Science Journal of Physics
ISSN: 2276-6367
http://www.sjpub.org/sjp.html

Published By
Science Journal Publication
International Open Access Publisher

Research Article

DOI: 10.7237/sjp/182

Development of Dye Sensitized Solar Cells Using Botuje Green Leaves (Jathopha Curcas Linn)

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Accepted 04 April, 2013

Abstract- Dye sensitized solar cell (DSSC) is the only solar cell that can offer both the flexibility and transparency. Its efficiency is comparable to amorphous silicon solar cells but with a much lower cost. Fresh green Leaves of Botuje (*Jathopha curcas Linn*) was extracted and used as a *sensitizers* for the development fabrication of *dye sensitized* solar cells . The Solar cells sensitized by Botuje (*Jathopha curcas Linn*) extracts achieved up to Jsc 0.69mAcm^2, Voc 0.054 V, Pmax 0.033mWcm^2 and ff 0.87. The energy conversion efficiency (η) of the cells is 0.12%. The Phytochemical screening of the extract indicates the absence of anthraquinones and presence of flavonoids. The results obtained with extracts of Botuje (*Jathopha curcas Linn* shows a conversion of visible light into electricity by using low costs developed natural dyes as wide band-gap semiconductor sensitizers in dye-sensitized solar cells.

Keywords: Botuje (*Jathopha curcas Linn)*, Anthraquinones, Flavonoids, TiO_2, Nitric acid, Plane mirror

Introduction

The technologies to utilize the enormous energy potential that lies in the Sun have existed for several decades already but the still high price of the photovoltaic (PV) panels and the current PV devices' suitability for only limited variety of applications have hindered solar power's large scale usage (O'Regan, B.; Grätzel, M. 1991). This is why development of new, more advanced, cheaper and efficient solar energy technologies is investigated to make renewable energy affordable and available to consumers (Grätzel, M., 2004).

This study concentrates on the third generation photovoltaic which is the Dye sensitized solar cell (DSSC), (Hara, K.; Arakawa H. 2003). The crystalline silicon represents the first generation photovoltaics and thin film technologies such as cadmium telluride (CdTe), copper-indium-gallium selenide (CIGS), copper-indium sulphide (CIS) and amorphous silicon (*a*-Si) are examples of the second generation. (Tulloch, G. 2004). Unlike the conventional, solid semiconductor solar cells (1st and 2nd generation), the Dye-Sensitized Solar Cell is a photo electrochemical device, which uses organic dyes to generate electricity from light. Its operating principle mimics the photosynthesis reaction of the green plants. In photosynthesis, light is converted into chemical energy. Chlorophyll and other pigments can eject electrons through photo-induced charge separation when struck by photons. (Grätzel, M., 2004).The advantages of this technology lie in its simple low cost, non-toxic, recyclable materials and energy-efficient. They are suitable for wide variety of end-user products, from small scale power production to consumer goods such as mobile phone chargers. (Gopal K. Mor, Karthik Shankar, Maggie Paulose, Oomman K. Varghese and Craig A. 2006). In this study, we have develop a DSSC using Botuje (*Jathopha curcas Linn*) a member of Euphorbiaceae family. It is grown in southern Nigeria and its primary use is for fencing while the secondary uses are as a source of edible leafy vegetable and as medicine (Olayiwola G., Iwalewa E.C.,Omabuwajo O. R, Adeniyi A.A.,E.J.Venpohl 2004). The Phytochemical screening of the extract was an integral part of the research.

Materials and Methods

The analytical grade reagents used with out further purification are titanium dioxide, ethanol, nitric acid, distilled water, hydrochloric acid, potassium iodide, iodine and carbon. The reagents are of Analytical grade and were used with out further purification. The dried leaves of Sorghum bicolor were obtained from a farmland in Badagry market, at Badagry local government Area of Lagos State, Nigeria. The other materials used are laboratory glassware, plane mirror, an oven, binder clips and soxhlet extractor. 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 spectrum Lab 23A GHM great medical Spectrophotometer model were used for measurement.

Extraction of Dye

Twenty five (25g) of the crushed Botuje (*Jathopha curcas Linn*) were extracted in ethanol. The Solid residues were filtered to remove any residual parts and then evaporated by using hot water bath to increase the concentration of dye to the solvent. The extract was allowed to dry at room temperature and then weighed. The obtained solution was

directly used as dye solution for the preparation of photovoltaic devices. Elucidation of the exact structures was not done since the aim of the study was to use them as available in the leaves without any isolation

Phytochemical Screening

The Phytochemical screening was performed using standard procedure (Ayoola G.A, Coker H.A.B, Adesegun S.A., Adepoju-Bello A.A, Obaweya K., Ezennia E.C. and Atangbayila T.O 2008). The test for presence of anthraquinones was performed by boiling 0.1g of the extract with 2ml of sulphuric acid (H_2SO_4) and filtered while hot. The filtrate was shaken with 1mi of chloroform. The chloroform layer was pipette into another test tube and 0.2ml of dilute ammonia was added .The initial color of the solution is brown and the resulting color is a white precipitate solution. This indicates absence of anthraquinones.

In testing for the presence of flavonoids, 1ml of diluted ammonia was added to 0.1g of the extract. Then 0.2ml of concentrated sulphuric acid (H_2SO_4) was added into the solution. A retentive yellow color was observed which indicates the presence of flavonoids.

Measurement

The absorption spectra of dye solutions and dyes adsorbed on TiO_2 surface were recorded using a VIS Spectrophotometer (Spectrum lab 23A GHM Great Medical England). Solar energy conversion efficiency (the photocurrent voltage (*I-V)* curve) was measured by using digital multimeters under illumination of sunlight.

Based on *I-V* curve, the fill factor (FF) is defined as,

$$FF = (I_{max} \times V_{max})/(I_{sc} \times V_{oc}) \quad (1)$$

where I_{max} *and* V_{max} are the photocurrent and photovoltage for maximum power output (P_{max}), I_{sc} *and* V_{oc} are the short-circuit photocurrent and open-circuit photovoltage, respectively. The overall energy conversion efficiency (η) is defined as,

$$\eta = (I_{sc} \times V_{oc} \times FF)/P_{in} \quad (2)$$

where P_{in} is the power of incident light.

pH Measurement

The pH of the dye solution and one mil (1ml) of extract dissolved in 3ml of water was determined using pH meter model Fisher brand Hydrus 300 model and the effect of pH of dye solution was studied by adjusting pH from the original pH using 0.1 M HCI solution to three different pHs (2.0 and 3.0).

Results and Discussion

The UV-VIS absorption spectra of Botuje (*Jathopha curcas Linn*) ethanol extract and adsorption on TiO_2 is shown in Fig 1. The absorbance decreases as wavelength increases and absorption peak is 400nm, even at different pH values as seen in Figure 2. This wavelength is not yet in visible region, we need more electrons to be involved in this process. There is a change in absorbance as pH values increases. We notice there is no difference in the absorption peaks, they were found at the same wavelengths for the ethanol extract, solution at different pH values and extract adsorption on TiO_2 surface. There is no difference in the absorption peak because of the binding of anthocyanin in the extract of the oxide surface.

Figure 3 shows the *I-V* (current-voltage) curve for the sunlight-illuminated Botuje (*Jathopha curcas Linn*) extract sensitized cell. Table 1 presents the performance of the DSSCs in terms of short circuit photocurrent (I_{sc}), open-circuit voltage (V_{oc}), fill factor (FF) and energy conversion efficiency (η). The efficiency of cell sensitized by the Botuje (*Jathopha curcas Linn*) is very low. This is because of the low interaction between Botuje (*Jathopha curcas Linn*) and TiO_2 film.

A phytochemical screening was performed for flavonoids and anthraquinones test. The extract obtained indicates presence of flavonoids and absent of anthraquinones . Flavonoids protect plants against external pathogens, ultra-violet light or heat.

Conclusion

Ethanol was use for the extraction of Botuje (*Jathopha curcas Linn*) Dye sensitized solar cell. The Phytochemical screening of the dye extracted indicates the absence of anthraquinones and presence of flavonoids. The results obtained with extracts of Botuje (*Jathopha curcas Linn)* shows a conversion of visible light into electricity . This is possible because of the use of low costs developed natural dyes as wide band-gap semiconductor and sensitizers in dye-sensitized solar cells.

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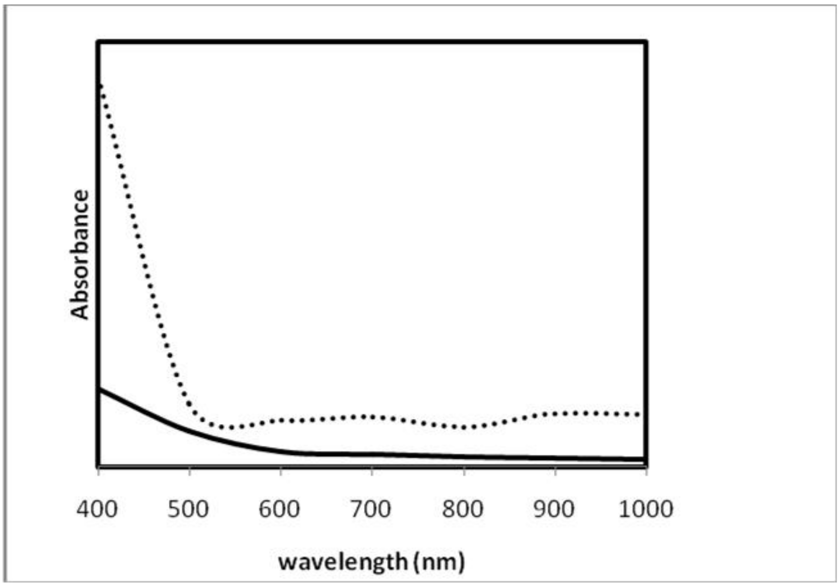

Fig.1 Absorption spectra of extract of Botuje (*Jathopha curcas Linn*)before (——)and after (_ _ _ _) being adsorbed onto TiO_2 surface.

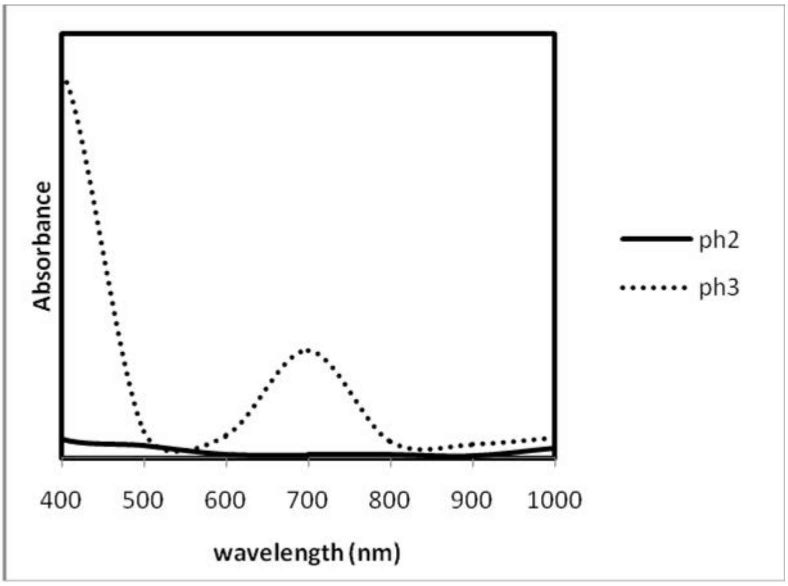

Fig.2 Light absorption spectra of dye solution of Botuje (*Jathopha curcas Linn*) at different pHs

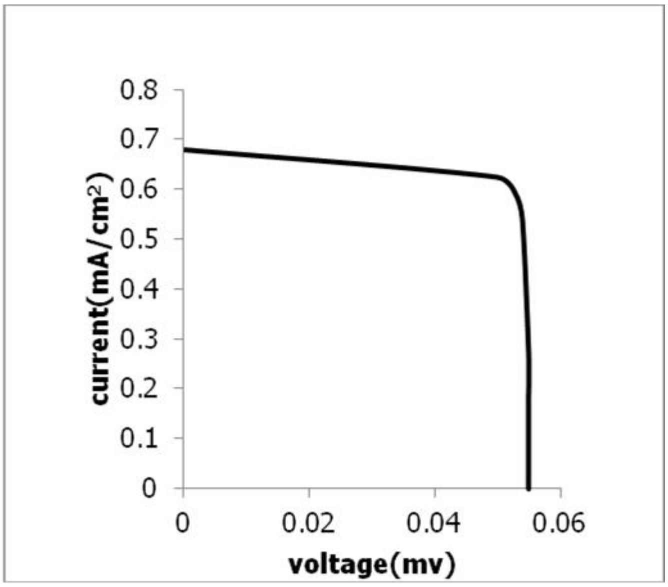

Fig.3 photo current voltage of Botuje (Jathopha curcas Linn) extract

Table 1 Photovoltaic performances of Botuje (Jathopha curcas Linn) extract

sample	I_{sc} (mA/cm^2)	V_{oc}(V)	FF	η %
Botuje (*Jathopha curcas Linn*)	0.69	0.054	0.87	0.12

How to Cite this Article: A.O.Boyo, I. O Abdulsalami, T.Oluwa, S.O.Oluwole, A.Umar "Development of Dye Sensitized Solar Cells Using Botuje Green Leaves (Jathopha Curcas Linn) " Science Journal of Physics, Volume 2013, Article ID sjp-182, 4 Pages, 2013. doi: 10.7237/sjp/182