PERFORMANCE OF TROPICAL DYE-SENSITIZED SOLAR CELLS

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This book dedicated to Mom and Dad.

Thank you for your love and sacrifice

***

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ABTRACT

Sunlight possesses generated current and voltage to generate the power energy of electricity. Therefore, the fundamental measure from the solar cells procedure will be generation of light whereby must regarded how to produced the carrier. Dye-sensitized solar cell is known to be the low cost production because of the material is easily to get. Dye-sensitized solar cell (DSSC) is fabricated using the screen printing method which Melastoma Malabathricum and Cucurma Longa used as the sensitizer of the solar cell. These natural dyes were extracted without addition of any chemical because to identify the parameters or the characteristic of the solar cell. Plus, the efficiency may affect due to the reaction. Titanium dioxide (TiO_2) is fabricated on the indium tin oxide glass before applying the sensitizer. The highest efficiency is about 0.025% where it is a cucurma longa or turmeric sensitizer with the mesh size 200 POL and 1g titanium dioxide viscosity. The value of the Voc is equal to 337mV, Isc is equal to 0.0214mA and the fill factor = 0.86. In other hand, this report will discussed the comparison with other types of sensitizer such as raspberry and dragon fruit.

ABSTRAK

Cahaya matahari mempunyai arus dan voltan untuk menjana tenaga kuasa elektrik. Oleh itu, langkah yang asas dari prosedur sel-sel solar akan menjadi generasi cahaya mana mesti dianggap bagaimana untuk dihasilkan pengangkut. Sel solar pewarna terpeka dikenali sel solar yang sangat murah dari segi kos pembuatan dan pengeluarannya di mana bahan-bahan yang digunakan mudah didapati. Sel solar pewarna terpeka (DSSC) menggunakan kaedah percetakan skrin di mana *Melastoma malabathricum* dan *Cucurma longa* digunakan sebagai pemeka sel solar. Pewarna semula jadi ini digunakan tanpa campuran sebarang bahan kimia kerana untuk mengenal pasti parameter atau ciri sel solar secara semulajadi. Tambahan pula, kecekapan boleh terjejas disebabkan tindak balas kimia. Titanium dioksida (TiO2) dilapiskan di atas kaca oksida timah indium sebelum meletakkan pemeka itu. Kecekapan paling tinggi adalah lebih kurang 0.025% di mana ia hasil daripada tindak balas pemeka *Cucurma longa* atau kunyit dengan saiz *mesh* 200 POL dan 1g kelikatan titanium dioksida. Nilai Voc=337mV, Isc = 0.0214mA dan *fill factor* = 0.86. Selain daripada itu, perbandingan dengan pemeka yang lain seperti buah rasberi dan juga buah naga akan turut dibincangkan dalam laporan ini.

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CdTe	-	Cadmium Telluride
CIGS	-	Copper Indium Gallium Selenide
DSSC	-	Dye-Sensitized Solar Cell
DSSCs / DSCs	-	Dye-Sensitized Solar Cells
OPVCs	-	Organic Photovoltaic Cells
NREL	-	National Renewable Energy Laboratory
TiO_2	-	Titanium Dioxide
Voc	-	Open-Circuit Voltage
Isc	-	Short-Circuit Current
Jsc	-	Short-Circuit Density
ITO	-	Indium Tin Oxide

CHAPTER 1

INTRODUCTION

1.1 Introduction

The rapid improvement along with the modern day development while increasing populations about 29.24 million people in Malaysia today offers the increasing of the energy usage in resource as well. Apart from that, developments of the population offers result in more propane make use of to generate electrical energy for the reason that the desire increased[1]. In addition, with the increasing expense of the electrical energy these days as well as the global heating along with local climate modify tend to be major concern dealing with the globe these days. The conventional resources additionally turn out to be major problem across the world seeing that right now there reducing daily for the reason that the increasing of the population along with due to in which green energy has been unveiled. Green energy or renewable energy usually thought as vitality emanates from healthy methods in which constantly replenished upon human being timescale just like sunlight, blowing wind, rainfall, tides, lakes and also geothermal warm.

Figure 1.1 : Example of renewable energy

Malaysia renewable energy is made of biomass, biogas and modest hydro and also solar cells. Biogas is usually identifies a new petrol that is generated by your breakdown of the normal subject inside the lack of oxygen. Biomass create subject operating out of carbon dioxide, hydrogen along with oxygen in term of modest hydro could be the improvement regarding hydroelectric strength as it is usually a renewable energy in which changes sunlight energy into electrical energy. There are four common solar cells and there are monocrytalline, polycrystalline, thin film and hybrid solar cell.

Monocrytalline cells develop the best efficiency among any kind of cells however as the increased generation expense in comparison with polycrystalline cells possess generally cheaper every watt as the strength develop but the polycrystalline cells slightly much less efficient when compared with monocrystalline cells yet need more space of roof area to get the same result volume. In thin film solar cells or also known as amorphous, silicon cells comprise with silicon atoms within a skinny layer rather than a very composition. Thin film solar cell can absorb the light readily compared to the other traditional solar cells. Therefore, the cells can be much slimmer and thinner[2].

Photovoltaic is currently the fastest developing technology in which accustomed to make electrical energy throughout electricity production. Over 90% of the material found in solar based on silicon for the reason that source material. This material is among the most valuable pieces of solar panels based on silicon. Thin films with silicon-based solar panels tend to be inexpensive choice. There are about three most common thin films solar panels these days for instance Copper Indium Gallium Selenide (CIGS), Cadmium Telluride (CdTe) along with Amorphous Silicon (a-Si).

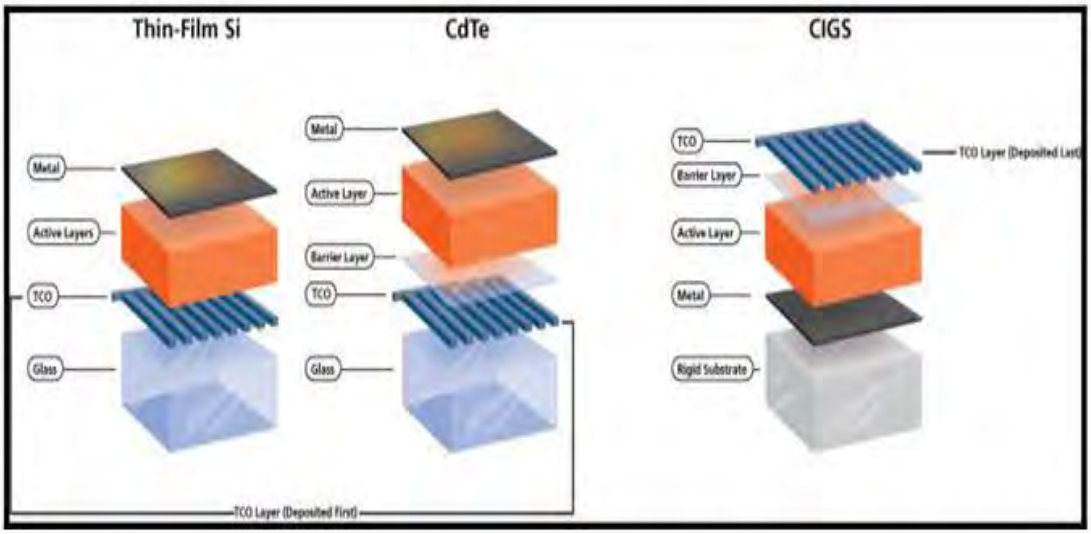

Figure 1.2 : Three types of common thin film solar cell

Figure 1.2 shows that three types of thin film solar panels in which common these days. CIGS has the best efficiency with having 20. 3% compared to the other two only 16. 5% along with 13. 3% for CdTe and as well a-Si. These efficiencies for cells area from ~0.25cm^2 to ~1cm^2 yet smallest cell area is a-Si with 0.25cm^2. TCO or transparent conductive oxide applicable to solar cells to increase the efficiency of the converted solar cells and matched with absorption spectrum of the solar cells. This is because solar cells suffer efficiency loss due to spectral mismatch. Although CIGS has highest efficiency yet CdTe has slightly different efficiency and also low cost in manufacturing. These low cost can reduce the money used in production and bill payment for user[2].

Dye-sensitized solar cell is one of the thin film solar cells. In addition, it is the latest generation of the thin film. It is well-known as the low cost manufactured

of solar cell[3]. Dye-sensitized solar cell made of low cost materials and cheaper manufacturer. The flexibility of the dye-sensitized solar cell give the advantage as it makes life goes easier. This is because due to the flexible dye-sensitized solar cell, it can be carrying out even can be fold and save more space. It can absorb diffused sunlight and fluorescent light. Moreover, the solar cells also work in cloudy weather and low light condition.

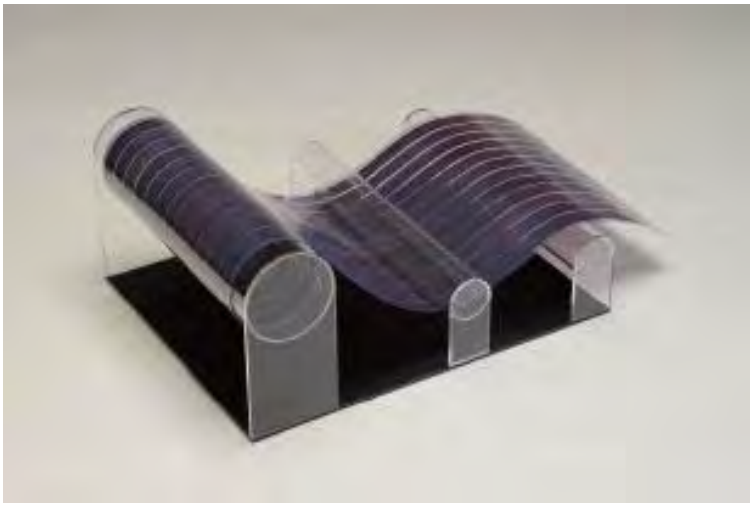

Figure 1.3 : Flexible dye-sensitized solar cell[4]

When the cost has been the benefit of the dye-sensitized solar cell, there are also drawbacks such as the current efficiency is still low compared to the other traditional solar cell. The electrolyte solution that used in developing the solar cell contains volatile organic solvents and must carefully seal[5]. Generally, dye-sensitized solar technology uses liquid electrolyte that has temperature stability problems. For example, at the low temperature, the electrolyte may freeze and stopping power production as well as lead to physical damage. While at higher temperature it will cause the electrolyte to expand and the panel sealing process a major problem.

Dye-sensitized solar cell is still at early stages of the development cycle. With widespread studies and experiment, the efficiency may gain as high as the traditional solar cell. The dye-sensitized solar cell has more advantages compared to the other solar cell as the manufacturing need low cost production. Besides that, it can be made only in laboratory or even in the garage. Overall, the dye-sensitized solar cell technology actually an attractive technology where by using the natural

dyes it may create different colour or even pattern for the solar cell. Although the efficiency not as high as the other, but currently even small increases in the dye-sensitized solar cell conversion efficiency may cause them suitable for some roles[6].

1.2 Objective

1) To develop low cost fabrication dye-sensitized solar cells.

The idea is to produce a simplest method and inexpensive compared to the traditional solar cells. Plus, it is using the cheaper material and abundant.

2) To analyze the parameters characteristic of two tropical dye

By using two tropical dyes; shrub and turmeric, it used as the sensitizer of the dye-sensitized solar cells. In order to analyzed the characteristic, it will coat TiO_2 and carbon soot.

1.3 Problem Statement

The increasing demand on fossil fuel is shocking as the increasing population worldwide. Therefore, the solar cell is produced to get the solar energy that generates electricity from the sun. But the cost of the crystal silicon-based production is massively high with the cost.

Cadmium telluride is the promising solar technology with the production cost as low as USD 0.75. In other hand, the solar cell is the biggest in Malaysia under First Solar Company. Although the cadmium is abundant, it is highly toxic and not safe for other people. Plus, the fabrication cannot be done in a free space because it will harm community.

As in the project, the thin film solar cells it used to overcome the silicon-based cost production but need to find the solution of toxicity material as well as the efficiency of the solar cells should be measured.

1.4 Scope

The objective of the project has been identified yet to achieve the objective, the scope of the project need to be identified. The scope projects includes :

1) The performances of the dye-sensitized solar cells not only depend on the sensitizer but also depend on the viscosity of titanium dioxide.
2) To ensure the result of the parameters is equivalent, the annealing process is equal to 200°C.
3) The titanium dioxide size area equals to 0.5 x 0.5.

1.5 Brief methodology

In this thesis, there will be five chapters where each chapter described all the project flow including the fundamental of the solar cell and also the equipments used in the project.

Chapter 1 : A brief introduction of the recent issue regarding the non-renewable sources. In addition, the aim the project as well as the problem statement and the scope of the project will be explained further in the chapter.

Chapter 2 : The fundamental of the solar cells will be described in the chapter and also the history of the solar cell may be explained as well. Furthermore, the feasibility study that related with the project also been explained in the chapter.

Chapter 3 : Methodology is the process that used in the project. In this chapter, the equipments and all the materials are explained. Plus, the procedures to fabricate the solar cell also included.

Chapter 4 : After the process done, the result and discussion as well as the analysis will be described and explained in this chapter. Nevertheless, the calculation of efficiency also been defined.

Chapter 5 : The final chapter is about the conclusion of all fabrication process and point the best material in the project. Not to forget, the recommendations also been described in the chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter includes the background study about the solar cell specifically about dye-sensitized solar cell also the working principle of the solar cell itself. In addition, this chapter will include the history or generation of the solar cell. It also discusses on the deposition of the solar cells.

2.2 Working principle

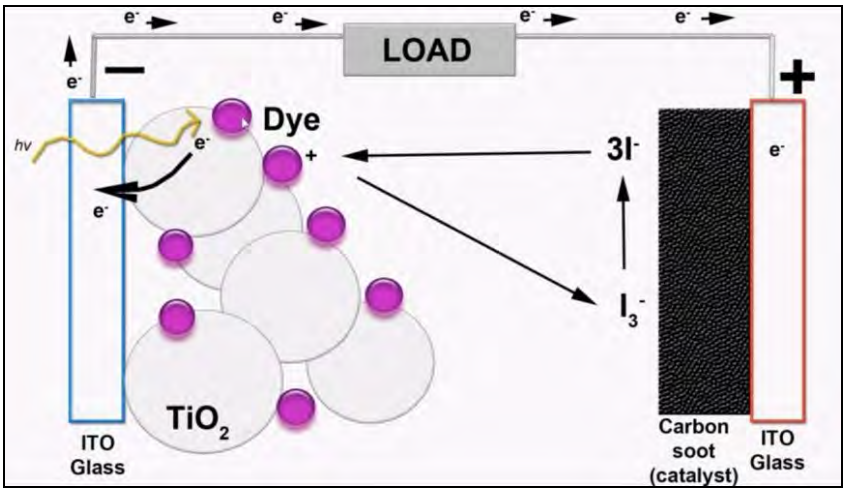

Figure 2.1 : Chemical reaction

When light hits the solar cells, the anthocyanin dye molecules absorb the light and inject electrons into the conduction band of the semiconducting titanium dioxide (TiO_2). The anthocyanin dye then oxidized during the process. The electrons in the titanium dioxide migrant along and eventually hit the conductive indium tin oxide (ITO) glass. After that, it flows as a current through the load. Then, the electrons leave the load and go to the back indium tin-oxide glass. Within the process, they reduce the tri-iodide ions into iodide ions using the carbon soot as the catalyst to speed up the reaction. The chemical electrolyte in the cell then closes the circuit so that the electrons are returned back to the dye molecules. The iodide itself becomes tri-iodide again and then reduced dye-molecules are now ready to convert the next photons of light[7].

2.3 Brief History

The discovery of photovoltaic happened in 1839 when Alexandre Edmond Becquerel the French physicist explains how sunlight can generate the electricity[8]. This is happen when he experimenting two metal electrodes or electrolytic cell placed in electricity-conducting solution. Then he found that electrical current could be increase when exposed to light.

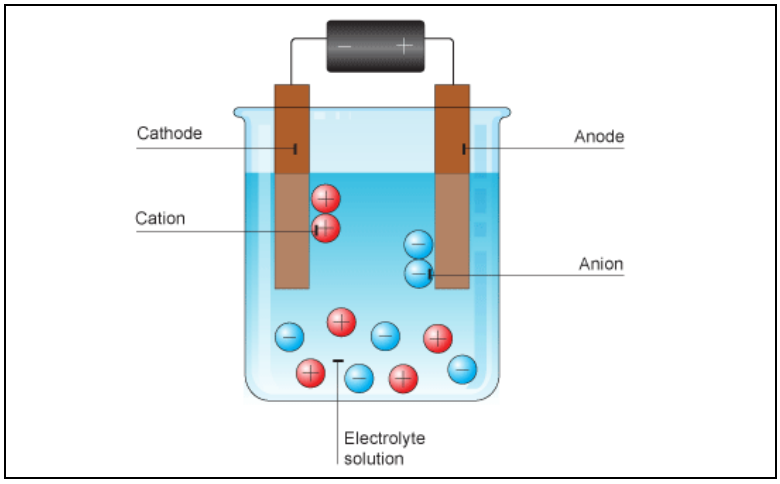

Figure 2.2 : Electrolysis

Albert Einstein the famous physicist received Nobel Prize for his understanding Edmond's work and he described theories of photoelectric effect in 1912.

2.4 Generations

Solar cells are divided into three main categories called generations. The first generation contains solar cells that are relatively expensive to produce. Traditional solar cells are made from silicon, are currently the most efficient solar cells. Silicon based solar cells long lasting compared to non-silicon but highly risk loss some efficiency as the temperature heating up highly.

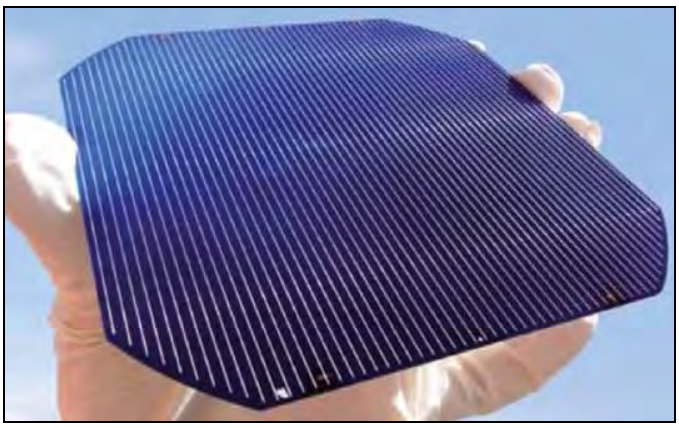

Figure 2.3 : Black silicon-based solar cell

The second generation contains types of solar cells that have an even lower efficiency, but much cheaper to produce, such that the cost per watt is lower than in first generation cells. Usually second generation solar cells are called thin-film solar cells such as amorphous silicon, CdTe and CIGS. The third generation solar cells are being made from variety of new materials including conventional printing press technologies, organic dyes and conductive plastics.

Figure 2.4 : First Solar CdTe solar cell

The third generation is used about cells that less efficient. Most techniques of this generation is not yet commercial, but there is a lot of research going on as the goal is to make the third generation solar cells cheap to produce.

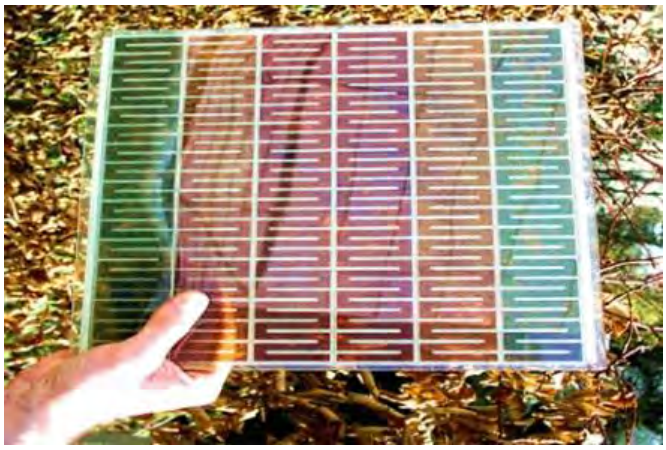

Figure 2.5 : Dye-sensitized solar cell

2.5 Feasibility study

A dye-sensitized solar cell also called as the Grätzel cell as it was named upon Michael Grätzel name because the solar cell was invented by him and Brian O'Regan during the year of 1991. The dye catches photons of incoming light which are sunlight and ambient artificial light[9]. Then use the energy to excite electrons; behaving like chlorophyll in photosynthesis. Grätzel has used mostly artificial dyes but also try some of natural dye. So the idea is can we use any dyes to generate electricity?

Conventional organic photovoltaic devices use a donor and an acceptor type of organic materials, which form a heterojunction favouring the separation of the excitation into two carriers. Those formed carriers are then transported to the electrodes by the same organic materials that are used for the generation of an excitation. That is a material for classical organic photovoltaic devices should have both good light harvesting properties and good carriers trans-porting properties which is a difficult task to achieve. On the other hand, the dye-sensitized solar cell (DSSC) technology separates the two requirements as the charge generation is done at the semiconductor-dye interface and the charge transport is done by the semiconductor and the electrolyte. That is spectral properties optimization can be basic molecule structure done by modifying the dye alone, while carriers transport