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## AGRO & CHEMISTRY

Proudly we present the first international, digital version of *Agro&Chemie*, aptly translated into Agro&Chemistry. Roughly three years ago we started our journey in the biobased economy by establishing a magazine for the biobased economy in the Netherlands and Flanders.

The basic idea behind *Agro&Chemie* was to connect the biomass side of the coin - agriculture, forestry, waste management - with the chemical industry and the manufacturing sector (plastics, biocomposites et cetera). Both sectors have to be aware of each other's possibilities and ambitions in the transition towards a biobased economy in order to succeed.

That we were bang on the money with this concept was illustrated by the broad support we have received from the Dutch and Flanders public and private sector. Renowned clusters such as Biobased Delta, Source B., Greenlinks, research institutions like VITO, TNO, Wageningen UR and companies such as DSM and Suikerunie: all have supported and are still supporting *Agro&Chemie* which has evolved into a platform, consisting of a quarterly, a web site, an app and a monthly newsletter.

Now this portfolio will be expanded with this publication: Agro&Chemistry, a digital magazine containing insightful information on the Dutch and Flemish biobased economy: research and development, interviews, feature articles on specific markets and - of course - compelling stories on companies/start ups venturing their way into the wondrous world of the bio-economy.

Ultimately, we want to expand our scope more and more towards 'biobased Europe' and report on need-to-know developments that will be of interest of the European sector. The competition in the biobased economy is of a global nature. Therefore, the focus of Agro&Chemistry ultimately should be pan-European. As you can read in this issue, Europe is not the lost continent in the global battle for biobased business. Let's make it into a winning continent!

## A 16 BILLION FOR (EUROPEAN) RESEARCH AND INNOVATION

**The European Commission will spend almost €16 billion on research and innovation in the next two years. This will go to the new work programmes of the Horizon 2020 innovation programme.**



The total Horizon 2020 budget will be divided across around 600 different topics over the next two years. These topics vary from the modernisation of the European economy, development of automatic driving, the 'Internet of Things', smart and sustainable cities and healthcare to the circular economy.

A considerable portion of the total budget will again be released for innovation in the SME sector. This means that the European Commission is providing €740 million for small and medium-sized businesses which contribute to the European economy through their 'disruptive' innovations. Unlike the other segments in the subsidy programme, SME's do not have to work together and they can obtain funding for the three phases of the innovation process: the feasibility study, development and commercialisation. The new work programmes will start on 1 January. More information is available on the website of the European Commission.

## Biobased coffee capsules from peeze among the winners

**Dutch coffee refinery Peeze won the Food Valley Award in October with its fully compostable coffee capsules.**



The capsules are made on the basis of PLA, using sugar beet as feedstock. This entailed the necessary technological challenges. Peeze established a separate company (CPC) to produce the capsules. The company already has several customers in Europe to which it will supply. The market is huge, amounting to 15 billion capsules per year. Peeze beat two other finalists in the competition: Pectcof (extraction of pectin from the pulp leftovers from coffee berries) and Marel Stork Poultry Processing with its Aeroscalder, a new system for removing the feathers from poultry. The professional jury of the Food Valley Award assessed the submissions on economic feasibility, innovation and cooperation.

## 'Shipping market ready for biofuels'

**In Rotterdam Boskalis (dredging), Wärtsilä (ship engines) and Goodfuels Marine (bio-fuels) recently presented the Sustainable Marine Fuel Program, aimed at the development of biofuels for the shipping industry.**

Biofuels for shipping are currently not or scarcely available. That is a missed opportunity. Luuk van der Wielen, chairman of BE-Basic and BioPort Holland (the Dutch platform for sustainable biofuels in aviation) stressed the importance of the Sustainable Marine Fuel Program during the meeting in Rotterdam: 'Biobased economy provides a tremendous opportunity for the Netherlands in terms of greenification of our fossil fuel-based economy.'

The new programme will focus on developing large-scale production, reliability of supply and industrial certification of biofuels for the shipping industry. The consortium will also perform a scalability study involving leading ship-owners, universities, NGOs, ports, bio-fuel companies and other industry stakeholders. Its aim is to identify opportunities for large-scale supply to the world's commercial shipping fleet.

Theo Baartmans, board member of Boskalis, emphasised how the use of biofuels is an important means of improving the sustainability of the industry. Roger Holm of Wärtsilä Marine declared his company's support for innovations that provide ship operators with greater flexibility and choice in how they can reduce emissions. According to Dirk Krone-meijer of GoodFuels Marine, the international shipping market is ready to embrace fuels that can meet all the technical, economical and sustainability standards, similar to the aviation market five years ago.



## LMC: BETTER FEEDSTOCK POSITION IN EUROPE AND US

**The US and Europe can compete better with other global regions as far as feedstocks are concerned. Martin Todd from the British consultancy LMC International stated this at the congress Agri meets Chemicals at the start of October in Utrecht.**

Todd sees opportunities for Northwest Europe for sugar beet as a competitive feedstock for the fermentation sector. Deloitte also came to this conclusion in its report in 2014. 'It looks like the scale is slowly tipping towards the US and Europe. About 20 years ago the US was number 1, with maize (dextrose) forming an unbeatable feedstock. Around 15 years ago Brazil worked itself up with dirt-cheap sugarcane. The competitive position of Brazil has since deteriorated considerably, mainly due to currency fluctuations. But it will improve in the coming years.'

Todd regards sugar beet as a crop which stands a good chance in comparison with other feedstocks. Certainly in the region Northwest Europe where the yields per hectare (in the European Union) and the output per factory are the highest. In the Netherlands, France, Belgium, Germany and the UK the yields are far above the average, with the Netherlands leading the way (approx. 14 tonnes per ha, eds.). Todd: 'These yields continue to grow, which is why the position of the beet in crop rotation has only become even stronger.'

## Corbion: polymer market attractive but also challenging



**Corbion expects much from the polymer market for its business (lactic acid). 'It is a promising market globally, but also a frustrating market which presents many challenges.' CEO Tjerk de Ruiter asserted this at the congress Agri meets Chemicals at the start of October in Utrecht.**

Corbion produces lactic acid for food and non-food applications, in the latter case PLA. 'Lactic acid was originally a relatively small market which mainly had applications in food. The market has since grown, partly due to population growth (in food), and the development of non-food markets for lactic acid,' according to De Ruiter. 'We particularly see opportunities in developing polymers based on biobased chemicals such as FDCA or bio-succinic acid. The problem is that the development process takes a lot of time and has many hurdles.'

COLUMN



NEW MARKET OPPORTUNITIES FOR BIOPLASTICS

Many things are happening in the ‘biobased economy’ and I am pleased that there has also been a great deal of activity concerning bioplastics in recent times. Bioplastics are a very essential part of the biobased economy: apart from the advantages of the reduced dependence on fossil fuels and decrease in CO<sub>2</sub> emissions, bioplastics offer another big advantage: the knowledge and added value of bioplastics for our economy is many times greater than other biobased products. In other words, if we want to put the emphasis on *economy* in biobased economy, the Dutch business community should fully embrace bioplastics. Many knowledge and educational institutions are already very much involved with bioplastics. But we also see new opportunities on the market side. Following the example of Coca-Cola with its ‘PlantBottle’, the Dutch FrieslandCampina company is now putting bio-plastic packaging on the Dutch market. The Dutch sector organisation for bioplastics, ‘Holland Bioplastics’, was launched at a large international conference in mid-May in Amsterdam. Holland Bioplastics aims to connect parties and share knowledge about bioplastics. Following on from European legislation, the Minister is working on restricting the use of plastic carrier bags and is considering making an exception for bioplastics carrier bags. It is high time that the Dutch government also clearly endorsed the benefits of bioplastics, so that bio-plastics become *the* driving force behind the biobased *economy*!

**François de Bie**  
Marketing Director Bioplastics Corbion  
Chairman of the Board European Bioplastics  
Co-founder Holland Bioplastics



Integrated biorefinery at the heart of the bio-economy

**Small, integrated biorefineries will be at the heart of the bio-economy, according to Tjerk de Ruiter, CEO of Corbion Purac. De Ruiter spoke at the EFIB15 which is being held in Brussels on the 28th and 29th of Octobre.**

‘Small, integrated biorefineries are economically the most viable option. The reason is partly the use of side streams, which in some cases, can become the most profitable ones. Also an attractive feature of the biorefinery is the integration of conversion processes and lower (shared) investments costs. The challenge of course is to recoup these investments back from the market. At Corbion, we are well positioned to do so.’  
In order to stimulate the arrival of these integrated biorefineries, several actions need to be taken, according to De Ruiter.

Unambiguous communication

‘A feedstock push is needed, not only 1st generation, but also 2nd and 3rd (for example syngas). Products from these feedstocks also need to be supported, for example in financial incentives for biobased chemicals.’  
Besides the feedstock push, a technology push is needed, for example in upscaling processes in order to make these economically viable. Finally, a consumer push is needed to create vibrant markets for biobased products. ‘This can be done with financial incentives, but also in communicating in a clear and unambiguous way.’



**Finland wants to increase its bio-economy output to 100 billion euros in 2025 and to create 100.000 jobs in the process. The forest-based bio-economy would take roughly 2/3 of the sector in Finland.**

Marianne Huusko-Lamponen, permanent representation of Finland to the European Union, stressed the importance of forestry to Finland at the EFIB15, held yesterday and today in Brussels. Momentarily, the bio-economy (wood processing, chemistry, energy, construction etc) in Finland generates a yearly turnover of 64 billion euros, giving work to 11 per cent of the professional population and taking 26 per cent of the export volume. ‘Our well-being in the future depends to a large extent to the bio-economy, in essence our ability to use renewable resources in an efficient and sustainable manner.’



*The representatives of the four clusters, signing the agreement on the first day of the conference EFIB15 in Brussels.*

Biobased not always greener

**There is a definite role for public procurement of biobased products. However, these products have to be demonstrably greener than their fossil counterparts.**

According to Reinhard Buescher (DG Growth European Commission), who spoke at the EFIB15 in Brussels, biobased products therefore have to prove that they are better in terms of sourcing, processing and end-of-life. ‘It has been proven that this is not always the case. Therefore, this is one of the big challenges for the private sector.’  
That the bio-economy holds great potential, is beyond questioning, according to Buescher. ‘If we want to reach the ambitious targets in reducing CO<sub>2</sub>-emissions, the transition into a bio-economy has to take place. Also the implications for the economy would be substantial, especially for the rural regions within Europe.’

EUROPE’S LEADING BIOECONOMY CLUSTERS WORK TOGETHER AS 3BI

**The leading bioeconomy clusters in the Netherlands, France, the UK and Germany have joined forces as the 3BI intercluster – Brokering Bio-Based Innovation. Their goal is to support European companies to access important new markets based on renewable raw materials successfully.**

3BI is a strategic European partnership that builds on the complementary strengths of four regional innovation clusters: Biobased Delta (Netherlands), BioEconomy (Sachsen-Anhalt, Germany), BioVale (United Kingdom) and Industries & Agro Resources (IAR, France). All four clusters use biorefining to convert biological resources into materials, chemicals, fuels, food and feed. They intend to work together in the research, development and deployment of novel high-tech approaches to the conversion of biomass and waste streams into value-added products and applications.

New markets

The bioeconomy creates new markets for innovative products across the globe. European companies need support if they are to access these important new markets successfully. The formation of the 3BI intercluster represents a common intention to explore business linkages between the clusters and their members. 3BI will help European companies to make the most of new markets and new opportunities from the bioeconomy. The 3BI partners focus on growth, innovation and smart specialisation of their regions. Their goal is to promote sustainable solutions for lower carbon footprint and to substitute fossil raw materials on an industrial scale.

Durable business opportunities

‘The necessity for companies to use green raw materials and make their process technologies more sustainable, is a daily priority’, Willem Sederel, director of Biobased Delta says. ‘For several years Biobased Delta has been working on international collaboration with leading regions in the world. Therefore I am very pleased with the establishment of 3BI as a European intercluster for long lasting collaboration with the leading clusters in the UK, Germany and France. This will boost durable business opportunities for the next decades.’

Stronger leadership

“The bioeconomy not only helps to significantly reduce our society’s carbon foot-print, but provides a lot of opportunities for new markets and high-value products and links the European agriculture and forestry to processing industries like chemicals, automotive or plastics’, Prof. Dr. Matthias Zscheile, BioEconomy states. ‘To combine the power of four of the leading bioeconomy regions within 3BI will strengthen the leadership of the European Union in a future economy based on renewable resources.’

# BIOBASED DELTA ON THE INTERNATIONAL MAP

The sugar fermentation study by Deloitte resulted in pleased reactions in ‘Biobased Netherlands’ at the end of 2014, as it showed the potential of the Netherlands in a powerful international playing field. The study was recently followed up by a new report, also by Deloitte, concerning the strengths and weaknesses of the Biobased Delta (see box).

Text Edwin van Gastel Image Suikerunie/Deloitte



Agricultural research in the Biobased Delta is being conducted, amounts other locations, at the Rusthoeve, the innovation and knowledge center in the province of Zeeland.

Meanwhile, Biobased Delta has picked up the gauntlet and decided on a campaign plan. An action document, under the denominator ‘Internal Agenda’ forms the guiding principle for cashing in on the opportunities. A discussion with Willem Sederel (Biobased Delta), Willem Vaessen (Deloitte), and Albert Markusse (Suiker Unie). Willem Vaessen, director at Deloitte Consulting, was in charge of drawing up the report evaluating the Biobased Delta. ‘With the study we show that the region is eminently positioned in the area of biobased raw materials, products, and biorefinery. Is that news? No. The reason is that while our fermentation study (editor’s note, published in September 2014) also produced surprising results for insiders, this is not the case now. However, it is new to investors and international stakeholders in the biobased economy from outside the region. For them the Biobased Delta has been put on the map.’ ‘The results of the report confirm the excellent starting position of the region,’ Willem Sederel (Biobased Delta Managing Director) also declares with satisfaction. ‘What especially stands out as a distinguishing strength is the availability of biomass because of our own raw material position based on sugar beets and other imported biomass flows in the deep sea ports. This is of great importance because in the next five years the decision will be made regarding the regions and clusters in the world where large-scale biobased economy will be established in the next few decades. We cannot be ignored because of the huge strengths we have.’

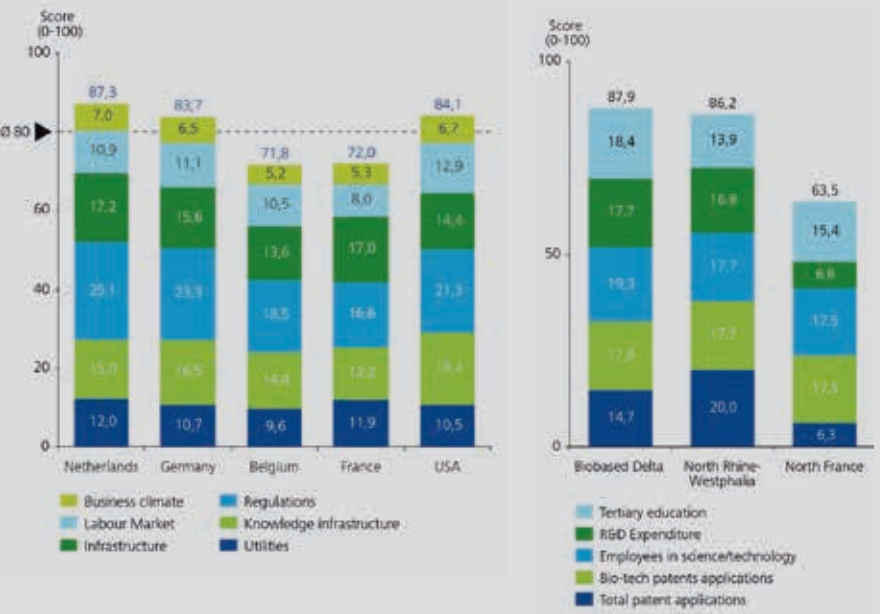
### DEMAND-DRIVEN DEVELOPMENT

According to Sederel, the next few years will be the time to quickly convert the opportunities into concrete and feasible business cases. ‘That must result in more process capacity for green building blocks, using biocatalysis (enzymatic conversion and fermentation) as well as greener chemical catalysis where great progress is still being made. The building blocks serve to produce the right sustainable products and materials for brand owners who ask for these. This creates demand-driven development of new value chains that form the basis of the new biobased economy.’ Sederel is aware that the Deloitte report also shows that there is still room for improvement. ‘There is still much that needs to be done, especially in the area of the labour market, training new people for the next economy. The same applies to regulation: unnecessary barriers must be removed, the demand must be stimulated, and a level playing field will have to be created.’ >>

### ‘THE BIOBASED DELTA – WHERE AGRO MEETS CHEMISTRY’ IN BRIEF

In het rapport ‘Biobased Delta, a globally competitive region for developing biobased business’ Deloitte has sorted out four likely ‘sugar regions’ in the report ‘Biobased Delta, a globally competitive region for developing biobased business’: Northwest Europe, the United States, Thailand, and Brazil. The report ensues from the previous fermentation study (September 2014), in which Deloitte studied the competitive position of crops in Northwest Europe on the international market for products obtained through fermentation. In the latest report, Deloitte compares the Netherlands, Belgium, France, and Germany as well as the clusters Biobased Delta, North Rhine-Westphalia, and Northern France. The Biobased Delta scores well in the report on the six criteria used, while the Netherlands failed to get the top score only on components 2 and 5 (knowledge infrastructure and labour market) (see graph):

- 1. Commercial climate:** the business climate is perceived as stable, the result of minimum risks in the area of safety, taxes, financial and political interference.
- 2. Labour market:** this has an international orientation due to the linguistic skill of the Dutch. However, the independence of managers with international work experience is evaluated higher than that in the competing regions.
- 3. Physical infrastructure:** this is evaluated as ‘extremely high.’ The road and water networks, as well as the quality and reliability of the telecom network.
- 4. Statutory and regulatory requirements:** The Netherlands is characterised by its transparent government and climate-friendly tax policy with a lot of room for investments and a low tax burden on profits.
- 5. Knowledge infrastructure:** the quality of scientific research and corresponding knowledge institutions is equivalent to that of the other regions. More patents are applied for, however.
- 6. Utilities:** the utility companies and energy infrastructure are qualified as adequate and efficient. Access to water is assured and well managed.



The Netherlands, global leader in biobased according to Deloitte. In a comparison of the big European clusters, a neck and neck race is going on between Biobased Delta and North Rhine-Westphalia.

INTERNAL AGENDA

Vaessen for his part is planning to share the study widely on an international scale. ‘And that starts at our own company. Deloitte employs more than 200,000 people, and our company is active in numerous sectors. Not only in the agricultural sector, but also in chemistry and at brand owners such as Nike, Procter & Gamble, and IKEA. I recently drew the attention of the latter company to the results of the study because they are spending a great deal of time on a very ambitious programme to change over to using 100 percent biobased and recycled materials. The Biobased Delta, as a region, is the classic example of an ecosystem. In the past few years, clusters of companies were formed

that collaborate in the biobased economy. At the same time the report shows that it is important to get a move on. For example, right before the summer break we sat down with a number of enterprises, including Clariant, DSM, KWS, SABIC, and Suiker Unie, and together we examined two specific important chemicals. The objective? Taking the step towards creating a good business case and production capacity for biorefinery together with small and medium-sized enterprises such as Novomer and GI Dynamics.’ Vaessen also mentions the ‘Internal Agenda,’ a document drawn up by the stakeholders in the Biobased Delta as a result of the Deloitte report. ‘The parties have used the document to ask

themselves “Now what?” A good starting position is fine after all, but now it is important to cash in on it. Five themes have been formulated to this end: optimising internal cooperatives; elaborating business cases; government involvement; the production capacity; and linking various green building blocks. Serious progress has already been made on the first item, and I furthermore believe the fourth and fifth items to be very important. As a region, the Biobased Delta does currently have the pilot plants in Delft and Gent (in Belgium) available for fermentation development. This means that companies do not have to have their beet pulp or juice validated in Canada or the United States, for example, to certify that the micro-organisms are able to make the right product. However, creating sufficient commercial production capacity is crucial if one does not want to miss the boat. With regard to linking and reinforcing various innovative building blocks, diverse parties will have to get together in order to optimise the three major steps (preprocessing, conversion/fermentation, and recovery) as a whole. That way you can end up with a sound business case.’

STRONG INITIATOR

“There must be one strong initiator in that framework, because everyone has his own agenda,” Vaessen concludes. ‘That could be Cargill, DSM, SABIC, or a different company saying: “We want to take the step towards large-scale production for the biobased economy.” You can then set up a good business case together fairly quickly. In the case of biorefinery, that will involve a plant with multiple inputs and outputs The vision of a single product facility, with a biomass flow and a final product, has been moved to the long term agenda. Even though you have to elaborate the business case per product case, you must eventually move towards biorefinery with a few products available in higher volumes and a few products with a higher added value. In the traditional petrochemical industry one also started at 0 and went through an enormous learning curve thanks to process integration and process intensification, among other things. This will also happen in biorefinery. As far as that is concerned, the region can be satisfied if in the next 2 to 3 years a consortium led by a company such as SABIC, Cargill, or IKEA is formed, the business case is formulated and one is ready to realise the actual investments.’ ●

*This article was created in collaboration with Biobased Delta.*

# BIODEGRADABLE SANITARY TOWELS IN BANGLADESH

Technological and social innovation often go hand in hand. Such is also the case in the Ritu project, in which Simavi, communications agency RedOrange and Rodenburg Biopolymers are working on sanitary towels that biodegrade in the soil for women in Bangladesh.

Text Lucien Joppen Image Simavi / photographer Jerry de Mars

M athilde Miedema, Innovation for Development programme manager at the Dutch contract R&D-agency TNO, is closely involved in the Ritu project, Bengali for season, a reference to the monthly cycle. ‘About 40 million women in Bangladesh rely on sanitary towels. However, only a fraction of women can afford them, because most are very poor. Most women use old rags, called nekra, which are not really comfortable or hygienic. Menstruation is still a taboo in the country, which is why the subject is kept under ground, literally and figuratively. In fact, many women “bury” the nekra.’ Ritu must now make sure that the women there switch over as much as possible to a more comfortable and more environmentally friendly product. This idea was originally conceived by Simavi, a Dutch NGO focusing on improving public health in developing countries.

BLEND WITH CLAY PARTICLES

Linking technology to social innovation is crucial to the success of the operation, according to Miedema: ‘The technological aspect is important, but introduction of biodegradable sanitary towels on the market can only be successful if it dovetails well with the local situation. Since most Bengali women bury their sanitary towels, we opted for a product that breaks down in the soil. The absorbent layer of the current sanitary towel is usually biodegradable, but the anti-leak



layer and adhesive strips are still made of plastic. We can make those biodegradable as well by using starch. However, in order to improve the functionality of this layer and reduce its cost price, we want to develop a blend with nanoparticles based on clay. TNO has a great deal of knowledge in this area, and, if the project gets the green light, is going to develop a prototype together with Rodenburg Biopolymers, specialists in starch plastics.’

INFORMATION CAMPAIGN

We will cross that bridge when we come to it. Parallel to the product development, there is a campaign in Bangladesh to have the introduction of the sanitary towel go forward as well as possible. The female population in Bangladesh,

including school-aged girls, will first have to be informed of the importance of feminine hygiene. There is close cooperation with the organisations active in healthcare and welfare in this project. Ruben Korevaar, business manager at Simavi: ‘It also entails collaboration with the Ministry of Education in order to include hygiene aspects in the curriculum at secondary schools. Youth in Bangladesh are by and large more open to new products and less bothered by the taboos surrounding menstruation. Another advantage is that Facebook is tremendously popular with young people, so we can approach this group online as well.’

1 BILLION PER YEAR

There is still the question of the market potential of the biodegradable sanitary towel. Based on a population of 40 million women, a market share of 10 percent, which is a realistic estimate, would result in 4 million users who use 10 to 20 towels each month: a market volume of 500 million/1 billion per year. Currently, only 5 percent of the women can afford conventional sanitary towels. According to Miedema, biodegradable sanitary towels can be manufactured cheaply using the new technology. The plan is to eventually manufacture the sanitary towels in Bangladesh. ‘The local economy will also benefit from this. We have already established contacts with a local manufacturer and distributor.’ ●



‘BIG LAUNCHING  
CUSTOMER TO MAKE  
FLYWHEEL TURN’

**Albert Markusse**, Suiker Unie CEO (a large sugar producing cooperation, based in the Netherlands), shows his satisfaction with the result of the latest Deloitte study. ‘I am pleased that an increasing number of parties is aware of the opportunities of biobased development in Southwest Netherlands. The basic infrastructure is in place and is actually fantastic. There are chemical technology, agricultural business, training institutes, and research institutes. One for one these are factors that can contribute to the biobased economy. Moreover, the companies and other stakeholders are willing to collaborate, integrated, but also on a bilateral and project basis.’ Markusse is also pleased that the interest of the chemical industry in the sugar molecule is increasing. ‘We have been using sugar in the food sector for hundreds of years and we expect the chemical sector to regard the sugar molecule as a raw material more and more. It is positive that the government is stimulating these developments. I hope the government will also contribute to attracting a big launching customer to the region in order to thereby make the flywheel turn. Cosun and Suiker Unie also are aware of the opportunities and are willing to participate in the investments.’

# GAME CHANGER FOR THE PAPER INDUSTRY?

**‘If this flies, it will shake up the paper and cardboard industry.’ Heiner Grussenmeyer, R&D Manager at Stora Enso Germany, is referring to deep eutectic solvents (DES), organic solvents intended to extract cellulose and lignin from the pulp fraction in a mild manner.**

text Lucien Joppen Images TU Eindhoven, VNP, Shutterstock

**S**tora Enso is one of 19 international industrial partners from the paper and cardboard industry participating in Provides. This project, coordinated by ISPT (Institute for Sustainable Process Technology), is going to study various aspects involved in the use of DES solvents over the next three years.

Annita Westenbroek is the leader of Provides on behalf of ISPT. ‘The project originated from an international contest organised by CEPI (Con-

federation of European Paper Industries) in 2012. In this competition, two teams, the red and the blue one, were challenged to find trail-blazing technologies the sector could use to considerably reduce its environmental footprint. The technologies also had to result in cost advantages in the process and, even better, ensure better final products.’

Westenbroek, a member of the blue team herself, had already contacted Professor Maaik Kroon (TU Eindhoven) before the competition.

Kroon’s study group had rapidly built a good reputation in the study of DES solvents. ‘The potential of this technology could be enormous,’ according to Westenbroek. The jury recognised the potential as well: the blue team won the contest and the road to Provides was paved.

## HIGH STANDARDS

The potential Westenbroek refers to involves the environment as well as the economy. As far as the first factor is concerned: the European



The Dutch paper industry imports pulp, which it then processes into paper and cardboard products.

industry aims to reduce its CO<sub>2</sub> emissions by 80 percent by 2050. That is a high standard. According to Westenbroek, trail-blazing technologies are required to meet that standard.

‘You can realise this by using different raw materials, manufacturing different products, and using different processes. With Provides we focus on the processes, more specifically on the way pulp is converted into various components: cellulose, lignin, and hemicellulose.’

The process is not really sustainable in its current form. It requires high temperatures, approximately 150 degrees Celsius, high pressure and heavy chemicals, and thus a great deal of energy. Moreover, the extreme processing conditions also have consequences affecting the semi-finished products. The lignin contains sulphur, for example, so this component can only be used as a source of energy for processing purposes.

## PROOF OF PRINCIPLE FOR LIGNIN

‘That’s what’s nice about DES solvents,’ says Westenbroek. ‘They have an effect at lower temperatures (room temperature up to a maximum of 80 degrees Celsius) and under atmospheric

pressure. They are also renewable, biodegradable, and, last but not least, cost efficient.’

The effect Westenbroek refers to has thus far only been demonstrated on the laboratory scale, and only for lignin (at a solubility of 25 percent). The optimum DES for lignin is currently a combination of choline chloride and glycolic acid. Cellulose does not dissolve in the DES and can thus be filtered from the DES fraction (solvent and lignin).

This is a spectacular improvement, but ideally a DES that can dissolve cellulose should also be available. ‘This paves the way for more interesting end markets for cellulose-based chemistry (textile, materials). Eventually this step will also open up the gate to the holy grail: paper production without water.’

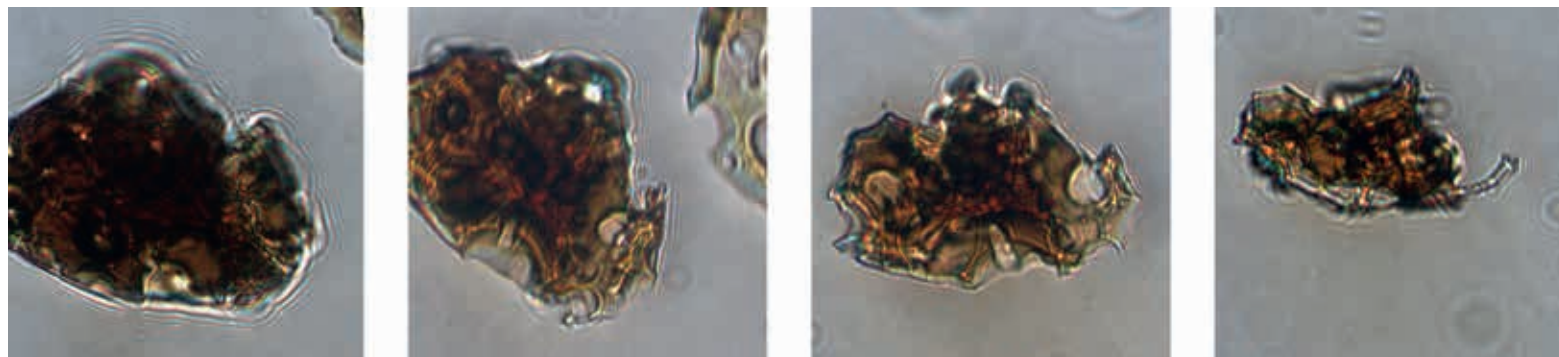
## DIFFERENT PROCESS CONFIGURATION

We will cross that bridge when we come to it. At present, the study group (3 assistant-researchers) employed by Kroon is industriously working on developing and testing DES solvents on a laboratory scale. Westenbroek: ‘The proof of principle for lignin is available, as I mentioned

## DES

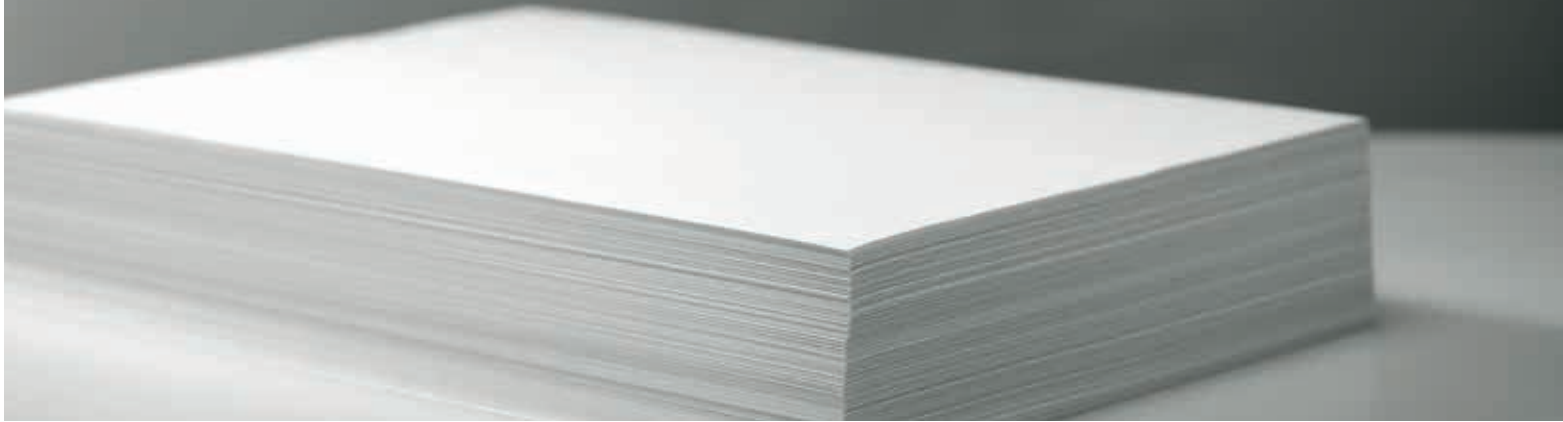
**Deep Eutectic Solvents (DES)** are formed by mixtures of two solids which, once mixed, turn liquid due to hydrogen bridge donation between the two components. The mixture has a melting point significantly lower than that of the individual components: the eutectic point. Because of this, solids can turn into liquids at room temperature and under atmospheric pressure. The existence of DES was not discovered until 2004. This makes DES an entirely new class of liquids and thus potential solvents. Many variants are still to be discovered and many application opportunities to be developed.

before. The one for cellulose still has to be found. The part of the process in Provides is the responsibility of the Kroon group. Eventually they must develop the best DES mixtures possible, while they are also experimenting with various cellulose-containing raw materials. Production of DES solvents is an important step, but certainly not the only one in Provides. DES efforts also result in a different process >>



Dissolving a lignin particle in a DES based on lactic acid and chlorine chloride (2:1).

‘YOU CAN REALISE THIS (REDUCTION OF CO<sub>2</sub>) BY USING DIFFERENT RAW MATERIALS, MANUFACTURING DIFFERENT PRODUCTS, AND USING DIFFERENT PROCESSES. WITH PROVIDES WE FOCUS ON THE PROCESSES, MORE SPECIFICALLY ON THE WAY PULP IS CONVERTED INTO VARIOUS COMPONENTS: CELLULOSE, LIGNIN, AND HEMICELLULOSE.’



configuration, says Westenbroek. ‘In theory, the process is not that complicated: the biomass is subjected to mechanical preparatory treatment and is stirred in a vessel containing DES. Separating the DES (including the lignin) from the fibre fraction is not a challenge either. However, the end of the process does present a challenge, especially separating the DES from the antisolvent. This last step is required, however, in order to use the DES again in the production process.’

### REAL HEADACHES

Heiner Grussenmeyer (Stora Enso) considers Provides (if it flies) as a game changer, with implications for all facets of the value chain. ‘Thus the diversity of companies in the consortium, each with its own specific interests. We are interested, for example, in the bleaching process of cellulose, for which the assumption is that less bleaching agent is required. As a manufacturer of biochemicals, we are also curious as to the quality of the lignin. The calorific value of lignin is currently round 300 to 400 euros per tonne (editor’s note: based on the oil price). Lignin as feedstock for the chemical process (editor’s note: phenols, for example) is higher by a factor 3.’ Grussenmeyer continues: ‘That’s still in the future. The TRLs are still relatively low (2 to 3) and there are still many real headaches. Which ones? Well, there are dozens of components

that could be problematic in the upscaling process. The question is: will these components dissolve in a DES or will they adhere to the lignin or cellulose? Ekhard Beuleke at Omya, a (global) supplier of industrial minerals, chiefly calcium carbonate and dolomite fillers and pigments, as well as a distributor of specialty chemicals, also recognises the potential of DES and the possible implications for the market. The most important markets for Omya are products from forestry (paper, cardboard, tissues), polymers, construction materials (including paint and coatings), and life sciences (food, feed, pharmaceuticals, etc). ‘The mineral content in some products, such as glossy magazine paper, is approximately half the weight. Therefore we would like to know what the consequences are for these components if DES is used for recycled paper flows. We are also interested in the quality of the cellulose fibres: does this have any consequences for the use of fillers and pigments, e.g. the proportion of the individual components?’

### PROFITABLE AT LOWER VOLUMES

In short, the race is all but over. Grussenmeyer expects the first commercial plant will not be built until 2025. ‘I would be surprised if it were to happen sooner, also in view of the low TRLs. In addition, sector-specific considerations also play a role. The paper and cardboard industry is

capital-intensive: a new plant would easily cost between a billion and 1.5 billion euros. Thus you will first have to write off your old plant in order to build a new facility based on DES, and you must be certain that the technology works on a large scale. A German paper producer went bankrupt a few years ago, in part because it opted for a new technology (editor’s note: organosolvents).’ According to Westenbroek, this ‘paper plant of the future’ does not necessarily need to be on the same scale. ‘Normally you are talking about volumes between 1 and 4 million tonnes. A plant running on the DES principle might already be profitable at 50,000 tonnes.’ ●

*Provides is co-financed by the Biobased Industries Joint Undertaking (Horizon 2020-programme)*

### PROTEIN FROM GRASS

‘Projects like Provides are extremely interesting considering the impact they may have on several sectors, not only the paper and pulp industry. Using DES solvents, you could also harvest proteins (rubisco) from non-conventional food crops such as grass in a mild manner.’

*Tjeerd Jongsma, managing director at ISPT*

## SECTOR LOOKS INTO BIOBASED

# IKEA AS TROUBLE-SHOOTER IN THE FURNITURE MARKET

The furniture industry has traditionally used natural materials such as wood, fabrics, and leather. The sector is experimenting with and by now is producing a new generation of biomaterials, such as biocomposites and bioplastics, albeit in dribblets thus far. Fortunately, IKEA is tackling this energetically.

Text Lucien Joppen Images Arco, NPSP, Avans, Shutterstock



*IKEA: completely recyclable and/or biobased by 2020.*

The Dutch furniture sector is preoccupied with other issues for the time being, i.e. survival. The Rabobank sector report (2014) shows that the combined sales have dropped 30 percent since 2007. This year might be the turnabout, according to the Rabobank. The willingness of consumers to buy is rising, and the number of those moving house, including due to an improvement in new housing construction, is increasing. These developments should result in an increase in the demand for kitchen and other furnishings in the private market. The Rabobank asserts that the consumer market is the most significant market driver, and that the role of the institutional market, such as office/business furniture, is considerably smaller.

The Dutch furniture sector was hit particularly hard in the crisis years, especially since it targets the medium and higher-level segments. The advantage is that it is very export-driven and can target wealthy markets in the Middle East and Southeast Asia.

SMALL SCALE

On the other hand, foreign providers dominate the domestic market: approximately 70 percent of the furniture sold in the Netherlands comes from abroad. As far as the scope and labour costs are concerned, the Dutch sector cannot compete with these companies, hence the focus on the higher price and other segments. The industry is small-scale, especially in comparison with sectors such as chemistry, pharmaceuticals or food: 95 percent of the 3260 companies have fewer than five staff members. Only 20 enterprises list more than 100 people on the payroll. The Rabo report also gives the trends that will determine the sector, the market and the consumer market in the next few years. From a biobased perspective, three developments are of interest in this: shorter production cycles due to (more) rapidly changing consumer wishes; more focus on the circular economy (re-use, recycling, biobased); and volatility of the raw material prices for oil, leather, wood and steel. Shorter life cycles and more attention to re-use/recycling benefit renewable raw materials. Higher and/or more volatile raw materials can be assumed to have a comparable effect.

SUPPLY-DRIVEN

It appears that the market is ready for it or, in any case more open to it. In practice it turns out to be not that bad. There are various reasons for this. The first lies in the way the chain is set up. Retailers have considerably less power than those in food or fashion, for example. A spokes-

man for VME Retail (including Trendhopper, Budget Home Store): 'The chain is supply-driven. Manufacturers design and manufacture their collections, present them at trade fairs attended by the retail chain buyers. We have insufficient sales volume to set requirements on the industry. Is the selection of material an argument for purchasing a certain line? No, design comes first.' Retailers having insufficient grip on the chain and a fragmented industry are the reasons that certain developments, such as biobased furniture, are not launched so rapidly. Nevertheless Rabobank expects that retailers will turn the chain around to an increasing extent and the industry will consolidate more.

IKEA WANTS MORE BIOBASED

Fortunately, 'we' still have IKEA, the Swedish furniture giant with 315 branches in 27 countries and sales of 28.7 billion euros (2014). Last year the company announced that by 2020 all plastics in IKEA products have to be made from recycled raw materials or biomass for 100 percent. Puneet Trehan, materials innovation leader at IKEA, asserted at the World Bio Mar-

kets conference this year that his company is open to new, innovative materials, particularly including those based on biomass. Meanwhile, IKEA is hard at work on starting production of a furniture line (chairs, couches, book shelves, etc). These products will be manufactured (in flat packs, of course) via a certain procedure based on paper pulp. IKEA designer Maja Ganszyniec states on the website Gizmodo that it is comparable to the manufacture of egg cartons. According to her, it results in much stronger and smoother material. Ganszyniec and her colleagues made prototypes of bucket seats, sofas and book shelves, among other things, from the paper pulp. These products should be available in the shops at a very competitive price level within two years.

LOGICAL FOLLOW-UP STEP

Back to the Netherlands. By now there are a number of manufacturers who are looking beyond the standard materials and biomaterials and also working with the new generation of biomaterials. ARCO Meubelfabriek, a family business in the Dutch city of Winterswijk with a history that goes back to the beginning of the

last century, regards these materials as a way to distinguish itself in the market. Jorre van Ast, the fourth Van Ast generation in the company, expresses it like this: 'As an innovative company, we are per definition interested in new materials, especially biobased concepts. Why? Because they are in line with the natural materials we already use. It is the logical next step.' Natural Solid Surface is a product developed by Arco together with floor manufacturer Senso. 'It is a biobased counterpart of Corian (Dupont), a material used as tabletop, among other things. It is easy to clean and scratch-resistant, but it does feel cold and hard. Using NSS, based on a polymerised vegetable oil combined with minerals and quartzes, we have a material that feels more natural and softer. Ideal for a work table or dining table.'

LIVE MATERIAL

Van Ast says that NSS 'lives,' just like leather or wood. The material does not have to be painted, but can be rubbed with oil. 'You can polish it as well. The material is softer and therefore more susceptible to scratches. This does not have to be a disadvantage. Consumers who buy more natural materials do not expect them to remain in virgin condition.' Arco is using NSS in a number of products by now, including a secretaire. The material is not cheap, which is due in part to the laborious production process (editor's note: casting instead

of pressing). 'The market has taken a wait-and-see approach so far. Time is also required to "land",' according to Van Ast. 'Our customers are in that case not triggered because it is more environmentally friendly or made from natural materials. The primary focus is on the material properties in combination with the design.'

NICHE MARKETS

Arco's experience with the market is confirmed by Bôke Tjeerdsma, research manager at SHR Wood Research and founder/managing director of BiobasedApplications and Orineo. SHR is a testing and knowledge partner for construction and construction-related products such as facade components, furniture, floors, etc. 'These new types of materials are now still being used in niche markets. They are chiefly used experimentally. If they are used, it still involves small numbers and often products with a high calibre design,' says Tjeerdsma. 'This is largely due to lack of familiarity with these materials. Customers want to know if they have the same or comparable properties (water resistance, UV sensitivity) as plastics do. This is currently not always the case, to which I should add that the chemistry/manufacturing industry invests a great deal of R&D in biobased materials so that the technical properties are approximating the fossil variants ever more closely.' Which biobased plastics are of interest to the furniture market? 'PLA is a material frequently used experimentally, often in combination with

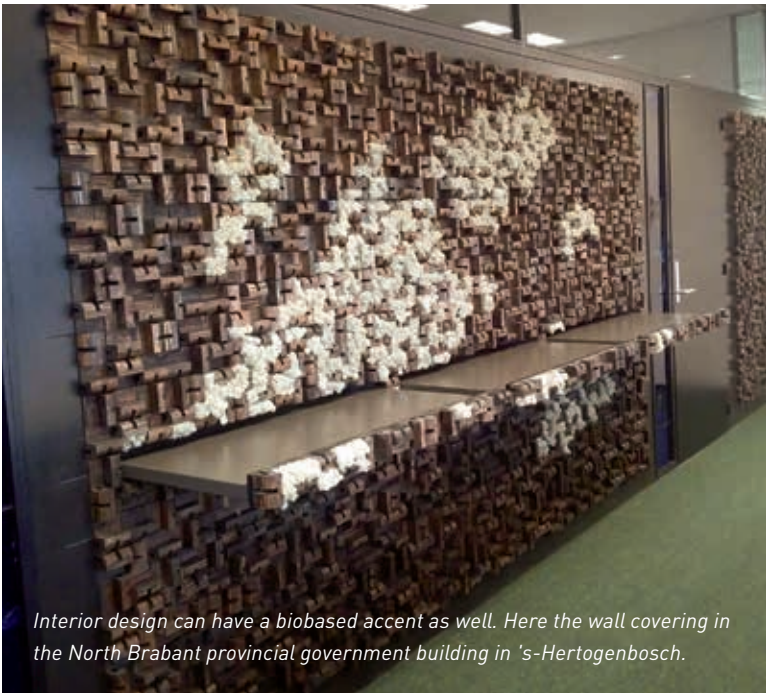
natural fibres like flax, jute, or hemp. The industry also focuses a great deal of attention on 3D-printed furniture based on PLA.'

TETRA PAK SHEET MATERIAL

The trend towards biobase in the furniture industry is not only related to the support materials, but also to substitution or even elimination of additives such as formaldehyde or resins. American firm Noble presses sheets based on cellulose, water, pressure and heat, thus without formaldehyde etc, which can be used for furniture, among other things. Noble is also present on the European market, with a production site in Serbia. It processes Tetra Pak packaging, office paper and corn plants into a pulp, from which it manufactures the ECOR sheets at this site. Eric Logtens, managing director of Noble Environmental Benelux: 'We use various cellulose-containing materials such as rice plants, wood chips, pulp, old paper, coffee grounds, etc. Our goal: to develop and produce furniture that is affordable, fashionable and recyclable. Not only is the material recyclable, but also the additives such as pigments or fire retardants are completely Cradle2Cradle-compliant. At the beginning of this year Noble Benelux announced that it will base its R&D, distribution centre and trade organisation in Venlo, a city located in the South of the Netherlands. It may add a production site to this. Logtens: 'This is certainly an option if the market has developed sufficiently.' ●



Arco's Joy Zeta with the Natural Solid Surface tabletop.



Interior design can have a biobased accent as well. Here the wall covering in the North Brabant provincial government building in 's-Hertogenbosch.

Regional and national governments as well as knowledge and research institutions have also set their sights on biobased furniture and interior decoration. For example, a special biobased meeting room was set up in the Brabant provincial government building in Den Bosch. 'With its economic agenda, the province is stimulating the transition towards this new economy, but we are also putting it into practice,' according to a spokesperson of the province of North Brabant. The raw materials in the meeting room are natural products, such as flax, hemp, straw, tomato plant leaves and sugar beet pulp. Just about 50 kilometres to the west, Avans students are researching biobased materials for the meeting chairs in the new biobased meeting room in the CoEBBE, under the aegis of the Centre of Expertise Biobased Economy. This is taking place in close cooperation with Ahrend, a well-known producer of office furniture. 'We are curious as to what the students will come up with,' says Geert-Jan Knoops, design consultant at Ahrend. Biobased materials are not often used in structural components. 'Exceptionally high user requirements are imposed on the steel frame, which makes the search for a biobased alternative a big challenge,' Knoops states. From a recycling point of view, the current metal of the structure is an excellent and re-usable material. Therefore the students are focusing on a biobased seat and backrest.

# BIORIZON APPROACHES CRUCIAL PHASE

It will be clear at the end of this summer how the processes devised for the production of bio-aromatics from organic waste and domestic waste are progressing on the laboratory scale. The first calculation of the returns and the cost can also be made at that stage. Biorizon business manager Joop Groen and Marcel Ligter, process technologist at Attero, are confident that these processes can be profitable.

Text Richard Bezemer Image TNO

Composting and fermentation are valuable processes for reusing organic waste. However, some of the biomass supply can also be utilised for other processes that add even more value. That is the vision of the Dutch waste sector, which intends to further develop into a raw materials supplier. In the Waste2Aromatics project, three waste companies [Attero, AEB Amsterdam and Orgaworld], along with the Waste Company Association and initiator Biorizon, are investigating how they can substantiate that vision. Biorizon is an

initiative of TNO, VITO and Green Chemistry Campus.

### ORGANIC WASTE

The first step in the project is defining waste types that are suitable as supply for the reactors where sugars are extracted from the biomass. 'The biggest flow by far is organic domestic waste, but there are still numerous other, more defined flows, which can be suitable candidates due to their components such as sugar and/or cellulose and hemicellulose,' asserts Marcel Ligter, process technologist at Attero. 'Together

with the other waste processors, we have specified a list of nine flows based on our expertise in waste processing. This includes waste from street sweeping and orange peels. In the laboratory we have analysed those nine flows, into which I am not allowed to provide further insight out of competitive considerations, for organic dust content, sugar content, and particle size. Parameters which we think are important for the assessment of whether said waste is a suitable basis for the eventual production of bio-aromatics.'

Based in part on those analyses, a short list of three waste flows was decided on, and the Biorizon process technologists have meanwhile begun to work on this. The project participants do not want to name the three flows in concrete terms here either. It should be clear that organic waste will certainly be included, because of its magnitude alone. Fractions rich in cellulose will also be researched further.

### TWO WAYS

Before you can actually start production of bio-aromatics, sugars and cellulose in the waste flows must be converted into furans. These are compounds from which bio-aromatics can be



The reactor in which cellulose and/or hemicellulose is converted into sugars.

made. 'We have two technologies available for that conversion, the use of which depends on the waste flow to be processed,' explains Joop Groen. 'The first one is SHS, "super heated steam", a technology patented by TNO that involves having super-heated steam pass through the biomass. This works well for biomass with a high dry dust content, also known as solid biomass, for example straw and organic waste. We can efficiently convert cellulose and/or hemicellulose into sugars in the reactor. Moreover, you do not have to stop there, because with the right catalyst you can also convert the sugars into furans. We are currently sorting out this interesting possibility on a small pilot scale of approximately one kilogram per hour. The challenge here is that specific sugars are converted into different furans, so you must make sure the reaction does not go too far. If that were to happen, we would lose the reactive ring we sorely need to produce the desired bio-aromatics in the last step of the process.'

SHS is not suitable for the wet fractions. We work with a two-phase system at Biorizon instead. It starts with an aqueous solution in which the sugars dissolve well and the reaction can take place. The reaction will continue to

proceed properly if the reaction product is output to the second phase, the organic one. 'To present we have experimented with this system on a small scale, in a microwave reactor system. Meanwhile we are building a bigger test system, on a scale of up to 10 litres per hour,' says Joop Groen.

### WINDFALL FUNCTIONALITIES

A complete pilot chain, from sugars to bio-aromatics, will eventually be built at the Green Chemistry Campus, where upscaling takes place. 'That is to say, with the furans you haven't gotten to the bottom of it yet. You need a downstream processing unit to purify those products, and reactors to convert those intermediary furans into the desired platform furans, which must subsequently be converted into the bio-aromatics in another reactor,' says Joop Groen. Considering all those steps, each of which has to be optimised and upscaled individually, Joop Groen cannot yet comment on commercial opportunities at this time. 'We are striving to be able to run one or several large-scale processes by 2020. From the market's point of view, I can argue that we have more opportunities with the specialties than with production of relatively

low-functionality bulk aromatics such as benzene and toluene. Our raw materials give us a slight advantage over the petrochemical industry, since the functionalities are windfalls, so to speak. Look at the structure of sugars. They contain hydroxyl groups, which are suitable for many things. Efficient use of the functionality available offers you good opportunities in the market of functionalised aromatics, the specialties, where the volumes are furthermore lower and the prices higher.'

### RAW MATERIALS STRATEGY

The chance of success is closely related to the capacity of efficiently obtaining one or several homogeneous raw materials flows from the heterogeneous waste flow that can be processed on a large scale. Ligter: 'We made a first selection by deciding on three candidate waste flows. Each of these flows still requires a number of pre-processing steps before they can be brought into the reactor. Consider organic waste alone, which consists of approximately 30% organic material, but for the rest contains a lot of water and sand. From our expertise on using organic waste in fermentation and composting, we already control those steps properly, but other flows, especially the smaller ones, still require the necessary development work. The efficiency of organising collection and processing also plays a role in those small flows.'

Green adds: 'A sound raw materials strategy, i.e. finding those raw materials that provide the best result for your money, is just as important as optimising the return, producing as much of the final product as possible per kilo invested. The combined expertise of the waste companies and the process technologists in the Waste2Aromatics project enables us to take optimum advantage of this combined action between raw materials properties and process parameters.' ●



From left to right: Marcel Ligter and Joop Groen.

### SHARED RESEARCH CENTER

Biorizon, an initiative of TNO, VITO and the Green Chemistry Campus, strives to bring together companies active in the fields of raw materials, conversion, equipment, intermediary and final products in the world of bio-aromatics. This takes place in a community and the Shared Research Center (SRC) at the Green Chemistry Campus in Bergen op Zoom, the Netherlands, where parties cooperate in various projects, including Waste2Aromatics, according to the innovation method. Interested companies can join the SRC and the community.

For further information: [www.biorizon.eu](http://www.biorizon.eu)

# AMBITIOUS IN WHITE BIOTECHNOLOGY

Flanders is exceptionally ambitious as far as the biobased economy is concerned. This does not come as a surprise: there are many opportunities in the combination of deep water, excellent chemical companies and agricultural environment. What are those ambitions in East and West Flanders? Special attention is paid to white biotechnology, so industrial biotechnology.



Text Koen van de Populiere Image Biobase Europe Pilot Plant

Flanders wants to be at the top with the most competitive biobased economic regions in Europe by 2030. The province of East Flanders is leading the way in the Flemish biobased economy. One of the reasons is Ghent University, which is investing substantially in genetic and biobased technology and materials science: these are the research areas in which the education and research institute excels.

Wim Soetaert, one of the professors at this university, is the driving force and CEO of the Bio Base Europe Pilot Plant (see photo), in the port of Ghent. This pilot plant is at the forefront in Europe in the development of new, biobased processes and products such as bioplastics, biodetergents, biosolvents, biochemicals and biomaterials. The plant celebrated its fifth anniversary in June. Two new 15,000 litre bioreactors were inaugurated by Minister Muyters during the celebration. ArcelorMittal was one of the companies which explained its operations as regards the biobased economy. The steel manufacturer wants to produce biofuel at its site in the port. This will be done by microbes that will ferment the blast furnace gas to create bio-ethanol. This biofuel can keep half a million vehicles driving every year.

‘THE DEVELOPMENT OF THE BIOBASED ECONOMY WOULD BENEFIT FROM INTERDISCIPLINARY COOPERATION FROM HIGHLY DIVERSE RESEARCH AREAS SUCH AS BIOTECHNOLOGY AND AGRICULTURAL SCIENCES.’

## INTERDISCIPLINARY COOPERATION

The Provincial Development Agency (POM) East Flanders is also taking initiatives to give the biobased economy a boost. For example, the POM understood that the development of the biobased economy would benefit from interdisci-

plinary cooperation from highly diverse research areas such as biotechnology, bio-information technology, agricultural sciences, (bio) chemicals and engineering sciences.

The POM therefore established the knowledge platform Ceebio. Through its databank CeebioDB, the platform provides access to information about researchers and companies that are active in the various fields of the biobased economy. Ceebio is open to new partners, and is keen to collaborate with similar platforms in other countries. It looks to the Netherlands in the first instance for further collaboration.

And then there is also CINBIOS, the Cluster for Industrial Biotechnology Solutions. This is an initiative of organisations that develop activities in the biobased economy: Ghent Bio-Economy Valley, FlandersBio and essenscia, the Belgian federation of the chemical industry and life sciences. CINBIOS facilitates networks between companies and knowledge centres (universities, universities of applied sciences and research institutes) that work on industrial biotechnology.

## TEXTILE

The VIB, Flemish Institute for Biotechnology, is similarly important. It performs basic research

with a view to applications in areas such as medicine and agriculture. One example of a biotechnology success in East Flanders is provided by Inbio.be, the expertise centre for industrial biotechnology and biocatalysis. This centre was the first to successfully create an imitation of mother's milk lactose, which is not found in cow milk, from sugar beet. New milk powder with this lactose could already be on the market by 2016. Spin-off Inbiose is now conducting negotiations with food sector giants like Nestlé and Danone to produce the lactose on a large scale. Strong textile companies are typical of the provinces of East and West Flanders, so examples of achievements in the biobased economy can of course also be found there. Thus both De Saeleir Textile Platform and Beaulieu Technical Textiles have spared no expense in the meantime with their biodegradable geotextiles.

## CLOSING CYCLES

The province of West Flanders has a more agricultural character than East Flanders, and there is less white (industrial) biotechnology. But outstanding initiatives can be noted there too. One of them is Inagro, which investigates and provides advice to the agricultural and horticultural sectors. The centre participates in

more than 100 projects every year. For example, Inagro is active in various research projects that investigate and make in-depth studies of energy cycles, or the recycling of nutrients. Thus the extent to which grass clippings can be used to generate energy through fermentation has been investigated. Inagro has also carried out field trials with biobased mineral fertilizers in the context of projects such as ARBOR and NutriCycle. COMBINE is another example of a project, which examined whether organic waste from cities and country areas could be converted into bio energy.

## BIOPLASTICS

Biogas-E, the platform for anaerobic fermentation in Flanders, is located in Kortrijk. There are three workgroups at Biogas-E: biomethane, biobased fertilizers and small-scale fermentation. Biogas-E recently participated in the BIORE-FINE project, which aims to valorise residual flows from the agricultural and food industries. The platform has also worked together with the Flemish Energy Agency, for example in consultation about operating shortfalls in green power and CHP projects.

Also in Kortrijk, you can find the Flemish Plastics Centre (Vlaams Kunststof Centrum), a

knowledge and research centre where considerable knowledge exists and is built up about biobased plastics. The FlaxHemPlast project was partly carried out at this location. Its aim was to use short-cut flax and hemp fibres to reinforce and further functionalise plastics. This project has since been completed and resulted in the ValorFlax project, which focuses on the further business development of the new materials obtained in FlaxHemPlast.

## VITO

Beologic is an example of a West Flemish company which is active in white biotechnology. It focuses on Wood-Plastic Composites (WPC). For example, PVC with 50 percent wood fibres. This therefore concerns materials or products which are made from a combination of one or more natural fibres or powders, and polymers. And then there is VITO, the Flemish Institute for Technological Research. This research organisation contributes to the transition to a biobased economy. VITO has six offices in Flanders. One of them is in Ghent, and another in Oostende, West Flanders. Flanders wants its biobased economy to be at the forefront in Europe. And let it be clear: East and West Flanders are determined to do their bit. ●

# BE-BASIC FOUNDATION'S INTERNATIONAL FOCUS

**‘The Netherlands will have to operate on an international level in order to continue to play a role of significance in the transition towards a more biobased economy. Therefore BE-Basic decided to operate on an international level from the very beginning. This applies to the technology development as well as to complementary research in the fields of sustainability and societal embedding.’**

Text Lucien Joppen Images Dick Teske, BE-Basic

As far as Luuk van der Wielen, Chairman of the Board of Directors of BE-Basic, is concerned, the development of local biobased economies cannot be seen as separate from international cooperation. Even though the Netherlands does not have the biomass available (Dutch biomass production would not be sufficient for energy purposes), it does have other assets (knowledge, money) that can be used in other countries. In

Van der Wielen’s view, there is a great need to operate on an international level. ‘The Netherlands, or more precisely the region of the Netherlands, Flanders, and North Rhine-Westphalia, is characterised by a strongly developed process industry (agricultural food, chemistry and energy). These sectors are currently still running on fossil energy. The question is whether this is economically and ecologically sound in the long term. Yes, the oil price is still

low and there are sufficient reserves. But the question is whether we can draw on these fossil reserves. According to the World Bank, we must leave two-thirds in the ground if we want to put a halt to global warming.’

### PROSPERITY AT ISSUE

Stopping the majority of these flows has great implications for the industrial complex in the above-mentioned region, both for the sales and for the balance of enterprises, according to Van der Wielen. ‘Our prosperity is also at issue, not only as far as the economic growth and employment in these sectors are concerned, but also regarding our pension provision, for example. Together, the big Dutch pension funds are sitting on a mountain of a trillion (thousand billion) euros and invest a significant part in fossil energy. What if this balloon empties faster than expected?’ Van der Wielen recognises the importance to anticipate, also for emerging economies or countries on their way to become an emerging economy (and less burdened by a fossil ‘addiction’). ‘Every country follows a different route in the

evolution towards a more biobased economy. In Vietnam, where BE-Basic has been active since 2010, we chiefly cooperate in finding new enzymes and bioactive substances in nature that can be used for improved pretreatment and decontamination of biomass. The scope in this country is totally different. It involves food and energy for tomorrow. An industrial complex is lacking, thus large-scale extraction of value to produce chemicals in the country itself would be less likely. Vietnam would rather play the role of biomass supplier.’

### DO NOT SEPARATE ENERGY FROM OTHER ASPECTS

Van der Wielen emphasises that bio-energy and other extraction of value cannot be regarded separately from one another in BE-Basic’s perspective. ‘Our scope is broad: from food, energy, chemistry, materials to the sustainability aspects of cultivation and production. It is a question of an integral approach. Take the relationship between energy and chemistry/materials, involving conversion of the high-energy fraction of biomass into energy, and of the low-energy fraction into materials. Wood is used for energy purposes in many countries. This is a suboptimum extraction of value. You can also convert wood into ethanol for energy purposes and subsequently produce lactic acid of acceptable quality, from which you can produce PLA for mobile telephones via a 3D printer. In essence, this is high-tech and possibly suitable for regions that lack large-scale industry and where the market is ready for small-scale, new business models. I think there are opportunities there because the playing field is still reasonably open.’

### SUCCESSFUL PARTNERSHIPS

In the ten years of its existence, BE-Basic has set up successful partnerships with private and public parties in Brazil, the United States and Vietnam. Van der Wielen comments not all ventures have been equally successful. Initially, our projects in Malaysia received green lights, but the collaboration did not gain the desired momentum. ‘It is also a matter of involving all stakeholders in the issue. It illustrates the importance of “soft” factors in order to allow the biobased economy to settle in, both in our country and on other continents. The fact that BE-Basic is willing to invest in these countries has certainly been of help. This way, you can dispel the idea that we are coming to take rather than to bring.’

### NOT JUST TECHNOLOGY

Van der Wielen already indicated this: technology development is necessary to convert biomass



Professor Luuk van der Wielen (left) and Professor Sergio Motioka (Federal University Vicosa, Brazil, right) during BE-Basic’s visit to a research site in Macaúbas, Minas Gerais (February 2015).

into semi-finished products and final products in a sustainable and cost-effective way. 12 flagship programmes are running at BE-Basic (including more than 80 projects), researching technology and aspects such as environmental impact. However, technology by itself is one side of the coin. Patricia Osseweijer is working at BE-Basic on societal embedding and is researching the transition to a BBE from a societal perspective. ‘Of course the economy (scale, cost aspects and market demand) plays an important role. However, acceptance of the new technology by the stakeholders (politics, civil society, etc) is also of importance. Genetic modification has shown us that resistance from consumers and NGOs in some European countries resulted in a (partial) prohibition, as a result of which we are currently using only a fraction of this technology. We must address the discussion involving bio-energy in the biobased economy. How? Among other ways by researching whether bio-energy does use up the land, for example for the food supply, and by mapping out what the impact of biobased innovation is in the various regions.’

### SUFFICIENT ACREAGE

In that framework the SCOPE report, a voluminous (800 pages) peer-reviewed document to which BE-Basic made a considerable contribution in content, was published at the right point in time, according to Osseweijer. ‘The report, which was presented in April 2015, shows that sufficient acreage (chiefly in Africa and Latin America) can be made available for energy purposes. This predominantly involves grasslands in less developed

areas, now often used for stock breeding, which can be converted into land for multifunctional use, meaning crops for food, fodder and energy. Such an operation would not come at the expense of nature reserves or food security.’ Osseweijer continues: ‘As long as local needs and opportunities are taken into account, this can in fact provide better living conditions: higher income, employment, healthier and more sustainable use of biomass for energy, and improvement of the infrastructure, which can also improve agriculture and the food supply. Streamlining this transition is important in this all. Political and social stability is required to make economic progress, attract investors, etc. Thus it is far from a fait accompli, but it is something that can revitalise poor rural areas worldwide.’ ●



Patricia Osseweijer: There is sufficient acreage for sustainable bio-energy.

BE-BASIC FOUNDATION IN BRIEF

BE-Basic, an international public/private cooperative, primarily develops biobased solutions based on industrial biotechnology for a more sustainable society. This involves not only technology, but also ecological research, education (including via MOOCs), and communication with the stakeholders. Various companies now bear the ‘BE-Basic Inside’ logo, such as the yeast used in production of ethanol from C5 sugars (POET-DSM), or the ChainCraft firm, formerly known as Waste2Chemical, which originated from a research line in the consortium.



**As the Monitor Biobased Economy 2014 published in the summer shows, the biobased clusters are making headway. The energy applications, however, are currently getting off to a better start. Chemistry and materials are lagging behind.**

Text Lucien Joppen

**A**gro&Chemistry talked with Paul Boeding (the Dutch ministry of Economic Affairs, the Monitor's client) regarding the power of the regional clusters, biobasing chemistry and materials, as well as the role of the government.

**Paul, the Monitor writes that an increasing number of companies have gone through the R&D phase and are ready to enter the market. Will it work?**

'It's a growth process. There's a difference between bio-energy and materials/chemicals. Energy applications are often started up earlier and reach the market more easily due to subsi-

dies. Meanwhile some technologies, such as pyrolysis (editor's note, the company Empyro) have been upscaled. The requisite activity has already been taking place in the area of manure (read: co-fermentation) as well. Materials, bioplastics/composites and chemicals are not subsidised on their way to the market and are not having an easy time, certainly with the current low oil price. On the other hand, there are fortunately sectors such as construction and the packaging industry that are looking for materials that entail lower CO<sub>2</sub> emissions and possibly have better properties. Meanwhile, companies such as Nova Lignum on the agro-industrial park Nieuw Prinsenland are also starting production. This is a positive signal. Biochemicals are also affected by low oil prices. I do expect

Northwest Europe will be able to play a role, certainly on the basis of sugar as feedstock. Not only in the area of R&D, but also with large-scale production. I do not expect the production of transport fuels to assume a leading position in Europe very quickly. Other countries like the US, Brazil, and players in Southeast Asia are considerably more active in this regard. The proximity of large biomass flows also plays a decisive role.'

**800 running projects, in which 700 companies are participating, were scanned in the past three years. A total of 1.5 billion euros was invested, 1.1 billion of which in energy. Isn't that a little lopsided, considering the ambitions?**

'Energy applications have a head start on other biobased applications. The ambitions in the Netherlands are focused more on complete utilisation of biomass through cascading. For this reason there is nearly always an energy component. I should also say that the numbers can be

**'THE AMBITIONS IN THE NETHERLANDS ARE FOCUSED MORE ON COMPLETE UTILISATION OF BIOMASS THROUGH CASCADING.'**

somewhat skewed. In part this is an administrative matter (editor's note, SBI coding). It also has to do with the possibility of receiving an energy component subsidy while the biomass is applied on a much broader scale. Our goal in any case is to make a clearer distinction in the next Monitor.'

**In the Monitor you assert that bio-energy is at the beginning of the S-curve. What is the expectation for materials and chemistry?**

'According to the nova institute, this curve will come to a conclusion in the period 2015-2020. It's still a matter of conjecture because the oil price for example plays an important role. Natu-

rally, there are frequently still the usual bumps that have to be smoothed out. The government can respond to this with statutory and regulatory requirements, standardisation/certification, purchasing, and subsidising. Developing biocomposites is, for example, one of the ways, but these must also be tested and certified and find their way to the market. These are often time and money-consuming projects that require perseverance from companies that generally do not have unlimited financial resources. We must support and accelerate these projects. The Dutch government and the EU also recognise and assume their role in this.

**You state in the Monitor that the biobased clusters in the Netherlands are doing well. Activity is pursued in concrete terms in a triple helix. Has the biobased landscape come to a conclusion by now?**

'Certainly. This landscape has largely been defined already by the presence of activity, knowledge institutes, and geographic position. In the Biobased Delta, (heavy) chemistry, agricultural feed, energy, and the proximity of deep sea ports in the provinces of Zeeland and Zuid-Holland have led to an accent on green raw materials, green chemicals, and the emphasis on large scale process industry. Some high-quality knowledge institutions are also contributing to this. I also see a strong will and motivation in the business community, the knowledge institutions, and government bodies in the Delta to achieve this agenda. The extent of organisation is also high, including in SMEs, in part because Biobased Delta was the first biobased cluster in our country: it has a jump start as far as time is concerned. Which does not alter the fact that the other clusters are making progress. Limburg is on the materials side in this, having a connection with Greenport Venlo which is active in the green domain, from cultivation to pretreatment. In Eastern Netherlands it's the number of technology companies, mostly SMEs, that play a role in (biobased) processes in the field of biomass and energy that stands out. Farther north, there is the fibre/yarn cluster round Emmen and Zwolle, as well as the cluster in and round the Eems Delta where basic chemistry and biomass (including hemp fibres) will determine the activity.' ●

*This article was created in collaboration with Biobased Delta.*

# THE GOAL: KEEP BIO-BUSINESS IN EUROPE

**'The essence of our activities is to connect different industries which will lead to new insights and exciting business opportunities. In the past, Europe has developed new technologies, or example in biotechnology, but the business landed outside our continent. With the programme BBI Joint Undertaking we want the bio-business to stay in Europe.'**

Text Lucien Joppen Image DSM

For Marcel Wubbolts, CTO of DSM and chairman of the Biobased Industries Consortium (BIC), the establishment of the aforementioned initiative is a clear signal that the industry (more than 100 companies) and knowledge institutions, bundled in BIC, and the EU have chosen for a more industry-led agenda. Both partners of BBI JU will invest 3,7 billion euro between 2014 and 2020. 'In that respect I am extremely happy that Philippe Mengal will start, as from October 1st, as the new managing director of BBI JU. Philippe has an extensive background in biotechnology, both in start-ups as well as in larger enterprises.'

For Wubbolts, the potential of a strong biobased sector is huge, not only in terms of meeting climate change targets and reducing the dependency on fossil feedstocks, but also in terms of economic growth. 'Europe has the industries, the expertise and the feedstocks to be a front-

runner in the biobased economy. The BBI JU aims to harness these strengths by setting up consortia with players from various sectors.'

### NEW VALUE CHAINS

According to Wubbolts, the synergies from these cross-sectoral collaborations are crucial for the development of innovative processes and products. 'For example the chemical sector and the paper and forestry sectors have discovered each other's assets and skills. The latter is very much advanced in what I would call "lignocellulosic refinery": the re-use of individual components of wood into paper or other products. The chemical industry is not so much interested in paper as such, but more in cellulose or lignin as a source of platform chemicals. Because of this cooperation under the BBI JU-umbrella both 'camps' have gained understanding of each other processes, products and markets and are more open towards establishing new

value chains. I must say both sectors are front-runners in terms of collaborating. This is not always the case. Some industries are more 'closed' than others. Ultimately, I foresee a more open attitude among companies across the board. Why? Because there is an economic rationale and an increasing pressure on companies from various stakeholders to make their businesses more sustainable.'

### CROSSING VALLEY OF DEATH

The focus of BBI is threefold: on a sustainable feedstock, preferably second generation or higher, setting up biorefineries to 'mine' these feedstocks and market development/optimizing policy frameworks. In terms of projects, BBI JU aims for a portfolio mix with projects ranging from TRL 1-3, to TRL 4-6 and TRL 7-9. Wubbolts: 'The added value of BBI lies more in bridging the gap between lab and industrial upscaling, the Valley of Death, say the TRL 4-6-stage. Once a

project has successfully crossed this gap, investment risk has dropped considerably and individual companies would be able to take it to market. The earlier phases in R&D are more tricky and risky. By joining forces and sharing risk through joint funding, BBI JU will make it easier for companies to cross the valley of death. Ultimately, actual biorefineries on a demo- and a semi-industrial scale should see the light of day. It is not about science primarily, but about scientific insights leading to actual business.

### OPPORTUNITIES OF MARINE BIOMASS

When asked about the various specific value chains which are of interest in the BBI JU, Wubbolts states there is one common denominator: most value chains are based upon feedstocks that have not been used to their fullest potential, such as byproducts from agriculture and forestry or municipal waste. 'In Europe we have large quantities of this biomass. Again, we need to develop new value chains and processes to transform for example lignocellulose into certain chemicals or materials. An interesting route also is marine biomass, such as microalgae or seaweeds. While most efforts have been targeted at land biomass, marine biomass has been somewhat neglected. This would be a missed opportunity. Marine biomass is already being used commercially, for example in food and pharma, but also applications in the fields of energy or biomaterials are viable. Opportunities galore, but also hurdles to take, for example in reducing extraction and refining costs.'

### FOCUS ON 2ND GENERATION BIOMASS

Wubbolts' employer DSM has been one of the founding member of BIC. What would be the benefits for DSM in having joined the BIC and the BBI JU? 'Our focus is on valorizing second generation biomass, both from a perspective of sustainability and economy. Lignocellulosic biomass is the most abundant feedstock on the planet. DSM has developed and continues to develop enzymes and yeasts in order to optimize the conversion processes to sugars and subsequently bio-ethanol. As you know, we have established a joint venture with POET in the US, resulting in a production facility for lignocellulosic bio-ethanol. We also see opportunities in the field of chemicals and materials. In our joint venture with Roquette, Reverdia, we are already producing Biosuccinium<sup>tm</sup>, succinic acid based on starch. This chemical is already being used in food, pharma and coatings. However, we also envision a broader usage such as in the production of biobased polyurethanes, PBS or solvents.'



‘THE CHEMICAL SECTOR AND THE PAPER AND FORESTRY SECTORS HAVE DISCOVERED EACH OTHER'S ASSETS AND SKILLS. THE LATTER IS VERY MUCH ADVANCED IN WHAT I WOULD CALL "LIGNOCELLULOSIC REFINERY": THE RE-USE OF INDIVIDUAL COMPONENTS OF WOOD INTO PAPER OR OTHER PRODUCTS.’

BRIGHTLANDS MATERIALS CENTER: NO ‘SPLENDID ISOLATION’

# TOP POSITION IN POLYMERS

The Brightlands Materials Center was founded in the middle of March. Various parties, public and private, work together at the research centre on plastics, possibly also on the basis of biomass. “‘Splendid isolation” is a thing of the past. We will have to combine our forces.’

Text Lucien Joppen Images Dols Fotografie

These are words spoken by René Corbeij, associate manager of the Brightlands Materials Center (BMC). Corbeij, who heads the research on polymers at TNO Eindhoven, regards polymers as the building blocks of the 21st century. Plain logic, as metals are scarce or are becoming scarcer and more expensive all the time. Moreover, metals have a high specific mass, which causes some industries, for example the automotive or aircraft construction, to switch to lighter plastics at an increasing pace. ‘In addition, polymers play a crucial role in the development of new technologies, for example in IT, 3D printing and solar cells. In short, we can take a top position in this field in the Netherlands, but to accomplish this, the companies and research institutions active in this field have to come closer together.’

## INDUSTRIAL CAMPUS

Marnix van Gulp, associate manager of BMC and previously employed by DSM Engineering Plastics in R&D, nods in affirmation. ‘In the Netherlands, there is a great deal of activity and

knowledge/research in the field of polymers. Brightlands, formerly the Chemelot Campus, is an international hot spot with numerous big global players and small enterprises. That is why

‘THE BMC IS A SOLUTION FOR SMES IN PARTICULAR, AS THEY WON’T BE SO KEEN ON GOING TO A UNIVERSITY WITH A CONCRETE QUESTION.’

BMC is based at this site, where it functions more as a hub with the “spokes,” which radiate out to TU Eindhoven, Wageningen UR, RWTH Aachen (in

Germany), the University of Maastricht, etc. The unique aspect of BMC is that it is an industrial campus. You often see campuses spring up around educational and research institutions, while the campus here in Geleen is built in amongst companies. We notice that this concept is appealing, not only to companies on the campus, but also to students, for whom it is easier to call on companies they are interested in.’

## SHARING EQUIPMENT

The BMC will eventually become a separate physical site, according to Van Gulp and Corbeij. At this point it is just a virtual building, while researchers use the existing facilities, for example analysis and characterisation equipment, on the Brightlands Chemelot Campus. ‘We will have to take a close look at what equipment we are going to purchase,’ says Van Gulp. ‘Of course this depends on the research programmes currently in process. It speaks for itself that expensive equipment is used as much as possible and thus also shared. These can represent considerable investments, not only to SMEs, but also to multinationals.’



Corbeij and Van Gulp during the official opening of the Brightlands Materials Center.



enterprises as profitable and to which research institutions can also contribute in a meaningful way. Isn’t this too much of a fundamental research centre for the bigger companies? No. In some cases you need fundamental insight, but always generated from the application. Demand is first created in the market, and then you reason back to material/technology and, in the end, fundamental insight.’ Van Gulp adds: ‘The BMC is a solution for SMEs in particular, as they won’t be so keen on going to a university with a concrete question. In contrast, at BMC this is possible provided the question dovetails with the research lines and the competences of the center.’

## SORELY NEEDED

Back to the research lines. It would take us too far to discuss these extensively. An interesting line is sustainable packaging material. ‘Packaging is sorely needed to protect products, but must not lead to environmental problems,’ according to Van Gulp. ‘One route is to make packaging thinner and lighter. The industry is already working on this, but this exercise is not finished yet. In order to go any further, more insight is required into the physical properties, for example the rigidity or the oxygen barrier of thinner materials. Another issue is the design with regard to recycling. Especially in the food industry, packaging is composed of several layers, for example cardboard in combination with laminate or aluminium, in order to protect the product from spoiling. This does make recycling more complex and more expensive. What if you could design mono-materials with the same or even better properties?’

In terms of properties, some biopolymers, for example PEF or PLA, score better for certain parameters than fossil fuels do. Is there any specific attention to bioplastics at BMC? Corbeij: ‘There is no separate research line for this, but bioplastics with exceptional properties may come into the picture. We are not interested in drop-ins.’ ●

## TOYS

Even though the ‘BMC house’ is virtual, the programme has (in part) already started. The programme in the field of 3D printing is already running. Sixteen doctoral students and three scientists are researching the specific requirements that materials in this programme line must meet in order to make high-quality applications for biomedical or industrial use. ‘The final products of 3D printing do not currently meet the strict standards that apply to B2B materials,’ says Corbeij. ‘You could call them toys. That is unfortunate, because the advantages of additive manufacturing are great: more freedom in design, an efficient use of raw materials, and customers are less dependent on suppliers. In additive manufacturing we are going to investigate and test how we can improve the performance of existing plastics, and whether we can develop new materials as print medium. We also want to increase the production speed, which is still often a bottleneck. The fundamental insights will be collected mainly in Eindhoven, while implications for biomedical applications form the métier of the University of Maastricht.’

## LOW THRESHOLD

Additive manufacturing is only one of a total of six programme lines at BMC. The following are also on the agenda: sustainable packaging, light-weight mobility, optic and electronic equipment, energy storage and conversion, as well as recycling/end of life. Corbeij: ‘The majority of these programme lines originate in the business community. They are markets likely to succeed, and/or enabling technologies, which are regarded by

The partners, including the Province of Limburg, TNO and DSM, will invest 45 million euros in the Brightlands Materials Center over a 5-year period. Not only big companies are participating, but a small player like Yparex, producer of extrudable adhesives, is also supporting the initiative. Managing Director Wouter van den Berg: ‘Our business is adhesives: connecting various types of materials, for example metals to plastics or plastics to each other. The trend is to unite as many functionalities as possible in a type of material, with regard to space utilised, for example mobile telephones, or with respect to end-of-life issues. All the same, in most cases (incompatible) materials have to be interconnected. The consequences of this in the long term are not always clear, for example delamination or corrosion as a result of moisture. Such aspects may be of interest for further research at BMC.’

# WAKING THE SLEEPING GIANT

Avantium will begin construction of its first commercial plant this year. The company was established fifteen years ago as a service provider for the chemical, petrochemical and pharmaceutical industries. It eventually developed its own production platform for FDCA, the biobased ‘counterpart’ of terephthalic acid. ‘We woke a giant from hibernation.’

Text Lucien Joppen Images Avantium, Jeroen Staats

**C**TO Gert-Jan Gruter was part of Avantium from the very start. He worked for DSM for seven years at the beginning of his career (see box). He was actively involved in the chemical giant’s polyolefin businesses in the effort of high throughput testing of catalysts. DSM was not the only company using this technology in its R&D. Companies like Shell, Pfizer, and Akzo were also working on this. When Shell decided to remove this specific discipline from its core activities, the seed was planted for Avantium.

**At what point did you come into the picture at the then start-up Avantium?**

‘It was a confluence of events. Former Shell employee Ian Maxwell, founder and CEO of Avantium, asked me to set up the chemical branch of Avantium. At about the same time, DSM decided to sell its polyolefin business (editor’s note: to Sabic). Initially I concentrated on this, building a team working on high throughput testing of homogeneous and heterogeneous catalysts for third parties, i.e. the big chemical, petrochemical and pharmaceutical companies that had also invested in Avantium. In 2004 I was given the role of CTO in order to develop proprietary technology and proprietary technology platforms in addition to contract research. Contract research is very safe, but it is still a freelance activity. If you are a company, you also have to take risks. At that time this was also the explicit wish of the venture capital companies that had invested in Avantium.’

**You soon took a certain direction: producing a better (biobased) version of terephthalic acid. Why this route?**

‘We chose catalytic conversion of biobased feedstock in part because that way we would not be competing with some of the clients in the petrochemical industry for contract research, and in part because it was still virgin territory. That

certainly applies to conversion of biomass using conventional catalysis. Was it a big risk? Because of the well-known 2004 report “Top Value Added Chemicals from Biomass” by the American DOE (editor’s note: Department of Energy), which described the 12 most promising biobased building blocks of the future, furans had a prominent position. In part this had to do with the excess of feedstock (the world is full of carbohydrates, so to speak) and the opportunities furans have to offer in material applications. More specifically, 2,5 furandicarboxylic acid (FDCA) was a sleeping giant. Production in a laboratory had already been successful at the end of the nineteenth century, but upscaling has proved to be an insurmountable hurdle ever since. Even though the properties of a number of FDCA-based polyesters and polyamides were already known, they had not been researched in upscaled applications.’

**‘WE ALL TREAT BIOBASED TOO HARSHLY, WHILE FOSSIL IS BARELY SUBJECT TO ANY QUESTIONS.’**

**You eventually succeeded in producing FDCA in large volumes at high quality, among other ways by adapting the step from carbohydrates to an interim product, HMF. Quite an achievement, but you still did not have a market.**

‘No, but you first had to prove that you could obtain a yield at a cost-competitive price. In the beginning, investors often asked us: “What is the yield?” Which is actually the wrong question.

The proper question is a yield that is “economically viable”. When we started testing, it turned out that our FDCA, in combination with ethylene glycol, also scored higher, in addition to the properties already documented (editor’s note: including glass transition temperature), in thermal and mechanical properties and the barrier for water, oxygen, and CO<sub>2</sub>. Of course you can use other agents instead of oxygen, such as oxygen scavengers in food packaging, but alternatives to CO<sub>2</sub> are not readily available. The good thing about it was that the soft drink industry and its suppliers, see the PET suppliers, were very busy with the process of making their packaging material “greener”. In other words, the market was ready for it. However, the additional advantages we were able to offer in comparison with bio-PET turned PEF into a potential game changer.’

**Would PEF still have flown if it had not had these properties?**

‘It would have been much more difficult and much slower. Providers of biobased applications often compete with the petrochemical industry, so you would certainly not be successful in the first few years as far as volume and price are concerned. However, if you could offer more functionalities, you would have a chance of making it through the first years after commercial production. That is why I see significantly better perspectives for new materials than for drop-ins. In the latter case you can only distinguish by price. We can ask for a slight premium in any case, although not a green one, because we can provide a specific performance for certain problems the industry is struggling with. After all, the relatively low CO<sub>2</sub> barrier causes problems, especially in the case of small-format PET packaging of 33 cl and less. Solutions are available, for example application of a nylon layer or coating on the PET, or cans or glass, of course, but these solutions are expensive, see the energy-wasting production of aluminium and the higher logistics costs of glass.’ >>

*Gert-Jan Gruter (Avantium): ‘Providers of biobased applications often compete with the petrochemical industry, so you will certainly not be successful in the first few years as far as volume and price are concerned. However, if you could offer more functionalities, you would have a chance of making it through the first years after commercial production.’*



**You just mentioned the green premium. Apparently, manufacturers cannot pass these on to consumers. Where is the value of the PEF bottle for manufacturers such as Coca-Cola?**

‘As mentioned before, small PEF formats can compete with the current solutions in cans, glass and multi-layered PET. Companies also

want to distinguish themselves by their sustainability enhancement policy. Packaging is a hot issue in society, see the plastic soup or litter. Therefore the FMCG companies cannot get around this issue, but must approach it proactively. Does it have an immediate impact on sales? In the case of Dasani, the Coca-Cola Company’s water brand, the introduction of the Plant Bottle [editor’s note: partially fossil, partially bio-PET] resulted in years of above-average growth in the bottled water category. However, bottling Coca-Cola in the Plant Bottle had less effect. Communication targeting the consumer (“How do I tell the story behind the Plant Bottle?”) requires precision, apparently. A water drinker will respond sooner to terms such as “natural” than a coke drinker, the purchases of which are geared more to perception, see the fun component. Insight into the motives is crucial to the success of (partially) biobased consumer products.’

**Regarding consumer preferences: I have noticed that biobased is having anything but an easy time in the public media in the Netherlands. Competition with food, land use, end-of-life issues, and so on. In any case, it seems to me that it is not beneficial to quick consumer acceptance.**

‘We all treat biobased too harshly, while fossil is barely subject to any questions. I can imagine that an issue such as food versus fuel can become urgent with a global population approaching nine billion. Food versus chemicals or materials is a non-issue, judging by the small volumes. Why could you not make an effort, as a country, to produce materials? Isn’t this happening with flax, hemp, or cotton? Sugar is a food product that we should by now be consuming less of, in any case, and its production is expected to increase starting 2017, when the quota system in the EU expires. Sugar or starch from food products are feedstocks that will have to suffice for the time being. Avantium is using glucose (from corn or beet and cane sugar) because there simply is no alternative. We will first have to develop routes based on the first biomass generation. There is no point in waiting for the time when the second-generation biomass will seriously come into the picture.’

**Isn’t it the case that you are also researching the FDCA from second-generation biomass route anyway?**

‘That’s right. We have developed a route in the laboratory entailing isolation of glucose from cel-



*The Avantium pilot facility at Brightlands Chemelot. The company will upscale the FDCA route from second-generation biomass here.*

lulose. We do this on the basis of an existing procedure [editor’s note: the Bergius process] which we optimised. We first dissolve hemicellulose and subsequently the cellulose in a step-by-step hydrolysis using concentrated hydrochloric acid. We thereby obtain a high yield of a purer final glucose product, which is not contaminated by other sugars or by lignin. We are also in the process of developing a method to remove the acid from the lignin so it can be used for energy purposes. We can use wood pellets, bagasse and straw as feedstock, or the short fibre fraction of old paper. After the summer we hope to start a pilot for this process at the Brightlands Chemelot Campus in Geleen. We are still looking for partners, so...’ ●

At the end of 2014, **Gert-Jan Gruter** won the award for best CTO (chief technology officer) in Europe. The award for ‘CTO of the Year’ is presented to a special ‘leader in technology’ at an innovative company: someone who inspires, a manager with vision who contributes to the development of sustainability of his/her industry and also of society as a whole. Gruter studied chemistry at the VU Amsterdam from the middle of the eighties to the beginning of the nineties. After taking his doctoral degree, he began his career in the business community at DSM Research in Geleen, a job he combined with a part-time professorship in polymer catalysis at the TU Eindhoven. Since 2000 Gruter has been working at Avantium, a company that has been in the global Cleantech Top 100 five times in a row. It was also given the award for ‘European Cleantech Company of the Decade’ in 2014.



# VARIOUS ROUTES TO MARKET



**High-performance constituents from biomass are leaving the research laboratories and emerging in trial projects with companies and concrete applications in final products. The rate at which this is happening and the underlying market drivers differ per product field, as is shown from a visit to biobased projects in the field of pigments, pharmaceutical products/functional foods, crop protection and natural rubber.**

Text Richard Bezemer Images Rubia Natural Colours, Vredestein

**T**he Russian dandelion is well on its way to becoming an alternative source for natural rubber, which is thus far exclusively extracted on Asian rubber tree plantations. 'Western countries want to be less dependent on those plantations. Moreover, we see that the production is stagnating there, while the demand for natural rubber is growing. Natural rubber is essential for many final products, such as tyres, because its quality can still not be imitated properly by synthetic rubber.'

That is how Ingrid van der Meer (Plant Research International, Wageningen UR) describes the most important drivers behind the Drive4EU demonstration project she coordinates. The intention of this EU project is to optimise and upscale all steps in the chain, from upgrading and agronomy to extraction and processing, in order to make competitive production possible. 'The quality of this rubber is no longer an issue, because it was already demonstrated in a previous project (EU PEARLS). However, much can still be gained in the optimisation process. Through plant breeding, the consortium has already managed to increase the rubber percentage in the root of some varieties from 4% to 15%. In combination with improvements in the cultivation method, the biomass yield per hectare will also increase considerably. The rubber yield may eventually become 1,000 kg/ha.'

Before this becomes reality, the preceding crops will have to be improved upon year by year. Companies do have confidence in this: while the project schedule assumes 6 hectares of dandelion fields in 2016, it was adjusted to 80 hectares due to the large demand (and additional financing) from businesses.

## EXTRACTING VALUE FROM RESIDUAL FLOWS

Things are not moving as fast in the other product classes as for natural rubber, because there is less urgency and there are often alternatives. Thus drivers are not manifested in the economic field, but in the area of sustainability, whether consumer-driven or not. Martijntje Vollebregt, researcher at Wageningen UR Food & Biobased Research, also sees this in the Infinity public-private cooperative project she coordinates. 'Infinity has the objective of researching high-quality processing of vegetable residual flows into ingredients for food and functional or pharmaceutical applications. Approximately 13 percent of the primary vegetable production does not end up on the consumer's plate. A great deal is already being processed into fodder or goes into the biofermentation process, but you can also extract more value from the product residues by extracting specific components. A good example are carrots from which you can use the beta carotene as pigment and the fibres for veggie burgers or other products you want to give a certain texture to. You can extract flavonoids from onions, substances that allegedly have all kinds of positive effects on one's health. Plenty of opportunities. Together

with our project partners, we are researching how you can extract those substances on a large scale. Everything depends on the possibilities of extraction and how you can stabilise that extract and preserve it. Meanwhile, together with Infinity partner TOP BV, we have obtained good results with beta carotene from carrots on a laboratory and pilot scale. This could potentially result in construction of a plant that can process several of these residual flows, which would allow you to supply qualitative and economically competitive semi-finished products throughout the year. However, this is on the condition that the food-processing companies stick their necks out and are willing to go along with that development, in which case their sustainable image could be the stimulus required.'



## PIGMENTS

The food-processing industry has been using biobased pigments for years. The number of applications for pigments in other markets (using Rubia Natural Colours, which provides pigments for some applications, the best known of which is Desso carpets), however, can still be counted on one hand. According to Leon Joore, managing director of Millvision and valorisation manager at BioBased Delta, this corresponds with the higher requirements imposed on the stability and shelf life of the product in order to use it as paint or in colouring plastics, coatings, leather, textile, paper and cardboard, for example. Nevertheless, as the quartermaster of the Colour Application Centre (KIAC), he thinks that an initiative from the Centre of Expertise Biobased Economy provides sufficient opportunity for developing viable business cases by coordinating the consumers' product requirements with the providers of biobased raw materials. 'Research on practical issues such as extraction, stabilisation and formula development is being done at KIAC's Green Chemistry Campus. Companies can take their questions there. But we are going one step

beyond that in the Natural Pigment Valorisation Cluster, in which 20 companies are currently working together and can specify in concrete terms what they need: which dyes or pigments have to meet which requirements? By presenting these concrete questions to the providers and/or the researchers, we can convert a pigment into a formula much more efficiently, use it in a trial run in an application, or test it in practice as a demo. By doing so you can in turn inspire other companies.'

## SCALE

An additional effect of bringing providers and customers together is creating scale. 'Combining the requisite small volumes in the beginning can enable production at a certain industrial volume, which benefits the cost price.' At the end of the ride, products may cost a bit more, according to Joore. After all, they contribute to the sustainable, green image, for which customers are also prepared to pay more. This does have to go hand in hand with a certain functionality and preferably with a unique quality in comparison with an oil-based product, for example. 'I consider sustainability to be an important market driver, which suppliers can use to distinguish themselves by their processes and products. A biobased pigment is part of that.'

## CROP PROTECTION

Sustainability and social and legal pressure on the use of chemical agents also force the crop protection industry to shift towards biobased. Even though we hold a strong position in the Netherlands in the field of biological control, no applications are involved using vegetative ingredients, especially herbs. This still requires a great deal of research, without any immediate prospect of a commercial product. And that is also the immediate reason why the business community has invested little in this way of green crop protection to date.

According to Gert-Jan van Delft, lecturer/researcher at HAS, that also has to do with the complexity of the natural systems. 'A herb can contain as many as hundreds of different essential oils, each of which having a specific effect, that can reinforce one another. A great deal of research is required to find an agent in that complexity that works for a certain crop against a certain harmful organism or micro organism. We are doing this at HAS in cooperation with a growing number of companies and other knowledge institutions: interest is growing!'

# ‘EUROPE IS NOT THE LOST CONTINENT’

Europeans can be inclined to play down their strong points, unlike people from other continents. And it is no different in the development of the biobased economy. A number of international clusters have fortunately joined forces to build up sufficient critical mass in research and valorisation.

Text Lucien Joppen Image IAR, Biobased Delta



The Memorandum signing in January 2014.

Agro&Chemistry attended the Plant Based Summit, held in early April 2015 in Lille, northern France, and spoke with Willem Sederel (Biobased Delta) and Christophe Luguel (IAR) about the cooperation between the two clusters. Almost a year earlier, in January 2014, IAR and Biobased Delta signed a Memorandum of Understanding. This encompasses a three-year course in which the clusters will work together on various levels such as (research) data exchange, joint R&D processes, applications for European funding and participation in conferences and trade shows etcetera. Sederel declared at the time that the synergy between the two clusters would have an impact on the development of a healthy and prosperous bio economy in Europe. One year later, IAR and BBD share a stand at the prestigious conference/trade show Plant Based Summit. But surely more has happened than just that?

## Willem Sederel:

‘In a relatively short time, IAR and Biobased Delta have already cooperated in different settings. Shortly after the signing of the Memorandum, a Biobased Delta delegation visited the biobased trade show SINAL in Châlons-en-Champagne. It was encouraging and refreshing to see that the Dutch embassy had been highly active in drawing Dutch businesses to the SINAL. It turned out to be a productive visit for the companies that attended the trade show. It was not so much a matter of large numbers of visitors but more one of the quality of the contacts and exchange of ideas. New contacts were also made: businesses presented their experiences during other meetings, such as a French company which discussed a biobased substitute for phenol formaldehyde resins during a Biorizon workshop (about bio aromatics, eds.) at the EFIB in Reims.’

## Christophe Luguel:

‘Bio aromatics are a classic example of a domain in which IAR and Biobased Delta both operate. The two clusters have high expectations of bio aromatics and have accordingly set up research programmes based on various feed stocks. Synergies are obvious, since IAR was set up more from a primary sector angle in view of the economy in northern France, and BBD more with a chemical slant. Setting up an international cluster will definitely cost time and energy. Consider how much effort is involved in getting a national cluster off the ground, let alone a cross-border cluster. All the more so now that the clusters have also expanded their network to the United Kingdom

(BioVale) and Germany (Bio-economy Cluster Sachsen Anhalt).’

## Sederel:

‘These connections have put the development of a European bio economy more clearly on the radar of national governments and the European Commission. Various Directors-General, for instance of Regional Development and Research, have applauded further international cooperation. The concept is crystal-clear: too much fragmentation of research and valorisation will result in a lower economic and social impact. Nor is it wise for clusters to conduct research which is almost identical, or build expensive laboratories and pilot plants. It is much better in that case to share research data and facilities.’

## Luguel:

‘IAR and BBD - and for that matter, also the clusters - consider that research is directed at innovation. Research transforms money into knowledge; innovation converts this knowledge back into money. We should not let the idea that Europeans are more successful in the former activity frighten us off. Admittedly, other continents have made a better impression when it comes to flagship projects and commercial plants. Different factors contribute to this: access to sufficient biomass, the proximity of consumer markets, energy prices, human capital etcetera. But we should not underestimate ourselves on these parameters. Europe has a large and prosperous internal market, a fully-

‘THE CONCEPT IS CRYSTAL-CLEAR: TOO MUCH FRAGMENTATION OF RESEARCH AND VALORISATION WILL RESULT IN A LOWER ECONOMIC AND SOCIAL IMPACT. NOR IS IT WISE FOR CLUSTERS TO CONDUCT RESEARCH WHICH IS ALMOST IDENTICAL, OR BUILD EXPENSIVE LABORATORIES AND PILOT PLANTS. IT IS MUCH BETTER IN THAT CASE TO SHARE RESEARCH DATA AND FACILITIES.’

developed chemical sector, considerable volumes of biomass thanks to a well-developed agricultural/food and forestry sector, and strong public-private partnerships. Our various major deep sea ports also provide us with access to biomass from overseas.’

## Sederel:

‘Research projects have undergone a paradigm shift. Increasingly it is industry that takes the lead, so that the focus has shifted more and more from fundamental to applied research, with shorter time horizons and more emphasis on the end markets. It has to be admitted, however, that many business cases are not yet ‘flying’; this is due to the low oil prices, the competition with proven materials and chemicals and risk-avoiding behaviour of buyers. Biobased alternatives must offer equal or better performance than existing options. It takes time to prove this, because buyers do not want to take risks. Is Europe less adept at converting knowledge into money? Perhaps, but we will and must improve on that point. The ‘birth’ of the Biobased Industries Consortium and the intensive cooperation between businesses and research institutes, within and beyond the international clusters, will only speed up this learning curve. This evolution will eventually result in market successes in the form of flagship projects and industrial activities on European soil.’ ●

*This article was created in collaboration with Biobased Delta.*

# LACK OF KNOWLEDGE AND INFORMATION TRUMP



The way in which manufacturers position and market their (partially) biobased products depends largely on how their customers interpret biobased products and what they expect from them. However, the European Open Bio survey programme, carried out in six European countries, shows that many consumers are not yet familiar with the concept of biobased and do not know exactly what it implies.

Text Lucien Joppen Image Mars Effem

Marieke Meeusen, of the Dutch Agro-economical institute LEI, is involved in the survey. She was a speaker at a meeting before the summer holidays organised under the auspices of Biobased Delta. The findings from the survey showed that the term biobased is far from established, especially in the Netherlands. Meeusen: 'We held the survey in six EU countries over the course of 2015. Countries at the forefront of the EU in the area of environmental awareness: Denmark, the Czech Republic, Slovenia, Italy, Germany, and the Netherlands. Two things stand out: many consumers are not familiar with the biobased concept or do not know what it means. Consumers in these countries do generally have the same impression of and associations with biobased. These are posi-

tive associations, related to the environment. However, there are also other associations that are not related to biobased, such as animal welfare. The key: products/energy from renewable raw materials, read biomass, are rarely mentioned, however.'

### HALLMARK NOT YET AN OPTION

To put it briefly, biobased has yet to be established as a [marketing] term. Thus it still remains to be seen whether manufacturers should be using this in a B2C setting. Meeusen concurs with this. 'There is a big chance that it will only lead to confusion. A hallmark or label could be a solution. The research shows that people are more apt to choose biobased products with a label than biobased products without a label'

In any case, consumers will have to be educated in certain cases, such as those involving biodegradable packaging, on how they will have to deal with this. 'That's right,' says Meeusen. 'We showed the respondents a biobased shopping bag, and many of them thought they could simply throw it away in nature because it would be biodegradable.'

### EVERYTHING HAS TO BE RIGHT

No matter how manufacturers approach their customers, it will not be the one size fits all method. Depending on the product and the proposition, biobased products received different evaluations. 'Biobased bags are evaluated very differently than biobased products like clothing, paint, or a dashboard. That makes sense, as the functionalities or advantages to the consumer are also diverse. It also depends on the type of consumer. Some wouldn't object to a higher price or less functionality if the impact on the environment were lower. Other consumers are also willing to pay an additional amount, but for an equal or even better performance. These consumers do expect the entire story to hold up. All aspects of sustainability must be right: environmental and social aspects

as well as climate effects and waste. These consumers also expect all links in the chain of production to be up to par. As soon as certain things prove not to be right, the consumers' willingness to purchase declines.'

### GUT FEELING

The question is also: how large is the consumer population that is open to biobased products? In a previous survey in 2011, the LEI developed a consumer typology for the Dutch consumer, aimed at sustainable food. It turned out that about 33 percent are open to more sustainable food, for quite diverse reasons. A small group, 7 percent, a priori chooses sustainable food because of nature and animal welfare. The second group, 13 percent, chooses sustainable food, but with the condition that it is tasty and affordable. The third group, also 13 percent, makes a choice based more on gut feeling for sustainable food. It remains to be seen whether this typology can also be used for biobased packaging. However, it is a fact that if the environment is used as a sales argument, this classification can give marketers something to go on.

### DO PRIVATE LABEL BRANDS BENEFIT MORE FROM BIOBASED?

A test in which the respondents were presented with three brands showed that biobased can indeed have an effect on perception and subsequently the sales of a brand: Coca-Cola, a private brand cola, and Garnier shampoo. The above-mentioned brands are (in part) available in a biobased bottle. 'The respondents gave these brands a higher evaluation when we told them about the biobased packaging. The positive feelings and willingness to purchase increased while negative feelings declined. It was notable that the positive feelings related to the private brand cola brand increased more than those related to Coca-Cola. This could imply that supermarket retailers can make more money with a biobased packaging line.' In the interview with Gert-Jan Gruter of Avantium in this digital magazine, it already became clear that the product type also plays a role in this. Water brand Dasani [editor's note, from Coca-Cola] did benefit from the Plant Bottle as far as sales were concerned, but the bottle had little or no effect on the sales of cola (thus on the Coca-Cola brand itself). This may also have to do with the associations consumers make with biobased. The aspect of naturalness, the environment, etc., does apparently appeal more to the water drinkers than the cola drinkers among us. ●

*This article was created in collaboration with Biobased Delta.*



‘THE QUESTION IS ALSO: HOW LARGE IS THE CONSUMER POPULATION THAT IS OPEN TO BIOBASED PRODUCTS?’

Mars is currently in the process of testing in France and Germany for a few months. It entails assessment of the consumer responses to its new biobased wrapper, which it developed together with Rodenburg Biopolymers and Taghleef. Dennis van Eeten, on behalf of Mars: 'We are going to test the wrapper in the out-of-home channel only, considering the large share of single packs, the individually available bars. At two locations we are going to ask consumers the question: how does the wrapper feel? How does it look? What is the experience with the process, from purchase to throwing the wrapper out? We also want to know what their conception of biobased materials and biodegradability is as a possible function of biobased. We still have insufficient consumer data at this time, which is why we are very curious about the results.' Van Eeten answers the question concerning what happens if a country scores negatively as follows: 'The chance that it will then be a no-go is still very slight. Marts wants to continue, but we will first have to wait for the results.' Should the wrappers be rolled out on a broad basis, possibly also for the other brands in the Mars portfolio, the question remains: is Mars going to communicate with the consumer regarding this step? 'It is too nice not to do anything with it,' Van Eeten says. 'We are already brainstorming on possible slogans. But we do have to take care we are not selling hot air. At any rate we have not yet decided.' At the meeting, Van Eeten together with Thijs Rodenburg mainly discussed the development process of the foil on the basis of which the wrapper is produced. The above-mentioned test period also includes a further upscaling of the production.

The international EU survey programme **Open Bio**, which runs from 2013 through October 2016, is aimed at facilitating the market access of biobased products in the EU. The consortium does this, among other ways, through consumer research, examining end-of-life options, developing norms and standards, as well as communication guidelines.

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