USE OF NATURAL ROSE FLOWER EXTRACT AS PHOTOSENSITIZER FOR SOLAR ENERGY CONVERSION AND STORAGE: ROSE EXTRACT – ASCORBIC ACID - NaLS SYSTEM

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ABSTRACT

Photogalvanic effect has been studied in system that contain natural extract of rose flower petals as photosensitizer, ascorbic acid as reducing agent and NaLS as surfactant. The photopotential and photocurrent generated were 790 mv and 140 µA, respectively. The observed conversion efficiency was 0.6769% and the maximum power of cell was 110.60 µW. The storage capacity of the cell was on electrical output of the cell was observed and a mechanism has been proposed for the generation of photocurrent in photogalvanic cells.

Key words: Ascorbic acid, Sodium lauryl sulphate, Fill factor, Conversion efficiency, Power point, Storage capacity.

INTRODUCTION

Solar cells convert sunlight directly to electricity with acceptable conversion efficiency. They are virtually renewable source of energy. The photogeneration of electricity has attracted attention of scientists as viable media for solar energy conversion and storage in photogalvanic cells with bright future prospects. First of all Bacquerel[1] in 1839 observed the flow of current between two unsymmetrical illuminated electrodes in sunlight. Thereafter, Eisenberg[2], Clark and Eckert[3], Hodes et al.[4], Fujishima et al.[5], Kaneko and Yamada[6], Fujihara et al.[7], Archer[8] and Rohtagi-Mukhejee et al.[9-11] have reported some interesting photogalvanic systems. Theoretical conversion efficiency of photogalvanic cell is about 18% but the observed conversion efficiencies are quite low due to low stability of dyes, back electron transfer, aggregation of dye molecules around electrodes etc.

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A detailed literature survey (Naka et al.[12], Taquikhan et al.[13], Ameta et al.[14,15], Gangotri et al.[16], Meena et al.[18-21], Chhagan Lal[22] and Sushil Yadav[23]) reveals that different photosensitizers and reductants have been used in photogalvanic cells, but no attention has been paid to use of natural extract of rosa Indica (flower petals) as photosensitizer and ascorbic acid as reductant and NaLS as surfactant in the photogalvanic call for solar energy conversion and storage. Therefore, the present work was undertaken.

EXPERIMENTAL

Rose flower petals (Rose Indica), ascorbic acid (LOBA), acetone (LOBA), sodium hydroxide (S.D. Fine) and NaLS (S.D. Fine) were used in present work. All the solutions were prepared in doubly distilled water and were kept in amber coloured containers to protect them from sunlight. A mixture of solution of rose petal extract, ascorbic acid, NaLS and sodium hydroxide was kept in a H-type glass tube. A platinum electrode (1.0 x 1.0 cm^2) was immersed into one arm of H-tube and a saturated calomel electrode (SCE) was kept in the other. The whole system was first placed in dark till a stable potential was obtained, then the arm containing the SCE was kept in the dark and the platinum electrode was exposed to a 200 W tungsten lamp.

A water filter was used to cut off infrared radiations. The photochemical reaction of rose flower extract was studied potentiometrically. A digital pH meter (Systronics 802) and a micro ammeter (New Tech. India) were used to measure the potential and current generated by the system, respectively.

RESULTS AND DISCUSSION

Effect of variation of pH

The electrical output of the cell was affected by the variation in pH of the system. It is observed form Table 1 that there is an increase, on increasing in pH values. At pH 13.2, a maxima was obtained. On further increase in pH, there was decrease in photopotential and photocurrent. Thus, photogavanlc cells containing the rose extract – ascorbic acid – NaLS system were found to be sensitive to the pH of the solutions.

Effect of ascorbic acid concentration

The electrical output of the cell was affected by the variation of reducing agent concentration (Ascorbic acid) in the system. The results are summarised in Table-2.

Table 1: Effect of variation of pH

Temp. = 296.7 K, Light Intensity = 10.4 mWcm^{-2}

Ascorbic acid = 8.0 x 10^{-3}M, NaLS = 6.0 x 10^{-4}M, Rose Ext. = 2.8 mL.

	pH				
	12.2	12.6	13.2	13.5	13.8
Photopot. (mV)	749	760	790	762	740
Photocurrent (μA)	129	135	140	136	125
Power (μW)	96.62	102.60	110.60	103.63	92.50

Table 2: Effect of ascorbic acid concentration

Temp. = 296.7 K, Light intensity = 10.4 mWcm^{-2}, NaLS = 6.0 x 10^{-4}M,

pH = 13.2, Rose Ext. = 2.8 mL.

	[Ascorbic acid] x 10^{3}M				
	6.4	7.2	8.0	8.8	9.6
Photopot. (mV)	765	778	790	760	745
Photocurrent (μA)	130	138	140	128	126
Power (μW)	99.45	107.36	110.60	97.28	93.87

Lower concentrations of reducing agents resulted in a fall in electrical output because fewer reducing agent molecules were available for electron donation to rose extract molecules.

Larger concentrations of reducing agent again resulted into a decrease in electrical output, because the large number of reducing agent molecules hinder the sensitizer molecules reaching the electrode in the desired time limit.

Effect of rose extract concentration

Dependence of photopotential and photocurrent on the concentration of rose extract was studied and the results are summarised in Table 3.

Table 3: Effect of rose extract concentration

Temp. = 296.7 K, Light intensity = 10.4 mWcm^{-2},

Ascorbic acid = 8.0 x 10^{-3}M, NaLS = 6.0 x 10^{-4}M,

pH = 13.2

	[Rose extract] in mL				
	2.2	2.4	2.8	3.00	3.2
Photopot (mv)	776	782	790	780	778
Photocurrent (μA)	133	137	140	136	134
Power (μW)	103.20	107.13	110.60	106.08	104.25

Lower concentration of extract resulted into a fall in photopotential and photocurrent because fewer sensitizer molecules are available for the excitation and consecutive donation of the electrons to the platinum electrode. The greater concentration of sensitizer again resulted into a decrease in electrical output as the intensity of light is reduced by sensitizer molecules present in path.

Effect of diffusion length

The effect of variation of diffusion length (distance between the two electrodes) on the current parameter of the cell was studied using H- cells of different dimentions. The results are show in Table 4.

It was observed that there was a sharp increase in photocurrent (i_{max}) in the first few minutes of illumination and then there was a gradual decrease to a stable value of photocurrent. This photocurrent at equilibrium is represented as (i_{eq}). This kind of photocurrent behaviour indicates on initial rapid reaction followed by a slow rate determining step. On the basis of effect of diffusion path length on the current parameter, it may be concluded that the leuco-or semi-reduced form of sensitizer and the sensitizer itself are the main electroactive species at the illuminated and the dark electrodes, respectively. However, the reducing agents and its oxidised products behave as the electron carriers in the cell diffusing through the path.

Table 4: Effect of diffusion length

Diffusion path length, DL (mm)	Maximum photocurrent (μA) i_{max}	Equilibrium photocurrent (μA) i_{eq}	Rate of initial generation of current ($\mu A\ min^{-1}$)
35.0	122	125	8.30
40.0	127	130	8.57
45.0	140	140	9.05
50.0	145	140	9.23
55.0	152	155	9.46

Electroactive species

Various probable processes may be considered for the photocurrent generation in photogalvanic cells. The results of the effect of diffusion length on current parameters were utilised to know more about the electroactive species. The possible combinations for electroactive species in photogalvanic cells are tabulated in Table 5. The oxidised form of the reductant is formed only in the illuminated chamber and it it is considered to be the electroactive species in the dark chamber, which must diffuse from the illuminated chamber to the dark chamber to accept on electron from the electrode. As a consequence, the maximum photocurrent (i_{max}) and rate of increase in photocurrent should decrease with an increase in diffusion length but this was not observed experimentally.

Table 5: Possible combinations for electroactive species

In illuminated chamber	In dark chamber
Sensitizer	Oxidized form of reductant (R^+)
Leuco-or Semi form	Oxidized form of reductant (R^+)
Leuco-or Semi form	Sensitizer

The i_{eq} was also observed to be independent with respect to change in diffusion length (rather it decreases slightly). Therefore, it may be concluded that main electroactive species are the leuco-or semireduced–form of sensitizer and the sensitizer in illuminated

chamber and dark chamber, respectively. However, the reductant and its oxidized products act only as electron carrier in the path.

Current-voltage (i-V) characteristics and conversion efficiency

The short circuit current (i_{sc}) and open circuit voltage (V_{oc}) of the photo galvanic cells were observed with the help of a multimeter (keeping the circuit closed) and with 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 multimeter, through which on external load was applied. The i-V characteristics of the photogalvanic cells containing rose extract – ascorbic acid – NaLS system shown in Fig. 1.
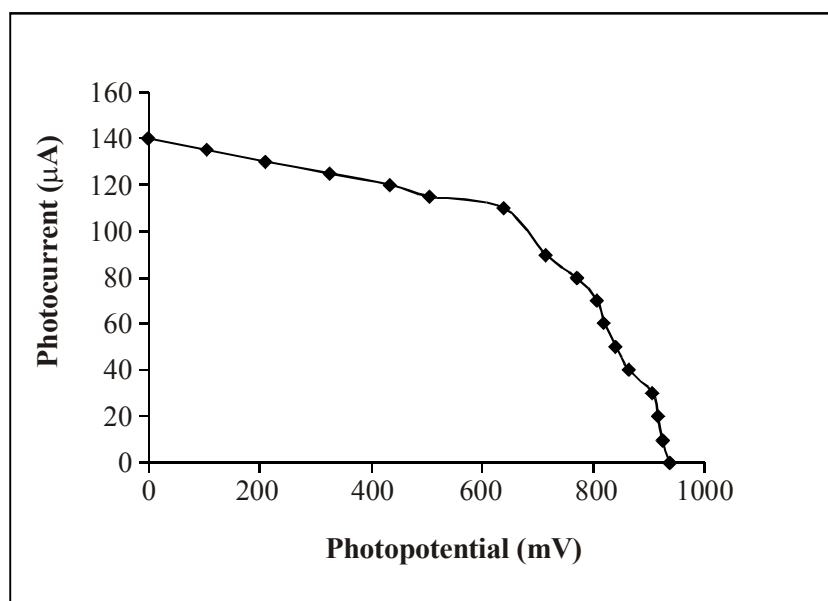

Fig. 1: i-V Characterstic of the cell

It was observed that i-V curve deviated from its regular rectangular shape. A point in i-V curve was observed, and is called power point (PP). At this point, the product of current and potential was maximum and the fill factor was calculated using the formula –

$$\text{Fill Factor} = \frac{V_{pp} \times i_{pp}}{V_{oc} \times i_{sc}} \qquad \qquad …(1)$$

$$\text{Conversion efficiency} \quad \frac{V_{pp} \times i_{pp}}{10.4 \text{ mWcm}^{-2}} \quad \text{x } 100\% \qquad \qquad …(2)$$

Where V_{pp} and i_{pp} represent the values of potential and current at power point, respectively and V_{oc} and i_{sc} are potential at open circuit and current at short circuit, respectively.

Cell performance

The performance of the cell was studied by applying on external load necessary to maintain current and potential at the power point after removing the source of light until the output (power) falls to its half value in the dark. It was observed that this cell can be used in the dark at its power point for 49.0 minutes.

Mechanism

On the basis of above investigations, a mechanism for the photocurrent generation in the photogalvanic cell can be proposed as follows –
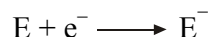
Illuminated chamber

Bulk solution

$$E \xrightarrow{\quad hv \quad} E^*$$

$$E^* + R \longrightarrow E^- + R^+$$
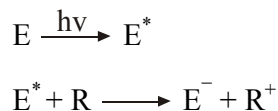
At Pt electrode

$$E^- \longrightarrow E + e^-$$

Dark chamber

At electrode

$$E + e^- \longrightarrow E^-$$

Bulk solution

$$E^- + R^+ \longrightarrow E + R$$

Where E, $E^-.R$ and R^+ are the rose extract and its leuco-or semi-reduced forms, reductant and its oxidized form, respectively.

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REFERENCES

1. K. Bacquerel, C. R. Acad Sci., Paris, **9**, 14 (1839).

2. M. Eisenberg and H. P. Silvermann, Electrochem Ecta., **5**, 1 (1961).

3. W. D. K. Clark and J. A. Eckert, Solar Energy, **17**, 147 (1975).

4. G. Hodes, D. Cahen and J. Manassen, Nature, **260**, 312 (1976).

5. A. Fujishima, T. Iwase and K. Honda, J. Am. Chem. Soc., **98**, 1625 (1976).

6. Kaneko and Yamada, J. Phys. Chem., **81**, 1213 (1977).

7. M. Fujihara, M. Ohishi and T. Osa, Nature, **268**, 266 (1977).

8. M. D. Archer, Solar Energy, **20**, 167 (1978).

9. K. K. Rohtagi-Mukherjee, M. Roy and B. B. Bhowmik, Solar Energy, **4**, 417 (1983).

10. K. K. Rohtagi-Mukherjee, S. Roy and B. B. Bhowmik, Indian J. Chem., **24A**, 5 (1985).

11. M. Nakao, T. Watanabe and K. Honda, Chem. Lett., **2**, 225 (1984).

12. K. K. Rohtagi-Mukherjee, B. B. Bhowmik, and S. Roy, Indian J. Chem., **24**, 388 (1986).

13. M. M. Taqui Khan, R. C. Bhardwaj and C. Bhardwaj, Inorg. Chem. Acta., **130**, 153 (1987).

14. S. C. Ameta, S. Khamesra, A. K. Chittora and K. M. Gangotri, Int. J. Energy, Res., **13**, 643 (1989).

15. S. C. Ameta, S. Khamesra, Manju Bala and K. M. Gangotri, Phil. J. Sci., **119**, 371 (1990).

16. K. M. Gangotri, R. C. Meena and R. Meena., J. Photochem. Photobiol., **123A**, 93 (1999).

17. K. R. Genwa and Anju Chouhan, J. Chem. Sci., **116**, 339 (2004).

18. R. C. Meena, Gautam Singh and K. M. Gangotri, Afinidad, **69**, 501 (2003).

19.   R. C. Meena and R. S. Sindal, Int. J. Chem. Sci., **2(3)**, 321 (2004).

20.   R. C. Meena and G. Singh, Res. J. Chem. Environ., **9(4)**, 90 (2005).

21.   R. S. Sindal, Mahesh Chandra, Sonal Sirvi and R. C. Meena, Int. J. Chem. Sci., **4(4)** 1011 (2006).

22.   Chhagan Lal, J. Power Sources, **164**, 926 (2007).

23.   Sushil Yadav, R. D. Yadav and Gautam Singh., Int. J. Chem. Sci., **6(4)** 1960 (2008).