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Polyhydroxyalkanoate production from fermented volatile fatty acids: Effect of pH and feeding regimes

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HIGHLIGHTS

- Mixture of sludge and food waste were fermented to obtain VFAs.
- VFA production and VFAs/SCOD ratio was the highest at an initial pH of 9.0.
- The fermentation liquid at pH 9.0 was a suitable carbon source for PHA biosynthesis.
- Continuous pulsed feeding had the highest PHA synthesis rate of 64.5%.

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ABSTRACT

The combined fermentation of sludge from the secondary sedimentation tank of municipal wastewater treatment plants and food waste enables not only waste reduction, but also the acquisition of volatile fatty acids (VFAs) for the biosynthesis of polyhydroxyalkanoates (PHAs). To better understand variables influencing the production of VFAs and PHAs, this study considered anaerobic fermentation of VFAs under different pH conditions. The production of VFA was the highest at an initial pH of 9.0, reaching 25,934 ± 1,485 mg COD/L and a VFAs/SCOD ratio of 0.61 ± 0.04. When the fermentation liquid was used as a carbon source for PHA biosynthesis, continuous pulsed feeding resulted in the highest PHA synthesis rate of 64.5 ± 1.8%, while the culture receiving a one-time feeding had the lowest rate of only 51.5 ± 2.0%.

1. Introduction

Food processing and consumption produce large amounts of food waste, which has become the main constituent of municipal solid waste (Salhofer et al., 2008). At the same time, sewage treatment plants produce large amounts of sludge that require disposal. Zhu et al. (2008) studied biological hydrogen production and found that co-digestion of food waste and sludge generates larger amounts of volatile fatty acids (VFAs) than fermentation of food waste alone. Feng et al. (2009) showed that adding food waste to sludge and controlling the ratio of C/N in a mixed fermentation system may change fermentation pathways and influence the components of the VFAs. Co-digestion of 88% food waste with sludge led to maximum VFAs production that was much greater than that from sludge alone (Chen and Wu, 2010).

The VFAs produced from waste sludge may serve as a carbon source for the biosynthesis of polyhydroxyalkanoates (PHAs) (Cai et al., 2009; Morgan-Sagastume et al., 2010) that can be used to produce substitutes for petroleum-based plastics (Bengtsson et al., 2008). Factors affecting the biosynthesis of PHAs include feeding regimes (Hafuka et al., 2011; Jiang et al., 2009; Albuquerque et al., 2011; Yan et al., 2008), pH (Qu and Liu, 2009; Villano et al., 2010), C/N and C/P ratios (Johnson et al., 2010; Wen et al., 2010), as well as temperature (Krishna et al., 1999). Jiang et al. (2009) used fermentation liquid from waste sludge as a carbon source for the biosynthesis of PHAs under different feeding regimes and found that the synthesis rate of PHAs with a three-time feeding pattern was higher than that with a one-time feeding. The production of PHA was also higher when the supernatant was drawn off before each feeding cycle.

In the present study, co-fermentation of food waste and sludge for the production of VFAs was evaluated under different pH conditions. The VFAs were used as carbon source for PHA biosynthesis using a PHA-producing mixed culture selected from activated sludge. The feeding regimes of the fermentation liquid containing VFAs were compared with respect to their PHA productivities to identify the most effective feeding practice.

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