# A better world: action not words!

**Chemicals, materials and fuels made from biological raw materials.**

**It is time to stop just thinking about the ideal world. We must take action to make it a reality,**

**believes Professor Luuk van der Wielen.**

MAAIKE MULLER

"This pen is made from maize sugar." Luuk van der Wielen, professor of bioseparation technology at the faculty of Applied Sciences, holds up a green ballpoint pen. It seems a perfectly ordinary pen. It bears the legend 'B-Basic', the name of the research programme of which Van der Wielen is director and TU Delft coordinator. "This one is made from the edible part of the maize plant," the professor explains. "Hopefully the next version will be made from the non-edible part."

That next pen will bear an extra 'e'. In late May, the conclusion of the B-Basic (Bio-Based Sustainable Industrial Chemistry) research programme was marked by the publication of a coffee table book and a symposium. The consortium of universities and private sector companies which is working to make the chemicals industry more sustainable will now continue as 'BE-Basic'. The 'e' refers to the ecogenomics consortium that has joined the programme and will contribute knowledge about DNA technologies that can be used to analyse the environment. (See the insert 'Lighting up contaminants'.)

The overall aim of the programme remains unchanged: the chemicals industry, which is heavily reliant on oil and other rapidly dwindling resources, must increase production from renewable, biological raw materials. "To avoid a serious problem, thirty per cent of chemicals production must be 'bio-based' within the next twenty years," Van der Wielen estimates. Academic knowledge must therefore be well matched to the demand of the companies themselves. "Over half of the partners involved in BE-Basic are from industry," says Van der Wielen. "We must all understand what is important and what isn't."

That the approach works is demonstrated by the successes of the programme's forerunner, B-Basic, launched in 2004. DSM has been able to switch from chemical to biological processes in manufacturing certain antibiotics.

PHOTO: SAM RENTMEESTER/FMAX

Luuk van der Wielen: "Much innovation relies on new starter companies"

## *The bacteria can make the soil as hard as concrete within days*

Purac now makes plastics from sugar and starch. Deltares, the independent research institute for water, soil and subsurface issues, will soon be using the very first 'bio-sandstone' (see insert: 'Bacteria with a healthy appetite'). No matter how important these companies are, innovation calls for the input of new companies, Van der Wielen believes: "Existing organisations devote only a small proportion of their financial resources to high-risk innovation projects. Much innovation relies on new starter companies." He sees encouraging the creation of such ▸▸


Wouter van der Star (Deltares) samples bio-sandstone.



## Bacteria with a healthy appetite

Sand, bacteria and a fluid rich in calcium: these are the ingredients of the bio-sandstone that Dr Wouter van der Star, researcher with Deltares, shows us. The material will soon be used for the first time to reinforce subsoil, allowing tunnels to be bored more easily or to strengthen railway foundations and dikes. If necessary, Van der Star's bacteria can make the soil as hard as concrete within days. The strain of bacteria in his mix is *Sporosarcina pasteurii*. This strain occurs naturally in soil, but high concentrations are needed for any significant hardening. Van der Star continuously rinses the bacteria with a calcium-rich solution for several days. The bacteria then produce calcite, which 'glues' the grains of sand together.

"The hard part is to ensure that the sandstone is of an even strength throughout," says Van der Star. "And to dose that strength." Contractors are now able to use the substance in practice. Van der Star is already developing a new type of bio-sandstone, since although the first version is extremely strong it does have certain drawbacks. One such drawback is an unwanted by-product of the production process: ammonium chloride, which encourages algae growth. Van der Star is now working in the laboratory on a new method which solves this problem.

"Another advantage of the new method is that the bacteria will multiply by themselves, since we will have introduced nutrients into the soil," he says. This means we don't have to culture them first, which will save money." The sandstone formed by this process is not as strong, but is quite strong enough for some applications, he believes. Dr Van der Star is now conducting experiments designed to ensure that the material is of constant strength throughout. To do so, he has built a larger set-up which uses 120 kilos of sand. He was able to fund the new equipment with the 100,000 euros he received as part of the Leo Petrus Award, of which he was joint winner in 2008. The other winner of this incentive prize offered by B-Basic was fellow TU Delft researcher Leon van Paassen, who is researching whether waste products from the food and fertiliser industries can be used as nutrients for the bacteria.

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companies as one of his most important tasks, but also one of the most difficult. "Our young researchers must be made aware of the commercial value of their knowledge," he says. "We have the annual Leo Petrus Award, whereby the person with the best business plan is given 100,000 euros to put it into practice."

Over the next five years, Van der Wielen has a budget of 120 million euros at his disposal. "That is a lot of money," he says, "but nevertheless we have far more ideas than we can actually afford to fund." One of the main points for attention is the transition to bio-based production using plant waste. Van der Wielen: "It's important to establish a link between industry and food production. If we can later make plastic from the non-edible parts of maize and other food crops, that will be a very good thing. Waste will then have its own value, which is good for the grower. And if we can also use the edible parts in times of surplus, that will be even better."

Within the B-Basic programme, researchers produced biomaterials from plant waste in the laboratory. In BE-Basic, the experiments are to be upscaled. The researchers and partner companies intend to use the test facility which DSM built to develop the processes used in the production of penicillin. The plan is that the plant should be transformed into a 'bioprocess pilot facility' for all BE-Basic partners. "A factory producing plastic can easily cost a quarter of a billion euros to build," explains Van der Wielen. "The pilot facility will enable us to test the processes on a larger scale than we have been able to so far. That is important if we are to identify any problems which were not apparent in the lab."

Van der Wielen believes the close cooperation between private sector companies and research institutes, the encouragement of start-up companies, and experiments at the pilot facility will help the bio-based industry to make rapid progress. And he says the companies themselves are eager to do so: "Not just to improve the world, but also to ensure an adequate supply of production resources in future."

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## Lighting up contaminants

To ensure that the materials, chemicals or fuels produced from natural resources are of constant quality requires ongoing vigilance. "The green raw materials that go into a reactor are always of varying composition," explains Professor Bram Brouwer. His company, BioDetection Systems, has developed luminescent (light-emitting) cells which allow the process in the reactor to be closely monitored. The cells can also detect contaminants which may stop the active bacteria in the reactor working as they should.

In the laboratory, Prof. Brouwer's colleague, Dr Harrie Besselink, shows us the cells under the microscope. At first sight, they seem to be perfectly ordinary cells on a Petri dish. But as soon as they detect a certain substance, they light up. "We've added a segment of DNA taken from the firefly," Besselink explains. "The cell then emits luciferase." Each cell also has a genetic 'switch' that turns on the light as soon as the cell comes into contact with dioxin, or with any of 15 other contaminants for which BioDetection Systems has developed specific detector cells.

"The nice thing is that the intensity of light is proportional to the quantity of dioxin present," says Prof. Brouwer. Once the test sample – which can be anything from a piece of pork to animal feed, a soil sample or matter from a reactor – has been prepared, it is introduced in solution to Brouwer's cells within a closed metal container. There, a special camera measures the light signals emitted and the data is transferred to a computer. Prof. Brouwer: "We then know the exact quantity of dioxin present. At first, we had to monitor for each substance separately but it is better to do so as an entire series," the professor continues. Dioxin, for example, is actually a generic term for hundreds of different chemical compounds. The cells can monitor for all types in one pass. "If you want to test for some materials, you must first take them out of a 'matrix'," Prof. Brouwer explains. "Heavy metals in the soil, for example. That takes a lot of time." The luminescent cells enable this step to be completed far more quickly. The cells can also be very useful after the production process to detect the presence of certain substances in the environment. "Even companies which produce biomaterials produce waste. It's nice if that waste can be used as the raw material for something else, although that isn't always possible," Prof. Brouwer adds. He believes that the transition from fossil fuels to a bio-based chemicals industry is good for the environment: "But you have to be able to prove it."

The luminescent cell is a genomics-based technology which, according to the professor, can be very useful to the BE-Basic programme. The director of the ecogenomics consortium which recently joined BE-Basic predicts that other partners will soon approach Prof. Brouwer in search of similar technologies. They may want to find precisely the right bacteria for their process, for example, or a method of countering the pollution they cause. "Industry creates pollution, the ecologist complains about it," Prof. Brouwer remarks. "That was always the status quo in the past. But it seems that we can also help each other."

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The luminescent cells can be useful in the BE-Basic-programme.

PHOTO: BIODETECTION SYSTEMS