Preparation of Dye Sensitized Solar Cell (DSSC) using anthocyanin color dyes from jengkol shell (Pithecellobium lobatum Benth.) by the gallate acid copigmentation

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Abstract. Research on the preparation of DSSC has been completed by using an anthocyanin dye from jengkol shell that copigmentation with gallate acid. The aim of this research is to know the variation of the duration of TiO$_2$ immersion with the dyes, Effect of TiO$_2$ coating on glass ITO, Effect of coating method of TiO$_2$ paste with dye to DSSC efficiency. Variation of immersion used (12 hours, 24 hours, 36 hours, 48 hours); Variations in the amount of TiO$_2$ coating used (1 layer, 2 layers, 3 layers, 4 layers, 5 layers); Variation of coating method of TiO$_2$ paste with dye (TiO$_2$ soaked with dye, TiO$_2$ mixed with dye). DSSC efficiency is obtained from the calculation of voltage and strong current generated by multimeter. The results showed that the efficiency of DSSC was higher at 48 hours of soaking period, the amount of TiO$_2$ coating on ITO glass showed the highest efficiency in coating 4 layers, the method of coating of TiO$_2$ paste with dye showed the highest efficiency with the method of coating TiO$_2$ immersed in dye. The UV-Vis characterization results indicate that the anthocyanin that is predominated by gallate acid shows a batochromic at a maximum wavelength of 536 nm. The result of FTIR characterization which obtained an absorption indicates the presence of OH bond which indicates the presence of anthocyanin in jengkol shell. Electrical energy conversion results obtained the highest efficiency at 48 hours of immersion and 4 layers of layer thickness by the method of TiO$_2$ paste soaked in anthocyanin dye which is dikomigmented with gallate acid that is 1.40%.

1. Introduction
The need for energy for human survival is increasing, while on the other hand, fossil energy is depleting its presence in nature. This is what prompted researchers to find clean and renewable energy sources, alternatively, for example energy from low-intensity light from the room. The utilization of solar light and indoor lights can be one effective solution that can be done to overcome the energy crisis[1-3].

Dye Sensitized Solar Cell (DSSC) as one type of solar cell developed by Gratzel (1991) has attracted a lot of attention because it can be an alternative as a substitute for fossil fuels[4]. DSSC requires no high purity material and relatively low production costs [5]. DSSC consists of semiconducting nanocrystals, dyestuffs, counter electrodes, and electrolytes [6]. These four major components can affect the efficiency of the resulting DSSC[7].

DSSC which has been developed is using organic dyes obtained naturally from plants containing anthocyanin compounds such as red cabbage extract dye [8] with an efficiency of 0.055%, glutinous
rice mixture and turmeric [9] with an efficiency of 0.207%, mangosteen peel [10] with an efficiency of 0.592%, and others. In addition, one source of anthocyanin that can be used as a dye in this study is the shell of jengkol. Jengkol shell (Pithecellobium lobatum Benth.) Is a food waste that can be used as a dye because it contains the active compound of flavonoids is anthocyanin.

In contrast to DSSC, the basic principles of photovoltaic commonly utilize surface modification[11,12] of sensitizers such as semiconductor materials, in order for the flow of energy. This energy can be converted as desired, such as for photovoltaic or photocatalytic reactions. In other research sections, photocatalysts are also applied to photo-splitting of water[13] and application of degradation of contaminant compounds such as humic acid in peatlands[14,15].

Anthocyanin compounds in addition to providing dyes in plants also serve as a photon absorber in the DSSC. Anthocyanin compounds have carbonyl and hydroxyl groups in their molecular structure, so anthocyanins may bind to TiO$_2$ surfaces. Antosianin is used because it has a spectrum of light in a wide enough range from red to blue [16]. The use of anthocyanin as a dye still yields a relatively lower efficiency than the ruthenium (II) polypyridyl complex which results in an efficiency of more than 11%, but the complex ruthenium has a high price and has a heavy metal content that can pollute the environment [17].

Copigmentation compounds which have been used in DSSC are malic acid and ascorbic acid [18] yielding solar cell efficiency of 0.30% and 0.29%. Coupigment compounds used in this study is a type of phenolic compound that is gallate acid. Gallate acids are used because they have a cheap price, easily dissolve in water, easily crystallized, dry, and stable in dry form. One of the factors influencing the efficiency of DSSC is TiO$_2$ coating variation. In this study, the duration of immersion of TiO$_2$ in the dye solution was varied for 12 hours, 24 hours, 36 hours, and 48 hours with anthocyanin dye from the shell of jengkol (Pithecellobium lobatum Benth.) was incultivated gallate acid.

2. Experimental Section

2.1. Tools and Materials
The equipment used in this research is knives, digital balance sheets, spatula, stirrer, dropper, 100 mL and 50 mL glasses, measuring cup, Whatman filter paper, buncher funnel, dark bottle, rotary evaporator, ITO glass, magnetic stirrer, oven, iron clamp, 2B pencil, furnace, spin coating and instrument tools (UV-Vis, FTIR, XRD, Multimeter). The ingredients used in this study were jengkol shell (Pithecellobium lobatum Benth.), 96% technical ethanol, HCL 1M, aquades, gallate acid, 0.5M potassium iodide, acetonitrile, iodine 0.05M, TiO2 Degussa P-25, cetyl trimethyl ammonium bromide (CTAB), ethanol, pencil powder.

2.2. Dyes Preparation
2.2.1. Jengkol Shell Extraction
The Shell of fresh jengkol was taken 40 g of shell, extracted with ethanol 96% 50 mL and HCL 1M 10 mL as solvent for 24 hours, extract in store in dark place. Filtrate filtered with filter paper, filtrate evaporated with a rotary evaporator to remove the solvent. The resulting extracts are stored in dark bottles or aluminum coated bottles (Characterization using UV-Vis and FTIR) [18].

2.2.2. Copigmentation of jengkol shell extract with Gallate acid
A total of 1g of concentrated extract obtained from jengkol shell was diluted with 10 mL of ethanol and then mixed with 1g of gallic acid with a ratio of 1:1 (w/w) (Characterization using UV-Vis and FTIR) [18].

2.3. Electrolyte Preparation
The electrolyte used is an iodide/triiodide electrolyte solution. The preparation by mixing 0.498 grams of potassium iodide was dissolved into 6 mL acetonitrile and then stirred. Furthermore, 0.076 grams of
iodine plus 6 mL acetonitrile were stirred until homogeneous. Combine the two solutions, mixed until homogeneous [19]

2.4. Preparation of TiO$_2$ Pasta
The TiO$_2$ paste is prepared from 1.5 grams of TiO$_2$ Degussa P-25 powder, then crushed, sifted, and fed into a beaker, mixed with 2.5 mL acetic acid and distilled for 30 minutes, adding sufficient cetyl trimethyl ammonium bromide (CTAB) and distirer for 30 minutes. The formed TiO$_2$ pasta is put into a bottle and closed.

2.5. Preparation of Opponent Electrode
The carbon electrode counter preparation refers to Maulina (2014)[20]. Carbon Counter Counter Preparation is prepared using graphite as a carbon source. The graphite is superimposed onto the ITO on its conductive part, then heated to a temperature of about 450ºC for 30 minutes. The temperature is then slowly lowered to a temperature of 70ºC, then chill at room temperature [19]. This process aims to make the graphite form a good contact among carbon particles with ITO. Perakitan Dye Sensitized Solar Cell (DSSC).

2.6. The assembly of solar cells
2.6.1. The assembly of solar cells for TiO$_2$ paste is immersed in dye for 12 hours, 24 hours, 36 hours, and 48 hours.
On the glass of ITO measuring 1.25 x 1.25 cm formed area where TiO$_2$ is positioned with the help of tape on the conductive glass to form an area of 1 x 1 cm. The TiO$_2$ paste is positioned over an area already prepared on ITO glass by a spin coating method with a speed of 3000rpm to flatten the paste. Coating is done as much as 1 layer, 2 layers, 3 layers, 4 layers, and 5 layers. The TiO$_2$ layer is dried for 15 minutes and heated to 450ºC [10]. The TiO$_2$ layer is immersed in dye solution for 12 hours, 24 hours, 36 hours, and 48 hours, in this process the dye adsorbs to the surface of TiO$_2$. The carbon electrodes are then placed on the TiO$_2$ layer to form sandwich structure. In order for the cell structure to be firmly clamped with clips on both sides. Liquid electrolyte is dropped in drops on the space between the two electrodes [10]. DSSC is ready for tested voltages and obstacles

2.6.2. The assembly of solar cells for the TiO$_2$ paste is mixed with the dye
On the ITO glass measuring 1.25 x 1.25 cm is formed the area where TiO$_2$ is positioned with the help of duct tape on the conductive glass section so that it forms a large area of 1 x 1 cm. The prepared TiO$_2$ paste is mixed with dye, to make the dyed mixed paste, simply add 1 mL of dye to 1 gram of TiO$_2$ paste and in the stirer for 10 minutes to get it all mixed evenly. The mixture of the TiO$_2$ paste and the dye is deposited over an area already prepared on ITO glass by a spin coating method with a speed of 3000rpm to flatten the paste. Coating is done as much as 1 layer, 2 layers, 3 layers, 4 layers, and 5 layers. The coating is dried for about 15 minutes and in the furnace at 200 ° C for 10 minutes [21]. Carbon electrodes are then placed over the TiO$_2$ layer to form sandwich structures. In order for the cell structure to be firmly clamped with clips on both sides [20]. The liquid electrolyte is dripped in drops on the space between the two electrodes. DSSC is ready to test the voltage and its resistance.

2.7. Dye absorption test
The dye absorption was analyzed using UV-VIS Agilent 8435 spectrophotometer. The light wavelength was used between 400-800 nm. Tests of anthocyanin functional groups were analyzed using FTIR perkinElmer brands. Solar cells that have been in the series of stress testing and barriers using a digital multimeter Sanwa brand. Light source used is a 24 Watt UV lamp

3. Results and Discussion
3.1. Dye absorption test and dyestigent coupling
Absorption is a quantity that states the ability of a material to absorb light. Prior to use as a dye in DSSC, jengkol shell extract was characterized in advance using the UV-Visible spectrum. UV-Visible Characterization is aimed to determine the ability of light absorption by anthocyanin from jengkol shell extract. The absorbance spectrum was measured at a wavelength of 400 nm-800 nm.

From Figure 1 it can be seen that the absorption spectra of jengkol shell extract is quite wide with maximum wavelength that is at 530 nm but at wavelength 661 nm there is one more uptake. The wide enough uptake of jengkol shell extract is good enough to be used as a dye source in DSSC. The appearance of two absorptions in the absorbance spectrum shows that the resulting jengkol shell extract contains not only anthocyanin but also chlorophyll, where absorbance absorption at 530 nm wavelength is the uptake produced by anthocyanin but absorbance absorption at 661 nm wavelength is the wavelength produced by chlorophyll.

![Overlaid Sample Spectra](image1)

**Figure 1** Absorbance Spectrum of Jengkol Shell Extract

Subsequent tests were the UV-Vis results of anthocyanin co-aggregation: gallate acid of the same ratio between anthocyanin and gallic acid of 1: 1 (w / w) seen in Fig. 2.

![Spectrum of Absorbance of Anthocyanin Copigmentation of Jengkol Shell Extract](image2)

**Figure 2.** Spectrum of Absorbance of Anthocyanin Copigmentation of Jengkol Shell Extract
From Figure 2, it shows that anthocyanin-galactic co-aggregation gives different effects on maximum wavelength shifts and measured absorbance values. Anthocyanin copigmentation-gallate acid gives a 6 nm effect of a 5 nm wavelength to a wavelength of 536 nm and a hypochromic influence of 7 nm from a maximum wavelength of 661 nm to a wavelength of 654 nm. It denotes the occurrence of anthocyanin and gallate acid coupling resulting in a shift towards the anthocyanin to the anthocyanin and a hypochromic shift in chlorophyll. The addition of copigmentation on jengkol shell extract which resulted in a shift in the anthocyanin batochromik due to the addition of double bonds in anthocyanin so as to absorb photons in the DSSC.

3.2. Testing of Functional Groups of Anthocyanin in Jengkol Shell Extract

The functional group test found in jengkol shell extract was done using FTIR instrument. The spectrum test of the wave number is performed using a wavelength of 4000-600 cm\(^{-1}\). The result of spectrum test of wave number is seen in Figure 3.

![FTIR spectra of anthocyanin jengkol shell extract](image)

The FTIR spectra of jengkol shell extract showed a stretch vibration absorption of -OH at the 3226.92 cm\(^{-1}\) wave number (3650-3200 cm\(^{-1}\)) of this spectrum thought to be OH of the alcohol group. Vibration uptake occurs in the wave number 1318.84 cm\(^{-1}\) (1350-900 cm\(^{-1}\)) which is a stretch vibration of C=O alcohol, this confirms that the anthocyanin of jengkol shell extract has a hydroxy functional group (OH) [22].

Other absorption bands are seen in wave numbers 1614.92 cm\(^{-1}\) (1680-1600 cm\(^{-1}\)) which are vibrations of C=C strains of non conjugated strain followed by vibration uptake of 754.41 cm\(^{-1}\) and 634.83 cm\(^{-1}\) (1000-650 cm\(^{-1}\)) which is a bend of alkenes = CH. The other absorption bands appear at 1443.34 cm\(^{-1}\) (1430-1690 cm\(^{-1}\)) wave numbers indicating the presence of a C-N group which is a chlorophyll group. Uptake of data obtained in accordance with the literature [22] and it can be concluded that the compound extracted from jengkol shell contains not only anthocyanin but also chlorophyll content. Table 1 is an absorption of wave numbers and functional groups of anthocyanin extract of jengkol shell.

Not much different from the anthocyanin spectrum, the FTIR spectrum in anthocyanin coagulation of jengkol shell extract showed a stretch vibrational absorption of -OH at 3230.92 cm\(^{-1}\) (3650-3200 cm\(^{-1}\)) wave numbers. This spectrum was supposed to be OH from an alcohol group. Vibration uptake occurs at 1299.92 cm\(^{-1}\), 1201.09 cm\(^{-1}\), and 1077.37 cm\(^{-1}\) (1350-900 cm\(^{-1}\)) wave numbers which are vibrational strains of C-O alcohols. Other absorption bands are seen at wave numbers 1616.27 cm\(^{-1}\) (1680-600 cm\(^{-1}\)) which is the vibration of the C=C group which produces a sharper uptake than C=C in the anthocyanin spectrum. This is due to the addition of phi bond (\(\pi\)) to the anthocyanin structure due to coupling with gallate acid. The emergence of vibrational uptake of 879.85 cm\(^{-1}\), 757.07 cm\(^{-1}\)
and 679.39 cm\(^{-1}\) (1000-650 cm\(^{-1}\)) is the bending of alkenes = C-H. Other absorption bands appearing at wave numbers 1444.35 cm\(^{-1}\) (1430-1690 cm\(^{-1}\)) indicate the presence of C-N groups which are chlorophyll groups.

**Table 1. Absorption of wave numbers and functional groups**

| Wave Numbers (cm\(^{-1}\)) | Wave Numbers (cm\(^{-1}\)) | Group       |
|-----------------------------|-----------------------------|-------------|
| 3236.92                     | 3230, 61                    | O-H         |
| 1614,92                     | 1616,27                     | C=C         |
| 1443,34                     | 1444,35                     | C-N         |
| 1318,84                     | 1299,92; 1201,09; 1077,37   | C-O         |
| 754,41; 634,83              | 879,85; 757,07; 679, 39     | =C-H        |

### 3.3. Electrical Flow Testing

To find out the amount of DSSC efficiency generated is measured voltage and resistance with the help of UW lamp 24 Watt. In this research, the thickness of layers and the duration of immersion and coating method of TiO\(_2\) on ITO glass. From the test it was found that the result of DSSC efficiency measurement from TiO\(_2\) immersed in anthocyanin dye and anthocyanin coagulation can be seen in Figure 4.

Based on Figure 5 it can be seen that anthocyanin coupling with gallate acid results in a higher efficiency than using pure anthocyanin. This is because coupling will make the anthocyanin more stable and has a good color intensity compared to pure anthocyanin so that the dye used is brighter and more concentrated in the absorption of photons by TiO\(_2\) layers. The effect of TiO\(_2\) layer thickness and duration of immersion on DSSC efficiency with anthocyanine coagigation dye can be seen in Figure 4.

**Figure 4.** Effect of TiO\(_2\) coating thickness and duration of immersion on DSSC efficiency using anthocyanin co-opmentation agent

From Figure 4, it can be seen that from the four variations of the immersion period, it was found that the duration of TiO\(_2\) immersion with anthocyanin copolymer dye for 48 hours resulted in the optimum efficiency of the coating of 4 layers of 1.40%.

The resulting efficiency is still better than Munawarroh's (2016)[18] research using mangosteen dye as well as the coupling of malic acid and ascorbic acid with an efficiency of 0.30% and 0.29%.
For the efficiency produced by TiO\textsubscript{2} mixed with the dye, the highest efficiency is still produced by TiO\textsubscript{2} mixed with anthocyanin coagulation agent with 4 coatings of 0.7262\% which can be seen in Figure 5.

**Figure 5. Results of DSSC Efficiency with TiO\textsubscript{2} mixed with anthocyanin dyes and anthocyanin co-aggregation**

From the efficiency obtained, the mixing technique of TiO\textsubscript{2} mixed with the dye obtained a low efficiency compared to TiO\textsubscript{2} immersed in the dyestuff. This is because at the time of calcination of the dyestuff-mixed TiO\textsubscript{2} layer at a temperature of 200°C resulted in the destruction of the antigianant antigensed structure, thus affecting the efficiency of the DSSC.

The results obtained in accordance with those reported by Ekasari and Yudhoyono (2013: 13)[21] using a dye of red ginger extract and liquid electrolyte that the resulting efficiency for the TiO\textsubscript{2} paste which is immersed in the dye is higher when compared to the TiO\textsubscript{2} paste mixed with the substance color. From the data obtained it also applies to dye of anthocyanin copigmentation jengkol shell extract using liquid electrolyte. The high efficiency of blending technique of TiO\textsubscript{2} paste soaked with dyestuff because the dyestuffs did not get the calcined treatment so that no damage to the antigianant structure was compensated.

In this study, the optimum efficiency of DSSC was obtained in coating of TiO\textsubscript{2} coated by 4 coatings. This is because the thickness of the TiO\textsubscript{2} layer affects the amount of the adsorbed dyestuff, with the addition of TiO\textsubscript{2} particles, the more dye bonded to the TiO\textsubscript{2} layer. The thicker TiO\textsubscript{2} layer also affects the resulting efficiency because it takes a long time for the dyestuff to be adsorbed onto the TiO\textsubscript{2} layer. This resulted in the efficiency of DSSC with 4 TiO\textsubscript{2} coatings higher than the efficiency with 5 TiO\textsubscript{2} coatings.

Immersion of TiO\textsubscript{2} paste with dye gives optimum efficiency at 48 hours immersion. This is because the longer soaking layer TiO\textsubscript{2} the more dye attached to TiO\textsubscript{2} layer. Then the better the cell performance because the intensity absorbed in the dye will be more so that it affects the current generated in the conversion process and allows the higher the occurrence of excitation electrons, resulting in the higher the efficiency of DSSC produced.

4. Conclusion
From the calculation of DSSC Efficiency value, the highest efficiency is 1.40\% with 48 hours of damping time and 4 coating using the TiO\textsubscript{2}, method soaked in dye extract of jengkol degraded gallate acid.

Reference
[1] Zainul R, Alif A, Aziz H, Arief S 2015 Disain Geometri Reaktor Fotosel Cahaya Ruang, Jurnal Riset Kimia 8 131-142
[2] Zainul R, Alif A, Aziz H, Arief S, Darajat S 2015 Modifikasi dan Karakteristik I-V Sel Fotovoltaik Cu\textsubscript{2}O/Cu-Gel Na\textsubscript{2}SO\textsubscript{4} Melalui Iluminasi Lampu Neon, Eksakta Berkala Ilmiah Bidang MIPA 15 50-56
[3] Zainul R, Alif A, Aziz H, Arief S, Dradjad S, Munaf E 2015 Design of Photovoltaic Cell with Copper Oxide Electrode by Using Indoor Lights, Research Journal of Pharmaceutical, Biological and Chemical Sciences 6(4) pp. 353-361

[4] Gratzel M 2003 Dye-sensitized Solar Cells Journal of Photochemistry and Photobiology C : Photochemistry Review 4 145-153

[5] Pradana I C, Susanti D 2013 Analisa Pengaruh Komposit Graphene- TiO2 terhadap Unjuk Kerja Dye Sensitized Solar Cell (DSSC), Jurnal Teknik ITS 2

[6] Nugraha W T, Susanti D 2015 Analisis Pengaruh Susunan Komposit Laminat Graphene-TiO2 sebagai Lapisan Semikonduktor terhadap Unjuk Kerja Dye Sensitized Solar Cell (DSSC), Jurnal Teknik ITS 4

[7] Song C B, Qiang Y H, Zhao Y L, Gu X Q, Zhu L, Song J, Liu. X 2014 Dye-sensitized Solar Cell Based on Graphene-TiO2 Nanoparticles/TiO2 Nanotubes Composite Films, International Journal of Electrochemical Science 9 8090-8096

[8] Maddu A, Zahri M, Irmansyah 2007 Penggunaan Ekstrak Antosianin Kol Merah sebagai Fotosensitizer pada Sel Surya TiO2 Nanokristal Tersensitasi Dye, Makara, Teknologi 11

[9] Dahlan D, Leng T S, Aziz H 2016 Dye Sensitized Solar Cells (DSSC) dengan Aemsitizer Dye Alami Daun Pandan, Akar Kunyit dan Biji Beras Merah (Black Rice), Jurnal Film Friesian 8

[10] Hardeli, Suwardani, Riky, T F, Maulidis, Ridwan S 2013 Dye Sensitized Solar Cells (DSSC) Berbasis Nanopori TiO2 Menggunakan Antosianin dari berbagai Sumber Alami, Jurnal Prosiding Semirata FMIPA Universitas Lampung 155-161

[11] Zainul R 2016 Design and Modification of Copper Oxide Electrodes for Improving Conversion Coefficient Indoor Lights (PV-Cell) Photocells Der Pharma Chemica 8 pp. 388-395

[12] Zainul R, Oktavia B, Dewata I, Efendi J 2018 Thermal and Surface Evaluation on The Process of Forming a Cu2O/CuO Semiconductor Photocatalyst on a Thin Copper Plate, IOP Conference Series: Materials Science and Engineering 335 012039

[13] Zainul R, Alif A, Aziz H, Yasthopi A, Arief S, Syukri 2015 Photoelectrosplitting Water for Hydrogen Production Using Illumination of Indoor Lights, Journal of Chemical and Pharmaceutical Research 7(11) pp. 57-67

[14] Zainul R 2016 Effect of Temperature and Particle Motion Against the Ability of ZnO Semiconductor Photocatalyst in Humic Acid Der Pharmacia Lettre 8 pp. 120-124

[15] Zainul R 2016 Determination of the Half-Life and the Quantum Yield of ZnO Semiconductor Photocatalyst in Humic Acid Der Pharmacia Lettre 8 pp. 176-179

[16] Nugrahawati D 2012 Fabrikasi Dye Sensitized Solar Cell (DSSC) Menggunakan Mawar Merah (Rose damascena mill) sebagai Pewarna Alami Berbasis Antosianin, Skripsi Universitas Sebelas Maret.

[17] Giribabu L, Kanarpathi R K 2013 Are porphyrins an alternative to ruthenium(II)sensitizers for dye-sensitized solar cells, , Current Science 104

[18] H M, Fadillah G, Saputri L N M Z, Hanif Q A, Hidayat R, Wahyuningsih S 2016 The Co-pigmentation of Anthocyanin Isolated From Mangosteen pericarp (Garcinia Mangostana L.) as Natural Dye for Dye-Sensitized Solar Cells (DSSC), Journal Material Sains and Engineering 107

[19] Pancaningtyas L, Akhlus S 2013 Peranan Elektrolit pada Performa Sel Surya Pewarna Tersensitisasi (SSPT), Surabaya ITS.

[20] Maulina A 2014 Preparasi Dye Sensitized Solar Cell Menggunakan Ekstrak Antosianin Kulit Buah Manggis (Garcinia Mangostana L), Jurnal Sainstek 4 158-167

[21] Ekasari V, Yudhoyono G 2013 Fabrikasi DSSC dengan Dye Ekstrak Jahe Nerah (Zingiber officinale L. ) sebagai Elektrolit, Jurnal Sains dan Seni Pomits 2

[22] Sastrohamidjojo D H 1992 Spektroskopi inframerah, Liberty Yogyakarta