Interreg North-West Europe WOW!

EUROPEAN UNION

European Regional Development Fund

PHA PILOT

FROM PRIMARY SEWAGE SLUDGE TO BIOPLASTIC PHA

PRODUCTION, EXTRACTION AND PROCESSING

BIOPLASTIC (PHA) FROM SEWAGE

Sewage contains valuable substances that can be used as raw materials for biobased products. One of these options is the production of PHA. For this the primary sludge of a sewage treatment plant is used. PHA is production is a bio-chemical process that consists of four main steps:

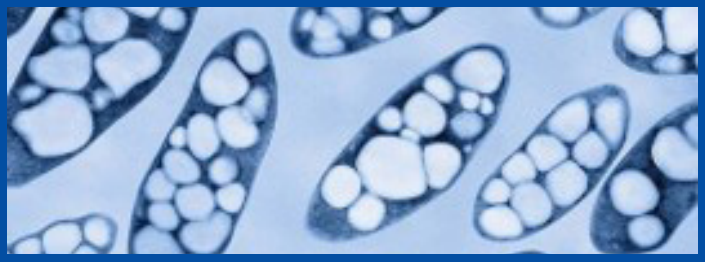
1. Acidification of primary sludge to produce a VFA-rich stream.
2. Enrichment and production of a mixed microbial culture (MMC) with a high PHA-storing capacity.
3. PHA accumulation using the MMC produced in the previous step and a feed with easily degradable organics mainly volatile fatty acids (VFAs).
4. Recovery of PHA from the PHA-rich MMC of step 2 by means of solvent extraction.

Next the PHA is compounded and processed to an end product such as plant pots or agricultural foil.

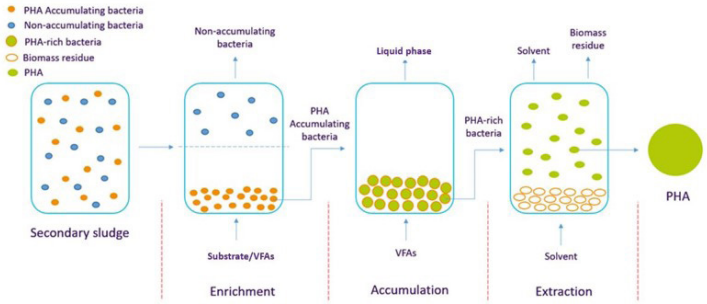
WHAT IS PHA?

Polyhydroxyalkanoates (PHA) are polyesters produced in nature by numerous bacteria. PHA serves as a source of energy and carbon storage for these bacteria.

PHA is composed of a combination of different monomers. Since there are more than 150 different monomers there is a wide range of different PHAs with different properties.



PHA PRODUCTION



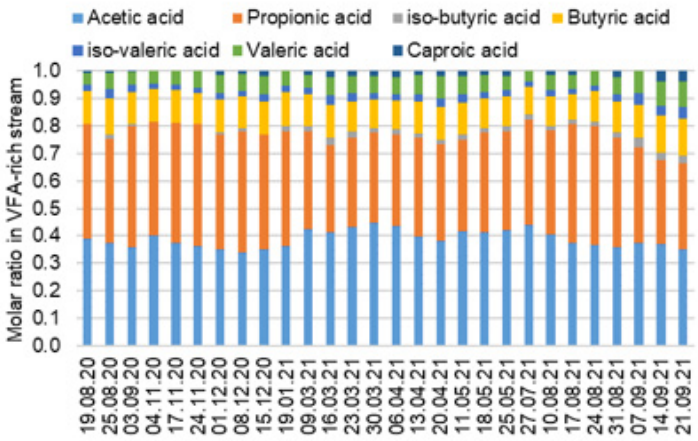
With the VFA-rich stream from the acidified primary sludge,PHA-contents of about 30 % of cell dry weight were achieved. In single batches even higher PHA contents were achieved.

The pilot-scale operation pointed out the weak points of the process and made it possible to develop strategies for up-scaling.

An all seasonal PHA production process is technically feasible.

PHA PILOT

Acidification of the primary sludge led to the production of 7 different VFAs with an average VFA-ratio of 45-55% (± 3%, C-molar-basis) during all seasons. The VFA ratio determines the composition and thereby the properties of the PHA that is produced. The observed stable VFA-ratio therefore suggests that primary sludge is a suitable raw material to produce PHA with stable PHA-properties. This was confirmed by an average HB/HV-ratio of all PHA-accumulation batches of 47 – 53% (± 7 %).



PHA EXTRACTION

The extraction of PHA from the PHA rich bacterial biomass is done by solubilizing the intracellular PHA using a solvent. This is followed by separation of the PHA and the extracted residual biomass and isolation of PHA from the solvent. Avans university of Applied Sciences developed a method for the extraction that uses dimethyl carbonate (DMC) as a solvent. DMC is considered to be a green solvent compared to the often used halogenated solvents such as dichloromethane. The method also allows re-use of DMC after extraction.

The extraction with DMC resulted in a PHA film with a purity of around 91%. This is much higher than with chloroform and dichloromethane as solvents and resulted in a much more elastic and less brittle PHA film. The PHA yield of extraction with DMC was a bit lower compared to chloroform and dichloromethane.

Together with the project PHA2USE, a pilot scale extraction of around 70 kg PHA rich biomass was performed with a PHA content of around 29%. The recovered PHA was 18 kg indicating that around 81-88% of the total PHA was extracted. The recovered PHA was used for further processing.

PHA PROCESSING

The extracted PHA was characterized by Natureplast and also 3 formulations were developed. Two formulations were developed with the aim to soften a commercial grade of PHBV that is rigid and brittle. The other formulation had the objective to adapt PHA to make it suitable for extrusion processes.

The results show that the PHA produced has very interesting properties. It's a soft PHA that does not exist on the market today. The PHA could be a solution for applications where a soft polymer is needed. Furthermore, it could be use with other more rigid biodegradable polymers (PLA, PHA, etc.) as a softening agent with the advantage of keeping the biodegradability of the material.

The PHA was easy to process although further optimization on the parameters is needed. The material has a low MFI which corresponds to an extrusion grade. With some work on the formulation, the PHA could be used on films or in blowing applications.

CONCLUSIONS

WOW! has shown that it is possible to produce PHA from primary sludge on a pilot scale. The PHA that was extracted (together with PHA2USE) has properties that could make it interesting for several applications such as usage as a softening agent for other biodegradable polymers.

On the road to fullscale PHA production additional research is needed on the stability of PHA production (quality and quantity), upscaling of the green extraction method with DMC and processing of PHA towards (prototype) products.

MORE INFORMATION

Download the complete report
Contact Jappe de Best jh.debest@avans.nl