IOP Conference Series: Materials Science and Engineering

PAPER • **OPEN ACCESS**

Role of Clathrin Protein to Increase Electric Current on Dye-Sensitized Solar Cell (DSSC) Based Natural Dyes

To cite this article: Prihanto Trihutomo *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **546** 072010

Role of Clathrin Protein to Increase Electric Current on Dye-Sensitized Solar Cell (DSSC) Based Natural Dyes

Prihanto Trihutomo[1,2*], Sudjito Soeparman[1], Denny Widhiyanuriyawan[1], Lilis Yuliati[1]

[1]Department of Mechanical Engineering, Brawijaya University, Indonesia
[2]Department of Mechanical Engineering, State University of Malang, Indonesia

[*]Corresponding author: prihantohutomo@gmail.com

Abstract. Dye-Sensitized Solar Cell (DSSC) has the cost of fabrication is relatively cheap, easy to produce, work on the area of the visible light and environmentally friendly. The shortage of DSSC, namely the efficiency is still low compared with solar cells of silicon. In this study, have been successfully fabricated DSSC with clathrin protein deposited. The method used in this research is to deposit clathrin protein in porous TiO_2 semiconductors with a concentration of 0%, 25%, 50%, and 75%. Tests carried out on the DSSC that has been made current testing electricity using a solar simulator to determine the changes in electrical current that occur in DSSC. The conclusion from this research is that with increasing concentration of the addition of the clathrin protein in the DSSC leads to an increase in the electric current generated by DSSC. From the results of testing using a solar simulator obtained the value of electric current is the highest, namely 5.247 mA with the addition of the concentration of the clathrin protein by 75%.

1. Introduction

Technical constraints the development of solar cells, namely, the need for single-crystal silicon to make solar cell panels that can produce efficiency of about 30% [1]. To resolve the issue today has found a new type of solar cells photochemical namely the Dye-Sensitized Solar Cell which is a type of solar cell exciton developed by O'Regan and Gratzel in 1991 [2].

Different solar cells of the conventional, the DSSC is a solar cell photoelectrochemical processes using an electrolyte as the medium transport charge. In addition to the electrolyte, the DSSC is divided into several parts consisting of nanoporousTiO_2, the dye molecule that adsorbed on the surface of TiO_2 and the catalyst is carbon, all of which are deposited between two conductive glass, as shown in Figure 1.

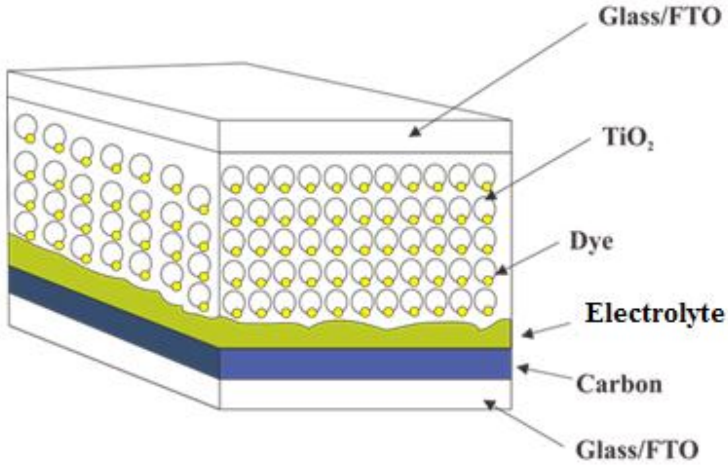

Figure 1. Structure of Dye-Sensitized Solar Cells [2]

Some of the advantages offered by the DSSC compared with the solar cells, namely the cost of fabrication is relatively cheap, easy to produce, work on the area of the visible light and environmentally friendly [3].

The scheme of work of Dye-Sensitized Solar Cell as shown in Figure 2.

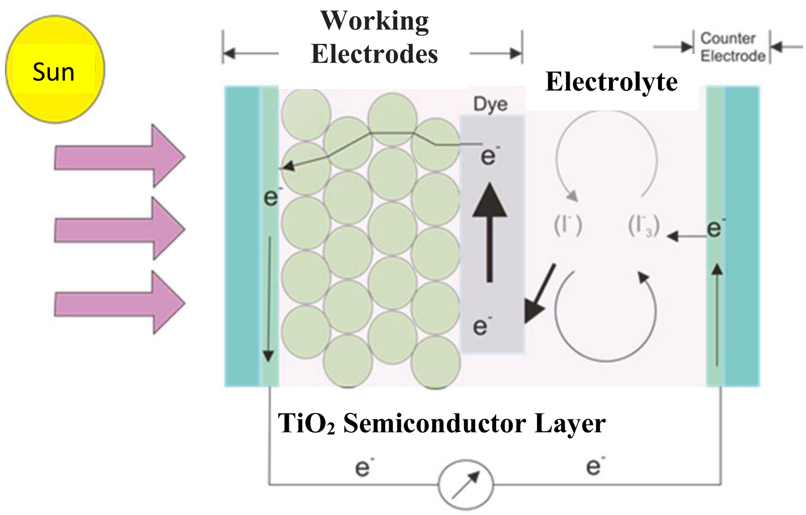

Figure 2. The Scheme of Work of the DSSC [2].

Basically, the working principle of DSSC is the reaction of the electron transfer. The process first begins with the onset of the excitation of the electrons in the dye molecule due to the absorption of a photon (hv).

Electrons excited from the ground state (D) to excited state (D*).

$$D + hv \longrightarrow D^*$$

Electrons from the excited state then directly injected towards the conduction band (ECB) of titania so that the dye molecule is oxidized (D^+).

$$D^* \longrightarrow D^+ + e^-$$

After reaching the electrode TCO, the electron flow toward the counter-electrode through the external circuit. With the presence of the catalyst at the counter-electrode, electrons are accepted by the electrolyte so that the hole formed in the electrolyte (I^{3-}), as an electron donor in the previous process, recombination with electrons to form iodide (I^-).

$$I^{3-} + 2e- \longrightarrow 3I^-$$

With the presence of an electron donor by the electrolyte (I^-) then the dye molecule back to its initial state (ground state) and prevent the capture of the returning electron by the dye being oxidized.

$$2D^+ + 3I^- \longrightarrow I^{3-} + 2D$$

Iodide is used to donate electrons to the dye which are oxidized, thus forming a cycle of the transport of electrons. With this cycle happening the direct conversion of sunlight into electricity.

The main problem found in the Dye-Sensitized Solar Cell is efficiency that is lower than silicon solar cells [4]. This low efficiency is caused by obstacles to the flow of electric current in DSSC. This obstacle is caused by less optimal contact between semiconductor particles because there is a gap or empty space between semiconductor particles. The presence of this gap or empty space causes the flow of current to be obstructed so that the efficiency of DSSC is low [5].

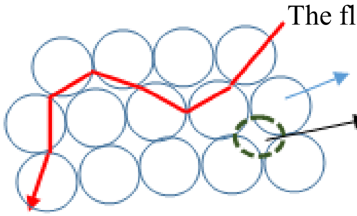

Figure 3. Gap or Empty Space Between TiO_2Particles

Various efforts have been made to improve the efficiency of the DSSC. Previous research that has been done to increase efficiency, namely by the deposition or addition of nano-sized particles on the structure of the semiconductor layers as did Hu (2016) with deposition nanoparticles Ag [6], Chou (2015) add particles of bamboo charcoal powder on the layer of TiO_2[7] and Kuang (2006) the addition of particles of Li^+[8].

One way to increase the flow of electric current and efficiency can be done by combining organic and inorganic elements on the structure of the DSSC. Organic elements in the form of the protein clathrin, whereas inorganic elements, namely semiconductor TiO_2.

From the research Schoen (2011) it is known that clathrin can do bonding with titanium dioxide. The size of the merging of the molecules clathrin around 30 nm can wrap the TiO_2 size of 11 nm. Titanium dioxide is a semiconductor material in Dye-Sensitized Solar Cell [9].

This study aims to determine the role of the protein clathrin in the increase of electric current on the Dye-Sensitized Solar Cell. In this study, the protein clathrin will be added to the Dye-Sensitized Solar Cell that will envelops a layer of TiO_2 and the dye so that it fills a gap or empty space in the layer of semiconductor TiO_2 resulted in contact between the TiO_2 particles becomes better and the displacement of the electrons becomes the maximum because can through all the parts of the semiconductor TiO_2. The addition of the protein clathrin is expected to increase the flow of electric current in Dye-Sensitized Solar Cell.

2. Research Methods

This research uses experimental methods to test the role of the addition of the protein clathrin to the increase of electric current on the Dye-Sensitized Solar Cell.

The procedure of the assembly of the DSSC which is as follows, on the conductive glass FTO that has been cut into a size of 1.5 x 1.5 cm^2 was formed area of TiO_2 deposition with the help of scotch tape on the sides of the glass part which has resistivity so that the formed area of 1 x 1 cm^2. Scotch tape can also be useful to control the thickness of the paste of TiO_2 if you want to paste more thick on the surface of the glass so the scotch tape can be stacked in layers according to need.

The TiO_2paste deposition on an area that has been made on conductive glass with the method of the doctor blade, namely with the help of the stirring rod to flatten the paste of TiO_2 on the substrate starting from the ends of the frame. Then the glasses transparent conductive that has been coated with a paste of TiO_2 is dried in a furnace at a temperature of 450^0C for 30 minutes. This process aimed to foster porosity and forming a contact adhesive which is better between the solution with the substrate glass FTO.

Conductive glass which has been deposited with TiO_2 paste and has been heated then soaked in dye solution for approximately 24 hours, then the TiO_2 layer on the conductive glass will become green. In this process, chlorophyll adsorption occurs on the surface of TiO_2.

Furthermore, clathrin solution was applied to TiO_2 and dye layers with variations in concentration levels of 25%, 50% and 75% towards TiO_2. Then the electrolyte solution is dropped on the TiO_2/dye/ clathrin layer.

The final step in the manufacture of DSSC is to unite both substrates. The carbon-catalyzed counter-electrodes are then placed on top of the TiO_2/dye/clathrin/electrolyte layer with a sandwich structure where each end is offset by 0.5 cm for electrical contact. Then so that the cell structure is firmly clamped with a binder clip on both sides. Furthermore, the DSSC has been made ready to be tested.

Tests carried out on DSSC, namely electrical current testing to determine the changes in electric current that occurs in DSSC.

3. Results and discussion

Electric current testing aims to determine the changes in electric current that occurs after the addition of clathrin concentrations of 0%, 25%, 50% and 75% in DSSC.

The results of testing the electric current for each concentration of addition of clathrin protein can be seen in Figure 4 and Table 1.

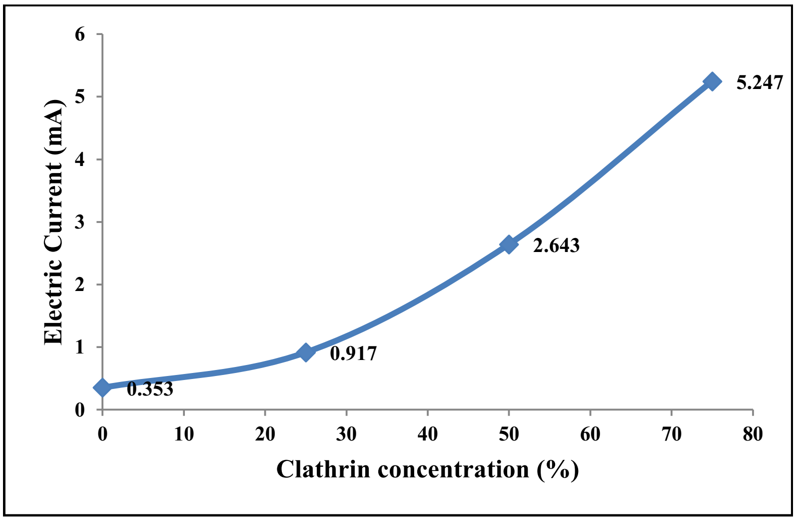

Figure 4. Comparison of electric current for each clathrin concentration.

Table 1. Test Results for Electric Current for Each Clathrin Concentration

Clathrin	0%	25%	50%	75%
Electricity currrent (mA)	0.353	0.917	2.643	5.247

Testing of electric current in DSSC with the addition of clathrin protein 0%, 25%, 50%, and 75% is done by measuring the change in electric current that occurs under the illumination of halogen lamps 1000 W/m^2. The results of testing the electric current for each addition of clathrin protein concentration can be seen in Figure 4 and Table 1.

From Figure 4 and Table 1, it can be seen that the increase in the amount of clathrin protein concentration added to the DSSC caused an increase in the electric current produced. The highest electric current value in DSSC is the addition of 75% protein concentration with an electric current value of 5.247 mA.

The increase in the value of the electric current in DSSC is due to protein molecules which are added on DSSC fill the gap or empty space on the TiO_2 resulted in contact between the TiO_2 particles becomes better and the displacement of the electrons becomes the maximum because can through all the parts of the semiconductor TiO_2.

4. Conclusion

Based on the results and discussion of this study, we can conclude that increasing the amount of clathrin protein concentration added to DSSC causes an increase in the electric current produced. The highest electric current value in DSSC is the addition of 75% protein concentration with an electric current value of 5.247 mA.

Increasing the value of electric current in DSSC due to clathrin protein molecules added to DSSC filling in the gap or empty space in TiO_2 so that they can reduce the resistance of electric current flow resulting in an increase in the electric current produced.

Acknowledgements

This research was funded by Lembaga Pengelola Dana Pendidikan (LPDP) Kementrian Keuangan Republik Indonesia: Beasiswa Unggulan Dosen Indonesia-Dalam Negeri (BUDI-DN) NIB, grant number 20161141011775.

References

[1] M. B. Askari, A. V. Mirzaei Mahmoud, Mirhabibi Mohsen 2015 Types of Solar Cells and Application American Journal of Optics and Photonics

[2] B. O'Regan and M. Gratzel 1991 A low-cost, high-efficiency solar cell based on dye-sensitized colloidal TiO_2 films Nature, **353** 737-740

[3] M.R. Narayan 2012 Review: Dye-Sensitized Solar Cells based on natural photosensitizers Renewable and Sustainable Energy Reviews. **6** 208-215

[4] Md. K. Nazeeruddin, Etienne Baranoff, Michael Gratzel 2011 Dye-Sensitized Solar Cells: A brief overviewSolar Energy **85** 1172–1178

[5] Jiefeng Yu, Dan Wang, Yining Huang, Xing Fan, Xin Tang, Cong Gao, Jianlong Li, Dechun Zou, and Kai Wu 2011 A cylindrical core-shell-like TiO_2 nanotube array anode for flexible fiber-type Dye-Sensitized Solar Cell Nanoscale Research Letters **6**(94) 1-9

[6] H. Hu, J. Shen, X. Cao, H. Wang, Y. Zhang, W. Zhu, J. Zhao, and C. Cui 2016 Photo-assisted deposition of Ag nanoparticles on branched TiO_2nanorod arrays for Dye-Sensitized Solar Cells with the enhanced efficient journal of Alloys and Compounds

IOP Conf. Series: Materials Science and Engineering **546** (2019) 072010 doi:10.1088/1757-899X/546/7/072010

[7] S.C. Chou, Y.C. Chen, H.S. Lin, H.W. Lu, and P. Wu 2015 Preparation of TiO_2/bamboo-charcoal-powder composite particles and their applications in Dye-Sensitized Solar Cells Advanced Powder Technology, **26** 711–717
[8] D. Kuang, C. Klein, J. H. Snaith, E. J. Moser, H.R. Baker, P. Comte, M.S. Zakeeruddin, and M. Gratzel2006 Ion coordinating sensitizer for high efficiency mesoscopic Dye-Sensitized Solar Cells: Influence of lithium ions on the photovoltaic performance of liquid and solid-state cells. Nano Letter, **6**(4) 769 – 773
[9] Schoen 2011 Template Engineering Through Epitope Recognition: A modular, biomimetic strategy for inorganic nanomaterial synthesis Journal of the American Chemical Society
[10] Templeton, Douglas 2002 Molecular and cellular iron transport Marcel Dekker, Inc, New York