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Innovation for Prospective Energy Source Through Solar Cell

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Abstract

The object of the research project is to enhance solar energy conversion into electricity and store it through photogalvanic cells. Various parameters were studied in a photogalvanic having D-Xylose+MB+Brij-35+NaLS PGS (photogalvanic system) for solar cell conversion and storage. The photo potential was observed at 684.00 mV for D-Xylose+MB+Brij-35+NaLS PGS for solar cells. The photocurrent was observed at 230.00 μA in D-Xylose+MB+Brij-35+NaLS PGS for solar cells. The impact of solar energy was studied by varying the various parameters in PGS for solar energy-based conversion and storage. The D-Xylose+MB+Brij-35+NaLS PGS for solar cell performance was found 110.00 minutes in absence of light. The value of fill factor of the cell (η) = 0.2810 was observed and the powerpoint of the cell (pp) = 56.23 μW was obtained for the solar energy conversion and storage. The mixed surfactants (NaLS+Brij-35) have experimentally proved the efficient system as the desired object of research with special reference to enhancing electrical out and storage of solar energy.

Keywords: Solar energy Innovation; Energy System; Electrical Power; Conversion Efficiency; Conversion and Storage

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1. Introduction

The consumption of fossil fuels like wood, coal, kerosene, etc. is swiftly reaching towards their almost complete depletion. The non-renewable energy sources have their own limitations along with hazardous processes involved and pollution creating environment. The global scientific community is compelled to search the renewable source of energy to feed the whole world with non-polluting nature and commercial viability. Thus solar energy is the best option to fulfill the energy demand. Promising photochemical reactions like photosynthesis and photolysis of water are the basis for solar energy contents. Rideal and Williams [1] were pioneers to observe photogalvanics. Whereas, Rabinowitch [2, 3] has systematically investigated the endergonic photochemical reaction between iron thionine system and has observed this photochemical reaction thoroughly and its suitability for trapping solar energy as source renewable energy. It was also supported by the research work of Suda et al. [4], Murthy et al. [5], Bayer et al. [6] for developed some

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photogalvanic cells with semiconductor. The optimum results have been mentioned by Wildes et al. [7], Dixit and Mackay [8], Albery and Archer [9], photoelectrochemical process have been observed by Memming [10], Hamdi and Aliwi [11] whereas some effiecnet photogalvanic systems have been reported by Ameta et al. [12, 13], Gangotri et al. [14], Lal [15], Gangotri and Meena [16], Madhwani et al. [17] using different reductant and photosensitizers in PG cells. In order to enhance the electrical output PG cell Genwa and Genwa [18], Genwa et al. [19] have also reported some efficient systems using surfactants. Gangotri and Gangotri [20] determined the photogalvanic effect in PG cell using surfactants and reactants and photosensitizer and observed the role of photosensitizers and a reductant for generation of electrical energy in photogalvanic cell and bhimwal et al. [21] have compare the research output of various sugar cell as reducing agents. Mao S, et al. [22], Thareja Pet al. [23], Molina-Bolivar JA, et al. [24], Lee NM and Lee BH [25] have also observed mixed micellization in PG cells to observed the electrical output as well as storage capacity. The group of scientists [26-30] is paying attention to enhance the results by selecting the cheaper compounds in PGS for their commercial viability.

2. Materials and Methods

2.1. Laboratory work for solutions Preparation

During the experiment stage, the solutions of Sodium hydroxide, D-xylose (Reductant), Dye-Methylene blue (photosensitizer), Brij-35+NaLS (mixed surfactants), were prepared in double distilled water. The prepared solution of NaOH was standardized by oxalic acid [31] in each PGS solar cell. All solutions are kept in an amber color flask to protect them from sunlight.

2.2 Methodology for set–up for solar cell

First of all, we have designed PGS (figure 1) having fabricated H-shape glass tube [32] and one arm of the H tube was completely blackened except a window in another arm to absorption of light. The known solutions of two different surfactants Brij-35+NaLS (mixed surfactants), D-xylose (reductant), Methylene blue (photosensitizer), sodium hydroxide, and double distilled water were filled in an H tube to make up 25.00 ml solutions for each set of all the experiments. In one arm of the H-tube, a saturated calomel electrode was dipped and, in another arm, a Pt electrode was dipped which has an unblocked window. During the experiment, both ends of electrodes were connected through the resistance key, carbon pot, microammeter, and Digital pH meter for complete electrical circuit for measurement of the potential and current of the PGS for solar cell. During experiments, 200 W electric bulb (W Filament containing) and water filter were used for light sources and to cut of IR radiations for experiment setup, respectively. The figure of methodology for the PGS is given in figure 1.

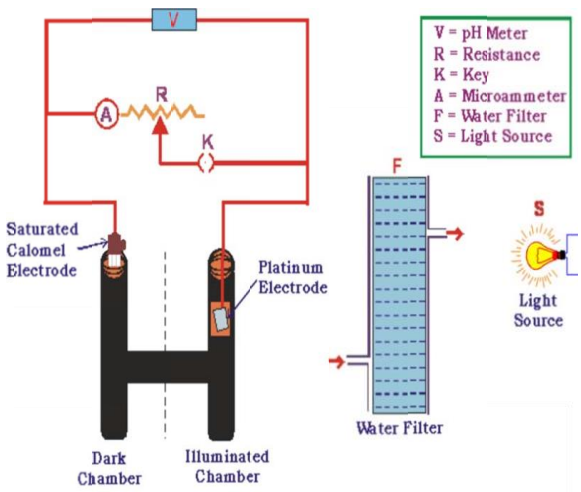

Figure 1 Methodology setup of PGS for solar energy

3. Results & Discussion

3.1. Variation of Photosensitizer Dye- Methylene blue concentration on the PGS

It was observed that when we increase the concentration of dye MB, the electrical output also increases and attain maximum value on a particular concentration value and then decreased in D-Xylose+MB+Brij-35+NaLS system. Table 1 and graphical figure 5 show the variation of photosensitizer (dye-methylene blue) concentration in D-Xylose+MB+Brij-35+NaLS system.

3.2. Variation of D-xylose on the PGS

It was observed that when we increase the concentration of reductant (D-xylose), the electrical output was also increase and attain maximum value on particular concentration value and then decreased in D-Xylose+MB+Brij-35+NaLS system. Table 1 and graphical figure 5 shows the variation of D-xylose concentration on D-Xylose+MB+Brij-35+NaLS system.

3.3. Variation of (NaLS+Brij-35) on the PGS

During experimental stage, the electric power of the PG cell having D-Xylose+MB+Brij-35+NaLS system was increased on increasing the concentration of Brij-35 keeping NaLS concentration constant (around its CMC value) and reached at optimum position and decreased on further increase the concentration of Brij-35. The concentration of NaLS was increased keeping Brij-35 concentration constant till it reached at optimum position and decreased on further change in concentration of NaLS. Table 1 and graphical figure 5 shows the variation of mixed surfactant in D-Xylose+MB+Brij-35+NaLS system.

3.4. Variation of pH on the PGS

It was observed that when we increase the pH, the electrical [33] output was also increase and attain maximum value on particular value (pH=13.00 at max) and then decreased in D-Xylose+MB+Brij-35+NaLS system. Table 1 shows the variation of pH on D-Xylose+MB+Brij-35+NaLS system.

3.5. Variation of diffusion length on the PGS

The current parameter of the cell (i_{max}, i_{eq}) and initial rate of generation of photocurrent of PG cell having D-Xylose+MB+Brij-35+NaLS system was observed with change in diffusion lengths (distance between two electrodes). It was found that with an increase in diffusion length maximum photocurrent (i_{max}) and rate ($\mu A\ min^{-1}$) go on increasing but the equilibrium photocurrent (i_{eq}) shows on negligible small decreasing trends. So, virtually it may consider as unaffected by the change in diffusion length. The table 2 shows the variation of diffusion length on D-Xylose+MB+Brij-35+NaLS system.

3.6. Variation of electrode area on the PGS

The current parameter – maximum photocurrent (i_{max}), equilibrium photocurrent (i_{eq}) of PG cell having D-Xylose+MB+Brij-35+NaLSsystem was observed that these were regular increase in maximum photocurrent but equilibrium photocurrent was almost independent on increase in electrode area rather effected in reverse direction.

Table- 1 Effect of Variation of Methylene blue, D-Xylose, NaLS, Brij-35 and pH on the system

Para meter	Photo potential (mV)	Photo current (μA)	Power (μW)
[Methylene blue] $\times 10^{-4}$ M			
3.00	608.00	202.00	122.82
4.00	684.00	230.00	161.13
5.00	612.00	205.00	125.46
[D-Xylose] $\times 10^{-3}$ M			
0.95	638.00	214.00	136.53
2.00	684.00	230.00	161.13
3.05	635.00	208.00	132.08
[NaLS] $\times 10^{-3}$ M			
5.90	638.00	216.00	137.81
6.40	684.00	230.00	161.13
7.90	642.00	212.00	136.10
[Brij-35] $\times 10^{-3}$ M			
8.97	633.00	210.00	136.70
9.00	684.00	230.00	161.13
9.03	652.00	213.00	138.22
P^H			
12.82	622.00	212.00	131.86
12.84	684.00	230.00	161.13
12.86	617.00	206.00	127.10

3.7. (i-V) characteristics (current–voltage) of the PGS

In the PG cell having D-Xylose+MB+Brij-35+NaLS system, the short circuit current i_{sc} is measured by microammeter keeping the circuit closed and open circuit voltage V_{oc} by digital pH meter keeping other circuit open. it is observed that the highest value of photopotential Vpp and photocurrent were measured by applying an eternal load with the help of carbon pot (log 470 K) connected in the circuit. The highest value of potential obeyed in the circuit is known as potential at power point corresponding to highest value of short circuit current is known as current at

power point i_{pp}. These four vales (i_{sc}, V_{oc} V_{pp} and $i_{pp,}$) were used in formula in one the determine the fill factor of PGS and formula to determine the power point of solar energy.

Table– 2 Effect of diffusion length on the system

Diffusion length (mm)	Max Photo current i_{max} (μA)	Equi photo current i_{eq} (μA)	Rate of initial generation of photo current (μA min^{-1})
30.00	262.00	245.00	7.28
36.00	266.00	240.00	7.39
42.00	270.00	235.00	7.50
48.00	275.00	230.00	7.64
54.00	280.00	225.00	7.78

The Table 3 shows the variation of electrode area on D-Xylose+MB+Brij-35+NaLS system.

Table- 3 Effect of electrode area on the system

Electrode Area (cm^2)				
value	0.72	0.82	0.92	1.02
i_{max} (μA)	260	265	270	275
i_{eq} (μA)	243	239	235	231

The fill-factor (□) was calculated using the following formula:

$$\text{Fill factor} = V_{PP} \times i_{PP} / V_{OC} \times i_{SC} \quad (1)$$

$$\text{Power point (pp) of solar cell} = V_{pp} \times I_{pp} \quad (2)$$

Where
V_{pp} is value of potential
i_{pp} is current at power point
V_{oc} is represent open circuit voltage
i_{sc} is short circuit current
The value of fill factor of cell (η) = 0.2810 was observed and the power point of cell (pp) = 56.23 μW was obtained for the PGS.

3.8. Cell performance and conversion efficiency on the PGS

The D-Xylose+MB+Brij-35+NaLS system was terminated the light source at the value of photocurrent so observed at the power point of the PG cell by applying electric load from the light source. The time was recorded at which the photogalvanic cell has reached half the value of the power in off-light mode. PG cell conversion efficiency [34] was determined as 0.5667 % using the following formula:

$$CF = v_{pp} \times i_{pp} \times 100 / A\ 10.4 mWcm^{-2} \quad (3)$$

Where
Cf is Conversion efficiency of cell
$V_{pp,}$ is photopotential at power point of cell,
i_{pp} is Photocurrent at power point of cell,
A is used electrode area of cell.

The performance of the cell was determined in term of $t_{1/2}$. The determined value was 110.00 min. Determination of PG cell performance is shown by figure 3 in term of $t_{1/2}$ and its observed value was 110.00 minutes in dark.

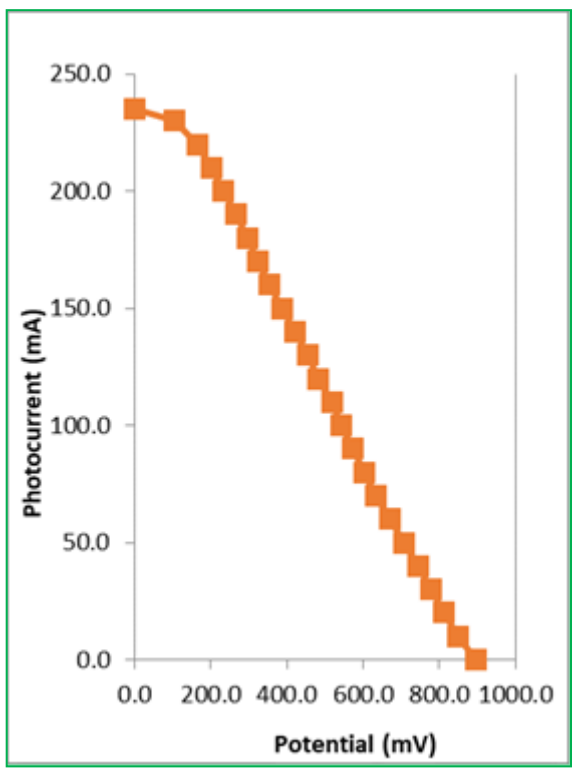

Figure 2 i-v curve of the PGS for solar energy

The Table 4 and graphical figure 3 shows the performance of the PG cell in D-Xylose+MB+Brij-35+NaLS system.

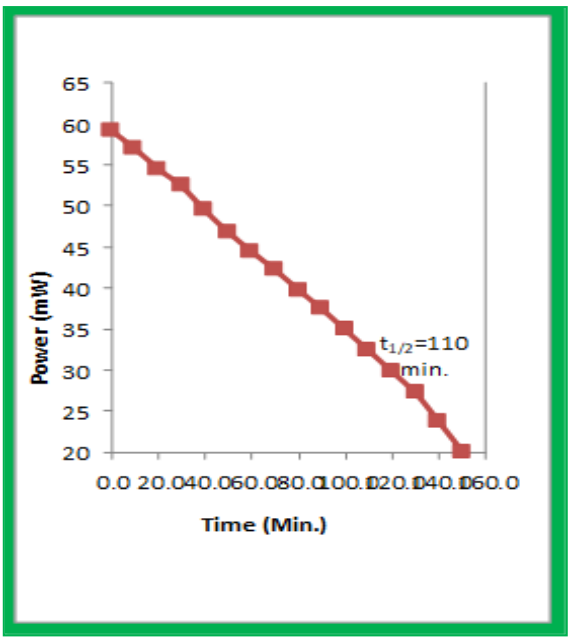

Figure 3 Cell performance of the PGS for solar cell

3.9. Mechanism for solar cell

Experimentally the following chemical transformation takes place; indicate the flow of electron in current.

3.9.1. Illuminate Chamber

MB molecules (photosensitizer) were got excited and excite MB accept electron and transfer to xylose

$$MB \xrightarrow{h\nu} MB^{*} \quad (4)$$

$$MB^{*} + R \longrightarrow MB^{-}(semi) + R^{+} \quad (5)$$

3.9.2. Photochemical reaction at Pt electrode

The semi or leuco form of MB (dye) loses an electron to electrode and converts into original dye molecule.

$$MB^{-} \longrightarrow MB + e^{-} \quad (6)$$

3.9.3. Photochemical reaction at dark Chamber

After reaction completion of illumination chamber, photochemical process is completed at dark chamber.

3.9.4. At counter electrode

Methylene Blue molecule (photosensitizer) accepts an electron from electrode and converts into semi or leuco form of dye molecule. During photochemical process, finally, Methylene blue (leuco/semi form) and the reductant (oxidized form), combine to give original methylene blue (MB) dye and Xylose reductant(R) molecules and the whole photochemical cyclic process continues.

$$MB + e^{-} \longrightarrow MB^{-} \quad (7)$$

$$MB^{-} + R^{+} \longrightarrow MB + R \quad (8)$$

Where
MB is Methylene blue (dye)
MB* is excited form of Methylene blue
MB^{-} is semi or leuco form of Methylene blue,
R is Reductant (xylose)
R^{+} is oxidized form of the reductant

For solar radiation energy transformation, proposed photochemical mechanism in PG cell is shown in Figure 6 for current generation.

Table 4 Effect of mixed surfactants [NaLS+Brij-35] for PGS

Results	NaLS	NaLS+Brij-35
(V_{OC})	870.0 mV	**884.0 mV**
(ΔV)	635.0 mV	**684.0 mV**
(i_{max})	175.0 µA	**268.0 µA**
(i_{sc})	90.0 µA	**230.0 µA**
(i_{eq})	90.0 µA	**230.0 µA**
(i_{pp})	55.0 µA	**128.0 µA**
(V_{pp})	595.0 mV	412.0 mV
PP	32.72 mW	**56.13 mW**
(η)	0.3630	0.2810
CF	0.310 %	**0.5676 %**
$t_{1/2}$	55.0 min	**11.0 min**
T	55.0 min	100.0 min

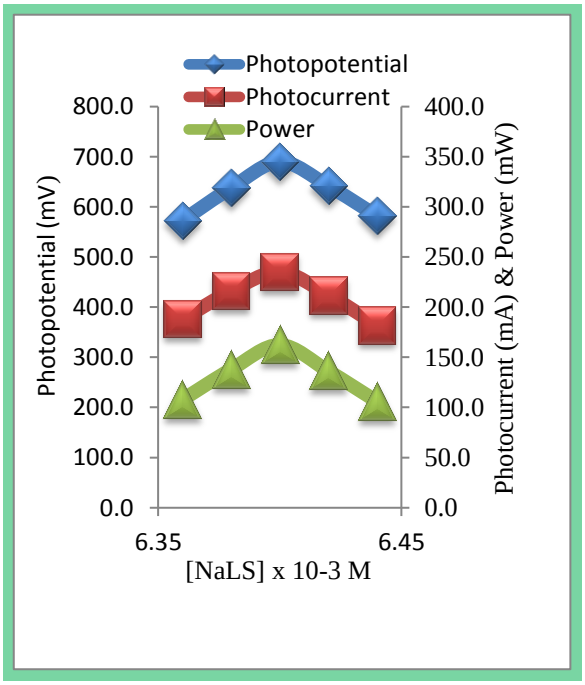

Figure 4 Cell parameters of the PGS for solar energy

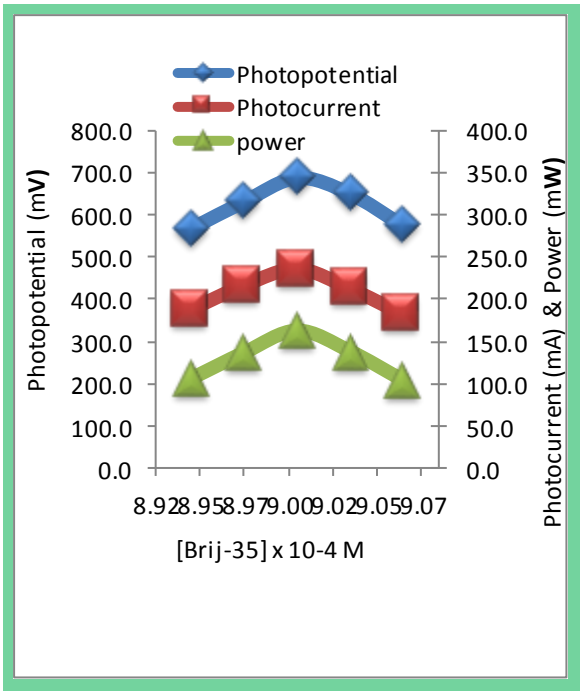

Figure 5 Cell parameters of the PGS for solar energy

As per the results so observed, shown in table 4, the efficiency of the solar cell for mixed surfactant has tremendously increased with special reference to current parameters, power, conversion efficiency and $t_{1/2}$ value (the storage capacity) almost doubled the charging time of the cell.

Methylene blue = 4.0×10^{-4} M, D-Xylose = 2.0×10^{-3} M, NaLS = 6.40×10^{-3} M, Brij-35 = 9.0×10^{-3} M, pH = 13.00, Temperature = 303 K, Intensity of light = 10.4 mW cm^{-2}

4. Conclusions

On the basis of the observed results of the PGS having D-Xylose+MB+Brij-35+NaLS system, we have observed that the mixed surfactants have not only enhanced the electrical output of cell but also enhance the energy conversion of the cell for PGS. These PGS played main role in reduction in their cost to make commercial viability by selecting the proper redox couple, with respect to photo storage and mixture of surfactants. The photogalvanic cells may be best fuel cell in field of solar radiation transformation and potential, with respect to current parameters. The effects will be made to develop the PG cell the having higher electrical output [35] than the reported photogalvanic systems.

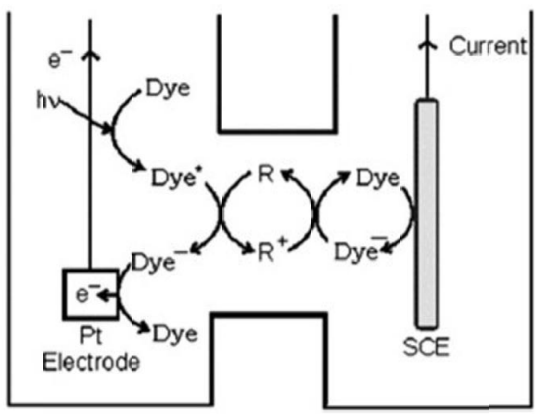

Figure 6. Process of reaction mechanism in a photogalvanic cell for solar energy

The efficient systems if reached to the desired extent of reduced cost and overall efficiency may replace the existing solar cells in the market and would be capable to the feed the electrical demand of humanity. The D-Xylose+MB+Brij-35+NaLS PGS for solar cell performance was found 110.00 minutes in absence of light. The value of the fill factor of the cell (η) = 0.2810 was observed and power point of cell (pp) = 56.23 μW was obtained for the solar energy conversion and storage.

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Nomenclature

i_{eq}= photocurrent at equilibrium

i_{sc}=short circuit current

i_{pp}=photocurrent at power point

mV=millivolt

ml=milliliter

M =molarity

$t_{1/2}$=storage capacity of cell

pp=power point

V_{pp}=photopotential at power point

V_{oc}=open circuit voltage

mA=microampere

η=fill factor

mW=microwatt

PGS = photogalvanic system

PG=photogalvanic cell

i_{max}=maximum photocurrent

MB= Methylene blue

NaLS =Sodium lauryl sulphate

CF = Conversion efficiency

LG = Lauryl glucoside

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