

UNIVERSITI TEKNOLOGI MARA

**CULTIVATION OF MICROALGAE
FROM LOW SALINITY WATER
FOR PRODUCTION OF BIODIESEL
BY DIRECT
TRANSESTERIFICATION METHOD**

AHMAD ROZAIMEE BIN MUSTAFFA

Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Chemical Engineering)

Faculty of Chemical Engineering

November 2019

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student : Ahmad Rozaimie bin Mustaffa

Student I.D. No. : 2013613218

Programme : Doctor of Philosophy (Chemical Engineering) –
EH950

Faculty : Chemical Engineering

Thesis Title : Cultivation of Microalgae from Low Salinity Water for
Production of Biodiesel by Direct Transesterification
method

Signature of Student :

Date : November 2019

ABSTRACT

Microalgae biodiesel are proven to be greater than fossil fuels in terms of life-cycle energy performance. Green microalgae namely, *Tetraspora species* represents one of the most favorable resources of biodiesel due to relatively high lipid content. The aims of this project are to determine the properties of low salinity water as a growing medium for the growth of *Tetraspora species* and compare the normal average growth, exponential and logistic models in indoor close (batch) systems. The present study focused on the cultivation of *Tetraspora sp.* with the fed-batch in 500 ml flasks with an initial 1.0 ml cells cell pipetted in 500 ml culture in the culture medium consists of low salinity water as a growing medium. Growth under Controlled Condition, the algae strains have been successfully grown in an indoor laboratory of UiTM Dungun for 20 days in the low salinity water medium. The comparative studied was also shown that biomass growth models follow normal, exponential and logistics growth model of *Tetraspora sp.* Determination of the effect carbon dioxide concentration on nutrient deficient (nitrate and phosphate) that accomplishes wastewater treatment. The outcomes indicated that nitrate content under cultivation of *Tetraspora sp.* was reduced from 5.84 ± 0.11 mg/L to 0.32 ± 0.05 mg/L in 14 days cultivation period. Meanwhile, the phosphate content was removed 100 % from 0.61 ± 0.01 mg/L for 13 days cultivation period. The effect of 15% CO₂ aeration, the nitrate is reduced from 5.27 ± 0.06 to 1.80 ± 0.20 mg/L. Meanwhile, for the phosphate concentration is reduced from 0.57 ± 0.15 to 0.13 ± 0.06 mg/L in 14 days cultivation periods. In this research, the determination in percentage of fatty acid methyl ester (FAME) by Direct- transesterification with homogeniser method with the effect of catalyst, reaction temperature, reaction time and ultrasonic-aided with homogenisation have been investigated. From the experimental results was proven that higher yield for the biodiesel from microalgae; *Tetraspora sp.* was achieved in direct transesterification without catalyst process due to the naturally existence of self-catalyst such as iron (Fe) of 1153.34 ± 10.40 , potassium (K) of 508.98 ± 32.59 , calcium (Ca) of 330.43 ± 4.03 and Caesium (Cs) of 153.07 ± 25.70 ppm respectively. The optimum reaction parameters were determined at 60°C temperature and 5 minutes reaction time using high speed homogeniser at 10 000 rpm is significant that contribute to higher average FAME of 98.61 ± 1.01 percent. Therefore, the direct transesterification of lipids in microalgae is an effective approach to reduce reaction time and costs of some operation steps such as catalyst recovery and purification of biodiesel can be eliminated through this method. Moreover, the experimental research results obtained in the present study proved that the biodiesel production of *Tetraspora sp.* is potentially feasible.

Keywords biodiesel, direct transesterification, microalgae, low salinity medium, self-catalyst

ACKNOWLEDGEMENT

Bismillahirrahmanirrahim

All *praise* is due to *Allah*, the Lord of the Worlds. The Beneficent, the Merciful. Master of the Day of Judgment.

Firstly, I would like to express my sincere gratitude to my advisor Proffesor Dr Ku Halim Ku Hamid for the continuous support of my Ph.D study and related research, for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my Ph. D study.

Besides my advisor, I would like to thank to Proffesor Ir. Dr. Jailani Salihon for his insightful comments and encouragement to widen my research from various perspectives.

My sincere thanks also go to En Mohibah Musa and all laboratories staff in UiTM Terengganu, Kampus Bukit Besi and Kampus Dungun, who provided me an opportunity to conduct and set up experimental works and who gave access to the laboratory and research facilities. Without they precious support it would not be possible to complete this research.

Last but not the least, I would like to express my very profound gratitude to my beloved wife, Puan Roslina bt Ramli, and dearly loved children and also to my parents; Al- Fatihah is recited to my lovely mother, Allahyarhamah
and my lovely father, and all my families for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. *Alhamdulillah...*

Thank you.

Author

Ahmad Rozaimie bin Mustaffa

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF SYMBOLS	xiv
LIST OF ABBREVIATIONS	xv
CHAPTER ONE: INTRODUCTION	1
1.1 An Overview of Biofuel	1
1.2 Research Background	2
1.3 Problem Statement	3
1.4 Objectives	5
1.5 Scope of Work and Thesis Outline	6
CHAPTER TWO: LITERATURE REVIEW	8
2.1 Introduction	8
2.2 Microalgae Species	8
2.3 Photosynthesis	9
2.4 Microalgae Classification	11
2.4.1 Chlorophyta (Green algae)	11
2.4.2 Filamentous algae	12
2.4.3 Characteristic of <i>Tetrasporidium javanicum</i> K. Möbius	12
2.4.4 Chemical Composition of Algae	13
2.5 Algae Growth Dynamics	13
2.6 Growth Kinetic Modelling	15
2.6.1 Exponential Model	15