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Short Communication

Cultivation of a microalga *Chlorella vulgaris* using recycled aqueous phase nutrients from hydrothermal carbonization process

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HIGHLIGHTS

- ▶ Process water from hydrothermal carbonization was recycled for algae cultivation.
- ▶ Algae grew faster on process water than on BG-11 medium.
- ▶ Algae removed TN, TP and COD by 45.5–59.9%, 85.8–94.6% and 50.0–60.9%.
- ▶ Algae grown on process water had higher carbon, hydrogen and lipids content.
- ▶ Recycling process water has the potential of reducing algae production cost.

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ABSTRACT

This study investigated the feasibility of using recovered nutrients from hydrothermal carbonization (HTC) for cultivation of microalga *Chlorella vulgaris*. Different dilution multiples of 50, 100 and 200 were applied to the recycled process water from HTC and algal growth was compared among these media and a standard growth medium BG-11. Algae achieved a biomass concentration of 0.79 g/L on 50× process water after 4 days. Algae removed total nitrogen, total phosphorus and chemical oxygen demand by 45.5–59.9%, 85.8–94.6% and 50.0–60.9%, respectively, on differently diluted process water. The fatty acid methyl ester yields for algae grown on the process water were 11.2% (50×), 11.2% (100×) and 9.7% (200×), which were significantly higher than 4.5% for BG-11. In addition, algae cultivated on process water had 18.9% higher carbon and 7.8% lower nitrogen contents than those on BG-11, indicating that they are very suitable as biofuel feedstocks.

1. Introduction

Hydrothermal conversion is a process in which biomass is converted to liquids, solids or gases in hot pressurized water. Hydrothermal technologies broadly cover chemical and physical transformations in high-temperature (200–600 °C) and high-pressure (5–40 MPa) water (Peterson et al., 2008). They have energetic advantages for wet biomass such as algae due to the elimination of energy inputs for water removal by evaporation. Many recent studies have shown that a bio-oil with a high heating value can be obtained from the hydrothermal liquefaction (HTL) of microalgae (Biller and Ross, 2011; Brown et al., 2010; Torri et al., 2012). A large amount of the process water containing carbon, nitrogen, phosphorus and minerals is produced as a co-product in this process. It is expected that these nutrients can be recycled for cultivation of microalgae to enhance the overall economic viability of algal biofuel process. There are very few reports on recycling process water from HTL for algae cultivation. Some previous studies (Biller et al., 2012; Jena et al., 2011) compared algae growth on diluted HTL process water and standard media, such as BG-11 and 3N-BBM+V. Algae grew slower and reached a lower final concentration on the diluted process water than on standard media. This is probably due to the high concentration of inhibitors, including nickel, fatty acids, phenols and other toxic compounds produced in HTL under high temperatures ranging from 250 to 400 °C. Hydrothermal carbonization (HTC) is another technology carried out in compressed water but at lower temperature (subcritical condition, ~200 °C) than HTL. HTC has been reported to produce energy densified solid fuels (Heilmann et al., 2010) and pretreat biomass for subsequent thermochemical processing, such as pyrolysis and gasification (Du et al., 2012, 2011; Hoekman et al., 2011). Our previous study utilized HTC as a pretreatment step to reduce the nitrogen content by hydrolyzing proteins in microalgae feedstock (Du et al.,

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