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Enhanced Efficiency Of Natural Dye-Sensitized Solar Cell: Cobolt Chelated Lonchocarpus Cyanescensextrac

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Abstract:- The crude ethylacetate extract of Lonchocarpus cyanescens has been found to be a potential sensitizer for dye-sensitized solar cells [DSSCs]. An attempt was made in this study to enhance the light harvesting properties of the dye by incorporating cobolt metal ion into it. The UV/VIS absorption spectrum of the processed extract showed a moderate auxochromic shift compared with that of the neat extract and an improved light conversion efficiency was observed from the solar cell produced from the former. The light conversion efficiencies of the cobolt incorporated extract DSSC is 1.69% greater than the neat extract DSSC.

Keywords:- *Lonchocarpus cyanescens, natural dyes, polypyridyl metal complexes, absorption peak.*

I. INTRODUCTION

The world energy consumption which is growing astronomically by the day can no longer be sustained by the limited fossil fuel reserves. There is therefore an urgent need for a sustainable alternative. Solar energy appears the most promising among other renewable energy sources due to its abundance and environmental compliance [Gratzel, 2005, Ibitoye et al., 2007 and Ofoefule, 2011]. Much attention has been given to the conversion of solar energy into electricity using photovoltaic devices made from inorganic materials. The materials for conventional photovoltaic cells which must be of high purity are rather too expensive and further research into new ways of manufacturing cheap and environmental friendly cells has led to the development of organic dye sensitized cells[Srikanth et al., 2011 and Jeroh et al., 2012]. The finest photovoltaic performance in terms of both conversion yield and long term stability has so far been achieved with polypyridyl complexes of ruthenium[Narayan, 2011]. However, the use of this expensive Ru metal, derived from relatively scarce resources corresponds to relatively heavy environmental burden [Preat et al., 2009]. Some organic metal-free compounds have been found to produce even cheaper photosensitizer for dye sensitized cells but they have very low solar-to-electrical power conversion efficiencies. The use of nontoxic, low cost and fully biodegradable natural dye has also attracted the attention of many researchers despite their low power conversion efficiencies [Ali et al., 2010, Meng et al., 2008, Kumara et al., 2006, Kay et al., 1993, Wrobel, 2003, Tadesse et al., 2012 and Narayan, 2012]. The search for efficient natural dye would continue until economically viable solar energy devices emerge. In this context, we have incorporated cobolt metal into the natural dye exract from Lonchocarpus cyanescens in a bid to improve its light harvesting capacity.

II. 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, Switzerland and $CoCl_2$ from Aldrich. Dye extract was obtained from (Lonchocarpus cyanescens) leavesand carbon soot from candle flame.

III. PREPARATION OF NATURAL DYE SENSITIZERS

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

IV. 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 dye solution. The dye stained film was rinsed with ethanol and dried. A counter electrode was prepared by coating an FTO slide with carbon soot from candle flame. The dye coated TiO_2 /FTO plate was laced with meltonix foil round about the TiO_2coatleaving two narrow slits on opposite sides to serve as openings into the cell. Thecounter electrodeslide was carefully placed on the photoanode and the slides sealed in a hot press at 80°C for about 30 minutes. Few drops of electrolyte was then introduced into the cell.

V. CHARACTERISATION OF DSSC

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

Based on the I-V curve the power conversion efficiency was calculated according to the equation:

$$\% = \frac{FF \text{ X } J_{sc} \text{ x } V_{OC}}{I}$$

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.

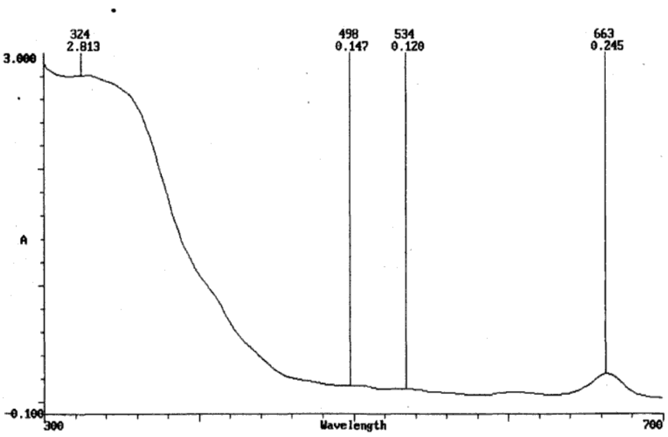

Fig.1:- Absorption spectrum of ethyl acetate extract of lonchocarpus cyanescens leave

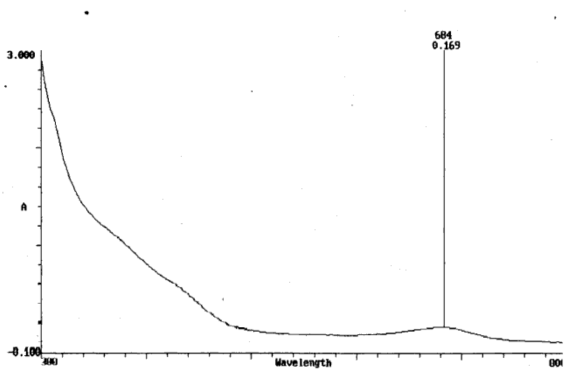

Fig. 2 :- Absorption spectrum of cobolt incorporated extract of lonchocarpus cyanescens leaves

VI. RESULTS AND DISCUSSION

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 [El-Shishtawy, 2009]. Preliminary phytochemical screening of lonchocarpus cyanescens by Sonibare et.al [Sonibare et al., 2012] showed the presence of alkaloids, anthraquinones, cardiac glycosides, cyanogenetic glycosides, flavonoids, saponins, steroids and tannins in the leaves. Flavonoids from various plant have been shown to give different sensitizing performances[Jeroh et al., 2012]. The ethylacetate fraction of lonchocarpus cyanescens neat extract exhibits absorption peaks at 505, 532, 604 and 664nm respectively (Fig. 1a). The absorption peak at 532 nm can be attributed to the presence of anthocyanins as these have been shown to absorb in the range of 500 nm [Chuanguang et al., 2010]. 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 [Narayan, 2011]. The spectrum (Fig.1b) for cobolt treated extract showed a moderate auxochromic shift compared with that of the neat extract. The shift can be attributed to specific modifications of electronic structures of extract due to the formation of cobolt complexes ofphytochemicals in the extract.

The efficiency of the solar cell from the cobolt incorporated extract is 1.69% greater than then eat extract of Lonchocarpus cyanescens.The results show that light harvesting property of leaf extract ofLonchocarpus cyanescenscan be enhanced by incorporating metal ions into the natural dye.

VII. CONCLUSION

The results show that metal incorporated extract of Lonchocarpus cyanescens gives a better dye-sensitized solar cell than the neat extract.

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