Polyhydroxyalkanoate (PHA) biosynthesis from whey lactose

M. Koller, P. Hesse, A. Atlić, C. Hermann-Krauss, C. Kutschera and G. Braunegg

Graz University of Technology; Inst. of Biotechnology & Biochemical Engineering, Petersgasse 12, A-8010 Graz, Austria

The increasing demand for polymeric compounds acting as packaging materials for the safe distribution of goods is undisputed. Contemporary strategies for disposing of end-of-pipe plastics cause serious global problems such as increasing piles of waste. Incineration of petrol-based polymers not only generates noxious compounds, but also elevates the atmospheric CO_2 concentration. This aggravates frequently discussed problems such as greenhouse effect and global warming. Recycling systems do not function as effectively as required for a real solution of the problem.

Although data for remaining amounts of mineral oil are changing quickly due to advanced methods for tracing and discharging, the reserves of fossil feed stocks are limited. In May 2005, the price per barrel of mineral oil amounted to US-$ 55; recently, this value has rocketed up to US-$ 74 (July 2007).

Utilizing alternative polymeric materials such as polyhydroxyalkanoates (PHAs) unites two major advantages: Firstly, they can be produced from renewable resources such as carbohydrates, making them independent from the availability of fossil feed stocks. Secondly, when being composted, these biopolymers undergo a biodegradation process by the action of various microbes resulting merely in CO_2 and H_2O, the starting materials for the photosynthetic regeneration of carbohydrates by green plants. Thus, the mass stream for carbon in the biotechnological production lines for PHAs is embedded into a closed circle. This is clearly in contrast to the life cycle of classic polymers, where carbon fixed in the bowels of earth since millions of years is converted to CO_2 which is released in the atmosphere.

Because recent studies point out that PHA production from purified sugars has been optimized to a high degree, further improvement of the fermentation technologies by using cheaper carbon sources as basis feed stocks is urgently needed.The work at hand studies the utilization of whey, the major by-product from cheese and casein production, as feed stock for the biotechnological production of PHA. Whey is not only a cheap raw material, but 13500000 tons of whey per year which contain 620000 tons of lactose (*D*-gluco-pyranose-4-β-*D*-galactopyranoside) constitutes a surplus product in the EU, causing a huge disposal problem for the dairy industry. Hence, the utilization of whey lactose for PHA production unites the diminishing of a waste problem and the increase of cost-efficiency in the bioinspired production of ecologically benign materials.

The work at hand presents and compares kinetic data and polymer characteristics for three different microbial strains that turned out to be capable of PHA accumulation from whey lactose (the eubacterial species *Pseudomonas hydrogenovora* and *Hydrogenophaga pseudoflava* as well as *Haloferax mediterranei*). Advantages and drawbacks of the organisms as potential PHA producers from whey on industrial scale are compared. The industrial significance of the study is underlined by economic appraisals for the investigated processes.

Keywords: Biodegradable polymers; Renewable resources; polyhydroxyalkanoates; whey

[1] G. Braunegg et al., *Polym. Plast. Technol.Eng.* **43**(6), 1779 (2004)
[2] M. Koller et al., *Biomacromol.* **23**(5), 561 (2005)
[3] M. Koller et al., *Bioproc. Biosyst. Eng*. **29**(5-6), 367 (2006)
[4] M. Koller et al., *Macromol. Biosci*. **15**(6), 218 (2007).