THE UNIVERSITY OF ADELAIDE AUSTRALIA

# Culturing and Harvesting Marine Microalgae for the Large-scale Production of Biodiesel

This thesis is presented for the degree of Masters of Engineering Science in the school of Chemical Engineering

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# Declaration

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# Abstract

In the commercial production of biodiesel from marine microalgae, the cost and efficiency of harvesting technique affects the overall cost and production of biodiesel. The commercial harvesting techniques being used for harvesting microalgae include centrifugation and filtration preceded by flocculation. Centrifugation and filtration are very high cost processes and different flocculation techniques like chemical flocculation, auto-flocculation and bio-flocculation (microbial flocculation) are being developed to achieve more efficiency in flocculation of algal biomass at lower costs. In this project, 'Electroflocculation'- a common process for flocculating contaminants, organic matter and metal ions from waste water was applied to flocculate marine microalgae.

The studies presented in the thesis aim to

1. determine the effect of electroflocculation on the flocculation of marine microalgae at lab scale
2. investigate the factors affecting electroflocculation i.e. current density, time, material of electrodes, distance between electrodes, salinity of the cultures and pH
3. scale-up the lab scale electroflocculation process to pilot-scale and investigate the cost effectiveness of pilot-scale electroflocculation process
4. theoretically optimize, design and analyse the costs for electroflocculation process, based on experiments performed and data available in literature
5. culture marine microalgae species starting from lab-scale to outdoor raceway ponds and study the reliability and stability of the cultures over a long period

The lab-scale experiments on electroflocculation of marine microalgae showed that this technique successfully flocculated the microalgae from the culture solution and the floccs floated to the surface that can be easily scrapped off and used for further dewatering or extraction purposes. Investigation of factors affecting electroflocculation indicated that factors like current density, time, distance between electrodes and electrode material should be optimized for lowering the costs. The higher salinity of cultures and pH around 7 are favourable factors for harvesting marine microalgae using electroflocculation.
Following the success of lab-scale experiments a 100L pilot-scale setup was built to analyse the cost effectiveness of electroflocculation at this scale. Results showed that minimum power requirement of 0.168kWh/$m^3$ was noted with more than 95% removal efficiency and concentration factor of 25 times was achieved.

The study also introduced a several key factors in understanding the optimization, design, and cost analysis of the process and to overcome the process drawbacks of electroflocculation.

The results enhance the current understanding of the electroflocculation process and further studies required to apply electroflocculation as a harvesting technique at large scale in the process of production of biodiesel from microalgae in saline water.

Prior to harvesting the marine microalgae species were cultured in laboratory upto 20L and outdoor raceway ponds upto 400L. The growth rate and productivities of the microalgae cultures in outdoor raceway ponds were investigated regularly over a period of 9 months and productivities of 1-5$gm^{-2}day^{-1}$ were reported. The study of effect of changing environmental factors on the growth rate and productivities showed that the marine microalgae species are reliable and stable and suitable for large scale culturing in the production of biodiesel.

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