Manufacturing an Organic Solar Cell and Comparing with Different Dyes

Lect. Ghassan Luay Yusif

Mechanical Department, University of Baghdad

ghassanalani65@gmail.com

ABSTRACT

A solar cell was manufactured from local materials and was dyed using dyes extracted from different organic plants. The solar cell glass slides were coated with a nano-porous layer of Titanium Oxide and infused with two types of acids, Nitric acid and Acetic acid. The organic dyes were extracted from Pomegranate, Hibiscus, Blackberry and Blue Flowers. They were then tested and a comparison was made for the amount of voltage they generate when exposed to sunlight. Hibiscus sabdariffa extract had the best performance parameters; also Different plants give different levels of voltage.

Keywords: photovoltaic, photo cell, organic cells, organic photo dyes, renewable energy

تصنيع خلية شمسية عضوية مع مقارنة اصباغ عضوية مختلفة

غسان لؤي يوسف

جامعة بغداد/ كلية الهندسة / قسم الميكانيك

الخلاصة

تم تصنيع الخلايا الشمسية من مواد محلية وقد تم طلائهم باصباغ مستخرجة من النباتات العضوية المختلفة. وقد تم طلاء الشرائح الزجاجية الخلايا الشمسية مع طبقة نانو المسامية بأوكسيد التيتانيوم والتي تم مزجها مع نوعين من الأحماض، وحمض النيتريك وحمض الخليك. تم استخراج الأصباغ العضوية من الرمان، الكركديه، و التوت البري والزهور الزرقاء. ثم تم اختبارها مع إجراء مقارنة لكمية فرق الجهد التي تولدها عن تعرضها لاشعة الشمس. النباتات المختلفة لهم كفاءات مختلفة و افضل اداء كان لنبات الكركديه الحاوي على صبغة "سابداريفا"

الكلمات الرئسية : الخلايا العضوية الشمسية , الخلايا العضوية , الخلايا الشمسية , الخلايا الفلطائية ,الطاقة المتجددة

1. INTRODUCTION

A solar cell is an electronic device that produces electricity when light falls on it. The light is absorbed and the cell produces dc voltage and current. The device has a positive and a negative contact between which the voltage is generated and through which the current can flow.

L.u.Okoli et. al.2011, performed a study on the performance of the Anthocyanin dye which is an extract from hibiscus sabdariffa which is an edible plant called zobo by Nigerians. He found that the photo conversion efficiency of the cell fabricated with the local dye is not poor when compared with the result of the Ruthenium-stained cell and other existing results.

Jill Johnsen 2006, used Blackberry juice Titanium oxide (TiO_2) as a light absorber and the oxidization of water (to produce oxygen, hydrogen, and electrons) replaces the I-/I_3 - cycle, replenishing the electrons released from chlorophyll. Ultimately, carbon dioxide acts as an electron acceptor, resulting in the fixing of carbon dioxide.

Khwanchit Wongcharee et.al 2006, fabricated solar cells by using natural dyes extracted from rosella, blue pea and a mixture of the extracts. The light absorption spectrum of the mixed extract contained peaks corresponding to the contributions from both rosella and blue pea extracts. However, the mixed extract adsorbed on TiO2 does not show synergistic light absorption and photosensitization compared to the individual extracts. The Dye-Sensitized Solar Cells (DSSCs) efficiency that used ethanol as an extracting solvent was found to be diminished after being exposed to the simulated sunlight for a short period.

Brian A. Gregga et al 2003, compared between organic and inorganic photovoltiacs.he concluded that The photoinduced generation of a free electron and hole in OPV cells is simultaneous with, and identical to, the initial separation of the electron from the hole across the interface. This is a fundamental mechanistic difference relative to conventional solar cells, in which generation and separation are two spatially and temporally distinct processes

For a PV cell to function, light must be absorbed and converted to electrons. This feat is accomplished by the anthocyanin, which has a molecular structure that acts like a photon antenna. As light is collected, the molecule enters an excited state whereby it dumps an electron wherever it can to relieve this "excitement". The electron is harnessed by attaching the anthocyanin to a semiconductor, titanium dioxide. Titanium dioxide, also known as titania, is one of the most common oxide compounds on Earth. Anthocyanins, as well as other inorganic compounds, attach themselves very well to titania due to a number of hydroxyl (-OH) bonds on both the titania and the dye. When electrons are produced by the dye, they conduct themselves through the molecule and into the titania. As long as the titania film is bound to a conductive surface, these electrons can be harnessed to do useful work, such as power a light bulb. As the adage goes, however, something cannot be got for nothing. The dye molecule cannot produce an endless supply of electrons and they must be regenerated. By using an electron donor, or redox electrolyte, the electrons are supplied back to the dye. Of course, this electrolyte does not have an unlimited supply of electrons either. The electrolyte receives its electrons from the return of the dye-generated electrons that were sent through the circuit. This cycle is important- electrons are never "used up" or destroyed, the power is just used to do some amount of work. This whole device: dye, titania, and electron donor complex creates what is known as a dye-sensitized solar cell, or DSSC. This type of cell was "invented" and published by Michael, **Grätzel in the journal Nature in 1991,** but nature itself has been performing this same process for millennia in plants by using chlorophyll. Smestad, G. P et.al

2.EXPERIMENTAL WORK

The **Fig. 1** shows how an organic solar cell works and in order to manufacture one the following steps are taken:

2.1 Preparing the ITO Slides

1. The ITO glass strips(5 x 4)cm were extracted from used mobile phones since their screens are manufactured from ITO glass i.e. that one side is electrically conductive.
2. Identify the conducting side of a tin oxide-coated piece of glass by using a MultiMate to measure resistance.
3. The conducting side will have a resistance of 20-30 ohms.
4. With the conducting side up, tape the glass on three sides using one thickness of tape. Wipe off any fingerprints or oils using a tissue wet with ethanol

2.2 Preparing the TiO_2 Paste

Grind about 0.5 gram of nanocrystalline titanium dioxide (TiO_2) in a mortar and pestle with a few drops of very dilute nitric acid. Alternate grinding and addition of a few drops of very dilute nitric acid until you obtain a colloidal suspension with a smooth consistency, somewhat like latex paint or cake icing, as shown in **Fig 2**.

2.3 Applying the Film

1. Add a small amount of titanium dioxide paste and quickly spread by pushing with a microscope slide before the paste dries. The tape serves as a 40-50 micrometer spacer to control the thickness of the titanium dioxide layer as show in **Fig 3**.

2. Wait couple of minutes for the coat to dry. Carefully remove the Scotch tape border.
3. Heat the coated glass strip gently until the wet paste dry's off and then gradually cool it off; So that it does not crack

2.4 Preparing the Dye

1. Prepare a couple of grams of blackberries and crush the in a glass container. The crushed juice slurry is then filtered with a filter funnel.
2. Put the coated face of the ITO glass strip on the blackberry juice that was just prepared and leave it for a couple of minutes so that it can soak up the juice, as shown in **Fig 4**.
3. After 10-15 minutes, gently rinse the coated ITO glass strip with distilled water followed by alcohol. This will represent the Anode electrode.

2.5 Preparing the Cathode Electrode

Light a candle, and tip the conductive side of the second piece of ITO glass strip at an angle so that it can collect soot from the candle as shown in **Fig 5.** The graphite from the soot functions as a cathode then an electrolyte is injected to the assembly.

2.6 Assembling the Solar Cell

Place the cathode with the soot face up on the table. Place a couple of drops of Iodine (electrolyte) on the anode and the place the anode electrode on top of it, as shown in **Fig 6**. And hold the two pieces of glass strips together with a rubber band or clamps.
The photovoltaic cell is now functional and all it needs to produce electricity is to be exposed to sunlight as shown in **Fig.7**.

The same procedure was performed in making the solar cells for all the other dyes that were used in this research and they were: Hibiscus, Pomegranate, Black berry and the blue flower. Then another type of solar cell as made similar to the first except instead of using Nitric acid with the $TiO_{2,}$ Acetic acid was used. Then their voltages were measured that was produced under two types of acid used and the types of dyes for each of the two sets of cells.

3. DISCUSSION and CONCLUSION

The highest voltage was generated by hibiscus it reached its peak after 15 minutes; **Table 1**; and then started to descend in voltage. The reason is owed to the probability that some of the dye and electrolyte evaporated due to the sunlight heat this is one of the drawbacks and disadvantages of open organic cells.

The lowest value was generated by the pomegranate; **Table 1**; this is due to that is was slightly more diluted than the rest of the dyes. All the dyes started at a low value and started to build up between 9 and 21 minutes. From **Table 2** find the pomegranate dye together with the blackberry dye produce more voltage than when nitric acid as used.

The voltage generated in the photovoltaic is due to that all of the extracted organic dyes have a compound known as “Anthocyanins “which is considered as a photo sensitizer. NEHA M. **NATARAJ et. al. 2012.**

Hibiscus sabdariffa extract has the best performance parameters, it corresponds to anthocyanins, because the chemical adsorption of these dyes occurs due to the condensation of alcoholic-bound protons with the hydroxyl groups on the surface of nanostructure TiO2 .**Jude O. Ozuomba1 et. al. 2013**. The reason behind the fact that the different dyes gave different levels of voltages is that they have different Ph concentration levels and thus the higher the acidity (the lower the Ph) the higher absorption of thelight wave length will be and thus a higher photo voltage will result. From this research it can be concluded the following:

1. It is possible to generate voltage from organic dyes.
2.Different plants give different levels of voltage

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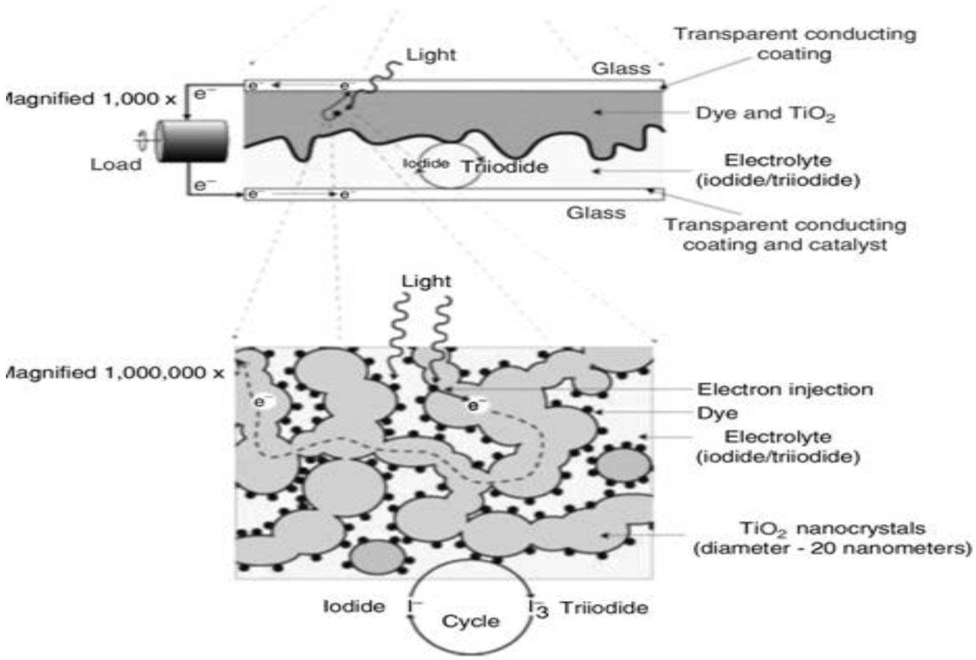

Figure.1 How a photochemical solar cell works Gavin D.J.Harper 200.

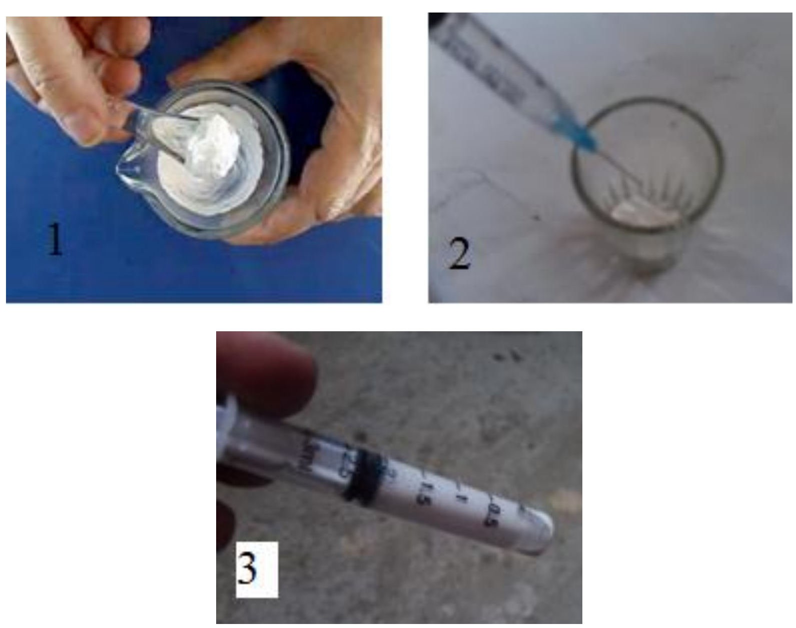

Figure 2. Preparing the TiO_2 paste.

Figure3. Applying the film of TiO2 to the ITO glass.

Figure 4: Applying the dye to the TiO.$_2$.

Figure 5. Applying the soot to the 2nd ITO slide.

Figure 6. Applying the Iodine Electrolyte.

Figure 7. The solar cell subjected to a light source.

Table 1. Different organic dyed solar cells in which nitric acid 10% was mixed with the TiO_2.

Blue Flower mV	Hibiscus mV	Black berry mV	Pomegranate mV	Time(min)
125	130	74	2	0
117	120	66	40	3
126	148	52	35	6
137	155	47	29	9
136	153	42	18	12
134	147	35	19	15
137	141	32	18	18
138	130	30	16	21
136	129	26	10	24
138	127	26	9	27
135	123	25	6	30

Table 2. Different organic dyed solar cells in which acetic acid 4-6 % was mixed with the Ti.

Blue Flower	Hibiscus	Blackberry	Pomegranate	Time min
147	145	103	212	0
110	88	114	182	3
88	58	124	180	6
106	39	125	162	9
98	49	117	152	12
92	48	123	139	15
86	56	110	127	18
78	29	114	115	21
81	35	120	116	24
75	41	127	112	27
71	47	125	105	30

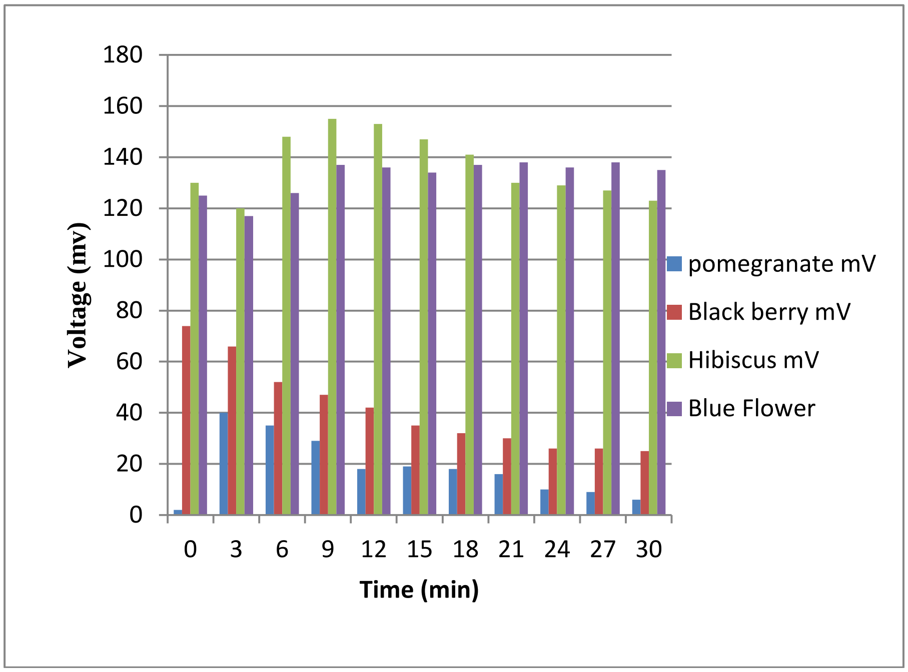

Figure 8. The different voltages generated in a time span of 30 minutes using in which Nitric acid was mixed with the TiO_2.

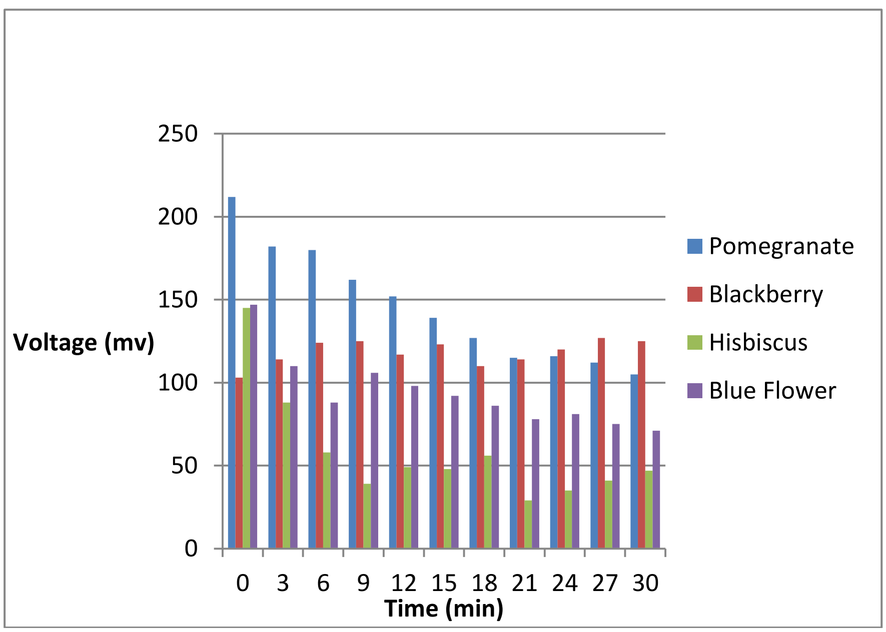

Figure 9. The different voltages generated in a time span of 30 minutes using in which acetic acid 4-6 % was mixed with the TiO_2.