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Study of Microalgae Bio-Fixation for Carbon Capture and Utilization (CCU)

Chan, S.S., Lam, W.Y.V.[1] and Chan, C.Y. [*]

Department of Construction and Environmental Engineering,
Technological and Higher Education Institute of Hong Kong.

[*]Corresponding author

Abstract

Human activities have significantly increased the global CO_2 level (>400 ppm) resulting in global warming and extreme climate changes. Microalgae can be used to remove CO_2 by its high bio-fixation rate. In this study, microalgae bio-fixation at different levels of CO_2 (i.e., atmospheric condition and flue gas ~20%) was conducted in the presence and absence of enzyme; carbonic anhydrase (CA), which was extracted from microbial cells to catalyse the conversion process between dissolved CO_2 gas and HCO_3^- ion in the growth medium, while microalgae can readily utilize the HCO_3^- for their growth and biomass production. Growth of microalgae was measured by OD_{600nm}, medium pH was critically monitored and bio-fixation rate was determined by dry weight of the biomass produced after the cultivation process. Results showed that growth of marine green microalgae; *Tetraselmis* sp. was double (OD_{600nm}) when adding higher amount of essential nutrient $NaNO_3$ (i.e., 0.4 to 0.8 mM). On the other hand, supply of CO_2 without proper pH control greatly affected the bio-fixation process, since initial acidification of culture medium in the presence of high CO_2 content (i.e., flue gas) was observed. Furthermore, slow microalgae growth was also observed at elevated pH (> 9) when more CO_2 was removed from the culture medium. The bio-fixation rates were determined in 2.473 g/L/day and 1.160 g/L/day at 20% CO_2 with 5 mL CA (3.304 mg/mL of total protein) and 0.04% CO_2 (atmospheric level) without CA, respectively. Optimization study on medium pH, CO_2 level and amount of CA would be further conducted to enhance the bio-fixation rate for achieving higher CO_2 removal. In summary, effective CO_2 removal is demonstrated by a simple microalgae cultivation process assisted with enzyme CA.

Keywords: carbon capture, carbonic anhydrase, CO_2 bio-fixation, CO_2 hydration, microalgae.