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Study of photogalvanic effect in photogalvanic cell containing Azur B-NaLS-Ascorbic acid system

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Abstract : Photogalavanic effect was studied in a photogalvanic cell containing NaLS, Ascorbic acid and Azur B as a surfactant, reductant and photosensitizer, respectively. The photopotential and photocurrent generated by this system were 971.0 mV and 185.0 μA respectively. The observed conversion efficiency was 0.9646% and fill factor was determined as 0.41. The cell performance was 135.0 min in dark. The effect of different parameters on the electrical output of the cell were observed, current-voltage characteristics of the cell have also been studied and mechanism has been proposed for the generation of photocurrent in photogalvanic cell.

Keywords : Azur B, ascorbic acid, photogalvanic cell.

Recently Gangotri *et al.*[1] observed the photogalvanic effect in photogalvanic cell containing dyes, reductants and surfactants. But no attention has been paid to the use of heterocyclic dye (Azur B)-Ascorbic acid-NaLS system in the photogalvanic cell for the solar energy conversion and storage. Therefore, the present work was undertaken.

Results and discussion

It was observed that the photopotential and photocurrent increases with increase in concentration of the dye [Azur B]. A maxima was obtained for a particular value of Azur B concentration above which a decrease in electrical output of the cell was observed. The effect of variation of Azur B concentration on photopotential and photocurrent reported in Table 1.

There is a fall in photopotential and photocurrent at lower concentration of dye because of fewer dye molecules were available for the excitation and consecutive donation of the electrons to the platinum electrode. The greater concentration of dye also results into a decrease in electrical output as the decrease in intensity of light reaching the dye molecule near the electrode.

Photogalvanic cell containing NaLS-Ascorbic acid-Azur B system was found to be quite sensitive to the pH of the solution. The system shows an increase in the photopotential and photocurrent of the cell with increase in pH value (in the alkaline range). At pH = 12.4 a maxima was achieved. On further increase in pH, there was a decrease in photopotential and photocurrent. The effect of variation of pH on photopotential and photocurrent are given in Table 1.

The electrical output of the cell increases with increasing on increasing concentration of surfactant (NaLS). A maxima was obtained at a certain value. On further increasing the concentration a down fall in electrical output has been observed (Table 1).

With the increase in the concentration of the reductant (Ascorbic acid), the photopotential was found to increase till it reaches a maximum value. On further increase in concentration of Ascorbic acid, a decrease in the electrical output of the cell has been observed. The effect of variation of [Ascorbic acid] concentration on the photopotential and photocurrent of system are given in Table 1.

The effect of variation of reductant (Ascorbic acid) concentration shows that the decrease in reductant (Ascorbic acid) concentration resulted into a fall in electrical output because fewer reductant molecules were available for electron donation to the dye molecule. Similarly, the increased concentration of Ascorbic acid also resulted in to a fall in electrical output because the larger number of reductant molecule may prevent the dye molecule to reaching the electrode in the desired time.

Effect of diffusion length : The effect of variation of difffusion length (distance between the two electrodes) on the current parameters of the cell (i_{max}, i_{eq} and rate of initial generation of current) has been studied using H-cells of different dimensions. It was observed that with an increase in diffusion length, both i_{max} and rate (μA min^{-1}) shows an increase but the i_{eq} shows a negligibly small decreasing behaviour with the increase in diffusion length so virtually, that it may be presumed as unaffected by the change in diffusion length. The results are summarized in Table 2.

It may be concluded that the leuco form of dye itself is the main electroactive species at the illuminated and dark chambers, respectively. However the reductant and

Table 1. Effect of variation of [Azur B], pH, [NaLS] and [Ascorbic acid]

Light intensity = 10.4 mW cm^{-2}, Temp. = 303 K

[NaLS], [Ascorbic acid]	[Azur B] × 10^5 *M*	Photopotential (mV)	Photocurrent (μA)
6.0; 4.8 × 10^{-3} *M* respectively	8.80	721.0	118.0
pH 12.4	9.00	812.0	160.0
	9.60	971.0	185.0
	10.00	901.0	165.0
	10.20	802.0	130.0
[Azur B], [NaLS], [Ascorbic acid]	pH		
0.096; 6.0; 4.8 × 10^{-3} *M* respectively	11.6	752.0	142.0
	12.0	806.0	150.0
	12.4	971.0	185.0
	12.8	820.0	165.0
	13.2	745.0	140.0
[Azur B], [Ascorbic acid]	[NaLS] × 10^3 *M*		
0.096; 4.8 × 10^{-3} *M* respectively	2.00	702.0	115.0
pH 12.4	4.00	868.0	148.0
	6.00	971.0	185.0
	8.00	879.0	162.0
	10.00	731.0	135.0
[Azur B], [NaLS]	[Ascorbic acid] × 10^3 *M*		
0.096; 6.0 × 10^{-3} *M* respectively	4.0	709.0	112.0
pH 12.4	4.2	848.0	145.0
	4.8	971.0	185.0
	5.2	879.0	155.0
	5.6	720.0	115.0

Table 2. Effect of diffusion length

[Azur B] = 9.6 × 10^{-5} *M*, light intensity = 10.4 mW cm^{-2}, [NaLS] = 6.0 × 10^{-3} *M*, Temp. = 303 K, [Ascorbic acid] = 4.8 × 10^{-3} *M*, pH = 12.6

Diffusion length D_L (mm)	Maximum photocurrent i_{max} (μA)	Equilibrium photocurrent i_{eq} (μA)	Rate of initial generation of current (μA min^{-1})
35.0	198.0	184.0	24.75
40.0	208.0	184.0	26.00
45.0	215.0	185.0	26.87
50.0	220.0	183.0	27.50
55.0	226.0	182.0	28.25

their oxidized products behave as the electron carriers in the cell diffusing through the path.

The effect of electrode area on the current parameters of the cell has also been studied. It was observed that with the increase in the electrode area, the value of maximum potential (i_{max}) is found to increase whereas the equilibrium photocurrent (i_{eq}) is found almost independent of this variation (rather it was affected in reverse manner). The effect of variation of electrode area on i_{max} and i_{eq} are reported in Table 3.

Table 3. Effect of electrode area

[Azur B] = 9.6×10^{-5} *M*, [Ascorbic acid] = 4.8×10^{-3} *M*, [NaLS] = 6.0×10^{-3} *M*, light intensity = 10.4 mW cm^{-2}, pH = 12.4, Temp. = 303 K

Electrode area (cm^2)	Maximum photocurrent i_{max} (μA)	Equilibrium photocurrent i_{eq} (μA)
0.36	195.0	186.0
0.64	205.0	187.0
1.0	215.0	185.0
1.44	226.0	185.0
1.69	235.0	184.0

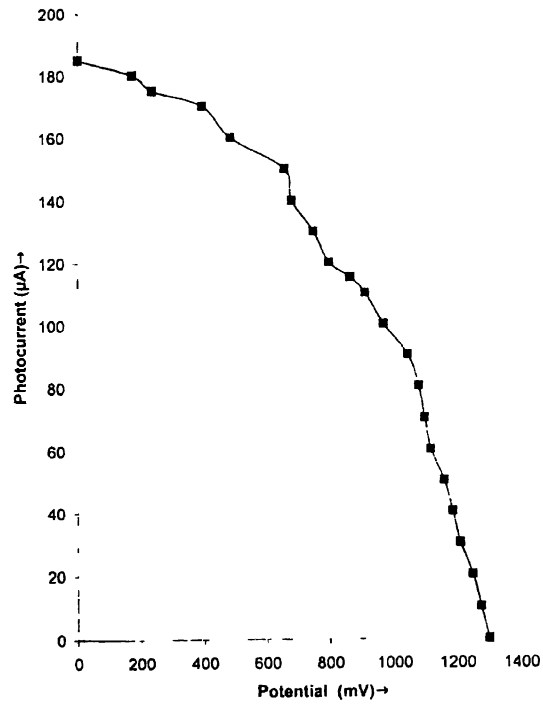

Fig. 1. Current-voltage (*i*-*V*) curve of the cell.

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 500 K) connected in the circuit of microammeter, through which an external load was applied. The *i-V* characteristics of the cell containing NaLS-Ascorbic acid-Azur B system are given in Fig. 1.

It was observed that *i-V* curve deviated from their regular rectangular shapes (Fig. 1). 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 0.41, using the formula :

$$\text{Fill factor } (\eta) = \frac{V_{pp} \times i_{pp}}{V_{oc} \times i_{sc}} \quad (1)$$

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

Cell performance and conversion efficiency : 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 $t_{½}$ (Fig. 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 135.0 min. The conversion efficiency of the cell was determined as 0.9646% using the following formula :

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

Mechanism :

On the basis of above investigations the mechanism of the photocurrent generation in the photogalvanic cell may be proposed as follows :

Illuminated chamber :

$$D \xrightarrow{h\nu} D^*$$

$$D^* + R \longrightarrow D^- + R^+$$

At platinum electrode :

$$D^- \longrightarrow D + e^-$$

Dark chamber :

At counter electrode :

$$D + e^- \longrightarrow D^-$$

$$D^- + R^+ \longrightarrow D + R$$

where D, D^-, R and R^+ were the Azur B and its leuco form, reductant and its oxidized form, respectively.

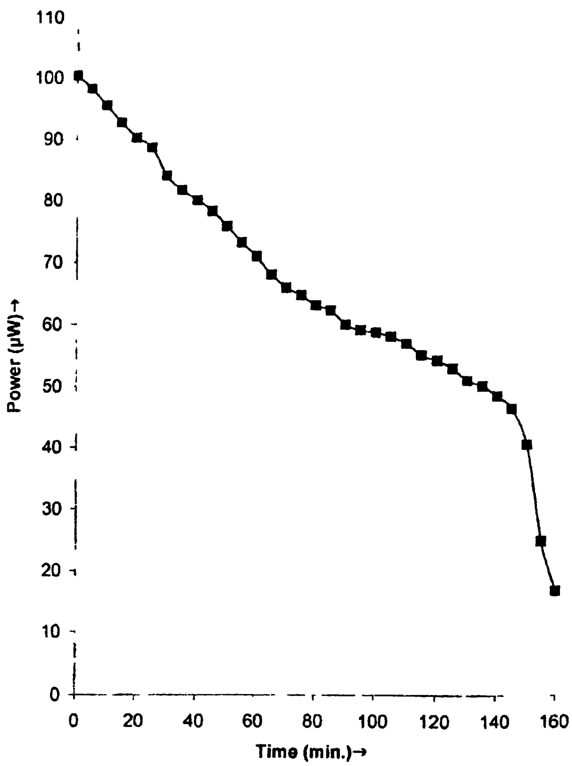

Fig. 2. Performance of the cell.

Conclusion :

The results obtained here were compared with results reported by using two different photosensitizers (Azur A and Azur C)[2] with NaLS Ascorbic acid and it is concluded that Azur B-NaLS-Ascorbic acid (present system) is most efficient then Azur A and Azur B photosensitizer systems. Therefore this system can be used in photogalvanic cell for solar energy conversion and storage.

Experimental

Sodium lauryl sulphate (LOBA), Azur B (s.d. fine), Ascorbic acid (LOBA), sodium hydroxide (s.d. fine) were used in the 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 solutions of Azur B, sodium lauryl sulphate, Ascorbic acid and sodium hydroxide was taken in a H-type glass tube. A platinum electrode (1.0 × 1.0 cm^2) was immersed in one arm of H-tube and a saturated calomel electrode (SCE) was kept in other arm. The arm containing platinum electrode was exposed to a 200 W tungsten lamp (Philips). A water filter was used to cut off infrared radiations. A digital pH meter (Systronics 335) and a microammeter (INCO-65) were used to measure the potential and current generated by the system, respectively. The current-voltage characteristics were determined by applying extra load with the help of carbon pot (log 500 K) connected in the circuit.

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References

1. K. M. Gangotri and Ranji Meena, *Afinidad*, 1998, **37**, 265; K. M. Gangotri, Kishna Ram Genwa, Chhagan Lal, Prashant Kalla and Rajni Meena, *Arab J. Sc. Engg.*, 1997, **22**, 115; K. M. Gangotri and O. P. Regar, *Int. J. Energy Res.*, 1997, **21**, 1345; *Arab J. Sc. Engg.*, 1999, **24**, 67; *J. Indian Chem. Soc.*, 2000, **77**, 347; K. M. Gangotri, R. C. Meena and Rajni Meena, *J. Photochem. Photobiol. A : Chem.*, 1999, **123**, 93; K. M. Gangotri and Chhagan Lal, *Energy Sources*, 2001, **23**, 267; K. R. Genwa and K. M. Gangotri, *Afinidad*, 2001, **58**, 157; K. M. Gangotri and R. C. Meena, *J. Photochem. Photobiol. A : Chem.*, 2001, **141**, 175; K. M. Gangotri and K. R. Genwa, *J. Indian Chem. Soc.*, 2004, **81**, 492.
2. K. R. Genwa and Anju Chouhan, *Solar Energy*, 2005 (in press); *Res. J. Chem. Environ.*, 2004, **8**, 55.