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The Development of Eco-friendly Photoelectrochemical solar cell Using Extract of *Lonchocarpus cyanescens* as a Natural Sensitizer

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ABSTRACT

In this study, the crude ethyl acetate extract of Lonchocarpus cyanescens has been used in the fabrication of a photoelectrochemical cell which produced light conversion efficiency of 0.37%. The result demonstrates the potential of the cheap, eco-friendly natural product as a promising alternative sensitizer.

Key words: *Lonchocarpus cyanescens,* anthocyanins

INTRODUCTION

The stage is globally set for a major shortage of energy supply as fossil fuel is drastically becoming depleted and the the need for sustainable alternative cannot be over-emphasised [1]. Several alternative sources of energy such as wind, hydro [2] and biomass [3] have been explored over the last decade. Solar energy alternative has attracted much attention with the attendant development of materials as absorbers in devices for photovoltaic conversion of solar energy [4-6]. The use of ruthenium – based dye sensitized solar cells (DSSCs) have produced an overall power conversion efficiencies of over 10% under standard illumination [2]. However, the cost of these dyes remain an issue and there is need for research into inexpensive and environmental friendly dyes. Various research work have been done using natural dyes extracted from leaves, fruits, and bark of trees as sensitizers [7-14]. Maximum overall conversion efficiencies above 2% have been achieved, which is comparable to that of natural photosynthesis [15].This study is aimed at fabricating low-cost solar cell using local dye from *Lonchocarpus Cyanescens* .

MATERIALS AND METHODS

MATERIALS

Transparent conductive oxide coated glass (TCO, 10 to 12 ohm/m^2, 5 x 5 cm), Ti- Nanoxide D, iodolyte and meltonix polymer foil were purchased from SOLARONIX, dye extract was obtained from a natural source (*Lonchocarpus cyanescens)* and carbon soot from candle flame.

PREPARATION OF NATURAL DYE SENSITIZERS

The dried leaves of *Lonchocarpus cyanescens* were made into powder and 4033g of sample soaked in ethanol for seven days, filtered and concentrated using a rotary evaporator. Further purification were carried through solvent-solvent extraction and the ethylacetate fraction was used as the dye sensitizer.

DSSC FABRICATION

TiO_2 paste purchased from Solaronix was coated by doctor blading technique on pre-cleaned fluorine doped tin oxide (FTO) conducting glasses. This sheet was then sintered at 450°C for about 20 minutes. Photoanode was prepared by soaking the TiO_2 coated FTO for 24hrs in the dye solution. The dye stained film was washed in ethanol and dried. A counter electrode was prepared by coating an FTO slide with carbon soot from candle flame. DSSC was fabricated by using the dye coated TiO_2 /FTO plate as photoanode and the carbon coated FTO plate as the counter electrode. The slides were sandwiched with the meltonix foil and sealing was done by keeping the structure in a hot press at 80°C for about 30 minutes. Few drops of electrolyte were then inserted between the two plates.

Characterisation of DSSC

The UV-visible absorption measurements of the extracts were carried out with Genesys 10 UV-visible spectrophotometer and the result is as shown in Fig. 1. The Photoelectrochemical measurements of DSSCs were performed under a standard solar radiation of 1000 W/m^2 using overhead Veeco-viewpoint solar simulator and a four point Keithley multimeter coupled with a lab tracer software was used for data acquisition at room temperature. The active cell area was 1.6 cm^2.

Based on the I-V curve as shown in Fig. 2, the power conversion efficiency was calculated according to the equation:

$$\% = \frac{FF \times J_{sc} \times V_{OC}}{I}$$

Where J_{sc} is the short-circuit current, I is the intensity of the incident light (W/m^2), V_{OC} is the open circuit voltage (volts),FF is the fill factor defined as:

$$FF = J_m V_m / J_{SC} V_{OC}$$

Where J_m and V_m are the optimum photocurrent and voltage extracted from the maximum, power point of the I-V characteristics.

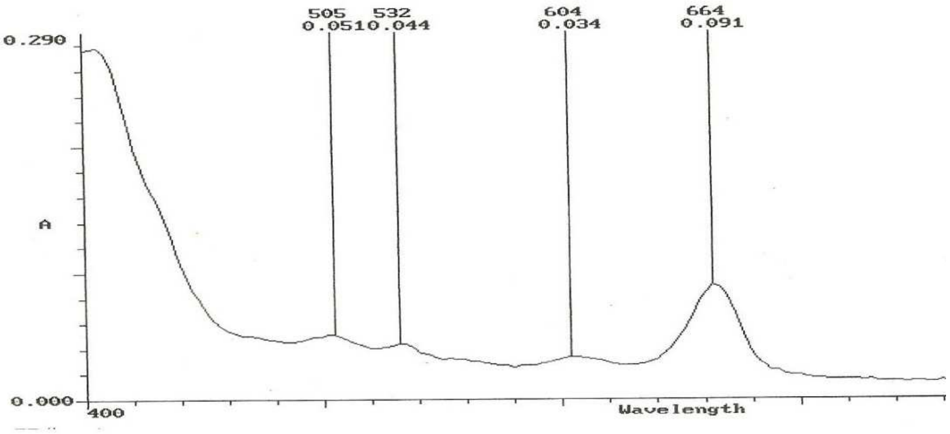

Fig.1: Absorption spectrum of ethyl acetate extract of *lonchocarpus cyanescens*.

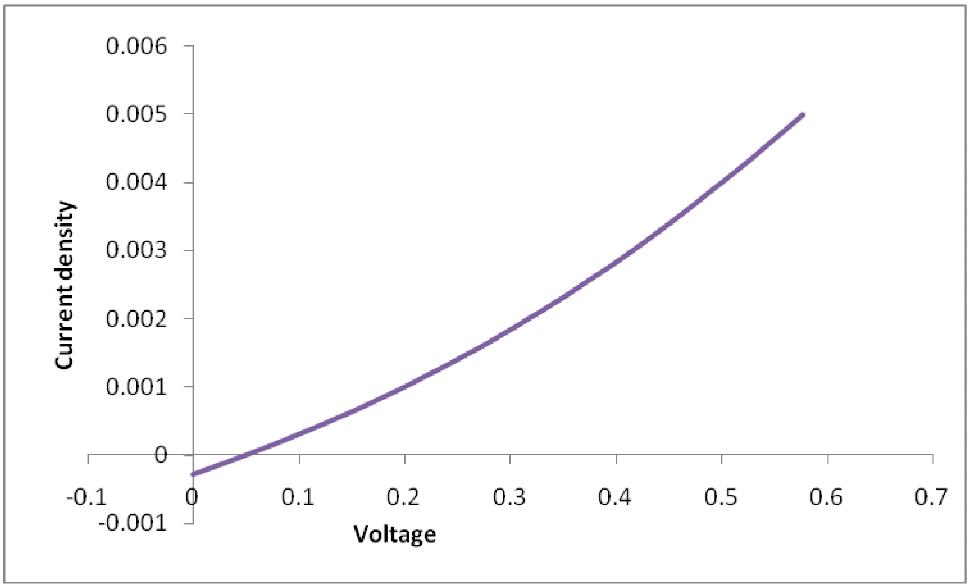

Fig.2: I-V curve obtained with the DSSC under illumination

RESULTS AND DISCUSION

The energy conversion efficiency of any solar cell depends strongly among other factors on light harvesting efficiency of the sensitizer. The ideal sensitizer should absorb all light below a treshold wavelength of 920 nm [16]. Preliminary phytochemical screening of *lonchocarpus cyanescens* by Sonibare et.al [17] showed the presence of alkaloids, anthraquinones, cardiac glycosides, cyanogenetic glycosides, flavonoids, saponins, steroids and tannins in the leaves. The ethylacetate fraction of *lonchocarpus cyanescens* in the present study exhibits absorption peaks at 505, 532, 604 and 664nm respectively (Fig. 1). Flavonoids from various plant have been shown to give different sensitizing performances[5]. The absorption peak at 532 nm can be attributed to the presence anthocyanins as these have been shown to absorb in the range of 500 nm [18]. The absorption peaks of 410nm and 664nm are due to the presence of chlorophyl- a. Chlorophyl is the pigment responsible for light absorption in photosynthesis [6].

The efficiency of the solar cell from *Lonchocarpus cyanescens* was 0.37% with a fill factor of 0.38, V_{oc} was 281Mv and I_{sc}, 3.465mAcm^{-2}. The results show that the ethylacetate fraction of *Lonchocarpus cyanescens* adsorbed onto the TiO_2 surface, acts as a good sensitizer and efficiently promotes electron transfer across the dye/semiconductor interface.

CONCLUSION

Natural dye obtained from crude extract of *Lonchocarpus cyanescens* gave effective conversion of visible light into electricity by sensitization of TiO_2. The plant extract appears to be a promising sensitizers in DSSCs because of its moderate energy conversion efficiency, simple preparation technique, environmental friendliness and low cost of production. However, there is need for further improvement on this dye to make them more efficient as sensitizers in DSSCs.

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