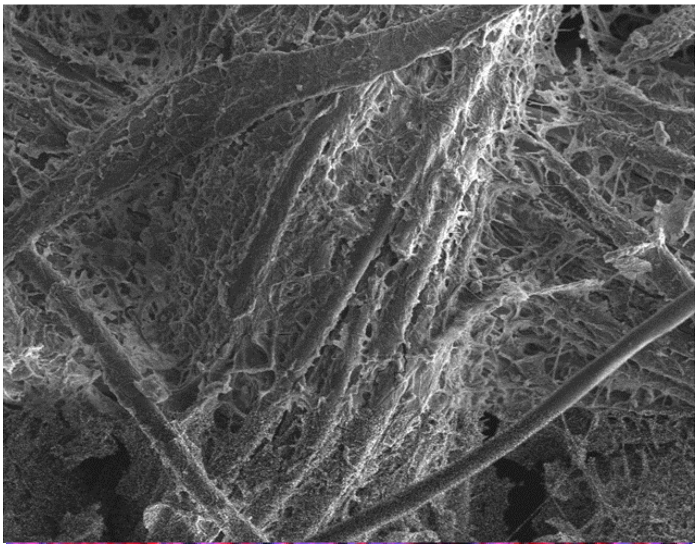
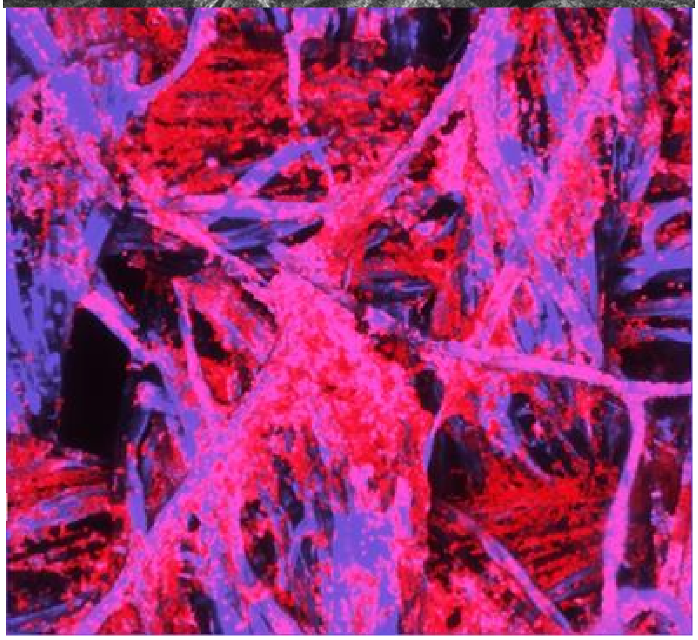
DEVELOPING A HARVESTING PROCESS FOR ALGAL BIOMASS PRODUCTION





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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Oksana Vronska, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy degree, in the Faculty of Science/School of Life Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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PREFACE

In my thesis, **Chapter 1**, **Chapter 2** and **Chapter 4** are intended to be submitted for publication in peer-reviewed journals. A certain degree of repetition is present.

In association with my PhD, I have been a co-author on a publication that is relevant to my thesis, but does not contribute to it. The work presented in Chekli et al. (2017) used titanium-based coagulants for microalgae removal from freshwaters as an alternative method of biomass harvesting.

Chekli, L., Eripret, C., Park, S.H., Tabatabai, S. A. A., **Vronska, O.**, Tamburic, B., Kim, J.H. & Shon, H.K. 2017, ‘Coagulation performance and floc characteristics of polytitanium tetrachloride (PTC) compared with titanium tetrachloride ($TiCl_4$) and ferric chloride ($FeCl_3$) in algal turbid water’, *Separation and Purification Technology*, vol. 175, pp. 99–106.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Microalgal biomass is a promising alternative energy feedstock. Its commercial production currently entails suspended cultivation of microscopic cells in large liquid volumes. Microalgal harvesting, *i.e*. separation of the cells from the liquid, is an energy-intensive and expensive process that makes large-scale biomass production economically challenging. In my thesis, an alternative technique for microalgal biomass cultivation and harvesting was developed. The cells were grown in biofilm systems attached to fabrics, thus being naturally concentrated and easy to harvest by simple mechanical scraping.

The selection of fabrics used for microalgal attachment remains an open question, and it is a critical factor in overall performance of a biofilm system. In my thesis, a durable fabric with a special web-like coating that promoted microalgal cell attachment was identified and tested. This fabric is being successfully used by an industry collaborator for bacterial biofilm cultivation and wastewater treatment. The distinctive features, fibre structure and arrangement of this fabric were compared with other fabrics commonly used in the literature to determine possible reasons for its improved performance. Gradual biofilm formation process was imaged by confocal laser scanning microscopy to analyse the specifics of cell attachment and development of a mature biofilm. A method for quick and easy biofilm thickness measurement was developed. Two microalgal biofilm systems were designed and custom-built for attached biomass growth and harvesting at laboratory scale and at pilot scale.

The maximum surface productivity achieved during attached microalgal cultivation was 25.2 g m^{-2} d^{-1}. The mass fraction of biomass to water of the harvested microalgal sludge was above 150 g kg^{-1}, which was comparable to dewatered and concentrated biomass from suspended biomass systems. The experiments also revealed a pattern of biofilm development, where the liquid-air interface of the fabrics was characterised by the highest cell attachment. This observation could be valuable for future design of attached systems. Mechanical scraping proved to be an efficient method of biofilm harvesting, with 95.2-98.7% biomass removed. The above-average algal productivity, together with the high dry biomass concentration and efficient harvesting, indicates that the growth and harvesting technique developed in this thesis represents a promising alternative to

suspended biomass cultivation. It does not require expensive dewatering and drying steps, so it could substantially decrease commercial biomass production costs.