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EDTA-TB-CETYL PYRIDINIUM CHLORIDE IN PHOTOGALVANIC CELL FOR SOLAR ENERGY CONVERSION AND STORAGE

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ABSTRACT

Photogalvanic effect was studied in photogalvanic cell containing CPC as surfactant, Ethylenediamine tetra acitic acid as reductant and Toluidine blue as photosensitizer. The photopotential and photocurrent generated were 762.0mV and 35.0μA respectively. The observed conversion efficiency was 0.1061% and the maximum power of cell was 11.04 μW.The storage capacity of the cell was 38 minutes in dark. The effect of different parameters on electrical output of the cell was observed and a mechanism has also been proposed for the generation of photocurrent in photogalvanic cell.

INTRODUCTION

Rideal and Williams[1] discovered the photogalvanic effect in 1925 but it was systematically studied by Rabinowitch[2], Later on Clark and Echert[3], Kaneko and Yamada[4], Fox and Kabir-ud-din[5] Murthy et al.[6], Ameta et al.[7-9], Gangotri et al.[10-11], Gangotri and Regar[12-14], and Gangotri and Chhagan Lal[15-16], have developed photogalvanic cells for conversion and storage of solar energy with remarkable electrical output and storage capacity. Genwa and Gangotri[17], Gangotri et al.[18] have reported the effect of micelles on the performance and conversion efficiency of photogalvanic cells.

Recently Ghosh and Bhattacharya[19] have reported the system consisting of anionic dye fluorescein with inorganic ions in aqueous solution generates photovoltage when studied in photogalvanic cell.Recently Singh and Mishra[20] have also studied on photoelectrochemical Conversion based on polycrystalline semiconductor materials prepared using electrochemical co-deposition techniques are briefly reviewed.Some more phenothiazine dyes like methylene blue, toluidine blue and azur-c have been used in photogalvanic cells containing micelles reductant and photosensitizers and reported the good amount of electrical output in photogalvanic cells with remarkable storage capacity. Recently Madhwani et al. [21], Genwa and Mahaveer [22] , Genwa et al. [23], Genwa and Khatri [24], Gangotri et al. [25], Gangotri and Gangotri [26], Yadav and Lal [27], Gangotri and Solanki [28] and Gangotri and Bhimwal [29] have developed some interesting photogalvanic cells with reasonable electrical output. A careful survey of the literature reveals that negligible attention has been received by Toluidine blue dye. Toluidine blue is stable and low cost dye Among the dyes, therefore, Toluidine blue dye with surfactants has been selected in the present investigations. The effects of variation of the different parameters on electrical output of photogalvanic cells were studied in detail.

II. MATERIAL AND METHODE

Toluidine blue (LOBA), EDTA (s.d.fine), CPC (LOBA), and Sodium Hydroxide(E. Merck) were used in present works. All the solutions were prepared in double distilled water.

A mixture of the solutions of the Dye, Reductant, Surfactant and Sodium hydroxide was taken in an H–Shaped glass cell. A platinum electrode (1.0×1.0 cm^2) was dipped into one limb of the cell and 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 platinum electrode was exposed to a 200W tungsten lamp (ECE) and the limb containing the SCE was kept in dark. A water

filter was placed between the exposed limb and the light source to cut-off infrared radiations. The photochemical bleaching of Toluidine blue was studied potentiometrically. The photopotential and photocurrent generated by the systems TB / reductant / surfactant / OH^-/ hν were measured by the digital pH meter (Systronics Modal 335) and microammeter (OSAW), respectively.The i-V characteristics of the cells were studied using an external load (log 470 k) in the circuit.

III. RESULTS AND DISCUSSION

3.1 VARIATION OF POTENTIAL WITH TIME

The photogalvanic cell is placed in dark till it attained a stable potential and then the platinum electrode is exposed to light. It is observed that potential changes on illumination and it reaches a constant value after a certain period. When the light source is removed, the direction of change in potential is reversed and a stable potential is again obtained after sometime.[TB] = 4.00 x 10^{-5} M [EDTA] = 2.40 x 10^{-3} M [CPC] = 2.00 x 10^{-3} M Light Intensity = 10.4 mWcm^{-2} pH = 12.77 ,Temp. = 303 K

Table 1:

Time (Min)	Current (μA)
0.0	0.0
1.0	70.0
2.0	81.0
3.0	92.0
4.0	98.0
6.0	102.0
8.0	107.0
10.0	110.0
15.0	103.0
18.0	96.0
20.0	90.0
25.0	88.0
30.0	86.0
35.0	82.0
40.0	78.0
45.0	73.0
50.0	69.0
55.0	65.0
60.0	61.0
70.0	56.0
80.0	50.0
90.0	44.0
100.0	39.0
115.0	38.0
130.0	36.0
145.0	35.0
150.0	35.0
160.0	35.0
170.0	35.0 (Light off)
180.0	34.0
190.0	26.0
195.0	21.0
200.0	20.0

3.3 EFFECT OF VARIATION OF pH

It is observed that there is an increase in the photopotential of this system with the increase in pH value (In the alkaline range). At pH = 12.77 a maximum is obtained. On further increase in pH, there is a decrease in photopotential.

[TB] = 4.00 x 10^{-5} M,[EDTA] = 2.40 x 10^{-3} M ,[CPC]= 2.00 x 10^{-3} M, Light Intensity = 10.4 mW cm^{-2} ,Temp. = 303 K

EDTA–TB–CPC System	pH				
	11.2	12.0	12.7	13.0	13.2
Photopotential (mV)	493.0	580.0	762.0	660.0	485.0
Photocurrent (μA)	18.0	29.0	35.0	30.0	22.0
Power (μW)	8.87	16.82	26.67	19.80	10.67

3.4 EFFECT OF VARIATION OF REDUCTANT [EDTA] CONCENTRATION

With the increase in concentration of the reductant [EDTA] the photopotential is found to be increase till it reaches a maximum. On further increase in concentration of EDTA, a decrease in the electrical output of the cell is observed.

[TB] = 4.00 x 10^{-5} M,[CPC] = 2.00 x 10^{-3} M Light Intensity = 10.4 mW cm^{-2} ,pH = 12.7,Temp. = 303 K

EDTA–TB–CPC System	[EDTA] x 10^3 M				
	1.0	1.6	2.4	3.2	4.0
photopotential(mV)	450.0	560.0	762.0	605.0	515.0
photocurrent (μA)	22.0	25.0	35.0	31.0	28.0
power (μW)	9.90	14.0	26.67	18.75	14.42

3.5 EFFECT OF VARIATION OF PHOTOSENSITIZER [Toluidine blue] CONCENTRATION

It is observed that the photopotential and photocurrent are increased with the increase in concentration of the dye. A maximum is obtained for a particular value of Toluidine blue concentration, above which a decrease in the electrical output of the cell is obtained.

[CPC] = 2.00 x 10^{-3} M,[EDTA] = 2.40 x 10^{-3} M pH = 12.77,Light Intensity = 10.4 mW cm^{-2} Temp = 303 K

EDTA–TB–CPC System	[TB] x 10^5 M				
	3.0	3.5	4.0	4.5	5.0
Photopotentia(mV)	485.0	600.0	762.0	630.0	520.0
Photocurrent (μA)	26.0	32.0	35.0	30.0	20.0
Power (μW)	12.61	19.20	26.67	18.90	10.40

3.6 EFFECT OF VARIATION OF SURFACTANT [CETYL PYRIDINIUM CHLORIDE] CONCENTRATION

It is observed that electrical output of the cell is found to increase on increasing the concentration of CPC reaching a maximum value. On further increase in their concentration, a fall in photopotential, photocurrent and power of photogalvanic cell is obtained.

[TB] = 4.00 x 10^{-5} M,[EDTA]= 2.40 x 10^{-3} M ,pH = 12.77,Light Intensity = 10.4 mW cm^{-2},Temp. = 303 K

EDTA–TB–CPC System	[CPC] x 10^3 M				
	1.2	1.6	2.0	2.4	2.8
Photopotential (mV)	580.0	660.0	762.0	590.0	450.0
Photocurrent (μA)	28.0	32.0	35.0	30.0	25.0
Power (μW)	16.24	21.12	26.67	17.70	11.25

3.7 i-V CHARACTERISTICS OF THE CELL

It is observed that i-V curve deviated from their regular rectangular shapes. A point in i-V curve, called Power Point (pp) is determined where the product of current and potential is maximum and the fill-factor is calculated using the formula

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

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

[TB] = 4.00 x 10^{-5} M,[CPC) = 2.00 x 10^{-3} M ,

[EDTA] = 2.40 x 10^{-3} M ,Light Intensity = 10.4 mW cm^{-2} pH = 12.77, Temp. = 303 K

Potential (mV)*	Photocurrent (μA)	Fill Factor (η)
1005	0	
953	5	
838	10	
676	15	
552	20	0.313
406	25	
298	30	
0	35	

3.8 PERFORMANCE OF THE CELL

The performance is determined in terms of $t_{½}$ i.e., the time required in 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 38.0 minutes.

[TB] = 4.00 x 10^{-5} M, [CPC] = 2.00 x 10^{-3} M ,[EDTA]

= 2.40 x 10^{-3} M, Light Intensity = 10.4 mW cm^{-2} PH

= 12.7 Temp. = 303 K

Time (min)	Power (μW)
0.0	11.0
5.0	10.8
10.0	10.5
11.0	10.3
12.0	10.2
13.0	10.1
14.0	10.0
15.0	9.3
16.0	9.0
18.0	8.4
20.0	8.2
25.0	7.4
30.0	6.7
32.0	6.4
35.0	5.9
38.0	5.4
40.0	4.8
45.0	4.3
50.0	3.7
55.0	2.8

3.9 CONVERSION EFFICIENCY OF THE CELL

With the help of current and potential values at Power Point (pp) and the incident power of radiations, the conversion of the cell is determined as 0.1061% in the presence of EDTA – TB – CPC system by using the formula : efficiency

$$\text{Conversion Efficiency} = \frac{V_{pp} \times i_{pp}}{10.4\ mW/cm^2} \quad 100\%$$

IV. MECHANISM

On the basis of these observations, a mechanism is suggested for the generation of photocurrent in the photogalvanic cell as follows.

Illuminated chamber

$$TB^- \xrightarrow{h\nu} TB^+$$
$$TB^*+R \longrightarrow TB^-(\text{leuco})+R$$

At platinum electrode

$$TB^- \longrightarrow TB+e^-$$

Dark Chamber

$$TB+e^- \longrightarrow TB^-$$
$$TB^-+R^+ \longrightarrow TB+R$$

Were TB, TB*, TB^-, R and R^+ are the Toluidine blue, excited Toluidine blue, semi-or leuco- Toluidine blue, reductant and oxidized form of the reductant , respectively.

V. CONCLUSION:

In the present study it has been observed that the micells CPC not only enhance the power,fill factor and conversion efficiency of the cell but also stabilizes the systemon a long run.

The efforts are still needed to enhance the electrical output as well as storage capacity along with

reduction in the cost of the photogalvanic cell by selecting suitable redox couple and surfactant.

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