Effect of Activated Variations Carbon From Oil Palm Empty Fruit Bunch To Solar Cell Efficiency p-n Junction Layer Cu_2O - TiO_2

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ABSTRACT

Research about influence effect of activated activated carbon from oil palm empty fruit bunch to solar cell efficiency p-n junction layer Cu_2O - TiO_2 and direct of sunlight. The layer of Cu_2O formed from copper (Cu) burned with temperature 550°C in 100 minutes. The solar cells are made with TiO_2 layer composed of activated carbon from oil palm empty fruit bunch of 0%, 10%, 15%, dan 20%. The parameters of the solar cell can be obtained by measuring the short circuit (I_{sc}), voltage open circuit (V_{oc}), maximum power and Fill Factor (FF) with resistor value (R) 0-50 k Ω . The composed of TiO_2 /activated carbon from oil palm empty fruit bunch analyzed using X-Ray Diffraction (XRD) and and Fourier Transform Infrared (FTIR) Spectroscopy. As a result addition of activated carbon from oil palm empty fruit bunch to solar cell efficiency is increase in the value, voltage and efficiency of solar cells. The results of the measurement of the highest efficiency of solar cells using a sun simulator and sunlight are found in variations of activated carbon 20%, with each efficiency values 0,043% and 0,0018%.

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I. Introduction

One source of energy that can be utilized to be converted into electrical energy is solar radiation energy. The potential of solar radiation energy in Indonesia is very large, especially in areas that are crossed by the equator. The intensity of solar radiation in the area averaged 4.8 kWh/m²/day [1]. Solar cell devices can be used to convert solar radiation energy into electrical energy through the photovoltaic process. One of the metal oxide materials that can be used as a constituent of solar cells is Copper (I) Oxide (Cu_2O). Copper (I) Oxide (Cu_2O) has an energy gap of around 2.1 eV. The energy gap has an acceptable range of values for the conversion of solar radiation energy [2].

Nurhidayah in 2017 conducted research on the manufacture of TiO_2 composite solar cells/graphite rosella flower extract produced solar cells with the highest efficiency reaching 0.003% [3]. Fadlly in 2018 conducted research on the characteristics of I-V Cu/ Cu_2O solar cells using star fruit electrolytes, in that study the highest efficiency solar cells were found in Cu/ Cu_2O -100 samples with efficiency values reaching 2.84% [4]. Based on these studies, this article will examine the effect of variations in activated carbon from on the efficiency of Cu_2O - TiO_2 p-n junction solar cells to broaden the analysis of solar cells in the hope of having high solar cell efficiency. The solar cell will be compared to a composite

comparison of TiO_2 with activated carbon from oil palm empty fruit bunch to get the best solar cell efficiency.

II. Method

A. Material Preparation

Cu_2O coating plates will be produced from Cu plates with a size of $5 \text{ cm} \times 2.5 \text{ cm}$ through a thermal oxidation process at 550°C in 100 minutes [4]. While activated carbon from oil palm empty fruit bunch is produced through a chemical activation method, where the oil palm empty fruit bunch carbon is immersed using 3 M H_2PO_4 solution for 24 hours. Then the results of the marinade are filtered using filter paper and a neutralization process is carried out using HCl and distilled water. The process produces activated carbon from oil palm empty fruit bunch [5].

B. Synthesis of TiO_2 /Activated Carbon Composite Paste from Oil Palm Empty Fruit Bunch

The manufacture of composite paste begins with the manufacture of polyvinyl alcohol (PVA) suspensions. In making a suspension, the PVA is stirred using a magnetic stirrer at a temperature of 80°C for 30 minutes [6]. PVA functions as a binder in the manufacture of TiO_2 /activated carbon composites from oil palm empty fruit bunch. Furthermore, to obtain the best composite results, TiO_2 powder and activated carbon powder from oil palm empty fruit bunch variation in weight percentages as shown in table 1.

Table 1. Percentage ratio of TiO_2 /activated carbon composite from oil palm empty fruit bunch

No	Sample	TiO_2 (w.t%)	Activated Carbon (w.t%)
1	TiO_2 -C 0%	80	0
2	TiO_2 -C 10%	70	10
3	TiO_2 -C 15%	65	15
4	TiO_2 -C 20%	60	20

After a comparison between TiO_2 and activated carbon crushed using a mortar survived 10 minutes. Addition of PVA to the composite using a ratio of 1:1. Then stir homogeneously so that a TiO_2 /activated carbon composite paste will form oil palm empty fruit bunch.

C. ITO Glass Coating

Homogeneous composite TiO_2 / activated carbon paste from oil palm empty fruit bunch was deposited on ITO glass with doctor blade technique to form a thin layer [7]. The area of the ITO glass to be deposited is $4.5 \text{ cm} \times 2.5 \text{ cm}$. The prototype design of solar cells that have been deposited with TiO_2 /activated carbon composites from oil palm empty fruit bunch is shown in Fig 1.

Fig 1. Prototype Design of Solar Cell

D. Data analysis method

TiO₂/activated carbon composites from oil palm empty fruit bunch will be analyzed using X-ray Diffraction (XRD) to identify the formation of a composite between TiO₂ and activated carbon from oil palm empty fruit bunch. Next, the Spectroscopy Fourier Transform Infrared (FTIR) test will be performed to support the XRD results. I-V characteristics of solar cells will be carried out using sun simulators and direct sunlight by measuring the parameters of the open circuit voltage (V_{oc}) and short circuit current (I_{sc}) with a resistance variation of 0-50 K Ω .

III. Results and Discussion

A. Analysis XRD and FTIR

The results of XRD analysis on TiO₂ powder identified rutile phase using Match software with PDF number 96-900-7532. The phase peaks which have TiO₂ are shown in Fig 2. In Fig 2 we see the peak intensity between carbon and TiO₂, no new peaks are found, so that between TiO₂ and activated carbon from oil palm empty fruit bunch can still be distinguished.

Fig 2. Analysis XRD

The results of the analysis of TiO₂/ activated carbon composites from oil palm empty fruit bunch using FTIR spectroscopy are shown in Fig 3. The range of wave numbers used in the process is 4000-400 cm⁻¹.

Fig 3. The FTIR composite spectroscopy of TiO₂/activated carbon from oil palm empty fruit bunch.

Based on the Fig 3, the infrared spectrum detected vibrations in bonds between atoms with their ideal state. At lines A, B, C, D E with wave numbers between 3760-3000 cm⁻¹ is an O-H stretching functional group originating from H₂O [8]. E line with wave number 2858 cm⁻¹ corresponds to group C-H. The C-H group is thought to originate from the impurity of organic compounds trapped in activated carbon

[9]. The peak of the active carbon spectrum at wave numbers 2353 cm^{-1} and 1701 cm^{-1} shown at lines F and G are functional group bonds C=O, wave number 1134 at line H refers to bonds C-O [10]. While at line I with a wave number of 690 cm^{-1} is a functional group O-Ti-O [11]. Addition of activated carbon from oil palm empty fruit bunch 20% to TiO_2 changes the peak of the spectrum. Based on the results of the FTIR graph, there is no functional group bond between TiO_2 and activated carbon, so that it can be stated the formation of a composite.

B. Characteristics of Solar Cell I-V

Characteristics I-V are performed under direct sunlight conditions and using a sun simulator. Based on the measurement results of the open circuit voltage (V_{oc}) and short circuit current (I_{sc}), the maximum voltage (V_{maks}) and maximum current (I_{maks}) can be determined through the optimal power (P_{out}) of the current characteristic curve against the voltage (I-V). The characteristics of I-V solar cells using sun simulator and sunlight are shown in Fig 4.

Fig 4. Curve I-V of solar cells (a) using a sun simulator, (b) using a sunlight

Based on Fig 4 there is a change between current and voltage, where the highest I_{sc} value is present when the solar cell is not given a load resistance. While the value of V_{oc} increases with increasing load placed on solar cells. The increasing value of the efficiency of solar cells is also influenced by the addition of activated carbon to the TiO_2 composite. That is because activated carbon can help the absorption of electrons to solar cells to be more maximal [12].

Table 2. The characteristic value of I-V solar cells using a sun simulator

Sample	V_{oc} (mV)	I_{sc} (mA)	V_{maks} (mV)	I_{maks} (mA)	P_{in} (mW)	P_{out} (mW)	FF	H (%)
TiO_2 -C 0%	44,2	0,006	23	0,004	11,14	0,09	0,34	0,008
TiO_2 -C 10%	70	0,014	37,5	0,006	11,14	0,22	0,22	0,020
TiO_2 -C 15%	75	0,015	39	0,009	11,14	0,35	0,31	0,031
TiO_2 -C 20%	82,5	0,17	43	0,011	11,14	0,47	0,35	0,043

The complete current and voltage values can be seen in Table 2 and Table 3. In Table 2 the highest efficiency of solar cells when using a sun simulator is found in the sample TiO_2 -C 20% by 0.043%. In this sample the weight variation of 60% TiO_2 and 20% of oil palm empty fruit bunch activated carbon were used. Then the solar cells when using direct sunlight the highest efficiency values are also found in the sample TiO_2 -C 20% by 0.0018% as shown in Table 3. The efficiency of solar cells using direct sunlight is much lower than the efficiency using the sun simulator test. This is due to the magnitude of the P_{in} value generated from sunlight. The power produced by sunlight reaches 830 W/m^2 , while the power from the sun simulator is 9.9 W/m^2 [4].

Table 3. The characteristic value of I-V solar cells using a sunlight

Sample	V_{oc} (mV)	I_{sc} (mA)	V_{maks} (mV)	I_{maks} (mA)	P_{in} (mW)	P_{out} (mW)	FF	η (%)
TiO_2 -C 0%	105	0,014	53	0,009	933	0,45	0,30	0,0004
TiO_2 -C 10%	150	0,028	76	0,018	933	1,33	0,31	0,0012
TiO_2 -C 15%	162	0,032	70	0,025	933	1,75	0,33	0,0016
TiO_2 -C 20%	180	0,035	67	0,031	933	2,08	0,33	0,0018

IV. Conclusion

The results of the characteristics of I-V solar cells p-n junction layer of Cu_2O composite TiO_2 /activated carbon from oil palm empty fruit bunch that has been implemented can be summarized as follows:

1. The XRD results identified the TiO_2 powder as a rutile phase and between the peak intensities of TiO_2 and activated carbon from oil palm empty fruit bunch can still be distinguished.
2. Based on the results of characteristic data of I-V, the highest efficiency value is obtained in solar cells with 20% active carbon variation.

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