



Sunlight Induced Photogalvanics for Conversion and Storage of Solar Energy: Coomassie Brilliant Blue-Isopropyl Alcohol-Sodium Lauryl Sulphate System

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ABSTRACT

Research plan was proposed for systematic observation with scientific way in the solar cell field of photogalvanics. It was analysis of experimental work under the solar energy output. The study of photogalvanic was done for solar energy conversion and storage by using of dye as Coomassie Brilliant Blue (CBB), reductant as Isopropyl alcohol (IA), and surfactant as Sodium Lauryl Sulphate (SLS). For this purpose, a specially designed H shaped photogalvanic system was used under investigation for innovative results. Different scientific instruments were used for methodology set up i.e., pH meter (digital), microammeter, and 200 Wt. W bulb (As light source), multi-meter, two electrodes (one was calomel and another was Pt), carbon pot 450 k, resistance key. Findings: The photogalvanic cells were studied using different parameters via photo potential, photocurrent, conversion efficiency, fill factor and cell performance. The above values are as follows: 533.0 mV, 201.0 μ A, 0.8796%, 0.3066 and 114.0 minutes. These cells were studied for the good results in solar energy field. Novelty: The observed results are very good over previously obtained results with respect to Coomassie brilliant blue, reductant as Isopropyl alcohol, and surfactant as sodium lauryl sulphate system.

Keywords: Coomassie Brilliant Blue, Solar energy, Photosensitiser, Sunlight, Photocurrent, Photopotential, Fill factor.

INTRODUCTION

Energy is unique key for scientific development of biosphere. Renewable and non-renewable sources of energy are under limitations. Depletion factor for wood, coal, kerosene, etc are responsible for next searching way for energy demand. The scientific groups are on way to search out the alternative source of energy

to fulfil the whole world with eco-friendly nature and commercially viability. Thus, the solar energy is the best option to fulfil the energy demand. Solar energy is based on photogalvanic cell and photovoltaic cells for energy transformation. With respect to storage capacity photogalvanic cells are best over photovoltaic cells and due to this scenario, research work has been taken under investigation. First of all, Rideal and Williams¹



were studied on FeI and Rabinowitch² was studied on the photogalvanic effect about photochemical reactions. Peter³, Hall⁴, Ameta⁵, Bhimwal and Gangotri⁶, Mohan Lal and Gangotri⁷, Gangotri KM and Lal Mohan⁸, Lal Mohan and Gangotri⁹, mixed surfactant¹⁰, Saini *et al.*,¹¹, Tartrazine¹², Sudan-I dye¹³, Main Progress¹⁴, transition¹⁵ has been studied. Later on, silver nanoparticles¹⁶, Indigo carmine¹⁷, cell dimensions¹⁸, Xylose+MB+Brij-35+NaLS¹⁹, fructose²⁰, and single surfactant²¹ for solar energy conversion and storage. The observed result are good over previous published results in solar conversion and storage, Gangotri and Lal, 2013; Lal and Gangotri, 2013). It is very cleared from above literature survey that different group of researchers worked on photogalvanic cells but on one worked on Coomassie Brilliant Blue, Isopropyl alcohol, and sodium lauryl sulphate system for better electrical output and due to reason, the present research work was undertaken for scientific investigation.

MATERIALS AND METHODS

Material required

Solutions used

Dye-Coomassie Brilliant Blue, reductant-Isopropyl alcohol, Surfactant-sodium stearate, NaOH (1N), Oxalic acid, doubly distilled water.

Scientific instruments

Especially designed H glass tubes, Saturated calomel electrode (SCE), Pot for Carbon function, Multi-meter, 250k Rheostat, Digital pH meter, Platinum electrode, Microammeter, Resistance key, and 200 W tungsten bulb.

EXPERIMENT

First of all, we have designed the specific photogalvanic cell for solar transformation of photochemical conversion and storage (kindly see Fig. 1). Specially designed photogalvanic cell having 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., Especially designed H glass tubes, SC electrode, Pot for carbon, Multi-meter, 450 k carbon pot, Digital pH meter,

Platinum electrode, Microammeter, Resistance key, and 200 W tungsten bulb. We have kept volume of solution up to 30 mL during electrochemical and photochemical process of photogalvanic cell. Water filter was used for ultra-filtration of radiations. Nature of solution was alkaline for pH measurement during experiment. The electrolytical configuration was as follow: Dye-Coomassie Brilliant Blue, reductant-Isopropyl alcohol, Surfactant-sodium lauryl sulphate, NaOH (1N), Oxalic acid, doubly distilled water. The strength of electrolytical solution were as follow: dye M/5000, Reductant M/2000, Surfactant M/200 and 1N NaOH. Fig. 1 represented the photochemical set up for energy conversion in Coomassie Brilliant Blue-Isopropyl Alcohol-Sodium Lauryl Sulphate System.

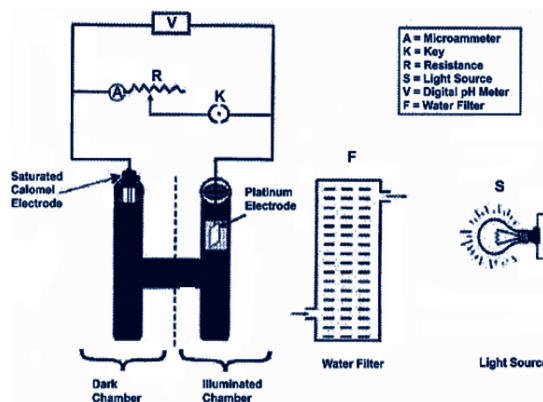


Fig. 1. Photogalvanic cell: Experimental set up

RESULT AND DISCUSSION

Variation of surfactant strength (sodium lauryl sulphate concentration) on the photogalvanics

On initial stage of photogalvanic experiment, electrical outcomes were increased on increasing of strength of surfactant and after particular range of strength (ongoing experiment) it reached at optimum position. After optimum position of electrical outcomes its decreased continually. above variation was obtained due to electron transfer process in hydrophilic hydrophobic interaction of large number of surfactant molecule in electrochemical process. At optimum position, three will be required number of surfactants molecules are responsible for results. The observed result are good over previous published results in solar conversion and storage, Gangotri and Lal, 2013; Lal and Gangotri, 2013). The photochemical outcomes of energy conversion and storage are given in Table 1 to 5.

Table 1: Effects of CBB on electrical output of photogalvanic

CBBX10 ⁻⁵ M)	Photo potential(mV)	Photocurrent(μA)
1.20	834	372
1.21	883	401
1.22	931	443
1.23	889	414
1.24	832	381

Table 2: Effects of isopropyl alcohol on electrical output of photogalvanics

(IA×10 ⁻⁴)	Photopotential(mV)	Photocurrent(μA)
2.10	819	380
2.11	887	411
2.12	933	432
2.13	885	404
2.14	813	376

Table 3: Effects of NaLS on electrical output of photogalvanics

(NaLSX10 ⁻⁴)	Photopotential(mV)	Photopotential(mV)
1.79	812	381
1.77	883	414
1.93	931	447
1.72	875	417
1.61	827	373

Table 4: Photogalvanic cell electrical output

S. No	Time (Minute)	Power (μW)
1	34.0	127.72
2	36.0	123.11
3	38.0	139.36
4	40.0	134.49
5	42.0	129.97

Table 5: Comparison of present study with Previous reports

S. No	Parameters	Coomassie Brilliant Blue, Isopropyl alcohol, sodium lauryl sulphate system Present Study	NaLS, Tween-80, Methylene blue, Xylose system	NaLS, CTAB, Methylene blue, Xylose system Past studies	DSS, Tartrazine, ISOPROPYL ALCOHOL system
1	Conversion efficiency	0.8796%	0.5313%	0.4326%	0.6163%
2	Storage capacity	114.0 minutes	100.0 minutes	90.0 minutes	100.0 minutes
3	Fill factor	0.3066	0.3024	0.2770	0.2800
4	Photopotential	533.0 mV	645.00 mV	655.00 mV	493.00 mV
5	Photocurrent	201.0 μA	210.0 μA	190.0 μA	130.0 μA

Variation effect of photosensitizer strength (Coomassie Brilliant Blue 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 shown in Table 1 to 5.

Variation of reductant strength (Isopropyl alcohol concentration) on the photogalvanics

On initial stage of photogalvanic experiment, electrical outcomes were increased on increasing of strength of reductant 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 reductant molecule (Isopropyl alcohol molecule) in electrochemical process. At optimum position, three will be required number of reductant molecule (Isopropyl alcohol molecule) molecules are responsible for results. The observed result are good over previous published results in solar conversion and storage, Gangotri and Lal, 2013; Lal and Gangotri, 2013). The photochemical outcomes of solar energy conversion and storage are reported in Table 1 to 5.

(i-V) Current and voltage characteristics of photogalvanics

The observed fill factor of photogalvanic was calculated by using photochemical values i.e., Photopotential =533 mV, power point current (i_{pp})=201 μA, open circuit Potential (V_{oc})=734 mV,

Current at short circuit (i_{sc})=140 μ A, and fill factor value=0.3066, The power point of photogalvanics (pp)=118, (see the Figure 2).

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

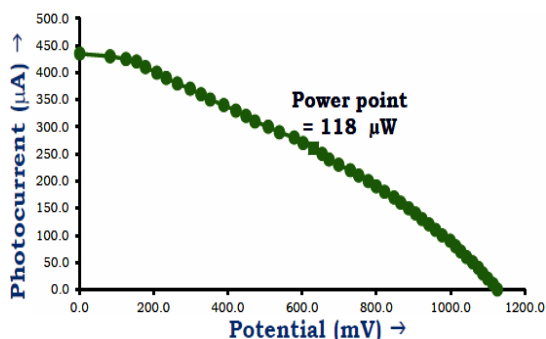


Fig. 2. Current and voltage curve of the cell

Cell Photogalvanic performance and efficiency of conversion

Efficiency of conversion in photogalvanics has calculated by using photochemical values i.e., Power point Photopotential (V_{pp})=323 mV, Photocurrent at power point (i_{pp})=201 μ A, Electrode area for photogalvanics (A) and obtained values was 0.8796% (See the Figure 3).

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

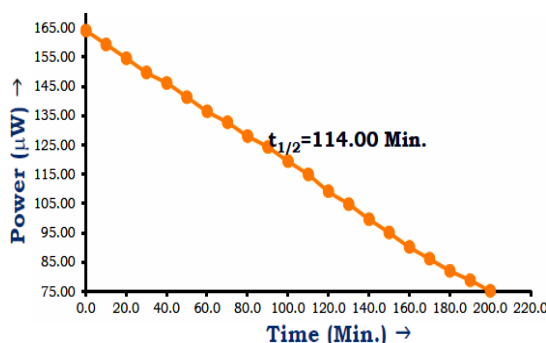
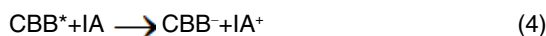


Fig. 3. Photogalvanic cell Performance

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:



Dark Chamber: At counter electrode

During the photochemical process, CBB molecule gain an es from electrode and converted into CBB^- and at ending stage, CBB^- converted into CBB molecule and oxidized form of Isopropyl alcohol combine with CBB molecule to give original dye and reductant molecule and the cycle will continue.



Where: CBB=Coomassie Brilliant Blue dye molecule, CBB^* =Excited Coomassie Brilliant Blue molecule, CBB^- =Semi form of Coomassie Brilliant Blue molecule, IA= reductant molecule, IA^+ =Oxidized form of the reductant.

CONCLUSION

On basis of observed electrical output, we are scientifically concluded that the Coomassie brilliant blue dye molecules are affected the photogalvanic cell more than existing dyes. The surfactant has also enhanced the efficiency of conversion and storage capacity of photo galvanic cells. Our recent reported results on photogalvanic cell about conversion efficiency and storage capacity, 0.8796% and 114.0 min respectively. These values are relatively higher in comparison to previously reported i.e. (0.6163% and 100.0 min), (0.4326% and 90.0 min), (0.5313% and 100.0 min), (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. These observed outcomes (0.8796% and 114.0 min) are relatively lower in conversion efficiency but higher in storage capacity in comparison to recently reported photogalvanic cells i.e. (27.79% and 115.0 min), (9.02% and 70.0 min), developed by Koli *et al.*, (2021), and Koli *et al.*, (2022), respectively. The conversion efficiency, $t_{1/2}$ and fill factor are recorded as 0.8796%, 114.0 min and 0.3066 respectively in PG system. Potential at power point, Potential at open circuit, power point of cell (pp) and current at short circuit were also studied. The obtained values are as follows: 734 mV, 533 mV, 201 and 140 μ A. Therefore, the photogalvanic cell containing Coomassie brilliant blue, sodium lauryl sulphate Isopropyl alcohol

system is more efficient than existing cells selecting suitable substances. Present study in photogalvanic as limitation and future scopes as becoming cost competitive with solar power.

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Conflicts of interest

Authors have no any conflict of interest.

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