PRODUCTION OF POLYHYDROXYALKANOATES FROM PALM OIL MILL EFFLUENT

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Introduction

Polyhydroxyalkanoates (PHA), accumulated in microbial cells as carbon and energy reserve materials, possess characteristics similar to conventional plastics. However, these bacterial plastics are biodegradable upon disposal in the environment – hence they are also referred to as biodegradable plastics or simply as bioplastics. Unfortunately, the cost of producing PHA is currently more than five times that of normal petrochemical-based plastics, which limits their widespread usage. The high cost is mainly due to the cost of raw materials and extraction/recovery of the PHA from the bacterial cells. Our strategy to reduce the overall production cost of PHA is by coupling its production with wastewater treatment. In our previous work, we have shown that palm oil mill effluent (POME) could be subjected to partial anaerobic treatment to yield organic acids (Hassan et al. 1996). The objective of this work was to produce PHA from POME through the organic acids route.

Materials and Methods

POME was first converted anaerobically to organic acids by palm oil sludge and later the acids were converted to PHA by a photosynthetic bacterium. In the first step, POME was added to an equal amount of sludge and treated anaerobically at pH 6.5 with mild mixing. Samples were taken daily and analysed for individual organic acids and residual ammonium content. The treatment was terminated when the total organic acids were maximum. The mixture was then sedimented by hydroxide precipitation, and the supernatant was used as the substrate for the PHA-producing bacterium in the second step. A glass photo-bioreactor was used. Lighting was provided and the temperature was controlled at 30°C. After an initial batch operation, continuous fermentation was carried out at different retention times until steady state was achieved. Organic acids and PHA were detected by HPLC and cell weight was measured by the oven method. Commercially available test kits detected ammonium and phosphate.

Results and Discussion

During anaerobic treatment of POME at pH 6.5, about 12-15 g/L organic acids could be produced. The main organic acids were acetic and propionic acids. Results showed that no PHA was produced when anaerobically treated POME containing sludge particles was used. This could be due to poor light penetration, whereby the photosynthetic bacteria would be deprived of the energy source required for growth. When the sludge particles were removed, PHA could be continuously produced from the organic acids obtained in the first step. At 14 days retention time, the total cell concentration reached 3 g/L, with more than 1 g/L of PHA at steady state. When the retention time was increased to 40 days, more than 2 g/L of PHA was produced, corresponding to more than 60% of dry cell weight. The effect of C/N was also important. When the C/N ratio was increased from 12 to 32, the cell PHA content increased from 30% to 60%. It was also observed that appropriate nitrogen and phosphate concentrations were necessary for optimal cell growth and PHA concentration.

Conclusions

The results of this study showed that PHA could be produced from POME through the organic acids route.

References

Hassan, M.A., Shirai, Y., Kusubayashi, N., Abdul Karim, M.I., Nakanishi, K. and Hashimoto, K. 1996. Effect of organic acid profiles during anaerobic treatment of palm oil mill effluent on the production of polyhydroxyalkanoates by *Rhodobacter sphaeroides*. *J. Ferment. Bioeng.* 82(2): 151-156.

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