Study of Photogalvanic cell for electrical output in solar energy conversion and storage: single surfactant as lauryl glucoside, Tartrazine as a photosensitizer and D-fructose as reductant

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Abstract
Actual plan of research work was proposed for systematic investigating in the field of photogalvanic cells for solar energy transformation. It was proposed to carry out experimental work under the solar parameters. The photogalvanic cells (photogalvanics or PG cells) were studied using different electrical outputs via photocurrent, photopotential, conversion efficiency, fill factor and cell performance. The above values are as follows: 385.0 μA, 1130.0 mV, 0.7965%, 0.5357 and 120.0 minutes.

PG cell containing lauryl glucoside, tartrazine and D-fructose were studied for the solar energy conversion and storage of electrical output. A detailed reaction mechanism for the proposed solar cell for generating photocurrent and photocurrent has been studied.

Keywords: Renewable energy, Photocurrent, Photopotential, Fill factor, Conversion Efficiency.

Introduction

The consumption of fossil fuels like wood, coal, kerosene etc. is so rapid that they are reaching towards their complete depletion. The non – renewable sources of energy have their own limitations along with hazardous processes involved and pollution. The scientific community is compelled to search out the renewable source of energy to feed the whole world with non- polluting nature and commercially viability. Thus, solar energy is the best option to fulfill the energy demand. At an earlier stage, Rideal and Williams [25] studied about iron iodide prose about action sunlight. The PG Cells are used for energy exchange i.e. chemical energy into light energy. Rabinowitch[26] studied on the photogalvanic properties of the thionine-iron system. Potter and Thaller[23] studied on efficiency of some iron thionine photogalvanic cells.

Peter et al[24] studied on sensitization of an iron-thazin photogalvanic cell to the blue. Shigehara et al[31] studied photogalvanic effect of thin layer photo cell composed of thionine/Fe (II) systems. Hall et al[16] studied electrodic phenomena at the anode of the totally illuminated, thin layer iron–thionine photogalvanic cell. Nasielski et al[21] observed the photoelectrochemistry of the Rhodamine hydroquinone system at optically transparent bubbling gas electrodes. Ameta et al[2] studied on use of sodium lauryl sulphate in a photogalvanic cell for solar energy conversion and storage: methylene blue –EDTA system. Ameta et al[1] studied on use of thionine- EDTA system in photogalvanic cells for solar energy conversion. Dube et al[6] studied on use of an Azur-A-NTA system in a photogalvanic cell for solar energy conversion. Gangotri et al[9] studied on use of micelles in photogalvanic cells for solar energy conversion and storage: cetyl trimethyl ammonium bromide-glucose-toluidine blue system. Gangotri and Meena[7] studied on use of reductant and photosensitizer in photogalvanic cells for solar energy conversion and storage: oxalic acid – methylene blue system.

Material and Methods

Dye-tartrazine, Reductant - D-fructose, Surfactant-lauryl glucoside, NaOH(1N), Double distilled water (DDW), Multi-meter, Calomel electrode, 250 k Roistered, H shaped glass tube, Saturated calomel electrode, Platinum electrode, Carbon pot, Resistance key, Digital pH meter, Microammeter and 200 W tungsten bulb were used. The present research project of PG Cell is studied by an H shaped glass tube which was fabricated. The total volume of the experimental set was 25 ml including solution dye surfactant and reductant. The electrical circuit was completed by using a calomel electrode, 250 k roistered, H shaped glass tube, A saturated calomel electrode platinum electrode carbon pot, (resistance) key, digital pH meter and micro ammeter and 200 W tungsten bulb were used. During experiments, a water filter was used for IR light. One limb of an H shaped glass tube was connected with a calomel electrode and another limb was connected with a platinum foil electrode. pH of the solution was adjusted and measured by a pH meter. H – type photogalvanic cells were fabricated with different surfactants; dye and reductant solutions were used for investigation.

Results and Discussion

Effect of variation of lauryl glucoside concentration on the PG-CELL*:* During experiment stage solar, electric output was increased on increasing the concentration of lauryl glucoside and reached to optimum position (at pH 12.18) and then subsequent decrease on increasing of lauryl glucoside concentration. The observed results are shown in tables 1, 2, 3 and 4.

Effect of variation of tartrazine (dye) concentration on the system: During experiment stage, solar electric output

was increased on increasing the concentration of tartrazine and reached to optimum position and on subsequent decrease on increasing of tartrazine concentration. The observed results are shown in table 1, 2, 3 and 4.

Table 1
Effect of variation of tartrazine concentration on electrical output of photogalvanic cell

S.N.	(Tartrazine X 10^{-5} M)	Photopotential (mV)	Photocurrent (µA)
1	1.10	950.00	204.00
2	1.50	1096.00	314.00
3	1.70	1130.00	385.00
4	1.90	1050.00	305.00
5	2.10	946.00	285.00

Table 2
Effect of variation of fructose concentration on electrical output of photogalvanic cell

S.N.	(D-fructose×10^{-3})	Photopotential (mV)	Photocurrent (µA)
1	2.16	985.00	281.00
2	2.20	1050.00	346.00
3	2.24	1130.00	385.00
4	2.28	1096.00	356.00
5	2.32	918.00	280.00

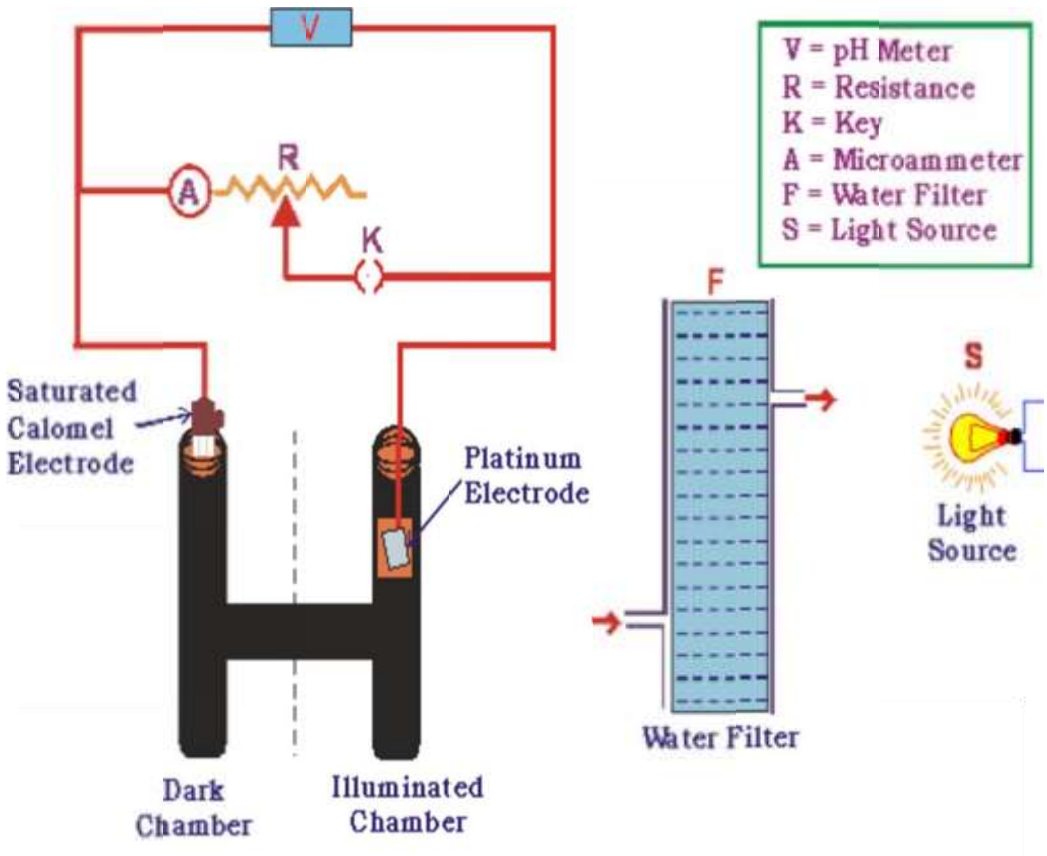

Figure 1: Methodology set up of photogalvanic cell for solar energy conversion and storage

Table 3
Effect of variation of lauryl glycoside concentration on electrical output of photogalvanic cell

S.N.	(Lauryl glucoside x 10^{-3})	Photopotential (mV)	Photopotential (mV)
1	1.70	930.00	296.00
2	1.84	1005.00	318.00
3	1.98	1130.00	385.00
4	1.72	1008.00	304.00
5	1.70	930.00	290.00

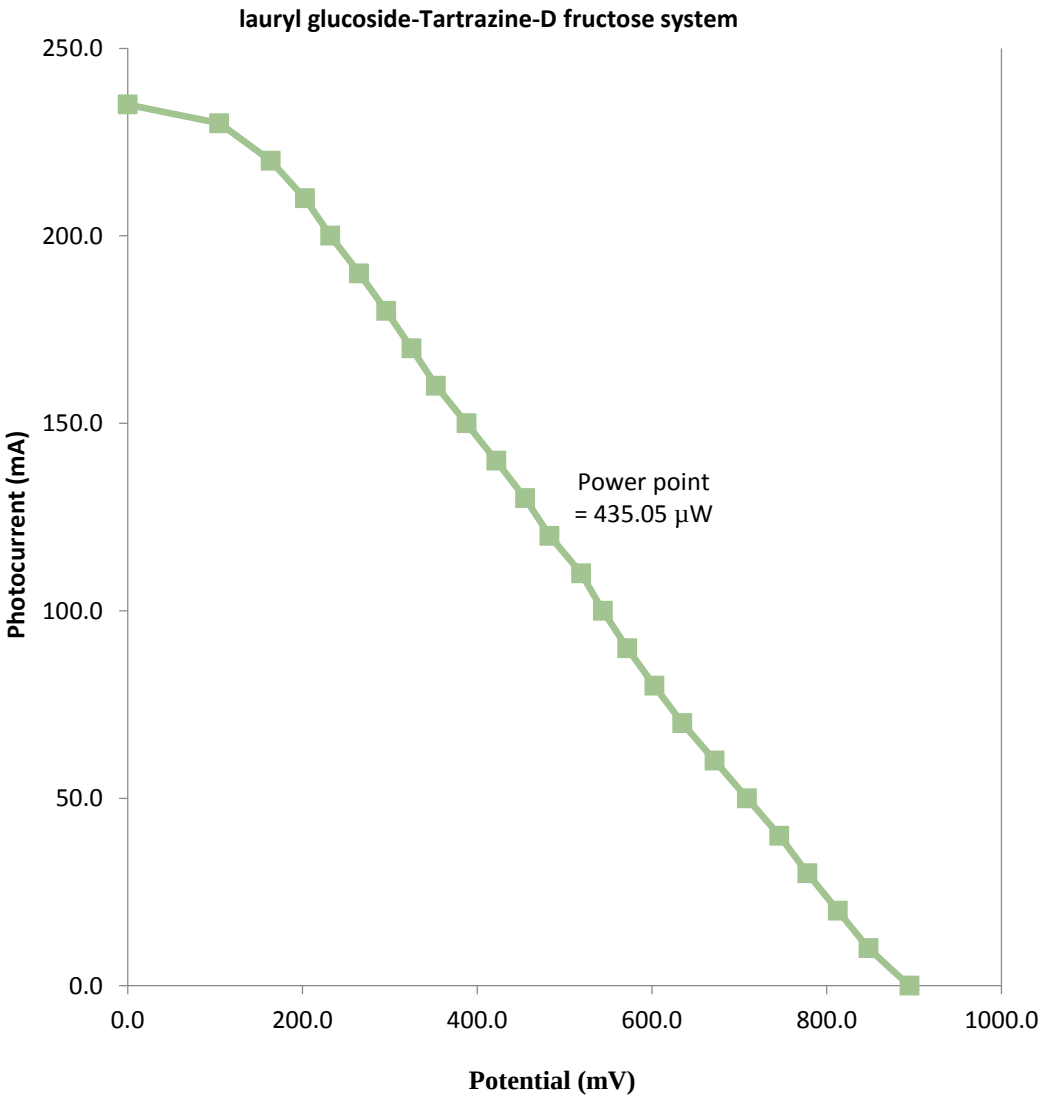

Figure 2: Cell Performance (i-V) curve of the Cell

Effect of variation of D-fructose (reductant) concentration on the system: During experiment stage, solar electric output was increased on increasing the concentration of D-fructose and reached to optimum position and then subsequent decrease on increasing of tartrazine concentration. The observed results are shown in tables 1, 2, 3 and 4.

Current–voltage (i-V) characteristics of the photogalvanic cell: By using following formula, fill factor of PG-cell was calculated.

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

where v_{pp} = Potential at power point=*1130 mV*, i_{pp} = Current at power point=*385 µA*, V_{oc} = Potential at open circuit =*1515 mV*, i_{sc} = Current at short circuit=*536 µA*, (□) = Value of fill factor= *0.5357* and *pp* = The powerpoint of cell (pp) = *435.050*.

Cell performance and conversion efficiency: By using, following formula fill factor of PG-cell was calculated:

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

where V_{pp} = Photo Potential at power point, i_{pp} = Photocurrent at power point and A= Electrode area for pg cell.

Mechanism of photovoltage and photocurrent generation in a cell

Illuminated chamber (at platinum electrode): During experiment, dye molecules get excited by absorption of sunlight and converted into semi or leuco form. Reductant molecule gets in its oxidized form and subsequently the semi form of the dye molecule loses the electron and returns into its original state.

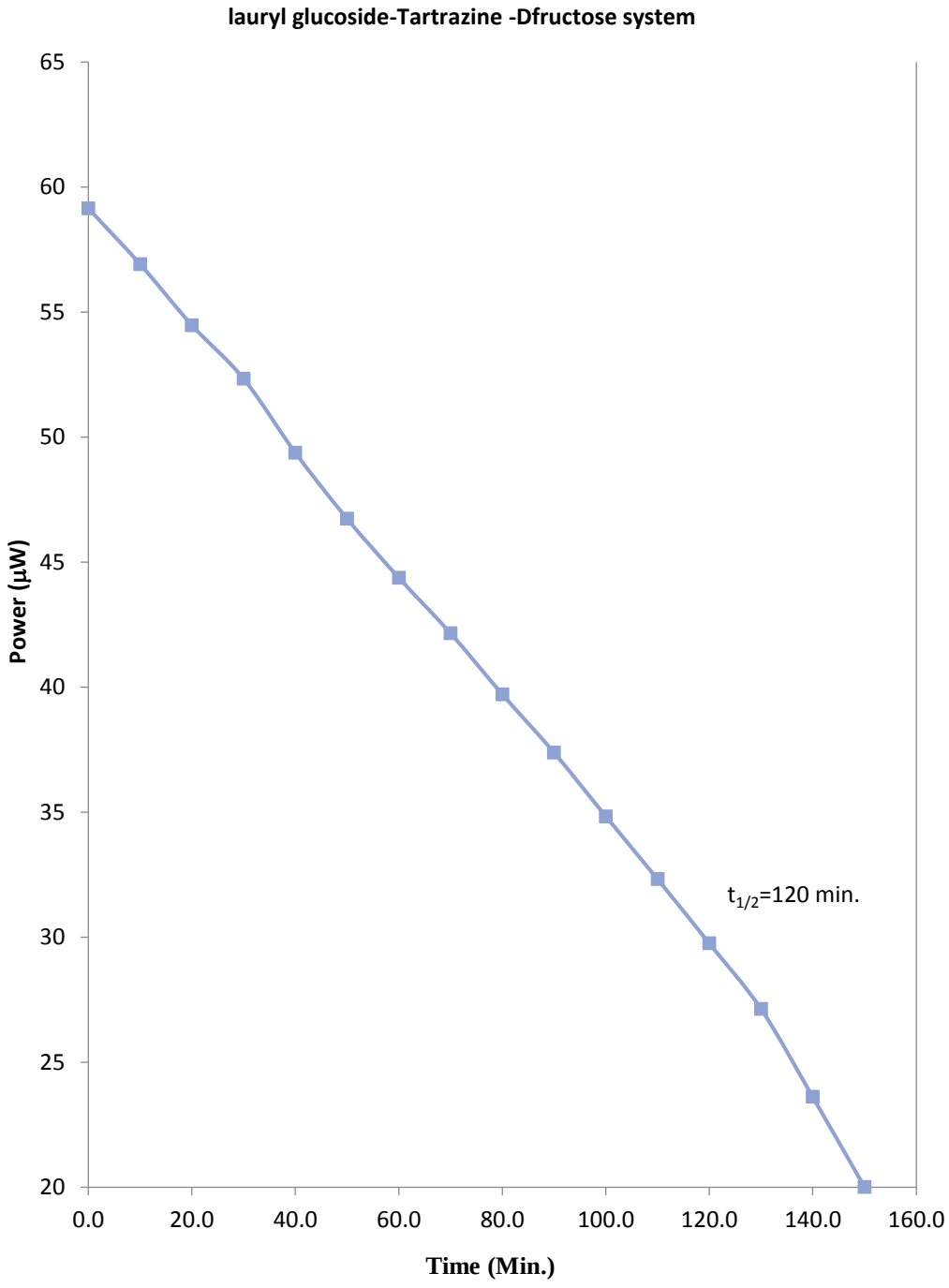

Figure 3: Performance of the Cell

Chemical Reaction at Illuminate Chamber:

$$TZ \longrightarrow TZ^* \quad \text{(i)}$$

$$TZ^* + F \longrightarrow TZ^- + R^+ \quad \text{(ii)}$$

Chemical reaction at platinum electrode:

$$TZ^- \longrightarrow TZ + e^- \quad \text{(iii)}$$

Table 4
Showing electrical output of photogalvanic cell

S.N.	Time (Min.)	Power (μW)
1	0.0	435.05
2	0.5	414.42
3	10.0	400.89
4	20.0	398.11
5	30.0	385.72
6	40.0	376.26
7	50.0	364.41
8	60.0	351.54
9	70.0	341.93
10	80.0	30.187
11	90.0	281.13
12	100.0	273.29
16	110.0	257.63
18	120.0	217.52
19	130.0	190.53
20	140.0	188.17

Dark Chamber: TZ molecule accept an electron from electrode and get converted into TZ^- and at termination stage, TZ^- converted into TZ molecule and oxidized form of F combined with TZ molecule to give original dye and reductant molecule and the cycle will go on

$$TZ + e^- \longrightarrow TZ^- \quad \text{(iv)}$$

$$TZ^- + F^+ \longrightarrow TZ + F \quad \text{(v)}$$

where TZ = Dye molecule, TZ * = Excited dye molecule, TZ^- = Semi form of dye molecule, F = Reductant molecule and F^+ = Oxidized form of the reductant.

Conclusion

On the basis of the observed results, we conclude that the single surfactant affected the photogalvanic cell more than mixed surfactant. The single surfactant has not only enhanced the conversion efficiency but storage capacities of photo galvanic cells also increase the storage parameters. The conversion efficiency, $t_{1/2}$ and fill factor is recorded as 0.5313%, 100.0 min. and 0.5357 respectively in the PG system.

Acknowledgment

Authors are thankful to Prof. Dr. Sangeeta Loonkar, Head, Department of Chemistry, Jai Narain Vyas University, Jodhpur, INDIA for providing necessary facilities

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(Received 21st January 2022, accepted 25th March 2022)