Construction of Dye Sensitized Solar Cell with Bouganvilla, Cordia Sebestena and Talinium Triangulare Flower

Awodibo Michael[1], Boyo Adenike [2], Oluwole Surukite[3] Abudusalam Ibrahim[4]
[1,2]Department of Physics, Reedemer's University,Ogun, Nigeria
[3]Department of Botany, Lagos state university, Ojo, Lagos, Nigeria
[4] Department of Chemistry, Fountain University, Oshogbo, Lagos, Nigeria
Email Corresponding author: adenikeoboyo@gmail.com

Abstract

Dye sensitized solar cells, are one of the most promising devices for solar energy conversion into electricity, due to their reduced production cost and low environmental impact especially those sensitized by natural dyes. In this study, three-flowers were used as sensitizer for the dye sensitized solar cell namely Bouganvillae flower (X), Cordea sebestina flower (Y) and Talinium triangulare flower (Z). The Cold extraction method was used with acidified methanol as a solvent to extract the dye from the three samples. The outdoor energy conversion efficiency and fill factor measurement of the solar cells sensitized by Bouganvillae flower extract is 0.15% and 0.56 while the indoor values are 0.006% and 0.54 respectively. For the extract of Cordea sebestina flower, outdoor energy conversion efficiency and fill factor values of the solar cells is 0.074% and 0.85 while the indoor values are 0.0083 and 0.47 respectively. Lastly, the outdoor conversion efficiency and fill factor value of Talinium triangulare flower extract is 0.059% and 0.9 while the indoor values are 0.017% and 0.51 respectively. Comparison of the samples outdoor and indoor measurement shows that solar cell made from Bouganvillae flower has the highest efficiency and would be very useful as a natural dye for dye sensitized solar cell.

Key words: - Bouganvillae flower, Cordea sebestina flower, Talinium triangulare flower, methanol

1.0 INTRODUCTION

Solar power makes use of the abundant energy from the sun. Many technologies in our world today use solar energy. Solar energy is beneficial because it is less harmful to our environment than other methods of energy production and does not create the waste caused by burning fossil fuels. Since solar energy makes use of an inexhaustible and free source of energy, the sun, this technology will lessen our dependence on fossil fuels and protect our natural resources.

Among a variety of renewable sources in progress is the solar cell. This means harvesting energy directly from sunlight using photovoltaics. The solar cells that have recorded the highest photon to current conversion efficiency are the first generation devices based on single silicon crystal (Belfar and Mostefaoui, 2011). The problem with this solar cell is their high cost of production and installation. Various researchers (Konan et al., 2007; Bhatti et al., 2002) have worked on Second generation devices consisting of semiconductor thin film, in order to reduce the high cost of production and improve the efficiency of first generation solar cells, although the efficiency challenges have not been removed. The third generation solar cells are the dye sensitized solar cells, heterojunction cells and organic cells. These are similar to plants that use photosynthesis to absorb energy from sunlight (Zainudin et al., 2011; Efurumibe et al., 2012). Dye Sensitised Solar Cell (DSSCs) use dyes or 'sensitisers' to convert sunlight into electricity. Electricity is created when the dye is 'energised' by solar radiation, which then 'flows' from the dye to the metal oxide surface (Zweibel K 1997 and Gratzel M.2004). Predicted consumer uptake of dye-sensitized solar cell will assist in decreasing our reliance on electricity generation derived from fossil fuels, thereby decreasing greenhouse gas emissions. They are inexpensive (Amao and Komori, 2004; Hao et al., 2006; Polo and Iha, 2006). This research focus on the fabrication of dye sensitized solar cell by using extracts from Bougainvillea, Cordia sebestena and Talinium triangulare flower as sensitizers. Bougainvillea is an immensely showy floriferous and hardy plant which can be use as hedges, curb-liners and house plant or hanging basket in cooler. Cordia sebestena is a fair-sized, deciduous tree with rough, grey or brown bark, and harsh, leathery, oval leaves. The flowers lie in a cup-shaped calyx and have five curling, white petals, revealing the long stamens. The fruit is like a pale cherry and develops in stalked clusters. The nut is edible and use for landscaping. Talinium triangulare commonly known as 'water leaf' grows mainly in the tropics and subtropics e.g. Nigeria and Cameron. It is a perennial plant, grown all years round with flowers possess two sepals and basal placentation (Idu M. et al 2007).Talinium is a weed, cultivated in gardens and large farms in Nigeria. The leaves of Talinium triangulare serves as vegetables in preparing soups and stews in some Nigerian homes.

The objective of this research work is to fabricate, characterize and identify stable high performing natural dye materials in improving the efficiency of the dye sensitized solar cell.

2.0 MATERIALS AND METHODS

Fresh Bougainvillea, Cordea sebestina and Talinium triangulare flowers were collected from a farmland in Mowe along Lagos-Ibadan Expressway, at Obafemi Owode Local Government Area of Ogun State. The flowers were air dried for one week at room temperature until they became invariant in weight; laboratory ceramic made pestle and mortal were then used to crush each dry specimen into tiny bits.

Fifty grams of each crushed samples was weighed and poured into 500ml acidified solution of methanol. This was left to age at room temperature in a dark place for 24 hours. After extraction, the decantation was done and the solid residues were filtered to remove any residual parts, and the filtrate was concentrated for use as sensitizer by using rotary evaporator – a water circulating multifunction vacuum pump (by Zheng Zhou Grsat wall Scientific Industry and Trade Co. Ltd). Also, a digital multi-meter, Fisher brand Hydrus pH meter 300 model , OHAUS Electronic weighing Balance Model Brain weight B1500 made in USA and UV-visible spectrophotometer (1600series) were used for measurement.

2.1 CONSTRUCTION OF THE CELL

Preparing the substrate for deposition

The titania paste was prepared by mixing 20ml of Hydrochloric acid with 20gram of powder titanium oxide and was well stirred to ensured there was no lumps. The active conductive side of the FTO glass was determined by using a multimeter.With the conductive side facing up, two parallel strips of tape were applied on the edges of the glass plate, such that about 1.5cm by 1.5cm was left uncovered in the middle of the glass for the titania to be deposited there.

A portion of paste was applied near the top edge of the FTO glass between the pieces of tape. and a glass rod, was use in spreading the paste across the plate with the support of the adhesive tapes on the four sides of conductive glass sheet to restrict the thickness and area of TiO_2. The operation was repeated until a reasonable homogenous layer was obtained and was placed in an oven at a temperature of about 100^0C for about 15 minutes and was later removed and soaked in the dye. Then a carbon counter electrode was made by carbon coating the conductive side of another FTO glass.

2.2 Arrangement of the electrodes.

The electrodes were arranged such that the two conductive sides were facing each other ie the stained titania faced the carbon of the counter-electrode. The gap left between the two glass plates was filled with electrolyte (potassium Iodide). The electrodes were pressed together, and the electrolyte soaked in the resulting stack by capillary effect. Two binder clips were used to gently hold the plates together at the edges. Connecting wires were connected to both the electrode (titanium dioxide coated side of the other slide) and the counter electrode. The cell was then taken out for outdoor readings and indoor readings were taken as well. The results of both the outdoor and indoor readings are in Table1-2

3.0 Result and Discussion

Table 3-4 presents the performance of the Dye Sensitized Solar Cells for all the samples extract in terms of short circuit photocurrent (I_{sc}), open-circuit voltage (V_{oc}), fill factor (FF) and energy conversion efficiency (η). We observe that Bouganvillae extract has the highest value of efficiency during the outdoor and indoor measurement. This is due to the presence of high content of Antocyanin in the extract; Anthocyanin helps the extract to stick to the oxide surface thereby increasing the light harvesting ability of the extract. The higher the Anthocyanin content in plant, the greater the rate of light harvesting ability and the efficiency of the cell. Talinium triangulare and Cordea sebestina extract has the least efficiency values because of the low interaction between the extracts and TiO_2 film (Tachibana, Y. S et al 2000). The Talinium triangulare sensitized solar cell has the highest value of fill factor for indoor readings while Bouganvilla sensitized solar cell has the least value of fill factor. For the outdoor measurement Bouganvillae flower sensitized solar cell has the highest value of fill factor and the Cordea sebestina sensitized solar cell has the lowest.This shows that there is minimal internal loses in the junction of the Talinium triangulare and Bouganvilla sensitized solar cell.

The UV-VIS absorption spectra of samples methanol extract and adsorption on TiO_2 are shown in Fig 1-3. It was observed that the pattern rises sharply between 400nm and 500nm showing that it has a good light absorbing capacity. As absorbance increases from 600-1000 there is a flat pattern, meaning no light absorption could occur at this range. We notice there is difference in the absorption peaks, they were found at the different wavelengths for the methanol extract and extract adsorption on TiO_2 surface (Cherepy, N.J et al 1997). The difference is due to the reaction of the extract with the oxide surface

CONCLUSION

The DSSC of reasonably high efficiency value can be developed using Bourganvillae flower, Cordea sebestena and Talinium with methanol as a solvent. The result for Bouganvilla flower extract showed that it has the highest value of efficiency for both outdoor and indoor measurement due to high content of Anthocyanin in the extract. Anthocyanin has the ability of absorbing titanium dioxide and that increasing the light harvesting capacity of the extract. It has also been established from the result that a higher value of conversion efficiency can be obtained when the intensity of the sun is high. Overall, natural dyes as sensitizers for Dye Sensitized solar cell are promising because of their environmental friendliness and low-cost production.

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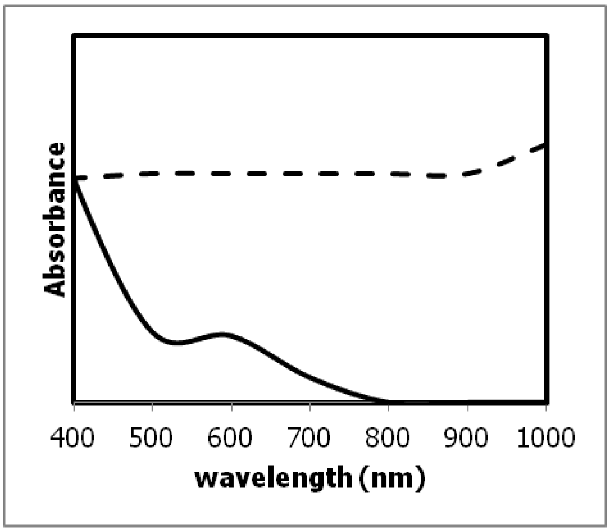

Fig.1 Absorption spectra of extract of BOUGANVILLAE FLOWER before (______) and after (_ _ _ _) being adsorbed onto TiO_2 surface.

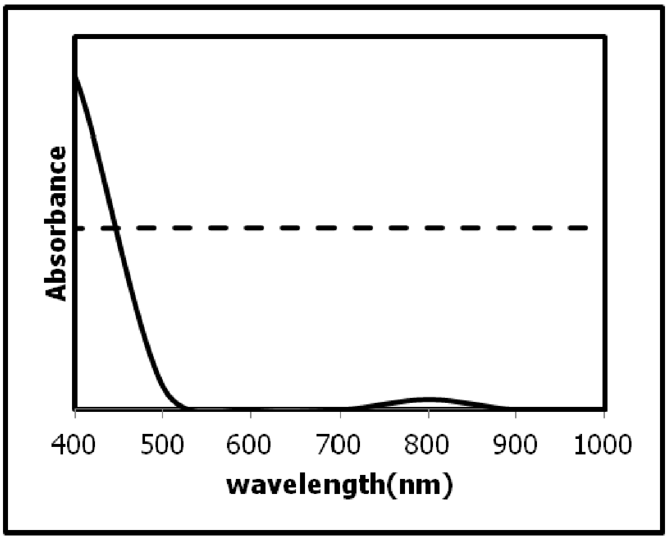

Fig.2 Absorption spectra of extract of CORDEA SEBESTINA FLOWER before (______) and after (_ _ _ _) being adsorbed onto TiO_2 surface.

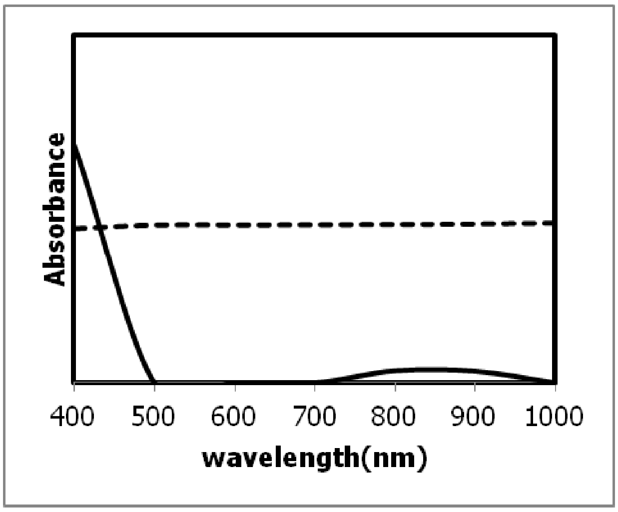

Fig.3 Absorption spectra of extract of TALINIUM triangulare FLOWER before (______) and after (_ _ _ _) being adsorbed onto TiO2 surface.

Table1. outdoor solar cell data for the Samples
X=Bouganvillae flower Y=Cordea Sebestina Z=Talinium triangulare(flower)

R	X			Y			Z		
	V(V)	I(A)	Power (W)	V (V)	I (A)	Power (W)	V(V)	I(A)	Power (W)
0	0	0.73	0	0	0.15	0	0	0.14	0
400	4.1	0.72	2.95	21.5	0.15	3.2	20.5	0.14	2.85
600	4.8	0.71	3.41	23.2	0.15	3.43	20.54	0.14	2.79
800	6.2	0.7	4.34	24.8	0.14	3.47	20.55	0.13	2.75
1000	7.5	0.68	5.1	26	0.14	3.51	20.6	0.13	2.68
1200	8.5	0.63	5.36	26.5	0.13	3.45	20.62	0.12	2.52
1400	9.4	0.62	5.83	26.8	0.13	3.35	20.65	0.12	2.48
1600	10.6	0.61	6.47	26.9	0.12	3.34	21	0.12	2.41
1800	11	0.6	6.6	27	0.12	3.24	21.2	0.11	2.37
2000	17.5	0	0	27.2	0	0	22	0	0

Table2. indoor solar cell data for the Samples

X=Bouganvillae flower Y=Cordea Sebestina Z=Talinium triangulare(flower)

R	X			Y			Z		
	V(V)	I(A)	Power (W)	V (V)	I (A)	Power (W)	V(V)	I(A)	Power (W)
0	0	0.2	0	0	0.2	0	0	0.2	0
400	0.1	0.2	0.02	0.24	0.2	0.04	0.5	0.1	0.07
600	0.4	0.2	0.07	0.6	0.2	0.09	0.8	0.1	0.11
800	0.7	0.2	0.11	1	0.1	0.14	1	0.1	0.13
1000	0.9	0.1	0.13	1.1	0.1	0.14	2	0.1	0.24
1200	1.1	0.1	0.15	1.2	0.1	0.14	4	0.1	0.44
1400	1.3	0.1	0.17	1.4	0.1	0.15	6.8	0.1	0.68
1600	1.5	0.1	0.2	1.6	0.1	0.16	7	0.1	0.7
1800	2.2	0.1	0.22	2.2	0.1	0.22	9.2	0.1	0.92
2000	2.4	0	0	4.6	0	0	10.2	0	0

Table 3. Photovoltaic performances of samples (outdoor analysis)

sample	ISC(mA/cm2)	Voc(V)	FF	η%
X	0.73	17.5	0.56	0.15
Y	0.15	27.2	0.85	0.074
Z	0.14	22	0.9	0.059

Table 4. Photovoltaic performances of samples (indoor analysis)

sample	ISC(mA/cm2)	Voc(V)	FF	η%
X	0.2	2.4	0.54	0.06
Y	0.18	4.6	0.47	0.0083
Z	0.15	10.2	0.51	0.017