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Enhanced Electrical Output by Mixed Surfactant for Solar Cells: EDTA+TB+NaLS+CPC+Tween-80 system

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ABSTRACT

Enhancing photogalvanics electrical output in the sphere of solar energy is the goal of the study. The use of fossil fuels is also limitation to energy conversion. The photogalvanic (PG) cell with EDTA + TB + NaLS + CPC + Tween-80 produces superior results than a system with just one surfactant. The photopotential (PP) and photocurrent (PC) of the EDTA + TB + NaLS + CPC + Tween-80 photogalvanics were measured at 689.00 mV and 234.00 uA, respectively. The efficiency and performance of the EDTA + TB + NaLS + CPC + Tween-80 photogalvanics were determined to be 0.2811% and 109.00 min respectively. The photogalvanic system with mixed surfactants (NaLS + CPC + Tween-80) is a productive one with improved electrical characteristics. The performance of PG cells can be slightly improved by using individual surfactants as opposed to surfactant combinations. Surfactant combinations with qualities that are superior to those of the individual components can be used in PG cell applications.

Keywords: CPC, Tween-80, NaLS, Photogalvanics, Storage.

INTRODUCTION

Photogalvanics were noticed by Rideal and Williams[1] and the endergonic photochemical reaction was studied by Rabinowitch[2]. The growth of PG cells has been successful observed to the research of Suda *et al.,*[3] Murthy *et al.,*[4] Bayer *et al.,*[5] for better results. Different reductants and photosensitizers were used in solar cells by Albery and Archer[6], Memming[7], Hamdi and Aliwi[8], Gangotri and Meena[9]. Using various micelles, reactants, and dyes, Genwa and Genwa[10], Gangotri and Gangotri[11], Gangotri and Lal[12], Lal and Gangotri[13] calculated electrical output for the photogalvanic in solar energy. Lee and Lee[14] have additionally noticed dual micellization in cells in order to evaluate their potential. In mixed surfactant solutions[15] investigated the relationship between wetting and deterging capacities. Very similar studies[16–18] that paid attention to improving the outcomes have been conducted. For the scientific environment, Rathore *et al.,*[19] Mall and Solanki[20], and Wu *et al.,*[21], innovations for dye reductant surfactant[22–23], mixed surfactant[24], and effective systems[25] were researched. By changing the different parameters in PG cells, the impact of solar energy was investigated. The mixed surfactants have experimentally demonstrated the effective system as the desired target of research with particular reference to improving electrical output and solar energy storage, based ecofriendly nature for the aforementioned acquired values[26]. Comparatively better result in PG cell is novelty of work and limitation of system is obtained result are still not enough for sustainable development.

Research on the interactions between surfactants and dye molecules has been made possible by the characteristics of surfactant mixtures. The propensity of various surfactants to form aggregated formations varies. Micelles, precipitate, and monolayers are a few examples of these aggregates. The propensity to generate aggregated formations in solutions containing combinations of surfactants might vary significantly from solutions containing simply the individual surfactants. In PG cells, the surfactant combination may lead to better precipitation than the individual precipitate of a single surfactant. For mixes, different components may have different propensities to disperse themselves between the unaggregated state and an aggregate. As a result, the composition of a micelle's three surfactants may be very different from the equilibrium composition of a single surfactant monomer. The processes of interest might merely be reliant on collect or monomers content. For instance, the composition and concentration of the surfactant affects the way it binds to dyes like toluidine blue, and the composition of the micellar solution affects how well the dye dissolves in it. Enhancing electrical output in terms of current and potential was the study's goal. The obtained results are compared with previous literature in the table format and explained how it differed from others (Table 6).

EXPERIMENTAL

Preparation of solutions

In distilled water, solutions of EDTA, TB, NaLS, CPC, and Tween-80 were prepared. These solutions are kept in glass containers with filter paper on top. For the experiment's electrical measurements, 25 mL of EDTA, TB, NaLS, CPC, and Tween-80 were used. In the experimental, the solutions concentration of 2×10^{-3} M EDTA, 4×10^{-5} M TB, 6.40×10^{-3} M NaLS, 8.94×10^{-4} M CPC, and 9.00×10^{-3} M Tween-80 were used.

Experiment set–up

Designed photogalvanic system (Fig. 1) and developed two-arm, H-shaped glass tubes. One arm received a dip of a saturated calomel electrode (SCE), and the other received a dip of a platinum electrode (PT). By employing a carbon pot, a digital pH meter, a resistance key, a micro-ammeter, and a function key, both SCE and PT were connected to the cell circuit. For the experimental stage, 25 mL solutions of the three surfactants NaLS+CPC+Tween-80 (mixed surfactants), EDTA (reductant), toluidine blue (photosensitizer), sodium hydroxide, and distilled water were utilized. Out of 25 mL of solutions, 2 mL were used for sodium hydroxide, 2 mL for sodium sulfate, 3 mL for CPC, 3 mL for Tween-80 (combined surfactants are 8 mL), 7 mL for EDTA, 6 mL for toluidine blue, 2 mL for sodium sulfate, and 2 mL for sodium hydroxide. A 200 W electric bulb was utilized as an artificial light source to measure the current-potential. The chemicals used in the PG cell are tabulated in Table 5.

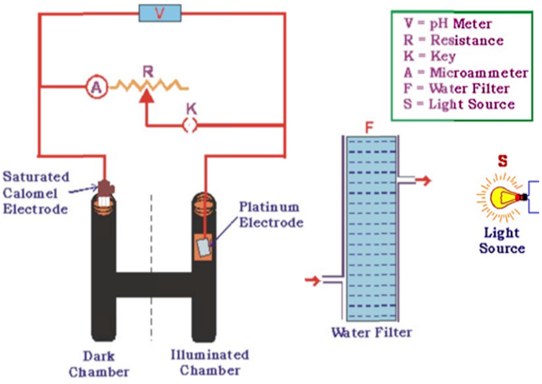

Fig. 1. PG Cell for three mixed surfactants

RESULTS AND DISCUSSION

Variations in toluidine blue concentration and their effects

Toluidine blue concentration increases initially, increasing electrical values (potential and current), achieving the maximum values (optimum values), and then decreasing in EDTA+TB+NaLS+CPC+Tween-80 photogalvanics. Table 1 and Fig. 2 show the photosensitizer concentration variation in the EDTA+TB+NaLS+CPC+Tween-80 system.

Table 1: EDTA+TB+naLS+CPC+Tween-80 (Variation of the three surfactants)

Light Intensity=10.4 $mWcm^{-2}$, pt electrode=1cmx1cm, Temperature=303 K			
Parameters	Photopotential (mV)	Photocurrent (μA)	Power (μW)
[TB]×10^{-5} M 4.00	689.00	234.00	161.11
[EDTA]×10^{-3} M 2.00	689.00	234.00	161.11
[NaLS]×10^{-3} M 6.40	690.00	234.00	161.11
[CPC]×10^{-4} M 8.94	689.00	234.00	161.11
[Tween-80]×10^{-3} M 9.00	689.00	234.00	161.11
PH 12.77	689.00	234.00	161.11

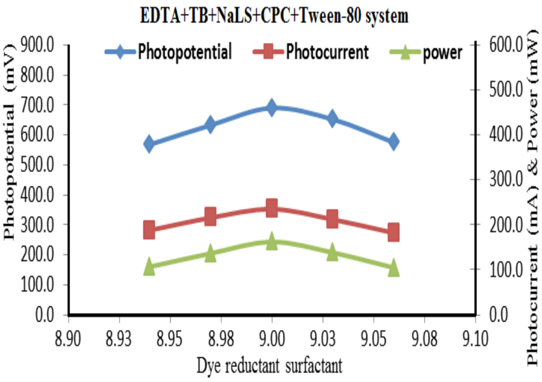

Fig. 2. Electrical output for three mixed surfactants

Variations in EDTA concentration and their effects

As the concentration of EDTA is increased, electrical values (potential and current) initially rise to their maximum levels (optimum values), after which the EDTA+TB+NaLS+CPC+Tween-80 photogalvanics experience reductions. Table 1 and Fig. 2, 3, and 4 show the fluctuation in EDTA concentration on the EDTA+TB+NaLS+CPC+Tween-80 photogalvanics.

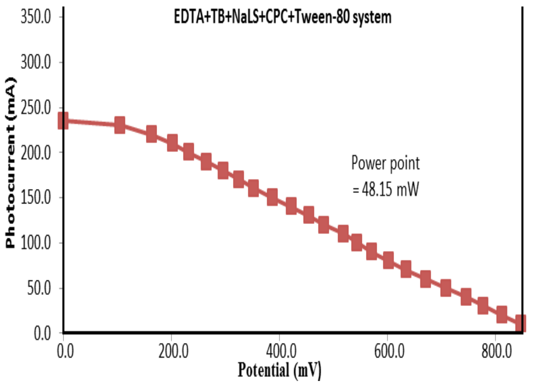

Fig. 3. Cell Performance (i-V) curve for three mixed surfactants

Table 2: Indicates that the diffusion lengths (DL)of the three substances vary

Light Intensity = 10.4 $mWcm^{-2}$, pt electrode=1cmx1cm, Temperature=303K			
DL(mm)	Maximum photocurrent i_{max} (μA)	Equilibrium photocurrent i_{eq} (μA)	Initial photocurrent generation rate (μA min^{-1})
45.0	265.0	234.0	7.4
50.0	274.0	229.0	7.5
55.0	279.0	223.0	7.4

Table 3: Empact of electrode area on the three surfactants

	Light Intensity = 10.4 $mWcm^{-2}$, pt electrode=1cm x1cm, Temperature=303K Electrode Area (cm^2)				
EDTA+TB+NaLS+CPC+Tween-80 photogalvanics	0.70	0.85	1.00	1.15	1.30
Maximum photocurrent i_{max} (μA)	261	261	274	276	281
Equilibrium photocurrent i_{eq} (μA)	242	234	234	232	226

Effect of variation of (NaLS+CPC+Tween-80) concentration

Electrical values (potential and current) increase initially in response to an increase in NaLS concentration (CPC+Tween-80 concentration will remain constant), then again in response to an increase in CPC concentration (NaLS+Tween-80 concentration remains constant), and so on. The electrical values in EDTA+TB+NaLS+CPC+Tween-80 photogalvanics drop after optimal values (maximum value) and on further concentration rise. Table 1 and Fig. 2, 3, and 4 show the fluctuation in EDTA concentration on the EDTA+TB+NaLS+CPC+Tween-80 photogalvanics.

Effects of pH changes

Electrical values (potential and current) initially grow with increasing alkaline nature to reach the maximum value, and then fall in EDTA+TB+NaLS+CPC+Tween-80 photogalvanics. Table 1 reports the PH Variation on the photogalvanics of EDTA+TB+NaLS+CPC+Tween-80.

Effect of variation of diffusion length

As the diffusion length is extended,

electrical values (potential and current) initially rise to their maximum levels and then fall in the EDTA+TB+NaLS+CPC+Tween-80 photogalvanics. Table 1 and Fig. 2 report the variation in diffusion length on the EDTA+TB+NaLS+CPC+Tween-80 photogalvanics.

Effects of Modifying the PG Cell's Electrode Area

The electrical values of the PG cell rise together with the electrode area, reaching their maximum value at an electrode area of 1 cm x1 cm. after which the EDTA+TB+NaLS+CPC+Tween-80 system declines. Table 1 and Fig. 2, 3, and 4 show the variation in electrode area of the cell on the EDTA+TB+NaLS+CPC+Tween-80 photogalvanics.

Current–voltage characteristics ((i-V)) of the PG cell

(Gangotri and Lal, 2013; Lal and Gangotri, 2022; Lal and Gangotri, 2013; Bhimwal *et al.,* 2013; Rathore J, *et al.,* 2022) used the formula to get the fill-factor.

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

power point (pp)= V_{pp} x i_{pp} (2)

Where

V_{pp} stands for cell potential

i_{pp} stands for "power point current of cell

V_{oc} stands for a cell's open circuit voltage

I_{sc} stands for short circuit current

Conversion efficiency and Cell performance

A formula was used to determine the conversion efficiency (CF) (Gangotri and Lal, 2013; Lal and Gangotri, 2022; Lal and Gangotri, 2013; Bhimwal *et al.,* 2013; Rathore J, *et al.,* 2022).

$$\text{Conversion efficiency} = \frac{V_{pp} \times i_{pp}}{A\ 10.4 mWcm^{-2}} \times 100\% \quad (3)$$

Where V_{pp}, is the cell's power point photopotential, i_{pp}, its power point photocurrent, and A, its electrode area.

In order to get better results, the PG cell's performance is reported (Fig. 3). In terms of $t_{1/2}$, its achieved value was 109.00 minutes in the absence of light (Fig. 4). For the EDTA+TB+NaLS+CPC+Tween-80 system, all electrical output findings were recorded (Table 4 and Figure 4).

Photochemical Reaction Mechanism

At illuminate Chamber-

$$TB \xrightarrow{hv} TB^* \quad \text{(excited form)} \quad (4)$$

$$TB^* + R \longrightarrow TB^- \text{(semi or leuco)} + T^+ \quad (5)$$

At platinum electrode:

$$TB^- \longrightarrow TB + e^- \quad (6)$$

At dark Chamber

$$TB^- + e^- \longrightarrow TB^- \text{ (semi form or leuco form)} \quad (7)$$

$$TB^- + R^+ \longrightarrow TB + R \quad (8)$$

TB stands for toluidine blue, TB* for its excited form, TB- for its semi- or leuco form, R for EDTA, and R+ for its oxidized form.

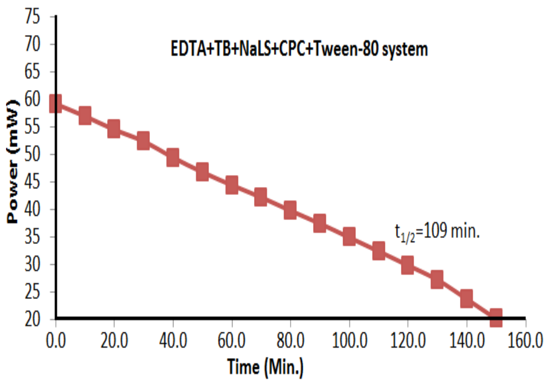

Fig. 4. Performance for three mixed surfactants

Table 4: Comparative study on three surfactants [NaLS+CPC+TWEEN-80] for solar cell

S. No	Objectional parameter	Single surfactant NaLS	Mixed surfactant NaLS+CPC+Tween-80
1	Photopotential (ΔV)	635.00 mV	689.00 mV
2	Maximum Photocurrent (i_{max})	175.00 µA	274.00 A
3	Short Circuit Current (i_{sc})	90.00 µA	234.00 A
4	Equilibrium Photocurrent (i_{eq})	90.00 µA	234.00 A
5	Current at Power Point (i_{pp})	55.00 µA	129.00 A
6	Power at Power Point (PP)	32.72 mW	54.13 mW
7	Fill factor(η)	0.3630	0.2811
8	ConversionEfficiency (%)	0.3100%	0.5477 %
9	$t_{1/2}$	55.0 min	109.0 min
10	Charging Time (min)	55.0 min	103.0 min
11	Open Circuit Voltage (V_{OC})	870.00 mV	897.00 mV
12	Potential at Power Point (V_{pp})	595.00 mV	453.00 mV

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Table 5: Materials used for Electrical Output by Mixed Surfactant for EDTA+ TB+ NaLS+CPC+ Tween-80 system

S. No	Chemical	Specification
1	EDTA	E Merk. Bombay, India
2	TB	Sigma Aldrich Chemicals Private Limited
3	Sodium Hydroxide (AR)	Sarabhai M. Chemicals, Baroda, India
4	NaLS	Loba Chemie Pvt. Ltd, Mumbai
5	CPC	E Merk. Bombay, India
6	Tween -80	Sigma Aldrich Chemicals Private Limited
7	Diamino benzoic Acid	S.D Fine chem. Pvt. Ltd. Boisar

Table 6: Comparation with previous literature and explanation

System Name	Results	References
NaLS+CTAB+MB+Xylose	PP 655.0 mV, PC 190.0 μA	Gangotri and Mohan, 2013
NaLS+Tween-80+MB+ Xylose	PP 645.0 mV, PC 210.0 μA	Lal and Gangotri, 2013
DSS+Tatrazine +EDTA	PP 493.0 mV, PC 130.0 μA	Rathore and Mohan, 2018
LG+Tartrazine+D-fructose	PP 1130.0 mV, PC 385.0 μA	Jayshree et al. 2022
Innovation for prospective energy source through solar cell	PP 684.0 mV, PC 230.0 μA	Mohan and Gangotri, 2022
D-Xylose+MB+Brij-35+NaLS	Cell performance 120.00 minutes and efficiency 0.2812%	Lal and Gangotri, 2022
Innovative study in renewable energy source through mixed surfactant system for eco-friendly environment	Photocurrent 243.0 uA and efficiency 0.6769% (Recent research work)	Lal, M.; Gangotri, KM., Environ Sci Pollut Res., 2023, 30(44),98805–98813. https://doi.org/10.1007/s11356-023-28246-w

CONCLUSION

The electrical characteristics of the PG cell as well as the performance of the PG cell system have been enhanced by the PG cells using the EDTA+TB+NaLS+CPC+Tween-80 system. Due to their low concentration, these PG cells were crucial in the development of the solar energy industry and the financial viability of non-polluting nature in a green environment. In terms of electrical outputs and potential electromagnetic radiation transformation, the PG cells may be a better fuel cell. The outcomes are wholly in favor of global sustainable development. The photopotential for EDTA+TB+NaLS+CPC+Tween-80 was measured at 689.00 mV. These results, which evaluate three surfactant systems, are far better than recently published data. The photocurrent in EDTA+TB+NaLS+CPC+Tween-80 was measured at 234.00 A. The performance of the EDTA+TB+NaLS+CPC+Tween-80 Cell was estimated to be 109.00 min in the dark. The results were included to the solar energy section of the scientific facts.

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Conflicts of interest

There are no conflicts of interest for authors.

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