British Journal of Applied Science & Technology
4(36): 5014-5020, 2014
ISSN: 2231-0843

SCIENCEDOMAIN *international*
www.sciencedomain.org

Lifespan of *Aspilia africana* Dye Sensitised Solar Cell Using Benzoic Acid

Boyo Adenike[1*], Kesinro Olasunkanmi[1] and Oseni Olanrewaju[1]

[1]*Department of Physics, Lagos State University, Ojo, Badagry, Lagos State, Nigeria.*

Authors' contributions

This work was carried out in collaboration among three authors. Author BA designed the study and wrote the protocol. Authors KO and OO got the materials and performed the experiment under the supervision of author BA. Authors KO and OO wrote the first draft of the manuscript and the manuscript was corrected by author BA. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2014/12416
Editor(s):
(1) Rodolfo Dufo Lopez, Electrical Engineering Department, University of Zaragoza, Spain.
Reviewers:
(1) Anonymous, Islamic University of Gaza, Palestinian Authority.
(2) Anonymous, Universiti Kebangsaan Malaysia, Malaysia.
(3) Anonymous, National Taipei University of Technology, Taiwan.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=700&id=5&aid=6306

Original Research Article

Received 30th June 2014
Accepted 3rd August 2014
Published 1st October 2014

ABSTRACT

Aspilia africana flower dye was extracted by using ethanol as solvent. Absorbance of the extracted dye were measured at different wavelengths and used in fabricating Dye sensitized solar cells. The mixture of dye with TiO_2 indicates changes in absorbance values and the phytochemical screening shows the presence of anthocyanin and flavonoids in the plant. Benzoic acid was mixed with the extracted dye to prolong the effectiveness of the dye and the solar cell was observed for a period of time. The sintered film for the control cell was characterized by FTIR and reported. We noticed that benzoic acid has a variety impacts on life span and electrical characteristics of the dye Sensitized solar cell. This can be concluded that the addition of benzoic acid can increase the life span of DSSC.

**Corresponding author: E-mail: adenikeoboyo@gmail.com;*

Keywords: Dye Sensitized Solar Cells (DSSCs); Titanium Dioxide (TiO_2); Aspilia africana flowers; benzoic acid.

1. INTRODUCTION

The worldwide demand for energy is expected to double by the year 2050 and triple by the end of the century [1]. Solar energy can also be used to produce heat for direct use or for further conversion to electricity [2]. Though, the prices of solar photovoltaic systems are currently high [3], investing in solar power assures free energy after a reasonable payback period.

Light from the sun is arguably the ideal source of energy. The solar flux striking the earth contains 10,000 times the average global power usage. An alternative type of solar cell made from simple common and relatively cheap materials is the dye sensitized solar cells(DSSCs) invented by Michael Grätzel and Brian O'Regan in 1991. The first solar cells were only capable of using light at the ultraviolet and blue end of the spectrum but by the turn of the century advances in technology were able to broaden the frequencies in which cells were able to respond. Grätzel M [4] is composed of a porous layer of titanium dioxide nanoparticles covered with organic dye that absorbs sunlight, similar to chlorophyll in green leaves.

Dye sensitised solar cell (DSSCs) have extensively researched over the past decades due to their high energy – conversion efficiency and especially low production cost as cheaper alternatives to silicon solar cells [1]. DSSCs typically consist of a nanocrystalline TiO_2 film covered by a monolayer of dye molecules, redox electrolyte and counter electrode.

Many photovoltaic devices have already been developed over the past five decades [5]. The abundant supply and environmental friendliness of solar energy make the efficient and cost – effective conversion of solar radiation in electricity a compelling scientific goal. Hence, it is necessary that devices like dye-sensitized solar cells are produced even at commercial scale to help meet Nigerians electricity and energy demand.

DSSCs are not currently suitable for commercial use due to their short lifespan. The three main factors that affect the lifespan of DSSCs are bacterial growth on the dye pigment, evaporation of the liquid electrolyte and the decrease in efficiency due to photo bleaching [6].

The objective of this work is to investigate the electrical performance of the DSSC utilizing the combination of *Aspilia africana* dye mixed with benzoic acid. *Aspilia africana* is a common weed of field crops in West Africa found in fallow land, especially in the forest zone. The flowers are showy yellow florets and the fruits are bristly and minutely hairy. The plant is used to treat different diseases in different ecological zones due to varying chemical composition as a result of various ecological conditions of different places. Benzoic acid is used has a preservative in foods. It inhibits the growth of mold, yeast and some bacteria. The mechanism starts with the absorption of benzoic acid into the cells.

In this study we are preparing DSSCs using *Aspilia africana* mixed with benzoic acid due to the availability of the plants' parts in parts of Nigeria. This research work is to determine the lifespan and electrical characteristics of the cell by adding benzoic acid.

2. METHODOLOGY

2.1 Sample Source and Preparation

Samples of the flower for *Aspilia africana* were obtained along Lagos–Badagry Expressway, Lagos state, Nigeria. The sample was pulverized with the aid of mechanical blender (liquidizer). 25g of the pulverized sample was weighed using OHAUS Electronic weighing balance model brain weight B1500 made in USA and soaked in 250ml acidified ethanol.

The extracting solvent and the mixture were placed in an orbital shaker (SLAUART SSL1 ORBITAL SHAKER at 25rpm) for 5 hours. The extract of the sample was decanted to remove the residual part of the samples. Simple distillation was carried out at 65°C in order to concentrate the dye of the samples. The Jenway pH meter model 3505 was used to determine the pH of extracts. To prolong the effectiveness of the dye 0.05M of benzoic acid is added to the dye. It was predicted that adding benzoic acid to the dye would be most effective as this inhibits bacterial growth.

2.2 Preparation and Construction of Cells

Conductive ITO glass with dimension of 2.5X2.0cm is to be used. The photo anode would be prepared using two slides of the conductive ITO glass. A digital multimeter was used to check the conductive side of the ITO glass and the value is 22Ω. Adhesive–tape are applied to the face of the conductive glass plate in order to create on opening of dimension 2.3X1.8cm^2 at the centre of the glass The cells were assembled and tested using the method reported by [7,8].

2.3 Measurement of Photoelectric Conversion Efficiency of DSSC

The absorption spectra of dye solution and dyes adsorbed on TiO_2 surface were recorded using a VIS Spectrophotometer (Spectrumlab 23A GHM Great Medical England) and the graphs are shown in Fig. 1. The control and modified solar cell was observed for a period of 120 hours, with current readings taken every 24 hours.

3. RESULTS AND DISCUSSION

When benzoic acid was added to the ethanol extract of Aspilia africana in order to extend the lifespan of the cell. It was observed that there was an increase in the output voltage and current when compared to the output from the control cell. After 24 hours the readings were recorded again but there was no output reading without electrolytes but when electrolyte was added to the cells, output voltages and currents were recorded. The cell containing benzoic acid showed better efficiency compared to the control cell. Also, 48 hours later the readings were taken and there was no output without electrolyte but when electrolyte was added the cells gave an output voltage and current witth the cell containing benzoic acid showing better efficiency when compared with the control cell. The electrical characteristics of the control and modified cell can be seen in Table 1. The I-V graph for the control cell and modified cell can be seen in Figs. 2–4. Also, the FTIR characterization of the modified cell was done to determie the constituents of the modified cell, the graph of FTIR characterization can be seen in Fig. 5.

The cells were left for over 2 weeks and when the readings were to be recorded there was no output voltage and current without electrolyte and when electrolytes were added.

The spectra show broad band between 500cm^{-1} and 700cm^{-1} which is due to normal TiO_2 streching. Also, the spectra shows one broad band at 3435cm^{-1} which can be attributed to the O-H bond in the sintered film. Other spectra peaks could be as a result of the dye constituent in the sintered film.

The phytochemical screening was done for anthocyanins and flavonoids. Anthocyanins have been used in organic solar cell because of their ability to covert light energy to electrical energy [9] due to its high presence in red plants. Flavonoids are the most important plant pigments for flower colouration, producing yellow or red/blue pigmentation. It was observed that the level of anthocyanin in the flower is low compared to flavonoids and does not improve the conversion of light energy to electrical energy.

Table 1. Electrical parameters for solar cells

		Jsc (mA cm^{-2})	Voc(mV)	FF	η (%)
Day 1	Control cell	0.0208	11.3	0.547	0.0013
	Cell+benzoic acid	0.020	16.8	0.784	0.0026
Day 2	Control cell	0.060	38.4	0.620	0.014
	Cell+benzoic acid	0.064	40.9	0.606	0.016
Day 3	Control cell	0.042	31.3	0.710	0.009
	Cell+benzoic acid	0.0372	33.8	0.810	0.010

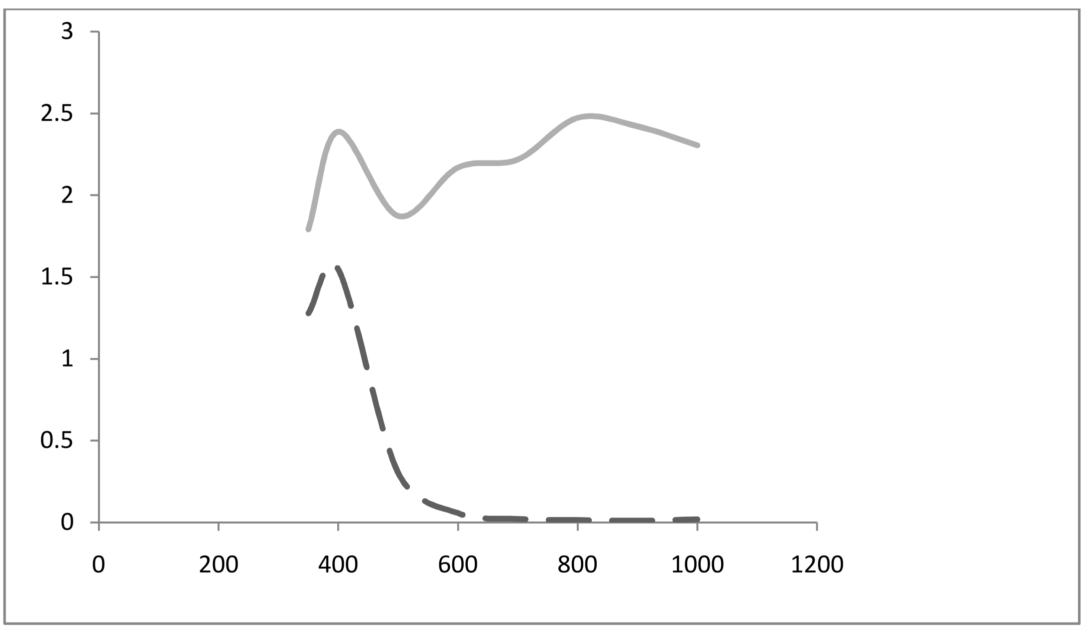


Fig. 1. Absorbance of dye (- - -) and absorbance of dye and TiO_2 (—)

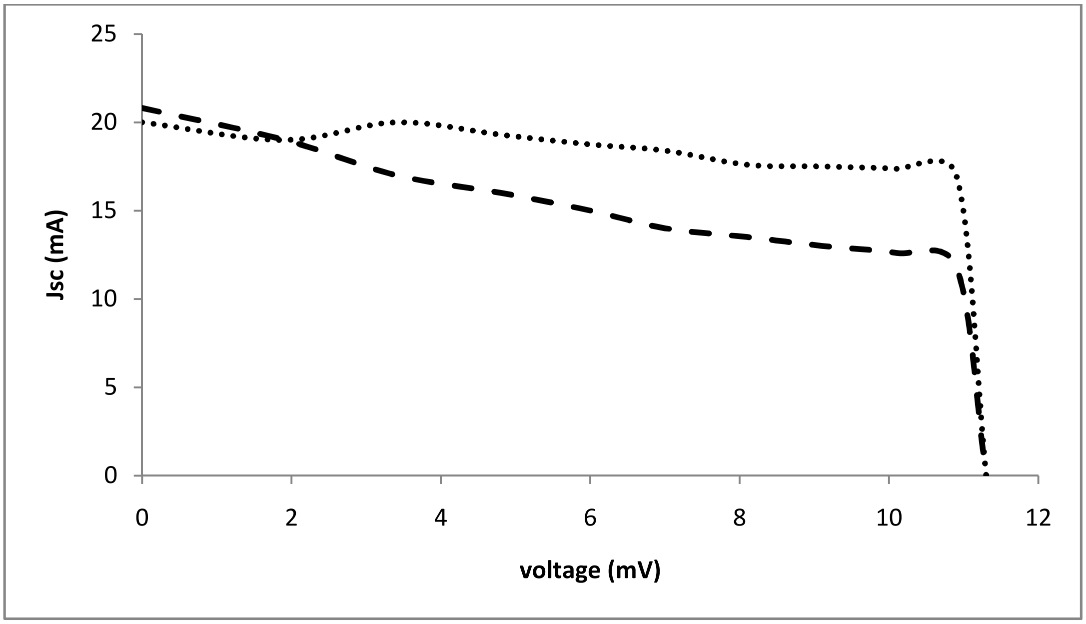


Fig. 2. I – V curve for control cell (- - -) and cell with benzoic acid (.....) day 1

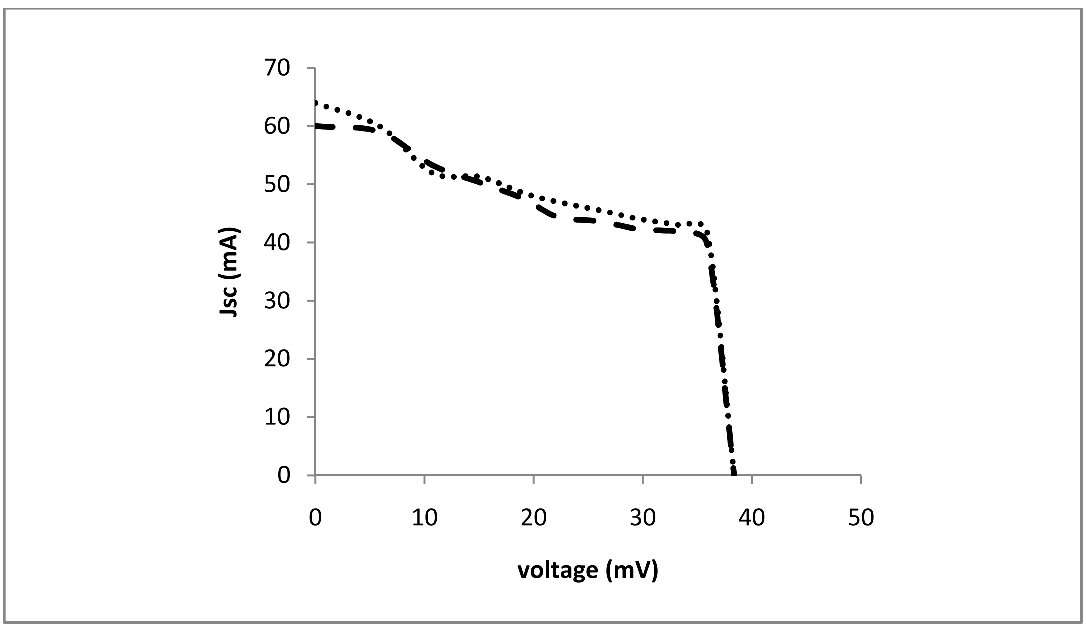


Fig. 3. I – V curve for control cell (- - -) and cell with benzoic acid (.....) day 2

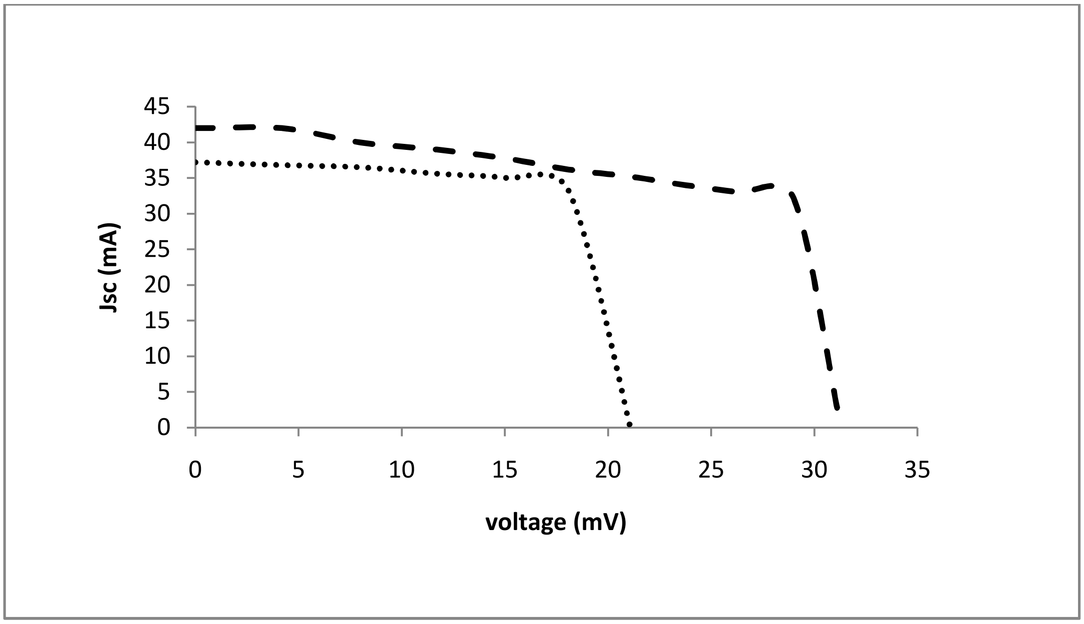
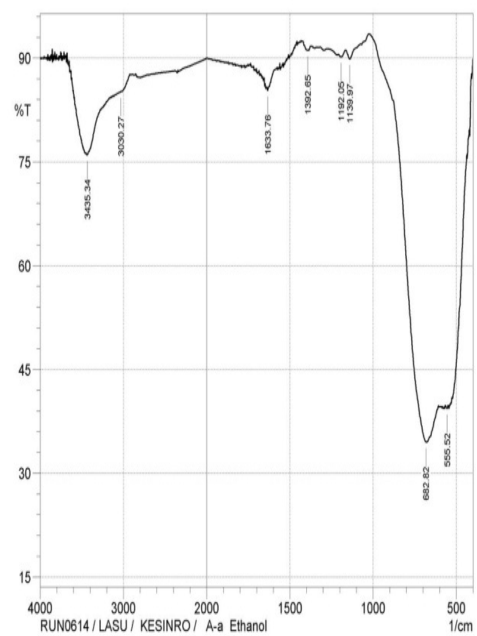


Fig. 4. I – V curve for control cell (- - -) and cell with benzoic acid (.....) day 3

SHIMADZU

	Peak	Intensity	Corr. Inte	Base (H)	Base (L)	Area	Corr. Are
1	555.52	39.37	0.45	565.16	549.73	6.22	0.04
2	682.82	34.49	1.05	1022.31	677.04	62.89	-21.83
3	1139.97	89.85	1.4	1163.11	1107.18	2.4	0.18
4	1192.05	90.15	0.61	1207.48	1166.97	1.76	0.07
5	1392.65	91.08	0.1	1396.51	1388.79	0.31	0
6	1633.76	85.33	0.57	1637.62	1624.12	0.91	0.02
7	3030.27	85.11	0.06	3032.2	3024.48	0.54	0
8	3435.34	76	0.16	3443.05	3429.55	1.6	0.01



Comment;
RUN0614 / LASU / KESINRO / A-a Ethanol

Date/Time; 6/5/2014 4:42:56 PM
No. of Scans;
Resolution;
Apodization;

Fig. 5. FTIR for sample material of control cell

4. CONCLUSION

In summary, we have successfully extracted the dye from *Aspilia africana* flower and determined the absorption spectra for the dye. Also, we determined the level of anthocyanin to be low compared to the flavonoids in the flower. FTIR studies show considerable increase in intensity with respect to peak. The benzoic acid cells exhibited higher current readings than the control cell, and maintained the increased current over the entire duration of the experiment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. O' Regan B, Grätzel M. A low cost, high efficiency solar cell based on dye sensitized solar colloidal TiO_2 films. Nature. 1991;353(6346):737-740.2.
2. Quaschning V. Understanding Renewable Energy Systems. Earthscan Canada. 2005;1-3.
3. Bakas I. Solar energy/photovoltaics. In solar energy and housing – Corpus. Copenhagen Resource Institute (CRI). 2011;1–6.
4. Grätzel M. Photoelectrochemical cells. Nature. 2001;414(15):338-344.
5. Liu J. Oriented nanostructures for energy conversion and storage. Chem. Sus. Chem. 2008;1:676.
6. Ali Samina. Biomimicry in solar energy conversion with natural dye-sensitised nano crystalline photovoltaic cells. Oberlin College, published research paper; 2007.
7. Boyo AO, Boyo HO, Abudusalam IT, Adeola S. Dye sensitized nanocrystalline titanium solar cell using laali stem bark (*lawsonia inermis*), Transnational Journal of Science and Technology Macedonia; 2012.
8. Smestad, Greg P, Gratzel Michael. Journal of Chemical Education. 1998;75:752.
9. Cherepy Nerine J, Smestad Greg P, Gratzel Michael, Zhang Jin Z. Ultrafast electron injection: Implications for a photoelectrochemical Cell Utilizing an Anthocyanin Dye – Sensitized TiO2 Nanocrystalline Electrode. The Journal of Physical Chemistry B. 1997;101(45):9342–51.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=700&id=5&aid=6306