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Enhanced Biogas Production of Micro-alga, *Hydrodictyon Reticulatum* by Hydrothermal Pretreatment

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Abstract. The filamentous algal biomass, *Hydrodictyon reticulatum* (*H. Reticulatum*) was used to evaluate the biogas production after hydrothermal preteatment in batch anaerobic digestion. The effect of hydrothermal pretreatment at range of 50 ~ 280 ^{o}C was tested with filamentous algal biomass. The solubilization by pretreatment showed a higher degree of disintegrated filamentous algal biomass and the soluble COD was increased 12.8 fold than untreated sample at 280 ^{o}C. Solubilization due to hydrothermal pretreatment increased the specific biogas production and volatile solids reduction rates. Using the hydrothermal treatment approach, the specific methane production were 161.8, 169.1, 178.4, 191.7, 274.9, 285.2 and 364.4 mL/g-VS of the pretreated at raw, 50, 100, 120, 180, 230, and 280 ^{o}C, respectively. The volatile solids reduction was greater with increased temperature applied, and the degradation increased 69.7% at 280 ^{o}C from 45.8% VS reduction of raw filamentous algal biomass.

Keywords: Filamentous algal biomass, *Hydrodictyon reticulatum*, Pretreatment, Biogas production, Hydrothermal treatment

1 Introduction

Recently, there has been increasing interest in assessing the energy potential of biofuels obtained from micro-algae (González-Fernández et al., 2011). Algae biofuels are an attractive option (Singh et al., 2011) due to its rapid growth rate comparatively, low land usage and high carbon dioxide (Jorquera et al., 2010). However, anaerobic digestion of microalgae is limited by lard cell wall (Chen et al., 1998). According to the report of Golueke et al. (1957) digested sludge provided a noticeable green color during anaerobic digestion because of the persistence of chlorophyll, which in an intracellular material. This result suggests that cellular lysis was not completed during digestion. Therefore, pretreatment of the algal biomass is needed because the complex cell wall structure of microalgae, composed by cellulose, hemicellulose and pectin, makes bacteria to attack difficult (Passos et al., 2013).

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The objective of this study was to investigate the solubilization of filamentous alga, *Hydrodictyon reticulatum (H. reticulatum)* using hydrothermal pretreatment. An additional aim of this work was to study the effects of different temperature for pretreatment to algal feed on anaerobic digestion.

2 Experimental Materials and Methods

2.1 Hydrothermal Pretreatment of Filamentous Algal Biomass

The filamentous alga used in this study, *H. reticualtum*, was cultivated in secondary wastewater taken from the municipal wastewater treatment plant in Ansan, Korea.

The total solids (TS) and volatile solids (VS) contents, soluble COD, and ammonia nitrogen concentration were analysed by using the method according to the APHA standard methods (APHA, 2005). A hydrothermal reactor was used to investigate the effect of hydrothermal pretreatment on the biogas improvement property performance of the filamentous algal biomass, *H. reticulatum*. Experiments were performed using a 1000 mL autoclave reactor consisting of a reactor body, a heater, and a steam condenser which was operated under N_2 gas. A 100 mL of *H. reticulatum* feed stock was mixed with an equal amount of water and leaded into the reactor. The operating temperatures and pressures ranged from 50 to 280 ^oC and the reaction time was 30 minutes. Typically the temperature was from 180 to 320 ^oC that present subcritical water. The components within the reactor were vigorously mixed using an agitator rotating at 200 rpm.

2.2 Biochemical Methane Potential (BMP) Test

Batch digestion was performed in a series of BMP assays by incubating algal biomass inoculated with anaerobic bacteria for a period about 35 days based on Angelidaki et al. (2009). A nutrient/mineral/buffer (NMB) medium prepared according to Young and Tabak (1993). Biogas production from inoculum and medium was recorded and used as the control. Substrate and inoculum were used at a ratio of 0.5:1 using the VS mass.

3 Results and Discussion

3.1 Solubilization of Filamentous Algal Biomass

Hydrothermal pretreatment focused on filamentous algal biomass to improve anaerobic digestion in this study. The biomass was subjected to hydrothermal pretreatment with the six different pretreatment temperatures. Two ranges of thermal pretreatment for anaerobic digestion batch experiments were conducted under mesophilic conditions. The first range was typical thermal pretreatment as 50, 100

and 120 ^{o}C, and the second was hydrothermal pretreatment range as 180, 230 and 280 ^{o}C. Typically the temperature was from 180 to 230 ^{o}C that present subcritical water. SCOD increased along pretreatment temperatures.

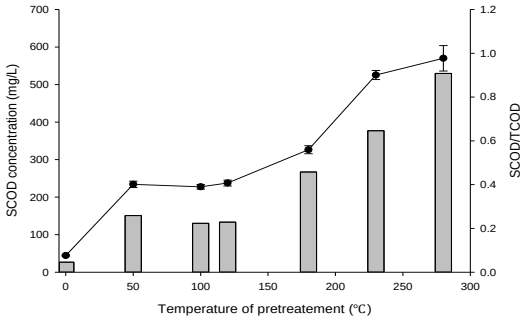

Figure 1 Solubilization of algal biomass depending on different pretreatment temperatures

3.2 Effect of Pretreatment for Biogas Production

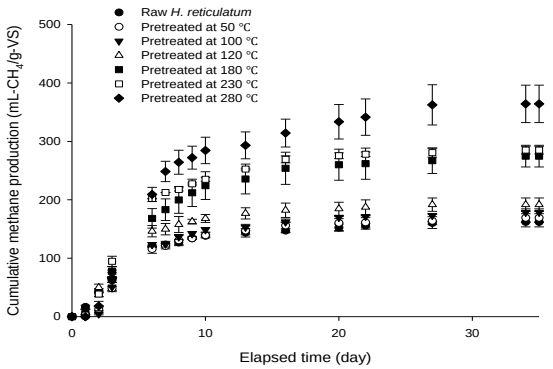

Figure 2 Methane production of algal biomass depending on pretreatment temperatures

The assessment of raw and pretreated algal biomass as substrate for the anaerobic digestion was evaluated by the BMP test over a period of 35 days (Figure 2). BMP assays were conducted to determine the specific conditions required for optimal methane production of algal biomass using different pretreatment temperatures from 50 to 280 ^{o}C. The filamentous algal biomass, *H. reticulatum*, was subjected to thermal pretreatment of different temperatures before the BMP assays. Methane production rate of all kinds of substrates was maximal during the first 8 days and decreased after that. Raw *H. reticulatum* substrate produced methane yield on VS basis of 161.8 mL/g-VS whereas pretreated samples at 50, 100, 120, 180, 230, and 280 ^{o}C resulted in 169.1, 178.4, 191.7, 274.9, 285.2, and 364.4 mL/g-VS, respectively.

4 Conclusion

This study demonstrated that filamentous algal biomass, *H. reticulatum*, is a potential substrate at different thermal pretreatment for anaerobic digestion. In batch anaerobic digestion carried out at different temperatures were conducted 161.8, 169.1, 178.4, 191.7, 274.9, 285.2, and 364.4 mL/g-VS at raw, 50, 100, 120, 180, 230, and 280 ^{o}C, respectively. The hydrothermal pretreatment was effective to improve methane production.

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