. Since the windshield is bonded to the chassis, it is printed black along the edge to cover the adhesive joint. If the plastic trims that cover the A-pillars are also black, they make the windscreen appear bigger because of the fluid transition between the printed glass and the black panel.

In 2001, the manufacturers of the MINI switched from the previously used high-gloss painted plastic covers to black PLEXIGLAS®. The finished piano black parts are produced by injection molding, without additional coating. Evonik developed both the material and the color, giving rise to the PLEXIGLAS® Hi-Gloss product family.

That also led to far-reaching changes in the supplier’s manufacturing chain. The plastic trims previously used for the MINI’s A-pillars were injection-molded at the Swiss factory of a German automotive supplier. The parts were then coated in Germany, before going back to Switzerland for the final processing steps. Once they were ready, the supplier sent the components to the OEM in the UK, where they were mounted to the vehicle.

When high-gloss non-transparent PMMA started to be used over 15 years ago, there was no further need for coating, and all of the processing steps could be handled in Switzerland. So the market launch of the component made from a new material also simplified logistics and quality assurance. It also meant a significant reduction of manufacturing costs.

Passing the field test

Before a new material makes the grade for serial production in the automotive industry, it has to pass a series of rigorous tests. That presents a real challenge for new technologies or materials, since test methods sometimes have to be specifically developed, or improvisation is called for.

The test that simulates the material’s surface resistance to abrasion illustrates the complications that may emerge in tests on high-gloss PLEXIGLAS®. In the AMTEC-Kistler test, uncoated polycarbonate initially appeared to show higher scratch resistance than PMMA: a finding that went against everything in the textbook.

Closer examination of the testing conditions revealed that the polyethylene bristles of car wash brushes leave a kind of greasy film on the polycarbonate surfaces at an early stage, giving them a protective layer that suggests higher scratch resistance.
The PLEXIGLAS® surface, on the other hand, was so smooth that the bristles were unable to rub off on the surface. So each stroke of the brush tested the actual abrasion resistance of PMMA.

The rear side windows of the MINI were made smaller when the model was given a facelift in 2007. This made it possible to install a large cover of high-gloss black PLEXIGLAS® on the C-pillar. Meanwhile, the material is used in many other vehicles besides the coveted MINI, and can now be found in models from all European and some Japanese carmakers as well as an American manufacturer. Frequently, but not exclusively, the application takes the form of high-gloss black pillar trims on these vehicles.

The material is being increasingly used for brand logos. At the moment, many manufacturers use back-molded plastic films that are not very weather-resistant. This means the emblems may fade over the years. That does not happen to PLEXIGLAS®, which can be colored in any imaginable shade.

**Color and function**
Evonik took advantage of the possibility of coloring the inherently clear-transparent material in virtually any color, for a trim panel on the trunk of a German high-volume model. Two specially developed colors made it possible to manufacture glass-like trim panels by means of sandwich molding. These panels are a perfect match for the rear window design.

PLEXIGLAS® Hi-Gloss also enables the manufacture of functional vehicle components. Seals made of thermoplastic elastomers can be injection-molded directly onto the component by sandwich molding, for instance.

**Multifold application possibilities**
Colored non-transparent PLEXIGLAS® is a persuasive choice, both visually and functionally, at many places on the vehicle exterior. Specialty PMMA molding compounds with customized property profiles have been developed to meet various requirements.
expensive. Since both of these system solutions call for high-gloss coating, this would have driven up manufacturing costs by a considerable margin. The components made from the Evonik plastic, on the other hand, can be injection-molded in a single all-in-one operation (using parts made with the mold for actual production purposes).

Manufacturing parts from high-gloss PLEXIGLAS® posed a challenge to some automotive suppliers. The gloss is obtained in a sophisticated injection molding process that uses a mold with a high-gloss-polished surface. PLEXIGLAS® has the ability to perfectly reproduce the mirror gloss of the mold surface. Not all plastics fabricators are familiar with such processes. In such cases, Evonik offers technical support. After all, every supplier who has mastered the process automatically becomes an ambassador for this technology.

High gloss inside the car

Although high-gloss PLEXIGLAS® began its triumphant career as an exterior part on the MINI, the material has also been an increasingly popular feature of car interiors for a number of years. This is due to the demands of car buyers, who set store by classy interior design. High-gloss piano-black surfaces meet these demands. The only plastic that can satisfy such requirements in terms of looks and wear-and-tear is PMMA. Coated surfaces, by contrast, always show more or less pronounced surface irregularities, referred to by specialists as the ‘orange peel’ effect.

So it was only a matter of time until high-gloss PMMA panels came to be used in vehicle interiors. Here the material is faced with different requirements than in exterior applications. Interior surfaces must provide greater chemical resistance, for example to hand creams and suntan lotion.

High-gloss surfaces create a wish to keep them free from dirt and dust. Car drivers and passengers therefore have an automatic tendency to wipe the plastic surface, which may cause fine scratches. At the wish of the automobile industry, experts at Evonik created a PMMA molding compound that shows greatly improved behavior, i.e. greater resistance to this wiping movement.

PLEXIGLAS® Hi-Gloss NTX-15 is a material that was developed on the basis of the tried-and-tested molding compound PLEXIGLAS® Hi-Gloss FT15, which meets these new requirements. The adjacent figure shows the improvement achieved in wipe resistance to dry wiping.

PLEXIGLAS® is set to play an even greater role in car interiors in the long term. Designers often come up with displays for operating vehicle functions that practically dictate the use of plastics as surface materials, owing to the complex geometries involved. Thinking ahead to the prospect of self-driving cars, with interiors that the automotive industry believes will be used in completely different ways, complex surface geometries will probably become even more frequent.

Front-end applications

High-gloss PLEXIGLAS® is conquering further applications in car exteriors too. Evonik has developed a material for this purpose whose impact strength far exceeds that of the standard grade. Interesting applications include exterior mirror housings and the radiator grille. Both applications involve key requirements in terms of pedestrian protection. The material recently developed by Evonik incorporates a special impact modifier and has already passed a large number of material tests. The first vehicle with a radiator grille made from PLEXIGLAS® Hi-Gloss NTA-5 9V022 (black) will enter serial production before the end of the year.

Given the spread of electric vehicles, the front radiator grille can be expected to undergo massive change. Unlike combustion engines, electric car engines do not need large radiator grilles for cooling purposes. Car-sharing can also be expected to increase in the initial years of large-scale electric car use. Fleet operators will then be interested in obtaining robust vehicles at the lowest possible cost. PLEXIGLAS®, with its positive properties and noble appearance, may play a major role in this respect. As an especially light material, it also helps to reduce vehicle weight.

Evonik is a leading player when it comes to PMMA applications for vehicles. The company provides the material and the requisite technical support, and maintains production sites on three continents. The vast majority of all high-gloss parts used today were manufactured using PLEXIGLAS® Hi-Glass materials from Evonik. Irrespective of where they were produced, they offer constant and uniformly high quality in terms of their color and function. The fascinating thing about them is that this success is based on a PMMA molding compound that has been on the market for more than 80 years. At the same time, it has never undergone so many modifications as in recent years.
CARRYING FOR TATTOOS

Tattoos last a lifetime. But without the right care for tattooed skin, a tattoo may fade and lose its brilliant colors. Evonik has the right recipe to protect and nurture the skin before and after tattooing.

In the past, tattoos decorated only the skins of sailors and prisoners, but nowadays they are also popular among celebrities and office workers alike. Unlike the disreputable tattoo wearers of the past, today’s hipsters value healthy and well-tended skin. They want their body adornments to look good for a long time without any unpleasant side effects.

In tattooing, color pigments are inserted under the dermis, the second layer of the skin. However, the uppermost skin layer, the epidermis, is also stressed in the process. If the skin is properly prepared and appropriately conditioned after tattooing, it can recover fast. Evonik’s products and know-how give valuable support in nurturing the skin before and after the tattooing process.

The Personal Care Business Line in the Nutrition & Care Segment has developed formulations that are used in seven care products for tattooed skin. The components of these formulations are also used in other cosmetic products. With the help of these components, the skin recovers quickly, is moisturized, and does not suffer from inflammation or irritation. The formulations contain a variety of active ingredients, such as SPHINGOKINE® NP, SKINMIMICS®, LACTIL®, SK-INFLUX®, TEGO® Natural Betaine, the plant extract TEGO® Turmerone, mild surfactants, emollients, and emulsifiers such as TEGO® Care PBS 6, which was recently launched on the market.

These formulations have many areas of application. Before the needle goes in, products from Evonik make the skin taut and stimulate the regeneration of the epidermis. The products can be used in lotions, for example.

Moisturizing and protecting the skin barrier

After tattooing, these products provide natural moisture and strengthen or restore the protective skin barrier. Raw materials from Evonik make the skin’s surface smoother so that the tattoo is more visible, and they help to preserve the tattoos and their colors: an important factor if the skin is exposed to lots of sun. And people who later regret their tattoos can use camouflage makeup before important meetings.
A HIGHLY DYNAMIC MARKET

Dr. Tammo Boinowitz, who heads the Personal Care Business Line at Evonik, on the challenges of the cosmetics business

Mr. Boinowitz, you seem to like getting things done fast.
If you’re referring to the Personal Care business: Yes. Our customers must work on their own customer acquisition almost daily by constantly offering something new. And we need to keep pace.

What does the consumer expect from care products?
There is no standard consumer of cosmetics. In this extremely heterogeneous and volatile market, there are countless consumer types which sometimes overlap with each other.

For example?
At first glance, purchasers of natural products and purchasers of luxury goods represent two completely different groups. But this is most certainly not always the case. If you add in factors such as age, the seasons, fashion trends, and budgets, you get an impression of the dynamics of the cosmetics business.

Where are the trends being set?
One of the trendsetters is Korea; a recent development to come out of this country is fluid foundation that is applied with a small sponge, for example. Cosmetics is a very regional business and new trends appear from all corners of the globe—like our new tattoo care concept, which was developed in our labs in Brazil.

What role does sustainability play?
It’s very important. Consumers want to use cosmetics with a clear conscience. Furthermore, the market for cosmetics is heavily regulated. Our customers want us to be able to document the substances we use down to the smallest detail because they themselves are obliged to verify to the public the substances that they use. For this purpose, they have established very efficient quality control systems. But we still need to verify more.

What do you mean?
Where are our materials produced and under what conditions, who benefits from the cultivation of our products, what are the qualifications of our suppliers? Any company that ignores these questions or cannot answer them will soon feel the consequences in their business.
Appreciation is an important driver of creativity. This is why work on promising projects is particularly well honored at Evonik. The Group’s annual Innovation Award honors outstanding research findings and the creative minds behind them. In 2017, three teams made the final cut in each of the two categories.

The innovations of the year

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

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

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

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

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

The CIO Award: surprising
The Chief Innovation Officer (CIO) Award acknowledges an individual achievement of an employee. In 2016 it went to Prof. Robert Franke for his expertise in combining internal and external competencies to generate added value.
Evonik aims to boost health and productivity in the chicken coop while simultaneously cutting down on the use of antibiotics. And it is now a step closer to this goal with GutCare®, a probiotic for poultry developed within the Group. For this achievement the team of developers from the Nutrition Care Segment has been nominated for the 2017 Evonik Innovation Award.

Subclinical necrotic enteritis is the somewhat unwieldy name of a widespread poultry disease in which Clostridium perfringens bacteria damage the gut wall. While the bird continues to eat, it does not gain weight as rapidly as before and infects other birds. The damage caused by the disease in poultry farms worldwide is estimated at several billion US$ annually.

Antibiotic growth promoters (AGPs) are therefore added to the feed as a prophylactic measure. Scientists now believe that this practice is partly responsible for the increasing emergence of multi-resistant microorganisms in humans, who can no longer be treated with many existing antibiotics. AGPs have been banned throughout the EU since 2006, but continue to be added to animal feed in other parts of the world.

A more elegant solution is the use of probiotics that stabilize the gut flora. This is where GutCare® comes into the picture. It has been shown in laboratory trials that this probiotic has a positive effect on the composition of gut flora and suppresses Clostridium perfringens as well as other pathogenic bacteria. In dietary studies in chicken farms, GutCare® was shown to improve gut health and significantly reduce mortality in broiler chickens.

GutCare® is a special strain of the bacterium Bacillus subtilis. During development of the product, the developer team investigated more than 500 strains and analyzed their probiotic properties. The product was launched on the US market in early 2017 and is now also available in China, India, and Bangladesh.

What has just half the calories of sugar, is exceptionally good for your teeth, and is even suitable for people with diabetes? Isomalt, a sugar polyol that Evonik began marketing this year in Southeast Asia under the name Risumalt®. Researchers at Creavis, Evonik’s strategic innovation unit, paved the way for the new product: work that earned the team a nomination for the 2017 Evonik Innovation Award.

At a demonstration facility in Thailand, Evonik has joined forces with its partner Rajburi Sugar to produce roughly 500 metric tons of the sugar replacement each year. Growth in the demand for healthy alternatives to sugar is particularly high in Asia, where nearly one in ten individuals is affected by type 2 diabetes and that trend is rising.

A real alternative to sugar and traditional sweeteners, Risumalt® can be used as a 1:1 replacement for household sugar, which means that the product not only lends products the right degree of sweetness: it also gives them the right shape and texture. Another property that distinguishes Risumalt® from other sugar polyols like sorbitol is that it absorbs virtually no moisture from the air, which keeps unpackaged candies from sticking together.

In order to produce the sugar polyol efficiently and sustainably, Creavis researchers worked with Evonik’s process engineering specialists to optimize the traditional manufacturing process. The starting material is household sugar from sugar cane, which is converted to isomalt in only a few processing steps, thus increasing the yield over the traditional process.

Evonik and Rajburi Sugar are marketing Risumalt® especially for use in sugar-free or reduced-sugar confectionery products, baked goods, and instant beverage powders. Halal certification and registration with the Thai authorities are already complete. The Evonik Health Care Research Center in India is also working in parallel on other applications. Researchers have already shown, for instance, that Risumalt® is superior to commercially available isomalt in certain specialized applications such as effervescent tablets.
A new process using water-based polyether polyurethane dispersions for the manufacturing of artificial leather:

Artificial leather based on polyurethane (PU) is very popular but its manufacture requires large quantities of the solvent DMF (dimethylformamide). Thanks to the newly developed surfactant Ortegol® P1, high-quality artificial leather can now be manufactured using water as a solvent. For this innovation, a team from the Nutrition & Care Segment and the Greater China Region has been nominated for the 2017 Evonik Innovation Award.

Shoes and clothing, bags and belts: In 2016, an estimated 2.3 million metric tons of PU based artificial leather was produced. The lion’s share, approximately 95 percent, was manufactured using the DMF coagulation process, in which a paste consisting of 30 percent by weight of PU and 70 percent by weight of DMF is applied to a textile fabric and dried. In 2016, 700,000 metric tons of the solvent were used in the production of artificial leather. DMF has been classified as a substance of very high concern under the EU Reach regulation.

A new process using water-based polyurethane dispersions represents a clear gain for environmental protection. These are foamed, applied in the required coating thickness, and then dried. The structure of the foamed polymer coating manufactured in this way has a major effect on the feel, look, breathability, and mechanical properties of the artificial leather. And this is where Ortegol® P1 comes in: As a processing agent, the surfactant ensures the required homogeneous, fine-celled foam.

To support the market introduction that is now underway, Evonik has entered a partnership with Covestro, a leading supplier of aqueous polyurethane dispersions for artificial leather. The most important market is China, which produces approximately 90 percent of the world’s PU-based artificial leather. Some of the major Chinese manufacturers have already tested the surfactant. And their conclusion is: Ortegol® P1 not only improves the properties of the artificial leather but also reduces energy and raw material consumption during the manufacturing process.

New surfactant: Environmentally friendly manufacturing of artificial leather

When using LIMA to manufacture MMA the lower energy requirement reduces CO₂ emissions by up to 40 percent.

Dr. Florian Zschunke, spokesperson for the nominated LIMA team

Dr. Michael Klostermann, spokesperson for the nominated Ortegol® P1 team

New Processes Category

MMA: A better raw-material base and higher sustainability

Elements #61 THE EVONIK INNOVATION MAGAZINE

Often unrecognizable at first glance: high-quality artificial leather

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The name of the new process, LIMA, clearly reflects the team’s aspirations: LIMA stands for Leading in Methacrylates. We can react the raw materials almost completely, with a conversion rate never before achieved; we’re also significantly relieving the burden on the environment by avoiding by-products and using new highly efficient catalysts for every process step, says Dr. Florian Zschunke, spokesperson for the nominated team.

LIMA combines known steps of established processes with other process steps that have been developed completely from scratch. It works entirely in the liquid phase and under moderate conditions, generally at temperatures significantly below 100 °C. The much lower energy requirement means that carbon dioxide emissions are reduced by up to 40 percent. Process control is simple, and minimizes wastewater streams as well as technical effort and maintenance requirements. With LIMA, yields of the end product are higher than 90 percent.

MMA is found in many everyday products such as coatings and adhesives, and is also a starting material for the production of soft contact lenses and dental implants. Evonik markets the polymer polymethyl methacrylate as PLEXIGLAS®. This is used in automotive construction and also in medical devices and optics.

Thanks to an intelligent combination of processes and efficient catalyst systems, the team succeeded in developing LIMA to the pilot phase within just five years. The pilot plant has now been running stably for a year in Darmstadt, and the process and product quality achieved is excellent: The MMA produced there can be used even for optical applications, which are the most demanding of all technical applications and place the highest requirements on product quality.

When using LIMA to manufacture MMA the lower energy requirement reduces CO₂ emissions by up to 40 percent.

Dr. Florian Zschunke, spokesperson for the nominated LIMA team

Dr. Michael Klostermann, spokesperson for the nominated Ortegol® P1 team

New Processes Category

MMA: A better raw-material base and higher sustainability
For the synthesis of propylene oxide, an important raw material for polyols and therefore polyurethanes, a team of researchers from the Catalysts, Active Oxygens, and Silica Business Lines of the Resource Efficiency Segment has significantly improved the titanium silicalite-1 catalyst (TS-1) with big benefits for the environment and customers, as well as improvements in cost efficiency. For its work the team has been nominated for the 2017 Evonik Innovation Award.

Polyurethanes (PU) are among the most important of plastics. In cars they serve as lightweight but durable materials for seat cushions and dashboards; as foams they insulate refrigerators and buildings, and are processed into high-grade cold foam mattresses. The key component in PU production is propylene oxide, for which Evonik and thyssenkrupp Industrial Solutions (tkIS) have now developed a new process, the new catalyst offers two decisive advantages: smaller amounts of raw materials and longer service life also a benefit for the environment.

The TS-1 catalyst for producing propylene oxide from propene

The tour de force of a team from the Performance Intermediates Business Line rises 90 meters into the air at the Marl site. A column was installed here in 2015 that, along with other installations, for the first time allows utilization of specific material streams from refineries for the production of C4 chemicals. For the development of the process, which now enables the production of a wide range of high-grade products from FCC-C4, the team has been nominated for the 2017 Evonik Innovation Award.

In the past, Performance Intermediates only utilized C4 streams from steam crackers as raw material. Since early 2015, however, it has also been possible to use FCC-C4 in Marl. FCC stands for fluid catalytic cracking, a process that enables refineries to convert heavy crude oil components into fuel components. Among the products is a C4 material stream that contains, in addition to the desired olefins, other components such as sulfur and nitrogen compounds. These components could cause damage to catalytic processes; this is why it had so far not been possible to utilize FCC-C4.

The existing integrated production network in Marl includes many catalytic steps to convert C4 hydrocarbons into valuable products such as methyl tert.-butyl ether (MTBE) and isononanol (INA) as well as 2-propylheptanol (2-PH) and diloisynyl phthalate (DINP). With analytical methods, some of which are newly developed, we’ve discovered and quantified more than 50 relevant components in the FCC-C4 stream, and we have investigated their influence on our catalysts. On the basis of the results we developed a cost-effective process for removing those substances which have a negative effect on our catalysts, says team spokesperson Dr. Markus Winterberg.

Through a skillful combination of classic scale-up experiments and modern modeling approaches, it was possible to avoid the costly construction of a pilot plant. Instead, the plant, which can process several hundred metric tons of FCC-C4 per day, was constructed directly on the industrial scale and integrated into the existing production network. Thanks to complex heat integration, the new process is highly energy-efficient and does not generate wastewater or waste gases. The process is so successful that the plant is currently being expanded.

Fluid catalytic cracking: Enabling utilization of C4 streams

In operation since early 2015: the new plant for processing FCC-C4

Catalysis: A more efficient route to propylene oxide

The TS-1 catalyst for producing propylene oxide

New Processes Category

New Processes Category

Dr. Stefan Wieland, spokesperson for the nominated TS-1 team

Dr. Markus Winterberg, spokesperson for the nominated FCC-C4 team
BLENDING BIOLOGY AND ELECTRONICS

Technology that goes under the skin

The digital transformation is well under way. But even as the Internet of Things links ever more devices, the next digital revolution—the integration of man and machines—is already on the horizon. In the future we won’t merely be surrounded by digital technologies; we’ll be carrying them in our bodies.

Science fiction has long had a name for these technologies: It terms them wetware technologies, implanted as they are in “wet” human and animal bodies. But this is no longer science fiction: Neil Harbisson of the UK, who is colorblind, has an antenna implanted in his skull that enables him to “hear” the entire color spectrum as aural tones. He says this antenna is for him an additional sense organ, and is as much a part of him as his nose. He came to international attention when he persuaded the UK authorities to renew his passport without his having to conceal the antenna on the photo.

Harbisson could therefore be regarded as the first officially recognized cyborg, and has become an icon of the biohacking community. The members of this global do-it-yourself movement advance the practical implementation of bioelectronics by experiments on their own bodies, for example by implanting self-programmed chips that open doors in the same way as a key card.

Industrial research in bioelectronics is also growing very rapidly, because it could potentially make major contributions in the next few years to environmental protection, food supplies, and medicine, where, for instance, intelligent implants could relieve parkinsonian symptoms. The first registration procedures for such implants have already been initiated. Bioelectronic implants could even provide us with additional senses, or enable digital telepathy to allow us to control devices with our thoughts or to communicate with other people.

However, we still lack the ideal materials for durable bioelectronics; mechanical properties and biocompatibility in particular need to be improved. The Corporate Foresight team of Creavis, Evonik’s strategic innovation unit, is therefore investigating, under its GameChanger focus topic, which growth opportunities wetware technologies hold for Evonik, for example in the area of high-performance polymers.
Neil Harbisson, who is colorblind, has an antenna on his skull that was implanted by an anonymous surgeon in 2004. It contains a sensor that recognizes the colors in his field of view and is permanently connected to a chip in his head that translates the colors into audible frequencies.
They may be present only in small amounts, but their effects are profound,” says Dr. Angélique Bé tard, a chemist in the Catalysts Business Line in Marl. She oversees the development of new catalysts and the improvement of existing solutions to make processes ever more effective. “Eighty percent of all chemical reactions are accelerated or enabled in the first place by at least one catalyst,” says Bé tard. “Without catalysts, an enormous amount of energy would have to be expended on the reaction. So they are crucially important for efficient and resource-conserving production.”

A good example here is Evonik’s HPPO process, in which propene and hydrogen peroxide are reacted to produce propylene oxide. The two starting materials would not react without high energy expenditure; they must therefore first be activated. This is done by a special catalyst, based on titanium silicalite, which is produced by the Business Line. The inorganic mixed oxide, with a structure in the nanometer range, is produced in the form of a powder and then molded into white rods that are 3 millimeters thick. These ensure that the hydrogen peroxide oxidizes the propene, with water as the sole by-product. The main product is propylene oxide, which Evonik’s customers use to produce polyurethane foam; this main product is the sole by-product.

The most important thing for our customers is that, at the end of the day, their process runs effectively, says Bé tard. “And one property of the catalyst is vital here: its tensile strength. Because this is the basic requirement for its use in reactors in the chemical industry, the catalyst must on no account be destroyed during use, even if it is subjected to high pressure in the reactor. Several metric tons of catalyst are filled into the reactor. The lower layers of catalyst must not disintegrate and pulverize, despite the extremely high weight of the overlaying layers, else the reactor would become blocked and the process would grind to a halt.”

The perfect job

“If that is to be prevented, much work must be invested in the forming, says Bé tard. “The forming process is extremely complex, as with baking. For example, a wide variety of ingredients must be mixed, kneaded, and molded; and even a slight variation in the use of the components could make a difference here. The moldings have the right tensile strength only if they are also dried and thermally treated under suitable conditions. It may be necessary to produce hundreds of samples before a formulation can be carried over into production,” she explains.

This is the perfect job for Bé tard because she can bring to it the experience gained from her studies as well as her doctoral research. During her undergraduate study of materials science in Paris, French-born Bé tard became familiarized with the oxide materials used to produce catalysts and with the catalysts’ synthetic pathways, properties, and applications. Following her master’s degree, she came to Germany for doctoral research at Ruhr University Bochum. “I wanted to work and do research in a place offering many opportunities for further development and exchange with other chemists as is the case in Germany,” says Bé tard. For her doctorate she worked on the preparation and detailed investigation of novel materials. While that work was not on catalysts, I can now apply my methodological knowledge every day in my present work with catalysts,” she says.

New generations

In the Business Line, she coordinates the research of her colleagues in the laboratory and the pilot plant. The aim is to develop new catalysts for new processes, or new generations of catalysts that can be used even more effectively than the preceding generation. This could mean, for example, that the yield increases, or that less catalyst produces more product, or that the service life of the catalyst is prolonged, saving costs and resources. “And ideally all of those,” says Bé tard. “For me the biggest satisfaction is when, at the end of the process, the catalyst is used at the customer’s and does exactly what it was designed to do.”

This is why it’s important to her to accompany the entire development of a new product, from its birth in the laboratory all the way to production in the plant. This is also necessary because of the allocation of work in our team, she says. “Specialization is the name of the game here. Every member of the team has their own particular expertise that’s needed to take us to success. That’s why I always want to stay on the ball, to understand the critical steps.”

The work-life balance

At the same time Bé tard did not want to forget family life: “Why shouldn’t it be possible to have both?” Fortunately, her husband also works in research at Evonik, and together they decided on a special part-time working model: “My husband works mornings and 1 work afternoons,” she says. “In this way we can both be there for the family and continue to stay active in the profession – which is the perfect solution for us.”

She plans to follow the same path with her second child: Following the birth in March, she will soon afterward resume her research in catalysts at Evonik. “My job is so varied that I learn something new every day,” says Bé tard. “Every process and every catalyst is different. There’s never a dull moment.”

Specialization is the name of the game here. Every member of the team has their own particular expertise that’s needed to take us to success. Dr. Angélique Bé tard
Striving for efficiency: Dr. Angélique Bétard researches new catalysts at Evonik and supports their development from the laboratory through the pilot plant to production.
In China as elsewhere, additive manufacturing processes are rapidly gaining importance, whether in medical technology and the pharmaceutical industry, the aviation and automotive industries, toys, or home decor. Apparently just about anything can be produced from a 3D printer, remarked the China Daily newspaper recently about this revolution in production. So it was no surprise that Evonik chose Additive Manufacturing as the theme of this year’s China science forum, Evonik Meets Science, which took place in Hangzhou, near Shanghai, in September. During the two-day event, Evonik’s experts discussed the topic intensively with Chinese scientists.

More than 100 participants attended the event. In contrast to previous events, the guests this time included not only academic scientists but also those from companies active in the area of 3D printing, with international companies such as EOS and HP being represented as well as national companies like UnionTech and TPM3D.

The reason is that in China, universities as well as high-tech companies, particularly start-ups, are working intensively on additive manufacturing processes; in close collaboration with one another, they cover all areas from materials research through process development to machine manufacture. Intensive collaboration between universities, research institutions, and companies in China has enormously increased the rate at which new technologies are being implemented. It’s unbelievable how rapidly new developments come on to the market here, said Dr. Claas Klasen, president of Evonik Asia Pacific North. As he emphasized in his opening address, among Evonik’s focuses of development in China are local solutions for China-specific megatrends. Digitalization with 3D printing plays a key role here as a growth driver, and Evonik exploits this to create significant value for its customers. Thanks to its materials science expertise, the specialty chemicals group has the experience needed to further improve additive manufacturing processes and develop new applications.

Evonik has been developing polymer powders for 3D printing for nearly 20 years, said Dr. Ulrich Kösthardt, Chief Innovation Officer of Evonik Industries, at the science forum. With polyamide 12 (PA 12) Evonik is already one of the leading global suppliers of materials in this area. We have explicitly marked out 3D printing as a core area for our strategic growth and will intensify collaboration with participating universities and industrial organizations in this field. PA 12 allows applications with sophisticated me-
Mechanical, thermal, and chemical requirements to be realized with almost unlimited freedom of design, so that series production is conceivable even for complex shapes and individualized objects.

Transfer from rapid prototyping to production

Following the opening of the event, participants first received an overview of additive manufacturing technologies, the extent to which they are used in China, and the country’s funding policy in this area. This was given by Prof. Chengtao Wang of Shanghai Jiao Tong University and Dr. Xiaoli Li, vice director of the Shanghai Industrial Technology Institute.

The Made in China 2025 national strategy aims to promote green, intelligent manufacturing as well as innovation and research; 3D printing has been accorded great importance here right from the start, as is becoming increasingly apparent in China. In the 13th five-year plan, which covers the period to 2020, the government envisages for 3D printing a transition from rapid prototyping, which is the current focus of activities, into production. Additive manufacturing processes based on polymer systems are expected to play an important role here. Chengtao Wang also emphasized that in forthcoming developments of 3D printing technology, research activities will now finally focus on materials, because a number of equipment-specific problems have now been solved.

A fast-growing market in China

According to the Additive Manufacturing Alliance of China, the production value of the 3D printing industry in China in 2016 was the equivalent of more than US$1 billion. This is an increase of nearly 90 percent over the previous year. By way of comparison, the global market for additive manufacturing in 2016 was US$6 billion, a 17 percent increase on the previous year, according to the market-research company Wohlers.

With regard to materials, about half of the systems are polymers, just under 30 percent are polymer-metal mixtures, and the remaining 20 percent are metals. The China Industry Information Institute expects that the production value of China’s 3D printing industry will reach the equivalent of US$7.7 billion in the year 2020, corresponding to about one third of the then anticipated world market.

It’s unbelievable how rapidly new developments in the area of 3D printing come on to the market in China.

Dr. Claas Klasen, president of Evonik Asia Pacific North

With PA 12 Evonik is one of the leading global suppliers of high-performance polymers for 3D printing. A new production line in Marl should increase annual capacities for specialty PA 12 powders by 30 percent from the end of 2017.
At the Evonik Meets Science forum, Sylvia Monsheimer, who is responsible for the New 3D Printing Technologies market segment at Evonik’s Resource Efficiency Segment, provided an overview of activities connected with additive manufacturing processes at the company. "Materials that allow customized functionalities for sustainable solutions and, what’s more, in serial production are a highly promising growth driver for our business," she said.

In view of this, Evonik has designated additive manufacturing as a strategic growth engine and is currently expanding its capacities in this area. A new production line in Marl should increase annual capacities in this area. A new production line in Marl should increase annual capacities in this area. A new production line in Marl should increase annual capacities in this area. A new production line in Marl should increase annual capacities in this area.

Because 3D printing is closely linked to industrial applications, companies were also invited to participate in this year’s Evonik Meets Science event to present their latest technologies, devices, and materials.

Printed implants for accident victims

Dr. Wenbo Jiang, who works on medical applications in 3D printing at Shanghai Jiao Tong University, reported on the use of additive manufacturing processes at Shanghai Ninth People’s Hospital, where accident victims already receive printed implants. The processes are also used in cosmetic surgery. Jiang believes that this approach will be a major trend in 21st-century medicine, which will become increasingly personalized.

Xiaofeng Cui, a professor at Wuhan University of Technology, goes one step further. He spoke about 3D bioprinting in translational medicine, which is the rapid and efficient transfer of preclinical research results into clinical development: by means of additive manufacturing processes. His presentation focused on the 3D printing of human tissues and organs. According to Cui, cells and tissues can now be printed, but these have so far been viable only for short periods.

That China offers a good environment for innovations in additive manufacturing was also confirmed by Luan Zhao, founder and CEO of the 3D printer manufacturer TPM3D. His company has grown significantly in the last 14 years, thanks to sales of laser sinter printers for polyamide.

The reason is that this technology from TPM (Trump Precision Machinery) is, according to him, economical, powerful, and easy to use. Compared with other sinter technologies, it uses 20 percent less PA powder with no loss of quality; moreover, the service life of the laser is longer and the digital scanners, with speeds of up to 21,000 mm per second, are extremely fast. TPM3D is a joint venture between Stratasys and the Chinese company Trump Precision Machinery.

The following two presentations described improvements in individual areas of 3D printing. Dr. Daosheng Cai of Huazhong University of Sciences and Technology, who is also the CEO of the 3D printer manufacturer Wuhan Easymade Technology, explained how 3D inkjet printing is becoming faster. The chemical reaction can be accelerated, and the properties of the printed components significantly improved, through the strength of the inkjet, the choice of curing agent, and the use of heated equipment.

Prof. Lixin Wu of the Fujian Institute of Research on the Structure of Matter, which is part of the Chinese Academy of Sciences, presented a new material system based on the thermoplastic terpolymer ABS and the mineral montmorillonite, which makes fast additive manufacturing possible.

High potential for chemical process engineering

Dr. Senada Schaack, a senior manager at Evonik Technology & Infrastructure, showed how 3D printing changes chemical process technology. As examples she mentioned burners for plants and reactors. There is high dormant potential here for process optimization, because the freedom of design offered by 3D printing allows the production of elements that are ideally suited to the
conditions of any specific process and thus, for example, ensure optimal heat and mass transfer. Finally, Prof. Tao Xie of Zhejiang University offered a glimpse into the future: the linking of additive manufacturing with other current technologies. 3D-printed shape-memory polymers, for example, could open up entirely new applications in aviation, medical technology, and flexible electronics, according to Xie.

The event concluded with a panel discussion moderated by Dr. Alexander El Azzawi, head of the Direct Manufacturing Innovation Field of Creavis, the strategic innovation unit of Evonik. Participants from the worlds of science, politics, and business in China threw light on the current and future situation of additive manufacturing processes in the country.

Expansion of China’s global presence
As in the earlier presentations, it was clear that while Chinese companies are currently focusing their activities mainly on the domestic market, they fully intend to strengthen their global presence in the future. China’s particular strength lies in its rapid testing and implementation of new manufacturing technologies in new applications, as was illustrated by Enquan Liang of COMAC, using the example of aircraft construction, and other participants.

It was clear overall that China is taking a focused and ambitious approach to additive manufacturing processes and is willing to experiment further. This may be good news for suppliers of equipment and materials, because China assigns great importance to research and to close collaboration between academia and industry. As Dr. Jing Feng, head of Corporate Innovation at Evonik in the Greater China Region, later summed it up, “We at Evonik are convinced that the China Region is not only a sales market for additive manufacturing but also the right place for innovation.”

**The China Region is not only a sales market for additive manufacturing but also the right place for innovation.**

*Dr. Jing Feng, head of Corporate Innovation at Evonik in Greater China*
Ernst Peter Fischer (70) is one of Germany’s most prominent science publicists. The versatile researcher studied mathematics, physics, and biology. Mr. Fischer was a professor of science history at the University of Heidelberg and is a consultant for the Forum für Verantwortung (Forum for Responsibility), which promotes research on sustainability. As a publicist, he advocates a greater role for the sciences in general education.

Science is performed by people, and I would like to see these people become as well known and familiar as musicians, poets, and philosophers. Beethoven and Bach, Schiller and Shakespeare, Kant and Kierkegaard, and many other names come to mind immediately when we speak about culture. Their art and its associated way of thinking are thus attributed almost human character. But natural sciences are left excluded from this.

In a roll call of the great scientists including the likes of Liebig and Lavoisier, Crick and Cantor, Maxwell and Mandelbrot—and with the exception of a certain Albert Einstein—most people will simply shrug their shoulders. This shows the disregard in which the activities of these people are held even though our civilized society is due in no small part to their efforts. If the public was as familiar with the names of great scientists as it is with those of the classical artists and composers, then science could finally become what I would like it to be—that is, a living part of our culture whose contributions we can actually enjoy.
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According to estimates by the FAO, global consumption of chicken meat will surpass the consumption of pork in 2020. That means poultry farmers will have to step up productivity without impacting animal welfare or meat quality. Precision Lifestock Farming (PLF), which Evonik is advancing with the digitalization of chicken farming, offers a solution. PLF enables the recording of chicken growth and health data to optimize feeding and livestock conditions.

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* HOW DIGITALIZATION WILL CONTRIBUTE TO CHICKENS’ WELL-BEING