Continuous biohydrogen production from food waste using dynamic membrane bioreactor

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Introduction

Food waste (FW) is one of the most abundant organic solid wastes, making up 15–63% of total municipal solid wastes worldwide (Asian Institute of Technology, 2010, Jang et al., 2015). If FW is not properly managed, it releases odor and leachate during collection and transportation because it has high volatile solids (VS: 85–95%) and moisture content (75–85%). However, due to its high energy content, the generation of fuel and chemicals seems ideal while reducing waste (Breunig et al., 2017). In particular, the recovery of clean fuels (such as hydrogen) through anaerobic fermentation process from FW can be more valuable. Due to its cleanness and high-energy yield (122 kJ/g), hydrogen is an appropriate alternative to fossil fuels. Anaerobic fermentation of FW produces various volatile fatty acids (VFA), H_2, CO_2 and other by-products. The reactions involved in hydrogen production are rapid and do not require solar radiation, making them useful for treating large quantities of organic wastes. Not only hydrogen gas itself is a beneficial energy source, but also VFA can be used either for methane production by methanogenesis or a readily biodegradable carbon source for biological nutrients removal (Lee et al., 2002, Llabres et al., 1999, Rustrian et al., 1999). The FW, a carbohydrate-rich organic solid waste, was used in this study as a substrate for hydrogen production.

Materials and Methods

Seed sludge was sampled from an up-flow anaerobic sludge blanket (UASB) reactor, located in a brewery wastewater treatment plant. The inoculum composition was as follows: total solids 74.32 g/L, volatile solids (VS) 67.4 g/L, and pH 7.3. The inoculum was exposed to heat treatment (at 90°C for 30 min) as a pretreatment strategy to enrich the hydrogen producers by killing the hydrogen consuming methanogens. Food waste was prepared according to the recipe of Korean Ministry of Environment.

A lab-scale dynamic membrane bioreactor (DMBR) was used for continuous hydrogen production. It was composed of a continuously stirred tank reactor (CSTR) with 1-L working volume and a dynamic membrane (DM) module with 0.5-L working volume. Effluent was taken through polyester screen mesh with 50-µm pore size, which was installed in the DM module. The fermentation liquor was recirculated 10-times faster than the feed-flow rate using a peristaltic pump from the CSTR to the DM module.

The amount of biohydrogen production from the DMBR used a wet-type gas meter (ISI-08B, Instrumentation & Scientific Instruments Private Limited Int., Chennai, India). The composition of H_2 and CO_2 in the biogas was measured via gas chromatography (SRI 310, SRI Instruments, Torrance, CA, USA). VFA analysis using high-performance liquid chromatography (Waters 717, Waters Corp., Milford, MA, USA) was configured with refractive index detection (Waters 2414, Waters Corp., Milford, MA, USA) and ultraviolet detection (Waters 2487, Waters Corp., Milford, MA, USA) (Park J-H. et al., 2014).

Results and Discussion

The DMBR showed stable biohydrogen production. Average hydrogen production was recorded as 6.35 L/L-d. Enhancement of biomass retention was observed in both suspended and attached forms, which provided the remarkable biohydrogen productivity. Anaerobic bacteria utilized carbohydrate fraction of FW as the sole source of electrons and energy, converting them into hydrogen. The most abundant byproduct in the effluent were butyric and acetic acids, which could be further valorized into methane, bioplastics, and other biorefinery products.

Conclusions

Food waste would be a viable feedstock for biohydrogen production. Hydrogen producing biofilm was successfully developed on 50-µm pore polyester screen mesh, which enabled high-rate hydrogen production from food waste.

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