International Journal of Sustainable and Green Energy
2015; 4(4): 137-140
Published online June 8, 2015 (http://www.sciencepublishinggroup.com/j/ijsge)
doi: 10.11648/j.ijrse.20150404.12

Annealing Effect on Efficiency of Aspilia Africana Flowers Dye Sensitized Solar Cells

Adenike Boyo[1], Henry Boyo[2], Olasunkanmi Kesinro[1]

[1]Department of physics, Lagos State University, Ojo, Lagos state, Nigeria
[2]Department of Physics, University of Lagos, Lagos State, Nigeria

Email address:
nikeboyo@yahoo.com (A. Boyo), princeboyo@yahoo.com (H. Boyo), olakesinro02@gmail.com (O. Kesinro)

To cite this article:
Adenike Boyo, Henry Boyo, Olasunkanmi Kesinro. Annealing Effect on Efficiency of Aspilia Africana Flowers Dye Sensitized Solar Cells. *International Journal of Sustainable and Green Energy.* Vol. 4, No. 4, 2015, pp. 137-140. doi: 10.11648/j.ijrse.20150404.12

Abstract: Energy was generated by using methanol as a solvent to extract dye from Aspilia africana Flowers. The maximum absorption of the extracted dye was observed at different wavelengths (350-1000nm). TiO_2 was annealed at different temperatures and phytochemical screening was done. We observed insignificant presence of anthocyanin compared to flavonoids in the flowers. The solar energy conversion efficiency changes from 0.21% to 0.52%, due to the sintering of the TiO_2 at different temperatures. The increase in solar energy conversion efficiency can be attributed to the changes in the morphology, crystalline quality, and the optical properties caused by the sintering effect.

Keywords: Aspilia Africana, Methanol, Anthocyanin, Flavonoids and Dye Sensitized Solar Cell

1. Introduction

The technology of harvesting solar energy in producing photovoltaic systems has attracted worldwide attention. Several researches have been done on photovoltaic technologies which includes dye sensitized solar cells [1],[5],[8], organic solar cells [4], and multijunction solar cells [9]. Dye sensitized solar cells (DSSCs) have played an important role in the development of photovoltaic technology, although encouraging efficiency of the DSSCs have been presented by many authors, but the use of the DSSCs is still not feasible for commercial applications. These low efficiencies of DSSCs might be due to challenges faced in obtaining suitable materials for its production. Thus, careful importance is placed in harnessing dyes that have a long lifespan, cheaper, and environmental friendly solar cells.

The nano-crystalline dye sensitized solar cell is a photo electrochemical cell. The basic working principle of DSSCs is that photons strike the monolayer of dye which gives up energy. This excites electrons from the dye, instead of generating electron – hole pairs. As shown in 'Fig.1' the solar cell consist of two conductive glass slides (ITO or FTO) with nanoparticle TiO_2 sintered on one of the conducting glass slides, stained with the dye and the other conducting glass slide is carbonized with soot. DSSCs are placed in the category of third generation photovoltaics where new trends in the photovoltaic technology are applied. In the first generation PV cells, the electric interface is made between doped n-type and p-type bulk silicon. First generation PV cells provide the highest so far conversion efficiency. The second generation PV cells are based on thin film technology. These cells utilize less material and they thus drop the production cost, however, they are less efficient than the bulk cells. Both first and second generation cells are based on opaque materials and necessitate front-face illumination and moving supports to follow sun's position. Thus they may be either set up in PV parks or on building roofs. Third generation solar cells, are based on nanostructured (mesoscopic) materials and they are made of purely organic or a mixture of organic and inorganic components, thus allowing for a vast and inexhaustible choice of materials.

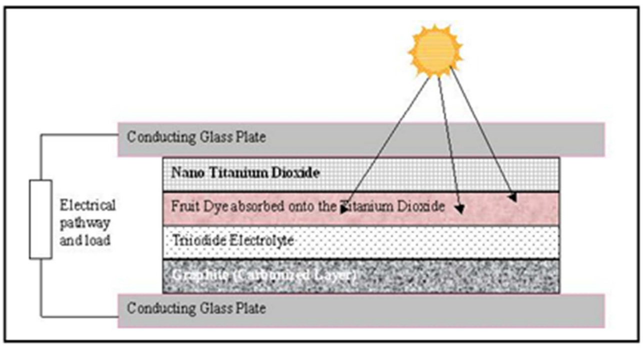

Figure 1a. *Dye sensitized solar cell.*

A liquid triiodide electrolyte is added in between the glass slide.. The absorption of photons causes dye molecules to be attached to the surface of the nanocrystalline titanium dioxide which produces photoelectrons. The titanium dioxide is the photoanode, photoexcitation of the dye results in the transfer of electrons into the conduction band of the nanocrystalline titanium dioxide.

Annealing nanoparticle titanium dioxide at different temperature plays an important role in the solar energy conversion performance of Dye Sensitized Solar Cells. These affect the physical, chemical and optical characteristic of TiO_2. Titanium dioxide (TiO_2) can crystallize in three different phases namely: rutile (tetragonal), anatase (tetragonal) and brookite (orthorhombic) [10]. The rutile-TiO_2 is thermodynamically stable at all temperatures and can be obtained in most crystal growth processes.

The anatase-TiO_2 and brookite are less dense and less stable in comparism to the rutile-TiO_2.phase [10].

We fabricated DSSCs using Aspilia africana flowers dye extracted from methanol and study the effect of annealing of TiO_2 films at different temperature intervals from 100^0C, to 500 ^{0}C for 30 minutes on the performance of DSSCs.

This study was borne out of the availability of these plants in Nigeria. Another important factor is that Nigeria uses about 3 trillion kWh of energy each year, and with energy requirement growing every year, it is the responsibility of the government and other institutions to develop energy harvesting technologies from renewable energy sources for a sustainable future.

Hence, in order to improve the generation of electricity in our country and beyond, it would be necessary that devices like dye-sensitized solar cells are produced at commercial scale to meet energy demands in Nigeria.

2. Methodology

2.1. Sample Source and Preparation

Samples of the flower for Aspilia africana were obtained from Magbon community along 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 methanol.

The extracting solvent and the mixture were placed in an orbital shaker (SLAUART SSL1 ORBITAL SHAKER at 25 rpm) for 4 hours .The extract of the sample was decanted to remove the residual part of the samples. Simple distillation was carried out at 650°C in order to concentrate the dye of the samples.

2.2. Preparation and Construction of Cells

We used conductive ITO glass with dimension of 2.5 X 2.5cm^2. The photo anode was prepared using a slide of the conductive ITO glass. A digital multimeter was used in detecting the conductive side of the ITO conducting glass and the value was 22 Ω. Adhesive –tape were used to the face of the ITO conducting glass plate in order to create an opening of dimension 2.0 X 2.0cm^2 at the centre of the glass where the TiO_2 paste will be applied. The cells were assembled and tested using the method reported by [2], [6].

2.3. Measurement of Photocurrent Voltage of the DSSC

The absorption spectra of natural dye of Aspilia africana flower and natural dye mixed with TiO_2 were recorded using a VIS Spectrophotometer (Spectrumlab 23A GHM Great Medical England). The photocurrent voltage was measured by using digital multimeters under indoor illumination. The electrical characteristics were taken for different sintering temperature.

After the TiO_2 paste was applied on each conducting glass. Each conducting glass was sintered at different temperatures (100 – 500°C) before the cells were assembled.

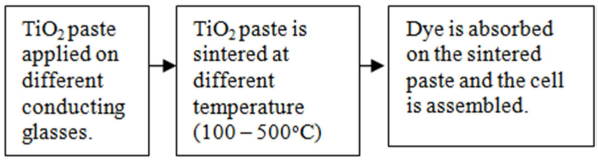

Figure 1b. *Flowchart of methodology.*

3. Results and Discussion

The absorption spectra for the extracts of Aspilia africana is presented in 'Fig.2'. The extract has optimal absorbance at 400nm. This indicates that extracts of Aspilia africana can be applied as an organic sensitizer in DSSCs

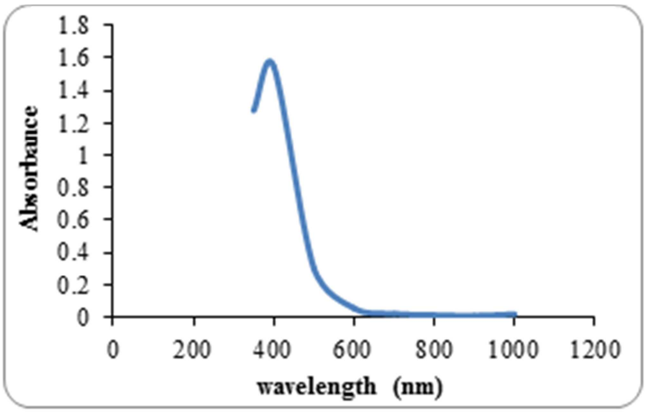

Figure 2. *Absorbance graph of Aspilia africana extract (series removed).*

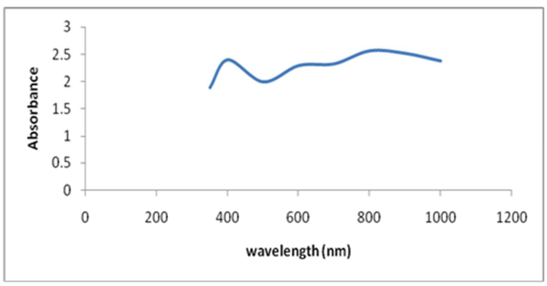

Figure 3. *Absorbance of TiO_2 with dye.*

'Fig. 3' shows the absorbance of dye with TiO_2 having the maximum peak at 800nm .The peak wavelength falls within the visible spectrum. This indicate that `the dye is complexed or chelated (attached) to the titanium dioxide and be able to absorb the photons' energy, exciting and freeing some of its electrons.

This research observed the effect sintering temperature has on cell efficiency by annealing the TiO_2 at different interval of temperatures from 100 ^{o} C to 500 ^{o} C. Each cell was fabricated using the same procedure except that the TiO_2 temperature was varied. Experimental results after electrical characterization are shown in Table 1

Table 1. *Photovoltaic performances of cells at different temperatures.*

Temp. ^{o} C	Isc (short circuit current) (mA)	Voc (Open circuit voltage) (mV)	FF (Fill factor)	Efficiency
100	0.62	140	0.59	0.21
200	0.7	138	0.63	0.24
300	1.06	232	0.45	0.44
400	0.9	198	0.68	0.49
500	0.98	220	0.6	0.52

This indicates that cell efficiency increased with increase in sintering temperature and maximum efficiency was observed at 500^o C. It was observed that as the sintering temperature increased there was also an increase in the photocurrent of the cell except for the cells fabricated at 300 ^{o} C which had a higher photocurrent compared to other fabricated cells. Higher photocurrent at 300 ^{o} C could be as a result of reduction in the particle size and better absorption of dye. Finally, the cell fabricated at 400 ^{o} C showed higher fill factor than that of others. The change in fill factor could be as a result of the size of the TiO_2 layer.

An unstable behavior is observed in the I-V curve at different temperatures in 'Fig.4 to Fig.8'. This unstable behavior indicates that the liquid electrolytes do not diffuse fast to deliver adequately charges for the regeneration of oxidized dye molecules, these results in a significant reduction of photocurrent.

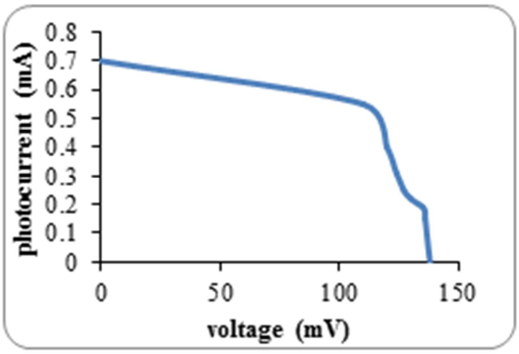

Figure. 4. *I-V curve at 100 ^{o} C. (series removed).*

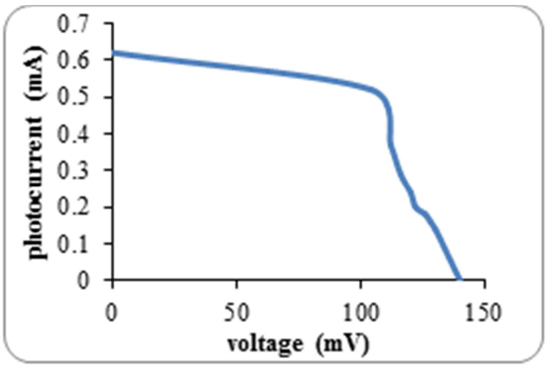

Figure 5. *I-V curve at 200 ^{o} C (series removed).*

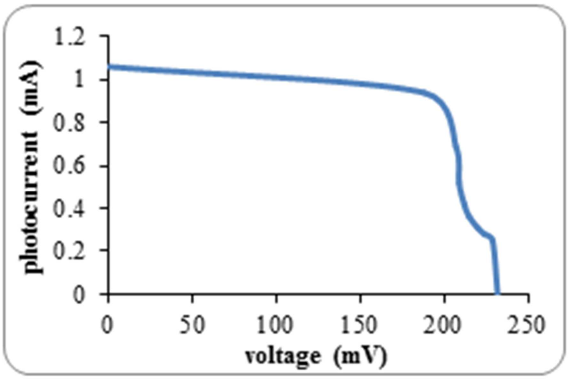

Figure 6. *I-V curve at 300 ^{o} C (series removed).*

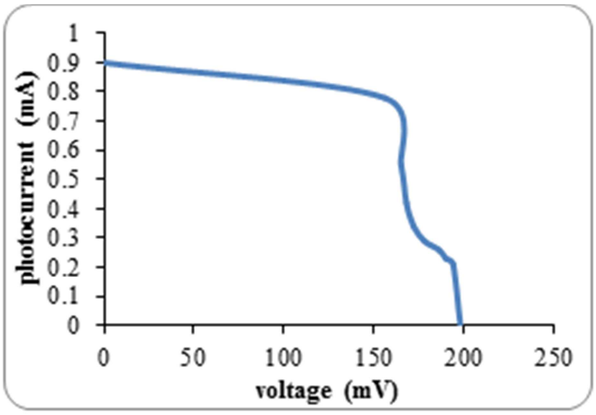

Figure 7. *I-V curve at 400 ^{o} C (series removed).*

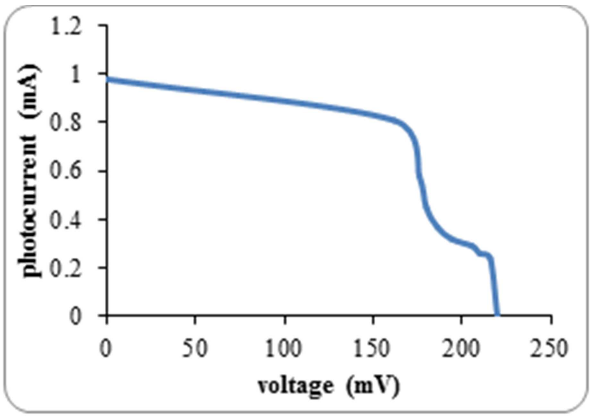

Figure 8. *I-V curve at 500 ^{o} C (series removed).*

The phytochemical screening was done for anthocyanins and flavonoids. Anthocyanins are used in DSSCs due to their ability to covert solar energy to electrical energy [3] due to its high presence in red plants. Most important plant pigments for flower colorations producing yellow or red/blue pigmentation are flavonoids. 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.

4. Conclusion

Using screen printing method, TiO_2 nanocrystals were successfully deposited on Indium Tin oxide (ITO) glass. Sintering was carried out at different temperatures to improve the efficiency of the cell. The significant improvement of the photovoltaic performance obtained can be attributed to the improvement in the crystal quality of TiO_2 nanocrystal and enhanced absorption of the cell. This is because as sintering temperature increases there is a reduction in the number of open pores in the TiO_2 resulting in dye absorption.

References

[1] B. O'Regan and M. Gr¨atzel, "A low-cost, high-efficiency solar cell based on dye-sensitized colloidal TiO2 films," *Nature*, vol. 353, no. 6346, pp. 737–740, 1991.

[2] Boyo A. O, Boyo H.O, Abudusalam I.T. and Adeola S. (2012). Dye Sensitized Nanocrystalline Titanium Solar cell using Laali Stem Bark (lawsonia inermis), Transnational Journal of Science and Technology Macedonia.

[3] Cherepy, Nerine J., Smestad, Greg P.; Gratzel, Michael; Zhang, Jin Z. (1997). "ultrafast Electron Injection: Implications for a photoelectrochemical Cell Utilizing an Anthocyanin Dye – Sensitized TiO2 Nanocrystalline Electrode". The Journal of Physical Chemistry B 101 (45): 9342 – 51.

[4] F. A. de Castro, F.N¨uesch, C.Walder, and R.Hany, "Challenges found when patterning semiconducting polymers with electric fields for organic solar cell applications," *Journal of Nanomaterials*, vol. 2012, Article ID 478296, 6 pages, 2012.

[5] H. S. Chen, C. Su, J. L. Chen, T. Y. Yang, N. M. Hsu, and W. R. Li, "Preparation and characterization of pure rutile TiO2 nanoparticles for photocatalytic study and thin films for dye-sensitized solar cells," *Journal of Nanomaterials*, vol. 2011, Article ID 869618, 8 pages, 2011.

[6] How to build your own solar cell: A nanocrystalline dye-sensitized solar cell (http://www.solideas.com/solarcell/english.html)

[7] Lapornik B., Prosek M., Wondra A.G., Food J., Eng. 2005, 71, 214

[8] M. Gr¨atzel, "Photoelectrochemical cells," *Nature*, vol. 414, no. 6861, pp. 338–344, 2001.

[9] M. Yamaguchi, "Multi-junction solar cells and novel structures for solar cell applications," *Physica E*, vol. 14, no. 1-2, pp. 84–90, 2002.

[10] R.C. Weast (Ed.), Hand Book of Chemistry and Physics, 67th Edition, (CRC Press, Boca Raton, FL, 1986–1987, p. B-140).