OPENING MINDS: RESEARCH FOR SUSTAINABLE DEVELOPMENT

Construction of Dye Sensitized Solar Cell Using Natural Dye Extraction from Petals of *Erabadu* Flower

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1 INTRODUCTION

In the present century demand for energy has risen immensely whilst the world is left with a handful of energy sources. With the industrialization of world many products demand more energy for their operations with new technologies (Rosana *et al.*, 2014). This demand for energy and deficit of naturally existing resources has paved the way to introduce or invent new technologies to equalize the demand and supply of the energy requirements. One such method is to convert solar energy directly to electrical energy by using Dye Sensitized Solar Cells (DSSCs).

Solar power is the most abundant, plentiful and economical source available with relatively minimum constraints. Capability of utilizing the total energy in the visible spectrum is one of the factors which determines the efficiency of DSSC. Therefore dye sensitizer in DSSCs plays an important role for harvesting solar energy and converting it to electrical energy with the aid of a high band gap semiconductor photoanode. Thus cell performance mainly depends on the type of dye used as the sensitizer (Monzir *et al.*, 2015). Organic and organo-metallic dyes are used as dye sensitizers in DSSCs. Synthesis of organo-metallic dyes is more expensive than the organic dyes. In this context the use of natural dyes that are suited for DSSCs to work efficiently is one of the most economical ways to get electricity from DSSCs.

In this research we found that DSSC are more approachable and low cost by replacing the currently used synthetic dyes with a natural dye. The dye used here is eco-friendly, cost effective and reachable (Neil, 2006; Calogero *et al.*, 2009). In this study a dye is extracted from the petals of the Erabadu (*Erythrina fusca*) flower to aqueous media and used as a sensitizer in DSSCs.

2 METHODOLOGY

2.1 Preparation of Natural dye solution

30 g of Petals of Erabadu flower were cut into small pieces and boiled with 100 ml of distilled water in a beaker on a hot plate at 150 ˚C until the appearance of pieces of red petals turned to pale pink colour. After that the dark purple colour of dye extracted from Erabadu petals was collected into an amber coloured bottle and it was stored in the refrigerator at 4 ˚C until use. Mixture of dye solution was prepared by adding 1 ml of acetic acid and 0.5 ml of ethanol into 6 ml of dye extraction in a test tube.

2.2Optical characterization of the dye

The analysis of chemical functional groups of the dye extracted into distilled water were characterized using FTIR spectroscopy after removing the water and the moisture. The absorption spectrum of extracted pigment in the aqueous solution were obtained using UV-Vis spectrometer.

2.3 Fabrication of the DSSC

Fluorine Doped Tin Oxide (FTO) conducting glass sheets in the size of 1.5 cm × 3 cm were cleaned respectively by using tap water, detergent and distilled water for 5 minutes at each step in an ultrasonic bath and dried. After cleaning, adhesive tape was applied on the conducting side opening 1 cm^2 on the glass plates to restrict the size and the thickness. Titanium dioxide (TiO_2) paste was prepared by using the commercial TiO_2 powder (Degusa P25). 0.5 g of TiO_2 powder was ground in a porcelain mortar and 0.1 ml of acetic acid, 0.2 ml of ethanol, 1 drop of terpenol and 1 drop of triton-x-100 was added. The mixture was ground for 15 minutes in a mortar using a pestle until a thick paste was obtained. The paste was spread on the open area of the conducting glass sheets by the doctor blade method. Then after removing the adhesive tapes, TiO_2 Film on the glass sheets were sintered in a furnace at 450 °C for 30 minutes. After cooling down the sintered TiO_2 film, they were immersed in the dye solution in the test tube for 12 h. Finally electrode was withdrawn from the dye solution and dried to be used as the photo electrodes.

Counter electrode was prepared by coating chloro platinic acid in ethanol solution (0.05 M) on conducting side of the FTO glass sheet and sintering in a furnace at 450°C for 30 minutes. To prepare the electrolyte for DSSCs, 0.83 g of potassium iodide (KI) and 0.127 g of iodine (I_2) were added into 10 ml volumetric flask. Then solution containing acetonitrile and ethylene carbonate at 8:2 ratios were added into the flask and stirred until the complete dissolution of solid materials.

The conducting side of counter electrode and dye coated TiO_2 film were placed face to face and held with clamps. The capillary space in between the two electrodes was filled with the electrolyte.

2.4 I-V Measurements of the cell

The photovoltaic measurements of the DSSCs were taken under 100 mW cm^{-2} light illumination using a computer controlled galvanostat/potentiostat (Autolab) with the help of Nova 2.1 software.

3 RESULTS AND DISCUSSION

3.1 UV-visible absorption spectrum

The absorption spectrum of pigments in petals of Erabadu flower is shown in figure 1. The absorption measurement was carried out in the visible range from 400 nm to 800 nm. The peak corresponds to maximum absorption was found around 500 nm. The absorption of the dye was spread throughout the range from 400 nm to 620 nm.

3.2 FTIR absorption analysis

FTIR absorption spectrum of the dye extracted from petals of Erabadu flower is shown in figure 2. FTIR spectra for the natural pigment in the dye extraction was recorded in the range from 600nm to 3900nm. A strong band at 3288 cm^{-1} is due to the –OH stretching and board absorption in the range from 3035 cm^{-1} to 3736 cm^{-1} is for wide variety of hydrogen bonding. The peak around 1045 cm^{-1} indicates the presence of C-O-C bonds. Therefore hydroxyl groups of pigment

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molecules in dye extraction of petals of Erabadu is possibly contributing to attach the pigment to the TiO_2 photo anode.

3.3 IV characteristic of the DSSC

The photovoltaic performance of photochemical cell under 100 $mWcm^{-2}$ light illumination is illustrated in Figure 3. The photocurrent and photovoltage of FTO/TiO_2 /dye /electrolyte /pt cell were respectively 0.966 mA and 459 mV. Fill factor and efficiency of the cell were calculated using IV curve were 45.8 % and 0.21 % respectively. Further investigations are needed to identify the pigment in the Erabodu petals which is responsible for the sensitization of TiO_2 photo anodes that is supposed to be an anthocyanin dye with the present available information.

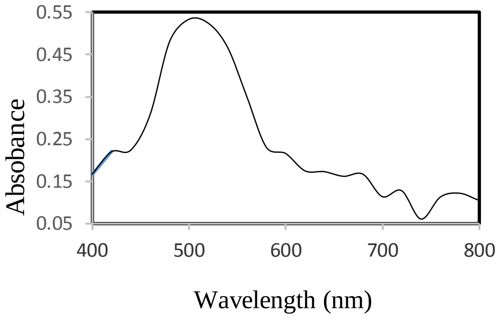

Figure 1: UV- Visible absorption spectra of natural pigment extracted from petals of Erabadu flower in distilled water.

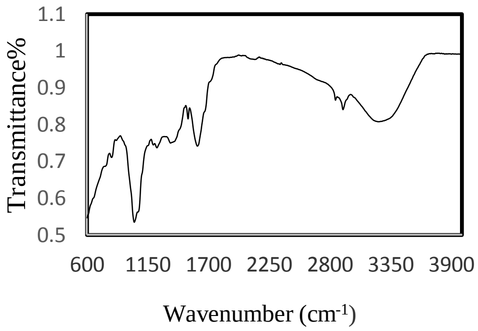

Figure 2: The FTIR spectra of the dye from petals of Erabadu flower

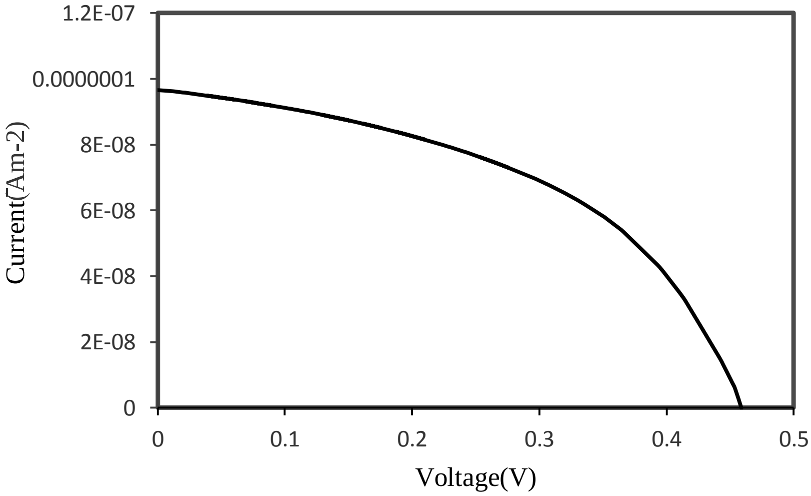

Figure 3: I–V characteristic curve of DSSC coated with the dye extracted from petals of Erabadu flower.

4 CONCLUSIONS

UV- visible absorption spectrum of the dye extracted from petals of Erabadu (*Erythrina fusca*) flower into aqueous medium broadly extend in the visible region where the maximum is at around 500 nm. The existence of the hydroxyl groups were confirmed by the FTIR measurements. The pigment absorbs visible light in a wide range. The efficiency of the photochemical cell fabricated using this dye with the configuration
FTO/TiO_2/dye/electrolyte/Pt was 0.21%.

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