2014 IEEE 8th International Power Engineering and Optimization Conference (PEOCO2014), Langkawi, The Jewel of Kedah, Malaysia. 24-25 March 2014

Solar cell using Sensitizer Extracted from Organic Substances

N.Gomesh[1, a], R.Syafinar[1], M.Irwanto[1], Y.M.Yusoff[1], U.Hashim[2], N.Mariun[3]

[1]Centre of Excellence for Renewable Energy (CERE)
School of Electrical Systems Engineering
Universiti Malaysia Perlis (UniMAP)
Taman Pengkalam Indah
Jalan Pengkalam Assam
01000, Kangar, Perlis.Malaysia

[2]Institute Of Nano Electronic Engineering (INEE)
Universiti Malaysia Perlis (UniMAP)
Taman Pertiwi Indah, Seriab
01000 Kangar, Perlis, Malaysia

[3]Department of Electrical & Electronics Engineering
Faculty of Engineering
43400 UPM Serdang, Selangor.Malaysia.
[a]gomesh@unimap.edu.my

Abstract- **Renewable energy is rapidly gaining importance as an energy source that supports conventional energy from the deteriorating fossil fuels and coals. DSSC is another type of solar cell which has an advantage as low cost, easy to fabricate and is clean from contamination. This project presents the fabrication of Dye Sensitized Solar Cell (DSSC) using organic dyes from dragon fruit and spinach extract (chlorophyll) Fabrication of DSSC uses conventional Dr.Blade's method and measurement of DSSC is tested under halogen lamp as the light source for solar cell. Results shows that by using dragon fruit as sensitizer, the solar cells efficiency is 4.07% which is better than the use of chlorophyll dye which is 3.60%.**

I. Introduction

All parts of the visible spectrum from near-infrared to ultraviolet can be captured and transformed into electricity [1]. This project focuses on the fabrication of Dye sensitized solar cells using Organic dye. Organic dyes extracted from dragon fruit and chlorophyll from spinach is prepared for the fabrication of DSSC as sensitizer. DSSC is low cost, easy to fabricate and clean to environment which is doesn't use any chemical oriented.

II. Dye Sensitized Solar Cell (DSSC)

Dye sensitized solar cells (DSSC) has a potential as like any other photovoltaic technologies in existence, and in fact bear a somewhat loose resemblance to photosynthesis [2]. Components in a DSSC consists of a thin film coated of an electrolyte sandwiched between two electrodes (the top electrode being transparent to allow light into the cell with a lattice of dye-coated nano-scale titanium-dioxide (TiO_2) particles coating one of the electrodes. Fig. 1 shows the typical configuration of DSSC [3].

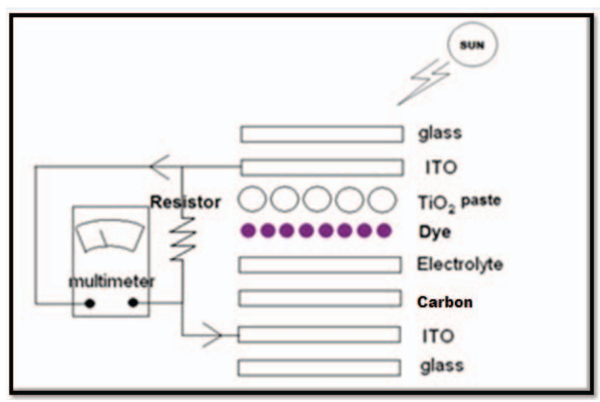

Fig. 1. Typical configuration of DSSC

This paper proposes the study on fabrication of dye sensitized solar cell DSSC mainly in using dyes from Dragon fruit, and Chlorophyll extracted from spinach. It is then compared in terms of Open Circuit Voltage (V_{OC}), Short Circuit Current (I_{SC}) and Solar cell Efficiency (η).

Organic Dye

Organic cells function in a slightly different way than most other cell technologies, instead of semiconductor p-n junctions, organic cells utilize electron donor and acceptor materials. The benefit of using organic materials is that it allows for the simple high volume low-temperature fabrication of flexible solar cells on plastic substrates. If the efficiency of the cells can be improved, organic cell technology could produce extremely low cost production of very versatile cells. Efficiencies of organic solar cells are currently around 10-11%, although vigorous research is being conducted to increase the efficiency values.

III. METHODOLOGY

Prepare Dye Solution for Dragon Fruit, Chlorophyll Dye and Blueberry Dye

For dragon fruit dye, fresh dragon fruit of weight 50 g is mixed into 50 ml distilled water with a ratio of 1:1 at room temperature [4]. Dragon fruit is blended with distilled water for 15 minutes until the dye changes into homogeneous in color (dark pink) as shown as Fig 2. For chlorophyll dye, spinach of a weight 100 g is mixed into 10 ml distilled water with a ratio of 1:1 at room temperature. This mixture is blended until mixture the dye is concentrated.

Fig 2. Organic Dyes as sensitizer

Preparation of Titanium dioxide (TiO_2) paste

3.5 g of (TiO_2) nano-powder P25 in 15 ml of ethanol is mixed. Solar bath it at least for 20 minutes. 0.5 ml of titanium (IV) tetraisopropoxide is added into the suspension based on Fig 3.

Fig 3. Preparation of TiO2 Paste

Fabrication procedure of dye sensitized solar cells (DSSC)

The scotch tape is applied on four corners of the conducting side of ITO glass; the scotch tape thickness is measured by using electronic digital calliper. Apply the TiO_2 paste and flatten it with a razor blade on the same side of the ITO glass. After the flattening process, the ITO glass is annealed on top of a hot plate at approximately 450 ºC for 30 minutes. After 30 minutes, the ITO glass is left to be cold in open air before it is dip into the dye solution (dragon fruit dye and chlorophyll dye) for a day. As for the counter electrode, graphite from pencil is sketched on the conducting surface of another ITO glass. The TiO_2/dye electrode is removed from the dye solution and is rinsed with ethanol to remove debris. The spacer is placed on the TiO_2/dye electrode and some drops of the electrolyte solution is drip onto the TiO2/Dye layer. Both the electrode and counter electrode is combined facing each other by a binder clips. Using binder clip, the p-n type will be combined together. Step by step process is shown in Fig 4.

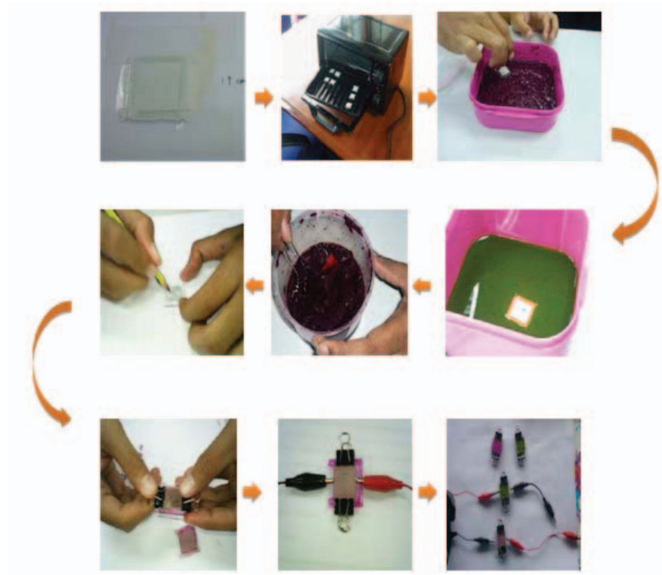

Fig 4. Steps of fabrication of DSSC

Procedure to record data of voltage and current (indoor)

The fabricated solar cell is than placed under a halogen lamp which acts as a light source. The required parameters are taken as shown in Fig 5.

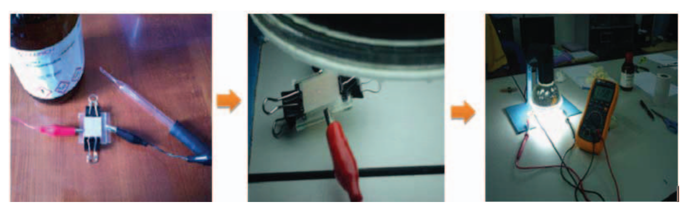

Fig 5.Indoor measurement by using halogen lamp

IV RESULT AND DISCUSSION

After fabrication, the DSSC are placed and measured under outdoor and indoor irradiation, the samples are measure in terms of its open circuit voltage (V_{OC}), current short circuit (I_{SC}), Fill Factor (FF) and Solar cells Efficiency (η). The effect usages of three dyes are than compared.

Fill Factor (FF)

Fill Factor is the ration of to the area of rectangle perform by and that commonly used number that characterized the solar cell is the fill factor (FF). Parasitic losses like series resistance and shunt resistance will strongly affect the Fill Factor (FF). Voltage open circuit (V_{OC}) also affects the Fill Factor (FF). When V_{OC} and I_{SC} are good, it can have drastic effect on actual efficiency. Calculation on FF using below Eq. 1:

$$\frac{I_m \times V_m}{I_{sc} \times V_{oc}} \qquad (1)$$

Efficiency (η)

The ratio of electrical power is delivered to the load to the optical power incident on the cell is the efficiency of solar cell. Maximum efficiency is when the power is delivered to the load, is called maximum efficiency. The equation of efficiency using Eq. 2:

$$\frac{I_{SC} \times V_{OC} \times FF}{solar\ irradiance} \times 100\% \qquad (2)$$

Summary of DSSC for indoor simulated solar irradiance by using halogen lamp

Tables 1 show the summary of results obtain from the indoor simulated solar irradiance of 512 W/m^2 for both dyes using dragon fruit and chlorophyll from spinach extract. The samples are placed just below 3 inches under the halogen light. The entire light from the lamp are focused on the solar cell.

Table 1. Result of DSSC using organic dye with different thickness of layers of TiO_2

Coating thickness (µm)	Dyes	Voltage Open Circuit, V,(V_{oc})	Current Short Circuit, µA, I_{sc}	W/m^2	Solar Cell Efficiency, η (%)
40	Dragon Fruit	0.42	58.79	512	4.07
	Spinach Extract	0.39	55.04		3.60

CONCLUSION

Based on the experiments result and data analysis one could conclude that, fabrication by using dyes from dragon fruit and chlorophyll extract has feasible chances to be proposed as the usage of an organic dye. This may be due to the content of anthocyanin pigments in the dyes. Anthocyanin is natural compounds that give color to fruits and plants [5].

ACKNOWLEDGEMENT

The authors would like to thank Center of Excellence for Renewable Energy (CERE) and the School of Electrical Systems Engineering, University Malaysia Perlis (UniMAP) for the technical and financial support. This project is funded by RACE grant scheme from Universiti Putra Malaysia (UPM).

REFERENCES

[1] *Renewable energy in South East Asia*, July 2012.

[2] D. Martineau. (2012). *Dye Solar Cells for Real* [Online]. Available: http://creativecommons.org/licenses/by-nc-sa/3.0/

[3] Y. Jiao, F. Zhang, and S. Meng. (2011). *Dye Sensitized Solar Cells Principles and New Design* [Online]. Available: www.intechopen.com

[4] M. Murugiah, Jamil Hashim, U. Nirmal, and M. Y. Yuhazri, "Synthesis and Fabrication of an Effectual Dye Sensitized Solar Cell," vol. 2, pp. 9-15, 2012.

[5] H. Chang, Y. J. Lo, "Pomegranate leaves and mulberry fruit as natural sensitizers for dye-sensitized solar cells", Solar Energy 84 (2010) 1833-1837.