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Dye Sensitized Solar Cell (Dssc) With Areca Extract As A Natural Dye Sensitized

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Abstract

Dye-sensitized Solar Cell (DSSC) is a solar cell that uses dye as one of its components. DSSC is interesting to develop because it can be fabricated simply with low production costs. This study aims to develop a DSSC that uses dye-sensitized from natural ingredients to be environmentally friendly. We chose betel nut (Areca catechu L.) as a natural dye source because betel nut has a reddish-brown color and is often used as a natural dye. The stages of this research consisted of betel nut extraction, TiO_2 deposition, manufacture of a carbon layer on the counter electrode, and DSSC fabrication. Measurement of DSSC performance under solar irradiation with an intensity of 292 W/m² shows that the fabricated DSSC can produce a voltage of up to 216 mV with a current of 0.03 mA. Variations in the concentration of TiO_2 positioned on the ITO substrate indicate that higher concentrations of TiO_2 can produce higher DSSC voltages.

INTRODUCTION

It is widely known that the use of fossil energy to meet global energy needs leaves a number of serious problems. In addition to its availability which continues to deplete because it cannot be renewed, the use of fossil fuels will produce carbon emissions that threaten the environmental balance and are suspected to be the main cause of climate change [1]. Therefore, various efforts have been made to find alternative energy sources that meet the requirements such as economical production costs and do not have a large impact on the surrounding environment. One possible alternative regarding renewable energy is by utilizing solar energy because it is clean and abundantly available. [2].

One of the ways to use solar energy is to use solar cell devices or photovoltaic cells. A solar cell is a device that can directly convert solar energy into electrical energy [3]. Seeing the prospect of developing solar cell technology today, a massive study of solar cell technology has been carried out. There are several types of solar cells that have been widely developed including solar cells made of monocrystalline and polycrystalline silicon, organic solar cells, and dye-sensitized or commonly known as Dye Sensitized Solar Cell (DSSC) [4].

Dye Sensitized Solar Cell (DSSC) is a type of solar cell which does not require a large cost or is affordable and environmentally friendly [5]. Basically, Dye Sensitized Solar Cell (DSSC) has a working principle by converting light energy into electrical energy on a molecular scale in the form of electron-transferred reactions [4]. Dye Sensitized Solar Cell (DSSC) has three main components, namely electrodes, counter electrodes and electrolyte solutions [6].

One of the developments of DSSC that is seriously considered is related to the selection and development of the type of dye used. Dye plays a very crucial role in DSSC and often determines the performance of DSSC. At this time the selection of natural dyes in DSSC is an interesting topic to be studied further. Not only because of its environmentally friendly nature, the use of natural dyes can be sustainable.

One of the natural ingredients that has the potential to be used as a dye and in abundance is betel nut (*Areca catechu L.*) [7]. Areca nut is one of the many plants that grow in mainland Asia such as India, Malaysia and Indonesia. In general, areca nut is often used to clean teeth (nyirih), to warm the body [8]. Areca nut has a hard texture with a reddish yellow color, the inside is slightly soft and there is an endosperm [9] [10]. Areca nut contains tannins, alkaloids, essential oils, fats, water and sugar [11]. Tannins and alkaloids are very important components in betel nut seeds, tannins belong to a group of polyphenolic compounds that are dissolved in glycerol and alcohol, but they are insoluble in benzene compounds [12].

METHODS

Research Tools and Materials

The tools used in this research include glassware, conductive glass (TCO) type ITO, magnetic stirrer, mortar, burning wax, tweezers, oven, filter paper, scotch tape, digital balance, and digital multimeter.

The materials used in this research include TiO_2 powder, aquades, potassium iodide (KI), iodine (I2), 96% ethanol, acetonitrile, PVA (Polyvinyl Alcohol), acetic acid and areca nut (Areca catechu L.).

Procedure

This research includes several stages, namely (i) Extraction of Areca Nuts (ii) TiO_2 Paste Deposition, (iii) Carbon Layer Making, (iv) DSSC Fabrication, (v) Data Collection Techniques and Data Analysis.

Extraction of Areca Nuts

Extraction of areca nut is obtained from the meseration process, namely the extraction process using the process of immersing the material with ethanol as a solvent. 10.2 grams of fresh betel nut was mashed using a blender, then 25 ml of 96% ethanol solvent was added, then the solution was soaked for 24 hours. After soaking for 24 hours, the anthocyanin dye extract was filtered using Whatman paper and stored in a dark bottle. Then the betel nut extract was concentrated using a rotary vacuum evaporator. The vacuum process is used to concentrate the betel nut extract solution, this serves so that the resulting color is concentrated.

Paste Deposition TiO_2

Material TiO_2 was deposited on ITO by thick layer technique. TiO_2 to be deposited was prepared in the form of a paste. Paste is done by mixing 3.07 grams of polyvinyl alcohol (PVA) into 30 ml of distilled water with2 3.10 grams of 40°C for 30 minutes and a good paste is formed to be coated.

Manufacture of Carbon Coating on the Counter Electrode

Components counter electrode is carried out by coating ITO glass with carbon. The carbon used comes from the flame of a burning candle. The coating of ITO glass with carbon is done by placing the ITO glass over a candle flame so that a layer of carbon from the fire soot covers the ITO conductive surface.

Electrolyte Solution

The materials used in the manufacture of the electrolyte solution are 0.127 grams of iodine, 0.83 grams of KI and 10 ml of ethylene glycol. The three solutions were mixed in a beaker then stirred using a stirrer until well mixed. When finished the solution is put into a dark bottle and tightly closed so that it is not exposed to sunlight.

DSSC Fabrication

After each DSSC component has been successfully fabricated, then fabrication is carried out to form solar cells with the following steps: First, at the ITO which has been cut into a size of 2.5 cm x 2.5 cm, an area where TiO_2 is deposited with the help of Scotch tape on conductive part of the glass so that an area of 2 cm x 2 cm is formed. Scotch tape also functions as a regulator of the thickness of the TiO2 paste. Furthermore, the TiO_2 paste is deposited over the area that has been made on the conductive glass by the doctor blade method, with the help of a stirring rod to evenly distribute the paste. Then the layer was dried for approximately 15 minutes and heated at a temperature of 150^{o}C for 30 minutes. Then the TiO_2 layer is immersed in a dye solution for 30 minutes then the TiO_2 layer will turn red. The ITO glass was then rinsed with distilled water, then rinsed with ethanol and dried. In this process, the betel nut extract adsorption occurs to the TiO_2 surface. Furthermore, the carbon counter-electrodes are then placed on top of a layer of TiO_2 with a layered structure where each end is offset by 0.5 cm for electrical contact. Then so that the cell structure is stable, the two electrodes that have been joined are clamped with clips on both sides. At the end of the electrolyte solution, approximately 2-3 drops are dripped into the space between the two electrodes using the principle of capillarity.

Data retrieval is carried out during the day from the direct illumination of bright sunlight. Measurement of solar intensity is done using a pyranometer. The performance of the DSSC prepared in this study was measured using a voltmeter and ammeter with a circuit scheme as shown in Figure 1.

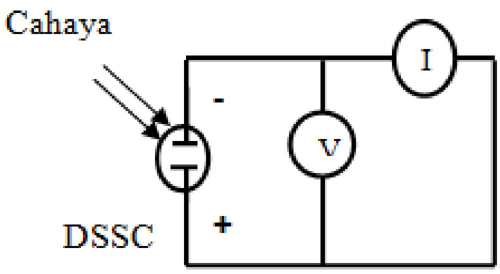


Figure 1. Electrical Circuit Schematic for DSSC Testing

X-Ray Diffraction (XRD) Test

X-Ray Diffraction (XRD) test was conducted to determine the crystalline phase in the sample. The samples tested consisted of 3 types, namely TiO_2 + PVA, TiO_2 + Areca Nut Extract, and TiO_2 + PVA + Areca Nut Extract. XRD diffractogram pattern analysis was performed at 2. from 10° to 90° using X'Pert Highscore Plus software

RESULTS AND DISCUSSION

Extraction of Areca nuts

Extraction of areca nut was carried out using the maceration method and the solvent used was ethanol. The areca nut extract filtrate is reddish brown as shown in Figure 2. Then the extract obtained is concentrated using a rotary vacuum evaporator. The vacuum process is used to concentrate the betel nut extract solution, this serves so that the resulting color is concentrated. Areca nut extracts contain polyphenolic compounds such as tannins, alkaloids, arekoline, arekolidine, arekain, guvakolin, guvasine, phenolic, gallic acid, latex, lignin, oil which has the potential as a natural coloring agent because it contains natural pigments [11] [12].

Figure 2. Areca Fruit Extract

Paste Depositions TiO_2

Deposition paste was carried out by mixing PVA with TiO_2 and then homogenized using a magnetic stirrer to form a paste. In the TiO_2 deposition processtwo the amount of TiO_2, variations of TiO_2, 3.10 grams and 4.10 grams. TiO_2 can be seen in Figure 3.

Figure 3. TiO_2 Paste

After the TiO_2 has thickened, the next process is the paste is applied to the ITO glass with a size of 2.5 cm x 2.5 cm ITO glass. The structure of the paste applied to the ITO glass. After finishing the paste, observe using an optical microscope (MO) to see the texture and thickness as shown in Figure 4.

(a) (b)

Figure 4. Optical Microscope Analysis Results (a) Thickness of TiO2 Paste(b) Texture of TiO_2Paste

Making a Carbon Layer

After the TiO_2 paste deposition process, the next step was to make a carbon layer using wax. ITO glass measuring 2.5 cm x 2.5 cm was burned on a candle flame with the shading position facing the fire. Burning is carried out until the fire soot covers the surface of the ITO glass as shown in Figure 5.

Figure 5. *counter electrode Coating with Carbon*

Uji X-Ray Diffraction (XRD)

In Figure 6, the results of XRD analysis are presented of TiO_2 added with areca nut extract, TiO2 added with PVA, and TiO2 added PVA and areca nut extract. The semiconductor material used is TiO2 nanoparticles in the anatase phase.

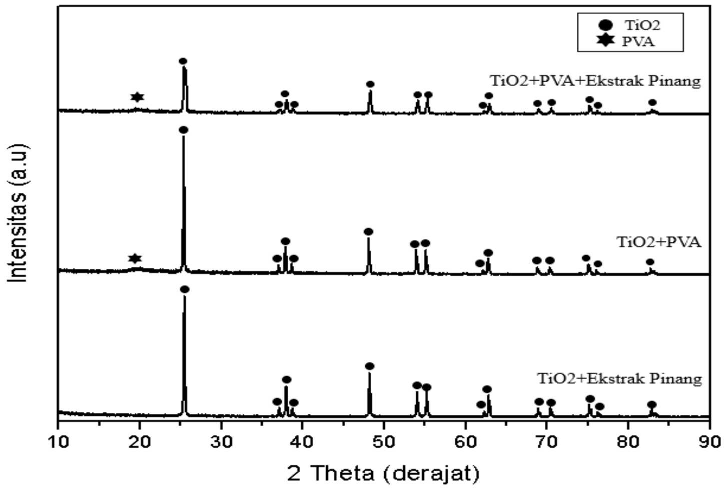
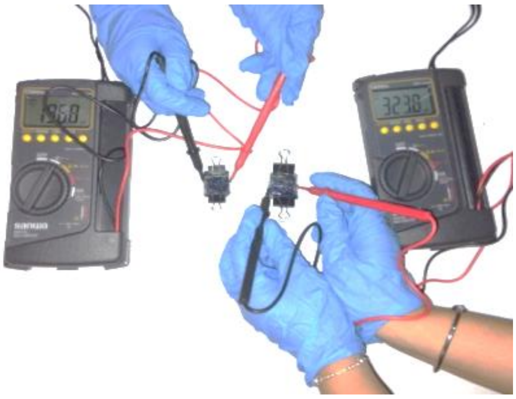


Figure 6. XRD Analysis Results

In the XRD diffractogram, the graph for TiO_2+ PVA + areca nut extract based on reference PDF-01-083-2243 the three highest peaks of TiO_2 are at 2θ: 25.62º; 37.88º; 48,28º. While the crystal structure of TiO_2 produced is tetragonal with lattice parameters a=3.7800 , b=3.7800 and c=9.5100 . Graph for TiO_2+PVA sample Based on reference PDF-01-071-1167 the three highest peaks of TiO_2 are located at 2θ: 25.34º; 37.08º; 48.04º. While the crystal structure of TiO_2 produced is tetragonal with lattice parameters a=3.7892 , b=3.7892 and c=9.5370 . Graphs for samples of TiO_2+ areca nut extract based on reference PDF-01-084-1285 the three highest peaks of TiO_2 are located at 2θ: 25.42º; 37.90º; 48,15º. While the crystal structure of TiO2 produced is tetragonal with lattice parameters a=3.7848 , b=3.7848 , c=9.5124 . The addition of areca nut extract did not change the TiO_2 or cause significant new XRD peaks. The addition of PVA to both TiO_2+ PVA and TiO_2+ PVA + areca nut extract was evidenced by the presence of a new peak around 20°. In several studies, this peak is the peak identified by PVA.the TiO2 phase, did not change significantly.paste₂ deposited on the ITO substrate still uses TiO_2 in the anatase phase.

Dye Sensitized Solar Cell (DSSC) Test

This research was conducted to determine the effect of TiO_2 concentrationas on ITO glass with betel nut extract dye added a working electrode on the voltage and current generated by the DSSC. Figure 6 shows the DSSC testing process.



Gambar 7. DSSC ready to be tested

Table 1 shows the characteristics of the DSSC results based on current (I) and voltage (V) measurements. Measurements were made under direct sunlight with an intensity of 292 W/m2. It appears that the higher concentration of TiO_2 DSSC with a larger stress. At a concentration of TiO_2 3.10 grams the resulting voltage is 123.35 mV while the concentration of TiO2 4.10 grams the resulting voltage is 216.45 mV.

Table 1. DSSC Data

No	Konsentrasi TiO_2 (gr)	Tegangan (mV)	Arus (mA)
1	3,10	123,35	0,03
2	4,10	216,45	0,03

CONCLUSION

In this research, DSSC has been successfully synthesized with betel nut extract as dye-sensitizer . This is because areca nut has long been known to be used as a dye that has a reddish brown color. XRD diffractogram pattern analysis showed that the addition of areca nut extract did not2 significantlyThe variation of TiO_2 concentrationdeposition process at the working electrode also shows that a higher TiO_2 concentrationDSSC to generate a larger voltage.

THANK YOU

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