



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**DEVELOPMENT OF DYE SENSITIZED SOLAR CELL**

This report is submitted in accordance with the requirement of the Universiti Teknikal  
Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology  
(Industrial Power) with Honours.

by

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**BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA**

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## **APPROVAL**

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

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## ABSTRAK

Krisis tenaga adalah apa yang dihadapi oleh setiap negara hari ini. Banyak usaha telah ditumpukan untuk mengatasi masalah. Salah satu daripada beberapa penyelesaian yang ditawarkan adalah untuk membangunkan sel suria (SCs) sejak tenaga solar banyak dan bebas untuk digunakan. Sel solar pewarna terpeka (DSSCs) telah disiasat kerana kecekapan penukaran mereka dan dikenali sebagai pengeluaran kos rendah kerana bahan mudah diperolehi. Dalam kajian ini, ekstrak *plumeria rubra* digunakan sebagai pewarna untuk pemeka sel solar. Titanium dioksida berasaskan TiO<sub>2</sub> yang direka di kaca *Fluorine-Doped Tin Oxide* (FTO) sebelum menggunakan pemeka. Serbuk TiO<sub>2</sub> adalah bersalut berputar di atas kaca konduktor *Fluorine-Doped Tin Oxide* (FTO) yang diuji pada suhu dan berat yang berbeza dari Tio<sub>2</sub>. Pengimbasan Mikroskop Elektron (SEM) digunakan untuk mencirikan morfologi dan struktur bahan. Pembangunan DSSC menyediakan maklumat berguna untuk kajian lanjut yang berkaitan dengan penggunaan pigmen semulajadi sebagai peka bagi sel solar. Sel solar yang sensitif dye dengan dimensi 2.5 cm x 2.5 cm dibuat dengan menggunakan kaedah percetakan skrin titanium dioksida (TiO<sub>2</sub>) dengan meletakkannya pada kaca bersalut Fluorine-Doped Tin Oxide (FTO). Kemudian, sel solar diuji di bawah cahaya matahari. Dye yang diekstrak dari plumeria rubra dengan kelikatan TiO<sub>2</sub> 1.0 g adalah pewarna semulajadi yang paling diingini dalam julat pewarna semulajadi yang dipilih, dengan nilai Isc (0.0064 mA), Voc (272.3mV), FF (0.833), dan  $\eta$  (0.00145).

## ABSTRACT

Energy crisis is what being faced by every country today. Many efforts have been devoted to overcome the problems. One of several offered solutions is to develop solar cells (SCs) since solar energy is abundant and free to use. Dye-sensitized solar cells (DSSCs) were investigated for their conversion efficiency and known as low cost production because of the material is easily to get. In this research, plumeria rubra extract was employed as the dye for TiO<sub>2</sub>-based DSSC. Titanium dioxide (TiO<sub>2</sub>) is fabricated on the Fluorine- Doped Tin Oxide (FTO) glass before applying the sensitizer. TiO<sub>2</sub> powder was spin-coated on top of Fluorine- Doped Tin Oxide (FTO) conductive glass tested at different temperature and weight of Tio<sub>2</sub>. Scanning Electron Microscope (SEM) were used to characterize the morphology and structure of the material. Development of DSSC providing useful information for further studies related to the use of natural pigments as sensitizers for solar cells. Dye sensitized solar cell with dimension 2.5 cm x 2.5 cm is fabricated by using screen printing method of titanium dioxide (TiO<sub>2</sub>) by putting it on Fluorine- Doped Tin Oxide (FTO) coated glass. Then, the solar cell is tested under sunlight. Dye extracted from plumeria rubra with TiO<sub>2</sub> viscosity 1.0 g is the most desired natural dye within the selected range of natural dye, with a value of I<sub>sc</sub> (0.0064 mA ), V<sub>oc</sub> (272.3mV) , FF (0.833), and  $\eta$ ( 0.00145).

## **DEDICATION**

To my beloved parents

Zairi Bin Razali (father)

Asiah Bt Seleman (Mother)

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Alhamdulillah and a great thanks to Allah for His willing to give me the permissions and strength to complete this final year project. I also want to express my deepest appreciation to my supervisor, Pn Emy Zairah Binti Ahmad for his guidance and supervision throughout the project. There are no proper words to convey my gratefulness and respect for all the guidance and information given regarding to the project of “Development of Dye Sensitized Solar Cell”.

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# TABLE OF CONTENTS

<b>TABLE OF CONTENT</b>	vii
<b>LIST OF TABLE</b>	x
<b>LIST OF FIGURE</b>	xi
<b>LIST OF ABBREVIATIONS, SYMBOL AND NOMENCLATURES</b>	xiii
<b>CHAPTER 1</b>	<b>1</b>
<b>INTRODUCTION</b>	<b>1</b>
1.0    Introduction	1
1.1    Research Background	1
1.2    Problem Statement	3
1.3    Project Objectives	4
1.4    Project Scope	5
<b>CHAPTER 2</b>	<b>6</b>
<b>LITERATURE REVIEW</b>	<b>6</b>
2.0    Introduction	6
2.1    Renewable Energy	6
2.1.1    Biomass Energy	7
2.1.2    Geothermal Energy	8
2.1.3    Wind Energy	10
2.1.4    Hydropower	12
2.1.4.1    Rate of Rainfall	13
2.1.4.2    Rate of rainfall in Malaysia	13
2.1.4.3    Rate of rainfall in Malacca	16
2.2    Solar energy	17
	xiii

2.2.1	Rate of Sunlight	18
2.2.2	Rate of sunlight in Malaysia	18
2.2.3	Rate of sunlight in Malacca	21
2.3	Type of Solar Cell	22
2.3.1	Monocrystalline Solar Panels (Mono-SI)	22
2.3.2	Thin Film Solar Cells	23
2.3.3	Dye-Sensitized Solar Cells	23
2.4	Review of Dye-Sensitized Solar Cell	24
2.4.1	Working Principles of Dye-Sensitized Solar Cells (DSSCs)	27
2.5	The Component of the DSSC	28
2.5.1	The Working Electrode (TiO <sub>2</sub> )	29
2.5.2	The Redox Mediator	30
2.5.3	The Two Electrode	31
2.5.4	The Sensitizer Dye	31
2.6	DSSC Construction	32
2.7	I.V Characteristics	34
2.8	Dye from Natural Plant	36
2.8.1	Dye from Plumeria rubra	36
<b>CHAPTER 3</b>		<b>37</b>
<b>METHODOLOGY</b>		<b>37</b>
3.0	Introduction	37
3.1	Project Work Flow	38
3.2	Materials and Method	41
3.3	Preparation of the TiO <sub>2</sub> Suspension	42
3.4	Preparation of the Dye	44

3.5	The Sensitizing Process	45
3.6	The Mounting of the Sample	46
3.7	The Scanning Electron Microscope (SEM)	48
3.8	Current-Voltage (I-V) Characterization	49
3.9	DSSC Design	50
3.10	Experimental Implementation	51
3.10.1	Experiment 1: Test DSSC in Terms of Different Weight	51
3.10.2	Experiment 2: Test DSSC in Different Temperature of TiO <sub>2</sub>	56
<b>CHAPTER 4</b>		<b>60</b>
<b>RESULT AND DISCUSSION</b>		<b>60</b>
4.0	Introduction	60
4.1	Analysis by Using Scanning Electron Microscopic (SEM)	60
4.2	Results of Effect dye loading period on Photovoltaic response	63
4.3	Results of Annealing Temperature on Dssc	67
4.4	Results of Viscosity of Titanium Dioxide Mixture	69
4.5	Analysis Current-Voltage (I.V) Characterization	72
<b>CHAPTER 5</b>		<b>75</b>
<b>CONCLUSION AND RECOMMENDATIONS</b>		<b>75</b>
5.0	Conclusion	75
5.1	Recommendations	76
<b>REFERENCE</b>		<b>77</b>
<b>APPENDIX</b>		<b>80</b>

## LIST OF TABLES

Table 2.0: The average of global solar radiation (G) and extraterrestrial solar radiation (Go)	20
Table 4.1: Effect of TiO <sub>2</sub> impregnation period into dye on voltage	63
Table 4.2: Effect of TiO <sub>2</sub> impregnation period into dye on current	64
Table 4.3: Results of Annealing Temperature on Dssc	67
Table 4.4: Results of Viscosity of Titanium Dioxide Mixture	70
Table 4.5: Result from calculation	73

## LIST OF FIGURES

Figure 2.1: Schematic View of Generating Electricity	10
Figure 2.2: Development of wind turbines estimate size	11
Figure 2.3: Global Annual Installed Wind Capacity 1997-2014	11
Figure 2.7: Electricity production in the world	12
Figure 2.8: Precipitation locations	14
Figure 2.9: Northeast monsoon and Southwest monsoon season	14
Figure 2.10: Intermonsoon season (MA) and (SO) [9]	15
season (MA) and (SO) [9]	15
Figure 2.11: The average of rainfall on Malacca	16
Figure 2.4: Annual average solar irradiance distribution	18
Fig. 2.5: The average of daily sunrays	20
Figure 2.6: Average monthly total of sun hours over the year in Malacca	21
Figure 2.12: Schematic representation of the components and of the basic operating principle of a DSSC [15].	28
Figure 2.13: Schematic configuration of DSSC	33
Figure 2.14: The photocurrent-photovoltage curve of the cell	34
Figure 2.15: Plumeria rubra flower	36
Figure 3.0: Flowchart of Project DSSC	38
Figure 3.1: Flowchart of material selection for DSSC	39
Figure 3.2: Process of blending a TiO <sub>2</sub>	43
Figure 3.3: A TiO <sub>2</sub> paste on FTO glass	43
Figure 3.4: The process of extracting chlorophyll pigments	44
Figure 3.5: Sintering TiO <sub>2</sub> paste	45
Figure 3.6: TiO <sub>2</sub> film immersed into dye solution	46

Figure 3.7: Filling of the DSSC with liquid electrolyte	47
Figure 3.8: Complete dye sensitized solar cell	47
Figure 3.9: Scanning Electron Microscope (SEM)/EDX Machine	48
Figure 3.10: Solar simulator	49
Figure 3.11: Isometric view	50
Figure 3.12: FTO coated glass	51
Figure 3.13: Digital analytical balance	52
Figure 3.14: Check for resistivity of FTO glass	52
Figure 3.15: Tape down the glass of each edge	53
Figure 3.16: Tio <sub>2</sub> paste on glass	53
Figure 3.17: FTO glass immersed into dye solution	54
Figure 3.18: Graphite coating	54
Figure 3.19: Filling liquid electrolyte	55
Figure 3.21: FTO coated glass	56
Figure 3.22: Tape down the glass of each edge	57
Figure 3.23: Tio <sub>2</sub> paste on glass	57
Figure 3.24: Process sintering	58
Figure 3.25: Graphite coating	58
Figure 3.26: Assemble DSSC	59
Figure 3.27: Process measurement in DSSC	59
Figure 4.0: The surface Tio <sub>2</sub> sample 1	61
Figure 4.1: The surface Tio <sub>2</sub> sample 2	61
Figure 4.2: The surface Tio <sub>2</sub> sample 3	61
Figure 4.3: The surface Tio <sub>2</sub> sample 4	62
Figure 4.4: The surface Tio <sub>2</sub> sample 5	62
Figure 4.5: Result comparison voltage each sample	65
Figure 4.6: Result comparison current each sample	65
Figure 4.7: Results comparison voltage based on temperature	68
Figure 4.8: Results comparison voltage based on temperature	68
Figure 4.9: Results comparison voltage based on viscosity Tio <sub>2</sub>	71
Figure 4.10: Results comparison current based on viscosity Tio <sub>2</sub>	71
Figure 4.11: Results I-V characteristic all sample	74

## **LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE**

CdTe - Cadmium telluride

CIGS - Gallium diselenide

CO<sub>2</sub> - Carbon dioxide

CRT - Cathode ray tube

DI - Distilled-water

DSSC - Dye-sensitized solar cell

FF - Fill-factor

FTIR - Fourier Transform Infrared Spectroscopy

FTO - Fluorine doped oxide

KWh – kilo watt hour

GWh – Giga Watt hour

In<sub>2</sub>O<sub>3</sub>: Sn or ITO - Indium tin oxide

SnO<sub>2</sub> - Tin Oxide

I<sub>sc</sub> - Short-circuit current

I<sub>max</sub> - Maximum current

EDX - Energy dispersive X-ray spectroscopy

N719 - Ruthenium dye or Black dye

SEM - Scanning Electron Microscope

SHETSCO - Sheda Science and Technology Complex Abuja

Si-Sc - Silicon Based Solar Cells

SnO<sub>2</sub>:F - Fluorine-doped tin oxide

TCO - Tin Coated Oxide

TiO<sub>2</sub> - Titanium dioxide

UV - Ultraviolet

UV-Vis - Ultraviolet-visible

Voc - Open circuit voltage

ZnO - Zinc Oxide



# CHAPTER 1

## INTRODUCTION

### 1.0 Introduction

In this section will explain the introduction of the project comprise of research background, problem statement, objectives, and scope of the project.

### 1.1 Research Background

The energy of solar that possibility could a decent candidate for a future renewable energy of source. Based on [1] the energy usage of the whole universe is a lot less than energy produced in one hour. Besides that, solar panel is catching energy from sun and convert to electrical energy with a minimal effort as a major test. The devices based on solar like photovoltaic cells being utilized to harvest energy from sun and the crystalline silicon photovoltaic cells is the greatest broadly utilized at give sun powered to power change efficiencies which is more than 20% for multicrystalline silicon solar cell but the

high cost of manufacturing and requirement of broad territory to put the solar panel. Solar cells have four types and one of them is crystalline silicon. A crystalline silicon is the supreme broadly utilized technology in terms of material type as well as in solar industry. Thin film solar cell are created due to cut cost and reducing the material.

Development of thin solar cells use thin layers that different type of semiconductor materials which is consists of formless silicon, cadmium telluride (Cdte), and copper indium gallium Di-selenide (CIGS). Though a thin film technology have need of fewer materials, an unpredictable generation procedures are costly and could possibly restrain the rare earth materials. (Souad A. M. Al-Bat'hi *et al.*, 2013).

Nanotechnology is as of now a blasting trend in the science and technology. Advancement of technology in sector engineering has created an innovative of photovoltaic resources with the systems is easy to understand as alternative way for next generation. The resources of photovoltaic an incorporate distinctive sorts of materials from natural things, non-natural things, and non-particle methods. The natural materials of solar cells have a few problem like a minor of efficiency compare to the inorganic in term of materials that have better efficiency (R. Syafinar *et al.*, 2015).

The others type of solar energy is a dye sensitized solar cells that the most of trending research and has been produced by Professor Gratzel in 1991. There are two types of dyes such as synthetic dye and natural dye. In term of costs, synthetic dye is expensive and effect to environment compare to natural dye that a low costs and eco-friendly. The DSSC construction consist a semiconductor material as a base and titanium

dioxide function used as an absorbers of light. A titanium dioxide is weak in term of efficiency, when process of changing energy from sun to electrical energy (Julio et al., 2016). The DSSC of solar cells is the best system to develop based on low cost of materials and suitable technology for the future, the venture of DSSCs as a technology that is environmentally friendly (Federico Bella et al., 2015).

## **1.2 Problem Statement**

Nowadays, non-renewable energy source like fossil fuel had been commanded in energy sector especially in Malaysia and others non-renewable energy source such as coal source also greatly used in Malaysia with 40%. Unfortunately, fossil fuel is constrained and will run out. Indeed, until now fossil fuel are fully imported from different nations which is coal and liquid natural gas (TNB 2015). The local charge was slightly increase with value 5.60 cents in January 2014 from 40 cents in June 2011 with the rate 301 to 600kWh every month (Kettha, 2016). The request for electrical energy is steadily high due to the issues. Hence, for our future generations, the renewable energy is utilized to keep it the nation's natural resources to settle this issue.

Ruthenium based complex sensitizers which at present gives the best efficiency is exceptionally costly, it is profoundly harmful and not safe for people. Accordingly, an elective organic dye for example a natural dyes is recommended with high absorption coefficients and similar characteristic. Thus, the present work should investigate some

natural plants for use as sensitizers for DSSCs. According to the advantages of natural dyes are low cost of production and their easy availability. The sensitizers in natural dyes are connected to the chlorophyll (Julio Leyrer Eng *et al.*, 2016) introduce in the plants. These constituent atoms in type of hydroxyl and carbonyl group occurs naturally in fruit, flowers and leaf and are in charge for the exhibition of the types of colour observed in the visible red-to-blue spectrum.

### **1.3 Project Objectives**

For this study, the purpose is to assemble dye-sensitized solar cells from natural plant extracts with the following objectives:

- (i). To develop low cost fabrication dye-sensitized solar cells. The idea stands to produce a simplest method and inexpensive compared to the traditional solar cells. Plus, it is using the cheaper material and abundant.
- (ii). To analyze the parameters characteristic of a dye. By using one dyes; plumeria rubra, it used for sensitizer of the dye-sensitized solar cells.

## 1.4 Project Scope

The target of the project has been recognized yet to accomplish the goal, the scope of the project should be distinguished. The scope projects includes:

1. The material selections use  $\text{TiO}_2$  that is suitable for fabricating DSSC.
2. To test DSSC in terms of different weight of  $\text{TiO}_2$ .
3.  $\text{TiO}_2$  paste will be prepared at different temperature.
4. No comparison with Ruthenium based complex sensitizers due high cost.
5. The five FTO coated glass only use in testing.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.0 Introduction**

In this section, the background theory regarding the project is discussed. These part additionally featured previous investigation linked to the project.

#### **2.1 Renewable Energy**

In fact, energy could be renewable is the energy which came from nature source being replaced that can run excellent and more efficient for future. These comprise of sun rays, various forms of biomass, geothermal heat, tides, the wind, and water. This energy can't be depleted and continually restart. The renewable energy is boundless assets which is clean energy that supplant utilization of fossil fuel. This energy also are innocuous toward the surroundings, rather could utilized as a part of our day by day life and for our future. In addition, a portion of the renewable source of energy effectively current used.

6

The sort of energy could be renewable comprises of solar, hydro, geothermal, biomass, and wind energy.

### **2.1.1 Biomass Energy**

Biomass is a form of energy that stored from organic matter through the procedure of photosynthesis as it originates from the sun. Through the natural way of life to creatures human or animal bodies is the way how they exists. Generally, biomass energy is a never runs out of source for the upcoming years or a decade that took to forms a fossil fuels. Then, chlorophyll that from plants catches the heat of sun through the procedure of photosynthesis and oxygen, hydrogen and carbon is a form of gases that made out of carbohydrates-complex mixes from a process water and ground. It will transform to gases which is carbon dioxide and discharge the vitality when carbohydrates were charred. After that, this kind of energy is a recyclable and also utilizations for fuel burning. Generally, in term of charge is more profitable by using this kind of energy. As indicated by (Cerutti *et al.*, 2015) ordinarily they cost around 1/3 not as much as fossil fuels doing likewise work.

Besides that, usually biomass energy utilized as dynamic purposes is straightforwardly to create heat after combustion, however an options could accessible toward give naturally stable warmth as fine and in addition transportation energizes from natural material. According to the framework shown in Figure 2.0, it discussed about the

quantity of people depending on out-dated biomass (millions) for culinary as prime source.

Region	2009 (Actual)			2015 Total	2030 Total	Share of populations on biomass (%)		
	Rural	Urban	Total			2009	2015	2030
Africa	481	176	657	745	922	67	65	61
Sub-Saharan Africa	477	1,176	653	741	918	80	77	70
Developing Asia	1,694	243	1,937	1,944	1,769	55	51	42
China	377	47	423	393	280	32	28	19
India	765	90	855	863	780	75	69	54
Other Asia	553	106	659	688	709	63	60	52
Latin America	60	24	85	85	80	18	17	14
Developing Countries*	2,235	444	2,679	2,774	2,770	54	51	44
World**	2,235	444	2,679	2,774	2,770	40	38	34
Africa in % of World	22%	40%	25%	27%	33%			

Figure 2.0: The quantity of people depending on out-dated biomass (Cerutti et al., 2015)

Bangladesh is the one of the country that have high potential in biomass energy. This is proven because there are a lot of biomass energy of source that available such as animal waste, crop, and lumber [4].

### 2.1.2 Geothermal Energy

Geothermal energy is generated by thermal energy on earth. They are free pollution and ecological. In addition, they are discovered a couple miles underneath of