The world's first bioplastic from sewage

The world's first PHA from sewage water has arrived. And, while sewage may not sound exactly like the most appealing source of bioplastic, this first kilo of sewage-based PHA represents a truly groundbreaking innovation. In a world first, PHA has been produced from bacteria that had first purified the wastewater treated at a full-scale wastewater treatment facility in Bath, located in the Dutch province of Zeeland, within the scope of an innovative project called PHARIO. The first kilo of PHA produced in this way was presented to Oerlemans Packaging director Joan Hanegraaf during a stakeholders conference hosted by the company in Genderen (NL).

Polyhydroxyalkanoates, or PHAs, are fully biodegradable plastics that, under normal conditions, will degrade within a relatively short period of time. PHAs are linear polyesters produced in nature by bacterial fermentation of sugar or lipids. They are made by bacteria to store carbon and energy, a function which in mammals is fulfilled by fat. These bioplastics are generating increasing interest, mainly because of their unique ability to biodegrade in water. As a result, the number of applications is starting to rise. However, the price of PHA has continued to be a major drawback: until now, the production of PHA has involved specially cultivated bacteria that fermented sugar, resulting in high production costs and, consequently, a reluctant market uptake.

The business case

The bacteria at wastewater treatment plants, however, also can produce PHA. Moreover, they are abundantly available. Could these bacteria offer an economically viable route to producing PHA biopolymers? Using the complex bacterial flora in a wastewater treatment plant, instead of a pure culture of PHA-producing bacteria would eliminate the need for special nutrient medium, as this would be provided by the wastewater. This would lead to lower production costs, and hopefully, lower market prices.

Three Dutch water boards and their partners decided it was worth putting to the test. This summer, they launched what is known as the PHARIO project, with the signing of the joint venture agreement at the wastewater treatment plant in Bath, located in the Dutch province of Zeeland.

The pilot project is a joint initiative of three Dutch water authorities Brabantse Delta, De Dommel and Wetterskip Fryslân, in collaboration with STOWA (Dutch Foundation for Applied Water Research), sludge treatment plant SNB, and two commercial parties, Veolia and KNN. Veolia Water Technologies is an international supplier of plants and services for communal and industrial wastewater treatment, and is participating in the project via its Swedish subsidiary

Wastewater treatment facility provides valuable feedstock for PHA production

At stakeholders event. Oerlemans Packaging director Joan Hanegraaf receives first kilo of sewage-based PHA

AnoxKaldnes that, together with KNN, is contributing specialist knowhow and technology for the production of PHA.

The partners in the project all contributed to the funding; in addition, the project was awarded a grant from the TKI Biobased Economy innovation program. The project is one of the most promising to come out of the *Green Deal* concluded in the Netherlands last year between the Dutch Water Authorities and the government.

Sewage sludge: a fertile feedstock source

The main purpose of a water treatment plant is to produce clean drinking water. However, this is a process that also yields various residual products, that together form a semi-solid slurry known as sludge. While part of the sludge is recycled, it is currently for the most part a waste product, which is pressed into sludge cakes and then burned.

This sludge, however, also contains the billions of bacteria that form part of the water purification process. These bacteria have gorged themselves on the organic waste in the water, consisting of carbohydrates, lipids and proteins, converting these into water, carbon dioxide and other non-toxic compounds. These are the bacteria that also produce PHA.

The challenge, however, is separating the PHA from the bacteria, without affecting the quality in any way. This is a step that requires sophisticated technology, and that therefore also influences the cost price of the material.

Successful production – on a small scale

Currently, this extraction step is carried out in Sweden at the pilot plant of Veolia subsidiary and project partner AnoxKaldnes. Veolia holds a number of patents for the technology used here. The Cella technology developed by AnoxKaldnes works by creating the best possible process conditions for increasing the presence of biopolymer-producing bacteria. The bioploymers are then harvested and further processed for industrial use. According to AnoxKaldnes, the processes "enable the recovery of value-added renewable resources including biopolymers, lipids, minerals, other platform chemicals and energy as by-products of process and wastewater management services. This is the future of traditional Environmental Engineering."

Importantly, the PHA produced using the technology is clean and hygienic. Measures must be taken to ensure the quality is consistent and stable in this respect. The current project is intended to demonstrate the possibilities and the quality of PHA which the technology offers. As Martin Tietema, Director KNN Bioplastic commented: "PHA bioplastic enables us to develop innovative and biodegradable products with which we can fundamentally revise the way our society uses plastics."

Value chains for PHA

The organizations behind the project organized the stakeholder meeting to show potential customers the first results of the project, which Hennie Roorda, member of the board of the Dutch Water Authorities called a "fundamental transition".

"This is the only way to describe the transition currently ongoing within the water authorities. By converting sewage into clean materials, sustainable energy and viable water, the water authorities are functioning as an important link in closing chains and cycles towards a sustainable society," she said.

Ultimately, the aim is to establish value chains for PHA. While current production capacity is small – a few kilos per week – the idea is to scale this up to include the total treated wastewater volume and ultimately resulting in a production capacity of 2,000 metric tons/year. To that end, investment – and the commitment of stakeholders – are required to make it possible to scale up the technology and create a market for the PHA produced. This first batch shows the potential of the technology – and that it works.

"Having successfully achieved continuous production of biopolymers from wastewater means that the PHARIO project has taken a big step towards a circular economy and resourcing the world", said Jacob Bruus, Executive Vice President Veolia Water Technologies, Sweden. "The results show that there is an alternative to plastics based on fossil fuels and that a solution to the plastics polluting our oceans lies within reach." **KL**

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