

## MASTER'S THESIS

### Algae grown anode microbial fuel cell and its application in power generation and biosensor

Xu, Chang

*Date of Award:*  
2015

[Link to publication](#)

#### **General rights**

Copyright and intellectual property rights for the publications made accessible in HKBU Scholars are retained by the authors and/or other copyright owners. In addition to the restrictions prescribed by the Copyright Ordinance of Hong Kong, all users and readers must also observe the following terms of use:

- Users may download and print one copy of any publication from HKBU Scholars for the purpose of private study or research
- Users cannot further distribute the material or use it for any profit-making activity or commercial gain
- To share publications in HKBU Scholars with others, users are welcome to freely distribute the permanent URL assigned to the publication

**Algae Grown Anode Microbial Fuel Cell and Its  
Application in Power Generation and Biosensor**

**XU Chang**

**A thesis submitted in partial fulfillment of the  
requirements for the degree of Master of Philosophy**

**Principal Supervisor: Prof. CAI Zong Wei**

**Hong Kong Baptist University**

**August 2015**



## **Declaration**

I hereby declare that this thesis represents my own work which has been done after registration for the degree of MPhil at Hong Kong Baptist University, and has not been previously included in a thesis or dissertation submitted to this or any other institution for a degree, diploma or other qualifications.

Signature: \_\_\_\_\_

Date: August 2015

## Abstract

Live green microalgae *Chlorella pyrenoidosa* was introduced in the anode of microbial fuel cell (MFC) to act as an electron donor. The electrogenic capability of algae *Chlorella pyrenoidosa* was investigated in two models of algal microbial fuel cells (MFCs) constructed with carbon electrodes and no mediator. The mechanism was studied by results of ATP inhibitor (Resveratrol) and protonophore (2, 4-dinitrophenol), which supporting the important role of mitochondria in electricity generation. The results of different light intensity and algae concentration indicate that low concentration of  $10^6$  (OD<sub>680nm</sub>) and low light intensity (2500 Lux) generated higher electricity. In the oxygen controlled study, it was found that oxygen generated by algae in anode was a limiting factor for electricity generation. Electricity generation was observed in two chamber algae MFC lasting at least for 24 hours. Results might provide a platform for the development of self-sustainable algal culturing microbial fuel cell (MFC). Electricity was found to increase in response to 4-nitrophenol (4NP) and 4-nitroaniline (4NA) for both measurements of current and open circle voltage (OCV). The positive response of algae to 4NP in increasing the 4NP production and electricity generation in MFC proposed the possible application in the detection of *E.coli*, as 4NP is involved in the intermediate step of the detection process. Results indicate Algae MFC was suitable for the detection of *E. coli* of concentration higher than  $10^6$  using OCV measurement.

**Keywords:** *Electricity generation, Chlorella pyrenoidosa, Microbial fuel cell.*

## **Acknowledgements**

I would like to express my sincere thanks to co-supervisor Dr. Karen Poon who is my major supervisor during my M. Phil. study, and also Prof. Cai for their kind encouragement and valuable advice on my research. The financial support from UIC College Research Grant R201207 is gratefully acknowledged.

## Table of Contents

Declaration.....	i
Abstract.....	ii
Acknowledgements.....	iii
Table of Contents.....	iv
List of Table.....	vi
List of Figure.....	vii
List of Abbreviation.....	xi
1. General Introduction.....	1
1.1. Development of bio-energy.....	1
1.2. Introduction of microalgae.....	2
1.3. Introduction of bio-energy from green algae.....	3
1.3.1. Different methods to extract biofuel from green algae.....	4
1.4. Introduction of Microbial fuel cell.....	6
1.4.2. Microbes in microbial fuel cell.....	9
1.5. The purpose of research:.....	10
1.6. Scope of study.....	10
2. Electricity generation of algae grown anode microbial fuel cell.....	12
2.1. Introduction.....	12
2.1.1. Development of bacteria microbial fuel cell.....	12
2.1.2. Development of algae microbial fuel cell.....	14
2.2. Materials and Methods.....	19
2.3. Result.....	25
2.3.1. Electricity generation in Model one: Algal MFC with algae grown at anode.....	25
2.3.2. Electricity generation in Model two: Algal MFC with algae in both chambers.....	36
2.3.3. Improve the function of power generation.....	38
2.4. Discussion.....	39
3. Stress response of algae to 4-NA and 4NP and their electricity generation in algae microbial fuel cell.....	46
3.1. Introduction.....	46
3.2. Method and materials.....	49
3.3. Result.....	52
3.3.1. Exposure of 4NA or 4NP to algae individually.....	52
3.3.2. Exposure of 4NA or 4NP to algae simultaneously.....	53
3.3.3. Algae MFC response to 4NA and 4NP.....	55
3.3.4. Algal cell permeability after chemical incubation.....	58
3.4. Discussion.....	59
4. Detection of E.coli by algae grown anode MFC.....	61
4.1. Introduction.....	61

4.1.1. Microbial biosensor .....	61
4.1.2. MFC based biosensor.....	61
4.1.3. Determination of E.coli.....	63
4.2. Method and material .....	66
4.3. Results.....	67
4.3.1. Live and dead cell staining picture. ....	67
4.3.2. Optimization of external resistant of algae MFC.....	68
4.3.3. Optimization of substrate concentration in E.coli. ....	69
4.3.4. 4NP concentration at different concentration of E.coli.....	71
4.3.5. Current generation and OCV changes of different concentration of E.coli .....	72
4.3.6. Real sample with E.coli contamination. ....	74
4.4. Discussion.....	77
5. Future works .....	79
5.1. Study the mechanism of algae electricity generation in details.....	79
5.2. Algae MFC with function as algae culturing facility.....	79
5.2. Algae MFC based biosensor .....	81
Conclusion .....	82
Reference. ....	82
CURRICULUM VITAE .....	93