DELFT OUTLOOK
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TU Delft

THEME

Plastics

Concern or blessing

MEMBRANES
COOKING WITH ATOMS AND MOLECULES

JAN VAN KRANENDONK
'Failure provides insight'

MYANMAR
Paradise for engineers

Cover photo: Mandy Barker's current photographic projects have been focused on the mass accumulation of plastic in the world's oceans. The impact of oceanic plastic is an area she has been committed to for many years and her work aims to stimulate an emotional response in the viewer by combining a contradiction between initial aesthetic attraction and subsequent message of awareness. mandy-barker.com

EDITORIAL
Frank Nuijens

Plastics

TU Delft lecturer Angeniet Kam regularly walks around the campus armed with a reaching tool (delta.tudelft.nl/28159). She is looking for plastic waste that is lying around. She was motivated by a video of young albatrosses with plastic bottle caps in their stomachs. In what has been called 'the Age of Plastics', our everyday lives would be inconceivable without this material.

The first plastic to be manufactured by humans was produced in the 19th century by the British inventor Alexander Parkes. It was called Parkesine. This nitrocellulose-based plastic was introduced at the 1862 International Exhibition in London, where it won a prize. Engineers at TU Delft have been developing plastics since the 1930s, according to the archives of the TU Delft Library.

In addition to convenience, the explosion in the number of applications has also led to an increasing amount of plastic waste in landfills and in the ocean. Recycling is a fruitful strategy for reducing this mountain of waste. The Netherlands recycles more than half of its plastic packaging, making it a leader in Europe. Because the demand for plastics is unlikely to decrease rapidly, it would pay to become smarter in their production (e.g. using bacteria from wastewater) and use (by integrating plastics with electronics). In this issue of Delft Integraal, we explore the future of this smart material.

Frank Nuijens,
Editor in Chief

page 07
Theme PLASTICS

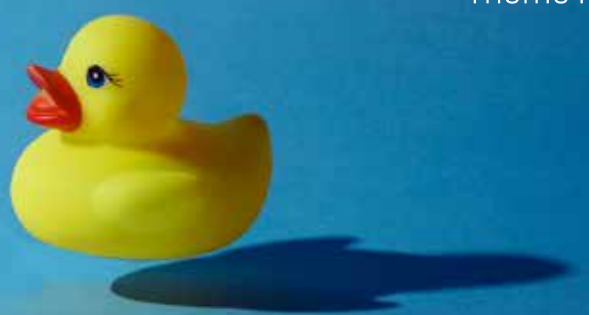

PHOTO: SAM RENTMEESTER

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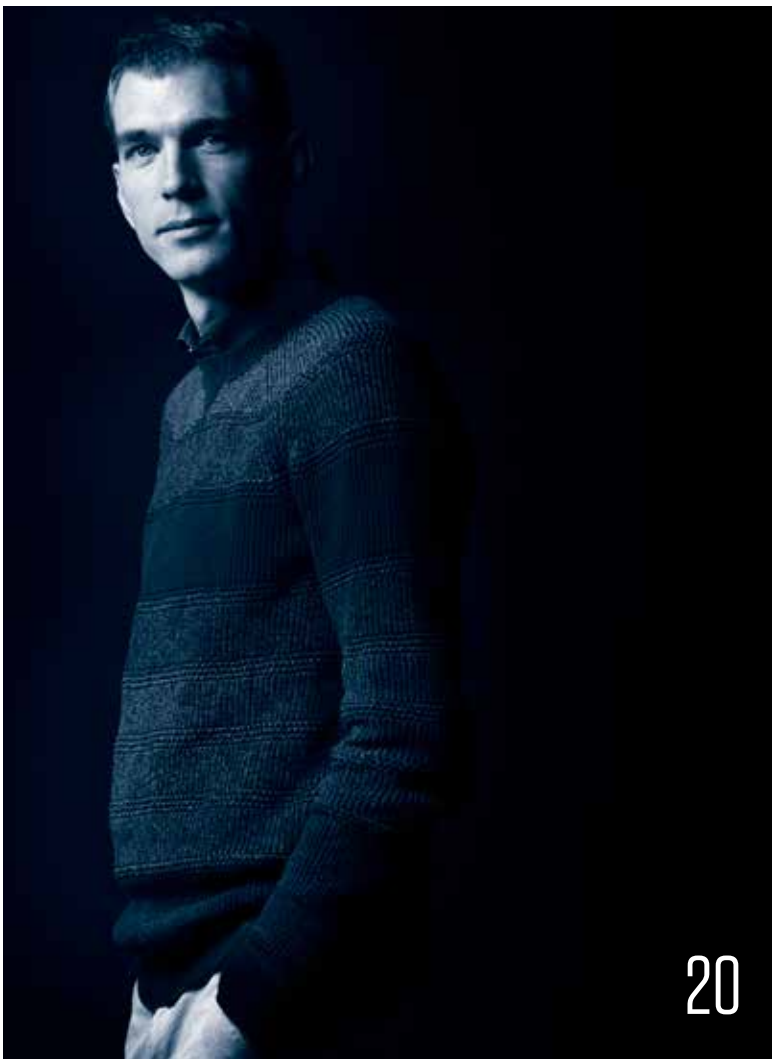
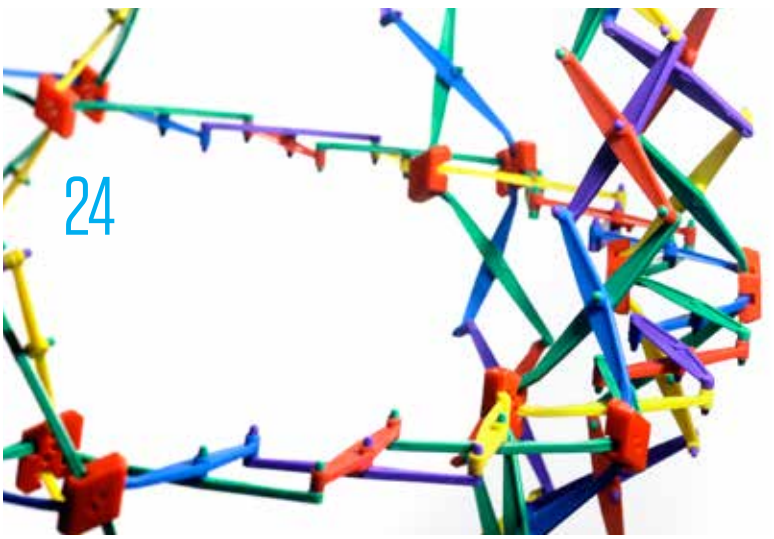




DELFT IN BRIEF

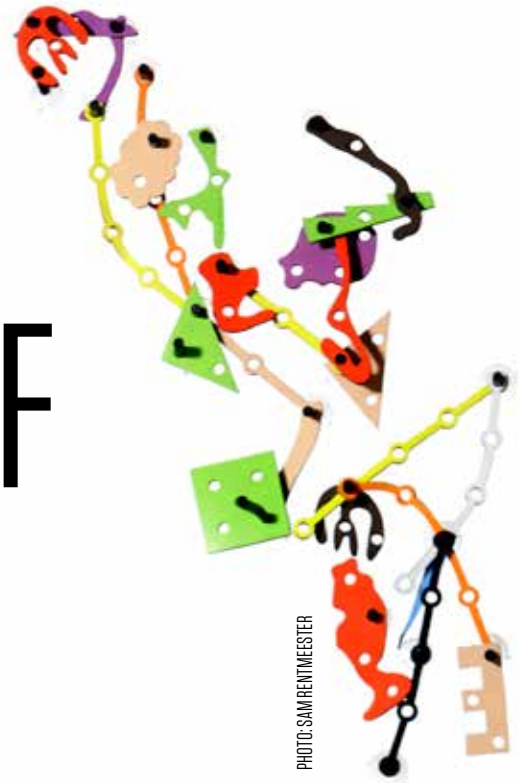


PHOTO: SAM RENTMEESTER

Child's play

For children with a serious illness, being in the hospital is overwhelming enough, let alone having to be in quarantine. Job Jansweijer (IDE) designed a game called 'KonneKt', which allows these children to play with others. The game consists of coloured plastic shapes that children can attach to both sides of a window. Jansweijer won a Design For Interaction award with this game.
delta.tudelft.nl/27883

PHOTO: JANUARDY DJONG

BICYCLE PUMP

Master's student Januardy Djong (TPM) has reached the finals in the Shell Ideas360 competition, together with Dimas Priawan (University of Twente). They developed the concept and design for the Unipump: a double water pump driven by a set of pedals and a gear. As the Indonesian students are well aware, there is a great need for small-scale irrigation. Their design would allow one person to pump water up to 14 metres, while another person waters the plants. Ideas360 is a global competition for original ideas in the areas of energy, water and food.
delta.tudelft.nl/28205

Solar cell record

PHOTO: THINKSTOCK

When fruit flies are attacked, they react like fighter planes, thrusting their bodies in a sharply slanted curve in order to avoid the attacker. This is a finding from a study conducted at the University of Washington using high-speed cameras. The results of the study, which was financed in part by the United States Army, were recently published in Science. The list of authors contains two names from TU Delft: Johan Melis (student) and Florian Muijres (alumnus). Fruit flies can change their course in less than 1/100 of a second.
delta.tudelft.nl/28138

Speedy fruit fly

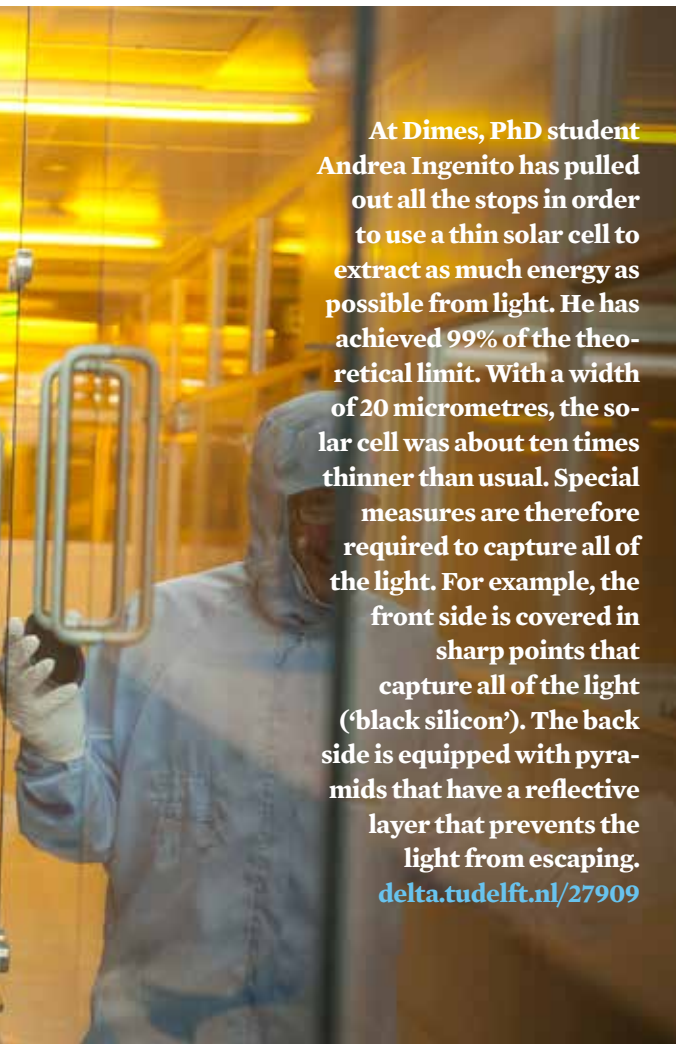


PHOTO: TOMAS VAN DIJK

At Dimes, PhD student Andrea Ingenito has pulled out all the stops in order to use a thin solar cell to extract as much energy as possible from light. He has achieved 99% of the theoretical limit. With a width of 20 micrometres, the solar cell was about ten times thinner than usual. Special measures are therefore required to capture all of the light. For example, the front side is covered in sharp points that capture all of the light ('black silicon'). The back side is equipped with pyramids that have a reflective layer that prevents the light from escaping.
delta.tudelft.nl/27909

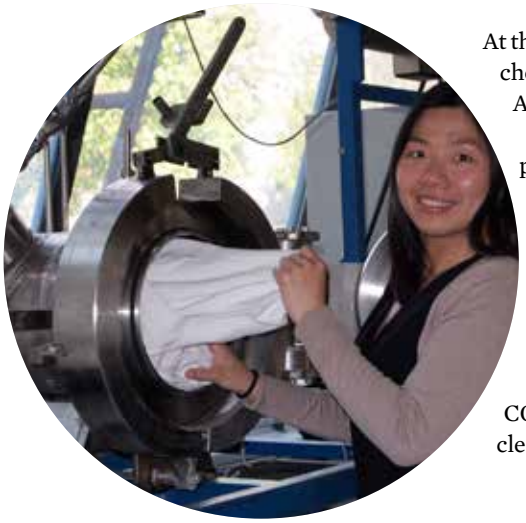
STRESS DETECTOR

Dr Iulia Lefter (EEMC) has developed a security-camera extension that is capable of recognising not only aggression and undesirable behaviour, but also stress, given that this can often lead to aggression. 'We have reached an intermediate level of understanding between pure observation and behavioural recognition', Lefter explains. The system can assign priority to images from particular security cameras when it appears that something is happening (or about to happen) in those areas.
delta.tudelft.nl/27975

RUNNY NOSE

Professor of bioprocess engineering Luuk van der Wielen (Applied Sciences), is collaborating with neurologist Stuart Firestein of Columbia University to develop an artificial nose, in order to investigate the importance of nasal mucus to our sense of smell. The TU Delft scientist, who usually focuses primarily on the pharmaceutical and petrochemical industries, considers it important to do something different every now and then. 'A while ago, we investigated the viscosity of wine gum. This eventually helped me to understand the behaviour of pellets in a gas chromatograph.'
delta.tudelft.nl/28215

WASHING WITH CO_2

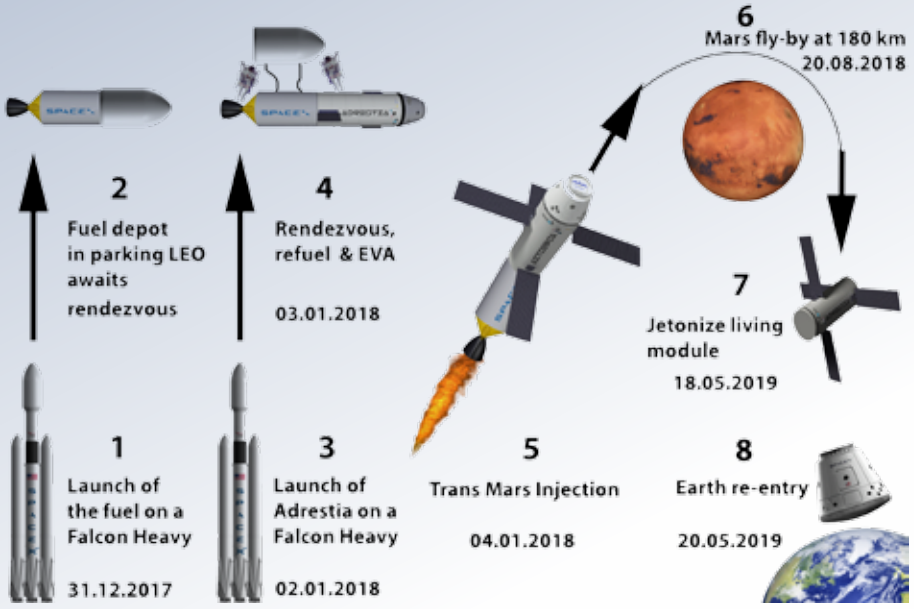


At the dry cleaners, clothes are washed in the chemical solvent PER (perchloroethylene). Although liquid CO_2 would be an environmentally friendly alternative, the high pressure would require heavy machinery. In addition, CO_2 does not remove stains easily, and it often leaves dirt behind elsewhere. Dr Stevia Sutanto, who has recently completed her PhD, reinforced the interaction of CO_2 with textiles, thereby increasing its washing power. She also calculated that washing with CO_2 would be less expensive than chemical cleaning using PER, as there are no disposal costs and the process requires no steam.
delta.tudelft.nl/28142

PHOTO: JOS WASSINK

ROUND-TRIP TO MARS

For their Bachelor's final project, ten AE students developed an idea for flying to Mars and back. With their plan, which consists of launching two carrier rockets with modules (one containing fuel and one containing personnel), which are coupled outside the atmosphere, the students are participating in the Inspiration Mars Design Contest. On 9 August, they will present their idea in the NASA Johnson Space Center in Texas.
delta.tudelft.nl/28144



INFOGRAPHIC: TEAM ADRESTIA

SPAGHETTI BRIDGE

Building bridges out of spaghetti is serious business in Delft. The annual spaghetti-bridge building competition organised by the study association Practische Studie (CEG) provided an exciting spectacle. The winning team of students built a bridge that could hold 25.1 kilos, i.e. 25.22 times its own weight. The LievenseCSO company won the professional competition with a bridge that could carry 149.79 times its own weight.

PHOTO: SAM RENTMEESTER

TELEPORTATION

Researchers of the lab of Professor Ronald Hanson (Kavli Institute for Nanoscience, Applied Sciences) have teleported information between two entangled quantum bits that were separated from each other by a distance of three metres. Entanglement is a strange phenomenon in quantum mechanics. When two particles are entangled, their identities fuse together. What happens to a single particle immediately affects the other. Hanson explains this in a video: fastfacts.nl/en/content/ronald-hanson-quantumteleportation.
delta.tudelft.nl/28316

THEME *plastic*

MAKING IT

Can you manufacture plastic using resources other than oil? Yes, says Iulian Dugulan, you can manufacture plastic out of biogas, with the help of an old-school chemical reaction (page 11). Or from chocolate bars, as Jelmer Telmis knows (page 12).

USING IT

A new polymer, named alginate, forms a watertight coating that strengthens concrete (page 8). The hard helmets of Protension are also a great development in the world of plastic (page 12). Printing plastic parts with a 3D printer saves a lot of time and money when developing medical instruments, explains Paul Breedveld (page 13).

DISPOSING OF IT

Plastic is a plague, says Boyan Slat, who plans to use floating screens to get rid of the plastic waste in the ocean (page 10). On the other hand, Peter Rem, the inventor of a magnetic separator, discovered that plastic can be recycled really well (page 14).

Flux Furniture, a company founded by alumni from the Faculty of Industrial Design Engineering, produces superflat foldable furniture from durable plastics. The folding technique was developed at TU Delft and is patented. Flux-furniture.com

PHOTO: SAM RENTMEESTER

TEXT: JOS WASSINK
PHOTO: SAM RENTMEESTER

Stone-hard concrete

A polymer prepared from waste water extends the useful life of concrete. It also appears to be suitable as a protective coating for offshore applications. Chemistry professor Stephen Picken predicts that this 'alginate' could become huge.

Innovation can sometimes come from an unexpected angle. 'The story begins about a year ago', recounts Prof. Stephen Picken (Applied Sciences). A PhD student (Jure Zlopasa, CEG) was trying to find a water-proof coating. Zlopasa's search led him to Picken, who is known as the polymer and coating expert at TU Delft. At the Microlab, where fundamental research is conducted in order to improve concrete, the young Croatian explained what he was looking for: a polymer with clay plates. These clay plates emerge when a small amount of clay is ultrasonically dissolved in water. They are discs with a thickness of 1 nanometre and a diameter between 100 and 500 nanometres. Binding these tiny, invisible but impermeable discs into a polymer creates a nano-coating that could be very useful in the concrete industry.

Contrary to what some may think, concrete should not actually dry, but harden completely. This process can take up to 28 days. For the hardening process, it is extremely important that there is enough water in the concrete mixture (gravel, sand, cement and water). As the outside of the concrete dries, small cracks appear in the surface. This will make it easier for water and salt to penetrate to the iron reinforcement bars, after which concrete degradation can occur.

On warm summer days, people at construction sites can be seen using large hoses to keep freshly poured concrete wet. In some cases, a water-repellent layer is added as well, although the result is sub-optimal, in addition to polluting the environment. This is one of the many issues being addressed in the STW concrete research program-

me 'Integral Solutions for Sustainable Construction' (IS2C).
As a solution to excessively rapid drying, Zlopasa and his PhD supervisor, Dr Eduard Koenders (CiTG) developed an idea for a polymer with nano-clay particles. With this polymer, water vapour from the concrete would have to take a long detour in order to circumnavigate the clay discs. One question remained: which polymer would be suitable? It was with this question that Zlopasa approached Picken a year ago in the former chemistry building.

Hydrophilic

Picken knew that the polymer would have to be water-based (hydrophilic), given that the nano-particles are dissolved in water. 'From cooking, I remembered that sodium alginate could be mixed with calcium chloride to form a gel layer', he notes.
According to Wikipedia, alginate is a natural hydrophilic polymer extracted from seaweed. Its primary component, alginic acid, is a polysaccharide, like starch. Rapidly hardening, inexpensive and non-toxic, it is used in the food industry as a thickening agent. Dentists use it to make dental casts, and it is used to bandage wounds in the emergency room.
Another use has thus been found: as a water-sealant layer on hardening concrete, which could last at least 20 years longer, according to Koenders's estimation.
Picken uses the presence of calcium in the cement to explains the polymer formation. Because calcium is bivalent, it links the two alginic acid molecules to each other, forming a closed network bound together by the clay plates to form a water-tight layer. This happens very quickly.
'The alginate hardens as soon as it touches the surface of the fresh concrete surface', explains Zlopasa. The water-tight, insoluble layer is only one tenth of a millimetre thick. It turns into a tough, yet flexible pale-yellow foil. Its transparency depends upon the amount of clay particles. 'The concentration of clay particles can be as high as 80%.'
Such a high concentration of neatly arranged clay particles results in special properties. Consider the example of natural mother-of-pearl: impenetrable, strong as concrete and non-combustible.

Protective coating

Picken predicts that alginate with nano-clay would also polymerise on iron (which is trivalent). This could provide a foundation for an extremely tough protective coating for offshore constructions. The valorisation centre is busily charting the various applications and patenting some of them.

The water-tight, insoluble layer is only one tenth of a millimetre thick

Examples include the use of alginate in optical products (in order to make cast lenses) and in the paper industry (using alginate from self-produced waste as a paper-surface treatment).
Alginate is an end product of the widely acclaimed Nereda waste-water purification system developed by Prof. Mark van Loosdrecht and RoyalHaskoningDHV. At the end of the purification process, the bacteria pellets contain 15%–20% alginate. Zlopasa presents a small plastic bottle containing a black liquid: alginate from sewage waste water. Although the origins can still be recognised in the odour, this should not pose any problems for non-food applications.
The clay alginate is a new, purely natural product with surprising properties and a growing list of possible applications. It can literally be used to create value from waste. 'If TU Delft plays its cards right, this could become huge', predicts Picken.

What is plastic

In common usage, 'plastic' is a relatively generic and mildly derogatory term for synthetic materials. It refers however, to the property of malleability, which is a property of what chemists refer to as thermoplastics. These are synthetic materials or polymers that can be softened by heating, because their long molecules have little or no branching. A plastic object can be hot sprayed or pressed in a mould, and will retain its shape after it cools. It can easily be recycled by melting it. Other polymers (i.e. molecules consisting of a series of identical or similar parts) form a strongly branched network when a hardening agent is added or when they are exposed to ultraviolet radiation, thus hardening permanently.
For this reason, not all polymers melt, but plastics do.
Finally, composites are compound materials consisting of a strong layer of fibres or metal embedded in a polymer. One well-known example is the aircraft material Glare, which is composed of several extremely thin layers of aluminium, glass fibre and epoxy.

Major clean-up

Floating screens that are one metre deep and a hundred kilometres long are expected to remove floating plastic waste from the ocean. Former TU Delft student Boyan Slat presented his plans for these screens from New York City on 3 June. The installation will be anchored to the ocean floor and placed in an ocean eddy current, Slat expects floating waste accumulate against the screen and to be easily removed in a kink. Slat spent a year testing the feasibility and the experts have provided a positive assessment. He wants to install a prototype in three to four years, and aims to accomplish this by means of crowd funding.

theoceancleanup.com

ARTIST IMPRESSION VAN DE OCEAN-CLEANUP

Plastic from biomass

An old chemical reaction – the Fisher Tropsch process – is expected to make it possible to produce plastic from biomass in the future. But there is still a long road ahead.

Olefins are the materials for plastic. They have traditionally been made by cracking oil. To make the process sustainable, people have been trying for years to use biomass as a raw material. To date, success has been limited: the reaction is inefficient and yields many undesired by-products. Dr Iulian Dugulan, a researcher in the department of fundamental aspects of materials and energy at the reactor institute (Applied Sciences) has succeeded in making substantial improvements in one of the steps of the reaction.

In his own words, he is investigating the most important process in the manufacture of olefins: catalysis. More specifically, Dugulan is examining the Fisher Tropsch process. This famous chemical reaction has been used since the 1920s to convert carbon dioxide and hydrogen into liquid fuel – olefins, which are a type of hydrocarbon. Traditionally, an iron-based catalyst has been used for this purpose.

Utrecht University has developed a new catalyst, which also contains iron, but to which nano-particles of sodium and sulphur have been added in order to improve the stability and efficiency of the process. This will make it possible to convert more biogas into olefins. At the reactor institute, Dugulan is examining the operation of this new catalyst during the chemical reaction. It is the only laboratory in the world where this is possible. 'It is important that we look at the active operation of the catalyst, given that it is positioned in a dynamic balance. It changes along with its environment.'

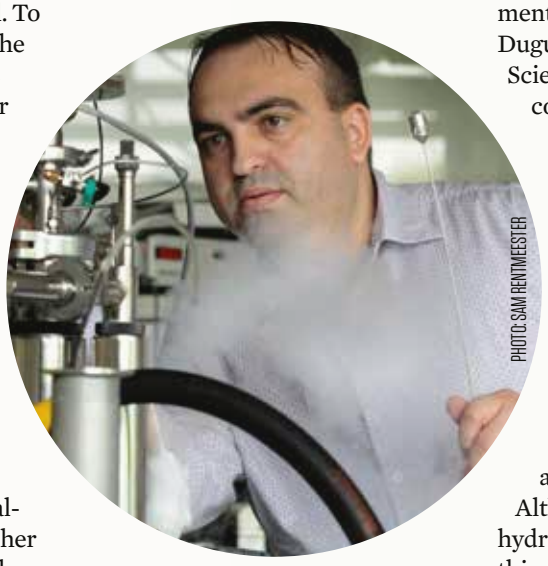


PHOTO: SAM RENTMEESTER

It is the only laboratory in the world where this is possible

Dugulan published his findings in Science in 2012, together with his colleagues from Utrecht. In that article, they also mentioned their collaboration with Shell, Dow Chemical and Johnson Matthey. According to Dugulan, these industrial partners already have large factories for the Fisher Tropsch process.

Whether this process actually is the perfect solution for the production of both energy and plastics remains to be seen. Although Shell is already making hydrocarbons and fuels without oil, this process has yet to be coupled with the manufacture of olefins. Dugulan placed it perspective, saying, 'We are still in the starting phase'. ECN is already working on burning biomass (i.e. agricultural waste products) in order to make gas. Nevertheless, we cannot yet make plastic out of this synthetic gas. 'In practical terms, it is still a long way from biomass to bio-plastics.' DH

PHOTO: SAM RENTMEESTER

Rock-solid helmet

Soldiers use helmets to protect their heads from bullets and bomb fragments. With their overwrapped composite helmet, the Protension company owned by TU Delft alumni Lucas van den Akker and Jack Wetzels aims to lift as much weight as possible from the shoulders of the soldiers. Lighter and safer.

A rotating mould, 32 thermoplastic fibre threads and a smart overwrapping technique – these features allow the machines of Protension to produce one helmet shell every 10 minutes. The shell is a few centimetres thick, a press reducing it to about 7 mm. In the meantime, a thermoplastic resin flows between the fibres. After cooling, the result is a compact, rock-solid helmet weighing 1 kg.

The TU Delft alumnus Lucas van den Akker established Protension as a technological consultancy firm after graduating in 2007. Jack Wetzels joined him in 2009. He had completed a graduation project on the overwrapping of carbon bicycle rims. This project resulted in a machine-based production process for superlight rims made of continuous carbon fibres. Protension patented this ring-overwrapping method. The bicycle industry has been using it ever since.

For two years, the company has also been developing overwrapped military helmets. The material used is a true plastic, a thermoplastic. 'It is actually the same material used in a sandwich bag', explains Wetzels. 'But it has been reinforced to the point that it has become the strongest fibre in the world, 15 times stronger by weight than steel.'

The Ministry of Defence has invested €200 thousand over the past two years. In the coming years, Protension hopes to continue working with the Ministry of Defence to develop what would be 'the world's lightest combat helmet'. 'The goal is to develop the helmet to be a perfect match for the requirements of the Ministry of Defence. The design, production technology and supply chain would then be ready, and we could start delivery – first in the Netherlands, and then internationally.' SB

Candy becomes plastic

The cream-coloured wastewater from the Mars, Bounty and Twix bars is filled with fatty acids and sugars. A small portion of this was used to feed plastic-producing bacteria, which produce long polyesters (polyhydroxyalkanoates or PHA), a type of body fat for the bacteria and a usable bio-polymer for people. Jelmer Tamis (biotechnology, Applied Sciences), who supervised the experiment on-site, brought the amount of PHA extracted from the wastewater to a new record: 1 gram of plastic from 3 grams of waste. This reduced the price of the substance to about €1 per kilogram, making it less expensive than polyethylene. Price is an important factor for determining whether the bio-plastic will be used in the industry.

The mobile test system is the result of fourteen years of research by the department of environmental biotechnology, which has already led to the discovery of *Plasticicumulans acidivorans*. These superbacteria are allowed to feed on the candy wastewater for five hours until they almost explode. The water is then tapped and harvested: more than 70% of the dried mass consists of PHA bio-plastic.

In the Netherlands, supplementary research is being conducted on the material properties and application of the bio-plastic. This is taking place within a programme of technology foundation STW, in collaboration with the universities of Wageningen and Eindhoven. In May, the pilot plant relocated to a cardboard factory in Groningen, whose wastewater contains many fatty acids. JW

PHOTO: JOS WASSINK

Printing plastic

By 3D printing parts in plastic, scientists are able to conduct much better research on new medical instruments. They are able to print tiny, complex parts simply, quickly and inexpensively.

On the table is a steerable, flexible medical instrument for keyhole operations, which looks like a pair of scissors, due to its handle with two large openings. At the other end, instead of a sharp cutting surface, there is a grasping tool, which can be manoeuvred in all types of curves. The flexibility of the grasping tool is due to its complex shapes. 'Including gears with tiny flaps and curving channels. These spatial forms are complex to produce', observes bio-inspired technology professor Paul Breedveld (3mE). He developed the medical instrument in collaboration with PhD student Filip Jelinek. 'Although it could be made with a machine, that would be very difficult and expensive. This is why we had the idea to make parts with 3D printing'.

That idea was right on target. The parts can be printed for around €100. That is quite a difference from the thousands of euros that Breedveld would have had to spend if they had been produced with a conventional processing machine. 'We conceive complicated shapes and try to imagine how they work. Now we can print such shapes inexpensively, in order to see whether our ideas are correct.'

It is changing the way in which Breedveld and his colleagues design. He points to the tip of the instrument. 'On the fifth attempt, everything was in place, and the instrument worked. In the past, when we produced things with a conventional processing machine, we often started big and then kept making it smaller. With 3D printing, we can usually make everything quite small right from the start.'

To produce small prototypes, Breedveld collaborates with several partners, including TNO. The instruments must be ultra-thin if they are to be used by surgeons, and TNO is able to print very thinly with high-quality plastic. 'Unfortunately, it is not always robust enough.' He displays a smaller version of the instrument, that looks like a pair of scissors. 'I recently dropped this on the floor from a height of one metre. Pieces flew off. Some of the flaps are only 0.3 millimetre thick. We are now exploring how we can print parts that are more robust. We will soon start working with ceramics as well, because we think that it would be stronger than plastic'.

Breedveld emphasises that not every part is suitable for printing. For example, the cables and the turnbuckles are made of metal. 'In this way, we combine the best of both worlds. We print about 70%; the rest, we don't print.' TvD

PHOTO: SAM RENTMEESTER

'Now we can print the shapes inexpensively, in order to see whether our ideas are correct'

Rivers of plastic

In the Delft recycling lab in the faculty of Civil Engineering and Geosciences, they don't like to talk about plastic waste. When the recycling experts pass pieces of shredded plastic through their magnetic density separator, they are left with nice piles of plastics that are ready for use as raw materials, each neatly separated according to density.

PHOTO: HANS STAKELBEEK

Prof. Peter Rem is the brain behind this machine, which operates with a magnetic fluid containing iron oxide. The density of this fluid can be varied from high to low by applying a magnet. This gradient causes plastics to float according to their density, making them easy to separate.

'In 2007, we received an EU subsidy to develop this technology', explains Rem's colleague, Dr Maarten Bakker. 'A Delft spin-off company has recently been trying to market the technology.'

The researchers now hope to develop acoustic sensors that will allow them to look into the fluid. 'The fluid streams are quite complex. Turbulence should be avoided, because that mixes the particles again. An acoustic sensor could help us to improve the calibration of the machine.'

In the field of medicine, acoustics are often used to look inside bodies. 'For our purposes, however, that technology is not usable', notes Bakker. 'The images that are generated require too much human interpretation. If a doctor is uncertain about what he sees, he will refer the patients to a surgeon. We don't have any room for uncertainty. The device has to know exactly what type of plastic it sees, because everything has to be done automatically.' AV

delta.tudelft.nl/27286

The first plastics

What was the role of TU Delft in the development of plastics? Information specialist Jorden Esser went searching in the archives of the TU Delft Library.

The modern plastics industry began with Bakelite, which was invented by the Belgian Leo Baekeland. He filed the patent in 1907. The oldest journal in the TU Delft Library in the field of plastics is *Kunststoffe*, which was launched in 1911. Unfortunately, it does not contain any truly historical contributions from Delft. According to the chemical engineering department (Applied Sciences), the 'plastic age' dawned in the 1930s. The first Delft publication (1933) listed in the TU Delft catalogue is *'Fabricage van bakeliet'* [The fabrication of Bakelite] by A. R. Veldman. In 1937, this researcher wrote a dissertation entitled *'De constitutie en de fabricage der phenol-formaldehyd-harsen'* [The constitution and fabrication of phenol-formaldehyde resins]. A symposium on plastics was held in January 1944. According to Web of Science, the first TU Delft article to contain the term 'plastics' was published as recently as 1977: 'Injection moulding of plastics: Some ideas about the relationship between mould filling and birefringence' by H. Janeschitzkriegl. JE

For the publications mentioned, please visit delftoutlook.tudelft.nl

PHOTO: SAM RENTMEESTER

Multi-functional materials

Constructions need to be increasingly light and strong. That can be done, according to Prof. Theo Dingemans (AE), almost exclusively using multi-functional materials.

A piece of carbon composite is lying on Dingemans's desk, in the department of novel aerospace materials. 'It is a wonderful material', observes the professor. 'As with so many materials in the aviation and aerospace industries, however, its density is somewhere between 1 and 1.5 grams.'

What Dingemans is trying to say is that the limits appear to have been reached. 'We are now trying to push the boundaries by building additional functions into materials.'

According to Dingemans, one particularly promising area is the work that is being done on plastics that can act as both solar cells and coatings. Dr Johan Bijleveld is one of the researchers in Dingemans's group who are working in this area. 'We need a semi-conductive polymer, a polymer with many double bonds. One example would be polyazomethines.' Bijleveld's computer screen displays a graphic representation of a piece of polyazomethine. It is a concatenation of several rings of benzene and thiophene.

One unusual thing is the X that is built in somewhere in the middle of the molecule fragment. Bijleveld explains: 'X is a side group that can do all sorts of things. Examples would be a nitrogen atom or an entire nitro or methoxy group. Some of these groups attract electrons, while others do not. By manipulating X, we can vary the electron density in the chain. This changes the efficiency with which the molecule transforms sunlight into electricity.'

'The silicon solar panels that people currently have on their roofs achieve an efficiency level of 15%. We have not yet been able to surpass 2%.'

Numerous groups all around the world are working with this technology. 'Some researchers are achieving yields in excess of 10%,' notes Bijleveld, 'but their polymers are expensive and very difficult to make. Our polymer, and thus our solar cell, can be ready within a week. It requires only three chemical steps at most.'

Thermo-electrical properties

Another promising material is the composite of plastic and carbon nano-tubes on which Bijleveld's colleague, Dr Maruti Hegde, is working. The addition of carbon nano-tubes to the plastic makes the plastic behave in a semi-crystalline manner. It is extremely stiff, resistant to high temperatures and it has interesting thermo-electrical properties.

'If you were coat an exhaust pipe with this material, you could use the temperature difference of several hundred degrees Celsius between one side of the exhaust pipe and the other to generate electricity', Hegde explains. 'Another feature that makes the material interesting is that it can be used to separate gasses. It could be used to filter carbon dioxide out of natural gas, for example. Believe me, you will be hearing a lot more about this material.' TvD

Self-healing plastic

Polymers that repair themselves after a crack has appeared. Sybrand van de Zwaag (AE) is developing 'self-healing plastic', which can be used for such purposes as repairing scratches in auto paint.

If you run your finger through hair gel, an opening appears in the gunk. It then becomes whole again. Self-healing polymers will work in about the same way. Researchers in Delft are developing a method with which to influence polymers at the molecular level. 'Suppose that a crack has appeared. It would close again, because the two halves would come back together following the application of slight pressure or a slightly higher temperature. This occurs due to reversible molecular bonds. Once these bonds have been reformed, the material would have the same conditions as before', explains Sybrand van der Zwaag, a professor in the faculty of Aerospace Engineering and the director of the Dutch Polymer Institute and the Delft Centre for Materials.

One possible application would be in the automotive industry. An example could involve coating a car with the self-healing material. If it gets scratched or if cracks appear, it would have to be heated to 50 or 60 degrees. This could be accomplished with a blow dryer or by building in a small electronic warming mechanism. 'But car paint also heats up on its own when it is exposed to sufficient sunlight. The coating would not melt, but the crack would close.'

'The polymer can't simply be self-healing; it must be stiff and solid as well'

The researchers are focusing their efforts primarily on creating a material that has the right mechanical properties. 'It can't simply repair, becoming gel-like in the process. That would make it impossible to use as a building material. It must be stiff and solid at the same time as well.'

Van der Zwaag shows a video of a PhD student and a cracked piece of polymer. She presses the two halves together and, within one minute, it becomes whole again. She then tries to pull it apart again, but does not succeed. It is a milestone in research on self-healing polymers. The process can repair cracks multiple times in the same place. 'But we are not there yet. We are now making self-healing polymers on a small scale. We would also like to produce them on a larger scale, and we would like to make the pieces much larger.' The research being conducted at TU Delft is part of a national programme that also includes the development of self-healing concrete, metals and composites. RV

YouTube

youtube.com, new self-healing polyimide from NovAM

PHOTO: SAM RENTMEESTER

Studium Generale

Several years ago, Studium Generale devoted attention to plastics in its Materials series (a multi-annual series that was organised by programme maker Marion Vredeling at that time). Various (historical) aspects of synthetic materials were discussed in this series, as well as innovations that were expected to have a significant impact on daily life. There were lectures, exhibitions, workshops and excursions. More information can be found on http://bit.ly/1pOHiHh.

In July and August, a film stream (created by M. den Breejen and M. Vredeling) will be shown about plastics in the hall of the TU Delft Library. More information: Marion Vredeling, m.vredeling@tudelft.nl

2030

Within 20 years, functional polymers will be the smartest material that exists, says Dr Kaspar Janssen (Industrial Design Engineering).

'Feel free to call polymers plastic, but I prefer to focus on material systems. Functional polymers are smart materials that are capable of interacting with their surroundings and with people. There are three types. The material structure can be influenced on an atomic scale to achieve such properties as biodegradability. To date, considerable effort has been invested in this area through the addition of starch, which breaks down under the influence of moisture and warmth. In addition, plastics can be made functional on a molecular scale. One example involves the addition of piezo crystals, so an electrical current can run through them. Finally, the third possibility is to design a material on the micro scale through the application of a texture to the surface. For example, micro-hairs can be used to make a product water-resistant. We refer to this as the lotus effect.

Although these sorts of things are now possible only in the laboratory, I think that in the future it will be very easy to manufacture much larger surfaces. Another promising production method is 3D printing. The advantage of 3D printing is that it allows you greater control over the material. Plastics always expand more than metal or ceramic. With 3D printing, you can determine the expansion coefficient with considerable precision. This also makes it possible to produce materials in which multiple functionalities can be integrated. Examples include transparent plastic with light channels, with the intensity of the light changing when it is touched.

I think that this type of integration of materials into electronics will become the most important field of research in the future. I can envision products – on your body, in your clothing, in your car or in your office – that take a wide range of continuous measurements and that remain in contact with each other: the 'internet of things'. For example, imagine clothing that could provide active cooling in a warm environment, buildings with smart coatings on the windows that selectively allow sunlight, or a remote control that changes colour when it needs to be charged. In our department, we are working to develop a vision for the future in this area.

One challenge will be to resolve the problem of energy in electronics, because it is very inconvenient to be changing batteries all the time. With 'energy harvesting', you could store the energy of every footstep in the sole of your shoe and use it to charge a battery. In addition, electronics will have to become more flexible. If you want stretchable chips that can be placed alongside each other in a piece of rubber, it is important for the electrical connections not to break. I'm convinced that smart tricks will be developed for this as well.' DH

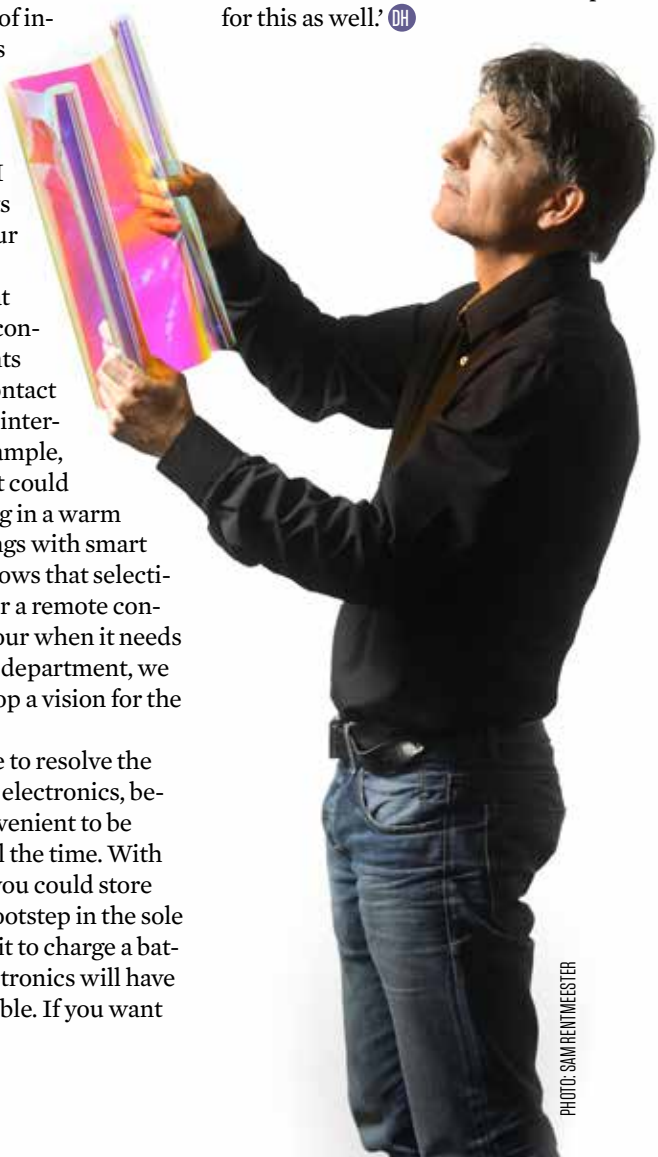


PHOTO: SAM RENTMEESTER

ALUMNI EVENT 2014

The Alumni Event brought approximately 350 alumni together at TU Delft on 6 June in order to discuss the latest developments and research, and to provide an opportunity for networking with fellow alumni. The theme of the day was 'university of the future'.

Vice-president of the Executive Board Anka Mulder officially opened the Alumni Event and spoke afterwards about TU Delft's prominent role in the area of online communication. The Canadian MOOC expert George Siemens subsequently spoke about the future of global online education. Host Bas Haring was assisted by little robot Nao; they introduced all speakers and occasionally asked critical questions.
The Prêt-à-Loger dream team showed their conceptual 'house with a skin' – the submission to the Solar Decathlon – with a personal short film. The parental home of one of the group members was the inspiration for their renovation project. They want to retain the old ambiance, but at the same time improve the living environment in the home.
Professor Dick Hordijk, an expert on concrete, explained that concrete might seem like 'no-tech', but more and more modelling is being done. Ewoud de Kok added an enthusiastic story about his (team's) start-up FeedbackFruits, followed by alumnus Adrian van Hooydonk, senior vice-president of BMW group design. Van Hooydonk talked about his study, about drawing as a means of communication and about the latest BMW designs. His latest design – the BMW i8, with which he arrived noiselessly at the event – attracted a lot of attention. His attendance was especially significant, because he was elected Alumnus of the Year 2014. The University Fund revealed the prize: he is the first alumnus with a spot on the 'Alumni Walk of Fame' in Mekel Park.
President of the Executive Board Dirk Jan van den Berg concluded with a presentation about the increasing progress that TU Delft has made in several respects: number of students, research budgets and the campus. This was followed by a social gathering and dinner, the DIG-it! Xperience and a campus tour, with visits to, the Library, the dead room and the collection of chairs at the Faculty of Architecture and the Built Environment.

Adrian van Hooydonk.


Alumnus of the year.


Dick Hordijk and Bas Haring.


George Siemens.


DIG-it! Xperience.


Walk of Fame.

THE FIRM

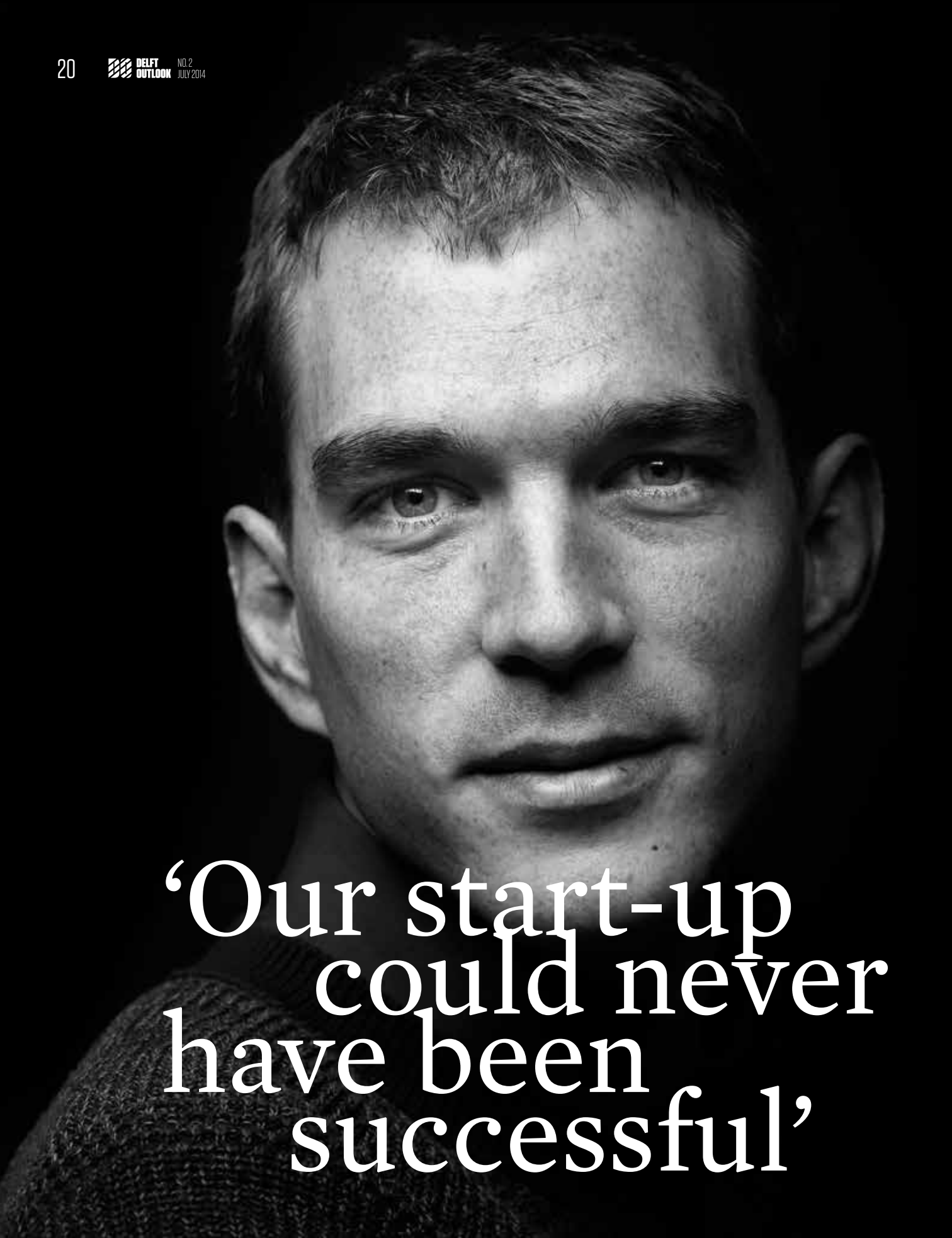
What's the worst that could happen? In January 1996, with this thought in mind, Jan-Jaap Koppert took the bold step of launching his company Advanced Lightweight Engineering. Now, 18 years later, his 'shop' is valued at €50 million, and Koppert has a wealth of stories and anecdotes.

Just ask Jan-Jaap Koppert about the origins and development of his company Advanced Lightweight Engineering (ALE) and stand back. From his years in the materials department of the faculty of Aerospace Engineering, he proceeds to tell of the poor labour market he entered as a young graduate in the mid-1990s. The scene shifts to show him sitting uncomfortably in an organisational consultancy firm, thinking about his future, wondering whether he should start his own company – obviously in the field of composites.
'I had no mortgage, no children. I thought, "What's the worst that could happen?" And so I did it.'
Koppert wrote 'a little business plan' and started searching for money. Banks were no help, but he was able to scratch together €4000 from people who understood him – entrepreneurs. These six men coached him and provided him with access to their networks. Koppert gave himself one year. 'After that, I would analyse how things had gone'.
No sooner had Koppert started than he was summoned to a shipyard. There, he saw a luxurious 50-metre yacht under construction. 'The customer wanted to be able to sail it at the unprecedented speed of 90 km/h. The hull was finished, made entirely of steel. Any weight to be eliminated would have to come from the interior. We made composite floors and walls. This allowed the yacht to reach the desired speed.'
One part of ALE is an engineering firm that specialises in composites. For example, Koppert and his 20 employees are working for the aircraft manufacturer Airbus to develop a method for

PHOTO: SAM RENTMEESTER

virtual imaging of invisible damage to composite fuselages. In addition, ALE produces automobile parts and antennae for satellites. The company has been earning money with these types of activities from the start.
This allowed him to finance his passion: producing composite overwrapped pressure vessels. Because they weigh much less than steel vessels, their uses include reducing the weight carried by cars running on LPG, thus improving their fuel efficiency. The largest consumer market that Koppert is currently targeting, however, is located in countries where people cook with bottled gas. 'Steel tanks are heavy, they rust, they require considerable maintenance and they can explode. We can reduce the weight by 80% with our much safer, flexible tanks. Using the machines we developed, we can overwrap them in two minutes.'
Malaysia was the first country in which ALE sold a licence. The Delft company shipped its overwrapping machines overseas to Kuala Lumpur. If Koppert has his way, Brazil, Russia and other countries will soon follow.
This would usher in the time for which he has been working for nearly 20 years: 'Our engineering firm is really an ordinary wage factory. We don't earn anything except when we're working. Now we'll be earning money while we sleep as well.' SB

Name:	Jan-Jaap Koppert
Degree programme:	aerospace engineering
Company:	Advanced Lightweight Engineering
Established in:	1996
Sells:	composite pressure vessels and materials knowledge
Mission:	to make pressure vessels safer and lighter
In five years:	ALE composite pressure vessels will be sold in many countries



‘Our start-up could never have been successful’

In July 2013, TU Delft alumnus Jan van Kranendonk and his business partner Thomas de Leeuw decided to discontinue their start-up company Sunuru. The reason was that customers were not interested in their ingenious solar project. Van Kranendonk spoke about his failure during the Failcon event in Amsterdam, which is modelled after similar events in Silicon Valley. 'Having your own company looks good on your CV.'

TEXT SASKIA BONGER PHOTO SAM RENTMEESTER

WHY DID YOU WANT TO TALK ABOUT YOUR OWN FAILURE AT FAILCON?

'Failcon is relatively important in Silicon Valley. The people there are more conscious of the type of company that a start-up actually is. As Jasper van Kuijk (assistant professor at TU Delft and comedian – ed.) once said: "Innovation is a fashionable term for something that often does not work". In the Netherlands, we are not yet sufficiently aware that failure goes with the territory. We'd obviously like to avoid it, but I take comfort in the notion that there's life after death. I have never received as many job offers as I did during the two weeks after we pulled the plug on Sunuru. Having your own company looks good on your CV. Moreover, failure taught me quite a bit about how a start-up works.'

WHAT WENT WRONG?

'As true engineers – we are both mechanical engineers – we designed a product containing tons of innovation. We did this in six months, and with €100,000. Our product had an attractive appearance and it was remarkably innovative. Our costs were low because we had used very little material. As an engineer, you tend to think, "This product is perfect. We'll just bring it to the market, and we're done". Subsidy agencies and investors in the Netherlands were enthusiastic. We were too, of course. We wanted a scalable product, something that could become really big. After six months, therefore, we went to California, one of the world's largest solar-energy markets. We proudly presented our product to prospective customers. Their reaction? "See ya!" Only then did we realise that customers don't simply consider the costs. They are concerned about the

'So many people just keep plugging away, wasting a lot of energy, emotions and government subsidies'

risks as well. And they considered the risks too great. In order to reduce the risks, we eliminated many of the innovations from our product. This increased the cost, however, and this in a market where solar were getting cheaper quickly. We discovered that we were unable to be cost-competitive.'

THAT MUST HAVE HURT.

'Absolutely. Another speaker at Failcon said, "Failure is a gradual process through which

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CV

Jan van Kranendonk studied at TU Delft between 2002 and 2011. After completing his propedeuse (first year) in mechanical engineering (3mE), he transferred to industrial design. Although he never completed this Bachelor's degree, he did start two companies. One of them was Numboards, which is still manufacturing cutting machines for Styrofoam. The other company was Pineapple Entertainment, which developed a game for mobile telephones. In his years at IDE, he also received a 'Young Wild Ideas' award of €10,000 for an algorithm for bending bamboo. In 2007, Van Kranendonk returned to 3mE, where he completed his Master's degree in mechanical engineering magna cum laude in December 2011. In the same month, he and Thomas de Leeuw established their company Sunuru. They are now exploring business opportunities within the industry, under the name VKI BV. For example, they gained access to the Argos oil company, which van Kranendonk says quickly generated a good plan for a new company. He prefers not to say what it is.

you slowly come to realise that your idea is bad". We pulled the plug after 18 months of hard work and €300,000 in investments. The most difficult time for me was during the two months before this decision. Deep down, you know that things are not going well, but you are afraid to acknowledge it. You become tired, moody and ill. Then we sat down together, and we both reached the same conclusion. It became obvious that it could never have been successful. I'm glad that we realised this relatively quickly. We did not want to become a zombie start-up. So many people just keep plugging away, wasting a lot of energy, emotions and government subsidies. Subsidies would have kept us going for years in a Dutch design niche, but that had nothing to do with manufacturing a scalable product. We were able to avoid bankruptcy and burnout. If you fail, fail fast.'

DO YOU HAVE ANY OTHER TIPS FOR TU DELFT ENGINEERS WHO WOULD LIKE TO BECOME ENTREPRENEURS?

'Participate in the YesDelft LaunchLab. It teaches all about entrepreneurship and provides concrete information about the methods you should use in order to become successful. We didn't start working on customer development until after we had completed our product. In the United States, we realised that customers are concerned about entirely different things than we were. For example, they have to estimate risks. No matter how hard you work to develop a product, if it's the wrong product, it's a waste of energy. Designing the product is only 20% of the work that an entrepreneur must do. I regard entrepreneurship as a science. You have a hypothesis. If it's negative, you make a note of it: nobody is interested in this product. Many students would like to build and sell the next 3D printer, drone or app. You can use these ideas to participate in the LaunchLab, but you should not think of the gadgets as your ultimate goal. Look around to see what is needed in the industry, and act on that. There are opportunities waiting to be found by entrepreneurial engineers.'

HOW CAN THEY FIND THESE OPPORTUNITIES?

'Together with my partner, I went to observe companies, including Nova Terminals, which was previously Argos. We looked around to see what they needed. We are now developing a product and a new company, but it's still under the radar.'

DOES A FAILED COMPANY LOOK GOOD ON YOUR CV?

'At first, I was a bit surprised that Nova Terminals was glad to have us and that they were willing to pay for our visit. Yet having your own company does look good on your CV. It attests to your entrepreneurial spirit. We have a good explanation

for why our company didn't make it. This has led to a different manner of working. We have stopped focusing on technology push and turned our attention towards market pull. Our experience with Sunuru taught us that the first strategy can be very risky. The second strategy makes it possible to validate your innovation quickly, almost like a scientific experiment. Companies are willing to pay for this, because they have neither the time nor the fresh perspective that it requires.'

HAVEN'T YOU EVER THOUGHT, 'I THINK I'LL TAKE A REGULAR JOB AFTER ALL'?

'That's not an option for me; I'm not cut out for that. I'm curious and stubborn, and I like to work outside my comfort zone. I'm not in business for the money. I think that is the case for most entrepreneurs. You want to have the greatest possible impact, and sometimes you can fall flat on your face. That's no fun, but if you know that it goes with the territory, you'll be less afraid to decide to pull the plug. In the Netherlands, if we could learn to accept such failure, we would be able to innovate more quickly. In the United States, a bankruptcy is regarded as a success factor, even by financiers. This is because people who have experienced bankruptcy are much less likely to go bankrupt again. When we decided not to continue with Sunuru, we were embarrassed to approach one of the largest subsidy agencies. He told us, "Congratulations. Now you're experienced".'

www.delta.tudelft.nl/27930

YesDelft

In recent years, 139 companies have been established with guidance from YesDelft. According to figures from the TU Delft incubator, five have gone bankrupt. Of the other companies, 17 have gone out of business. Sunuru is one of them.

LETTER TO THE EDITOR

'Boffin'

When I graduated in the sixties, engineers were highly regarded. A new era followed, however, in which this regard was systematically dismantled. Jurists, economists and sociologists believed that engineers only built things and needed guidance. They therefore believed that it was their job to determine what could be made by engineers. Unfortunately, few Dutch members of parliament were and are engineers. To my great disappointment, technology lost its importance and the word 'techneut' (boffin) was made up to rob engineers of their standing. We entered the era of the managers, who were not required to know much about technology, yet still made all the decisions in this field. The consequences would soon be felt. Magnificent laboratories were closed, interest in technical studies waned and innovation suffered. When it finally became apparent that innovation is a very important pillar of our wealth, state commissions were appointed to stimulate innovation. For a long time, people did not understand that innovation is connected to good engineering degree programmes and sufficient numbers of engineers, who are not led by jurists, sociologists, economists, etc. The appreciation for the field of technology seems to be growing, however. Nevertheless, the contribution of Prof. Han Vrijling, in Delft Outlook 2013.3, shows that the expertise of engineers in their own field is still not recognised and valued. When will this change?

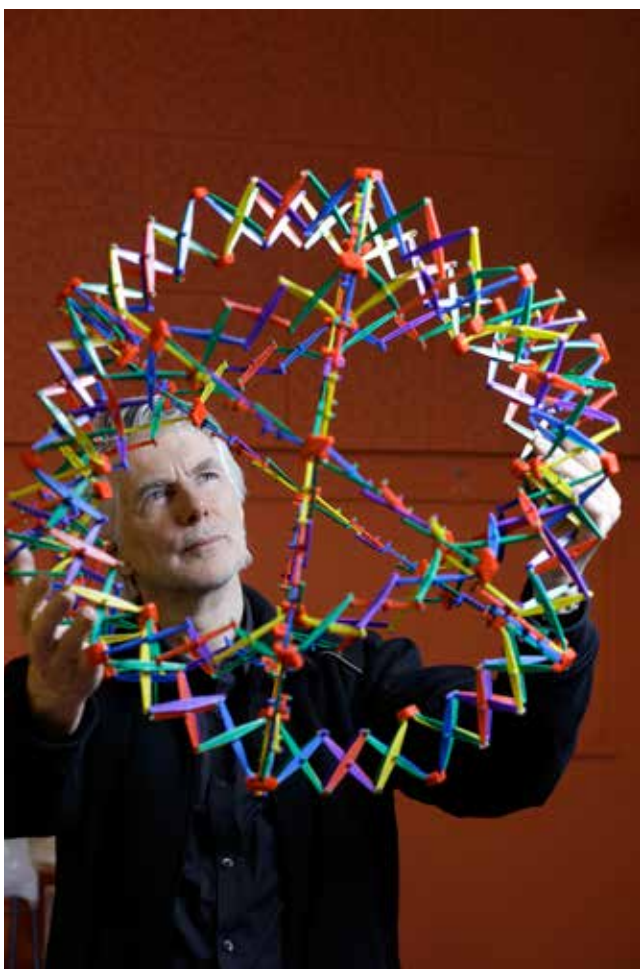
The same journal contains an article by Saskia Bonger, entitled 'Muurvaste Protheses' (Solid Prostheses). A beautiful story about innovation, which, in this case, is not led by managers with a law or financial degree, nor by sociologists. Nevertheless, the article opens with "Delft boffins and Leiden doctors", which deeply disappointed and disturbed me. Why should we engineers be called boffins in this article? I find that word derogatory and propose that it be banned, at least from the Delft Outlook journal.

Dr. C. Spaans

New construction kit for chemists

TU Delft is heading a European research programme on CO_2 capture, with a budget of €10 million. This could result in the first large-scale application of a new class of porous materials.

TEXT JOS WASSINK PHOTOS SAM RENTMEESTER



The prestigious M4CO_2 research project was launched in early February in the ChemE catalysis laboratory of Prof. Freek Kapteijn and Prof. Jorge Gascon (Applied Sciences). Sixteen European partners are involved in the project, which is part of the European Seventh Framework Programme. Within four years, the project is expected to result in the development of membranes that allow the selective permeation of CO_2. This will make it possible to remove CO_2 from flue gasses, as desired by the European Union (EU).

The process would eventually be considerably less expensive than the current method, which involves fluids (amines) that bind with CO_2 at low temperatures and release it at high temperatures. Raising and lowering the temperature costs a lot of energy, and therefore money. According to a recent report from the Massachusetts Institute of Technology (MIT), the cost of CO_2 capture ranges from €30 to €90 per ton, depending upon the type of power station. The EU is aiming for a continuous process, with a target price of €15 per ton.

The price of the CO_2 capture will determine whether the technology will be used or whether the greenhouse gasses will be released into the atmosphere. According to recent estimates, the capture and storage of CO_2 costs at least €45 per ton. Emission rights on the European emissions market (EEX) are at less than €6 per ton of CO_2. What would you do?

'Reductions in the emission of CO_2 from major sources, such as coal-fired power stations and other energy-intensive industries, could help in the fight against climate change', argues Dechema, one of the research partners, in a press release. For this to happen, however, sequestration would have to be so inexpensive that industries would apply it. This is the most important idea underlying the M4CO_2 research programme 'mixed matrix membranes based on metal-organic frameworks (MOFs) and polymers for continuous CO_2 separation'.

'To date, people pinned their hopes on membranes made of polymer or zeolites', explains Dr Jorge Gascon, an associate professor in Kapteijn's catalysis department. Each of these membranes, however, has its own deficiencies. Polymer membranes are not permeable enough for the large amount of gas that must pass through them. Zeolite membranes are too brittle. 'The new approach proceeds from a polymer with built-in CO_2 filters', Gascon explains. 'This combines the simple production of a polymer with the selectivity of porous material. MOFs are very good at this.'

> 'To a chemist, space inside a molecule is the same thing as a large house is to a designer'

CONSTRUCTION KIT

MOFs – short for 'metal oxide frameworks' – are the new construction kit for chemists. Their most remarkable property is that they are extremely hollow. 'One gram of material has an internal surface the size of a football field', explains Gascon. Although it is difficult for laypeople to imagine, chemists were quite excited by this in the 1990s. 'To a chemist, space inside a molecule is the same thing as a large house is to a designer: a world of possibilities.'

Prof. Freek Kapteijn shares this enthusiasm: 'MOFs can be used as a gate that allows or blocks the permeation of specific molecules, as a catalyst (which causes molecules to react with each other – ed.) or as storage for hydrogen or other substances. They can be activated thermally, electrically or with light. It's really a construction kit with countless possibilities.'

To date, tens of thousands of MOF variants have been developed. One property that they all share, however, is the combination of a metal atom with organic molecules as branches. As Gascon describes it, 'You can choose whichever metal you like, along with a random organic "linker" (in many cases, organic acids – ed.), and combine them however you like. The possibilities are virtually unlimited.'

Gascon explains that the preparation of MOFs is a lot like cooking in a pressure cooker. He shows a sturdy steel cylinder used for this purpose. The cylinder is filled with a mixture of a salt (for the metal cores) and a multiple carbon acid dissolved in water or an organic solvent. The proper proportions determine the end product – a layer of white, yellow or light-green powder, depending upon the metal used.

As in the kitchen, mastery is revealed in the details. 'By changing the conditions, it is possible to steer the process in a certain direction', says Gascon. The temperature, the salt used, the type of acid that is added, the proportions of the mixture and the choice of whether to use a solvent all affect the ultimate result.

APPLICATIONS

One of the first applications is in the form of a catalyst, facilitating chemical processes.

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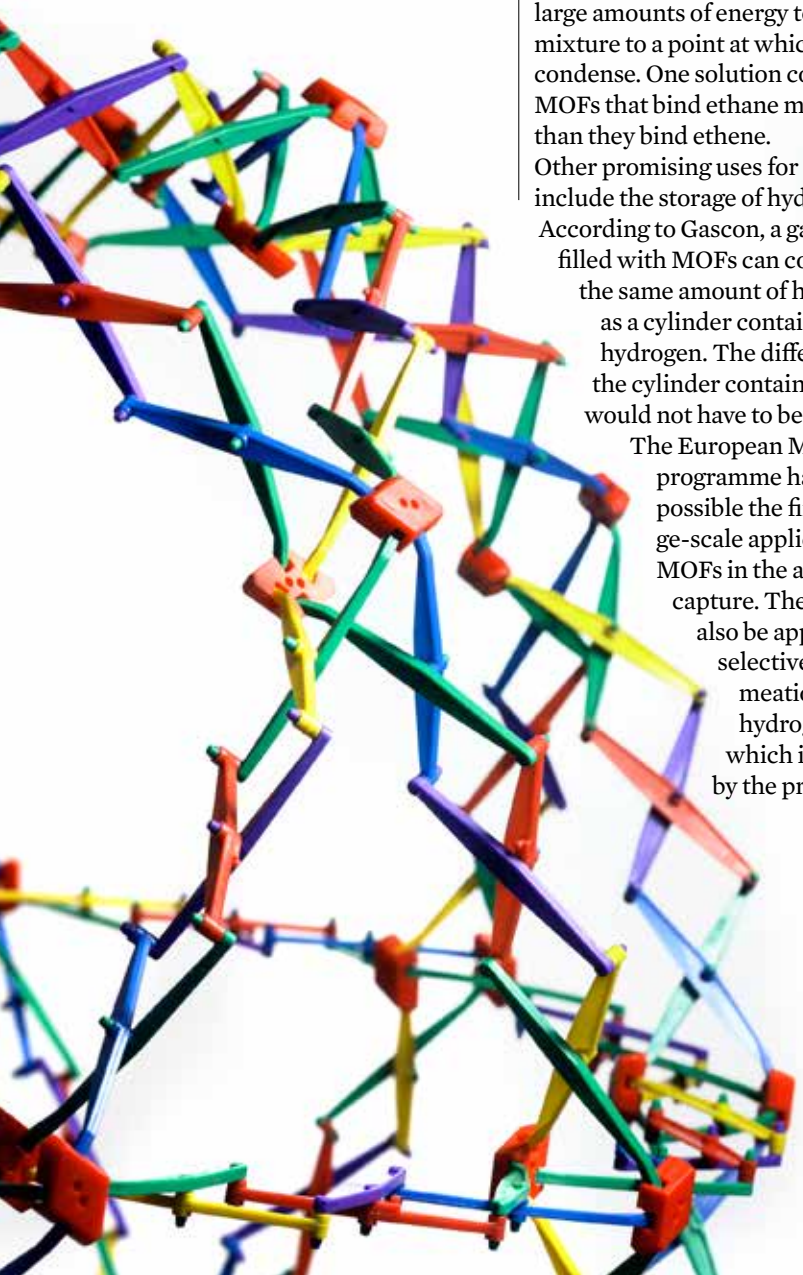
Smartly dimensioned molecules in the MOFs could serve as antennae for visible light. Kapteijn explains: 'These antennae collect energy from the photons and bring the metal core to a higher energy level, such that it can start a chemical reaction.'
One application that could save a great deal of energy is the separation of ethene and ethane. This separation of gasses is highly important for the chemical industry, which must invest large amounts of energy to cool the gas mixture to a point at which the gasses condense. One solution could be MOFs that bind ethane more strongly than they bind ethene.
Other promising uses for MOFs include the storage of hydrogen gas. According to Gascon, a gas cylinder filled with MOFs can contain nearly the same amount of hydrogen gas as a cylinder containing liquid hydrogen. The difference is that the cylinder containing MOFs would not have to be cooled.
The European M4CO_2 programme has made possible the first large-scale application of MOFs in the area of CO_2 capture. They could also be applied for the selective permeation of hydrogen gas, which is covered by the project as well. 'The greatest challenge will be to make membranes that will allow the permeation of enormous streams of gas', observes Gascon. 'This means that the resistance will have to be very low and that we will have to work with ultra-thin separation layers. This will require an exceptionally good match between the polymer (for the membrane) and the MOFs (as pores – ed.). We are therefore developing the chemistry for both the MOFs and the polymer.'
The filter material will be processed into long, hollow straws that are packed together in a bundle to form the gas filter. When flue gasses are blown through the filter, only CO_2 should be able to permeate the membrane.
At the end of the project, in four years' time, the consortium hopes to deliver two modules: one for CO_2 capture and one for hydrogen separation. These will be tested for at least two months under realistic conditions by one of the industrial partners. <<



Why this is important

The emission of CO_2 is continuing to increase throughout the world. The use of membranes to remove CO_2 from flue gasses is less expensive than the current method, using liquids. This is an important point, given that the price of CO_2 capture will determine whether the technology will be used or whether the greenhouse gasses will be released into the atmosphere.

After Delft

Aeronautics or mechanical engineering? More than 30 years ago, Richard Cobben (50) was not sure. After the open day at TU Delft, he opted for mechanical engineering. 'Aeronautics seemed so complex to me', he recalls. He now manages 300 people at Fokker Aerostructures.

FOTO: SAM RENTMEESTER

He had not planned it this way in advance, because he started with pure mechanical engineering: structural analyses of train cars at Stork Alpha Engineering. That was until factory construction within Stork became more appealing to him. 'A process design, a building, bringing disciplines together – those have always been driving forces for me.' Cobben thus became a project engineer, first in the Netherlands and later in Thailand, where he designed and became a project manager for a pharmaceutical factory. As he describes it, the factory was a good combination of process industry and packaging lines under the same roof. This is when it truly began to become interesting for him, particularly after he completed his second Master's degree: logistics and computer science at Montfort University.

A subsequent Stork post was in the petrochemical industry in Kuala Lumpur. 'Building chemical factories in the middle of nowhere. You arrive with your suitcase and start with nothing. Fantastic. You're dropped into a Muslim culture and immediately have an entirely different dynamic between Chinese, Muslims and Indians. Very multicultural.'

The post required Cobben to delve into the culture. 'Thailand is Buddhist, with a somewhat timid culture, while the Muslim culture is more macho. You have to be careful with that, but a basic attitude of "respect" can go a long way. Listening is a good skill. I'm more analytical: listen first, and then speak. That is an advantage in such a situation.'

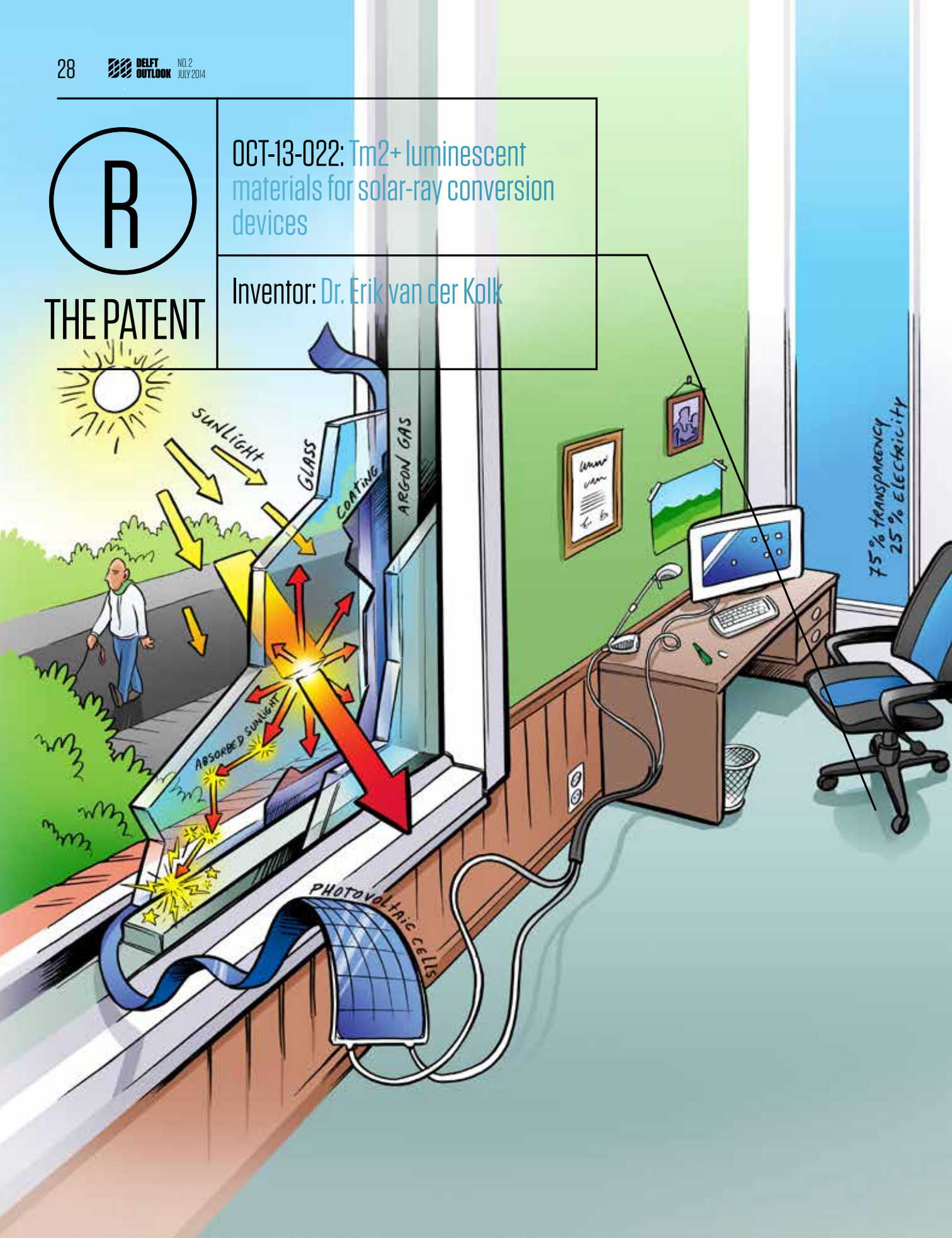
In 2001, aeronautics re-emerged in the picture: Stork had purchased the movables of Fokker, which had gone bankrupt in 1996, and was looking for programme managers. For one year, Cobben worked on the moving parts of an Airbus 300 wing, in order to become familiar with the aircraft profession. 'Aeronautics and mechanical engineering are not that far apart; we took many courses together', he recalls. He set up a major new programme for the Fokker Aerostructures subsidiary: the F-35 (Joint Strike Fighter). The focus of this project was primarily on the control surfaces of the wing and on doors that could open quickly without being detected by radar.

Cobben is currently responsible for research and development at Fokker Aerostructures. The division is familiar with the aircraft material Glare, which was developed at TU Delft. The subsidiary has become the market leader in thermoplastics, which are used to counteract material fatigue. Fokker is currently trying to apply the material in larger aircraft. Cobben now feels that it might have been easier if he had opted for aeronautics in the first place. 'On the other hand, I now have the breadth and the connections between industries. I am fascinated by such breadth.' CvU

THE PATENT

OCT-13-022: Tm2+ luminescent materials for solar-ray conversion devices

Inventor: Dr. Erik van der Kolk



IN the 1970s, researchers were working to develop a window that could absorb light and convert it into electricity. The small piece of bright red plastic that Dr Erik van der Kolk has in his office at the Reactor Institute Delft is a souvenir of that time. Although a window with such a coating absorbs light, nobody wants red windows. For this reason, the electricity window was at a dead end for a long time. That was until two years ago, when van der Kolk and a graduating student started searching for another coating – a luminescent material with a less disturbing colour that would convert light into electricity. The researchers found this material in thulium-halides. This is now a black powder in van der Kolk's lab. The more thickly this powder is applied to the glass, the more electricity will be generated by the solar cells at the edges of the window. Although this technique does not yield the same capacity as the average solar panel does, it can be used as a window. According to van der Kolk, there are 5000 square metres of windows in Europe alone. 'If we were to replace even a small portion of them with electricity windows, we could have a major impact.' The researcher notes that potential customers have reacted enthusiastically. It will take several more years of research to demonstrate how thulium-halide can be applied to windows as a coating without scattering incoming light, however. At that point, he thinks that he will have a prototype and be able to find a commercial party to produce and sell the product. SB

Undercover nimby

The syndrome has seldom been outlined as clearly as it was recently on the programme EenVandaag on Radio 1. In the broadcast, I participated in a debate on the proposition 'Citizens are sidelined in major wind-turbine projects'. Results from a survey were presented in order to start the debate: 73% of nearly twenty thousand respondents were in favour of wind energy; 17% were opposed to it, and the rest had no opinion. Only 70% favoured the actual installation of wind turbines. It seems that some people would like to eat good food, although they are opposed to cooking.

Further, 71% would not mind having wind turbines in their own provinces, and 60% would not object to having them in their own municipalities. Yet the results revealed an entirely different story when it came to having them in the neighbourhood. Only 35% would feel good about that, and 55% cried out with a roaring 'nyet'. In other words: 'Turbines? Great! But not in my backyard.'

That having been said, the issue at hand was whether citizens are being pushed to the sidelines in this type of projects. This was certainly the opinion of my opponent in the debate, the director of the NLVOW, the Netherlands association of people living in areas with wind turbines. I disagree. Each year, we are free to elect our representatives, there are many opportunities for public participation and any citizens who are still not satisfied have the right to bring their complaints before a judge. Moreover, the NLVOW pays regular visits to members of the House of Representatives, and the labour party (PvdA) recently went so far as to submit a proposal to Economic Affairs that would require all plans for wind turbines to be discussed with the association in advance. How can anyone say that citizens are being 'sidelined'?

Politicians truly are listening. The problem is that they often tend to pay the most attention to the militant, media-manipulating undercover NIMBYs who are dominating the debate. Like the Socialist Party, which threw out its negative slogan 'Say no; vote SP' several years ago, these 'undercovers' know that a simple 'no' is no longer effective. Their motto is 'We're not against it, but...'. For example, one resistance group in my neighbourhood is not opposed to a new supermarket, but it does oppose loading and unloading. The NLVOW is similarly not opposed to wind energy, but... 'Wind' is not unique: the same patterns can be observed in nearly all collective-use engineering constructions.

Politicians are currently investing considerable time and energy in the 'dialog' with neo-NIMBYs, even though they have no need for such discussions, given that they are categorically opposed. For this reason, upstanding, involved citizens who have not dug their feet into the sand are now being short-changed. It is high time to separate the wheat from the chaff.

Ir. Remco de Boer is a communication specialist for technology and science.

Follow the crowd

Earthquakes, tsunamis, rushing mobs – in the Transport and Planning department, test subjects are being immersed in a 'disaster', with the ultimate goal of improving the usability of traffic models for evacuation.

TEXT TOMAS VAN DIJK PHOTO THINKSTOCK

The day started out fine in the virtual world that the scientists of the Transport and Planning department (CEG) use to chart human behaviour in order to improve their traffic models.
'You will be attending a concert on an island', PhD student ir. Mignon van den Berg informs her dozens of 'guinea pigs', many of whom have been recruited through newspaper advertisements. We are all seated at computers. 'You will go there by helicopter. Once you are there, each of you will take a car in order to drive to the concert. You can use these arrows to move forward, backward, left and right', she explains, pointing to the keyboard.
The group that has gathered is quite diverse, including young as well as old people, from all ranks of society. A teenager wearing a baseball cap and holding a can of soda is well aware of how to navigate in a gaming environment. An older woman is reading the instructions carefully.

NERVES

Although the situation in which the participants find themselves is fictitious, the sounds, the rushing avatars and the clock that continues to tick makes people nervous. 'This is reflected in the responses to the questionnaire that we have the participants complete at the end of the session', notes van den Berg. 'After the session, people report that they have experienced an increased level of stress.'
The PhD student is part of the research team of Prof. Serge Hoogendoorn. In 2009, the NWO awarded a Vici grant to this professor of transport to conduct research into questions including how traffic models could be made more useful for evacuations.
Models assume that travellers are largely aware of what they can expect on the road, that they have clear destinations and that they make well-considered choices regarding their route and time of departure. But this would obviously not be the case if a dyke should break or if a tsunami should occur.
'In such situations, people behave like herd animals', asserts Hoogendoorn. 'They will do what they are used to doing. This mental state is known as "bounded rationality". People will not adjust their behaviour unless they become truly aware that their actions are not wise.'
Can virtual worlds be used to study this type of traveller behaviour during crisis situations? According to the TU Delft scientists, not much is known in this regard. Van den Berg: 'I was therefore interested to see whether we could use this technology to develop a quantitative overview of this type of following behaviour during evacuations. To date, this has been impossible.'

TEST SUBJECTS

In recent months, van den Berg has conducted ten experiments, each with about 30 subjects. She is now charting the behaviours of these test subjects. Who went in which direction, and when? How did people influence each other?
That last question is particularly interesting. 'It seems that people also behave like herd animals in this virtual world. This provides an initial indication that the programme could be useful for improving evacuation models.'

> Although the situation is fictitious, sounds, rushing avatars and the clock that continues to tick make people nervous

Hoogendoorn has great expectations. 'Our current models – like the one for predicting how quickly an area can be evacuated in case of a flood – have been developed with the understanding that we do not know much about how people react. This results in margins of uncertainty. We hope that this type of research, using avatars, will help to reduce these margins.'
The researchers are also able to manipulate the situation. Unbeknownst to the other participants, several

IN A VIRTUAL WORLD PEOPLE ALSO BEHAVE LIKE HERD ANIMALS.

of van den Berg's colleagues also play along as avatars. 'These "moles" have been instructed to run away from the concert at particular times', the PhD student explains. If the moles run away as soon as they feel the earthquake, without waiting for the news bulletin, many of the participants will survive the disaster, provided that the moles run in the right direction.
'This program is quite advanced', observes Hoogendoorn. 'We can analyse the avatars to determine exactly how they reacted after receiving particular information. Did they start to flee when they felt the earth shaking? Did they leave only after they heard the news bulletin? Or did they follow the rest of the group? This type of analysis is usually dependent upon surveys after the fact.'
The design of the experiment is largely van den Berg's brainchild. The underlying programming is from the National Institute of Informatics in Tokyo. Hoogendoorn and his colleague, Prof. Hans van Lint, who was recently appointed as an Antoni van Leeuwenhoek professor, had been invited to deliver lectures there several years ago. The plan to use the computer program in Delft was concocted later in a Belgian bar in Japan's capital city.

In the coming years, Hoogendoorn and van Lint would like to conduct more experiments with virtual worlds. 'We are thinking about designing a football stadium from which all of the visitors must evacuate en masse', relates Hoogendoorn. Such research will take place in a new laboratory that van Lint will be starting: the Delft Integral Traffic & Transport Laboratory, or DITT Lab.
It remains a remarkable fact that people can experience stress from a simulated earthquake and tsunami, even when safely seated at a PC. To van den Berg's colleague, psychologist Erica Kinkel (Transport and Planning), this does not come as much of a surprise. 'The situation was deliberately created to immerse people as deeply as possible in the virtual world. The sounds that the participants hear through their headphones help in this regard. The individual participants must do the best they can to make it to the helicopter by a certain time in order to evacuate. Even if the situation is not life-threatening, people experience stress due to time pressure.' The psychologist admits that the comparability of created crisis situations with actual disasters remains a complicated issue. 'It's the same in real life, however, given that no two earthquakes or tsunamis are the same.'

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IN PERSON

Prof. Nynke Dekker
BIONANOSCIENCE

She is conducting pioneering research on the forces in DNA molecules, and is a role model for young women. The European Physical Society therefore honoured Dekker with the Emmy Noether Distinction for Women in Physics, a prize that is intended to generate attention for talented young women scientists. The prize is named after the German mathematician Amalie Emmy Noether (1882-1935), who made major contributions to abstract algebra and theoretical physics.

Prof. Mark van Loosdrecht
ENVIRONMENTAL BIOTECHNOLOGY

This year, four professors, including Mark van Loosdrecht, will receive the prestigious Spinoza Prize from research funding organisation NWO. They will each receive 2.5 million euros to spend on their research. Van Loosdrecht studies the properties of micro-organisms in technical systems. His research into bacteria enables the development of new methods for water treatment and the creation of useful substances from waste material. The Spinoza Prize is the highest scientific distinction in the Netherlands.

Prof. Frances Brazier
SYSTEMS ENGINEERING TPM

The Adrem project has been approved for the international smart-grid programme of the NWO. Brazier is collaborating with Professor Sri Niwas Singh of the Indian Institute of Technology to develop ICT that will bring consumers and producers of energy into contact with each other automatically. Dependence on national networks and major energy producers can be eliminated if people are able to purchase a surplus of locally generated energy automatically within their own communities. This system would also improve the ability of the national network to cope with unpredictable peaks and troughs.

Prof. Wubbo Ockels
PROFESSOR EMERITUS

Upon his death on 18 May, the former astronaut and most famous TU Delft professor Wubbo Ockels left behind a letter for humanity, his last message for a sustainable world. He inspired many through his projects, including Nuna, the Superbus, the solar boat and the ladder mill. Colleagues and students in Delta refer to him as creative, dynamic, optimistic, controversial, a pioneer and a man with a mission.
delta.tudelft.nl/28268

Echo Award

Chinese student of sustainable energy technology and chemical engineering Yingying Luo has won the Echo Award for the category of Science and Technology. The other nominee, the Turkish student Emel Çankaya, is also a student at TU Delft (aerospace engineering). The Echo Award is a 'prize for talented students of non-Western origin who are the first in their social circles to pursue higher education'. Upon being nominated, Çankaya said that she hoped to win in order to 'motivate more foreign and native students – particularly women – to believe in themselves and pursue their dreams'. Luo wanted to win in order to be 'a good example for many foreign students. I have worked hard to master the Dutch language, to make a positive contribution to society and to realise my own ambitions'. Luo won an all-expenses-paid summer course at the University of California in Los Angeles. The Echo Awards are financed by ING, Shell, KPMG, Randstad Nederland and the Dutch Railways.

HORA EST

Thick books are the graveyards of past ideas

Dr. Alimzhan Zhubayev, geophysicist

'I grew up with science. As a child, I was impressed by all the thick books on theoretical physics that my father had in his bookcase – books from the 1950s and 1960s, filled with ideas and theories. There was so much reading material that I would never have been able to read it all in my lifetime. Unfortunately, almost nobody reads old books anymore. People simply look through the most recent scientific articles and try to elaborate on them with new theories. They overlook the old books, even though their 'new' ideas might have been described in them long ago. Scientists should take more time to conduct thorough literature research.'

Europe will not be a united and independent political power until national armies will be replaced by a federal military force.

Gabriele Bulgarini
physics engineer

An advantage of living in The Netherlands is that almost everybody speaks English; a disadvantage of living in The Netherlands is that almost everybody speaks English.

Sara Salvador Cob
chemical engineer

To see the true limits of the human body, doping should be legalized in professional sport.

Gianni Campoli
materials engineer

Time is discrete instead of continuous.

Yunhe Zhang
materials engineer

As long as drug production, supply, and possession are prohibited by governments, unnecessary deaths will be on the rise.

Ivan Garcia Triana
mathematical engineer

Measuring researchers' qualities by counting numbers of publications makes science replicate existing studies instead of encouraging innovation.

Marja-Ilona Koski

An engineer's paradise

Myanmar is opening up to the outside world. Engineers from TU Delft are discovering some great opportunities to conduct research and teach there. 'It is an engineer's paradise.'

TEXT TOMAS VAN DIJK PHOTOS ALWIN COMMANDEUR/RENS HASMAN

'Everyone was always talking about Ayeyarwady, but no one had ever seen this great river. It is almost the size of the Mekong, but still it meanders freely through the country, unhindered by dams or quays. In its course, it swallows up ancient pagodas.'

The trip report by Alwin Commandeur (24) almost reads like the diary of a 19th-century adventurer travelling. Early this year, the student of hydraulic engineering navigated Myanmar's largest river, the Ayeyarwady, in a river boat. During his thousand-kilometre journey, he passed places unseen by Western engineers for decades.

"My trip was a kind of reconnaissance mission", explains civil engineering student Alwin Commandeur. "I was researching the navigability of the river by measuring its depth every few hundred metres using an echo sounder. I also took a lot of photographs. I recorded the location of any infrastructure and its condition. It is a truly wondrous area: a vast wilderness."

As well as Commandeur, several other TU Delft students have set off in search of adventure in Myanmar in the last six months, a country that was until recently in the hands of the military regime.

FIERCE COMPETITION

The students were commissioned by engineering firms in the Netherlands, including Royal HaskoningDHV, Arcadis, Grontmij and the Deltares research institute. Next year, the group intends to submit a report about integrated water management to the Myanmar government. It will include recommendations on the administrative aspects of water management as well as advice on generating energy from hydroelectric power (which currently only happens on a piecemeal basis) and more efficient irrigation, without threatening drinking water supplies or the navigability of the rivers. The group is receiving support from the Dutch Ministry of Infrastructure and Environment, which has signed a cooperative agreement with Myanmar and is also investing money. For example, the Ministry funded the studies by the TU Delft students and several engineers from Deltares.

The firms hope to be able to secure contracts this way. But competition is fierce. Myanmar is rich in all kinds of resources, including oil, wood and minerals. It is opening up to the outside world at a rapid pace. There will be elections in 2015, the World Bank is standing by with a loan and international businesses and NGOs are eager to do business in the country.

NEED FOR EDUCATION

According to Tjitte Nauta, who works for Deltares on water-related projects in south-east Asia, the Netherlands is a step ahead of its competitors when it comes to water. "Whereas others concentrate solely on a specific aspect of water management, such as reservoirs or irrigation channels, we focus on >>

integrated water management. With integrated water management, we can develop an excellent new revenue model."
This is something that the country is crying out for. Nauta: "The Dutch water sector has become too expensive and is suffering from competition from Japan, South Korea and China. In Myanmar, we can reinvent ourselves."
In other words, ambitious plans are afoot and TU Delft students are not the only ones working to achieve them. The University is involved in a different way too. Prof. Nick van de Giesen (water management department), Prof. Marcel Stive (hydraulic engineering department) and emeritus professor in hydraulic engineering Prof. Han Vrijling are members of a committee including former Minister of Agriculture Cees Veerman that is providing advice to the consortium of engineering firms.
In the last two years, Van de Giesen has travelled twice to Myanmar to establish contacts, accompanied by Marjan Kreijns from the TU Delft Valorisation Centre, one of the initiators of the project in Myanmar. According to Van de Giesen, what the country needs most of all is education and training. "There is a group of people over the age of 60 with a lot of knowledge, many of them qualified in Delft. (See box 'The Delft connection'). But the military junta was fiercely opposed to intellectuals and the level of knowledge at the universities plummeted. A whole generation is now in need of a fast-track education and this is what we are focusing on. For this reason, we have our own project designed to achieve capacity building, running parallel with the engineering firms' water plan project."

'Ambitious plans are afoot and TU Delft students are not the only ones working to achieve them. The University is involved in a different way too'

NO INTERNET

"Close your eyes and imagine 1988, the year when the country closed itself off to the outside world", continues Van de Giesen. "There was no internet or mobile telephones then. It may seem slightly exaggerated, but in Myanmar it is still like that now to a great extent. You are quite isolated, with almost no internet and it is impossible to make international telephone calls. Remote-sensing satellites are almost unheard of here."
Van de Giesen's PhD student, ir. Martine Rutten knows all about it. Last autumn, she and several colleagues from CEG taught courses in Myanmar that covered such areas as the use of remote sensing and modelling of water flows. The courses were taught to engineers at the ministries of agriculture & irrigation and transport as well as students at the Myanmar Maritime University.
"When computer modelling really took off, the country had closed itself off to the outside world", explains Rutten. "So they missed out on that. When I ask students and engineers to do simple calculations on a computer, you can see their eyes light up. Then they reach the same result as the international consultants. They understand that it is not rocket science or some kind of magic."
This month, Rutten is setting off to another university, the once highly-reputed Yangon Technical University. TU Delft has had a cooperative alliance with this university since last autumn. She will be teaching there for three months. "Until last summer, university sites were off-limits for people from abroad", says Rutten. "According to the regime, universities were a hotbed for revolutionary ideas."

De Delft connection

"They were the golden years", says Aye Myint (65). He is referring to the period when knowledge was still shared with the outside world. He himself spent a year in 1982 studying hydrology at the Unesco-IHE Institute for Water Education in Delft. He is one of many alumni of this research institute and TU Delft. Until 1988, there were strong links between these institutions and universities in Myanmar. The alumni event held in 2012 in Myanmar attracted almost a hundred people.
"Around twenty years ago, researchers in this country were cut off from the outside world by the military regime. We are now missing a generation of professional engineers in my country. I am absolutely jubilant about the renewed cooperation with Delft."
Myint works for the Myanmar-based engineering firm, National Engineering & Planning Services. During the last year, he has assisted TU Delft students and Martine Rutten in collecting data and outlining the current water issues in Myanmar. "Many of his former colleagues also studied in the Netherlands", says Rutten. "We've had some exciting discussions with these men who are truly committed to water management in their country."
One of Myint's former colleagues is Tin Maung (73). He studied hydrology at TU Delft in 1969 and 1970. "Thanks to that time in Delft, I gained a respectable position as an engineer in my country", he explains. "My dream is one day to return and tell my TU Delft colleagues about my experiences after Delft."

Alwin Commandeur crossed Ayeyarwady on the 'Dolphin'.

Commandeur sailed the meandering river for 1,000 km.

Student Rens Hasman collected data for this research from old books.

Engineers from Delft in the delta

A fishing town in the South of Myanmar, an area that floods easily.

PhD student Martine Rutten trained engineers in Yangon and Bago.

(ILLUSTRATION: ALWIN COMMANDEUR)

Rutten feels that it is important that the people she is training can use the knowledge to arm themselves against all the foreign companies they are set to encounter.

NOT PHILANTHROPIC

However, the cooperation with Myanmar is not solely philanthropic, according to Professor Stive. "I firmly believe that Dutch companies will soon need the students we are teaching to do business with. Since 2001, we have also been working on capacity building in Vietnam. Lots of students and PhD candidates from Vietnam have come to Delft. Dutch engineering firms are now being successful in that country too. Here, we are replicating what we have done in Vietnam."

"It is also in the interest of our own students for us to participate in these kinds of projects", continues Stive. "If I want to continue to give my students a good education, I need to get to know Myanmar. That is reason enough in itself."

> 'There is a group of people over the age of 60 with a lot of knowledge, many of them qualified in Delft'

Asked to describe it, Stive has this to say about the country: "A valley runs from North to South between two ridges of mountains, where the Ayeyarwady and its tributaries flow. The discharge of the river is 40,000 m3 per second, which is equal to that of the Mekong. The Mekong flows through five countries (China, Laos, Thailand, Cambodia and Vietnam) but the Ayeyarwady flows through Myanmar alone. Only 10% of the potential hydroelectric power is used. The Delta region is extremely fertile, although vulnerable to flooding. There is a lot of precipitation, but it is unevenly distributed. As is the case in many Delta regions, there is also oil. It is an engineer's paradise." <<

Alumni Chapters

A number of alumni meetings were held around the world again in the previous period. In Athens, a TU Delft alumni chapter was started.
A group of alumni got to know each other during an alternative city walk, which resulted in a group of volunteers that will plan the next event.
In Jakarta, a group of very active alumni organised the conference 'Flood safety for Jakarta: from threat to opportunity', which was held on 12 June.
At a number of locations (San Diego, Boston and Aruba), an attempt was made to provide a networking opportunity for alumni by organising a joint social gathering or dinner party.
LinkedIn plays an increasingly important role in connecting alumni with each other around the world. In addition to our Delft University of Technology alumni group, separate LinkedIn groups are emerging for active alumni at specific organisations. There are already alumni groups in Belgium, London, Jakarta, Singapore (3TU) and Mexico. We warmly invite you to become a member if you live in one of these places.

Young talent

Every year, the University Fund awards various prizes to students as a reward for their hard work and academic achievements. Last spring, the UfD-Damen Bachelor Awards and the UfD-IHC Merwede Teamwork Award were presented, among others.

UfD-Damen Bachelor Awards

On 31 March 2014, the UfD-Damen Bachelor Awards were presented. All winners of the UfD-Damen Bachelor Awards 2014 have excelled in their final Bachelor assignment with daring, a multidisciplinary approach, social engagement, practical applicability and an innovative look at technical problems. Among the five winning projects was a study conducted by a group of Aerospace Engineering students, who were developing an autonomous, unmanned aircraft to search for water in extremely dry areas, and a civil engineering study into the application of self-healing concrete. Each inspiring project was rewarded with a Bachelor Award amounting to 2,500 euros.

UfD-IHC Merwede Teamwork Award

The UfD-IHC Merwede Teamwork Award is awarded on an annual basis to three teams consisting of TU Delft students and PhD candidates. The main prize of 7,500 euros was awarded this time to the Nuon Solar Team, which demonstrated what can be achieved in the field of high-end technology and sustainable energy with Nuna 7. Project team Jamaica Bay conducted research into flood risk reduction in New York City. Team Rosen researched sustainable energy storage in silicones. These two teams received 2,500 euros.
Would you like to support talent, technology and TU Delft with the Delft University Fund? Then become a 'Friend of TU Delft' at universiteitsfonds.tudelft.nl.

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tudelft.nl/dig-it

CONTACT

Do you have tips, ideas, questions or comments for the alumni office? Send an e-mail to: alumnibureau@tudelft.nl or call +31 (0)15-2789111

ALUMNIPORTAL

Do you want to change (alumni) information, communication preferences or sign up for alumni events? You can do that through the alumni portal www.alumniportal.tudelft.nl

LINKEDIN

Do you want to contact other alumni? Join the 'Delft University of Technology –Alumni LinkedIn' group.

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OAPS

Guus Berkhout

Like other employees, professors retire when they turn 65. But there are exceptions. One of them is the geophysicist and innovation consultant Prof. Guus Berkhout (73).

Yellow flooring and a painting on the wall, two leather chairs and a chess board – the furnishings of Berkhout's office are not standard for TU Delft, and neither is its occupant. Berkhout will soon be leaving for The Hague to attend a discussion at the European headquarters of Saudi Aramco, one of the world's largest oil suppliers and a client of Berkhout's Delphi Consortium. Later that day, he will go to the Bel Air Hotel. That is where he likes to meet with project directors and PhD students.

Since 1982, the Delphi Consortium has been providing new geo-imaging solutions to more than 30 affiliated companies. 'We are the new eyes of the geo-industry', Berkhout says. By opting for a consortium of international enterprises, he and his 20 employees are able to avoid becoming trapped in the specific problems of companies while, in his words, being able to 'stay involved with strategic, fundamental activities and work on the technology of the future'.

Berkhout points out one important difference between what he is doing now and his work before his retirement in 2005: the elimination of the 'financial hassles' and the meetings. 'We have introduced so much bureaucracy at the university that people are too busy with protocols to have much time left to think calmly about what they are doing.' The number of days has not changed ('seven!'), and his current contract with the CEG faculty is valid until 2015.

PHOTOS: SAM RENTMEESTER

Berkhout is working on three major projects. In addition to the Delphi Consortium, these projects include a model for social-economic development and a proposal for a new democracy.

The development model is a sort of natural law in social-economic development. 'It is ingenious, because it shows what is happening in the world at a glance.' The professor emeritus displays a chart with the y-axis representing the poverty rate in a country and the x-axis representing the national income divided by the number of inhabitants. All national economies appear as dots in the chart. What turns out? All of the economies are located in the same hyperbole: the poorest countries are at the upper left, and the wealthiest are at the lower right. As an economy develops, it apparently moves along the curve from left to right (more income per inhabitant) and from top to bottom (the poverty rate decreases). 'If we succeed in reducing poverty, we will have an enormous shortage of energy, food and water.'

For Berkhout, this insight provides considerable clarity regarding the orientation towards the future. For example, TU Delft should profile itself much more clearly with regard to water and energy, given the enormous demand that will be emerging in these areas. 'Now that is a vision. Without a strong profile, we will become mired in mediocrity.'

His political vision for the future also proceeds from this point. He advocates a programme of governance that is established by the population, that can be implemented by skilled professional ministers and in which citizens can participate as co-creators.

He sent us his motto by e-mail: 'Always make sure you have a motivating goal in your life.' JW

CONTINUATION P.39

After earning a degree in electrical engineering at TU Delft (1963), Guus Berkhout completed a PhD cum laude in physics (1970). He began working for Shell in 1964 and returned to TU Delft as a professor of geophysics and seismic imaging in 1976. Between 1998 and 2001, he served on the TU Delft Executive Board. In 2001, he was appointed to the chair in innovation management within the TPM faculty. He has been working at CEG since 2008. Berkhout is a member of the Royal Academy of Arts and Sciences and AcTI (the Netherlands academy for technology and innovation).

‘If we succeed in reducing poverty, we will have an enormous shortage of energy, food and water’