Cost-Efficient Polyhydroxyalkanoate (PHA) Production by Selection of Inexpensive Carbon Feed Stocks

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Abstract

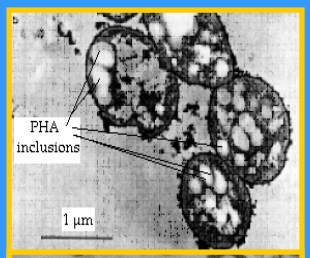
Cost efficiency in biopolymer production is mainly determined by the price for required raw materials; they contribute with up to 50% to the expenses of the entire process. Recent studies underline that PHA production from pure substrates can be considered as optimized to a high degree. Hence it is important to enhance economics of biopolymer production by substituting pure substrates by cheaper carbon sources or by integrating PHA production into energetically autarkic production lines of the carbon source. The research of the authors of this study that is carried out in narrow cooperation with industrial partners provides novel insights into the enhancement of cost-efficient PHA production.

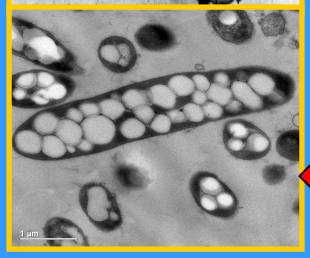
Industrial plant for PHA production

(here: PHBISA, Brazil)

Downstreaming Processing & Product Refining

Solution strategies

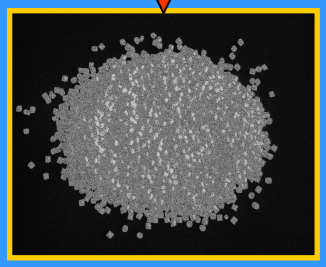




Production strain

Research on laboratory scale

Scale up



Whey lactose from dairy industry

Raw glycerol phase (GLP) from biodiesel production

Cane sugar (PHA production integrated into saccharose- and Bioethanol production)

Cheap Carbon source

Granulated PHA for processing

Vendible, compostable biopolastic items

(Sinterack, ETH Zürich)

Whey, a surplus product from dairy industry

The utilization of surplus whey combines an economic benefit with solving an ecological hazard. Whey lactose was applied as carbon source for several wild type PHA producers. Among the investigated strains, *Haloferax mediterranei* constitutes the most promising candidate for whey-based PHA production due to its high robustness and genetic stability. The high salt demand for growth reduces the risk of microbial contamination, thus saving a lot of energy for sterility precautions. The strain grows on whey with a max. specific growth rate $\mu_{max.}$ of 0.11 h^{-1}. PHA was accumulated at a max. specific production rate of 0.08 g/g h. The conversion yield for whey to PHA amounted to 0.3 g/g. The production of PHA copolyesters without cosubstrates, the excellent polymer characteristics together with a cheap isolation method make the strain of special interest [1,2,3].

Raw glycerol liquid phase from Biodiesel production

H. mediterranei was also used for PHA-production on glycerol liquid phase (GLP), a side stream of the biodiesel production from plant oils and tallow, containing about 70 wt.-% glycerol. In all Europe, the total production of biodiesel is estimated for 2008 with 2,649.000 metric tons. GLP nowadays constitutes a surplus material. Its utilization as substrate leads to an enormous cost reduction compared with commercially available pure glycerol, possessing a market value of 900 € per metric ton (year 2002). *H. mediterranei* was able to grow on GLP at a specific growth rate of 0,06 h^{-1} and produced PHA (76% of cell mass) at a specific rate of 0,08 g/g·h. At a final concentration of 16,2 g/L PHA, the yield for PHA from glycerol was calculated with 0,23 g/g, [1,2,3].

Sugar cane sucrose: Integrated process towards Sugar, Bioethanol, Energy and PHA

An alternative approach is found by the utilization of carbon sources possessing a considerable market value and therefore do not constitute waste materials, but are produced within a process integrating the fabrication of the carbon substrate and PHA. This will soon be realized in the south-central region of Brazil: starting from sugar cane, saccharose, ethanol and PHB are produced by *Wautersia eutropha*. The required energy for polymer production is directly available from burning bagasse, a major by product of the sugar production. Due to the autarkic energy supply and the at-house availability of the carbon source saccharose, the production costs per kilogram PHB are expected to drop below US$ 3 [3, 4].

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References

[1] M. Koller et al., Macromol. Biosci. 15(6), 218 (2007).

[2] M. Koller et al., Biomacromol. 23(5), 561 (2005)
[3] M. Koller et al.,article in press
[4] R. Nonato et al., Appl. Microbiol. Biotechnol.57, 1 (2001)