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Design of Photovoltaic Cell with Copper Oxide Electrode by Using Indoor Lights.

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ABSTRACT

This research aims to develop PV cell which utilizes natural and artificial incident light comming into indoors. This breakthrough is done to take advantage of the energy wasted from the low lighting in the room. PV cell of indoor lights is developed by modifying the electrode copper-oxide with some design reactor for PV cells to get the best performance. Optimum performance is obtained with a Vmax 0,988 V and the current (I) maximum 0.635 mA. The measurement results show that cells of Cu_2O/Al electrode pair better than the cell uses electrodes Cu_2O/Cu, comparison with the efficiency of 122: 1 in indoor lights and 307: 1 in neon lights.
Keywords :Photovoltaic Cell, Copper oxide, Reactor Design, Indoor Lights

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INTRODUCTION

In recent years, most of the energy comes from fossil fuels that can cause many problems(1; 2). Among others; First, the air pollution as a result of burning coal and oil that produces carbon dioxide (CO_2). Second, the limited availability and can't renewable. Third, the distribution of the number of countries making the cost of relocation and distribution to is swelling and very expensive(3; 4). Therefore, the necessary research for new energy sources, which are friendly to the environment (ecological), cheap (economical), sustainable for availability and abundant in nature.(5-9)

Solar energy is a clean and abundant energy. Total solar energy that bathes the entire surface of the Earth every year around 3 x 10^{24} J, or about 10,000 times that of the total world energy consumption per year (4, 10). The density of its power 1 kWm^{-2} during sunny days, and the power of solar energy globally approximately 160,000 TW(11). The availability of a large potential for renewable and sustainable energy sources.

During this time, the utilization of the light coming into the room felt very less. This is of concern to us for a cell that is designed to take advantage of the lights, using the technology of photovoltaic cells. The purpose of this research is the PV cell is designed to be able to work on the sunlight coming into the room (indoor lights) and also the lightsemanatingfrom a lights source fluorescent bulbs.

METHODS AND MATERIALS

Tools and materials

Tools and materials used in this research is a Multimeter (Heles), Lightmeter, SEM-EDX (Hitachi S-3400N), XRD (PANalytical pw30/40), fluorescent lamps (Philip 10 Watts), paper (separator), carbon paper, Furnace, Analytic Tools, and Scales tools glasses. The materials used in this research is the glass, glue the glass, Plate of Cu and Al, sodium sulfate (Na_2SO_4) (Merck), gelatin powder, chloroform (Merck) and aquades.

Experimental Method

Manufacture of electrodes the electrode Cu_2O

Cu_2O is made with a plate of Cu on calcination temperature variation of 300, 350, 400, 450 and 500^oC, for 1 hour. Result of a plate of Cu_2O characterized using XRD and SEM-EDX.

The manufacture of PV cells

Photovoltaic cells are designed with the variation of the distance and type of electrode used. Cathode (Cu_2O) and anode (Cu, Al) is limited by the glass (3 mm thick) and a 6 mm, to design 1 and 2. On the design of glass outer wall, 1 at the anode used glass black, whereas in design 2 used carbon paper. In design 3, the cathode and anode are only limited by paper 0.32mm thick membrane and the outer glass anode is limited by carbon paper.

PV cells are made with three designs like the Fig. 1.

Sodium Sulfat (Na_2SO_4) gel electrolyte solution preparation

A total of 14,206 grams of Na_2SO_4 dissolved in 400 mL of water and added that as many as 2 grams of powder. The mixture was stirred and heated to boiling until the solution becomes clear.After that, add a few drops of chloroform. In hot conditions the electrolyte solution is poured into the PV cell.

Current and voltage PV Cell measurements

Each PV cell that is filled with sodium sulfate, and then irradiated with sunlight coming into the room and fluorescent lights bulbs. Current and voltage of each cell was measured using multimeter.

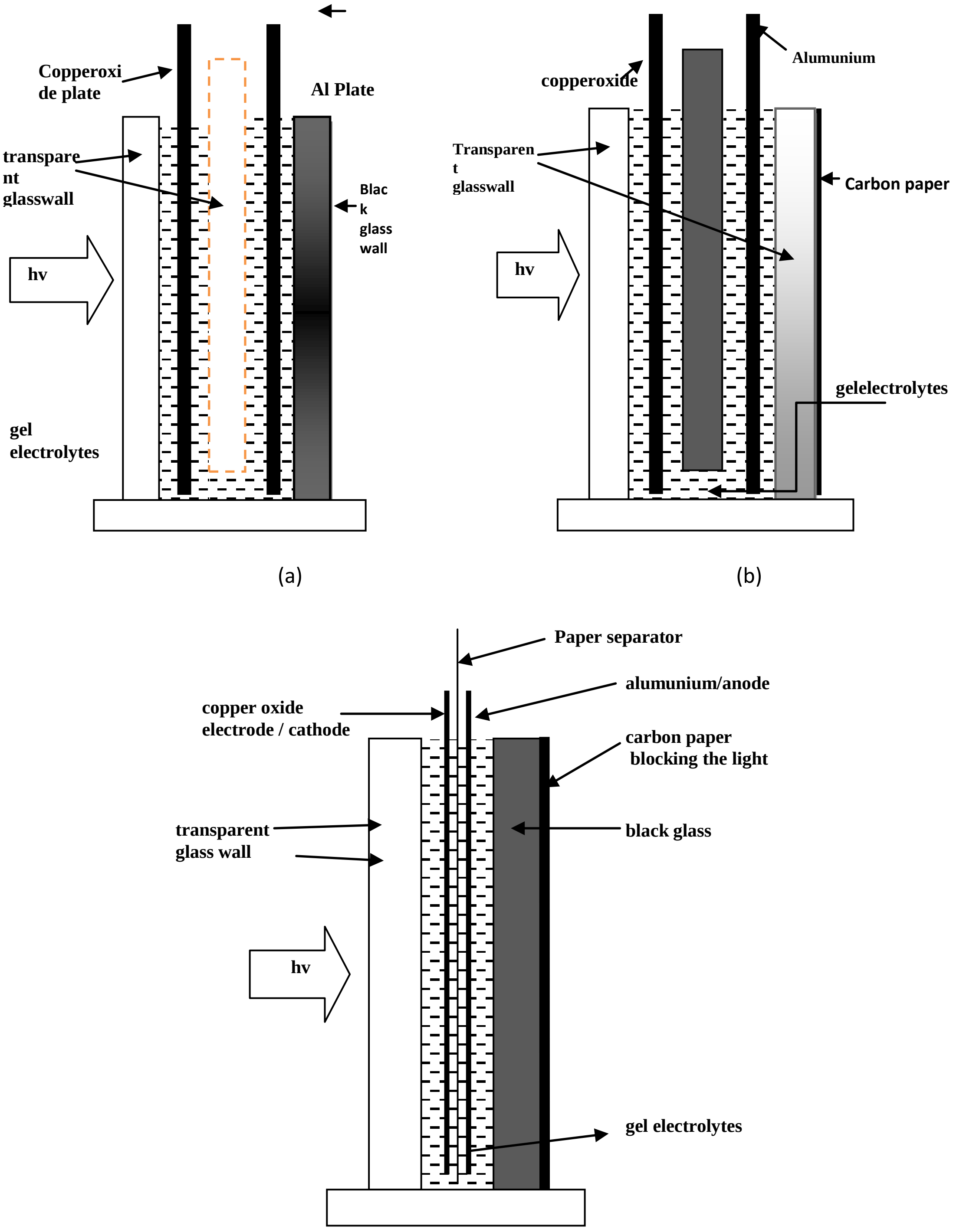

Figure 1: Schematic design for the design of PV cells 1 (a), the design of 2 (b) and design 3 (c)

RESULTS AND DISCUSSION

SEM EDX analysis

From Fig. 2, it appears there is a change on the surface of the Cu plate before and after calcination. From EDX analysis indicated in Table 1, note an increase in the amount of oxygen on the surface of the Cu plate originally 1.22 percent. In the calcination temperature of 400^{o}C obtained for 16.5 percent oxygen. At 500^{o}C, percent oxygen on the surface of the Cu plate by 15.27 percent. This result indicate that Cu plate after calcination at 400^{o}C has more CuO at the surface compare with Cu plate after calcination at 500 ^{o}C.

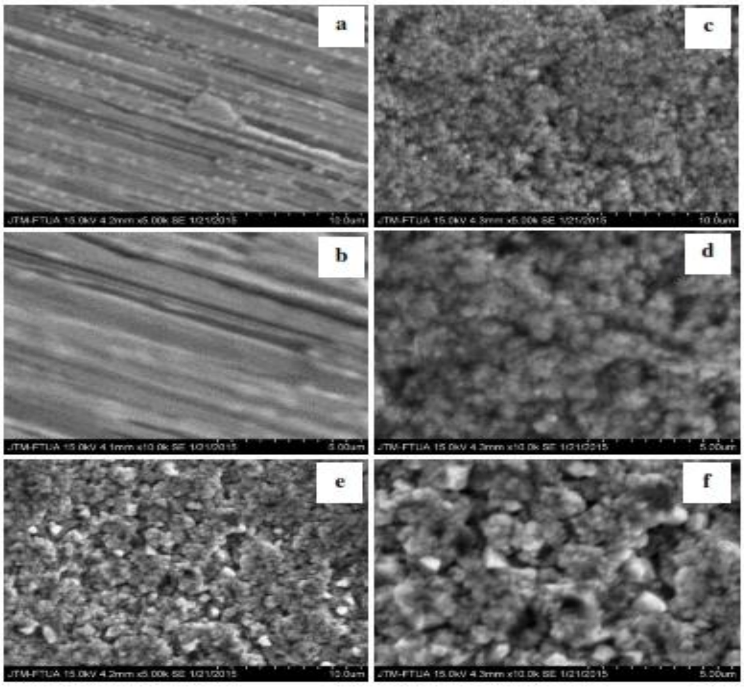

Figure 2: SEM images of the surface of the copper plate before being calcinated (a) 5000x, (b) 10000x And after calcinating at a temperature of 400^{o}C (c) 5000x, (d) 10000x and calcinating at a temperature of 500^{o}C (e) 5000x and (f) 10000x

Table 1: Results of EDX copper plates before calcination and after calcination at temperatures of 400 ° C and 500 ° C

Element	Weight percent		
	Calcination		
	Without	400^{o}C	500^{o}C
Carbon	10.46667	10.45	6.7
Oxygen	1.226667	16.34	15.27667
Copper	88.31	73.20667	78.02333

XRD analysis

From Fig. 3.seen the peak of the curve is formed which indicates the formation of copper oxide compounds. From Table 2, it is known that a compound formed by 26.7 percentCuO and Cu_2O at 73.3 percent.From this result was obtained, there two kind of copper oxide was formed, CuO and Cu_2O. This two compund was formed because under temperature 1000^{o}C will form mixture of CuO and Cu_2O, while Cu_2O was formed first and followed by CuO.(12)

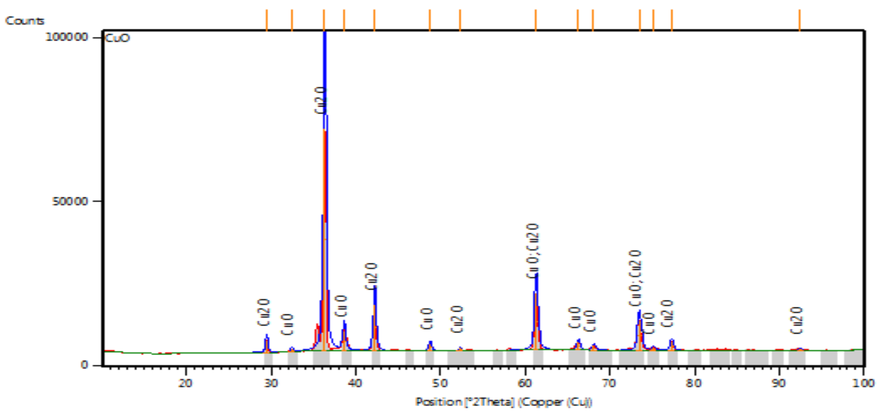

Fig 3: XRD Results copper plate after calcination at a temperature of 400°C

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Table 2: Results of XRD copper plates after calcinatingat a temperature of 400°C

Formula	Percent	Compound
CuO	26.7%	Copper Oxide
Cu2O	73.3%	Copper Oxide

Current and Voltage Measurement results PV Cells

Current and voltage with temperature variations calcinations

From the results of current and voltage measurements with calcinationtemperature variations was obtained optimum conditions at temperature 400^{o}C.This result also obtained by Sears in preparation Cu_2O via thermal treatment. He said Higher temperatures produced too thick or too non-uniform a layer, whereas lower temperature oxide layers were too thin.(13)At temperature 400^{o}C, the PV cell electrode pair Cu_2O/Cu provide daily average currentat indoor lights is13.6 µAand voltage of 28.28 mV. Power output reached 116µWatt/m^2.

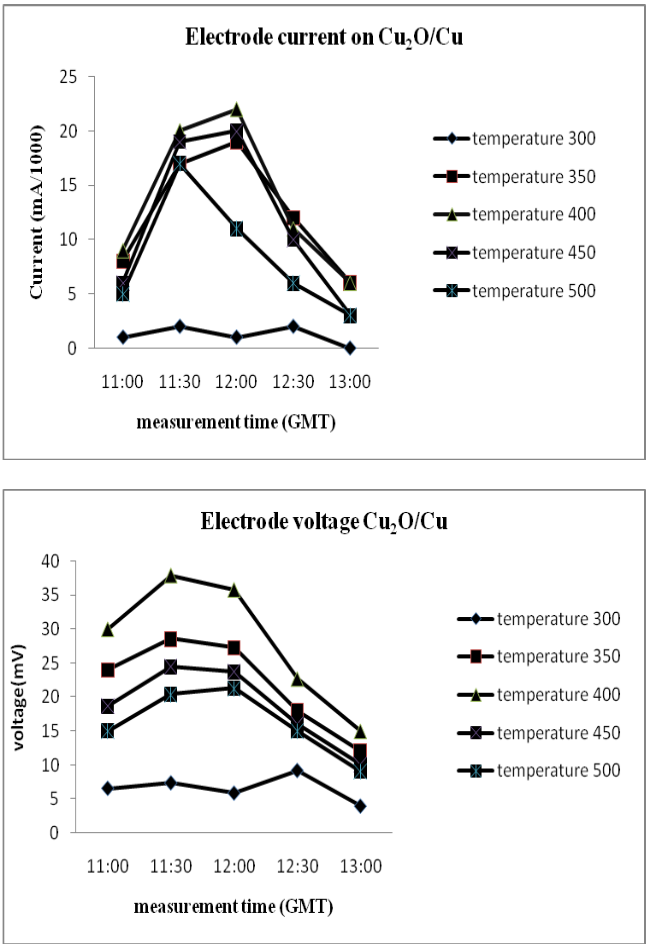


Figure 4: Graph current and voltage of the PV cell electrode pair Cu_2O/Cu at the calcinations temperature variations

Current and voltage with a variation of PV cell design

From the results of current and voltage measurements with various designs of PV cells was obtained optimum conditions in the PV Cells Design 3. In the design of PV cells 3, the pair of electrodes Cu_2O/Cu provide a daily average currentat indoor lights is 28.2 µA and a voltage of 36.5 mV. Power output reached 277.4µWatt/m^2. PV cells with using design cells number 3 has the best performace because in this design, both electrodes have a small distance. Small distance between electrode can improve performance of photovoltaic cell, this result also obtained by Chang, in his experiment was found that electrode distances can enhance the short-circuit current density (J_{sc}) and thereby conversion efficiency.(14)

Current and voltage PV cells with an electrode pair Cu_2O/Cu and Cu_2O/Al

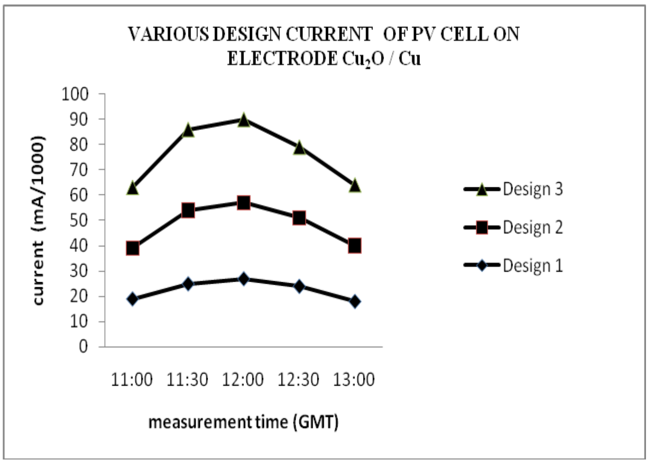
From the results of current and voltage measurements with the PV Cells electrode pair Cu_2O/Cu produced a daily average current of 28.2μA and 36.5 mV voltage at indoor lights, and with electrode pair Cu_2O/Al is 600 μA and 635 mV . In the PV cell electrode pair Cu_2O/Cuunder indoorlights irradiation, generated daily averages current35 μA and voltage 36 mV, with electrode pair Cu_2O/Al generated daily averages current 318.3 μAdan 438.7 mV. Power output of PV cell electrode pair Cu_2O/Cu reached 0.28 mWatt/m^2 under indoor lights and 0.34 mWatt/m^2 under neon lights, and power output of Cu_2O/Al reached 50.6 mWatt/m^2at indoor lights and 41.6mWatt/m^2 for neonlights. This result because $Cu_2O$is a natural semiconductor type P. If we use Cu_2O/Cu, Cu will accelerated recombination hole and electron because Cu has positive reduction potential, it contrast with Al with negative reduction potential.(15)

Circuit of PV cells in series and parallel

From the results of current and voltage measurements under irradiation sun lights which enter to the room, on the circuit of several PV Cells electrode pairs Cu_2O/Al produced a daily average currentis 482 μA and voltage is 1575 mV for 3 series arrangement of cells.At 5 and 7 series arrangement each cell produced current 400 μA, 431 μA, and the voltage of each cell is 2340 mV, 3580 mV. In the parallel arrangement of the PV cell 10 electrode pairs Cu_2O/Al produced current 2330 uA current and voltage 580 mV. At 7 series arrangement of PV cells, obtained a power of 415.7855 mWatt/m^2.

Table 3: The results of the current and voltage measurement electrodes daily average Cu_2O / Cu at the calcination temperature variations

Temperature (°C)	I (μA)	V (mV)	Daya (μW)	Daya (μW/m^2)
300	1.2	6.62	0.00914	2.462948
350	12.4	21.98	0.29698	80.02695
400	13.6	28.28	0.43106	116.1574
450	11.6	18.58	0.24834	66.91997
500	8.4	16.14	0.15462	41.66532



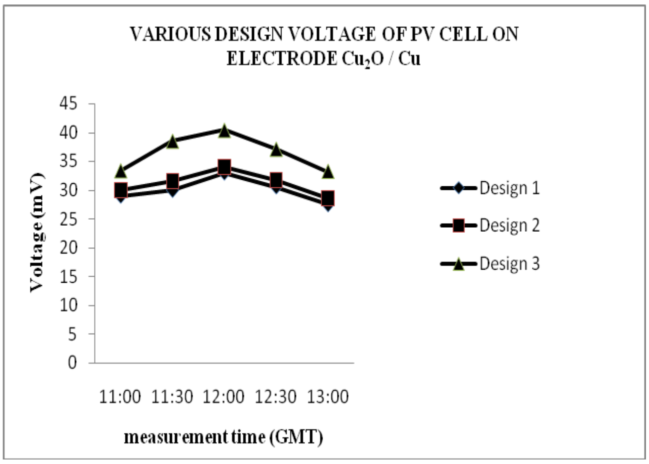


Figure 5: Graph of current and voltage of the electrode pair Cu_2O/Cu at various PV cell design.

Table 4: The results of the current and voltage measurement electrodes daily average Cu_2O/Cu in various designs PV Cells

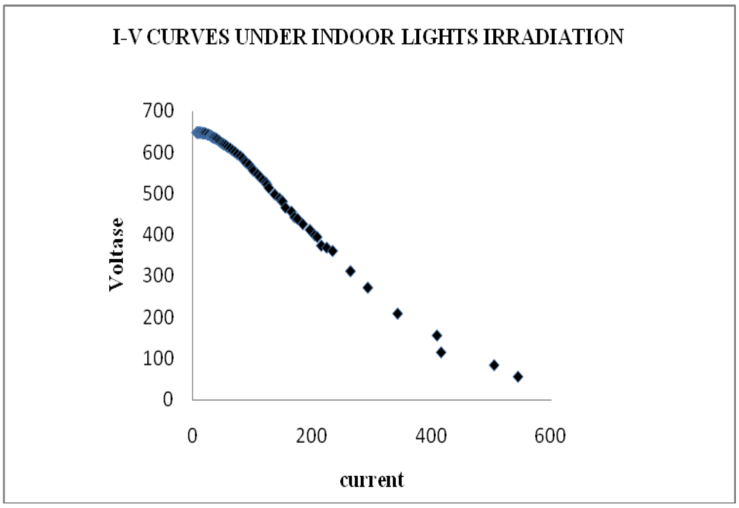
PV Design	I (μA)	V (mV)	Daya (μW)	Daya (μW/m^2)
1	22.6	30.02	0.678452	**182.8218809**
2	25.6	31.16	0.797696	**214.9544597**
3	28.2	36.5	1.0293	**277.3645918**

Table 5: The results of the current and voltage measurement electrodes daily average Cu_2O/Al on the lights source used

Cell	Under indoorlights irradiation			Under neon lights irradiation		
	Current(μA)	Volt (mV)	P (mWatt/m^2)	current(μA)	Volt (mV)	P (mWatt/m^2)
Sel 1	200	580	31.25842	113	536	16.32121
Sel 2	257	581	40.23632	235	407	25.77338
Sel 3	121	353	11.50984	120	280	9.054163
Sel 4	980	635	167.6906	988	606	161.3387
Sel 5	167	486	21.87065	166	395	17.66909
Sel 6	258	454	31.56346	231	380	23.654
Sel 7	315	473	40.14956	371	367	36.69011
Sel 8	273	500	36.78254	350	516	48.66613
Sel 9	600	635	102.6677	361	548	53.30854
Sel 10	201	401	21.71948	248	352	23.52358
Average	**337.2**	**509.8**	**50.54487**	**318.3**	**438.7**	**41.59989**

Table 6: Results Measurement of current and voltage in series and parallel from multiple cell electrode pairs Cu_2O/Al.

circuit	current(μA)	Volt (mV)	Power(mW)	Power(mW/m^2)
Series 3 cells	482	1575	0.75915	204.5675
Series 5 cells	400	2340	0.936	252.2231
Series 7 cells	431	3580	1.54298	415.7855
Parallel 10 cells	2330	580	1.3514	364.1606



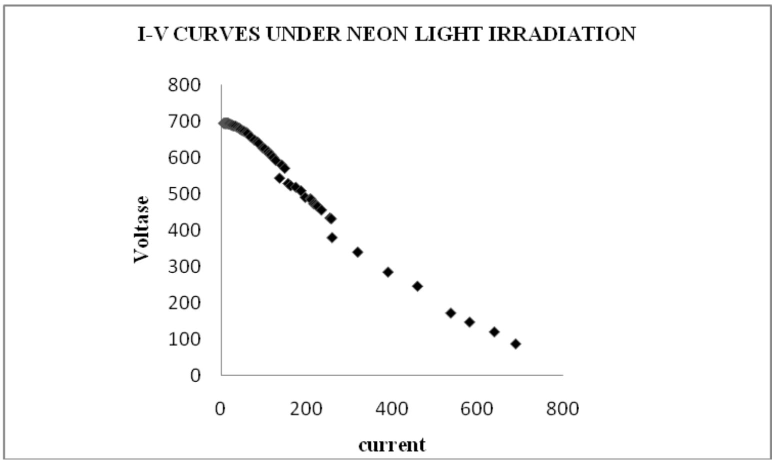


Figure 6: Current and voltage curves of the electrode pair Cu_2O/Al under indoor lights irradiation and neonlights irradiation

Table 7: I-V Characteristic Curve; Open circuit currents (I_{OC}), the open circuit voltage (Voc), Maximum Flow (I max), maximum voltage (V max), Value Fill Factor (FF) and efficiency of PV Cells (η)

under indoor lights irradiation on Cu_2O/Al					
I oc	V oc	I max	V max	FF	η (%)
337.2	509.8	690	694	2.785615	**0.752**
under neon lights irradiation on Cu_2O/Al					
I oc	V oc	I max	V max	FF	η (%)
318.3	438.7	545	647	2.525204	**1.3**
under indoorlights irradiation on Cu_2O/Cu					
I oc	V oc	I max	V max	FF	η (%)
20.2	28.55	46	36	2.871461	0.00618
under neon lights irradiation on Cu_2O/Cu					
I oc	V oc	I max	V max	FF	η (%)
18	22	39	37	3.643939	0.00424

I-V measurement

Table 7 shown the efficiency of PV cell with electrodes Cu_2O/Al under irradiation neon lights was bigger than under irradiation sun lights which enter into the room, this occur because intensity of neon lights is bigger than sun lights which enter into the room.

CONCLUSION

From result of this research can concluded was PV cell with design number 3 is the best design. PV cell with electrode Cu_2O/Al was given the best performance compare with PV cell with electrodes Cu_2O/Cu. Maximum voltage of PV cell with electrode Cu_2O/Al was generated is 0.988 mV and maximum current is 0.635 mA and efficiency 1.3 % under neon lights and 0.752 % under indoor lights.

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