Potato Waste treatment by Two Chamber Microbial Fuel Cell
- Effects of particle sizes on its removal and electricity generation -

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1. Introduction

Vegetable waste has the potential to generate energy for its high organic composition and easily biodegradable nature. It is characterized by a high percentage of moisture (>80%), high organic content (>95% of total solids) (Jiang et al., 2012). Microbial fuel cell (MFC) as a promising anaerobic waste treatment device, which uses bacteria as catalyst, has been developed for effective bioelectricity generation from diverse organic waste (Feng et al, 2008; Min et al., 2005; Zuo., 2006). A number of studies have shown that electrochemically active microorganisms can utilize volatile fatty acids (VFAs) from food fermentation as carbon sources for current generation in MFC (Chio et al., 2011; Freguia et al., 2010; Li et al., 2013; Mohanakrishna et al., 2010). Power generation through stabilization of fruit based waste (Mohan et al., 2009), food process waste (Cui et al., 2011; Bibiana et al., 2010; Goud et al., 2011) and rice mill wastewater (Behera et al., 2010) was reported in MFC. Rikame et al. (2012) found that the performance of dual chambered MFC, induced with acidogenic food waste leachate as substrate, was affected by the resistance due to membrane fouling, and high substrate concentration caused the decrease of power output and COD removal efficiency. However, the particle size impact of solid waste has not been investigated. This study used six fractions of potato waste classified based on sizes as substrate in the anode chamber of MFC for investigation of the effects of potato sizes on its removal and electricity generation. For this purpose, the changes of voltage output, dissolved organic carbon (DOC) and total and dissolved COD were measured, and the concentrations of organic acids and the population structure of bacteria in MFC were analyzed.

2. Material and Methods

MFCs with two chambers, having a size of 240 cm^3 for each chamber, were assembled and fixed with carbon felt electrodes (6.0 cm×4.0 cm×0.5 cm). Two chambers were separated by cation exchange membranes (CEM, Zhejiang Qianqiu Group Co., Ltd. China). The anode and cathode felts were connected to a data acquisition unit (midi LOGGER GL200A, Graphtec Corporation, Japan), which records the voltage (measured as the voltage difference between two electrodes) of MFC every minute, using an external resistor of 100 **Ω**. The anode chambers of six MFCs, which had been operated with acetate acid for a mouth, were added with potato divided based on sizes into six different fractions: a liquid fraction with sizes below 0.5μm, five particle fractions with sizes <0.5, 1, 3, 5 and 7 mm. Bacteria were obtained from a wastewater treatment plant in Japan. All MFCs were operated at a controlled temperature of 30 ^{o}C. 0.5 mL of liquid sample in each anode chamber and 3 mL of sample in each cathode chamber of MFCs were taken and filtered using 0.2 μm membrane filter for DOC determination. In the anode chamber, 0.5 mL of two parallel samples were taken from the solution for COD determination, with one of them being filtered using 0.2 μm membrane filter for dissolved COD analysis. After running for about 4 months, from each anode chamber, 10 mL of sample was taken for bacterial analysis using PCR-DGGE.

3. Results and Discussion

Organic matter removal

There has no clear difference of COD change when sample was filtered (Fig. 1). Liquid has higher COD accumulation than other solid potato wastes. Compared to particle size of < 0.5 mm and 1 mm which has a direct decrease of COD, other particle size of potato wastes have a slight increase of COD at first 20 days and then gradually decrease. COD increase trend become gradual with increase of particle size. Anaerobic condition is most suitable for food waste treatment (Jia et al., 2013), then it is a reasonable option for decomposing of potato waste. COD difference between sample with filtration and that without filtration is very little due to high content of organic matter of potato waste (Jiang et al., 2012).

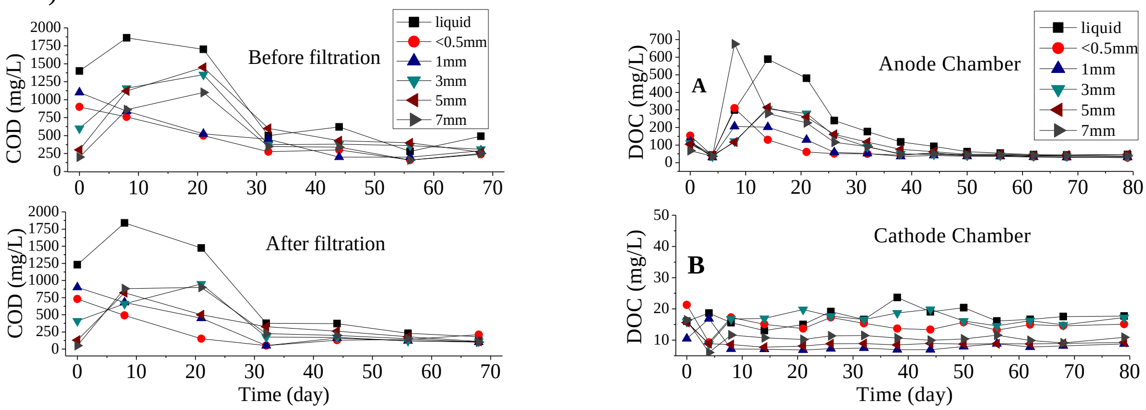

Fig. 1 COD degradation in MFCs with or without filtration

Fig. 2 Degradation of DOC at different particle sizes

Involvement of cathode chamber in organic matter removal

Samples were taken from the two chambers respectively and filtered using 0.2 μm membrane filters for DOC determination. In the anode chamber, DOC decreased to the lowest level after 4 days due to rapid metabolism of bacteria. DOC increased during the time length of 8-14 days and then gradually decreased (Fig. 2A). The increasing extent was smaller for the potato fractions with larger sizes. But when the size of increased to 7 mm, the accumulation has an obvious increase, suggesting that large particle size is more suitable for decomposing of potato waste. DOC in cathode chamber always keeps within a stable range of 0-25 mg/L (Fig. 2B), indicating that the cation exchange membrane between anode and cathode chamber has good selectivity.

Comparison of Electrical output in MFCs

The power output of MFCs with different particle sizes of potato wastes were determined (Fig. 3). All three MFCs demonstrated a remarkable increase on electricity production from the beginning. Different particle size of Potato waste has less effect on the electrical output, while the largest particle size shows better stability of electricity generation. All MFCs maintained a stable electricity production for 30-40 days. The highest voltage output reaches up to 100-140 mV.

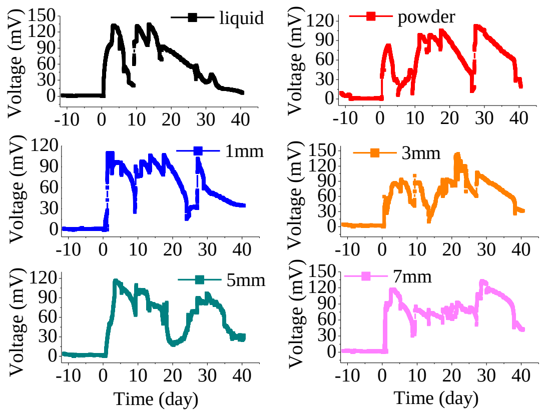

Fig. 3 Electrical output of MFCs with different particle sizes

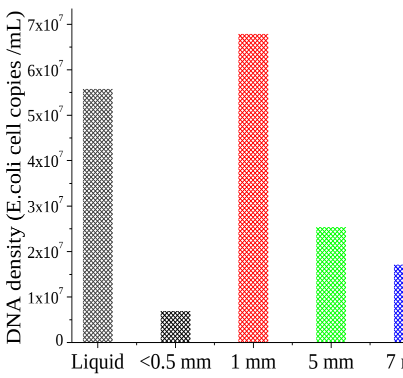

Fig. 4 The quantity of bacteria in anode chamber of MFCs

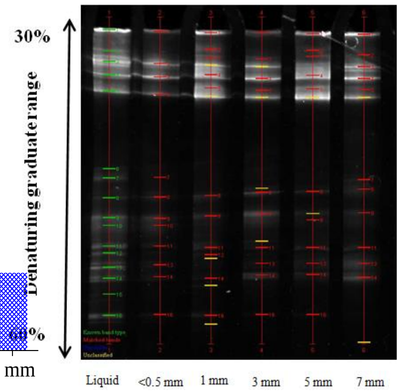

Fig. 5 DGGE profile of 16 rDNA amplified using DNA extracted from anode chamber of MFCs

Microbial Community Structure and Quantity of Anode biofilm

Bacteria composition in anode chamber of MFCs of analyzed using Real-Time PCR (Fig. 3). The MFC with particle size of 1mm has highest quantity of bacteria. There has a decrease of bacteria quantity with increase of particle size when it high than 1mm. MFC with particle size of < 0.5 mm has the lowest quantity of bacteria but MFC with liquid of potato waste has relatively high content of it. The bacterial composition was analyzed by PCR-DGGE using DNA extracted from anode chamber of MFCs (Fig. 4). A total of 16 bright bands were detected in the DGGE gel of MFC with liquid of potato waste. Most of these bands were also found existed in other MFCs with different particle sizes of potato wastes, suggesting that there has high similarity for the populations of microbes in all MFCs.

4. Conclusion

Bacteria composition in anode chamber of MFCs was analyzed using Real-Time PCR (Fig. 3). The MFC with particle size of 1mm has highest quantity of bacteria. There has a decrease of bacteria quantity with increase of particle size when it high than 1mm. While MFC with particle size of < 0.5 mm has the lowest quantity of bacteria and MFC with liquid of potato waste has relatively high content of it. The bacterial composition was analyzed by PCR-DGGE using DNA extracted from anode chamber of MFCs (Fig. 4). A total of 16 bright bands were detected in the DGGE gel of MFC with liquid of potato waste. Most of these bands were also found existed in other MFCs with different particle sizes of potato wastes, suggesting that there has high similarity for the populations of microbes in all MFCs.

5. References

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