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Innovative Study of Photogalvanics in Solar Energy Transformation and Performance Analysis: Alizarin Cyanine Green, EDTA and Sodium Stearate System

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ABSTRACT

A systematic analysis of experimentally, solar parameters of photogalvanics has been studied for performance analysis using the D-R-S (Dye-Reductant–Surfactant) system as alizarin cyanine green–EDTA- sodium stearate system. A H shaped photogalvanic system was used under investigation for innovative results. Different scientific instruments were used in methodology set up i.e., microammeter, digital pH meter, and light source (200 W Philips bulb), multi-meter, calomel electrode (saturated), Pt electrode, and circuit key. The photogalvanic parameters were studied using H cell glass tubes as PP (Photo-Potential), PC (Photo-Current), CF (Conversion Efficiency), FF (Fill-Factor) & PA (Performance Analysis). The experimental results are as follows: 733.0 mV, 477.0 mA, 1.7984%, 0.2640 and 180.0 minutes. The observed electrical outputs are better than previously published electrical outputs with respect to alizarin cyanine green, EDTA, and sodium stearate system.

Keywords: Solar energy, Alizarin cyanine green Photogalvanic cell, Photocurrent, Photopotential, Fill factor,

INTRODUCTION

The global scientific community continually works on energy for scientific development. Solar energy is a unique key in the field of energy and plays an important role as an alternative energy source. Depletion of fossil fuels are responsible for next searching way of alternative energy. Solar energy is based on photogalvanic and photovoltaic cells for energy transformation and storage with respect to electrical outputs. The dye-based storage capacity of photogalvanic are good over photovoltaic cells and due to this reason, D-R-S (Dye-Reductant–Surfactant) system is comparatively good in field of photogalvanics.

In 1925, Eric Keightley and Edward Gardner were studied light action[1]. In 1940, Rabinovitch was studied on light iron based system[2]. In 1977, Iron-thazina photogalvanics[3], In 1978, Hall *et al.,* were observed the electronic

phenomena[4], In 1989, Ameta *et al.,*[5], In 1999, miscelles[6], In 2010, Safranine[7], In 2011, performance of photogalvanics[8] studied. In 2013, Mohan Lal and Gangotri KM[9], In 2013, Gangotri KM and Lal Mohan[10], mixed surfactant[11,12], In 2017, Saini Shiv and Meena Shankar & Meena Ramesh[13], In 2018, single surfactant[14], In 2021, sudan-I dye[15], In 2021, Perovskite Solar Cells[16], In 2021, Zhao, *et al.,*[17] also studied. In 2021, Chen, *et al.,*[18], In 2021, Koli et al.,[19] reported outstanding work. Later on, Optimum results[24], improved efficiency[25] and very similar work reported on TB (Toluidine Blue)[26]. Genwa and Shraddha[27] and in order to performance[28-30], and A numerous Photochemists[31-34] worked and also symmetrical results on photogalvanic[35-36] solar cells. The different group of researchers worked on photogalvanic cells but on one worked on Alizarin cyanine green, EDTA, and sodium stearate system for better electrical output and due to this reason, the present research work was undertaken for scientific investigation.

MATERIAL AND METHODS

Solutions used for photogalvanics

Dye-Alizarin cyanine green, reductant-EDTA, Surfactant- sodium stearate, NaOH (1N), Oxalic acid, and double distilled water.

Scientific instruments used for photogalvanics

A specially designed glass tubes, calomel electrode (saturated), Carbon pot, Multi-meter, 250 k Roistered, Digital pH meter, Platinum electrode, Microammeter, Resistance key, and 200 W tungsten bulb.

Experiment Method

A Speciallydesigned photogalvanics cell was used for solar transformation of photochemical conversion and storage (Fig. 1). The photogalvanic cell has two lobes named as dark chamber and illumination chamber. Saturated calomel electrode connected with dark chamber and platinum electrode connected with illumination chamber. The photochemical electrical circuit was completed by using of required scientific instrumentations i.e., specially designed glass tubes, calomel electrode (saturated), carbon pot, Multi-meter, 250 k Roistered, Digital pH meter, Platinum electrode, Microammeter, Resistance key, and 200 W light sources. We have kept the volume of solution up to 30 mL during the electrochemical and photochemical process of the photogalvanic cell. Water filter was used for ultra-filtration of radiations.

Nature of the solution was alkaline for pH measurement during the experiment. The electrolytical configuration was as fellow: Dye- Alizarin cyanine green, reductant-EDTA, Surfactant- sodium stearate, NaOH (1N), Oxalic acid, doubly distilled water. The strength of electrolytic solution were as follows: dye M/5000, Reductant M/2000, Surfactant M/200 and 1N NaOH. The Fig. 1 is given for the photochemical set up for performance analysis.

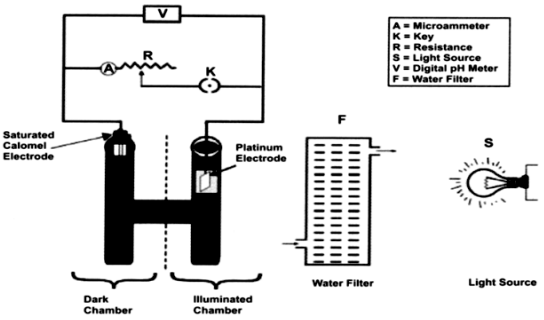

Fig. 1. Experimental set up of photogalvanics

RESULT AND DISCUSSION

Variation effect of surfactant strength (sodium stearate concentration) on the photogalvanics

In the initial stage of the photogalvanic experiment, electrical outcomes were increased on increasing the strength of surfactant and after a particular range of strength (ongoing experiment) it reached an optimum position. After optimum position of electrical outcomes, it decreased continually. The variation was obtained due to the electron transfer process in hydrophilic hydrophobic interaction of a large number of surfactant molecules in electrochemical processes. At optimum position, three will be required: a number of surfactants molecules are responsible for results. The photochemical outcomes of energy conversion and storage are given in Table 1 to 5.

Table 1: Effects of variation of Alizarin cyanine green concentration on electrical output of photogalvanics

S. No	Concentration of dye taken for experiment: Alizarin cyanine green$X10^{-4}$ M)	Observed results of photopotential (mV)	Observed results of photocurrent (μA)
1	1.20	837	377
2	1.40	883	407
3	1.60	935	442
4	1.80	888	410
5	2.00	833	380

Table 2: Effects of variation of EDTA concentration on electrical output of photogalvanics

S. No	(EDTA×10^{-4})	Observed results of photopotential (mV)	Observed results of photocurrent (μA)
1	2.15	816	381
2	2.20	886	410
3	2.25	934	439
4	2.30	889	406
5	2.35	819	379

Table 3: Effects of variation of sodium stearate concentration on electrical output of photogalvanics

S. No	(Sodium stearate X 10^{-4})	Photopotential (mV)	Photopotential (mV)
1	1.72	817	382
2	1.77	882	413
3	1.98	935	440
4	1.76	873	410
5	1.68	821	379

Table 4: Electrical output of photogalvanics for performance analysis

S. No	Time (Minute)	Power (W)
1	35.0	137.76
2	40.0	133.11
3	45.0	129.33
4	50.0	124.47
5	55.0	119.98

Table 5: Comparison of present study with Previous reports

S. No.	Parameters	Alizarin cyanine green, EDTA, sodium stearate system Present Study	Methylene blue, Xylose NaLS, Tween-80 system	Methylene blue, Xylose NaLS, CTAB system Previous works	DSS, Tartrazine EDTA system
1	Conversion efficiency	1.7984%	0.5313%	0.4326%	0.6163%
2	Storage capacity	180.0 minutes	100.0 minutes	90.0 minutes	100.0 minutes
3	Fill factor	0.2640	0.3024	0.2770	0.2800
4	Photopotential	733.0 mV	645.0 mV	655.0 mV	493.0 mV
5	Photocurrent	477.0 A	210.0 A	190.0 A	130.0 A

Variation effect of photosensitizer strength (alizarin cyanine green concentration) on the photogalvanics

On initial stage of photogalvanic experiment, electrical outcomes were increased on increasing of strength of photosensitizer and after particular range of strength (ongoing experiment) it reached at optimum position. After optimum position of electrical outcomes its decreased continuously. above variation was obtained due to electron transfer process in hydrophilic hydrophobic interaction of large number of photosensitizer molecule (dye molecule) in electrochemical process. At optimum position, three will be required number of photosensitizer molecule (dye molecule) molecules are responsible for results. The photochemical outcomes of energy conversion and storage are given in Table 1 to 5.

Variation effect of reductant strength (EDTA concentration) on the photogalvanics

In the initial stage of the photogalvanic experiment, electrical outcomes were increased on increasing the strength of the reductant and after a particular range of strength (ongoing experiment) it

reached an optimum position. After optimum position of electrical outcomes, it decreased continuously. The above variation was obtained due to the electron transfer process in hydrophilic hydrophobic interaction of large numbers of reductant molecules (EDTA molecule) in electrochemical processes. At optimum position, three will be required: a number of reductant molecule (EDTA molecule) molecules are responsible for results. The photochemical outcomes of energy transformation and performance analysis are given in Table 1 to 5.

Current–voltage (i-V) characteristics of the photogalvanics

The fill factor of photogalvanics was calculated by using photochemical values i.e., Potential at power point (V_{pp})=462 mV, Current at power point (i_{pp})=200 µA, Potential at open circuit (V_{oc})=1033 mV, Current at short circuit (i_{sc})=477µA, and obtained value of fill factor (η)=0.2640, The power point of cell (pp)=164.1mv, (see the Figure 2).

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

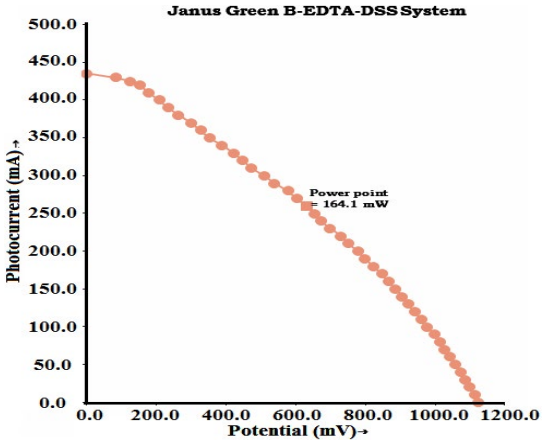

Fig. 2. Current-voltage (i-V) curve of the photogalvanics

Photogalvanic performance analysis and conversion efficiency

The conversion efficiency of photogalvanic was calculated by using photochemical values i.e., Photopotential at power point (V_{pp},)=462 mV, Photocurrent at power point (i_{pp})=200 µA, Electrode area for photogalvanics (A) and obtained values was1.7984% (See the Figure 3).

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

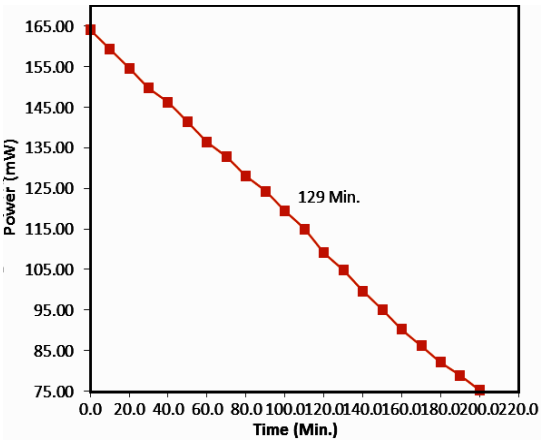

Fig. 3. Photogalvanics performance analysis

Photochemical reaction Mechanism of current generation in the photogalvanics

Illuminated chamber (at platinum electrode)

Photochemical reaction at illuminate chamber and photochemical reaction at platinum electrode as below:

$$ACG \longrightarrow ACG^* \quad (3)$$

$$ACG^* + EDTA \longrightarrow ACG^- + EDTA^+ \quad (4)$$

$$ACG^- \longrightarrow ACG + e^- \quad (5)$$

Dark Chamber: At counter electrode

Proposed reaction mechanism is given for alizarin cyanine green, EDTA, and sodium stearate system.

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

$$ACG^- + EDTA^+ \longrightarrow ACG + EDTA \quad (7)$$

Where: ACG=Alizarin cyanin green dye molecule, ACG*=Excited alizarin cyanin green molecule, ACG^-=Semi form of alizarin cyanin green molecule, EDTA=reductant molecule, $EDTA^+$= Oxidized form of the reductant,

Scientific comparison with past studies in photogalvanics for conversion and storage

All observed results are good in comparison to previous photogalvanics i.e., conversion efficiency and storage capacity, 1.7984% and 180.0 min respectively. These results are relatively good in comparison to previously reported cells containing

as DSS, Tartrazine and EDTA as given (0.6163% and 100.0 min), NaLS+CTAB, Methylene blue and Xylose (0.4326% and 90.0 min), NaLS+Tween-80), Methylene blue and Reductant (0.5313% and 100.0 min), Micellar Effect on Photogalvanics: Solar Energy Conversion and Storage–EDTA-Safranine O-TWEEN-80 System(0.1469% and 20.0 min) developed by Rathore Jayshree and Lal Mohan (2018), Gangotri KM and Mohan lal (2013), Lal Mohan and Gangotri KM (2012) and Gangotri and Gangotri (2010), respectively.

The observed electrical values are (1.7984% and 180.0 min) relatively lower in conversion efficiency but higher in storage capacity in comparison to recently reported photogalvanic cells with Indigo Carmine dye (27.79% and 115.0 min), bromo cresol green (9.02% and 70.0 min), developed recent. Therefore, the photogalvanic cell containing Alizarin cyanine green, EDTA, and sodium stearate system is better than existing cells.

CONCLUSION

Case study in photogalvanics and Limitation and Future scope

A huge proportion of world electricity generation is based on coal industries. The theoretical conversion efficiency of PG cells is about 24-35%, but observed conversion efficiency is quite low (0.7995%) due to dye based photochemical environment. This limitation encountered in the area of development of photogalvanic cells is discussed from time to time. However, over the next few decades, the world will have to significantly reduce its coal and oil use to accelerate climate action. Currently, about more than half of the world energy requirement is fulfilled by hydrocarbon materials.

Novelty of Alizarin cyanine green, EDTA, and sodium stearate system

The Alizarin cyanine green, EDTA, and sodium stearate system is more efficient than mixed surfactants with methylene blue. The sodium stearate has not only enhanced the conversion efficiency but storage capacity of photo galvanic cells in a catalytic way. Alizarin cyanine green, EDTA, and sodium stearate systems have conversion efficiency, $t_{1/2}$ and fill factor are recorded as 1.7984%, 129 min and 0.2640 respectively. Alizarin cyanine green, EDTA, and sodium stearate system have potential at power point, Potential at open circuit, power point of cell (pp) and current at short circuit were also studied and obtained values are as follows: 164.1 mV, 1033 mV, 200 and 477μA.

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Conflicts of interest

Authors have no conflict of interest.

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