Abstract

The disposal of food waste (FW) has become a social problem in recent years, and consequently, food recycling methods have gained more attention. Methane fermentation has a number of benefits for food recycling as a treatment technology, including greenhouse gas and odor reduction, increased nutrient availability, and reduced pathogen risk. Many recycling projects are based on anaerobic digestion, and many FW pretreatment methods have been explored in order to improve digestion performance. In preliminary research, ethanol fermentation pretreatment (EP) improve the performance of biogas fermentation in many aspects. Such as increased the buffering capacity of the methane fermentation system, while improves methane concentration in biogas, etc. However, previous research were only reported in short-term studies such as batch experiments. Thus, it is necessary to understand the characteristics of the process under continuous operation in a stable state to discuss the feasibility of its use in practical facilities, which are usually operated through continuous feeding. Therefore, all series of biomethanation in this study was examined by sequential batch experiment. In the Chapter 2, artificial food waste (AWF) which was saccharized and ethanol fermented without any evaporation of ethanol was fed to methane fermentation reactor for 130 days. It was compared with a control experiment without pretreatment. In the Chapter 3, combining the conclusions and shortcomings of Chapter 2, anaerobic membrane bioreactor (AnMBR) system was tried. This chapter examined whether AnMBR is effective as a practical form of EP. In Chapter 4, high-load operation examined by the EP system using AnMBR was tried. To make clear effectiveness principle of EP for methane fermentation, it was discussed on the thermodynamics, pathway (accumulation of

intermediate), stoichiometry bacterial and archaeal community. A summary of each chapter is as follows.

In Chapter 2, methane yields of the control (without pretreatment) and EP series were 420 and 460 mL/g (10%pt improved) of the added volatile solids (VS), respectively. The methane content were 53% and 68% (10% higher), respectively. Sludge yield of VSS were 0.082 and 0.014 g-sludge/g-added (reduced to one-fifth), and 87% and 94% for VS biodegradability (7%pt improved), respectively. The results of the methane concentration in biogas increasing by about 15% followed stoichiometry. The Gibbs free energy for ethanol degradation could explain lower sludge yield in EP series than that of the control. However, lower sludge yield means difficulties of keeping biomass in the reactor. A wash out bacteria also occurs when the processing load is increased by raising the feed volume, thus limiting the treatment of higher loads. Treatments utilizing the traditional methodology can only operate on a long hydraulic retention time (HRT). Practical method to extend the solid retention time (SRT) is needed under the shorter the HRT conditions.

In Chapter 3, Due to using of AnMBRs, to maintain efficient operation. AnMBR effectively prevent the washout of these slow growing anaerobic bacteria, enabling operation at longer solid retention times than HRT. The control series was operable to an organic loading rate (OLR) of up to 8.8 g-COD/L/d, whereas EP series was 26.5 g-COD/L/d. EP series can still reduce the sludge yield by 27-46%. In the control series, the major VFA produced by acidogenesis in the reactor was propionic acid, while the control series was acetic acid. Based on Gibbs free energy variations, the conversion of propionic acid to acetic acid is more difficult than the conversion of ethanol to acetic acid because the former requires more free energy. EP proved effective in avoiding propionic acid accumulation and subsequent decreased pH. Therefore, EP significantly improves

AnMBR performance. In this chapter, increasing the load on the EP system did not inhibit methane fermentation. In the next chapter, in order to understand the biodegradability limit of the EP system, a higher load was operated.

In Chapter 4, by using AnMBR, the EP series was operable to an OLR of 43.5 g COD/L/d, 3 times higher than the capability of the control series. This ability is the highest in the previous reports. In high load operation, EP also proved effective in maintaining a stable methane yield and stable long-term operation of the reactor; together, this demonstrates that EP of AFW significantly improves anaerobic digestion performance. The functional archaeal community and bacterial community were investigated in the two reactors. The results showed the significant shifts in the dominate bacteria and archaea.

This study clarified the performance during the high load and long-term operation of methane fermentation of EP using AnMBR and the main metabolic pathways of the microbial communities. This research provides an important reference for future practical application and continued research.