

Comparative Studies of Micelles in Photogalvanic Cell: for Solar Energy Conversion and Storage

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ABSTRACT: The photogalvanic effect was studied in photogalvanic cell containing dye, reductant and surfactants. The maximum potential were observed 1065mV and 1005mV in EDTA-TB-NaLS and EDTA-TB-CPC system respectively. The fill factors, Photocurrent, conversion, efficiency and storage capacity were also determined. The effect of different parameters on electrical output of the cell is observed. The mechanism of cell reaction was proposed for the generation of photocurrent in photogalvanic cell.

KEYWORDS: Photopotential, Photocurrent, fill factor, Conversion efficiency

I. INTRODUCTION

The consumption of non renewable source of energy like oil, gas and coal is increase at alarming rate. The time has finally come to look some other renewable sources of energy i.e. solar wind and geothermal energy. Solar energy is most important renewable source of energy for life forms. The main benefit of solar energy is that it does not produce any pollutant and is one of the cleanest and free source of energy. Conversion of solar energy into electrical energy through photogalvanic cell is the most important and desirable route for obtaining electricity. The photogalvanic cell works on photogalvanic effect. The effect was reported by Rideal and Williams[1] but it was systematically studied by Rabinowitch[2-3] and later by various other workers time to time[4-5], Ameta et al.[6-7], Gangotri et al.[8-12] have developed photogalvanic cells for solar energy conversion and storage. Genwa et al.[13-14] have reported the effect of micelles on the performance and conversion efficiency of photogalvanic cells. Role of surfactant in photogalvanic cell for solar energy conversion and storage studied by Gangotri and Meena[15]. Some more dyes have been used in photogalvanic cell containing micelles reductant and photosensitizers and reported the good amount of electrical output in photogalvanic cell with remarkable storage capacity. The photochemical conversion of solar energy into electrical energy was observed by[16-20]. The study of photogalvanic cell consisting dyes with reductant and surfactant work done[21]. Toluidine blue is stable and low cost dye among the dyes, therefore Toluidine blue dye with surfactant has been selected in the present investigation. The variation of different parameters on electrical output of photogalvanic cell was studied in detail.

II. MATERIALS AND METHOD

Toluidine blue (LOBA), EDTA (s.d.fine), CPC(LOBA) and Sodium Hydroxide(E.Merck) were used in present work. 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 ($1.0 \times 1.0 \text{ cm}^2$) was dipped into one limb of the cell and saturated calomel electrode (SCE) was kept in the other limb. The whole system was first placed in dark till 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

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cut-off infrared radiations. The photochemical bleaching of Toluidine blue was studied potentiometrically. The photopotential and photocurrent generated by the system TB/ Reductant/Surfactant/ $\text{OH}^-/\text{h}\nu$ were measured by the digital P^{H} meter (Systronic Modal 335) and microammeter (OSAW), respectively. The i-V characteristics of the cells were studied using an external load (log 470k) in the circuit.

III. RESULT AND DISCUSSION

A. VARIATION OF POTENTIAL WITH TIME OF EDTA-TOLUIDINE BLUE -NaLS SYSTEM

It was observed that photopotential increases on illumination and reaches at constant value after certain time. potential of EDTA -TB-NaLS cell is measured at different P^{H} values and maximum potential is found at 12.6 It was observed that potential increase on illumination to a value of 1065mV in 220 minute. On further illumination it remains constant when the light source is removed the direction of change in potential is reserved and stable potential is again obtain after sometime but does not regain the original value. The variation of potential with time shown by fig -1

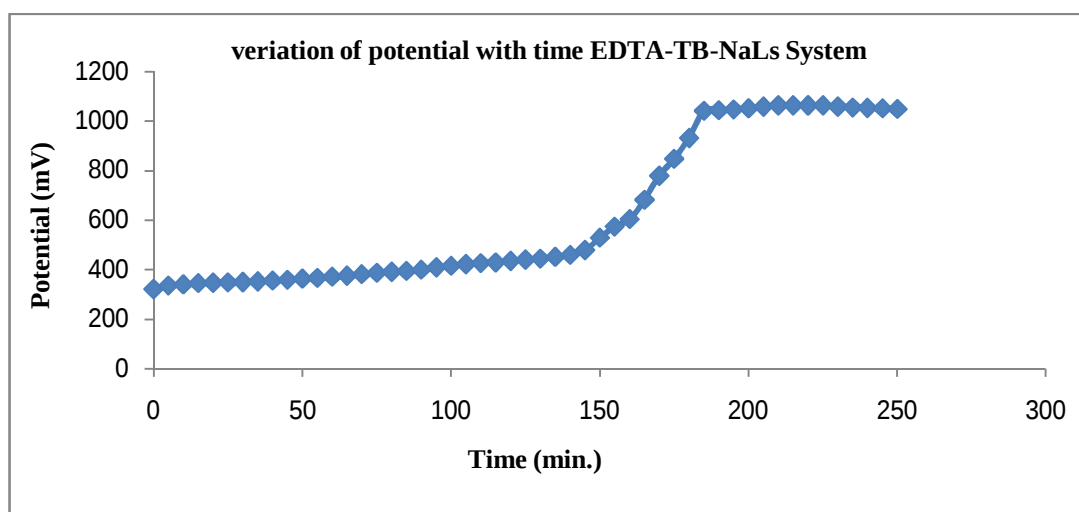


Fig-1 Variation of photopotential with time in EDTA-TB-NaLS system

B VARIATION OF POTENTIAL WITH TIME OF EDTA -TOLUIDINE BLUE -CPC SYSTEM

It was observed that photopotential increases on illumination and reaches at constant value after certain time. potential of EDTA-TB-CPC cell is measured at different P^{H} values and maximum potential is found at 12.7. It was observed that potential increase on illumination to a value of 1005mV in 170 minute. On further illumination it remain constant and when the light source is removed the direction of change in potential is reserved and stable potential is again obtain after sometime but does not regain the original value. The variation of potential with time shown by fig -2. The observed photopotential and photocurrent in EDTA-TB-NaLS cell are higher than EDTA-TB-CPC system. The data are reported in table-1

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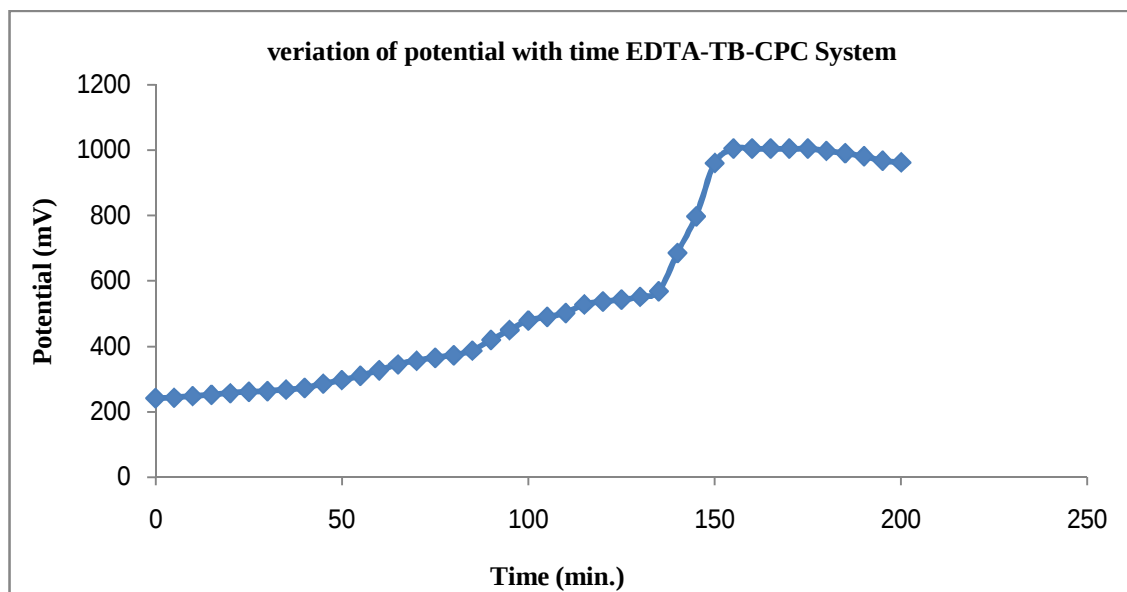


Fig-2 Variation of photopotential with time in EDTA-TB-CPC system

Table-1 Electrical output

S.No	parameters	Observation TB-EDTA-NaLs	Observation TB-EDTA-CPC
1	Open circuit voltage(V_{oc})mV	1065	1005
2	Photopotential Δv (mv)	743.0	762.0
3	Equilibrium photocurrent i_{eq} (μA)	70.0	35.0
4	Maximum Photocurrent i_{max} (μA)	150	110
5	Short Circuit Current i_{sc} (μA)	70	35
6	Initial generation of Photocurrent μA (Min)	16.6	11.0
7	Charging Time (Min)	220	170
8	Fill Factor (η)	0.367	0.313
9	Storage capacity $t_{1/2}$ (Min.)	24	38
10	Conversion Efficiency (%)	0.2630	1.1061

C. VARIATION OF PHOTOCURRENT WITH TIME

It was found that within the first few minutes on illumination the current of photogalvanic cells increase rapidly and reaching a maximum value(i_{max}) on further illumination current is found to decrease, finally reaching a constant value at equilibrium it is represented as i_{eq} . On illumination maximum photocurrent 150 μA and 110 μA is obtain in EDTA-TB-NaLs and EDTA-TB-CPC system respectively. Variation of photocurrent with time in EDTA-TB-NaLs and EDTA-TB-CPC system shown in fig-3and fig-4 respectively. The trend in short circuit photocurrent of EDTA-TB-NaLs is much better than EDTA-TB-CPC system. (Table-1)

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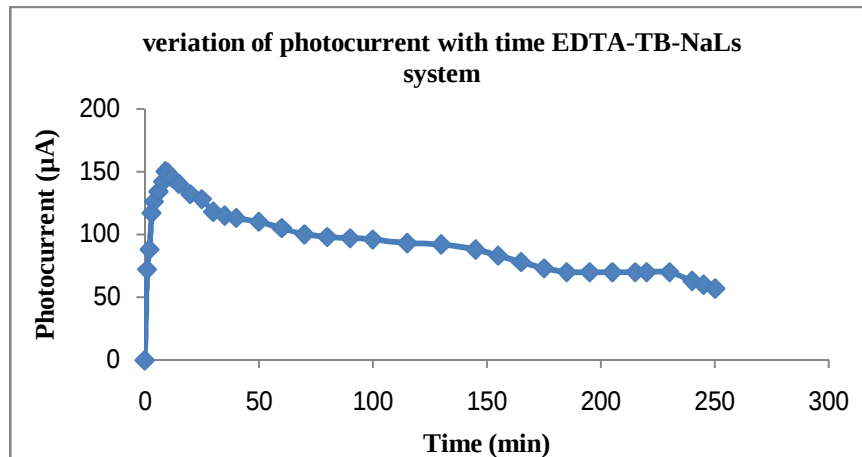


Fig-3 Variation of photocurrent with time in EDTA-TB-NaLs system

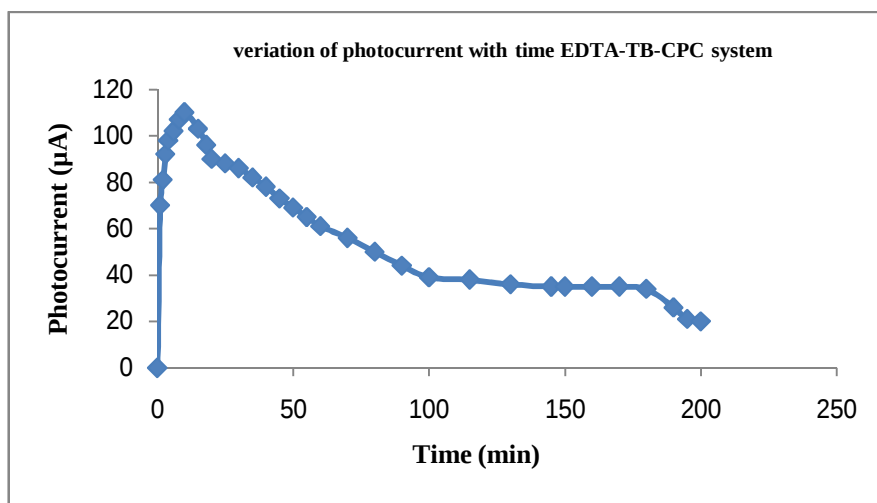


Fig-4 Variation of photocurrent with time in EDTA-TB-CPC system

D. CONVERSION EFFICIENCY OF PHOTOGALVANIC CELL

Conversion efficiency is most important characteristics of any photogalvanic cell. It was observed that i-V curve deviated from their regular rectangular shapes. A point in i-V curve, called Power Point is determined where the product of current and potential is maximum and the fill factor and conversion efficiency are also calculated by using the formul.

$$\text{Fill Factor} = \frac{V_{pp} \times i_{pp}}{V_{oc} \times i_{sc}}$$

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

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The conversion efficiency of EDTA-TB-NaLs photogalvanic cell has been calculated to be 0.2630% and in EDTA-TB-CPC cell conversion efficiency has been calculated to be 0.1061%. The conversion efficiency of these two cell are reported in table-2. On the basis of these data EDTA-TB-NaLs system has high conversion efficiency than EDTA-TB-CPC

Table-2 Characteristics of the cell

System	V_{oc} (mV)	i_{sc} μ A)	V_{pp} (mV)	i_{pp} (μ A)	Fill factor (η)	Conversion efficiency(%)
EDTA-TB-NaLs	1065	70	608	45	0.367	0.2630%
EDTA-TB-CPC	1005	35	552	20	0.313	0.1061%.

E. PERFORMANCE OF THE CELL

The performance is determined in term of $t_{1/2}$. The time $t_{1/2}$ was determined after removing the source of light. It is time taken in reaching half the value of power. The performance of cell were studied and comparative value are summarized in table-3. On the basis of these data the performance of EDTA-TB-CPC is much better then EDTA-TB-NaLs.

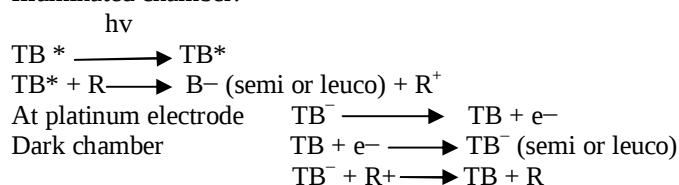
Table-3 Performance of the cell

System	Power (μ W)	$t_{1/2}$ (min.)
EDTA-TB-NaLs	52.01	24
EDTA-TB-CPC	26.67	38

IV. MECHANISM

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

Illuminated chamber:



where 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 is concluded that photogalvanic cell are better option for solar energy conversion and storage capacity. Photogalvanic cell are economic because of low cost material are used in these cell. The electrical output of anionic micelles (NaLs) are more than cationic micelles (CPC) In these two cell EDTA-TB-NaLs cell is more efficient than the EDTA-TB-CPC cell. This cell with better electrical output, good performance and storage capacity may be used in near future.

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