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Simultaneous CO_2 fixation, C-phycocyanin production, and heavy metals removal via *Thermosynechococcus* sp. CL-1 (TCL-1) cultivation

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Extended Abstract

Exploration of environmental protection through mitigation of CO_2 and removal of water pollutants, such as heavy metals, has gained high interest. Cultivation of photosynthetic microorganisms, such as cyanobacteria, to deal with both environmental issues is considered a promising approach with high feasibility [1]. *Thermosynechococcus* sp. CL-1 (TCL-1), an isolated cyanobacterium from a hot spring in Taiwan, has a high tolerance to be cultivated in an environment with high temperature and alkalinity [2]. TCL-1 has been reported to achieve rapid biomass growth and CO_2 fixation rate even in the test under the presence of pollutants [3] or using swine wastewater [4]. During TCL-1 cultivation, C-phycocyanin is observed as the major generated valuable pigments [5].

This study compared the influence of Pb and Cd in TCL-1 performances, including CO_2 fixation, heavy metal removal, and production of C-phycocyanin. Test was conducted using 5 folds of modified Fitzgerald/MF (5MF) as the growth medium, which was supplemented by 113.2 mM dissolved inorganic carbon/DIC to simulate the conditions of almost saturated CO_2 in wastewater of a chemical scrubber system. Various concentrations of Pb or Cd were given in the range of 0-10 mg/L. Tests were conducted with 3 g/L initial TCL-1 biomass concentration in a flat panel photobioreactor/FPBR under incubation at 50 ºC for 12 h. An aeration system with a flow rate of 0.5 vvm was set at the bottom of the FPBR to provide uniform mixing, and lighting in the intensity of 2,000 $\mu E/m^2/s$ was set to simulate the average sunlight condition in Taiwan during daytime. Observation on heavy metal removal was supported by the analysis of removal mechanism and detection of functional groups on the TCL-1 cell surface.

TCL-1 cultivation under the absence of heavy metals achieved 65.7±5.6 mg/L/h biomass productivity along with 118.1±12.5 mg/L/h CO_2 fixation rate. Increasing Cd and Pb content led to decline in biomass productivity similar to a previous study by Nanda, et al. [6]. However, compared to Pb, the presence of Cd presented a less severe effect on TCL-1 cultivation which was proven by insignificant differences among the tested levels. Besides, the presence of either Pb or Cd promoted a higher increment of carbon content in biomass compared to the control without heavy metals. The best CO_2 fixation rates of 105.2±5.0 and 98.5±18.9 mg/L/h were achieved by TCL-1 cultivation with 0.5 mg/L Cd and Pb, respectively.

TCL-1 cultivation presented Cd removal in the range of 59.25-91.89% which was higher than that of Pb (50.17-67.28%). Supply of high light intensity in this study beneficially supported the photodegradation process as tested in the blank experiment. Nevertheless, bioadsorption was measured as the dominant heavy metals' removal mechanism by TCL-1 which might be supported by the functional groups on the biomass surface. Detection of functional groups indicated the presence of carboxyl bonding which might play an important role in bioadsorption process. The presence of Cd or Pb insignificantly influenced TCL-1 performance in producing C-phycocyanin. Thus, TCL-1 can be considered as a potential candidate to deal with various environmental issues along with production of phycocyanin.

Keyword: CO_2 fixation, Heavy metals removal, Cyanobacteria, *Thermosynechococcus*, C-phycocyanin.

References

[1] B. Narindri Rara Winayu, Y.-C. Chen, H.-T. Hsueh, and H. Chu, "*Thermosynechococcus* sp. CL-1 cultivation for Zn removal in swine wastewater with simultaneous CO_2 fixation and macromolecules accumulation," *Journal of Water Process Engineering,* vol. 54, p. 103927.

[2] H. T. Hsueh, H. Chu, and C. C. Chang, "Identification and Characteristics of a Cyanobacterium Isolated from a Hot Spring with Dissolved Inorganic Carbon," *Environmental Science & Technology,* vol. 41, pp. 1909-1914.

[3] J.-Y. Chang, B. Narindri Rara Winayu, H.-T. Hsueh, and H. Chu, "Nitrogen and 17β-Estradiol level regulate *Thermosynechococcus* sp. CL-1 carbon dioxide fixation, monosaccharide production, and estrogen degradation," *Bioresource Technology,* vol. 336, p. 125313.

[4] B. Narindri Rara Winayu, H.-P. Chuang, H.-T. Hsueh, and H. Chu, "Elimination of inorganic carbon and nitrogen resided in swine wastewater using *Thermosynechococcus* sp. CL-1 enriched culture," *Bioresource Technology,* vol. 336, p. 125325.

[5] S. K. Hoi, B. N. R. Winayu, H. T. Hsueh, and H. Chu, "Light factors and nitrogen availability to enhance biomass and C-phycocyanin productivity of *Thermosynechococcus* sp. CL-1," *Biochemical Engineering Journal,* vol. 167, p. 107899.

[6] M. Nanda, K. K. Jaiswal, V. Kumar, M. Verma, M. S. Vlaskin, P. Gururani, H. Kim, M. F. Alajmi, A. Hussain, "Bio-remediation capacity for Cd(II) and Pb(II) from the aqueous medium by two novel strains of microalgae and their effect on lipidomics and metabolomics," *Journal of Water Process Engineering,* vol. 44, p. 102404.