Immobilized microalgae based wastewater treatment and biodiesel extraction from produced biomass

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Keywords: immobilized microalgae, wastewater treatment, fatty acid methyl ester, biodiesel

INTRODUCTION

Today, wastewater is inevitably generated due to various human activities, and steadily increasing (MOE, 2019). To control eutrophication, the reduction of nitrogen and phosphorus concentration in wastewater is essential for maintaining the health of the aquatic ecosystem. Microalgae, one of the biological treatment methods used for wastewater treatment, are excellent at removing nitrogen and phosphorus, and may suggest more environmentally friendly and sustainable options. Because they can achieve the additional goal of lipid production, convertible to liquid biofuel. Especially, when microalgae were immobilized on polymers, biomass that can be used as a by-product can be highly concentrated and its separation from the treated wastewater is much easier. However, little research has tried microalgal immobilization strategy for microalgal biofuel production. Therefore, this study evaluates the effect of alginate-based microalgae immobilization on the removal of nitrogen and phosphorus removal from wastewater to confirm the potential of immobilization as an effective microalgal technology for wastewater treatment and resource recovery.

MATERIALS AND METHODS

Microalgae beads preparation

Chlorella vulgaris, cultured in BG11 for 12 days, was centrifuged (5000 rpm, 5 min) to separate only the biomass and resuspended in distilled water. Then, it was mixed with algal suspension and 3% sodium alginate solution in a 1:1 ratio (V/V). The mixed solution was slowly dropped into a 3% $CaCl_2$ solution using a syringe. The beads (4 mm in size) left for 12 hours for hardening and then washed with distilled water.

Direct transesterification for FAME extraction

This study used direct transesterification to extract FAME from microalgal biomass. First, microalgal beads lyophilized at -40°C and 5 mTorr were mixed with 0.5 M acid catalyst (HCl) at a ratio of 1:10 (W/V) for one hour. Thereafter, direct transesterification was carried out at 90 °C. The FAME extracted after the reaction was separated into a hexane layer. The extracted FAME was analyzed using a gas chromatograph-flame ionization detector (GC-FID) (GC-2010, Shimadzu, Japan).

RESULTS AND DISCUSSION

Nutrients removal efficiency

Figure 1 shows the change in T-P and T-N concentrations over 120 hours. Both groups showed a decreasing tendency for phosphorus and nitrogen, but the immobilized microalgae group showed a 10% higher removal rate than that of control. Microalgae immobilization could remove more nutrients by adsorption (Tam and

Wong 2000). It also could achieve higher phosphorus removal because of the possibility of phosphorus precipitation by the Ca-alginate matrix (Jiménez-Pérez, Sánchez-Castillo et al. 2004).

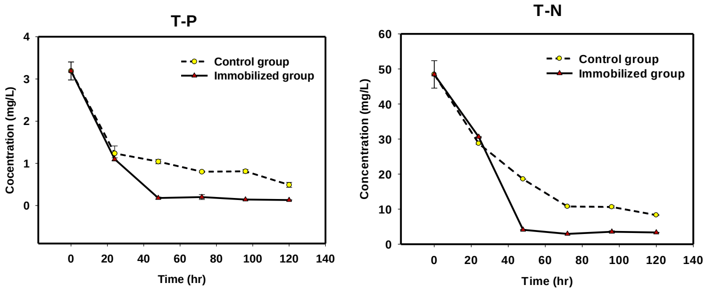

Figure 1. Removal efficiency of T-P and T-N

FAME composition

Table 1 shows the composition (%) of FAME extracted from immobilized microalgae biomass. The main components of FAME were decanoic acid (C10:0) and stearic acid (C18:0), each showing more than 20%. Next, myristic acid (C14:0) and caprylic acid (C8:0) each showed 8% or more. The quality of biodiesel is primarily associated with a high proportion of saturated and monounsaturated fatty acids. However, saturated fat components such as methyl palmitate and methyl stearate can worsen the low-temperature fluidity of biodiesel fuel in winter (Hong and Hong 2007) .

C10:0	C18:0	C8:0	C14:0	C12:0	C16:0	C18:2	C18:1	C20:0	C18:3	C22:0	C16:1	C24:0
26.4	23.2	8.5	8.5	6.9	6.5	5.3	4.9	3.7	2.8	1.6	0.8	0.8

Table 1. FAME composition (%)

CONCLUSION

This study showed that wastewater treatment using immobilized microalgae can achieve higher removal efficiency of nitrogen and phosphorus than those of free-living microalgae. Also, microalgae immobilization allowed highly concentrated biomass useful for better harvesting. Extracted FAME mainly consisted of C10:0 and C18:0, saturated fatty acids. In summary, this study showed that wastewater treatment using immobilized microalgae can be a more sustainable and environmentally friendly option that can contribute to building carbon neutral society together with safe water recycling.

ACKNOWLEDGEMENT

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2020R1F1A1056613) and Korea Ministry of Environment (MOE) as 「Knowledge-based environmental service (Waste to energy) Human resource development Project」 .

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