



RESEARCH ARTICLE

**Photochemical study of Bismark brown in Photogalvanic Cell for Solar
Energy Conversion and Storage**

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Manuscript No: IJPRS/V2/I4/00272, Received On: 29/12/2013, Accepted On: 31/12/2013

ABSTRACT

Photogalvanic cells are photoelectrochemical cells chargeable in light for solar energy conversion and storage. They may be energy source for the future, if their electrical performance is increased. In this study, a photosensitizer Bismark Brown, D-Xylose as a Reductant and NaLS as a Surfactant have been used in the photogalvanic cell. The generated photopotential and photocurrent are 750.0 mV and 275.0 μ A respectively. The conversion efficiency of the cell, fill factor and the cell performance were observed 1.0157%, 0.2498 and 160.0 minutes in dark respectively. The effects of different parameters on the electrical output of the photogalvanic cell were observed. A mechanism was proposed for the photogeneration of electrical energy.

KEYWORDS

Bismark Brown, D-Xylose, Photopotential, Photocurrent, Fill Factor, Conversion Efficiency

INTRODUCTION

All activity requires energy can be obtained from two types of sources- renewable and non-renewable. Non-renewable sources are fossil fuels, coal, crude oil, etc. Renewable sources are Sun radiations, wind, biomass, etc. Non-renewable sources are limited and polluting in nature. Sun is the most powerful source of energy. The solar energy is the most readily available non-conventional source of energy. It is abundantly and freely available non-polluting source of energy. The solar energy can be harnessed in the form of solar power through solar energy conversion and storage by photogalvanic effect. The photogalvanic effect was first of all observed by Rideal and Willams (1925) but it was systematically studied by Rabinowitch (1940).

Solar energy conversion and storage has also been studied by the Fox MA and Kabir-ud-Din (1979), Optimum efficiency of photogalvanic cell for solar energy conversion has been studied by Murti and Reddy (1980), Ameta SC (1994) observed that solar energy can be directly stored by photo capacitor. Conversion of sun- light into electricity by dye sensitized solar cell have also been studied by Rohatgi KK, Mukherjee, Roy M and Bhowmik BB.

Gangotri and Lal (1994) have used EDTA as a reductant and mixed dye methylene blue and toluidine blue in photogalvanic effect. Gangotri and Meena (2001) have used oxalic acid as a reductant and methylene blue as photosensitizer in the photogalvanic cell for solar energy conversion and storage. Genwa et.al (2001) have comparatively studied the photogalvanic effect by using Toluidine Blue and Malackite Green as photosensitizer with Arabinose-NaLS system.

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EXPERIMENTAL

A glass tube of H-shape was used containing known amount of the solutions of photosensitizer – Bismark brown, reductant- D-Xylose (Ranbaxy), surfactant- Sodium Lauryl Sulphate (S.D. Fine), and Sodium hydroxide (Merck) in the present work. The total volume of the mixture was always kept 25.0 ml making up by doubly distilled water. All the solutions were kept in amber coloured containers to protect them from sunlight. A platinum electrode ($1.0 \times 1.0 \text{ cm}^2$) was dipped in one limb having a window and a Saturated Calomel Electrode (SCE) was immersed in another limb of the H-tube. The terminal of the electrode was connected to a Digital pH meter (Systronics Model-335) and the whole cell was placed in the dark. The potential (mV) was measured in dark when the photogalvanic cell attained a stable potential. Then the limb containing platinum electrode was exposed to a 200 W tungsten lamp (Sylvania) as light source. Employing lamps of different wattage varies the Light intensity. A water filter was placed between the illuminated chamber and the light source to cut-off infrared radiations. On illumination, the photochemical bleaching of Bismark brown was studied potentiometrically. The photopotential and photocurrent generated by the system was measured with the help of the digital pH meter and microammeter (Ruttonsha Simpson), respectively. Microammeter was also connected through a key to close the one circuit and open the other circuit. A resistance (a carbon pot log 470 K) was used to study the i - V characteristics of the photogalvanic cell. The experimental set-up is given in figure.

RESULTS AND DISCUSSION

Effect of Variation of Concentration of Photosensitizer

In Bismark brown-D-Xylose-NaLS system it was observed that with the increase in the total concentration of the photosensitizer, the photopotential was found to increase till it reaches a maximum value. On further increase in the total concentration of photosensitizer, a

decrease in the electrical output of the cell was observed.

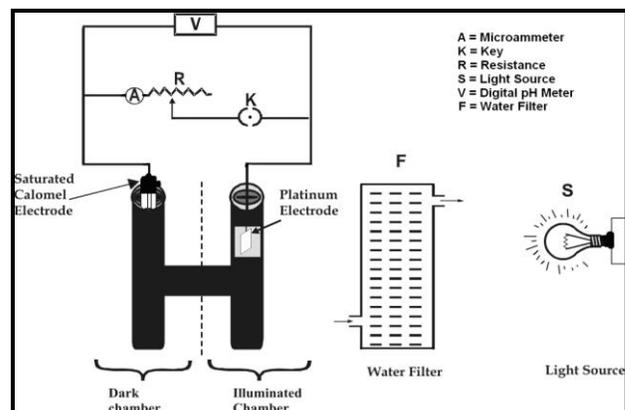


Figure 1: Experimental Set-Up of Photogalvanic Cell

The fall in power output was also resulted with decrease in concentration of dyes due to less number of molecules available for electron donation to Pt electrode on the other hand the passage of radiations may be hindered by the higher concentration of mixed dyes to reach the electrode in the desired amount and it will also result in to a decrease in electrical output. The effect of variation of mixed photosensitizer concentration on the photopotential and photocurrent of system is given in Table.

Effect of Variation of Reductant (D-Xylose) Concentration

With the increase in concentration of the reductant the photopotential and photocurrent were found to increase until they reach a maximum value. On further increase in concentration of reductant the decrease in electrical output of the cell was found. The effect of variation of the reductant concentration on photopotential and photocurrent of is given in Table and graphically Bismark brown- D-Xylose-NaLS system represented in Table.

Effect of Variation of (NaLS) Concentration

The effect of Variation of $[\text{NaLS}]$ was investigated in Bismark brown- EDTA- NaLS system. It was observed that electrical output of the cell was found to increase on increasing the concentration of surfactant reaching a maximum value. On further increase in their

concentrations, a fall in photopotential, photocurrent and power of the photogalvanic cell was observed. The results are reported in Table.

Table 1: Effect of variation of Bismark Brown, D-Xylose-NaLS Concentration

Conc ⁿ	Photo potential (mV)	Photo current (µA)	Power (µW)
[Bismark brown] x 10 ⁻⁵ M			
3.6	690	210	78.25
4.0	705	235	82.15
4.4	750	275	90.75
4.8	725	230	80.20
5.2	710	220	72.25
[D-Xylose] x 10 ⁻³ M			
2.00	695	220	74.15
2.04	735	235	81.35
2.08	750	275	90.75
2.12	740	245	82.20
2.16	715	215	75.30
[NaLS] x 10 ⁻³ M			
1.12	605	143	78.30
1.16	667	193	84.25
1.20	750	275	90.75
1.24	680	181	80.20
1.28	653	164	75.30

i-V Characteristics of the Cell

The short circuit current (i_{sc}) and open circuit

voltage (V_{oc}) of the cells were measured with the help of a microammeter (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 were recorded with the help of a carbon pot (log 470 K) connected in the circuit of microammeter, through which an external load was applied. The IV characteristics of the cell containing Bismark brown-D-Xylose-NaLS system is given in graphically represented in Figure .It was observed that i-V curve deviated from their regular rectangular shapes. A point in i-V curve, called power point was determined where the product of current and potential was maximum and the fill factor was calculated as 0.249 using the formula.

$$\text{Fill factor (n)} = \frac{V_{pp} \times I_{pp}}{V_{oc} \times I_{sc}} \dots\dots\dots(1)$$

Where, V_{pp} and i_{pp} represent the value of potential and current at power point respectively.

The Performance of the Photogalvanic Cell

The performance of the photogalvanic cell was observed by applying an external load (necessary to have current at power point) after termination the illumination as soon as the potential reaches a constant value. The performance 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 was observed that the cell can be used in dark for 160 minutes.

Conversion Efficiency

The conversion efficiency of the cell was determined as 1.0157 % using the following formula.

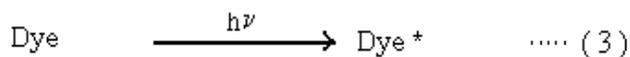
$$\text{Conversion efficiency} = \frac{V_{pp} \times i_{pp}}{10.4mWcm^{-2}} \times 100\% \dots\dots(2)$$

Mechanism

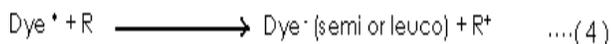
On the basis of above investigations the mechanism of the photogeneration of electricity in the photogalvanic cell is proposed as:

Illuminated Chamber

On illumination, the dye molecules get excited



The excited dye molecules accept an electron from reductant and get converted into semi or leuco form of dye, and the reductant gets converted into its oxidized form.



At Platinum Electrode

The semi or leuco form of dye molecules lose an electron and converted into original dye molecules.



Dark Chamber

At counter electrode

Dye molecules accept an electron from electrode and get converted in to semi or leuco form.



Finally leuco/semi form of dye and oxidized form of reductant combine to give original dye and reductant molecules and the cycle will go on.



Where Dye, Dye*, Dye⁻, R and R⁺ are the dye (Bismark brown), their excited form and semi or leuco form, reductant and its oxidized form, respectively.

CONCLUSION

Scientists have been studying the harvesting of solar energy in various forms of solar cells like photo electrochemical, photovoltaic and photogalvanic cells. Photovoltaic cells are widely used in most countries for conversion and storage of solar energy but owing to their nil storage capacity, photogalvanic cells are emerging as thrust research area as they have the added advantage of inherent storage capacity. The use of photosensitizer Bismark brown- D-Xylose-NaLS system not only

enhances the electrical output of the cell but also increases the conversion efficiency and storage capacity in comparison to the photogalvanic cell using single photosensitizer. Efforts will be made in future to make it more efficient. The comparative values for various parameters of photosensitizer Bismark brown- D-Xylose-NaLS system are given in Table.

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