

THE NEW PATHWAY  
TO HELIUM

THE DIRECT PATHWAY  
TO ISOMALT

# ELEMENTS

JUNE 2017

# 59



**HAPPY  
WITHOUT FISH\***



**\* ...HOW TO PREVENT WILD FISH LANDING UP IN FISH FEED**



We're often asked exactly what part we play in tomorrow's pioneering products. It's the pioneering part.

Evonik is the creative industrial group from Germany. Our experts draw on their wealth of ideas coupled with years of experience and specialty chemicals know-how to develop responsible solutions for tomorrow – from lightweight construction to new display technologies. Creavis, our strategic innovation unit, is a visionary driving force opening up new opportunities for our customers. And happily also for you. Visit the future at [www.creavis.com](http://www.creavis.com).





Evonik launches low-calorie sugar substitute in Asia.  
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## EDITORIAL

### Growing with partners

Two years ago we defined six growth fields in which we aimed at achieving sales of at least one billion euros by the year 2025. It is the task of our researchers to bring this vision to life and they are rising splendidly to the challenge, as is clear from examples in the growth fields of Sustainable Nutrition, Membranes, and Advanced Food Ingredients.

The Animal Nutrition Business Line and DSM, for instance, have developed a fermentation process to produce algal oil. This will replace the fish oil in the feed that provides farmed salmon with omega-3 fatty acids, thus relieving the burden on the marine ecosystem. Via a joint venture, Evonik and DSM plan to invest US\$100 million each in a suitable plant.

The High Performance Polymers Business Line has now made its SEPURAN® membrane technology available also for helium upgrading. In Mankota (Canada), a unique facility extracts 99.999 percent helium from the 250,000 cubic meters of gas produced daily, although the crude gas contains not even two percent of helium. The plant was constructed by our partner Linde.

Finally, Creavis, in conjunction with Process Engineering, has optimized the production process for the sugar substitute isomalt, which is suitable even for diabetics. A demonstration plant has now been started up in Thailand—in the region where, with almost every tenth Asian suffering from type 2 diabetes, global demand is at its highest.

All of these three developments, which are close to market launch, take us nearer to our growth target. The formula for this success is the integration of internal and external expertise into a powerful team. Because cutting-edge research is not carried out behind closed doors.



**Dr. Ulrich Küsthardt**  
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# A BIG FISH

**Evonik and DSM plan to help the salmon aquaculture industry to achieve further growth in a sustainable way. By producing an algal oil through fermentation they offer customers an alternative for omega-3 fatty acids, which to date can only be provided to salmon in the form of fish oil. Today millions of tons wild fish are needed to produce fish oil, a finite resource. DSM and Evonik are able to contribute with this alternative for fish oil to help restore marine biodiversity. And salmon feed is only one of the many possibilities for its use.**

*Dr. Christoph Kobler and Dr. David Nickell*

**T**he year 2015 marked a turning point for aquaculture: More than 180 million metric tons of fish, crustaceans, and shellfish were caught or produced globally, and for the first time the quantity produced from aquaculture was as large as that fished from the sea.

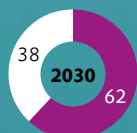
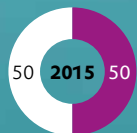
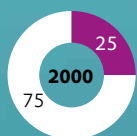
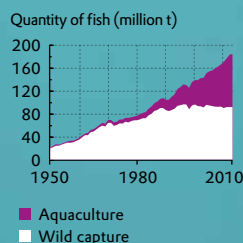
The figures indicate that demand for fish is growing, and with it the importance of aquaculture. The main reason for this is the growing world population because fish, ahead of pork and poultry, is the most important animal protein source for humans. It is very rarely beset with religious taboos and is readily available in many coastal regions of the world.

Fish contains not only valuable protein but also the essential long-chain polyunsaturated omega-3 fatty acids EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). Many studies have confirmed that EPA and DHA promote neuronal development in children, protect against cardiovascular disease, and lower the risk of dementia or Alzheimer's disease in the elderly, among other benefits.

EPA and DHA are essential nutrients: The human organism can produce them only in very small amounts and they are largely ingested from food. Humans are therefore dependent on fish, particularly fatty fish such as mackerel, herring, and salmon. These accumulate EPA and DHA in their flesh and are the main source of omega-3 fatty acids

## Aquaculture versus wild capture

Aquaculture is gaining in importance because wild capture cannot meet the demand for fish. According to the FAO, 62 percent of the fish produced will come from aquaculture by the year 2030.



Data in percent

in human nutrition. International health organizations such as WHO (World Health Organization), the British Nutrition Foundation, and the Heart Foundation recommend that (depending on the organization) between 250 and 500 milligrams of omega-3 fatty acids should be ingested from food every day. One meal of fish each week will provide this amount.

## Insufficient supply with omega-3 fatty acids

Countries such as Portugal, Finland, Korea, and Norway, where fish is a staple due to their geographical position, easily achieve the recommended values, and Malaysia, Japan, and Iceland even significantly exceed them. But large parts of the world, including Germany, the USA, and, bringing up the rear, Bulgaria and China, receive less than the recommended amount. In many countries, therefore, health considerations require that fish be eaten more often, and this also fuels demand.

But there's a fly in the ointment. Already at the end of the 1980s the world's oceans had been fished to their full natural capacity. Since that time, the quantity of fish and other aquatic animals taken from the sea annually has leveled out at about 92 →

**More than 30 percent of industrially fished species are being caught at an unsustainable level. They are over-fished.**

Source: FAO (2016)



→ million metric tons. But, although the constancy of the figure may seem to point to the attainment of some kind of equilibrium, these 92 million metric tons are dearly bought: More than 30 percent of industrially fished species are being caught at an unsustainable level and are overfished (FAO, 2016). Fishermen need to go ever further out to sea because the coastal regions are already overfished. They need more fuel and expensive equipment to be able to fish at greater depths, and more time to catch the same quantity of fish.

This makes fishing in some cases less profitable, and fish more expensive, which is particularly problematic in poorer countries. But the highest price is paid by the marine ecosystem, because overfishing continues apace, reducing biodiversity.

Adequate provision of humans with omega-3 fatty acids and overfishing of the seas are therefore in direct conflict. One way out of the dilemma is offered by aquaculture, or fish farming. It has been clear since the mid-1990s that the growing demand for fish can be met only by aquaculture.

Without measures, aquaculture itself will contribute to overfishing because wild stocks of predator fish like anchovies are increasingly exploited to feed farmed fish. Anchovies are converted to fish meal and fish oil: The meal provides protein and thus the most important amino acids, while the oil provides fatty acids for aquaculture.

Moreover fish oil contains the valuable omega-3 fatty acids that are accumulated over the food chain. The original sources of the omega-3 fatty acids EPA and DHA are microalgae, which are natural producers of these long-chain polyunsaturated omega-3 fatty acids. Across the food chain—from algae, through krill and small fish, to fish oil—fatty acids reach fish reared by aquaculture through their feed, and eventually arrive on our plates.

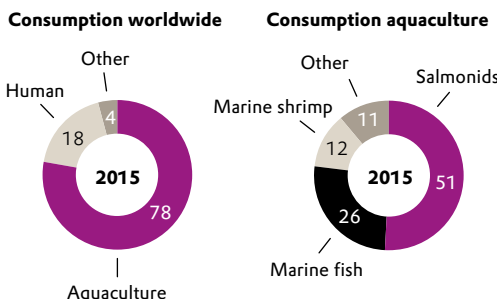
### Fish oil is a limited resource

Every year 16 million metric tons of wild fish are caught for processing to fish meal and oil; this represents about 18 percent of total wild capture. From sardines, herrings, sprats, and anchovies about 3.6 million metric tons of fish meal and about 1 million metric ton of fish oil are produced in this way; a small amount also comes from fish wastes and by-catches. Only this quantity of about 1 million metric tons of fish oil is thus available globally each year and can-

### Global consumption of fish oil

1 million metric tons of fish oil were produced in 2015, of which 400,000 metric tons were used in the aquaculture of salmonids (salmon and trout).

Data in percent



not be significantly increased because wild capture is limited.

And that also limits the future growth of aquaculture. In 2015 about 78 percent of fish oil went into aquaculture, the greater part of this for salmonids, comprising salmon and trout. About 400,000 metric tons of fish oil is used annually in their food; a classic feed mix contains about 10 percent by weight.

### Alternative sources of EPA and DHA necessary

In view of the scarcity of fish oil and the resulting increase in price, fish farmers have been trying over the last few years to further reduce the proportion of fish oil in feed and replace it with, for example, rapeseed or soybean oil. However, these vegetable oils do not contain the essential omega-3 fatty acids EPA and DHA, and feeding studies have shown that below a certain critical concentration of EPA and DHA mortality in salmon rises.

It is therefore clear that the problem can be solved over the long term only with an-

other source of omega-3 fatty acids. Chemical synthesis is not an option here. EPA contains five, and DHA six, unsaturated double bonds in the cis configuration, and chemists have to delve deep into their box of tricks to prevent the synthesis from proceeding in the direction of the energetically more favorable trans configuration. This makes a chemical process very complicated and uneconomical.

Given the food chain—microalgae, krill, small fish, large fish—it makes sense to start with the algae. The simplest method is to breed the algae in industrial fermentation plants and dry them to give a fat-containing powder that is added to the feed.

This causes problems for feed producers, however. Feed mixtures are normally processed without fish oil to feed pellets, which have a microporous surface. The fish oil is then sprayed onto these in vacuum and is absorbed by the pellets. Algae, on the other hand, must be processed directly with the feed mix, and their high fat content can give rise to severe technical problems in pelleting.

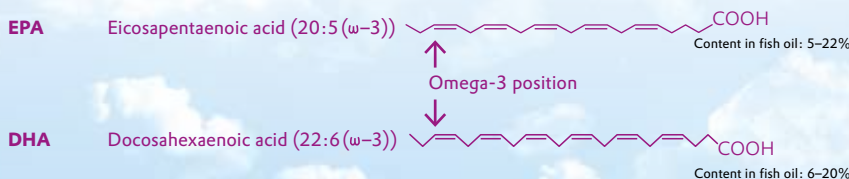
### Natural microalgae for healthy fish

Evonik and DSM have decided on a more elegant solution: fermentative production of omega-3 fatty acids from natural microalgae. The process produces an algal oil containing EPA and DHA in a concentration of about 50 percent. The liquid product form is perfectly suited to the production processes of feed manufacturers, who in the future can spray the algal oil onto the feed pellets at the end of the process, as previously with fish oil. In addition, the high concentration gives them adequate flexibility in feed formulation and in the individual composition of feed formulations.

Moreover, DSM and Evonik use a natural strain of algae that is not genetically

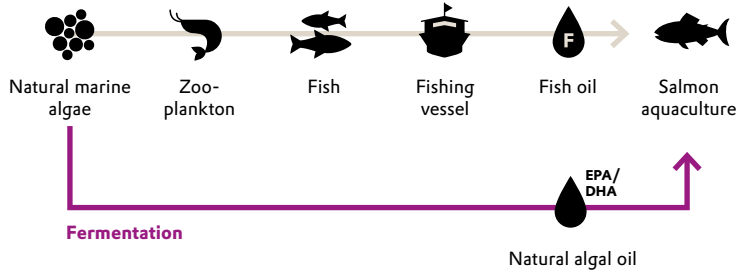
### EPA and DHA

Due to the cis configuration of EPA and DHA, which is energetically less favorable than the trans configuration, chemical synthesis of the omega-3 fatty acids is complex and therefore economically unviable.



### Uncoupling from wild capture

By fermentative production of omega-3 fatty acids Evonik and DSM plan to bridge the food chain from marine algae to salmon, and so to uncouple from wild capture.



modified. End consumers expect natural, healthy, sustainably produced foods, a need that DSM and Evonik have taken into consideration from the start in their joint development. Additionally, the European salmon industry in particular puts great emphasis on natural raw materials. The newly developed algal oil is convincing from the aspects of both sustainability and naturalness.

The starting point of this process is a strain of algae of species *Schizochytrium sp.*, which simultaneously offers two advantages. It produces EPA and DHA in markedly high concentrations and obtains its energy from dextrose—a stroke of luck for fermentation.

During the process, the algae accumulate the fatty acids in oil vesicles, which at the end of the fermentation contain between 60 and 70 percent oil. In the downstream process that has been developed in-house, the cells are macerated and the oil phase is separated from the aqueous phase and dried. In a final step, natural tocopherols are added as an antioxidant because the omega-3 fatty acids, due to their many cis double bonds, must be protected against oxidation by atmospheric oxygen.

### Production already in planning

Evonik and DSM started the joint development of the fermentation process and strain optimization in mid-2015. The pilot-scale production is now taking place at a plant at DSM's existing Kingstree site in the U.S. state of South Carolina, and the development is now ready for the next stage: commercial-scale production. The process, which is currently being further developed,

### The advantages expected

The oil produced from natural marine algae is particularly rich in EPA and DHA. This means that:

**50**

percent EPA and DHA is the minimum content of these substances in algal oil.

**15**

percent of the demand of the salmon aquaculture industry for EPA and DHA will be met by the new plant.

**2**

tons of wild caught fish can be saved per ton of salmon feed.



Most farmed salmon comes from Norwegian aquaculture.

is protected by 40 patent families in many countries of the world.

One critical factor in this success was that the partners forged ahead at full steam with the project, in which more than 100 employees from both companies are participating. Together they have all the tools needed for the development of a solution of this kind: expertise in the cultivation of marine organisms, strain development, fermentation, and commercial implementation of the biotechnological processes. The algae strain used as well as strain development and optimization are contributed by DSM, while Evonik lends its experience in the development, optimization, and scale-up of biotechnological processes.

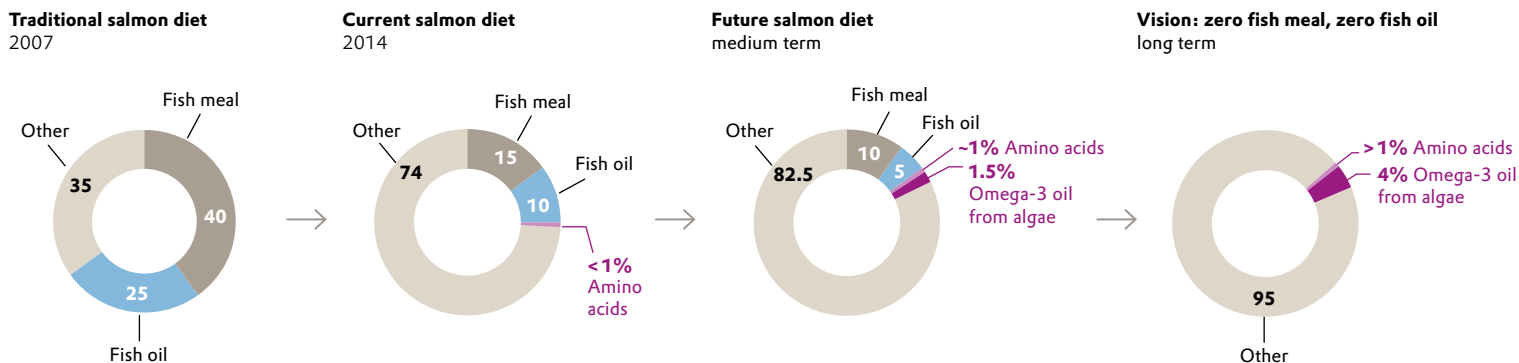
DSM and Evonik have now moved on to the next stage: The companies will together build a commercial-scale production facility at an existing site of Evonik; it is expected to come on stream in 2019. The planned initial annual production volume will meet about 15 percent of the current demand of the salmon aquaculture industry for EPA and DHA. Production management and marketing will be carried out by the newly established joint venture Veramaris, in →



### Less fish in fish feed

By the addition of amino acids, and now also algal oil, the proportion of fish-derived ingredients in salmon feed can continue to be reduced—in the ideal case to zero at some time in the future, according to the expectations of Evonik and DSM.

Data in percent



→ which DSM and Evonik each have a 50 percent stake.

About 3.5 million metric tons of salmon are consumed every year, which is about five percent of total fish consumption. The market is therefore relatively small as compared with other fish species from aquaculture: For carp, for example, which is very popular in India and China, the figure is about 18 million metric tons. Aquaculture of salmon with substitution of fish oil nonetheless offers the best lever for improved sustainability, because about 40 percent of global fish-oil production flows into salmon farming.

#### Ambitious vision: zero fish oil, zero fish meal

For many years now salmon feed has been using the amino acids DL-methionine, L-lysine, and L-threonine from Evonik. This has made it possible to partly replace animal protein with plant protein: In 2008 salmon feed contained about 40 percent fish meal, compared with just 15 percent today. With the combination of amino acids and algal oil in the feed, the proportion of fish meal will be further reduced to ten percent, and that of fish oil from the current ten percent to five.

So salmon farming will become significantly more sustainable: As a result of the addition of fish oil and fish meal, a salmon

**“Consumers expect natural, healthy, sustainably produced foods, a need that we have taken into consideration from the start.”**

*Dr. Christoph Kobler*

today needs the equivalent of about 2.6 kg of fish to gain 1 kg in weight. The new feed concept will make it possible to reduce the quantity of fish required to less than one kilogram. But Evonik and DSM are already thinking ahead: Their vision is nothing less than zero fish oil and zero fish meal.

And salmon is just the beginning, because other animals also need EPA and DHA—not just bream, sea bass, and shrimp, but also dogs and cats, whose feed also contains fish oil. But that is expected to change for pet food manufacturers from 2020 onward: Large producers of dog and cat food will from that date be under a self-imposed obligation to avoid the use of fish oil, on sustainability grounds.

In view of their aim to bring the first batches of algal oil onto the market in 2019, Evonik and DSM have chosen the perfect time to establish their new joint venture. If their plan succeeds it will also be good news for the world’s oceans.

#### The experts



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**Dr. David Nickell** is Vice President Global Marketing & Business Development, Animal Nutrition and Health at DSM Nutritional Products.

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**Video on the topic:**  
[bit.ly/2pKsQsH](http://bit.ly/2pKsQsH)

## Guest commentary

# Important for brain and heart

*Prof. Dr. Clemens von Schacky*

In many countries in the Western world, large segments of the population have low levels of the two marine omega-3 fatty acids EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). Levels of these substances are usually assessed in red blood cells with a standardized analytical procedure (HS-Omega-3 Index®). Low levels of EPA and DHA are associated with a short life expectancy, cardiovascular disease, cognitive impairment, attention deficit hyperactivity disorder (ADHD), major depression, and other health issues.

Meta-analyses of intervention trials in cognitive impairment, ADHD, major depression, and other issues of brain function rather consistently demonstrate the positive effects of EPA and DHA, thus establishing causality. EPA and DHA have also been demonstrated to slow the aging process of the brain and the muscle tissue.

By contrast, the majority of trials in the cardiovascular field had neutral results. However, these were most likely due to methodological problems recently detected in the measurement of EPA

**“Meta-analyses of intervention trials have shown rather consistently that EPA and DHA have a positive effect on cognitive disorders such as cognitive impairment, ADHD, and depression.”**



**Prof. Dr. Clemens von Schacky** is a professor at the Ludwig-Maximilian University of Munich Medical Center, where he is head of Preventive Cardiology for the Medical and Outpatient Clinic I (Medizinische Klinik und Poliklinik I). The cardiologist is also Managing Director of Omegamatrix GmbH.

and DHA levels. Trials in the cardiovascular field that inadvertently avoided these methodological problems had positive results.

All in all, these findings show that there is a widespread deficit of EPA and DHA in humans. Interestingly, this does not seem to be restricted to humans: In dogs, meta-analyses of intervention trials demonstrated positive effects of EPA and DHA on joint problems, and some trials showed positive effects on skin problems. Fewer, but similar, data have been published for cats.

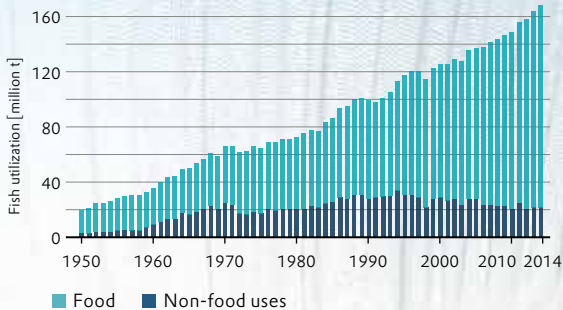
In order to fight the dire consequences of the deficit in EPA and DHA, their supply must be increased since neither humans, dogs, nor cats can synthesize these omega-3 fatty acids in sufficient quantities. The main sources of EPA and DHA are fish and fish oils from the sea. The yield of EPA and DHA from the sea has been constant for many years and cannot be increased, which has led to increasing prices.

As a consequence, fish farmers use less EPA and DHA to feed their fish, causing the levels of these omega-3 fatty acids in farmed fish to decrease over the years and aggravating the problem of a deficit in humans. At least some of the EPA and DHA not used in aquaculture is redirected to production of dietary supplements. Clearly, however, there is a huge need for novel sources of EPA and DHA.

### Growing demand

In 2014, 167 million metric tons of fish were utilized worldwide. The most important non-food use is the production of fish meal and fish oil.

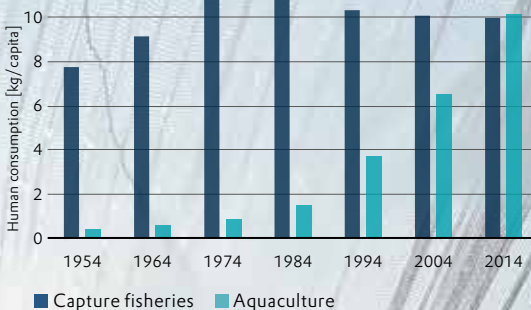
Source: FAO (2016)



### Stagnating traditional fish catch

In 2014, for the first time, the quantity of farmed fish consumed equaled the quantity of captured fish.

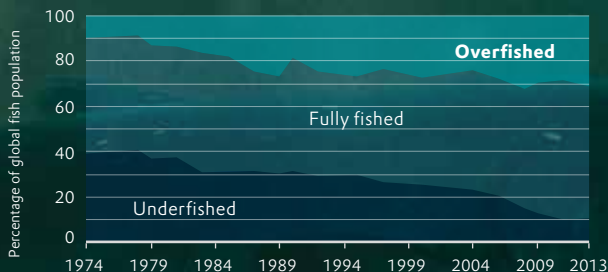
Source: FAO (2016)



### Overfishing continues

Approx. 90% of the world's fish stocks are in a critical state. Approx. one third is already overfished.

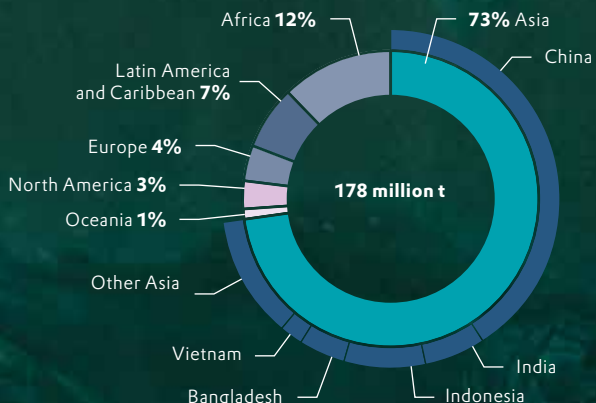
Source: FAO (2016)



### Greatest demand in Asia

In 2025, according to FAO, 178 million metric tons of fish will be consumed, nearly three quarters of this in Asia.

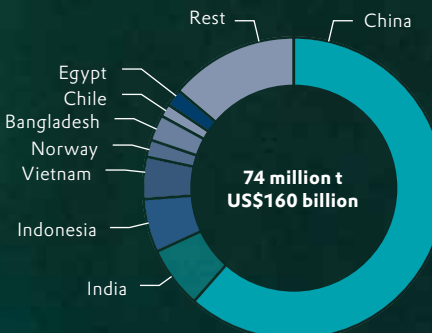
Demand by region (2025)  
Source: FAO (2016)



### Aquaculture by country

In 2014, 74 million metric tons of fish was produced in aquaculture (estimated value: US\$160 billion). Nearly 62% of this came from China.

Aquaculture production by country (2014)  
Source: FAO (2016)



# 2.2 g

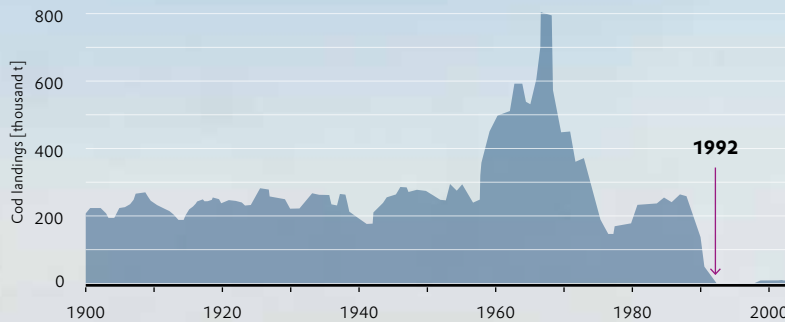
unsaturated omega-3 fatty acids

are typically contained in 130 g of Atlantic salmon. This covers the weekly requirement of a human.

DATA MINING

# Oceans under pressure

Fish is a valuable source of protein and omega-3 fatty acids. Since 1961, the consumption of fish has grown by an average of 3.2 percent annually, twice as fast as the world's population. The Food and Agriculture Organization of the United Nations (FAO) estimates that fisheries and aquaculture support the livelihoods of 10–12 percent of the world's population. Since many types of fish are fully fished or overfished, aquaculture is becoming more and more important.



### Overfishing: Atlantic cod as an example

Up to 1960, the Atlantic cod stocks were stable. As of 1970, they decreased as a result of intense fishing and collapsed in 1992. Due to strict fishing quotas, they are making a gradual recovery.

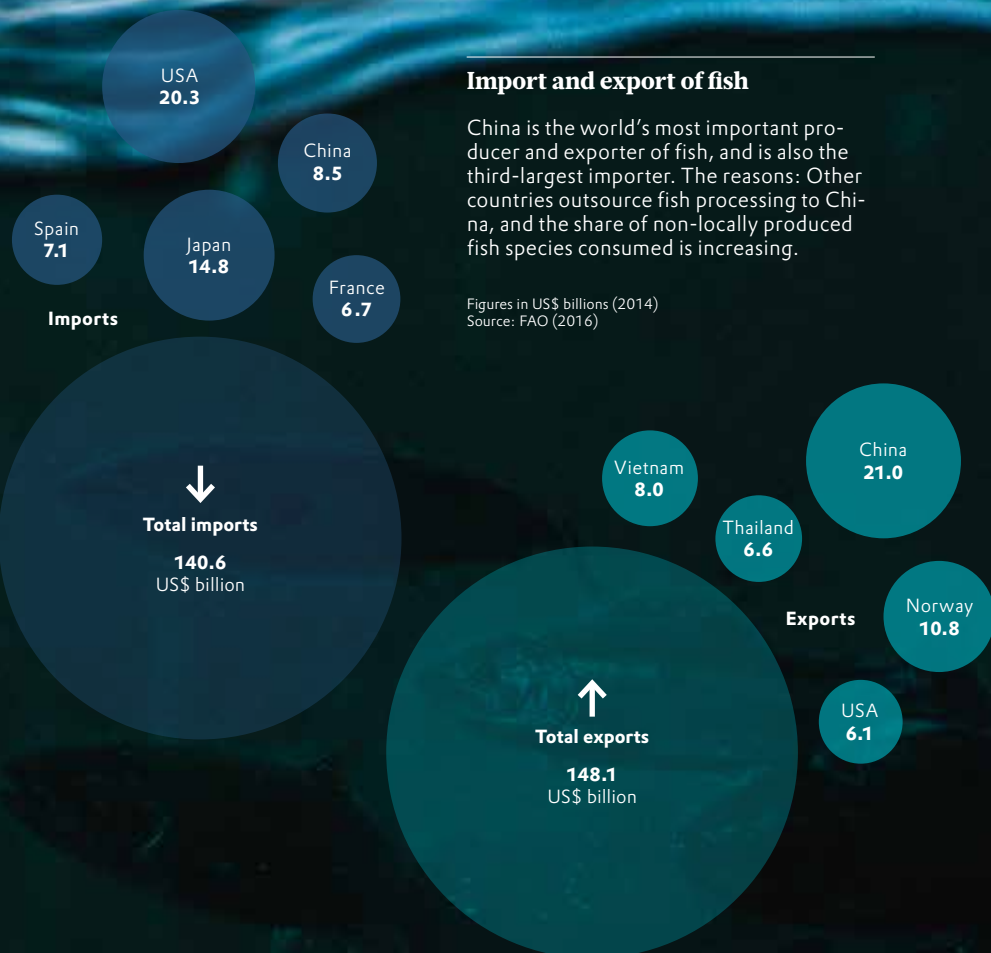
Source: UNEP/Grid Arendal (2005)



### Import and export of fish

China is the world's most important producer and exporter of fish, and is also the third-largest importer. The reasons: Other countries outsource fish processing to China, and the share of non-locally produced fish species consumed is increasing.

Figures in US\$ billions (2014)  
Source: FAO (2016)



### Efficient feed converter

For only 1.3kg of feed, a salmon will gain 1kg of body mass because it requires very little energy to maintain its body temperature and to move.

Figures: kg of feed required to gain 1 kg of body mass



Sources: B. Tolkamp et al. (2010). Review of nutrient efficiency in different breeds of farm livestock. SAC Animal Health; www.bcsalmonfacts.ca (2012); Albert G. J. Tacon (2016)

# SEPARATING NOBLE GASES

**Within a mere four years, the SEPURAN® Green hollow fiber membrane has conquered the biogas upgrading market. A more advanced variant is now in use that helps separate and recover the noble gas helium.**



12



Being lighter than air, helium is used as a lifting gas for balloons and airships.

Dr. Jörg Balster, Dr. Goetz Baumgarten, and Dr. Daniel Bergmair

Chemists describe “noble” as those substances that bind to other substances only with relative difficulty; this applies to noble metals like platinum and gold and also to noble gases like helium. Most people, on the other hand, understand “noble” to mean valuable—and they wouldn’t be wrong: Platinum is known to be considerably more expensive than, for example, iron. And one cubic meter of gaseous helium costs between €8 and €30 depending on the purchase quantity and the purity, among other factors. By comparison, one cubic meter of natural gas is available to a private customer for only about 60 euro cents.

One reason for the high price of helium is its high demand. The gas is used to cool magnetic resonance tomographs (MRTs) in hospitals and to fill balloons and airships. It is also used in glass fiber production, welding, and the electronics industry, and in leak detection for systems and equipment. But helium is rare. It has been extracted from the few natural gas sources worldwide where it is present in proportions between two and eight percent. The world market is currently divided between the producing countries: the USA, Algeria, Qatar, Russia, and Poland.

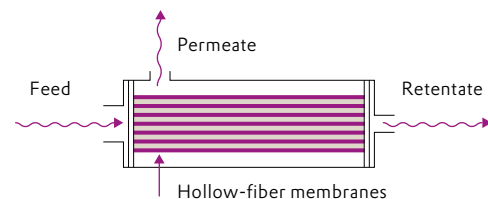
### Membrane technology for Canada

Since August 2016 Canada has also been producing helium. A unique plant has come on stream in Mankota, which extracts 99.999 percent helium fully automatically from the 250,000 cubic meters of gas produced daily. The plant was built by the Engineering Division of the Linde Group. Its distinguish- →

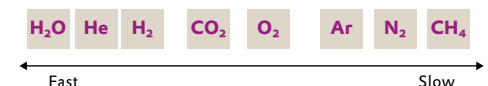
#### Different speeds

The hollow-fiber membranes of the SEPURAN® family exploit the different permeation rates of gas components through porous membrane structures to selectively enrich certain components.

#### Mode of operation of a membrane module for gas separation



#### Relative permeation rates of various gases



Photography: istockphoto | Graphic: C3 Visual Lab



Helium upgrading in Mankota (Canada): The membranes (above) and the plant constructed by Linde.



→ ing feature is that Linde has combined an established gas-separation process with Evonik's new SEPURAN® Noble membrane technology. This hybrid process allows particularly efficient enrichment of helium in the Canadian gas source, where the helium content is well below two percent. Linde was thus able to make a persuasive case to Weil Group Resources, the owner of the gas source, and to come out ahead in global competitive bidding.

SEPURAN® membranes consist of polyimide, a high-performance polymer whose resistance to high temperatures and aggressive chemicals has been proven over many decades. For example, the polyimide is also used in hot-gas filtration in cement and steel smelting plants. Spinning systems at Evonik's site in Schörfing (Austria) produce the material in the form of fibers with a very special architecture: Their interiors are hollow. The material is highly porous all the way up to this cavity. The pores become progressively smaller toward the exterior. A relatively dense shell, less than 100 nanometers thick, forms the surface of the fibers.

Gases whose molecules are very small (kinetic diameter) can permeate this skin faster than those whose particles are larger. In this way the skin can distinguish between, for example, carbon dioxide and methane, or helium and methane. The remaining porous part of the fiber does not help in gas separation because the pores are too large for this purpose; it serves as a supporting element, lending the material mechanical stability. Evonik bundles tens of thousands of these hollow fibers into a membrane module in a stainless steel housing.

The SEPURAN® Green membrane modules currently in use for biogas upgrading in more than 100 facilities worldwide are not perfectly suited for extracting helium: Due to the low proportion of helium in natural gas, SEPURAN® Green membranes do not upgrade the noble gas to the desired extent. What is needed is a membrane that can select helium from the rest of the gas even

more effectively than SEPURAN® Green. Evonik's specialists have succeeded in producing such a membrane by modifying the spinning process for fiber production. Evonik markets this membrane under the name SEPURAN® Noble.

### Customized hollow fibers

If you now think that a higher separation efficiency than that offered by SEPURAN® Green would also work for methane and carbon dioxide, and could thus also improve biogas upgrading, you wouldn't be wrong. But SEPURAN® Noble would not allow sufficient permeation of either gas: The higher selectivity of this SEPURAN® variant comes at the cost of lower productivity.

In the case of helium this is not critical, however, because it can pass through the membrane much faster than, say, carbon dioxide. The skill of the SEPURAN® team

thus lies in customizing the properties of the hollow fiber membranes for the application in question. In this way it fully exploits the already very good gas separation properties of polyimide.

In the hybrid reference plant in Mankota, SEPURAN® modules upgrade the crude gas to a helium content of about 50 percent. From the resulting gas mixture, almost pure helium is then obtained by pressure swing adsorption (PSA). In this well-established method, the pressurized gas mixture is passed through a solid bed. Helium remains almost totally unadsorbed on this solid while the other gas components are deposited on or in it. As soon as the adsorption capacity of the solid is exhausted, it is regenerated by reducing the pressure. Two solid beds are operated concurrently so that PSA continuously provides helium; while one of these is in the adsorption mode, the other is being regenerated.

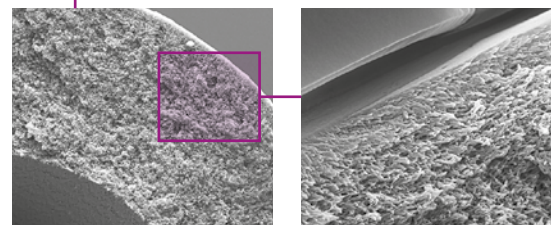
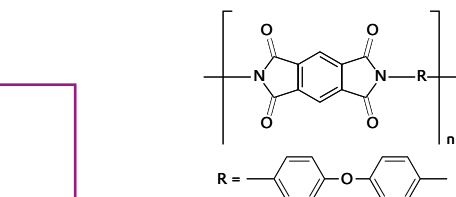
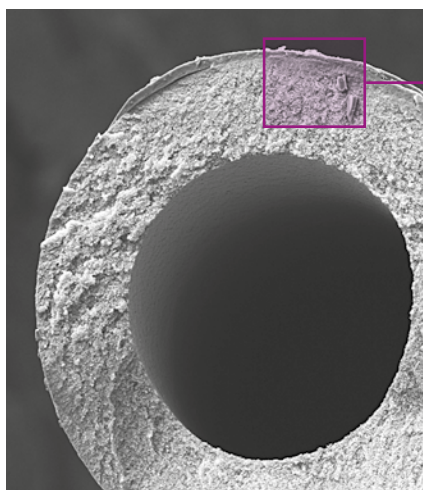
The PSA process only functions well with a helium content of at least 25 percent, and its effectiveness increases with the helium content. This is why initial upgrading of the crude gas by SEPURAN® membranes is necessary. The two processes complement each other perfectly because the membrane process produces an unpressurized helium gas mixture that is subjected to pressure by PSA. The pure helium finally obtained is thus also under pressure, which reduces transportation costs.

### Collecting and upgrading used helium

Helium is expensive, and large users may find it worthwhile to recover the used noble gas; they too can benefit from SEPURAN® Noble. These large users include producers of optical fibers transmitting internet data and phone calls. The helium is particularly

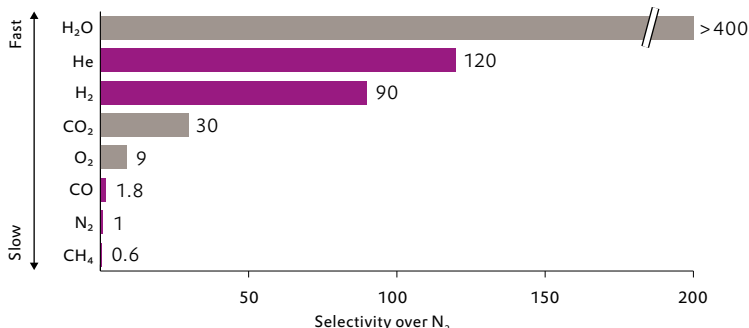
### Structure and chemistry of a SEPURAN® membrane

Scanning electron micrographs show the large-pore supporting structure of the hollow fibers and the fine-pore separating skin. The base chemical material is polyimide.



## Highly selective

SEPURAN® Noble is distinguished by high selectivity in the separation of helium from natural gas (CH<sub>4</sub>); the selectivity is the ratio of the permeabilities of the gases.



Mixture	Selectivity
H <sub>2</sub> / CO	50
H <sub>2</sub> / N <sub>2</sub>	90
He / N <sub>2</sub>	120
He / CH <sub>4</sub>	200

effective for cooling the glass fibers as these are drawn from the hot melt. This increases production speed: A single plant can produce more than two kilometers of fiber per minute. But helium cooling is costly: Many glass fiber production facilities spend hundreds of thousands of euros on helium annually.

Nextrom, a leading global plant engineering firm for the glass fiber industry, has now developed a solution for fiber producers that is based on SEPURAN® Noble. It offers a system in which the used helium is collected, cleaned, and re-used for cooling. As much as 90 percent of the helium can be recovered in this way.

A mere two years after market launch, SEPURAN® Noble has now become established in the glass fiber industry; the SEPURAN® team owes this success partly to the support of their colleagues from Silanes, who are familiar with this sector. Moreover, membrane technology can be very easily integrated into glass fiber production because the upgraded helium need not be liquid nor ultrapure. But this is not the case for other helium applications, such as magnetic resonance tomography, where it will take somewhat longer for SEPURAN® Noble technology to gain a foothold. Membrane experts are nonetheless convinced that the technology will also establish itself in applications other than optical fibers.

## Also valuable for hydrogen

Hydrogen passes through membranes as easily as helium: Although hydrogen consists of diatomic molecules, these are not much larger than a single helium atom. SEPURAN® Noble modules can therefore also be used to separate hydrogen from carbon monoxide and other gases. Carbon monoxide and hydrogen are the main components of synthesis gas, obtained for example from coal but increasingly also from biomass and waste. Synthesis gas can be

processed further in specific ways to yield a very wide range of products such as liquid gasoline-like fuels or methanol. The proportion of CO and H<sub>2</sub> in synthesis gas must be adjusted according to the product desired; this is done by using membranes.

SEPURAN® Noble membranes also allow hydrogen to be recovered from nitrogen-hydrogen mixtures. This is important in, for example, the synthesis of ammonia, which is the starting material for nitrogenous fertilizers, because in the Haber-Bosch process the reaction between nitrogen and hydrogen to yield liquid ammonia does not go to completion. The remaining gas mixture is fed back into the process after the hydrogen content has been increased by membrane methods. Here, as in the upgrading of synthesis gas, the use of membranes is well established. But, thanks to its superior gas separation properties, SEPURAN® Noble could potentially replace the membranes currently being used.

The inert gas helium is expensive and in high demand. It is obtained from a few natural gas sources scattered throughout the world.



## The experts



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In the future, Evonik will not only produce cast PMMA sheets but also carry out the stretching and polishing processes.

*Roland Mickal*

**T**hat feeling when even the highest peaks and summits appear smaller and smaller and major cities are all but glowing dots on the ground—the view from an airplane is truly breathtaking. The only ones who can really enjoy it, however, are those sitting right next to the windows, which, after all, are only 29 centimeters high. Larger panels would mean that all passengers could share the enjoyment. A clear view above the clouds for all passengers—according to concept studies on future airplanes, this could become a reality in several years. Experts even assume

that fully-glazed airplanes will circle the skies of the future, with huge panoramic windows that offer an unobstructed view to passengers and pilots alike. But already today, the trend is clearly towards larger cabin windows in commercial airplanes.

With its PLEXIGLAS® brand of products (PMMA, poly(methylmethacrylate)), Evonik has been one of the leading manufacturers of aerospace materials for more than 80 years. The fact that the brand-name acrylic glass is used in aircraft production is due to its high optical quality, good processability, and outstanding resistance to UV radiation and to the elements. In addition, PLEXIGLAS® is considerably more durable

# A PERFECT VIEW WHEN FLYING

There is an increasing trend towards ever larger airplane windows. Evonik is therefore investing in a new stretching and polishing line with the goal of delivering extra-large PLEXIGLAS® panels for the aerospace industry starting in 2018.

**“As of 2018, we will provide the largest sheets worldwide.”**

*Martin Krämer, head of the Acrylic Products Business Line*

than glass and weighs only half as much—two factors that are particularly important at high altitudes.

## Full-service provider for the aerospace industry

A special type of PLEXIGLAS® is used in airplanes and helicopters. In simple terms, this means that certified sheets from cast PLEXIGLAS® are elongated or stretched in a highly elaborate and complex process. The advantage of stretched PMMA sheets is that they have improved impact resistance and increased chemical stability. Evonik already ranks among the leading manufacturers of the primary product needed for stretched

sheets. With the new plant in Weiterstadt, Evonik will also be able to stretch and polish the sheets at its own facilities as of 2018—including sheets that are considerably larger than the ones being produced today. The Acrylic Products Business Line at Evonik will thus become a full-service provider of cast and stretched PMMA sheets for the aerospace industry. This is yet another example of the smart way the Group is shaping its business with PLEXIGLAS®.

When windows and cockpit windshields in airplanes and helicopters are to become larger, there is no way around producing stretched PLEXIGLAS® sheets in the largest size possible. Full-glazed airplanes and →

# 30,000

The **number of airplanes** that the four largest manufacturers of passenger planes are expected to deliver by 2031.



Helicopter glazing made from PLEXIGLAS® ensures good visibility—despite extreme changes in temperature and aggressive UV radiation.

→ panoramic windows above the clouds may still be some way off, but the airplane manufacturer Boeing has already started by enlarging the windows of its current Dreamliner model by two-thirds.

## Large glazing made from a single piece

There are limits, however, to what the industry can achieve in terms of extra-large windows. The current maximum size of stretched sheets made of PMMA is only 2.5 by 2.5 meters. Multiple windows for passenger planes can be cut from sheets like these, but this format is too small for large panorama windows or sophisticated cockpit windshields cut from a single piece.

Evonik will be launching stretched sheets with a size of up to 3.7 by 5.4 meters and delivering them directly to manufacturers of airplane windows. This large format of stretched sheets paves the way for new designs of extra-large glazing, which means that the specialty chemicals company is laying an important foundation for the production of panorama windows in airplanes.

In addition, as the format increases, so does the production efficiency for smaller cabin windows. The advantages of these



Quality control of sheets from cast PLEXIGLAS® at the Evonik plant in Weiterstadt (Germany)

extra-large stretched sheets, after all, apply to more than just growing window sizes and cockpit windshields: Manufacturers of conventional airplane windows can also produce more windows than before from a single stretched sheet.

Evonik is investing a two-digit million euro amount in the new facility being built in Weiterstadt (Germany), which will be the most modern of its kind anywhere in the world. Here, cast PLEXIGLAS® sheets will be heated and then stretched, expanding their surface area from one square meter to three. The cooled material will then be sanded and polished. Thanks to the new sanding and polishing process that Evonik is establishing at the plant, the stretched sheets will have considerably better thickness tolerances than materials currently made by competitors. This reduced thickness tolerance will result in more uniform technical properties throughout the material, making it easier to process the stretched sheets into the end product, i.e., the airplane window. One look at the market demonstrates that the investment in the new facility was a smart move: Forecasts indicate a demand of roughly 30,000 new passenger planes by 2031.

### The expert



**Roland Mickal** heads up the Transportation market segment of Evonik's Acrylic Products Business Line.

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# Company News

## “CLEAR, CONSISTENT, COOPERATIVE”

For Evonik’s new Chairman Christian Kullmann, innovation is essential. Together with his Executive Board colleagues he wants to make Evonik the world’s best specialty chemicals company.

**C**hristian Kullmann also has a very clear idea of how the goal can be attained. Innovation plays a key strategic role here, as is clear also from the fact that the Group’s annual investment in R&D exceeds €400 million. “From now on we will focus on our future markets with a clear strategy and defined milestones. We have the vision of making Evonik the most innovative company in the world.”

Corporate strategy is centered on the acceleration of steady and profitable growth. But growth does not mean merely increasing sales revenues. “Far more important are our return on investments, which we intend to increase to the top levels in our industry, and to keep them there,” said Kullmann.

He pointed out that Evonik’s strengths are its leading market positions, its maintenance of high market entry barriers, and intensive long-term partnerships with customers. “We don’t merely want to sell products: We want to offer our customers solutions,” said Kullmann.

He stated that a strong corporate culture is a key lever for reaching these ambitious goals. “We’ll do this together, with a success-oriented management culture following the motto ‘clear, consistent, cooperative.’ Say clearly what is on your

mind; and then act consistently in a spirit of cooperation,” he said during a town hall meeting in Essen that the approximately 35,000 employees were able to view on the intranet.

Kullmann took over from Klaus Engel as chairman of the Executive Board on May 23, 2017. He will also be acting head of Innovation until September 1, when Dr. Harald Schwager joins the Executive Board as the new deputy chairman with responsibility for chemicals and innovation. Schwager, who is a chemist, was on the Board of Executive Directors at BASF until May 2017.



Christian Kullmann, the new Chairman of the Executive Board at Evonik

## Acquisition in cosmetics

**E**vonik has acquired Hamburg-based cosmetics specialist Dr. Straetmans GmbH, who develop and market alternative preservatives for the cosmetic industry. This move allows Evonik to complement the specialties portfolio of its cosmetics business and to further consolidate its position as a leading global partner for the cosmetics industry.

Dr. Straetmans, which employs over 60 people, will continue to operate as a legal entity. The company's Hamburg site will become the Evonik Group's global competence center for preservative



Dr. Straetmans specializes in preservatives for cosmetics products.

solutions. In the future Evonik will be able to offer complete formulation systems including preservatives.

Alternative preservative systems perform additional functions in the final product, such as acting as a moisturizer.

## New coatings laboratory

**E**vonik has opened a new coating additives laboratory at its Tuzla (Istanbul, Turkey) site. The lab, which also includes a customer service center, will support customers with the development of innovative surface coatings throughout the Middle East.

The state-of-the-art laboratory features a spray booth and a climatic chamber, allowing the lab staff to process a wide array of customer requirements for paint and coating applications. With the lab it is possible to formulate, apply, and test a variety of industrial coatings, transportation coatings, wood

coatings, and also architectural coatings and printing inks in water-based, solvent-based, or radiation-curing formats.



The coatings lab in Turkey.

## Leading additive supplier

**T**he acquisition of the Performance Materials division of the US company Air Products has transformed Evonik into one of the leading suppliers of additives for the coatings industry. Evonik has now merged its former Coating Additives Business Line, the coatings business of its Silica Business Line, and the specialty additives branch of Air Products with a focus on substrate wetting additives.

The new Coating Additives Business Line employs a workforce of around 450 across some 30 production and research sites and offers around 500 products. Its broad technology platform enables the development of innovative solutions for just about any formulation challenge in the paints and coatings industry.

## Evonik invests in Chinese fund

**B**y investing in the Chinese Hosen Capital Fund III, Evonik is boosting its corporate venturing activities in Asia. The fund invests in leading businesses and technology companies with a focus on the agriculture and nutrition sector.

Evonik's products and services in the area of animal nutrition play a key role worldwide in the production of healthy and affordable food, while preserving natural resources and reducing the



The focus of the Chinese fund is on food and agriculture.

ecological footprint. "Strategic involvement in the Hosen Capital Fund III promises Evonik access to partnerships with innovative technology start-ups in the Chinese agriculture and nutrition industry, which will provide impetus for further business development.

## Investment in Nanotech

**T**hrough its venture capital arm, Evonik has invested in Nanotech Industrial Solutions, Inc. (NIS), headquartered in Avenel (New Jersey, USA), and now holds a minority share in the company. NIS has developed a unique particle technology for the lubricants industry.

The company produces oil additives for engine oils, oil and water formulations for metalworking fluids, industrial oils, and additive formulations for greases. Under certain physical conditions, its patented technology releases nano-structured materials, which reduce friction and wear in moving parts. This technology therefore makes a substantial contribution to the resource efficiency of cars, power plants, and industrial plants.



NIS produces high-performance additives for lubricants.

## LCA for green tires

**I**n a Life Cycle Assessment (LCA) Evonik investigated the environmental implications of green tires with S-SBR rubber grades and silica/silane technology.

Among others, the study analyzed the global warming potential, the photochemical ozone creation potential, and the primary energy demands when using silica/silane and S-SBR in treads of passenger car tires over a driving distance of 150,000 km. Additionally, it looked at gasoline consumption, fuel savings, and lifetime.

According to the study, silica/silane technology in green tires is able to significantly reduce emissions and environmental impacts in the



Treads have an enormous impact on tire performance.

basic scenario in any analyzed impact category. Consequently, the global warming potential can be reduced by 4.9% in total over the whole life cycle; by replacing carbon black and E-SBR with silica/silane and S-SBR, emissions of up to 1.4 metric tons of CO<sub>2</sub> equivalent per 150,000 km driving distance are avoidable.

Further information on the Life Cycle Assessment:

<http://bit.ly/2mBhN1A>

## Progress in indulgent surgery

**E**vonik's VESTAKEEP® PEEK was selected as the material of choice for use in the KATOR™

Suture Anchor System, which has already been used successfully in surgical practice.

VESTAKEEP® PEEK's high fatigue resistance has proven critical in the successful development of the KATOR™ Suture Anchor System. The KATOR™ Suture Anchor System's anchors receive high stress loads throughout the healing process.

The repair construct's superior strength allows surgeons to repair rotator cuffs or reattach Achilles tendons using fewer suture anchors. This helps preserve more bone, and improve blood flow available for tendon healing.



VESTAKEEP® PEEK in the new KATOR™ Suture Anchor System.

## Joint venture for composite solutions

In collaboration with the Forward Engineering company, Evonik has established the joint venture VESTARO GmbH. With this project, the two companies intend to drive forward the implementation of composite solutions for the industrial mass production of fiber composite components for the automotive industry.

The core competencies of VESTARO are technology consulting and also the selection and adaptation of matrix formulations to meet specific customer requirements for efficient manufacturing.

Evonik is contributing its expertise in amine hardeners (VESTAMIN®) for epoxy resin formulations and isocyanate (VESTANAT®) for polyurethane formulations to the material developments of the new company.

VESTARO is to be managed jointly by Evonik and Forward

Engineering, with Evonik holding 49 percent of the shares. You will find further information at:

[www.vestaro.com](http://www.vestaro.com)

## Multi-layer PMMA films

Evonik has approved construction of a new production plant for high-quality flat



Facade with PMMA film.

films made from multi-layer polymethyl methacrylate (PMMA). To finance the project, the company plans to invest a sum in the double-digit millions in its Weiterstadt site. The plant is scheduled to supply the initial commercial film batches by the end of 2018.

Multi-layered PMMA films are used in medical technology, window and facade construction, and in the graphics industry.

The new plant allows the production of particularly wide films with a large number of layers, previously unattained. These PMMA films enable particularly long-lasting and sustainable products and offer customers new design and processing possibilities.

## New generation of superabsorbents



Even more absorptive: FAVOR®max high-performance absorbent.

With FAVOR®max, Evonik has developed the next generation of superabsorbents with unique properties that make baby diapers and incontinence products even more absorbent and reliable.

Just a few grams of the new FAVOR®max high-performance superabsorbent ensure fast absorption of large amounts of fluids and lasting dryness. This is made possible through a finely balanced combination of the superabsorbent's key performance parameters, which are adapted to the specific design of the absorbent core.

## BUNDLING DIGITAL EXPERTISE

Evonik is setting itself up for the digital future with its own new subsidiary, Evonik

Digital GmbH, which includes a team of about 20 experts. Under the Evonik umbrella, the company is developing new digital business models and acquiring digital expertise. In the newly created position of Chief Digital Officer (CDO), Dr. Henrik Hahn will coordinate digitalization activities for the Group. This way, Evonik is establishing a central contact point for technical dialog and strategic aspects as well as Group-wide digital innovations. Hahn is also Chairman of the Management Board of Evonik Digital GmbH, which is headquartered in Essen.



With a new subsidiary Evonik is setting itself up for the digital future.

# GUILT-FREE INDULGENCE

Evonik has developed a new process to produce the sugar substitute isomalt. Dispensing with the intermediate crystallization step, this innovative process is energy- and cost-efficient.

Jan Wolter and Thomas Hüller

**S**ugar substitutes promise enjoyment without a guilty conscience: Sweet-tasting polyols (sugar alcohols) are used in sugar-free candies, chewing gums, and desserts. They differ from ordinary household sugar in their greater stability against human digestive enzymes, as a result of which they are metabolized much more slowly. Polyols like isomalt therefore barely affect the blood sugar level and are moreover metabolized almost independently of insulin.

At 2.4 kilocalories per gram, their energy content is only half that of sugar—so you need not have a guilty conscience after eating them. Moreover, bacteria in the human oral cavity cannot convert sugar substitutes into acids that attack tooth enamel, causing caries. These are all compelling reasons for the end customer to opt for sugar substitutes.

Demand for sugar substitutes is therefore rising rapidly worldwide, and manufacturers of sweets are increasingly focusing on products with less sugar. The sugar substi-

### Advanced Food Ingredients

The Advanced Food Ingredients growth field focuses on natural food ingredients with scientifically proven health benefits and on formulation technologies that release ingredients at the right location in the human body.

tute isomalt is a particularly favored choice in the production of candies and chewing gums. It is the only sugar substitute to be produced from commercial-grade sugar and is easily handled in the manufacturing process. Like sugar, isomalt gives the finished product form and texture, but it absorbs almost no moisture from the air. Unpackaged candies therefore do not adhere to one another but are stable in storage and so meet customers' aesthetic requirements.

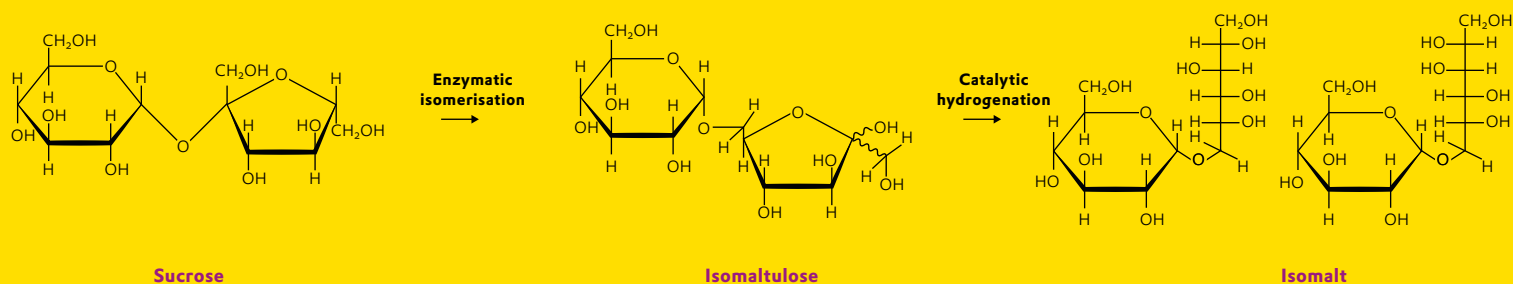
### A challenging process

But isomalt production has for many years posed a challenge to the industry: For sweets manufacturers to be entitled to describe their products as sugar-free, the residual sugar content of the sugar substitute used must meet the statutory requirement of less than 0.5 percent sugar.

And it has so far only been possible to satisfy this requirement by an additional purification step: In the two-stage production of sugar polyols, commercial-grade sugar (sucrose) is first converted enzymatically into an isomaltulose mixture and then hydrogenated to give isomalt (**Fig. 1**). In the first step, small proportions of two to three percent of sucrose remain in the mixture. Sucrose cannot be hydrogenated and remains in the isomalt end product, which therefore cannot be used in sugar-free candies, for example. →

**Figure 1: The classical pathway to isomalt**

First, sucrose is converted to isomaltulose, which, however, still contains small amounts of sucrose. Before hydrogenation to isomalt, the sucrose must be removed by crystallization. Otherwise it will be present in the end product, so that sweets produced from this end product may not be described as sugar-free.



Sucrose

Isomaltulose

Isomalt



→ In the classical production method, therefore, the mixture must be crystallized to separate the sugar residues from the isomaltulose, a process that involves considerable technical effort. The crystallization is typically repeated twice to obtain isomaltulose of at least 98 percent purity.

And this is where the disadvantage of the conventional process lies: It removes not only the sucrose starting material but also saccharides such as trehalulose, fructose, and glucose. These could also be hydrogenated, however, and are permitted as isomalt components by food standards (JECFA Codex Alimentarius, FCC Monograph). The investment- and energy-intensive crystallization process therefore leads to a large yield loss of up to 25 percent.

## Exploiting expertise

This is where Evonik's new process for isomalt production comes in. Researchers from the strategic innovation unit Creavis investigated the conventional method with a view to designing the manufacturing process more efficiently. Their aim was to develop a new process in which the isomaltulose mixture, including the residual sugars, is hydrogenated directly, without an additional process step. For this Creavis drew on two of the Group's core competencies: biocatalysis and chemical catalysis.

To optimize the first step of the process a new immobilization process was developed

for the biocatalyst used, which offers considerable advantages: The new biocatalyst is easily produced, releases no hazardous substances during immobilization, is stable in storage, and reduces transport costs because, unlike the familiar biocatalyst, it contains no water—and all these advantages come without any reduction in service life. An attractive plus here is that the support materials for the biocatalyst are also from Evonik.

The second process improvement, catalytic hydrogenation, was crucial for the overall process. Working jointly with the Reaction Process Engineering unit, Creavis identified a precious metal catalyst distinguished by its good performance from the Catalysts Business Line. The key advantage here is that while hydrogenating the isomaltulose mixture the catalyst also splits sucrose into the monomers glucose and fructose, both of which can be hydrogenated; this allows hydrogenation to be performed directly, without crystallization (Fig. 2).

To allow the product to be supplied as a solid, a new drying process was also necessary. The challenge here is that the various components affect the physical and chemical parameters of isomalt. This leads to a tacky product if the water is removed by conventional drying processes. In conjunction with the Particle Process Engineering unit, Creavis developed a new process in which a crystalline and therefore free-flowing powder is obtained.

## Quality check

It was then necessary to definitively establish the quality of the isomalt produced by direct hydrogenation, because it has a different composition from conventionally produced isomalt. It consists mainly of the two isomers 1,1-GPM (1-O- $\alpha$ -D-glucopyranosyl-D-mannitol) and 1,6-GPS (6-O- $\alpha$ -D-glucopyranosyl-D-sorbitol); with the new process, however, small amounts of the sugar substitutes sorbitol and mannitol are also present. Each of the polyols present has different properties, which influence the physical and chemical parameters of the end product.

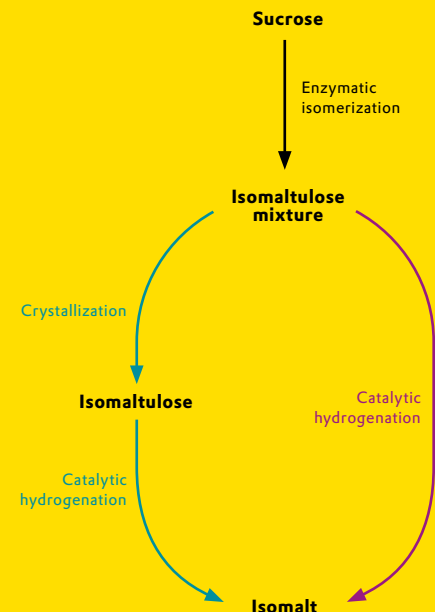
To prove that the isomalt meets the high requirements of customers, Evonik put it to the test: The scientists ordered production of blue menthol candies. The blue colorant normally added to the transparent isomalt raw material serves to check the quality of the raw material. This is because candies that may contain impurities change to a yellowish color when heated at 160 °C; if the blue coloring is then added the sweet acquires a green tint or discolors altogether. Evonik's candies remained a brilliant blue and passed the quality test.

They also gave convincing results in the stress test (Fig. 3): Even at an atmospheric humidity of 80 percent they absorbed less than three percent moisture from the air, which is significantly lower than for can-

**Figure 2: The new pathway to isomalt**

At the core of the new process is a new catalyst. This allows the isomaltulose mixture to be hydrogenated directly to isomalt without the need to remove the sucrose by crystallization beforehand.

- ➔ Conventional process
- New process



## Diabetes mellitus

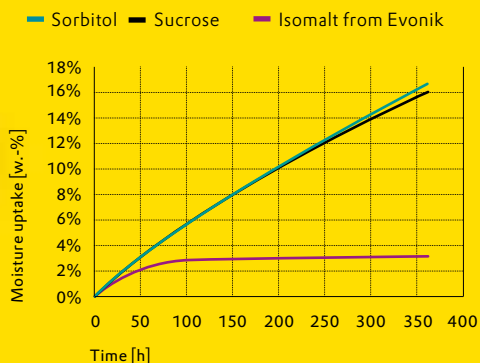
is a chronic metabolic disorder that manifests as a permanently elevated blood sugar level. Diabetes occurs in various forms, the most common being type 1 and type 2 diabetes.

**Type 1 diabetes**, also known as juvenile diabetes, is an autoimmune disease caused by a disturbance of the immune system at an early age. The body no longer produces sufficient insulin.

**Type 2 diabetes** is the most common form of the disease and results from inefficient use of insulin in the body. Experts consider the main causes to be unhealthy eating, lack of exercise, overweight, and obesity.

**Figure 3: Stress test passed**

Candies made from sorbitol, sucrose, and Evonik's isomalt were stored at 25 °C and 80 percent relative humidity. After more than 350 hours the candies with isomalt had taken up less than three percent moisture.



dies containing either the sugar substitute sorbitol or conventional sugar.

The result impressed the Thai sugar producer Rajburi Sugar, with which Evonik has established the joint venture RSC Evonik Sweeteners Ltd to build a demonstration plant. The joint venture is the first supplier of isomalt produced directly in South-East Asia, where demand for sugar substitutes is rising steadily. This is due in part to the explosive growth in the population of overweight and diabetes, caused by increasing westernization of dietary habits as well as a higher genetic prevalence of type 2 diabetes. Almost every tenth Asian now suffers from this most common form of the disorder, and current studies predict that the figure will almost double over the next 25 years.

One special feature of the plant is its modular construction. All the plant components were pre-installed, set up, and tested in what are known as frames in the Netherlands before being shipped to Thailand. This procedure ensures fast and smooth start-up at the installation site.

**Healthy prospects**

In order to be able to provide samples to Asian customers, the necessary registration processes for the isomalt have already been initiated with Thailand's Food and Drug

**Diabetes in figures (2014)**

**1 out of 3 adults** over 18 is overweight.

**415**

**million** adults worldwide have diabetes. In 1980 there were 108 million.

About **90**

**percent** of these have type 2 diabetes.

Source: WHO, Global Report on Diabetes

Administration and for Halal certification. At the same time work on application technology for isomalt in food supplements is in full swing: Studies at the Evonik Health Care Research Center in India have already shown that the new product is superior to commercially available isomalt in certain specialty applications such as effervescent tablets.

Before the end of 2017 the plant will be handed over to Evonik's Health Care Business Line and its Pharma & Food Ingredients Product Line, where isomalt will supplement the range of Advanced Food Ingredients. The product, marketed as Risumalt®, will thus become part of the Advanced Food Ingredients growth field.

With this new process Evonik has taken the first step into a new market, because the patented process is a technology platform for further product developments. As the second product, the isomaltulose mixture is to be produced as a functional sugar mix on the same platform and launched on the market in 2018 under the brand name Riso-maltulose®. Along with the Evonik Health Care Research Center, the newly opened Technical Service laboratory of Health Care in Bangkok, which works on new application areas and customized formulations, is also investigating applications of both products. Candies with exotic flavors, such as mango-sticky rice, are conceivable for the local market.

**The experts**

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**Jan Wolter** heads the Food Ingredients and Care innovation fields at Creavis.

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Dietary supplements are a growth market. Evonik is banking on natural ingredients **with proven effects**.  
 Left to right: Dr. Rosario Lizio, Dr. Michael Schwarm, Dr. Bodo Speckmann.

# “WHERE GROWTH IS PLANNED, WE HELP OUT”

Which business ideas are worth following up? What is required to get into a business area with good prospects? How can existing skills be utilized to generate growth? Questions like these are very successfully handled in the Nutrition & Care Segment by a team specializing in New Business Development.



Livestock farming: Diagnostics and data collection are important instruments for **improving animal welfare**. Left to right: Dr. Emeka Ignatius Igwe, Dr. Florian Böhl, Dr. Andreas Kappel, Dr. Achim Marx.

**M**EDOX®, probiotics, and algae oils are just three examples of innovations with which Evonik plans to tap into new markets in the Nutrition & Care Segment. They all have to do with human and animal health, holistic feed concepts for livestock, and the preservation of marine ecosystems. All three products are highly relevant in these times of increasing health consciousness and environmental awareness. And they also fit well with Evonik’s competencies: Health-promoting nutritional supplements and additives for animal feeds utilize skills available in the company and are relevant for attractive growth markets that are driven by global megatrends.

The above examples are not random successes, but the result of highly targeted activity in prospecting for new businesses. “There has never been any shortage of interesting ideas,” says Dr. Michael Schwarm, “but we need the capacities to evaluate them in a structured way and then promote them

systematically.” He was an employee in the then Health & Nutrition Business Unit when a team for New Business Development (NBD) was established in 2011. Today he heads the Food & Health area there.

### Strategy is key

The initial team, consisting of four employees with varying backgrounds and many years of experience between them, accepted existing ideas and generated many new ones. The ideas of using algae to produce omega-3 fatty acids for animal nutrition and of developing probiotics for livestock were first proposed back in 2010, as part of the growth agenda of the then Bioproducts Business Line and then further developed by NBD. Nutrition & Care then found in DSM the appropriate collaboration partner for the omega-3 fatty acids and the project gained momentum (see page 4). In the case of the probiotics, the NBD team initiated in-house research and identified the probiotics business of the company NOREL as a takeover target, so as to accelerate market launch (see *elements* 58).

The strategic framework for many of these activities is provided by the growth fields defined by the Evonik Group: These include Sustainable Nutrition for animals as well as Advanced Food Ingredients for human nutrition. “As the population continues to age, people are increasingly willing to invest in their health,” says Schwarm. This makes food supplements, and in particular natural ingredients with proven effects, an interesting potential market for Evonik—because this strongly science- and technology-driven company feels entirely comfortable in the field.

Here again the “new business developers” very quickly scored an initial hit, leading to a marketing alliance with the Norwegian company MedPalett in 2015 and its takeover in 2016. Evonik has since added to its product range a particularly anthocyanin-rich berry extract for functional foods (Healthberry®) and is also, for the first time, directly marketing a food supplement (MEDOX®), based on Healthberry®. Anthocyanins have properties that reduce inflammatory reactions in the body and have demonstrated their health-promoting potential, in the cardiovascular and other areas, in many international studies. The Health Care Business Line, which has excellent contacts with the food and pharmaceuticals →

**“In addition to expert knowledge and methodological skills, intuition is called for.”**



Focus on the consumer: Evonik aims to understand consumer needs in order to be able to develop **optimum solutions**.  
 Left to right: Dr. Christiane van der Kuil, Jenny Sarina Taheri, Dr. Katja Skrabania, Hitesh Vashisht, Maike Kipker.

→ industries, can effectively expand its business in this way.

In a second project for Advanced Food Ingredients, a novel dosage form of omega-3 fatty acids was successfully developed that makes these more attractive to people as a food supplement. Unlike conventional oils, this product is a solid and particularly stable, and is distinguished by very good bio-availability. The Health Care Business Line has initiated market launch in the USA.

Evonik's Cosmetic Solutions and Health-care Solutions growth fields are also being supported by NBD. In the cosmetics area, activities aimed at selective support of healthy skin bacteria are under way. NBD is also participating in preliminary work in the area of wound healing and tissue regeneration.

"Where growth is planned, we help out, working in close collaboration with the business lines," as Dr. Walter Pfefferle, head of Innovation Management and NBD in the Nutrition & Care Segment, describes the activity of the team, which has now grown to include 15 employees. This could mean identifying suitable targets for a takeover—if, for example, a technology gap is to be closed—or starting up in-house development projects that are then supervised by NBD for three to five years. For full development of

their potential the projects require the infrastructure of an operational unit, and are therefore handed over sooner or later to one of the seven business lines of Nutrition & Care. The last two years alone have seen three such large program blocks with a sales potential exceeding €100 million (2025).

### A wide-angle view of things

NBD's success is based partly on its structured processes for these activities and the wide spectrum of skills and experience of its very heterogeneous team. "We look at things from different perspectives and so make new discoveries," says Pfefferle. In addition to expert knowledge and methodological skills, a healthy dose of intuition is called for here. Persons with the necessary disciplines are added to the team as required: Apart from chemists, engineers, biologists, and a pharmacist, the team now also has a sociologist and will very soon include a nutritional scientist. It also has available a growing network of external partners, including consultants and universities.

A big advantage of NBD is its perspective across the entire segment. All of the seven business lines in the segment contribute toward fulfilling basic human needs, from health and nutrition, across body care and comfort, to cleanliness. Commonalities are evident, but can best be perceived from a bird's-eye view.

This is why Pfefferle, in his capacity as head of Innovation Management, has carried out competence mapping over the entire segment. The aim was to find where the core competencies of Nutrition & Care lie, and how these could be utilized to open up new growth fields.

"By core competencies, we mean a set of competencies that is not very easily copied," says Dr. Harald Schmidt, who heads the Care area of NBD. In assessing the competencies reported by the business lines, certain patterns quickly became evident: "We're particularly good at formulation, understanding interfacial phenomena, removing dirt, and handling microorganisms in all conceivable ways," is how Schmidt sums up an important finding. The message

**"By core competencies, we mean a set of competencies that is not very easily copied."**



Starting from core competencies: Existing formulation technologies offer a **wide range of possible applications**.  
 Left to right: Dr. Walter Pfefferle (head of the NBD team), Natalia Hinrichs-Tontrup, Dr. Harald Schmidt.

here is that several business lines in the Nutrition & Care Segment are working on the formulation and controlled release of pharmaceutical, cosmetic, and agrochemical active ingredients, or on influencing microbial communities (microbiota). If competencies like knowledge of health, nutrition, and agriculture are added to the mix, attractive new application possibilities arise, such as the “packaging” of microorganisms as plant protection products for agriculture.

The microorganisms protect crops against harmful organisms by parasitizing them, producing biostatic substances, or competing with them for space and nutrients. Plant protection is thus possible that is highly environmentally friendly and minimizes the problem of chemical pesticide residues in food. But some of these living microorganisms are not sufficiently stable to withstand processing, storage, and application in the field. A functional encapsulation—of the type Evonik routinely uses for active ingredients—could solve this problem.

A similar solution could be used for personal care products. It has long been known that the skin microbiome is strongly influenced by pH, along with other factors. This is why many consumers use pH-neutral soaps. “But skin health is even more spe-

cifically influenced by certain bacteria or by changes in milieu,” says Schmidt. That could be another field in which Evonik could apply its special expertise.

### Geared to consumer wishes

However, NBD is also contributing brand-new skills in methodology, for example in the area of consumer research. “It often happens that we have no first-hand knowledge of the wishes and expectations of end consumers: Instead, our customers outline what a new product solution should look like,” as Schmidt describes the typical situation of a specialty chemicals company. In customer projects this can lead to working in one particular direction, as stipulated by the customer. But entirely different solution spaces also exist, which the company can identify through its own investigation of consumer wishes—and with markets becoming ever more dynamic and customer-specific, this would appear to be a suitable approach.

Schmidt’s goal is to orient innovation projects systematically to consumer needs. Along with colleagues he develops the appropriate tools—or sets out himself to do the fieldwork. A recent example is the Happy Chicken project: In connection with chicken consumption, the team wanted to assess

## €100 million

is the sales potential of the projects that NBD has transferred to the Business Lines in the past two years.

the role of animal welfare in consumers’ consciousness. For this purpose they visited markets, supermarkets, and restaurants worldwide, spoke with chain stores, studied menus and inscriptions on product packages, and sought consumer opinions. The question, ultimately, is whether the consumer would be prepared to pay more for chicken from animals reared in a more animal-friendly environment. Only in that case would the trade be willing to offer higher-priced chicken products; only then would it be promising for Evonik to invest in the development of appropriate products for animal nutrition.

Pfefferle is excited by the wide range of possibilities offered by the competencies of Nutrition & Care. “We sometimes rush too far ahead and are too ambitious,” he admits. But that’s exactly what NBD sets out to do: to push hard, in order to generate growth for Evonik and added value for customers and end consumers.

READY FOR USE IN RECORD TIME

# Printed, not built

WE PRINT  
BUILDINGS

3D printing is making progress: Eyeglass frames, sports shoes, and even hearing aids can now be printed out. Simple printers that use as “inks” such plastics as polylactides or acrylonitrile butadiene styrene copolymers are already available on the market for less than €300. The technology is already being used industrially: Boeing, for example, is printing spare parts relevant to safety for the Boeing 787 at the point of use, thus saving transport and storage costs.

A game-changing technology of this kind does not stop even at the construction industry: In fact it's here that 3D printing can offer solutions to existing problems. To take an example, about 900 million people currently have no acceptable accommodation: They live in uninsulated corrugated iron huts and tent camps without sanitation, in some cases without even a roof over their heads. By the year 2025 the number of such people could rise to 1.6 billion. Moreover, the construction industry is among the largest generators of greenhouse gases, with a share exceeding 30 percent. 3D printing

technology promises to alleviate this situation: According to Ma Yihe, CEO of WinSun, a leading house printing company, 3D printing allows savings over conventional construction of 60 percent in materials, 70 percent in time, and 80 percent in labor. He is particularly proud of its low resource consumption. WinSun uses as printing material a mixture of building rubble, industrial waste, cement, and hardener. In addition, house printing uses only as much material as is necessary: Wastage of construction material is now a thing of the past.

And this new method of construction is impressively fast. The Russian-American company Apis Cor needed just 24 hours to print the shell of a 38



In Russia, Apis Cor has for the first time printed off an entire house instead of individual modules that are then assembled. The windows, roof and other components were added manually.

square meter house, and at a price that would warm the heart of any builder: The finished house, ready for occupation, is expected to cost as little as US\$10,000.

As part of its current GameChanger focus topic, the Foresight team of Creavis, Evonik's strategic innovation unit, is studying the impacts on the construction industry and the opportunities they offer for Evonik. Dubai is a good example of the high expectations connected to house printing: The Emirate is the first place to showcase the first office building ever to be constructed from printed modules. By 2030, 25 percent of all buildings in Dubai are expected to come from 3D printers.



DR. JENNIFER HOLTZINGER

# Tracking down microcracks

Chemical companies need experts in a wide range of disciplines. Take the example of Dr. Jennifer Holtzinger, an engineer who specializes in tribology and analyzes high-performance additives for lubricants at Evonik.

**D**r. Jennifer Holtzinger, who works in an interdisciplinary capacity in the Oil Additives Business Line, enjoys expanding her horizon. Her specialist area of tribology brings together expertise from mechanical engineering, material science, physics, and chemistry. “As the science of friction, tribology focuses on lubrication, friction and wear and tear in mechanical elements,” explains Holtzinger. That’s an important aspect for Oil Additives because the business line develops additive technologies for the prevention of abrasion and material fatigue to ensure greater fuel and energy efficiency, based on a special polymer architecture designed by Evonik. It enables the use of low-viscosity oils, which promise better performance with less consumption without impairing the protection of machine elements. Do the additives keep what they promise?

“That’s where I come in,” says Holtzinger. “My team in the Performance Testing Laboratory in Darmstadt evaluates whether our products offer full performance under a wide range of environmental conditions. Of course, we not only look at our additives, but also at the materials in which they are used or with which they come into contact.”

## Remain flexible and open

Holtzinger earned her Master’s degree in material science in Nancy, France. Even at that time, the Frenchwoman enjoyed thinking beyond boundaries, including across national borders. She took the opportunity to do research in Spain and Sweden and was so impressed by her international contacts that she accepted a position in the

research laboratory of the Indian Institute of Science in Bangalore (India). “That was a challenge, but also a great opportunity,” she recalls. “I had to quickly adjust to the prevalent working methods in India. The key is to remain flexible and open—in every situation.”

After working in India, she initially transferred to the company PPG Aerospace, where she was employed in the research and technology department. “That’s where chemistry moved to the foreground of my work,” she recounts. “I became aware that there are still many fields in which I can deepen my knowledge.” She began her doctoral studies in the tribology team of the Imperial College London, where she studied the influence of viscosity index improvers on hydrodynamic friction. After successfully completing her degree, she returned to employment in the industry. “I missed the contact with the market and customers,” she says. “I want to develop and improve products that offer a specific benefit.”

## Provide valid purchase arguments

She joined the product development team at Oil Additives of Evonik in 2011 and transferred to her current position in the Perfor-

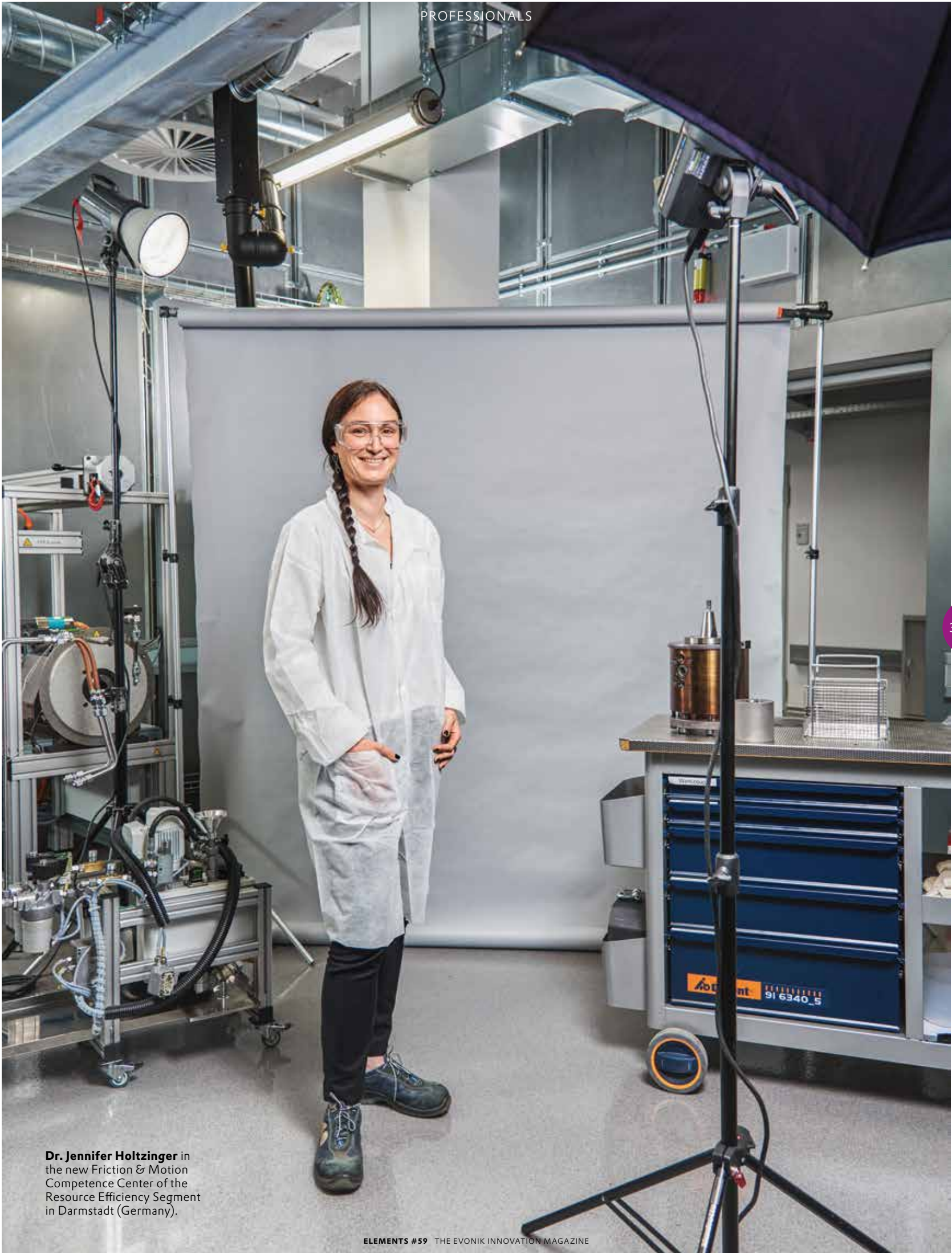
mance Testing Laboratory three years later, where she and her team of five support the other units of the business line with performance tests. They assess the friction reduction caused by the applied lubricants, study material fatigue, and test how additives influence the longevity of the entire system—to further optimize the company’s products and to provide valid purchase arguments. “Customers want to know what our products can do,” explains Holtzinger. “To give you an example, we were able to prove that materials last three times longer with the use of our additives. That’s a convincing argument.”

The data for evaluating products come from a series of tests that are performed with special equipment. “We have outstanding equipment, which makes us a point of contact for external customers who don’t have a full range of test devices,” says Holtzinger. One example is a test for micropitting, which describes signs of fatigue in materials for example for transmission applications. Micropitting occurs when the contact surfaces of two opposing components moving under high strain form microfine cracks, which lead to faster material breakage. “That has to be prevented,” says the engineer. “Transmissions are expensive.”


To test which lubricants and additives can extend the lifetime of the materials, the test laboratory puts two rotating pieces of steel in contact—with and without Evonik products on the contact surface. The rotation generates pressure and high temperatures—a challenging requirement for the materials: “After the tests we can be sure that our products keep what we promise.”

To further expand her horizon, Holtzinger works closely with other units and international colleagues as well. Thus, she is involved in the establishment of the Friction & Motion Competence Center, which will work to define the strategic orientation of the business line and the Resource Efficiency Segment in the area of tribology. “I enjoy sharing my knowledge and I’m learning a lot from my colleagues,” says Holtzinger. “I am also glad to see that tribology is getting more attention. It strengthens the interdisciplinary research in the company.” Good for Evonik. And good for Dr. Jennifer Holtzinger: “It’s a chance to continue my interdisciplinary work.” ●

**“I enjoy sharing my knowledge and I’m learning a lot from my colleagues.”**



**Dr. Jennifer Holtzinger** in the new Friction & Motion Competence Center of the Resource Efficiency Segment in Darmstadt (Germany).



**They bond materials that normally wouldn't and separate materials that are not meant to come into contact with each other: Even in small quantities, silanes can have a big influence on material properties. Evonik carries out research into new applications at its new high-tech competence center in Rheinfelden.**

**W**hile in the early hours of the morning in Rheinfelden (Germany) the production plants are buzzing and the many trucks contribute to the traffic noise, focused silence prevails on the four floors of the silanes competence center. Through the large windows, daylight fills the laboratories, offices, and clean rooms where about 100 employees carry out research into innovative applications and look for solu-

tions for customers all around the world. The roughly 3,000 square meter research center opened just over a year ago, and the building is now home to applied technology, research, quality management, and process development.

Rheinfelden was not chosen by chance. Once upon a time, the border triangle region between Germany, France, and Switzerland was the cradle of silane chemistry. In 1895, work started on the construction of the world's first hydraulic power station in Rheinfelden. Directly beside this, in 1898,

the Elektro-Chemische Fabrik Natrium was established to produce sodium hydroxide, chlorine, carbide, and chlorinated lime. In 1928, the first patents for silanes were issued in Rheinfelden: for the production of  $\text{SiCl}_4$  and  $\text{SiBr}_4$  from ferrosilicon and the manufacture of silicic acid esters from  $\text{SiCl}_4$  and anhydrous alcohols.

Research flourished on the High Rhine in the following decades of the 20th century. In 2000, the former Degussa moved its entire silane research from Hanau-Wolfgang to Rheinfelden—into an especially built re-



Silanes protect buildings not only against corrosion but also against graffiti.

search and laboratory building, the predecessor of today's silane competence center.

"Consequently, at the site we have many years of experience in silane research and production," says Dr. Stefan Bade, who is head of Innovation Management Silanes. "This is why the company's investment in the new competence center was not only an important recognition of the significance of the Rheinfelden site, it also acknowledged a lived tradition of research."

Certain technologies, such as modern tire technology and glass fiber reinforcement of

plastics, would be inconceivable without the use of organofunctional silanes. This explains why in Rheinfelden research is carried out on silanes that could be used as coupling agents, surface modifiers, cross-linkers for polymers, or binders in coating systems. "To put it in a nutshell: Silanes help to separate substances by means of a suitable surface coating and also to bond materials that cannot otherwise be bonded," says Bade.

Demand for innovative special silanes is high in all markets. They protect build- →



Applied technology, research, quality management, and process development in one building—the silanes competence center in Rheinfelden.

→ ings, bridges, and monuments from corrosion, make smartphones more powerful, and enable production of fuel-saving tires and durable paints. “Resource efficiency is a common theme in all of our research projects. Whether they involve the design of wind turbines, the tire industry, or building insulation—we try to make all our applications as sustainable as possible.”

By the way, that applies not only to the products that are being researched, but also to the building itself. To ensure the safety of people and the environment, high-tech laboratories must always be well ventilated, which can result in extremely high heating costs. Therefore, to satisfy safety requirements and also save energy, in Rheinfelden heat from the exhaust air from the laboratories is recovered. Another Evonik product was also installed in the facade: CALOSTAT® high performance thermal insulation panels based on silicon dioxide.

### Silanes bond: the example of green tires

The trend to sustainability has also reached the tire industry. For many years, tire pro-

ducers and car owners have realized that tires can make a significant contribution towards safety and also help reduce fuel consumption. This is possible due to a special mixture of silica and silanes, which are constantly being researched in Rheinfelden with the aim of improving them even more.

Dr. Alexander Köpfer is one of the scientists in this area. “Previously, carbon black was used as a filler in tires,” explains the chemist. “However, in modern tires, the trend is towards a filler system that is based on a combination of rubber silanes and precipitated silica.”

Tires are high-tech composite materials; the composition of the tread in particular has an enormous influence on their performance. Compared to conventional tires made from E-SBR with carbon black as a filler, “green” tires made from S-SBR with silica/silane technology have much lower rolling resistance. This reduces CO<sub>2</sub> emissions and lowers fuel consumption.

They also stick to the road better in wet weather. This is where the bonding property of silanes plays a role. “As a filler in the tread, silica is responsible for the wear resistance of a tire—but it’s not really compatible with S-SBR. The trick for bonding the two materials: We use a silane as a chemical coupling agent.” Compared to the other components, the amount of silane used in a tire is very small but it does have a significant effect on the tire properties. “Without silanes, nothing would work,” explains Alexander Köpfer. “And the rising demand for ‘green’ tires has forced us to continuously improve the system.”

### Silanes separate: the example of building preservation

House owners and motorists have a common problem: structural damage to building materials. This can cause severe damage not

**100**

Employees carry out research into innovative applications in the roughly 3,000 square meter silanes competence center.

## FROM THE TEST TUBE TO THE CUSTOMER

An interview with Dr. Stefan Bade, head of Innovation Management Silanes

### Dr. Bade, which project is the most interesting one for you at present?

That would be corrosion protection with our water-based silane systems, which are formulated as two-component systems with, for example, zinc dust. We developed DYNASYLAN® SIVO 140 as an organic-inorganic binder that is used with zinc dust paints in the area of corrosion protection. The advantage of this water-based product is that it contains almost no volatile organic compounds or VOCs. Other advantages include curing at room temperature and the improved temperature stability compared to organic binders. Our products, DYNASYLAN® SIVO 140 as a binder for zinc dust paints and DYNASYLAN® SIVO 160 for corrosion protection of hot-dipped steel and aluminum, are trendsetters for environmentally friendly corrosion protection.

### How do you remain close to the market and to your customers?

We are in close contact with our long-



### “Personal contact with the customers is the most important thing.”

*Dr. Stefan Bade*

term customers—and when we develop a new product with improved properties, we present it to them directly. On the other hand, customers also approach us with their wishes and then we try to develop something special for these requirements. Apart from this, we are represented at national and international conferences and trade fairs, such as the European Coatings

Show, the Freiberg Silicon Days, and the JEC World in Paris, and we are also involved in various committees. But personal contact with the customers is and will remain the most important thing for us. This includes our application engineers together with the market segment heads visiting them systematically at their sites around the world.

### What can we expect to see in terms of silane research in the coming years?

Resource efficiency is one of the key areas that we will continue to focus on in the future. On the one hand, specialty silane chemistry will continue to develop. I'm thinking of mixtures, oligomers, hydrosils, emulsions, pastes, and even solid silanes. There is still a lot of innovation potential in this field. On the other hand, with our products that are already established in the market, cost positions and technology will be the focuses. We will continue to optimize and streamline processes.

only to houses, but also to frequently used bridges and roads. Moisture is the main cause of almost all damage to mineral construction materials. “This is because construction materials, such as bricks, concrete, and natural stone, are porous, which means that water and the pollutants it contains can penetrate them,” says Dr. Susanne Martens, who, together with her team, is responsible for building protection applied technology in the silanes competence center.

Structural damage can occur in many forms: as corrosion on metal parts, efflorescence on the facade or damage due to frost and de-icing salt. Consequently, one of the most important ways of protecting buildings is to prevent water penetration. “Generally, on a molecular level, conventional polymer building protection materials such as acrylate or silicone systems are so large that they close the substrate pores of the structure,” explains Susanne Martens. “Initially, this is quite effective in preventing water penetrating; however, it also keeps the water vapor inside. This can cause further damage.” Another disadvantage: UV radiation can damage or completely decompose this form of coating so that water can once again penetrate the surface.

Therefore, in Rheinfelden, building protection technologies have been high on the research agenda for more than 50 years.

“Silanes can help create an effective barrier between the structure and the water. The silane-based products with which we work here consist of very small molecules and have a very low viscosity so that they can penetrate the structure quickly and deeply,” explains the chemist. “Through a chemical bond to the structure this creates an extremely durable hydrophobic protection layer.”

The advantage of hydrophobization with silanes is perfectly clear: The protective effect cannot be destroyed by UV rays or mechanical stress. It does not change the appearance of the building and endures much longer than a coating.

### Short channels, close collaboration

It's now just after 9 a.m. Here, close to the Swiss border that means one thing: It's time for Znüni—in the Alemannic language region, this is a snack between breakfast and lunch. The break rooms fill with laboratory technicians, scientists, and application engineers.

“Innovation is always teamwork,” emphasizes Stefan Bade. “The closer the colleagues are to each other, the more they discuss their experiences—whether this is in the lab or during a coffee break, where they tell each other what they are currently working on.”

This was another reason to pool all the departments, which were previously scattered among various buildings, in one competence center. “We want to concentrate our competence here at the site in the same way that we bond materials into high performance products with our silanes.”

### “Innovation is always teamwork.”

*Dr. Stefan Bade*

**Prof. Katharina Landfester**

has been a director of the Max Planck Institute for Polymer Research in Mainz (Germany) since 2008. After studying chemistry at the Technical University of Darmstadt and in Strasbourg (France) and obtaining her PhD from the University of Mainz, she completed a three-year post-doc at Lehigh University in Pennsylvania (USA). On the basis of work completed at the Max Planck Institute of Colloids and Interfaces, she habilitated in 2002 at the University of Potsdam and then took the chair of Macromolecular Chemistry at the University of Ulm in 2003 before assuming her current position.

**WHAT I HOPE FOR FOR SCIENCE**

# Katharina Landfester

**A CHILD'S CURIOSITY**

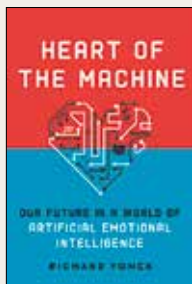
Children have a wonderfully unprejudiced way of asking questions, they are curious and passionate about discovering new things and thereby understanding the little details of our daily lives. However, this boundless openness, this enviable and often refreshing naturalness vanishes quickly in the course of their school careers.

This is the reason why I hope for science that we will be able to motivate our children to continue dreaming, to stay curious about the new, be open to experiments of all kinds, to question the little things in their daily lives, and to absorb with enthusiasm all things new to them. We need children who are enthusiastic about the apparently simple phenomena of our daily lives and who wonder about things, question them and want to understand. They will only remain open to the unexpected, the innovative, and the new if they can and want to question, doubt, discover and experience things. This is the only way of bringing to life, dreaming up, realizing, implementing, and making new ideas a reality for the future. I hope our children will be able to live out their visions and through their dedication make them reality later on in their lives.



# NON-FICTION BOOKS

on emotional machines, collective intelligence, and greater innovation to reduce poverty.

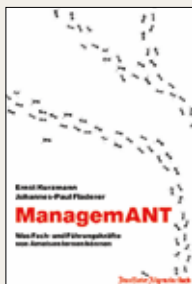


## Machines with a heart

**A** robotic stuffed animal that can read and respond to a child's emotional state or a commercial that can change based on a customer's facial expression? Futurist Richard Yonck argues that emotion is at the heart of how we will soon work with and use computers. But for every benefit this progress may bring to our lives, there is a possible pitfall. Emotion recognition could lead to advanced surveillance and become a method of mass control. Heart of the Machine is an exploration of the ways in which mankind and technology will interact.

**Richard Yonck:**  
*Heart of the Machine. Our Future in a World of Artificial Emotional Intelligence*

Arcade Publishing, March 2017



## Swarm intelligence

**W**hat can we learn from ants? As it turns out, quite a lot! Finding the best way from A to B, for example, since the collective intelligence of ants relies on the swarm principle. Many GPS systems therefore use "ant-based routing" to find a destination. In their book, business trainer and consultant Ernst Kurzmann and biologist Johannes-Paul Fladerer describe how the mechanisms of swarm intelligence can be transferred to corporations, e.g. for teambuilding or in difficult forecast situations.

**Ernst Kurzmann, Johannes-Paul Fladerer:**  
*ManagemANT: Was Fach- und Führungskräfte von Ameisen lernen können*

Frankfurter Allgemeine Buch, June 2017



## Ideas for fighting poverty

**T**his book argues that we need more innovative approaches to eliminate hunger and poverty. Walter Leal Filho, director of the Research and Transfer Center for Application of Life Sciences in Hamburg, focuses on initiating and supporting practical, interdisciplinary research projects, which he considers the only option to meet the Sustainable Development Goals of the United Nations. The book describes model cooperations between universities and the industry as well as innovative teaching and research approaches.

**Walter Leal Filho (ed.):**  
*Innovation in der Nachhaltigkeitsforschung. Ein Beitrag zur Umsetzung der UNO-Nachhaltigkeitsziele*

Springer Spektrum, May 2017

### Masthead

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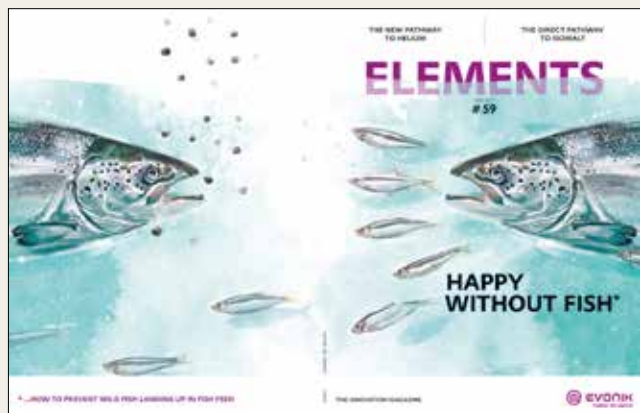
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## THE COVER #59

Farmed salmon also need fish from wild capture: Billions of wild fish, in the form of fish oil, are mixed with feed to provide the salmon with the omega-3 fatty acids they need for growth and health. In fermentatively produced algal oil, Evonik and DSM offer a fish-free alternative that counters overfishing and contributes toward maintaining marine biodiversity.