SOLAR CELL CHARACTERIZATION BASED ON PITAYA DYES WITH CONDUCTIVE GLASS

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Abstract— Solar energy is one of the energies that are being developed nowadays. One application of solar energy is utilization in the conversion of light energy into electricity that is with solar cells. Solar cells themselves are one of the alternative energies that works to convert solar energy into electrical energy. Dye Sensitized Solar Cell (Dssc) is one type of solar cell to be used in this research. Making this type of sensitized solar cells is relatively easy and does not require expensive. Efforts to improve the efficiency of the DSSC will continue. Therefore, in this research will be formulated anthocyanin extract of dragon fruit for natural dyes as sensitizer on DSSC. In addition, the effect of the volume fraction of the TiO2 crystal structure will also be studied. The manufacture of FTO (flourine-doped tin oxide) is also expected to replace the function of ITO (indium tin oxide) due to the simple manufacturing process and the relatively low cost. The precursor of tin chloride with fluorine doping by coating process with spray pyrolysis technique may be considered as a new breakthrough in the structure of dye-sensitized solar cell devices. The purpose of this research is to know the characteristic of Tin (II) Chloride solution layer on conductive glass, to produce electric energy using solar cell and to know the characteristic of solar cell using Tin (II) Chloride solution with natural color of dragon fruit.

Index Terms— dragon fruit, solar cell, DSSC, FTO, conductive glass, Tin (II) Chloride, energy alternative.

1 INTRODUCTION

Energy plays an important role in human survival. There have been many occurrences of the global energy crisis phenomenon, especially fossil energy. So that there are many innovations in utilizing renewable energy. Renewable energy is suggested as an alternative energy to overcome the current crisis including solar energy, biomass, wind and hydropower [1]. Solar energy for a country with a topical climate such as Indonesia is one of the most widely used alternatives because it is very promising [2]. One of them is in terms of abundance in nature and health aspects such as cleanliness, security and enabling energy generation in remote areas [5,6].

Solar cells are one of the potential alternative energy sources to be developed. Solar cells are a source of electrical energy produced from sunlight. The energy produced reaches 3 x 1024 joules per year which is equivalent to 10% of the energy needs of the world community [3,4].

Solar energy is a conversion from solar radiation to electrical energy or referred to as photovoltaic cells. Radiation emitted by sunlight is actually only received by the surface of the earth at 69% of the total radiant energy of the sun [10-12].

The huge need for energy throughout the world makes researchers try to develop various types of solar cells with high efficiency [13]. The development of solar cells is also on easy fabrication techniques that save money. Until now there are several types of solar cells that have been successfully developed by researchers to obtain high-efficiency solar cell devices and easy fabrication techniques [8,9].

The first solar cell is made using silicone material. These conventional solar cells have high efficiency, but the manufacturing costs are relatively more expensive than other solar cells [7]. This is because conventional solar cells must use high purity silicon and hazardous chemicals at a high cost [14]. Therefore, a new generation of solar cells is developed without using silicon so that the price is cheaper than conventional solar cells. This device is known as the dye sensitized solar cell (SSTP) or Dye Sensitized Solar Cell (DSSC) that uses the sun as energy that is converted into electrical energy [20-22].

DSSC with dye synthesis solar cells was developed as an alternative concept of conventional photovoltaic devices. Many studies of DSSC have been developed. Semiconductor materials commonly used in DSSC are TiO2 (Titanium Oxide) which has a mesopore structure [15]. Titania semiconductors have an energy gap of 3.2 eV and absorb light in the ultraviolet region. This material was chosen besides because it has many advantages including cheap, wide use, non-toxic, and many are also used as basic ingredients for the manufacture of health products as well as paint pigments [16-19].

TiO2 applied to DSSC must be prepared on a wide surface so that the dye is absorbed more. This is expected to increase the photocurrent. The other main thing is the use of dye capable of absorbing a wide spectrum of light and in accordance with the TiO2 energy band [26,27]. Dye can be either natural dye or synthetic dye. Natural dyes are easier to find in nature [25].

In this study, the sample used was extract of red dragon fruit as a dye in DSSC. Dragon fruit is a plant that comes from dry tropical climates. In addition to the flesh, dragon fruit skin can be used in food production as a natural food coloring agent and as a basic ingredient in making cosmetics. This is because dragon fruit skin contains compounds that can be useful as antioxidants, one of which is the compound content of dragon fruit skin is anthocyanin [20-21].

Anthocyanin is a substance that causes red, orange, purple and blue and is abundant in flowers and fruits. Anthocyanin pigments in sweet potatoes are of higher concentration and more stable than anthocyanins from other sources, such as cabbage, blueberries and red corn [22]. The development of DSSC using red dragon fruit extract (Hylocereus costaricensis) as a sensitizer is a promising choice because it is available in sufficient quantities in nature. In addition, the dye also functions as a good conductor of electrons so the use of dyes as a sensitizer to DSSC will be cheaper. Based on the background above, a study was conducted on the characterization of dyes from skin and meat extracts from red dragon fruit (Hylocereus costaricensis) as DSSC coloring agents extracted using various types of solvents such as water, ethyl, methyl, and ethanol. By varying the time of immersion [23,24]

2 Methodology

2.1 Substrate preparation

ITO glass is cut to a size of 2cm x 2cm, then put in a beaker containing alcohol. The ultrasonic cleaner is filled with distilled water to the specified limit. A chemical glass containing ITO glass and alcohol is put into an ultrasonic cleaner. The cleaning process is set to 60 minutes. After 60 minutes, the glass is taken and dried using hair drayer.

2.2 Making TiO2 Pasta

TiO2 paste made from 6 grams of TiO2 powder was first crushed in pestle and sieved mortar. Then put in a beaker, add 10 ml of acetic acid, stir it with a magnetic rod (distirer) for 10 minutes and add 10 drops of triton X-100. Stir for 30 minutes. Then, the formed TiO2 is put in a drop bottle and closed. Before use, the bottle containing TiO2 is shaken first.

2.3 Extract of red dragon fruit

Red dragon fruit flesh (Hylocereus Polyrhizus) is separated from the skin and cut into small pieces, weighed 100 grams and put in a blender, plus 10 solvents, in the extraction process variations are carried out on the solvent as follows: Dye 100 grams Red Dragon Fruit added 10 ml Aquades, Dye 100 grams Red Dragon Fruit added 10 ml of ethyl, Dye 100 grams Red Dragon Fruit added 10 ml of methyl, Dye 100 grams Red Dragon Fruit added 10 ml of methanol. Dial the same thing in the extraction process on dragon fruit skin extract, and after adding the solvent, the dye is smoothed, and filtered with filter paper. The filtration solution is put in a bottle that has been coated with aluminum foil and stored in a dark place.

2.4 Characterization of Dye

Absorbance testing of wavelengths from extracts of dye made from red dragon fruit meat. When testing the red dragon fruit meat extract, calibration of the tool is done by using blank cuvvet as a blank solution. Then, red dragon fruit flesh extract and red dragon fruit skin are included in Cuvet. Testing is done to determine the sensitivity of the extract to the absorbed wavelength. The tool used in this test is a Spectrometer.

2.5 Making electrolytes

Electrolytes are made from a mixture of potassium iodide (KI) with 10% iodine solution, 6 g KI plus 3 ml 10% iodine solution, then stirring with a magnetic stirrer for 30 minutes. Put in a drop bottle

2.6 Characterization of Dye

The TiO2 paste is positioned above the area that has been made on the conductive glass with the doctor blade method, namely with the help of a stirring rod (spatula) to flatten the paste. Previously, resistance testing, the conductive side of the ITO glass was carried out using a multimeter. Then on the conductive side of the ITO glass, an area was formed to deposit TiO2 above the conductive surface. The ITO glass side is taped with tape as a barrier with a distance of ± 5 cm. The TiO2 paste stored in the bottle is shaken first. Then deposited on the ITO glass surface that had been prepared, and flattened with a spatula. Then the layer is left for ± 5 minutes. After that, it was heated (sintering) on the hot plate to a temperature of 300oC for about 20 minutes. The TiO2 layer made with a size of 1.5 cm x 1.5 cm surface area was immersed in the extract of dye red dragon fruit flesh in a petri dish. Soaking is done with a variation of time for 12 hours and 24 hours. After the work electrode is finished, electrolyte is applied to the working electrode. Electrolyte placement in the working electrode, namely TiO2 electrodes that have been sensitized by dye before being arranged into sandwich layers. Detection is done in 3 drops. Indium Tin Oxide (ITO) glass is shaded using 2B pencil evenly. Then it is burned on fire from the candle until a carbon layer is formed. On the 3 edges of the glass, rub the bud to make a border. The DSSC layer is made by offset the dye-sensitized TiO2 layer with a carbon electrode layer. Before the offset is arranged, liquid electrolyte is given first on top of the dye sensitized TiO2 layer. Then clamped using a clip binder. Preparation off set so that it is easy to test. Conductive glass that has been coated with a thin layer of TiO2 which is a working electrode is combined with a conductive glass that is not coated with TiO2 (opposing electrode). The merger is glued with paper clips on both sides. Perform steps 1 to 13 using dye red dragon fruit skin extract. The DSSC layer formed is characterized by its current and voltage using a voltmeter (V) and an amperemeter (A). The light source is directed perpendicular to the cell surface. Tests are carried out with halogen light sources. The DSSC structure is created as follows:

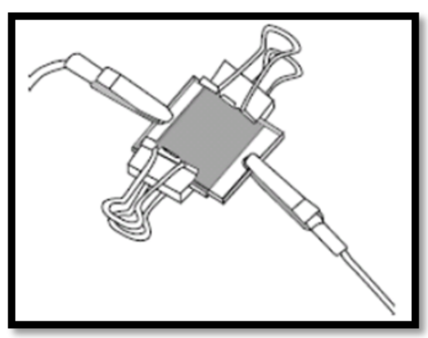

Fig. 1. DSSC structure in this study.

Perform steps 1 to 13 using dye red dragon fruit skin extract.
The DSSC layer formed is characterized by its current and voltage using a voltmeter (V) and an amperemeter (A). The light source is directed perpendicular to the cell surface. Tests are carried out with halogen light sources.

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3 Results and Discussion

This study aims to study the effect of dye solvents on optical absorption of TiO_2 thin films which play a role in photoanodes in DSSC, assessing the effect of dye concentration on DSSC electricity due to variations in immersion time, and assess the effect of dye solvents on DSSC electrical performance. Analysis was carried out on dye extraction, and voltage current characterization (I-V) DSSC.

3.1 Conductive Glass

Making conductive glass using spray technology is carried out at a temperature of 500oC. To produce conductive glass, after the glass has been cleaned using an ultrasonic cleaner, first the glass is given a heat treatment praheating using a heat gun for 10 minutes at 500oC. Preheating heat treatment is carried out to provide initial heat to the substrate, so that $SnCl_2$ solution can be directly attached to the glass, because if not preheated a lot of $SnCl_2$ solutions that do not stick to the glass substrate due to large pressurized hot air coming out of the heat gun mouth. After that, when the glass is still hot, sprayed a solution of $SnCl_2$ with ethanol on the surface of the glass exposed to the heat by using a nano sprayer for 3 seconds at a distance of 5 cm. After the entire surface of the glass has been coated, a solution of $SnCl_2$ with ethanol is reheated using a heat gun for 10 minutes at a temperature of 500 oC. Measuring the resistance value of each glass coated with $SnCl_2$, the glass chosen for TiO_2 semiconductor paste is glass which has the lowest resistance value with a thin and transparent layer, meaning the maximum performance value of a cell. Based on the research conducted by (Aliah, 2016) the resistance value of the glass substrate has a large effect on the performance of a DSSC, the lower the resistance value of the glass substrate, with a thin layer, and appears transparent, the greater the efficiency or performance of solar cells (DSSC). If the resistance is zero, then a short circuit current or Isc is obtained as a function of solar cell irradiance. If the resistance is very large, then there is less or even no current passing through it, this condition is the same as disconnecting the connector at the ampere meter and the result of the appointment on the voltmeter gauge is open circuit voltage or Voc (Bowono, 2010).

3.2 Coating of TiO_2 Electrodes

In this study, TiO_2 used was micro-sized with anatase phase, this is because the anatase phase is more photo-active than the rutile and brookite phases. In making TiO_2 paste, the ratio of the amount of TiO_2 with liquid material (acetic acid and Triton X-100 detergent) must be considered, with a mixture of 6 grams of TiO_2, 25 ml of ethanol mixed with HEC (Hydroxy Ethyl Cellulose), as a thickener because Cellulose is double water, and 9 ml of acetic acid and 2 drops of substitute solution for triton X-100 (detergent), because if the ratio of TiO_2 is too high while the liquid material is low then the resulting TiO_2 paste is too thick and later can make a thin layer of TiO_2 produced too thick, so it tends to peel off the TCO glass surface. Conversely, if the TiO_2 ratio is too small and the liquid material is too high, the resulting TiO_2 paste is too runny and later can make the thin layer of TiO_2 produced too thin which will result in volatile layers and the resulting solar cells not strong enough to absorb sunlight. After making TiO_2 layer, then the layer is heated using a heat gun at 450oC for about 30 minutes. This heating process is carried out in order to form porous (pores) so that a TiO_2 layer is formed which has a large surface area, also to eliminate organic compounds that are still left in TiO_2 pores so that TiO_2 particles are stronger and can conduct electricity.

3.3 Dye extraction

In this study the extraction of the skin and flesh of red dragon fruit has been used. The skin and flesh of the red dragon fruit were extracted using different types of solvents namely aquades and ethanol. Red dragon fruit is separated between the skin and the peeled meat is then cut into small pieces and weighed 150 grams. Then crushed using a blender mixed with various solutions (aquades and ethanol), each with a 15 ml solution. After that it is stored in a dark place for 48 hours. The macerated extract is then stored for 7 days with the aim of accelerating chemical degradation (a chemical change reaction or decomposition of a compound or molecule into simpler compounds or molecules) the compounds contained in the extract so that this affects the antioxidant activity in the extract, then filtered using filter paper. Extraction is done by maceration method. The maceration process is done by soaking plants in organic solvents such as aquades and ethanol. The maceration method aims to take the active substance or compound contained in a material using a particular solvent, where in extracting the dyestuff a method is needed that is in accordance with the nature of the material (source of pigment) to produce high pigment stability. When braking, there will be a breakdown of the cell wall where the pigments such as anthocyanoplast and chloroplasts are due to differences in pressure inside and outside of plant cells. The pigments that come out of the cell are then dissolved in organic solvents. The extracted pigment is closely related to the wavelength of sunlight absorbed. An effective sensitizer must absorb light beyond the range of visible light to the infrared region, and its excitation state must be greater than the TiO_2 conduction band. The extraction results obtained two dyes of red dragon fruit skin and two dyes of red dragon fruit flesh with different solvents (aquades and ethanol).

3.4 Current and Voltage Measurement Results

The solar cell system in this test acts like a diode, which has the nature of giving up alternating current. The solar cell system is said to be dead, if the current generated by the system when the voltage 0 (Isc) is zero, this indicates that the system does not occur the flow of electrons that can produce electric current. This is due to p-type and n-type semiconductor connections, if the p-type semiconductor is contacted with an n-type semiconductor there will be hole and p-type diffusion towards the n-type and electron diffusion from n-type to p-type. This diffusion will leave a more positive area at the n-type boundary and a more negative area at the p-type boundary. The boundary at which the difference in charge occurs at the p-n connection is called the depletion area. More electrons entering the p-type material cause the side of the depletion region to be negatively charged, which tends to attract other electrons from the region n. In equilibrium, quite a large number of electrons will stop the flow of electrons completely. The difference in charge on the depletion area results in the emergence of an electric field that is able to stop the rate of subsequent diffusion. The electric field resulted in the emergence of drift currents. But this current is offset by diffusion currents, so that overall there is no electric current flowing in the semiconductor p-n connection. Electrons are charged particles that are capable of being influenced by the electric field. The presence of an electric field on electrons causes electrons to move. When the semiconductor connection is illuminated, there will be the release of electrons and holes in the semiconductor. The release of the charge carrier results in the addition of the electric field strength in the depletion area. In this situation the drift current is greater than the diffusion current, so as a whole the current is generated in the form of drift current which is the current generated due to the electric field appearing. This current is then used by the p-n solar cell connection as a lithic current. The performance of solar cells is strongly influenced by the construction of the solar cell system itself, such as the working electrode, the opposing electrode (counter electrode) and the electrolyte solution used. In addition, the performance of measuring instruments can also affect the measurement of solar cell performance. The process begins by connecting a positive probe on a substrate coated with platinum from a negative probe on a substrate coated with TiO2 using a jumper or crocodile clamp. Short circuit current (Isc), open circuit voltage (Voc), maximum power (Pmax), performance can be generated, light intensity measurement using lux meter or solar meter power. But first doing a fill factor determination, empirically the fill factor can be obtained through the equation:

$$FF = \frac{V_{OC} - \ln(V_{OC}+0,72)}{V_{OC}+1} \quad (1)$$

Where Voc here is "measurable Voc" obtained using a multimeter. By knowing the Fill Factor (FF) value, the PMax value can be known, so that the large performance value of a DSSC solar cell can be obtained.

$$\eta = \frac{P_{max}}{P_{Light}} \times 100\ \% \quad (2)$$

Based on the above equation, Pmax and Pin parameters are needed. Pmax is divided by the equation:

$$P_{MAX} = V_{OC} \times I_{SC} \times FF \quad (3)$$

While P Light is obtained through the lux parameter. Lux is lumen per unit. Lux (luminous flux) can also be interpreted as the total of visible light which shows the intensity of lighting on a particular surface. The light will appear even dimmer as you increase the area of the irradia ted area. Light has the duality of nature as matter and wave. By itself light has a certain level of energy. The power (W) sent by a light source is directly proportional to the illumination, Ev (lux) multiplied by the area (m2) divided by luminous efficiency, η (lm / W), can also be obtained by dividing (Φ) the intensity of irradiation with η (lm / W), luminous efficacy. Which is described as follows:

$$P_{Light} = Ev\,\frac{A}{\eta} = \frac{\Phi}{\eta} \quad (4)$$

By using a 20-watt LED light as a source of lighting, lux values were obtained at 91666 lux, with luminous efficacy of 90 lumens per watt. Then obtained a P value of 0.1018 Watt with an area of 1cm2, so that the PLight is obtained at 101.8 mW / cm2. Output or output that can be viewed from solar cells is performance. Performance shows the ability of solar cells to convert solar cells into electrical energy. The performance of a solar cell can be known by reviewing the characteristic curve of I-V (voltage-current). The performance of solar cells can be defined as:

$$\eta = \frac{V_{OC} \times I_{SC} \times \text{FF}}{P_{Light}} \quad (5)$$

So, if you want to get high performance solar panels then Pmax must be large with a minimum cross-sectional area. The following are the results of testing using extracted dragon fruit as a dye with variations in immersion time, and variations in type of solvent:

TABLE 1
THE RESULTS OF THE TEST USING THE RESULTS OF EXTRACTING DRAGON FRUIT + ETHANOL AS A DYE WITH LONG IMMERSION VARIATIONS.

Test Results with Dragon + Ethanol skin immersion media						
Immersion time	V (mV)	A (mA)	FF	Pmax (m/Watt)	Plight (mW/cm^2	Ferformance %
12 hours	2	0,4	0,33	0,26	101,8	0,0026
24 hours	2,3	0,6	0,36	0,49	101,8	0,0049
48 hours	2,5	1	0,38	0,95	101,8	0,0093

TABLE 2
THE TEST RESULTS USING THE EXTRACTION OF DRAGON FRUIT + AQUADES AS A DYE WITH LONG IMMERSION VARIATIONS.

Test Results with Dragon + Ethanol skin immersion media						
Immersion time	V (mV)	A (mA)	FF	Pmax (m/Watt)	Plight (mW/cm^2	Ferformance %
12 hours	3,3	1,5	0,44	2,19	101,8	0,021
24 hours	3,5	1,7	0,45	2,72	101,8	0,026
48 hours	4,3	2,3	0,50	5,01	101,8	0,049

TABLE 3
THE RESULTS OF THE TEST USING THE EXTRACTION OF DRAGON FRUIT + ETHANOL AS A DYE WITH LONG IMMERSION VARIATIONS.

Test Results with Dragon + Ethanol skin immersion media						
Immersion time	V (mV)	A (mA)	FF	Pmax (m/Watt)	Plight (mW/cm^2	Ferformance %
12 hours	4,3	3	0,50	6,53	101,8	0,064
24 hours	6,9	3,7	0,61	15,73	101,8	0,154
48 hours	8	4,7	0,64	24,37	101,8	0,239

The performance of a solar panel is indeed very important, because the higher the performance of a solar cell, the better performance of a solar panel. Performance greatly affects the Maximum Power (Pmax) and the cross-sectional area of a solar panel. But if you want high-performance solar panels at the expense of the area being minimized, this is a big mistake and is not recommended because it will affect the life time of a solar panel. Characterization of the I-V curve is done to see the

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electrical properties of the DSSC that have been made. Tests carried out are using the I-V measurement system or multimeter with a light source using LED lights using lux meters to measure the intensity of light concerning solar cells (PLight) to reach an intensity of 1000 Watt / m2. The results of characterization I-V were carried out to determine the electrical properties of the DSSC that was ready to be tested. When light carries photon energy about DSSC, there will be electrons from the dye that push electrons from excited TiO_2 from the conduction band to the valence band and towards the working electrode to create a current in the DSSC. Its performance is influenced by several parameters, namely Isc (short circuit current), Voc (open circuit voltage) and (A) surface area of solar cells that are irradiated.

Isc is a short circuit current that occurs when a voltage can be zero or close to zero. This current is the same as the number of photons converted into electron-hole pairs. The more electrons are excited, the greater the performance produced. Voc is a voltage value when there is no current flow because all exitons are combined so that the current does not flow in the DSSC. FF is the ratio of maximum power (Pmax) to the contact current (Isc) and open circuit voltage (Voc). The Fill Factor increases with increasing electron mobility. Increasing electron mobility will increase current. If the fill factor value is higher than 0.7 or 70% then the cell is better. Open circuit voltage (Voc) with the extraction of dragon fruit flesh dye dissolved using 96% ethanol, the best results obtained by immersion 48 produce a voltage reaching 8 mV with a current strength of 4.7 mA with a performance of 0.239437%. The output current of solar cells (also called photon flow) is still relatively low when compared to the results obtained by Nur Hasbi Wahab (2016). By using red tomato as dye in DSSC with a voltage of 8.6 mV and a current of 5.8 mA with fill factor of 0.2308 and a performance of 0.003892%.

The small output current produced is caused by the very large resistance of the TiO_2 semiconductor and electrolyte electrode layers. With this very large resistance value, the injected electrons from dye experience very large obstacles in the TiO_2 layer, so that the number of electrons flows into the outer circuit becomes small. Other causes can be caused by the not optimal function of dye in generation and injection of electrons into the TiO_2 electrode layer. It can be seen that the performance of the dye of red dragon fruit flesh. Higher than dye using red dragon fruit skin. Due to the light absorption in the red dragon fruit flesh dye is higher than the red dragon fruit skin dye. Absorbance is influenced by the anthocyanin content in the solution and is absorbed (adsorbed) on the surface of TiO_2, where the anthocyanin content is proportional to the absorbed light (absorbance).

The fig 5 above shows that the duration of immersion and type of solvent affects the absorbance value. Soaking time has an influence on the voltage and current strength generated by DSSC. Where the longer the immersion time, the higher the voltage and the strong current produced. The graph above shows that all DSSCs have the highest value at 48 hours of immersion time and DSSC with 24-hour immersion in dye has a higher current strength value compared to DSSC with 12-hour immersion time.

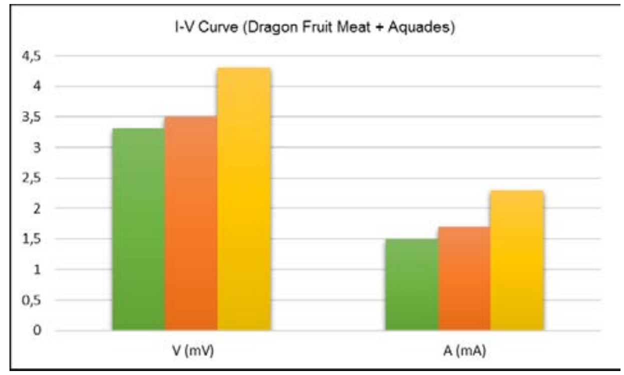

Fig. 2. I-V graph results of testing using dye dragon fruit meat + Aquades

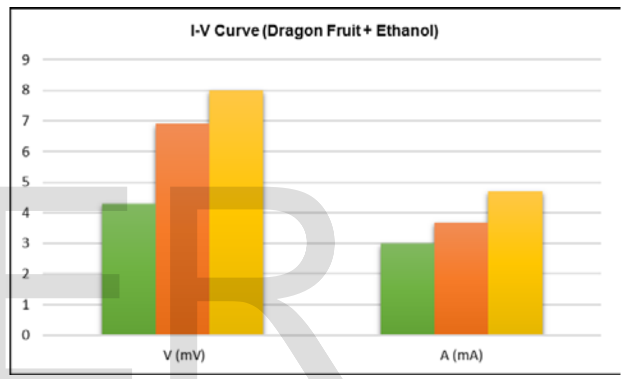

Fig. 3. I-V graph results of testing using dye dragon fruit meat + Ethanol

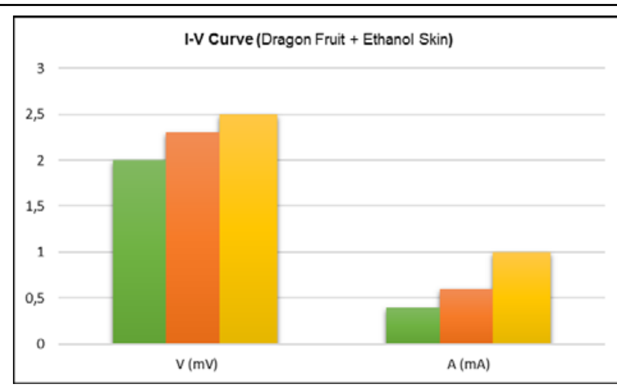

Fig. 4. I-V graph results of testing using dye dragon fruit skin + Ethanol

The highest average strong current that can be produced by a 48-hour DSSC is 7 mA. While the average voltage value of the 48-hour DSSC is also the highest voltage DSSC with other immersion times of 8 mV. Variation in treatment of long immersion, which is 12 hours, 24 hours, and 48 hours. This is because each semiconductor has a maximum limit in absorption of dye extraction, based on previous research, with dye guava leaf extract, optimal immersion time in absorption of TiO2 is 36 hours, in addition to the 48-hour soaking time TiO2 has begun to dissolve. in dye so that the results of voltage measurements and current strength appear to decrease, causing a reduced ability of solar cells to convert light energy emitted by the sun into electrical energy. In addition, the absorption of dye that is less optimal also makes the voltage and strong values of the resulting current quite low.

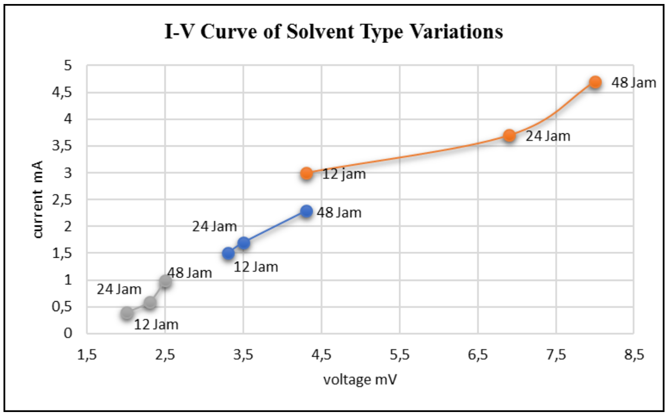

Fig. 5. I-V graph results of testing using dye variations of red dragon

The duration of immersion affects the absorbance value. This is because the longer the immersion time the higher the concentration of anthocyanin molecules adsorbed on the surface of TiO2 particles. The longer the immersion the darker the color (dark purple). While the absorbance value is influenced by the anthocyanin content in the solution and is absorbed (absorbed) on the surface of TiO2, where the anthocyanin content is proportional to the absorbed light. Dye guava leaf extract, it can be seen that the immersion time of the working electrode on dye affects the voltage and current produced, the immersion variation of 36 hours is the optimum soaking time in this study. This is because the dye that is able to be absorbed by TiO2 has a maximum limit for filling cavities found in TiO2. The increasing number of dyes attached to the TiO2 layer and the more photon energy absorbed and the greater the power possessed by the DSSC prototype. But if too much dye is attached to the TiO2 layer it will cause the TiO2 layer to be covered by dye, thus inhibiting the rate of electrons excited by dye towards the electrode as happens at 48 hours immersion, where 48 hours of immersion and the resulting voltage are smaller than 36 hours immersion. Decrease in current and voltage output as long as immersion is also caused because most layers of TiO2 are degraded by dye solutions, so TiO2 functions to accommodate electrons from dye less optimally because of the ability of TiO2 to bind dye to a lesser extent While the concentration of the ethanol solvent affects the stress produced by Dye Sensitized Solar Cell (DSSC). The highest voltage value is found in DSSC which uses absolute ethanol as a paste solvent. While the lowest stress value is found in DSSC with aquades as a solvent for precision. This is in accordance with Mori (2010) statement who said, generally organic solvents for TiO2 paste can form a more uniform film layer compared to pasta from a mixture of water. So that the stress produced using ethanol solvents is higher than that using distilled water solvents. Testing samples using SEM was carried out to determine the morphology of the sample. SEM analysis was performed on the best samples of each solvent, namely samples with absolute ethanol solvents three coatings, samples with 50% ethanol solvent three times coating and samples with distilled water solvent three times coating. In general, TiO2 particles have a spherical shape. According to Shanmugam (2015), Spherical TiO2 particles can increase dye adsorption on the surface of the substrate. If the adsorption of the Dye molecule goes well, it will increase electron injection so that the efficiency of the solar cell gets better.

4 Conclusion

Based on the results of the experiments and the data that have been obtained, it can be seen that the resulting voltage is quite good and stable but the current produced is not optimal. This is because the DSSC resistance is still very large, so that the electrons injected from the dye have resistance, so the number of electrons flowing is small, the dye function is not optimal in generating and injecting electrons into the electrode layer and the light source used. Intensity greatly affects the output power of DSSC. The greater the intensity, the more the number of photons involved in the conversion process, so the greater the current produced. In addition, the low output current is also caused by several factors, namely particle size and thickness of TiO2 paste deposited on ITO glass, dye immersion time, and electrolyte use. In DSSC the resulting voltage comes from the difference in the conductivity level of TiO2 semiconductor electrodes with electrochemical potential of the redox electrolyte pair, while the current generated is related to the number of photons involved in the conversion process and depends on the intensity of irradiation and the work of dye used. Based on the experimental results and the data that have been obtained, it can be seen that the resulting voltage is good enough but the resulting current is not optimal. This is because the DSSC resistance is still very large, so that the electrons injected from the dye have resistance, so the number of electrons flowing is small, the dye function in generation and electron injection to the electrode layer and the light source used are also influential. Intensity greatly affects the output power of DSSC. The greater the intensity, the more the number of photons involved in the conversion process, so the greater the current produced. In addition, the lack of stability of the output voltage is also caused by several factors, namely particle size and thickness of TiO2 paste deposited on conductive glass, dye immersion time, and electrolyte use.

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