PERFORMANCE EVALUATION OF DYE SENSITIZED SOLAR CELL FOR VARIATION TiO_2 THICKNESSES

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LIST OF SYMBOLS, ABBREVIATION OR NOMENCLATURE

Ω	Ohm
μ	Mikro
η	Efficiency
λ	Wavelength
%	Percent
^{o}C	Derajat Celcius
A	Ampere
V	Volt
W/m^2	Watt Per Meter Square
mL	Milli Liter
$Ti0_2$	Titanium dioxide
PTEC	Photon to Electric Conversion
Jsc	Short circuit current
Voc	Open circuit current
ITO	Indium Tin Oxide
FTO	Fluorine doped Tin Oxide
TCO	Transparent and Conductive Oxide
DSSC	Dye sensitized solar cells
EDC	Electronic Digital Calliper
FF	Fill Factor
SEM	Scanning Electron Microscopy
N-Type	Negative
P-Type	Positive
EHS	Electromagnetic Hyper Sensitivity
AC	Alternating Current

DC	Direct Current
PWM	Pulse Width Modulation
MPPT	Maximum Power Point Tracking
NIR	Near Infrared
CERE	Centre of Excellence for Renewable Energy
PV	Photovoltaic
RM	Ringgit Malaysia
kW	Kilo Watt
kWh	Kilo Watt Hours
TNB	Tenaga Nasional Berhad
CIGS	Copper Indium Gallium Selenide
CdTe	Cadmium Telluride
A-Si	Amorphous Silicon
C-Si	Crystalline Silicon
QDSC	Quantum dot solar cells
QDs	Quantum dots
PECVD	Plasma Enhanced Chemical Vapor Deposition

Penilaian Prestasi Pewarna sensitif Sel Solar Untuk Perubahan Ketebalan TiO_2

ABSTRAK

Pewarna nanotitanium dioksida sensitif (TiO_2) sel solar (DSSC) adalah sejenis perabot sel solar menggunakan penggunaan pewarna untuk absorp sinaran matahari yang lebih kepada sel sel solar dan untuk mengarahkan sinaran solar di dalamnya untuk Circulate elektron. Komponen yang digunakan untuk membina nanotitanium dioksida (TiO_2) pewarna sensitif sel solar boleh dibahagikan kepada 4 bahagian dalam kes ini nanotitanium dioksida (TiO_2) sebagai anod dan karbon sebagai elektrod kaunter, merendam ia masuk Yang bertindak sebagai mekanisme penyerapan pewarna, menambah elektrolit dan akhirnya memasang mereka sebagai satu unit sel solar. Proses ini berfungsi sebagai penyerapan foton solar dari molekul matahari berfungsi sama seperti dalam fotosintesis daun hijau. A nanotitanium Pewarna sensitif dioksida (TiO_2) sel solar dengan dimensi 6 x 2 cm adalah rekaan dengan perubahan ketebalan 40 µm, 80 µm dan 120 µm daripada nanotitanium dioksida (TiO_2) dengan ia disapukan pada timah indium oksida (ITO) kaca bersalut. Ia kemudiannya diuji di bawah purata solar 693.69 W/m^2 sinaran dan suhu, 44.4 °C masing masing. Tesis ini mencadangkan penggunaan syzigium buah oleina sebagai pewarna organik novel. Syzigium oleina merupakan genus tumbuhan berbunga perabot milik keluarga myrtle, Myrtaceae. Penggunaan syzigium oleina pewarna berbanding blueberry menunjukkan penyerapan sinaran suria yang lebih tinggi dan boleh digunakan sebagai alternatif bagi lain lain jenis buah organik. Tesis ini mencadangkan juga merupakan sumber alternatif bahan karbon dari pada bateri kitar semula untuk fabrikasi elektrod kaunter sel solar sensitif pewarna. Berdasarkan siasatan ujikaji untuk ketebalan yang berbeza daripada 40 µm, 80 µm dan 120 µm, hasil Perabot menunjukkan voltan litar terbuka, nilai VLT adalah 0.21 V, 0.16 V dan 0.00063 V, masing masing manakala J_{SC} litar pendek 121.28 µA, 69.89µA dan 0 µA, manakala kecekapan sel sel (η) adalah 4.92%, 2.66% dan 0% dan mengisi faktor (FF) nilai adalah 1.1845, 1.49 dan 0 masing masing. Keputusanya nipis ketebalan lapisan sel sel solar TiO_2 prestasi yang lebih baik dan dengan menggunakan pewarna novel syzigium oleina kerana ia meningkatkan sel sel solar kecekapan. Keputusan juga menunjukkan am Perabot dengan menggunakan bateri kitar semula karbon dari tang ia membantu dalam kecekapan solar kepada 9.78%. Berdasarkan harga, kos DSSC direka 100 Watt adalah RM 688.05, dengan TiO_2 bahan, Indium timah oksida kaca bersalut, TritonX-100, Methoxyproprionitrile, syzigium oleina sebagai pewarna, kitar semula karbon dari bateri. Kami telah memilih Nhung Kerana bahan bahan yang mereka telah menghasilkan yang terbaik untuk peranti DSSC setakat ini, tenaga murah dan hijau dan menjimatkan RM 204.435,00 arang batu harga pasaran jika dibandingkan jenis PV modul 100 monocrystalline W dengan harga RM 750.00 setiap modul.

Performance Evaluation Of Dye Sensitized Solar Cell For Variation TiO_2 Thicknesses

ABSTRACT

Dye sensitized nanotitanium dioxide (TiO_2) solar cell (DSSC) is a type of solar cell that utilises the usage of dye as to absorp more sun rays on solar cells and to direct solar irradiance in it as to circulate electron. The components used to build a nanotitanium dioxide (TiO_2) dye sensitized solar cells can be divided into 4 parts in this case the nanotitanium dioxide (TiO_2) as the anode and carbon as the counter electrode, soaking it in dye which act as absorption mechanism, adding of electrolyte and finally assembling them as a unit of solar cell. The process of solar absorption works as the photons from the sun molecular works similarly as in photosynthesis of green leaves. A Dye sensitized nanotitanium dioxide (TiO_2) solar cell with a dimension of 6 x 2 cm is fabricated with variation thickness of 40 µm, 80 µm and 120 µm of nanotitanium dioxide (TiO_2) by smearing it on an indium tin oxide (ITO) coated glass. It is then tested under the average solar irradiance and temperature of 693.69 W/m^2, 44.4 ^oC respectively. This thesis proposes the use of syzigium oleina fruit as a novel organic dye. Syzigium oleina is a genus of flowering plants that belongs to the myrtle family, myrtaceae. The usage of syzigium oleina as dye compared to blueberries shows higher solar irradiance absorption and can be used as alternative of other types of organic berries. This thesis also proposes an alternative source of carbon material from recycled battery for the fabrication of the counter electrode of a dye sensitized solar cell. Based on experimental investigation for different thickness of 40 µm, 80 µm and 120 µm, result shows that the open circuit voltage, V_{oc} value is 0.21 V, 0.16 V and 0.00063 V, respectively while the short circuit J_{sc} are 121.28 µA, 69.89 µA and 0 µA, respectively while the cells efficiency (η) are 4.92%, 2.66% and 0% and fill factor (FF) values are 1.1845, 1.49 and 0 respectively. Results indicates that the thinner the TiO_2 coating thickness the better the solar cells performance and by using syzigium oleina as a novel dye it does increases the solar cells efficiency. Result also shows that by using carbon from recycle battery it helps in increasing the solar efficiency to 9.78 %. Based on prices, cost of fabricated 100 Watt DSSC is RM 688.05, with materials TiO_2, Indium tin oxide coated glass, TritonX-100, Methoxyproprionitrile, syzigium oleina as dye, carbon from recycle battery. We have chosen these materials because their combination has resulted in the best DSSC device so far, cheap and green energy and save RM 204,435.00 if compare than market price type of PV module is 100 W monocrystalline with price of RM 750.00 per module.

CHAPTER 1

INTRODUCTION

1.1. Background

Dye sensitized nanotitanium dioxide (TiO_2) solar cell (DSSC) have recently been developed as a cost effective photovoltaic system due to their low cost materials and facile processing. The production of DSSC involves chemical and thermal processes but no vacuum is involved.

A lot of researchers examined the dye sensitized solar cells M. Gratzel since the trade journal published in 1991 in which dye sensitized solar cells is very promising as a good alternative energy and easy manufacturing process. Dye-sensitized solar cells (DSSC) show great promise as an inexpensive alternative to conventional P–N junction solar cells. Investigations into the various factors influencing the photovoltaic performance in this novel approach have recently been intensified (M. Grätzel, 1998). Highly performance photon to electrical conversion, combined with ease of manufacturing and low production costs, make the DSSC technology an attractive approach for large scal esolar energy conversion (Smestad G, 1994).

M. Grätzel and O’Regan (1991) dye-sensitized solar cells (DSSC) have been studied in which the first DSSC design was based on single crystal zinc oxide. Due to the low film surface area for dye molecule adsorption, the performance of the first generation DSSC was very poor with photon to electrical conversion of 1 %.

Bai Yu & Cao yiming (2008) in their article that was published in nature materials demonstratedphoton to electrical conversion of 8.2% using a new solvent-free liquid redox electrolyte, as an alternative organic solvents (electrolyte solution) processed using advanced technology.

Huang and his team (2010) placed a TiO_2 thin film in between the carbon nanotube thin film and the porous layer. They found that the performance of dye sensitized solar cells with TiO_2 thin film was significantly better than those without it. However, they also found that the photon to electrical conversion of their new dye sensitized solar cells was only 1.8%, which is lower than that of conventional solar cells using ITO electrodes. This is due to the higher electrical resistances and reduced optical transparency of the carbon nanotube films, which limits the amount of sunlight entering the cell (www.akserooz.com).

In this thesis, the dye sensitized solar cells (DSSC) is fabricated without using any expensive equipment. The use of dyes and titanium dioxide (TiO_2) is one of the most promising approaches to obtain both high performance at low cost. A high photon to electrical conversion performance can be obtained from thickness variation of titanium dioxide (TiO_2) layers. Here, one also proposes an alternative to the p-type material which is carbon from recycle battery as the anode of solar cells. This approach is to improve the performance of dye sensitized solar cells. Finally to propose a new organic dye which is from syzigium oleina, this fruit is widely grown in Perlis, Malaysia and has sufficiently high adsorption characteristic.

In order to fabricate DSSC devices characterized by high performance and long term stability, further understanding on the area of DSSC is important. The key points of the DSSC mechanism are as follows:

1. Identifying the suitable Indium tin oxide conductive glass.
2. Preparation of TiO_2 paste containing suspension of TiO_2 particles.
3. Staining an Organic dye.
4. Preparation of counter electrode.

Each point listed above is necessary for the evaluation performance of DSSC. One of the key materials is the TiO_2 electrode, which has been fabricated by using the 'Dr.Blade' method, with this method the TiO_2 particle size and the thickness of the titanium dioxide TiO_2 layer can be varied. Thus, we can optimize the design of the porous TiO_2 electrode and sensitized the dye.

1.2. Aims and Objective

The aim of this research is to investigate variation thickness of nanotitanium dioxide (TiO_2) or N-Type material, novel organic dye and recycle carbon as counter electrode material. It is then investigated in terms of the characteristic of fabricated nanotitanium dioxide dye solar cells towards Solar Irradiance.

The objective of this research is to :

a) Fabricate dye sensitized nanotitanium dioxide (TiO_2) solar cell (DSSC)
b) Investigate the variation of N-Type thickness (40µm, 80µm & 120µm) towards open circuit voltage; Voc, short circuit current; Jsc, fill factors and solar cell efficiency (η).

c) Investigate the variation of counter electrode material by using carbon from worn out batteries as a recycling process and from pencil lead.

d) To investigate the performance of dye sensitized nanotitanium dioxide (TiO_2) solar cell (DSSC) by using novel organic dye.

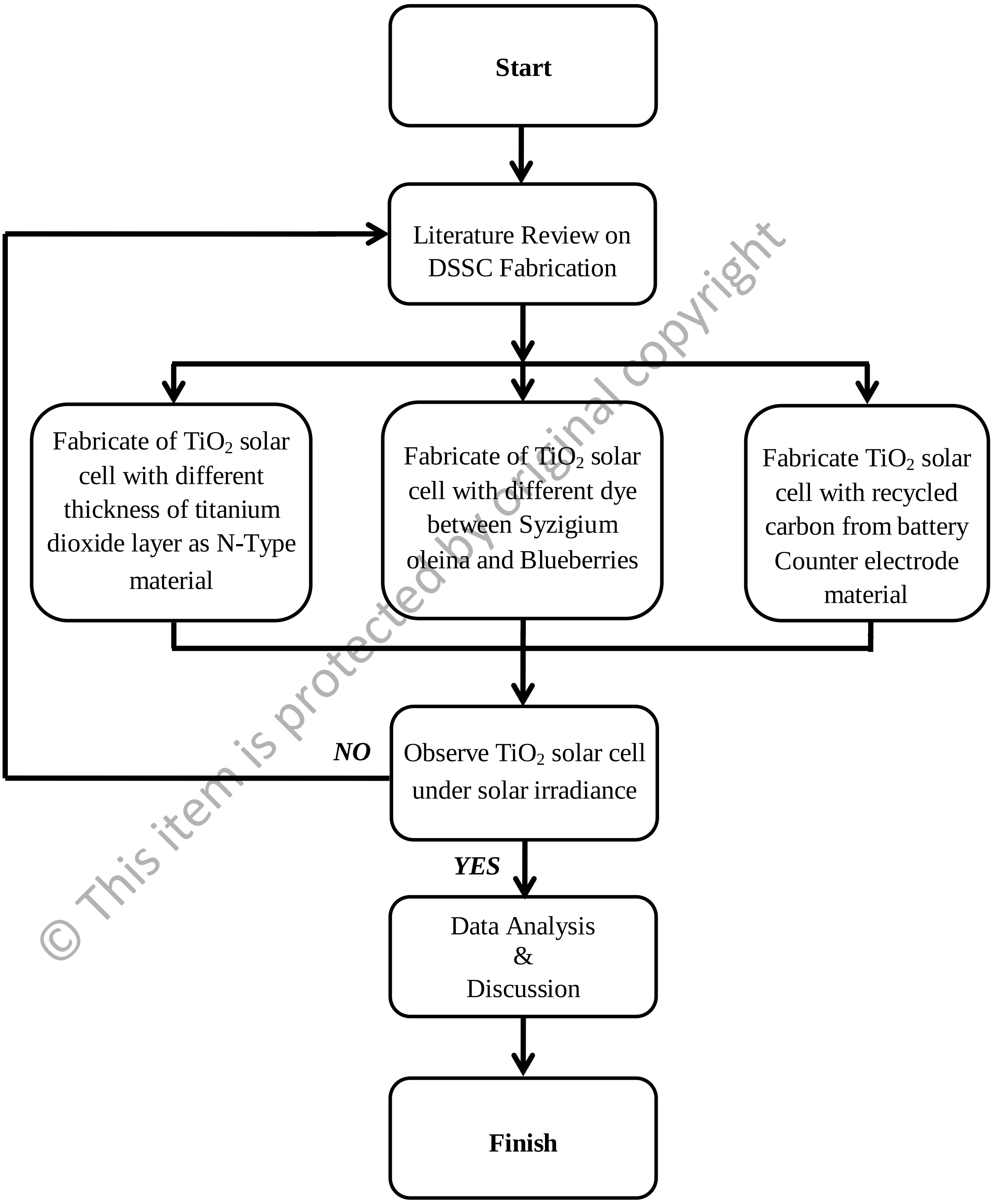
1.3. Problem Statement

There are several problems with solar cell. Most of these problems though are being solved. Currently the main problems faced by the solar cell industry are ;

1. Hard to manufacture
2. Manufacturing cost
3. Photon to electrical conversion(PTEC) too low
4. Type of Materials
5. Health hazardous

1.4. Project Flow

The project flow chart of research activities as shown in below.



1.5. Scope

The scope of this thesis revolves around the understanding of Solar cells physics and properties. It is important to know the effect of nanotitanium dioxide (TiO_2) thickness on dye sensitized solar cells performance, and also to know the chemical properties of TiO_2 for DSSC fabrication. Once the physical property of the TiO_2 is known, then the fabrication method of DSSC is essential for fabrication method. Finally the photon to electrical conversion (PTEC) efficiency is known and relevant information such as the open circuit voltage; Short circuit current and fill factors are known.

CHAPTER 2

LITERATURE REVIEW

2.1. Solar Technology

Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever evolving technologies. Solar energy technologies include solar heating, solar photovoltaics, solar thermal electricity and solar architecture, which can make considerable contributions to solving some of the most urgent problems the world now faces (IEA, 2011).

Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air (IEA, 2011).

In 2011, the International Energy Agency said that "the development of affordable, inexhaustible and clean solar energy technologies will have huge longer term benefits. It will increase countries" energy security through reliance on an indigenous, inexhaustible and mostly import independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating climate change, and keep fossil fuel prices lower than otherwise. These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared (IEA, 2011).

2.2. Energy from the sun

The Earth receives 174 petawatts (PW) of incoming solar radiation (insolation) at the upper atmosphere (Smil& Vaclav, 1991). Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near infrared ranges with a small part in the near ultraviolet (Smil& Vaclav, 2006).

Earth's land surface, oceans and atmosphere absorb solar radiation, and this raises their temperature. Warm air containing evaporated water from the oceans rises, causing atmospheric circulation or convection. When the air reaches a high altitude, where the temperature is low, water vapor condenses into clouds, which rain onto the Earth's surface, completing the water cycle. The latent heat of water condensation amplifies convection, producing atmospheric phenomena such as wind, cyclones and anti cyclones. (NASA Langley Research Center, 2006) Sunlight absorbed by the oceans and land masses keeps the surface at an average temperature of 14°C. (Somerville & Richard, 2007) Byphotosynthesis green plants convert solar energy into chemical energy, which produces food, wood and the biomass from which fossil fuels are derived (Vermass, 2007).

The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000 exajoules (EJ) per year. In 2002, this was more energy in one hour than the world used in one year. Photosynthesis captures approximately 3,000 EJ per year in biomass. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non renewable resources of coal, oil, natural gas, and mined uranium combined. Solar energy can be harnessed at different levels around the world, mostly depending on distance from the equator (Smil & Vaclav, 2006).