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STUDY OF DYE SENSITIZATION FOR SOLAR ENERGY CONVERSION INTO ELECTRICAL ENERGY IN TROPAEOLIN OO EDTA SYSTEM

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ABSTRACT

Photogalvanic cells are electrochemical devices capable of solar power generation and storage. Tropaeolin OO is used as a photosensitizer in photogalvanic cell for solar energy conversion. EDTA was used as an electron donor. The system gave a photopotential of 860.0mV, photocurrent 340.0µA and power 150.68µW. The conversion efficiency and fill factor was determined as 1.44% and 0.51 respectively. The storage capacity of the cell was 80.0 minutes in dark.

KEYWORDS: Tropaeolin OO, EDTA, Photocurrent, Photopotential, Conversion efficiency, Fill factor,

INTRODUCTION

Solar energy is also called "Heat Trapper" as it is the automatic, non-mechanical, sun ray trapper.Solar cells are devices that are able to convert solar energy into electrical energy. The air of solar cell research is to increase the solar energy conversion efficiency at low cost to provide a cost effective sustainable energy source. The Photogalvanic cells are based on "photogalvanic effect". This term was first time used by Rabinowitch [1-2].The photogalvanic effect was reported by Clark and Eckert [3], but the systematic investigation was done by Suda et [3],Hall et al[4] and Rohtagi Mukerjee et [4-8] reported some interesting photogalvanic systems. Use of some reductant and Photosensitizer in photogalvanic cells for solar energy conversion and storage [9-11]. Recently the photogalvanic effects in various interesting system were observed by [22-27]. The photochemical conversion of solar energy into electrical energy was observed by [28-32]. Role of photosensitizer for generation of electrical energy in photogalvanic cells were studied by [33-37]. Electrochemical Studies of anionic and cationic surfactants in photogalvanic cell for solar energy conversion and storage [28]. 'Photochemical studies of micelles in photogalvanic cell for solar energy conversion and storage' [29]. Electrochemical studies of anionic and cationic surfactants in photogalvanic cell for solar energy conversion and storage [30]. Role of photosensitizer (orange - G) in photglvanic cell for generation of solar energy [31]. Studies of surfactant and photosensitizer in photo cell or solar energy conversion and storage [32]

MATERIAL & METHODS

Structure of the compound used

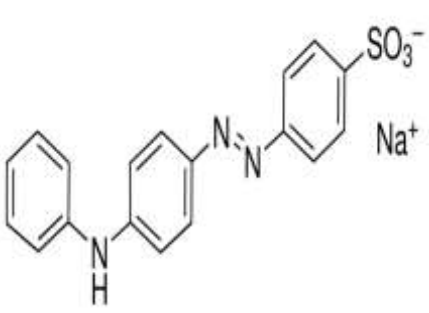

Fig.-1. Tropaeolin OO (Orange IV)

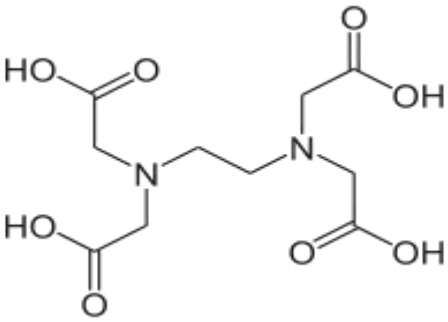

Fig. 2: EDTA (Ethylene Di amine Tetra Acetic acid)

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Experimental set up

An H-shape glass tube was used containing Tropaeolin OO, EDTA, Oxalic acid, Sodium Hydroxide and water. Water used in the reported system is distilled twice in the laboratory only. A platinum electrode of different areas (0.25-1.0cm^2) was dipped in one limb having a window and a saturated calomel electrode (SCE) were immersed in another limb of the H-tube. Bulk solution of all the reagents are kept in amber coloured bottles. The terminals of the electrode were connected to a digital pH meter (Agronic Model 111) and whole cell was placed in the dark. The platinum electrode was exposed to a 200W tungsten lamp. A water-filter was used to cut off infrared radiations. The photochemical bleaching of Tropaeolin OO was studied potentiometrically. The potopotential (V) and photocurrent (i) were used to measure the digital pH meter and micro-ammeter (OSAW,India).

RESULT AND DISCUSSION

EFFECT OF VARIATION OF PH

The photogalvanic system is quite sensitive for pH variation. The electrical output of the photogalvanic cell was changed by the variation of pH on the system. It is observed from figure - 3 that there is an increase in electrical output of the cell with the increase in pH values. At pH 11.6 a maxima is obtained. On further increase in pH, there is a decrease in photoelectric parameters. It is observed that the pH for the optimum condition has a relation with pKa of the reductant and the desired pH is higher than in pKa value (pH>pKa). The reason of the change in electrical output is that the availability of the reductant in its anionic form, which is a better donor form.

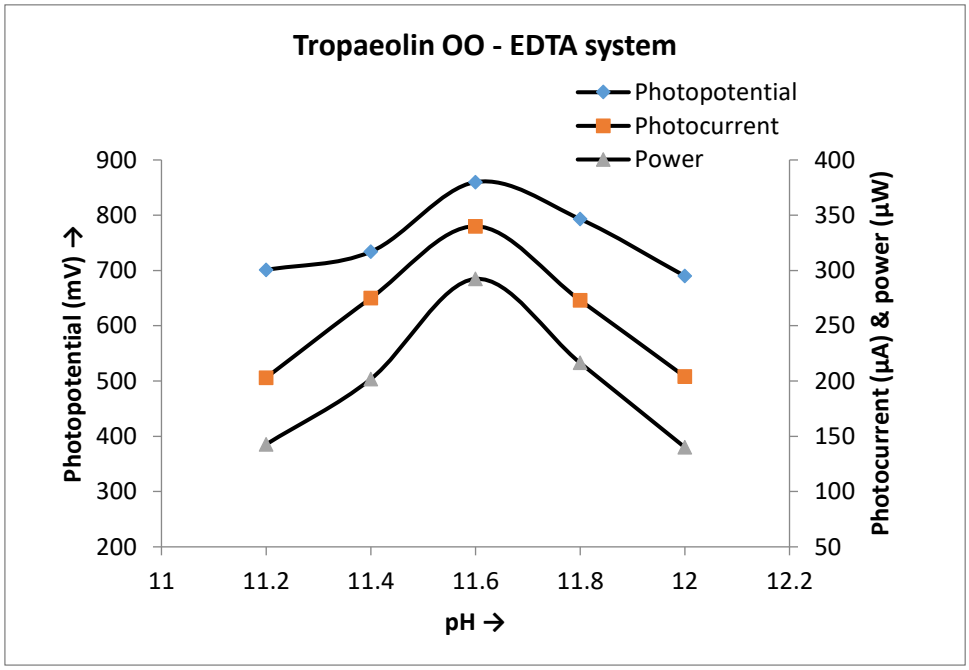

Fig - 3 Variation of photopotential, photocurrent and power with pH

EFFECT OF VARIATION OF TROPAEOLIN OO CONCENTRATION

Dependence of photopotential and photocurrent on the concentration of Tropaeolin OO was studied and results are summarized in figure – 4. It was observed that the photopotential and photocurrent were increased with the increase in concentration of the dye. A maximum was obtained for a particular value of Tropaeolin OO concentrations, above which a decrease in the electrical output of the cell was obtained. The reason of the change in electrical output is that lower concentration of photosensitizer resulted into a fall in electrical output because fewer photosensitizer (Tropaeolin OO) molecules are available for the excitation and consecutive donation of the electrons to the platinum electrode whereas the higher concentration of photosensitizer (Tropaeolin OO) again resulted into a decrease into electrical output as the intensity of light reaching the dye molecules near the electrode decrease due to absorption of the major portion of the light by dye molecules present in the path.

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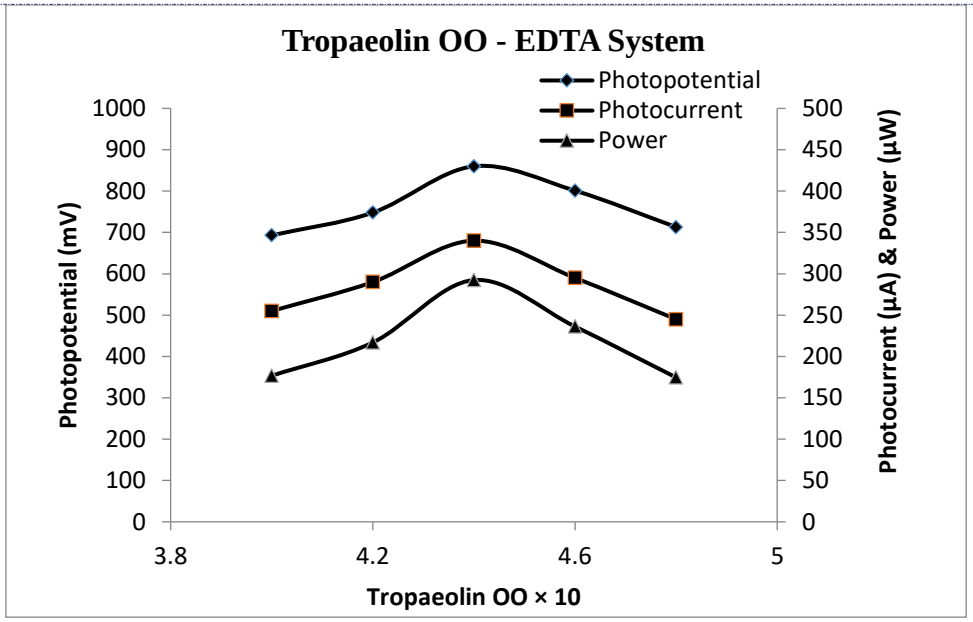

Fig – 4 Variation of photopotental, photocurrent and power with Tropaeolin OO

EFFECT OF VARIATION OF EDTA CONCENTRATION

The effect of variation of EDTA concentration was investigated in the present system. The electrical output of the cell affected by the variation of reducing agent concentration (EDTA) in the system: It can be seen from figure - 5. Lower concentration of reducing resulted in a fall in electrical output because fewer reducing agent molecules were available for electron donation to Tropaeolin OO molecules. Large concentration of reducing agent again resulted into a decrease in electrical output; because the large number of reducing gent molecules hinder the dye molecules reaching the electrode in the desired time limit.

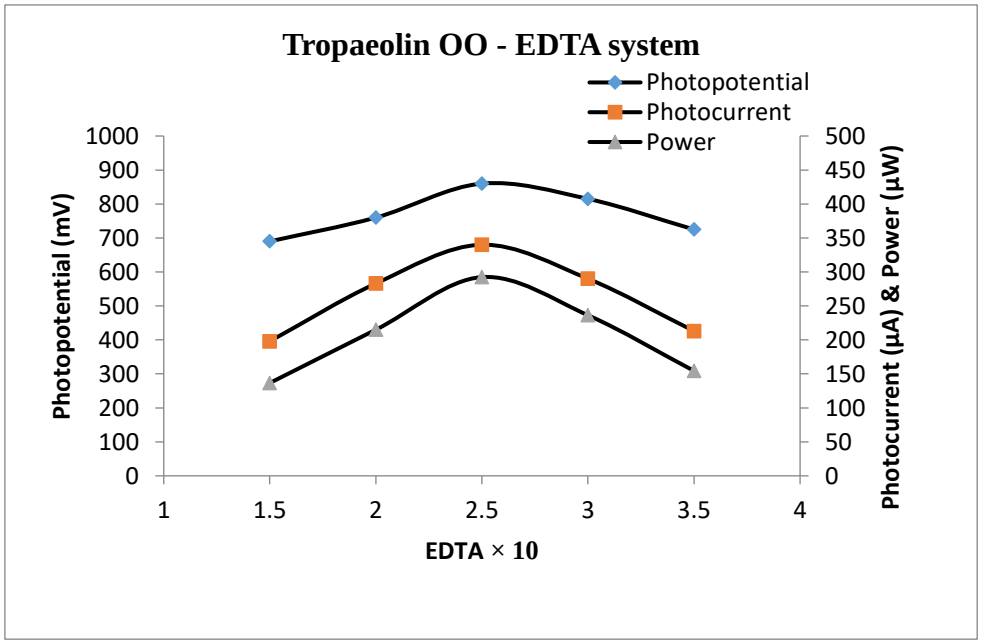

Fig – 5 Variation of photopotential, photocurrent and power with EDTA

EFFECT OF DIFFUSION LENGTH

The effect of variation of diffusion length (distance between the two electrodes) on the current parameters of the cell was studied using H-cells of different dimension. The results can be seen figure - 6 Conversion of solar energy into electrical energy of the cell is also affected by the diffusion length of the cell. With the increase in the

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diffusion length the current also increases. Maximum current of the cell is observed to increase first with increase in diffusion length and then decrease on further increase in diffusion length whereas equilibrium current i_{eq} and rate of generation of current are found to increase slightly.

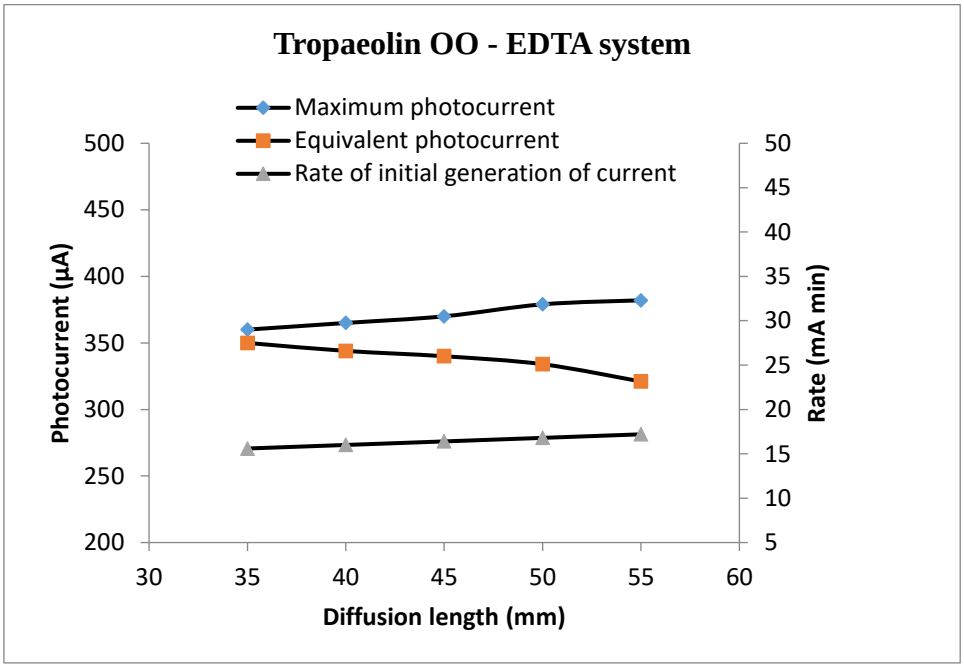

Fig - 6 Variation of current parameter with diffusion length

EFFECT OF LIGHT INTENSITY AND TEMPERATURE

Photogalvanic effect is a light induced phenomenon and depends upon the intensity of light. Intensity of light increases photcpotential and photocurrent both increases. Tungsten bulbs of various watts were used o vary light intensity and the result in figure - 7.

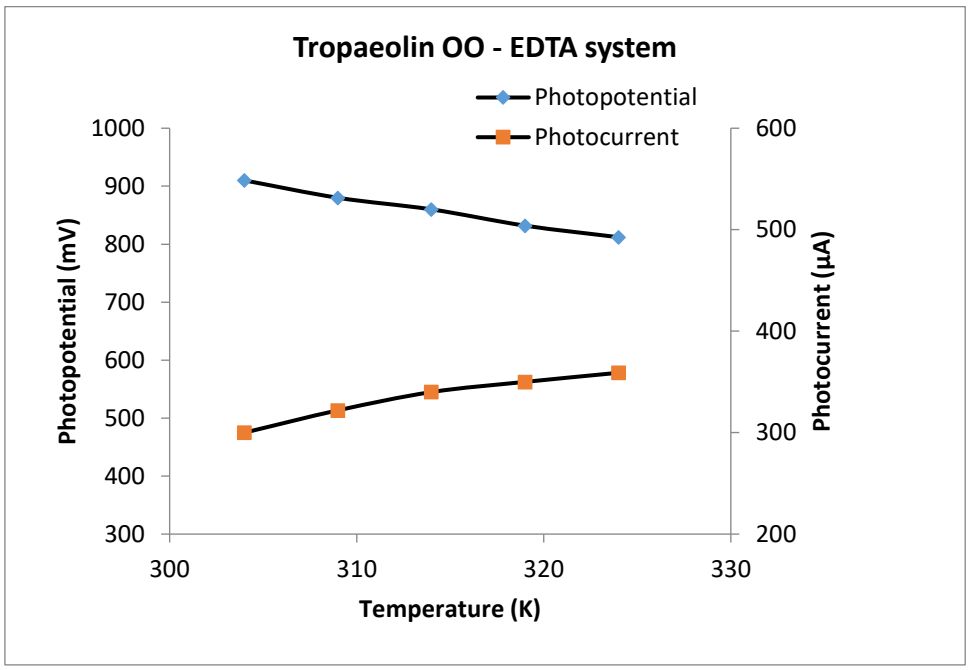

Fig - 7 Variation of photopotential and photocurrent with temperature

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EFFECT OF ELECTRODE AREA

The effect of variation of electrode area of Pt electrode on the electrical output of the cell was studied using different measurements of electrode areas. The results are graphically represented in figure – 8. It was observed that with the increase in the electrode area the value of photopotential is found to increase.

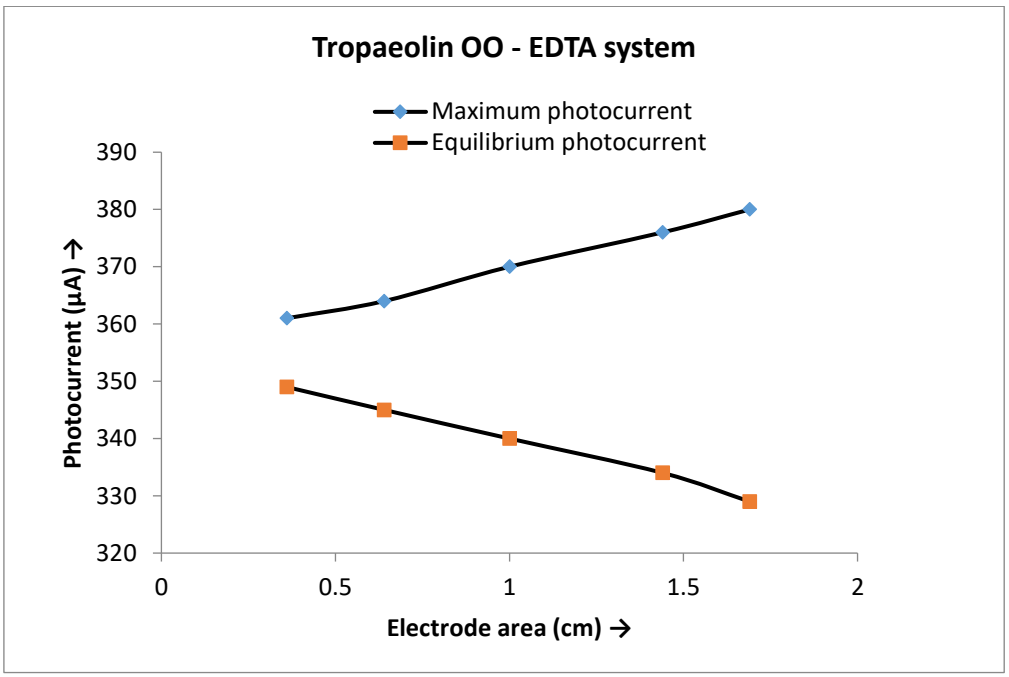

Fig - 8 Variation of current parameter with electrode area

CURRENT-VOLTAGE (I-V) STUDIES OF THE CELL

The short circuit current (isc) and open circuit voltage (Voc) of the photogalvanic cells are measured with the help of a multimeter (keeping the circuit closed) and with a digital pH meter (keeping the other circuit open), respectively. The current and potential values in between these two extreme values are recorded with the help of a carbon pot (log 470 K) connected in the circuit of Multimeter, through which an external load is applied. The Current-Voltage (i-V) characteristics of the photogalvanic cells containing Tropaeoin OO – EDTA system are given in table and graphically shown in figure – 9.

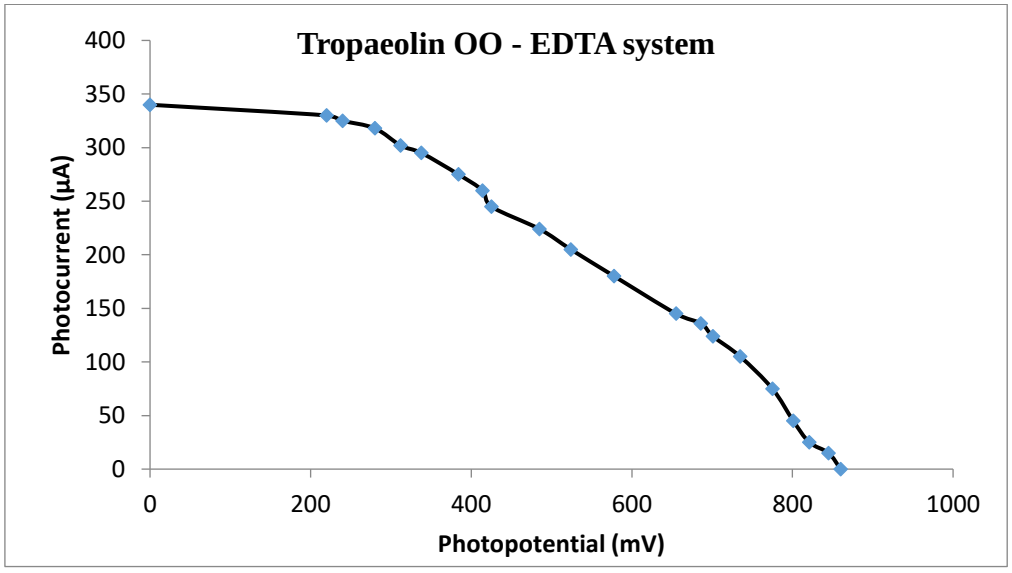

Fig - 9 Current – Voltage curve of the cell

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CONVERSION EFFICIENCY AND STORAGE CAPACITY OF CELL

The storage capacity (performance) of the photogalvanic cell is observed by applying an External load (necessary to have current at power point) after terminating the illumination as soon as the potential reaches a constant value. The storage capacity is determined in terms of t1/2, i.e., the time required in the fall of the output (power) to its half at power point in dark. It is observed that the cell can be used in dark for 140.0 minutes. So the observed storage capacity of the cell is 80 min. The results are graphically presented in Figure 9. The conversion of the efficiency of the cell is determined as 1.44 % with the help of photocurrent and photopotential values at the power point and the incident power of radiations by using the formula

$$\text{Fill factor } (\eta) = \frac{\text{Vpp x ipp}}{\text{Voc x isc}} \quad (1)$$

$$= 0.51$$

$$\text{Conversion Efficiency} = \frac{\text{Vpp x ipp}}{10.4\ \text{mWcm}^{-2}} \text{ x100\%} \quad (2)$$

$$= \mathbf{1.44\ \%}$$

PERFORMANCE OF THE CELL

The performance of the cell was observed by applying an external load necessary to have current at power point after terminating the illumination as soon as the potential reaches a constant value. The performance and storage capacity of the cell was determined in terms of $t_{1/2}$ i.e. the time required in fall of the output (power) to its half at power point in dark. It 80.0 minutes and conversion efficiency of the cell is 1.44%. The effect of variation of light intensity of the photopotential and photocurrent is graphically represented in figure – 10

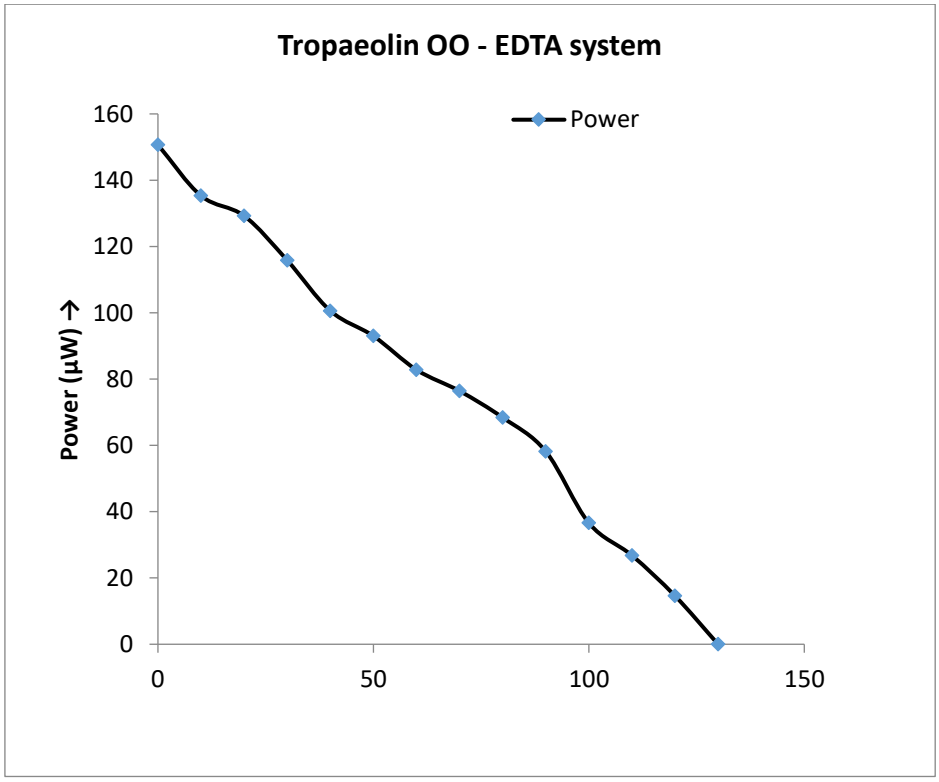

Fig -10 Performance of the cell

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MECHANISM OF PHOTOCURRENT GENERATION

On the basis of these observations, a mechanism is suggested for the generation of Photocurrent in the photogalvanic cell as:

ILLUMINATED CHAMBER

Dye h□ □Dye* (I)

Dye* + R Dye– (Semi or leuco) + R (II)

AT PLATINUM ELECTRODE:

Dye – Dye + e – (III)

DARK CHAMBER

AT CALOMEL ELECTRODE:

Dye + e - (IV)

Dye– (Semi or leuco) (6) (V)

Dye – + R+ Dye + R (7) (VI)

Where Dye, Dye*, Dye–, R and R+ are the dye, excited form of dye, semi or leuco form of Dye, reductant and oxidized form of the reductant, respectively.

CONCLUSION

On the basis of above results, it is concluded that Tropaeolin OO can be used successfully as photosensitizer in a photogalvanic cell. Performance of the cell is studied in dark when external load is applied necessary to maintain current and potential. The conversion efficiency of the cell is 1.44% and the cell can be used in dark at its power point for 80.0 min. Photogalvanic cells have the added advantage of having in – built storage capacity. The time is not far off when the conversion efficiency of these cells will be comparable with that of existing solar cells. Thus , photogalvanic cells show good prospects of becoming commercially viable.

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NOMENCLATURE

ieq = photocurrent at equilibrium
imax = maximum photocurrent
ipp = photocurrent at power point
isc = short circuit current
mv = millivalt
m = molarity
pp = power point
t1\2 = storage capacity of cell
Dv = observed photopotential
VoC = open circuit voltage
Vpp = photo potential at the power point
n = fill factor
mA = microampere
mW = microwatt

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