DISSERTATION ABSTRACT

Title: Application of Photochemical and Biological Approaches for Cost-effective Algal Biofuel Production
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Rapid growth of energy consumption and greenhouse gas emissions from fossil fuels have promoted extensive research on biofuels. Algal biofuels have been considered as a promising and environmentally friendly renewable energy source. However, several limitations have inhibited the development of cost-effective biofuel production, which includes the unstable cultivation caused by invading organisms and high cost of lipid extraction. This dissertation aims to investigate the photochemical approaches to prevent culture collapse caused by invading organisms, as well as the biological approaches for the development of cost-effective lipid extraction methods.

First, UV-based treatment has been widely applied in water and wastewater treatment, which is a prospective option for water treatment in algal cultivation to control invading organisms. However, the use of UV-based processes will require appropriate methods for reactor validation. As such, marine alga *Tetraselmis sp.* and algal virus *Paramecium bursaria Chlorella virus 1* (PBCV-1) were examined as challenge organisms for methods validation purpose. The concentration of viable (reproductively/infectively active) cells/virus were quantified by most probable number (MPN) assay and plaque assay. A low pressure collimated-beam reactor was used to investigate UV_{254} dose-response behavior of both challenge organisms and a medium pressure collimated-beam reactor equipped with a series of narrow bandpass optical filters was used to investigate the action spectrums of both challenge organisms. Both challenge organisms showed roughly five log_{10} units of inactivation for UV_{254} doses over 120 mJ/cm^2. However, the most effective wavelengths for inactivation of *Tetraselmis* were from 254 nm to 280 nm, in which the inactivation is mainly contributed to the UV-induced damage to DNA. On the contrary, the most effective wavelength for inactivation of PBCV-1 was observed at 214 nm, where the loss of infectivity is mainly contributed to the damage to proteins. These results provided information for the development of appropriate methods for UV reactor

validation that could be applied to minimize the impact of invading organisms in algal cultivation systems.

Secondly, a virus assisted cell disruption method is proposed for cost-effective lipid extraction from algal biomass. Detailed mechanistic studies were conducted to evaluate infection behavior of *Chlorovirus* PBCV-1 on *Chlorella sp.*, impact of infection on mechanical strength of algal cell wall, lipid yield, and lipid distribution. Viral disruption with multiplicity of infection of 10^{-8} was able to disrupt concentrated algal biomass completely in six days. Our results indicated that viral disruption significantly reduced the mechanical strength of algal cells for lipid extraction. Lipid yield with viral disruption increased more than three times compared to no disruption control and was similar to that of ultrasonic disruption. Moreover, lipid composition analysis showed that the quality of extracted lipids was not affected by viral infection. The results showed that viral infection is a highly cost-effective technique as extensive energy input and chemicals required by existing disruption methods are no longer needed.

Overall, this dissertation provides demonstration and insights for the development of stable and cost-efficient biofuel production, which could be beneficial for researchers and scientists in algal biofuel studies.