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Microbial Community Engineering for Polyhydroxyalkanoate production from wastewater

Robbert Kleerebezem,
Delft University of Technology, Department of Biotechnology, Julianalaan 67, Delft, The Netherlands.
r.kleerebezem@tudelft.nl

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Polyhydroxyalkanoates (PHA) are biodegradable plastics without properties comparable to petrochemical plastics that can be produced by a wide range of microorganisms. Currently PHAs are produced using a process based on traditional biotechnology using corn based glucose as feedstock and pure cultures of (genetically modified) bacteria. An alternative approach for PHA production is based on Microbial Community Engineering (MCE) and aims for the creation of a selective environment that enables the enrichment of superior PHA producing bacteria from a natural inoculum. This approach aims for the use of low-value wastewater rich in volatile fatty acids as feedstock.

Until recently, a comparison of both PHA production methodologies was complicated by the pros and cons of both approaches. Mixed culture based PHA production was characterized by the lower processing costs and cheaper substrates, but also by a lower cellular PHA content and therefore more complex down-stream processing. This latter point limited practical implementation of the waste based PHA production process, whereas the pure culture process has been implemented on various places. Recently, however, it has been shown that by optimizing the culture selection procedure, a mixed culture process can be established that is capable of generating equal cellular PHA contents as pure culture based processes. Herewith the main disadvantage of the mixed culture PHA process is eliminated and the second generation of mixed culture PHA production awaited demonstration at pilot or full scale.

However, when eliminating one bottleneck from a process development scheme, others arise. For MCE based PHA production the main bottleneck seems to be the effective utilization of the PHA produced. Waste based production processes for production of chemicals have a bad reputation for the added value of the product generated. For PHA it seems that downstream processing and some specific polymer properties limit its current applicability. This opens up the need for alternative processing methods for PHA, like the production of biofuels or chemical building blocks.

Another potential bottleneck is the economy of scale of the MCE based PHA production process. Wastewater is not generated in a scalable amount and for economically attractive large scale polymer production, large quantities of suitable wastes are required. These will normally not be available at one industrial facility. This suggests the need for a separation of local upstream biological PHA production and harvesting of the PHA containing biomass, and centralized downstream processing.

In the past years we have been working on these different aspects of PHA production from wastewater as a resource recovery process. A research and development program has been established on the overall value chain of PHA production from wastewater, including the bioprocess for PHA production at pilot scale, downstream processing, product utilization, and overall life cycle assessment. Results of this research program involving a number of universities and companies will be presented.