
THE RAW MATERIALS CAN BE HARVESTED AGAIN AND AGAIN

Bioplastics on demand



The time has come for bioplastics. More and more companies are considering making their products out of plant-based plastics. Christiaan Bolck from Wageningen UR Food & Biobased Research helps them find the right formula.

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This morning, a furniture maker phoned to ask whether bioplastics could be used for the seat of a chair they were designing. Even though this is not a standard query and it is for a small-scale application, Christiaan Bolck is still prepared to consider the matter and discuss the options with the craftsman. But the Wageningen UR Food & Biobased Research programme manager's busy agenda is mostly taken up with potential assignments on a larger scale. One example is Océ in Venlo, now part of Canon, where they are working on frames made of bioplastics for photocopiers. Bolck is helping the chemicals company Croda in Gouda find ways to make bioplastics tougher so that they can withstand knocks and are suitable for use as car bumpers.

In collaboration with Synbra in Etten-Leur, a method has been developed to produce foam packaging based on vegetable sources.

WORKING OVERTIME

And Bolck could list plenty more examples. The labs on Wageningen campus are working overtime. Multinationals such as Braskem (Brazil) and Corbion (formerly Purac, Purac/CMS CSM) are regular clients. 'We can make pretty much anything here,' says Bolck. 'The challenge is to do so while keeping costs affordable, as we managed with the bioplastic foam. We are often able to develop a biobased product to replace a conventional product in less than a year, based on existing biopolymers. That includes arranging patents and testing prototypes on a commercial scale.' The companies, often from the SME segment, generally come to Wageningen UR wanting to know whether a specific finished product can be manufactured from biomass. 'Based on that request, we work with them to identify the product's features and then look for the appropriate biomass sources. We work directly for the private sector,' says Bolck.

He gets an espresso from a vending machine and proudly brandishes the coffee cup. 'It looks like ordinary plastic, and luckily it's just as heat resistant and not much more expensive. You can't tell, but the cup is actually made from sugar beet. Bacteria convert the sugars into lactic acid molecules that we string together to produce polylactic acid (PLA). And the great thing is that we can use sugar beet here in the Netherlands, but Brazil is better off using sugar cane, the United States has maize and in Thailand cassava is a good source of vegetable raw material for such coffee cups.'

OIL IS RUNNING OUT

The advantages of bioplastics are obvious: they do not have the problems associated with plastics based on petroleum. Whereas oil reserves are rapidly running out, the raw materials for bioplastics can be harvested afresh after each new growing season. As long as the biomass is of sustainable origin and not grown in places that used to be covered by rainforest, generating it is environmentally friendly, whereas oil extraction involves considerable damage to the environment plus the risk of accidents on drilling platforms and with oil tankers. >

PLASTIC FROM PLANTS

Traditional plastics, thermoplastic polymers, are made from oil. These polymers can also be manufactured from plant materials. The characteristics and applications of bio-plastics are just as varied as those of traditional plastics.

BREAKDOWN AND CONVERSION

Biomass

Biomass – such as sugar beets, sugar cane, cassava, maize as well as beet leaves, potato peel, tomato leaves and straw – contains natural polymers.



BIOREFINERY

Plant fibres

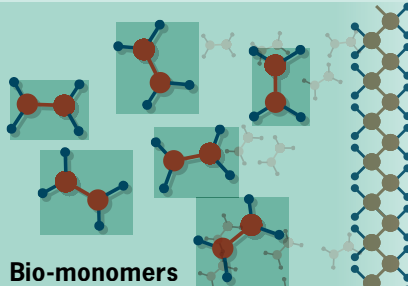
Some polymers present in plants can be extracted directly without breaking them down.



CONVERSION BY MICRO-ORGANISMS

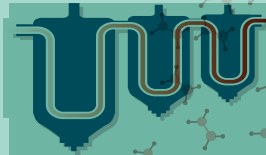
Green waste and sewer water

Micro-organisms can make polymers out of green waste and sewer water too.



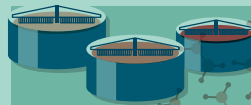
Bio-monomers

Natural polymers can be broken down and converted into bio-monomers, the basic building blocks for plastic, using enzymes, bacteria or traditional chemical processes.



Extraction

Using biorefinery (extraction and separation processes) natural polymers can be extracted directly from plant material.



Conversion

Fruit and vegetable waste or sewer water can be converted into fatty acids in the form of PHA (polyhydroxyalkanoate), and into other polymers.

Plastics

Bio-monomers can be used to make common traditional plastics such as polythene (PE), polystyrene (PS), polyethylene terephthalate (PET) and polyurethane (PUR), as well as polylactic acid (PLA), a biodegradable plastic.



Fibres

Tomato growers and Wageningen UR developed a tomato plant tray made entirely of tomato leaf fibres. Other examples of materials made by extraction are hemp and flax fibres.



PHAs and other polymers

PHAs can serve as the base for paint. One much-studied PHA has characteristics similar to those of polypropylene and polyethylene. An advantage of PHAs is that micro-organisms can break them down again.



Finally, the CO₂ emitted in the combustion of bioplastics after use is about the same as the amount of CO₂ fixed during growing. When oil is burned, CO₂ is released that was fixed long ago and this causes global warming.

Wageningen UR has been working on products based on vegetable sources for 25 years now. In the days of agricultural surpluses such as butter mountains and milk lakes, this research was mainly motivated by the desire to find new uses for agricultural products. Later on, the impetus was to reduce waste and toxic compounds, such as the plasticisers used in pvc. The focus shifted to climate problems at the turn of the century. In the last few years, biobased products have also been seen as a way of making efficient use of the available raw materials, thus enabling the needs of the growing and increasingly affluent global population to be met. Bolck says the rise of bioplastics does not have to be at the expense of farmland for food – a frequently heard objection to biobased products. ‘We get an increasing proportion of the basic raw material for bioplastics from the inedible or discarded parts of crops, such as stalks and husks. In addition, we can do more and more with agricultural residues, such as beet foliage, potato peelings, tomato leaves and straw.

Fruit and vegetable remains and even the organic residues in sewage can also be used as raw material for bioplastics.’

This means that the impact on land use is limited, says Bolck. If biomass (excluding biofuels) was to replace oil in all products made from petroleum in the petrochemicals industry, it would require less than 10 percent of the available farmland in Europe.

FREE PLASTIC BAGS

In short, bioplastics have great sustainable potential, which cannot be said for their fossil-fuel friends – plastics based on oil. Plastic packaging in particular has come to symbolize the ‘throw-away society’ in recent decades, with the free plastic bags for your purchases at supermarkets and in markets as the ultimate culprit. The European Commission wants to put an end to the uncontrolled consumption of plastics. Bolck keeps a close watch on the debates. Both the EU and the Dutch government consult him about biobased products, including bioplastics. For example, in an assignment for the Ministry of Economic Affairs, he concluded last spring that replacing conventional plastic carrier bags with bioplastic carrier bags was technically feasible.

He expects there to be far more bioplastic options available in the years to come.



CHRISTIAAN BOLCK,
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**‘The government should
introduce more incentives’**

‘A key factor is the price of oil,’ he says. Up to ten years ago, oil prices were 40 dollars per barrel. It was difficult for bioplastics to compete with that price, certainly given the state of the technology at that time. ‘I can still remember a study by LEI Wageningen UR in which they only included a scenario with an oil price of 70 dollars after quite some pressure,’ says Bolck. ‘And now oil prices have been consistently above 100 dollars per barrel for several years. At the moment there is a slight dip, but prices are bound to go up again.’ That high oil price is one reason for the increasing popularity of biobased materials among the international business community. Based on estimates by the German institute NOVA in Cologne, the current volume of production of biobased materials will increase threefold or fourfold by 2020. >

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WHAT DO CONSUMERS WANT?

At LEI Wageningen UR, Marieke Meeusen is investigating the acceptance of bioplastics. In the EU project Open Bio, she took six groups of 18 people from six different EU countries, including the Netherlands, and presented them with various biobased products, including a plastic bag, a patio tile, a T-shirt and paint. 'Consumers in all countries accept the biobased product if it is at least as good as and preferably better than the conventional product,' says Meeusen.

The 'entire message' also has to be right. 'Suppose a manufacturer claims that biopaint is healthier than ordinary paint. The subjects were inclined to accept this provided that the claim was made to seem plausible.' There are also negative 'frames'. 'If a bioplastic bag comes from China, consumers immediately associate that with child labour and have doubts about the product.'

Consumers are not necessarily prepared to pay more. 'It seems as if consumers will only pay more for bioplastics if the product is better too.'

LEI Wageningen UR is currently investigating that willingness to pay more and the degree of acceptance in a follow-up study. This will involve 1000 people in each country completing a questionnaire.

Figures for 2013 from the European bioplastics industry give production levels of 195 thousand tons of bioplastics per annum, about 3.4 percent of the total market of 57 million tons. But the industry says the market is growing by 20 to 30 percent per annum. The industry is expecting 10 percent of all packaging to be made from bioplastics by 2020. Car interiors (dashboards, seats, interior parts of car doors) could even consist of 40 percent bioplastics by that time.

SPOILING LESS QUICKLY

But oil prices are not the only factor. Bolck's ambition is to use bioplastics to create products that have superior properties to their fossil-fuel equivalents. 'Materials that are just a little bit lighter, for example, or

packaging for fruit and vegetables with improved gas permeability, so that apples and tomatoes don't spoil so quickly.' The Biobased Products business unit, part of Wageningen UR Food & Biobased Research, is also working on high-grade biopolymers such as polyamides made from natural oils. 'These materials are used "under the hood" because they have greater heat resistance than polyamides based on petroleum.' Sometimes a new biobased product will supersede an existing biobased product. Bolck: 'One example is the new technique we discovered together with Plant Research International Wageningen UR for extracting natural rubber from dandelions and the desert shrub guayule. This helps satisfy the demand for natural rubber, which has risen sharply.'

Investigations into a biopolymer can sometimes have interesting spinoffs. 'For instance, when we were developing the coffee cup, we discovered an additive that makes the bioplastic less pliable. That substance can also be used in conventional polystyrene coffee cups.'

SETTING A GOOD EXAMPLE

Now that bioplastics are an increasingly attractive option, Bolck feels that the government and NGOs should adopt a more positive attitude. 'The government could introduce more incentives, such as a lower VAT rate, to encourage businesses and consumers to opt for biobased products.' The government should also set a good example by purchasing bioplastic products or stipulating their use in public tenders for major projects such as motorway renovation.

And then there are NGOs that are not keen on biobased materials. 'It's right that questions are being asked, for example about where the biomass comes from or whether there is a risk of biomass competing with food,' says Bolck. 'However, NGOs that delve more deeply into the subject often conclude that many biomaterials are a step in the right direction. But good is not good enough for some NGOs. An attitude like that holds back progress in sustainability.'

An example is Coca-Cola's PlantBottle, says the researcher. The PET (polyethylene terephthalate) bottle is based partly on cane sugar. 'The NGOs said the bottle couldn't be called a "PlantBottle" because bioplastics only make up 30 percent; the rest comes from traditional petrochemicals.' He thinks taking Coca-Cola to task for this is not fair. 'The important thing is that Coca-Cola has taken this first step and is now collaborating with Danone and other PET users to persuade



**‘You don’t want
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breaking down your
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the whole production chain to use PET-like materials that are made entirely from biomass.’

ON THE COMPOST HEAP

What many consumers find confusing is that not all bioplastics are biodegradable. What is more, it is possible to make biodegradable plastics from petroleum. The wrapper around this magazine bears the text ‘7P0059 Compostable’, the code for what is known as a starch blend. ‘It is made from about 50 percent vegetable material and 50 percent petroleum that are both biodegradable. Wageningen World’s wrapper is certified in accordance with the European standard for compostable packaging material. The plastic can simply be thrown on the compost heap.’

But some other bioplastics are not biodegradable at all. And sometimes that is just as well, says Bolck. ‘You don’t want your car’s dashboard or bumper to be broken down by microorganisms. In the case of these products, we are actually working on making them less biodegradable.’ So it depends on the product whether it is made from bioplastic or petroleum-based plastic and whether it should be degradable or not.

However, all plastics can generally be reused for a while, by refilling them with soft drinks or reusing them for groceries. But that is inevitably followed by the waste disposal stage. ‘If bottles or bags are made from polyethylene and they end up in the plastics recycling process, it doesn’t make

any difference whether they were originally biobased or mineral,’ says Bolck. Neither is degradable and their properties are exactly the same. When they are sorted after the rubbish collection, they can easily be chopped up into granules, after which they can be melted as recycled material to produce bottles or bags.

So people who think bioplastics are a solution to the plastic debris threatening to clog up the world’s oceans are mistaken. Bolck says that both petroleum-based plastics and bioplastics should be put out for the rubbish collection and not be left as litter in the street or on the beach. ■

www.wageningenur.nl/en/bioplastics