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Role of Carmine in Tween 60 –Ascorbic Acid System for Energy Conversion

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Abstract

The photogalvanic effect studied in H-cell containing Ascorbic acid as reductant and Carmine as photosensitizer. The photopotential and photocurrent generated in cell were 884.0 mV and 190.0 µA, respectively. The observed conversion efficiency 0.8184% and the maximum output (power) of the cell was 85.12 µW. The photogalvanic cell can be used at this power level for 170 minutes. The effect of different parameters of electrical output of the cell was investigated and a cell photoreaction mechanism for the generation of the photocurrent in this photogalvanic cell has also been proposed.

Keywords: Ascorbic acid, carmine, conversion efficiency, tween 60.

Introduction

Solar energy presents a scientific challenge beyond the efficient conversion of solar photon to electricity fuel and heat. Once conversion on a large scale is achieved, we must find ways to store the large quantities of electricity and heat that we will produce. Access to solar energy is interrupted by natural cycles of day- night cloudy sunny and winter summer variation that are often out of phase with energy demand. Solar fuel production automatically store energy in chemical bonds. Electricity and heat, however are much more difficult store cost effectively storing even a fraction of our peak demand for electricity of heat for 24 hours is a task well beyond present technology[1]. The Photoelectrochemical process is a visible means of converting solar energy directly into electricity[2-3]. The physical chemical principal of photovoltaic conversion with nanoparticales, mesoporous dye sensitized solar cell[4]. Whereas Mayer have presented the molecular approaches to solar energy conversion and storage in photogalvanic cell[5].

Later on studies on solar energy conversion and storage in photogalvanic cell reported time to time[6-9]. Efficiency of light conversion in photogalvanic cell, water cleavage system and conversion of light into electricity was reported by Dung and Kozak[10]. Ghosh et al. studied the role of nonionic micelles of tweens in photogalvanic generation using fluorescien dye[11]. Studies of photochemical conversion of solar energy into electrical energy reported by Balzani et al.[12]. Some new photogalvanic systems reported recently[13-16]. In present work electronic output of Tween 60 – Carmine – Ascorbic acid system examined experimentally the storage performance and to development cost effective photogalvanic cell system for sustainable development.

Material and Methods

The solution of Carmine, Tween 60, Ascorbic acid and NaOH having concentration $7.2x10^{-5}$ M, $1.24x10^{-3}$ M, $1.96x10^{-3}$ M and 1.0 N were used respectively. All solutions were prepared by direct weighing and prepared in double distilled water, and kept in amber coloured container to protect from light. Photogalvanic effect of dye was studied using H- shaped glass tube which consist known amount of the solution of Carmine, tween 60, ascorbic acid, NaOH. A platinum electrode (1.0x1.0 cm^2) was dipped in one limb and a saturated calomel electrode (SCE) is immersed in another limb of the H- tube. The terminals of the electrodes were then connected to a digital pH meter and the whole cell is placed in dark. The photopotential was measured in dark when the cell attains a stable potential.

The limb containing platinum electrode was focused to the light source (projector Tungsten lamp). The intensity of light was measured in laboratory with the help of solar intensity meter (Surya Systems, Ahmadabad). A water filter placed between the illuminated chamber and the light source to cut off thermal radiation upto with radiations is observed by cell itself. Photopotential and photocurrent were measured by digital pH meter (Systonics modal 335) and digital ammeter (Osaw). Absorption spectra were recorded using Systonics Spectrophotometer 106 with the matched pair of silica cuvetts (path length 1cm).

All spectral measurements were duplicated in a constant temperature water bath maintained with in ±1 ^{0}C and mean values were processed for data analysis. The dye observed absorption peak (λ_{max}) in visible region with maximum at 515 nm. Maximum absorption is recorded at Carmine - Tween 60 combination of concentration $7.2x10^{-5}$ M + $1.24x10^{-3}$ M.

Results and Discussion

Effect of variation of dye (Carmine), surfactant (Tween 60), and reductant (Ascorbic acid) concentration: Effects of dye, surfactant and reductant concentrations are shown in table-1. It was observed that the photopotential and photocurrent of tween 60 – carmine – ascorbic acid system for the better performance of the photogalvanic cell proper concentration of dye needed. Experimentally, photopotential and photocurrent increased with increase in concentration of the carmine. A maxima was obtained at certain dye concentration.

On future increasing in concentration of dye a decrease in the electrical output is observed. On the lower concentration range of photosensitizer, there are limited number of dye molecules to absorb the major portion of the light in the path and therefore, there is minimum electrical output, where as high concentration of dye again resulted in a decreased in electrical output due to intensity of light reaching the molecule near the electrode decreased due to absorption of the major portion of the light by the dye molecules present in the path. Therefore corresponding fall in the power of the cell was observed.

Tween 60 is used as a surfactant in the system. The photopotential and photocurrent of the cell was increased on increasing the concentration of tween 60. A maxima was obtained at a certain value and decrease on further increase in surfactant concentration. The most important properties of miceller systems are the ability to solubilize a variety of molecules and substantial catalytic effect on chemical reaction. With the increase electricity output of the cell also depend on variation of reductant (ascorbic acid) concentration of the ascorbic acid photopotential and Photocurrent was found to increase to maximum value of Photopotential of 884.0 mV and photocurrent of 190.0 μA and then decrease in electrical output because fever reductant molecule, were available for electron donation to photosensitizer (Dye) molecule.

Higher concentration of reductant again resulted in a decrease in electrical output, due to the large number of reductant molecules hinder the dye molecule from reaching electrode in the desired time limit. Ascorbic acid is a better photochemical reducing agent in photogalvanic cell.

The effect of variation of electrode area on the current parameters of the cell also studied using thin platinum electrodes of different diameters. Experimentally it is observed that with increase electrode area the value of maximum photocurrent (i_{max}) was found to increase and (i_{eq}) is all most independent to change in electrode cell. However, photocurrents of system, the results are summarized in table-2.

Table - 1
Effect of variation of electrode area and light intensity

Concentration	Photopotential (mV)	Photocurrent (μA)
[Carmine] x 10^{-5} M		
6.4	816	104
6.8	843	146
7.2	884	190
7.6	851	152
8.0	825	118
[Tween 60] x 10^{-3} M		
1.16	762	126
1.20	828	164
1.24	884	190
1.28	845	176
1.32	812	151
[Ascorbic acid] x 10^{-3} M		
1.88	802	143
1.92	832	159
1.96	884	190
2.00	849	163
2.04	822	147

Table – 2
Effect of electrode area

Tween 60 – Carmine-Ascorbic acid System	Electrode area (cm^2)				
	0.25	0.64	1.00	1.21	1.96
Maximum photocurrent i_{max} (μA)	197	223	250	262	314
Equilibrium photocurrent I_{eq} (μA)	136	162	190	201	252

[a][Tween 60] = 1.24 x 10^{-3} M, [b][Carmine] = 7.2 x 10^{-5} M, [c][Ascorbic Acid] = 1.96 x 10^{-3} M, [d]Light Intensity = 10.4 mW cm^{-2}, [e]Temp. = 298 K, [f]pH = 10.04.

The intensity of light is also affects the electrical output of the cell. This effect was observed by using solar intensity meter. Results are reported in figure-1. It was observed that photocurrent showed a linear increasing behavior with the increase in light intensity whereas photopotential increase in logarithmic manner.

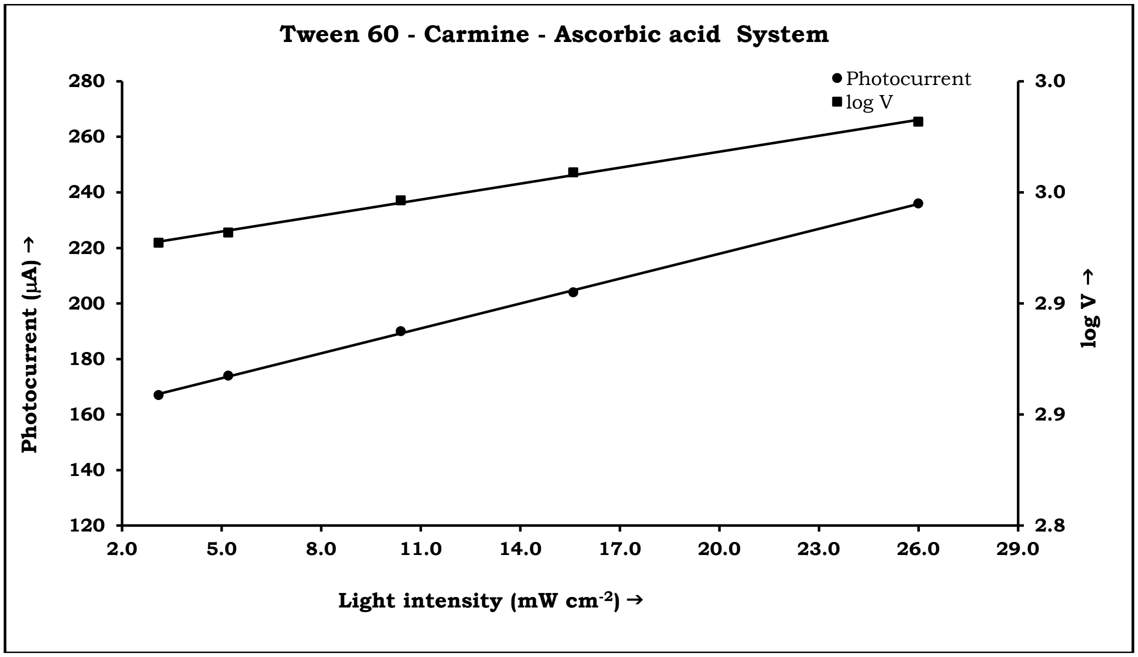

Figure - 1
Variation of photocurrent and log V with light intensity

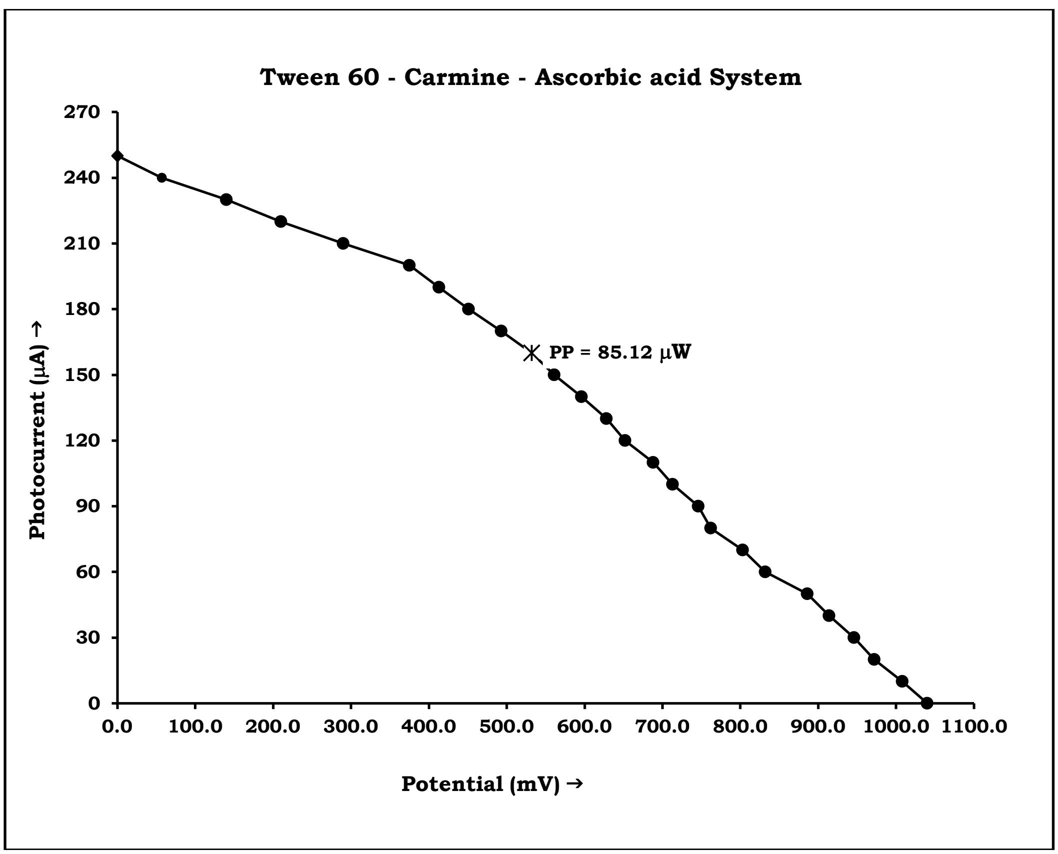

Figure - 2
Current - potential (I-V) curve of the cell

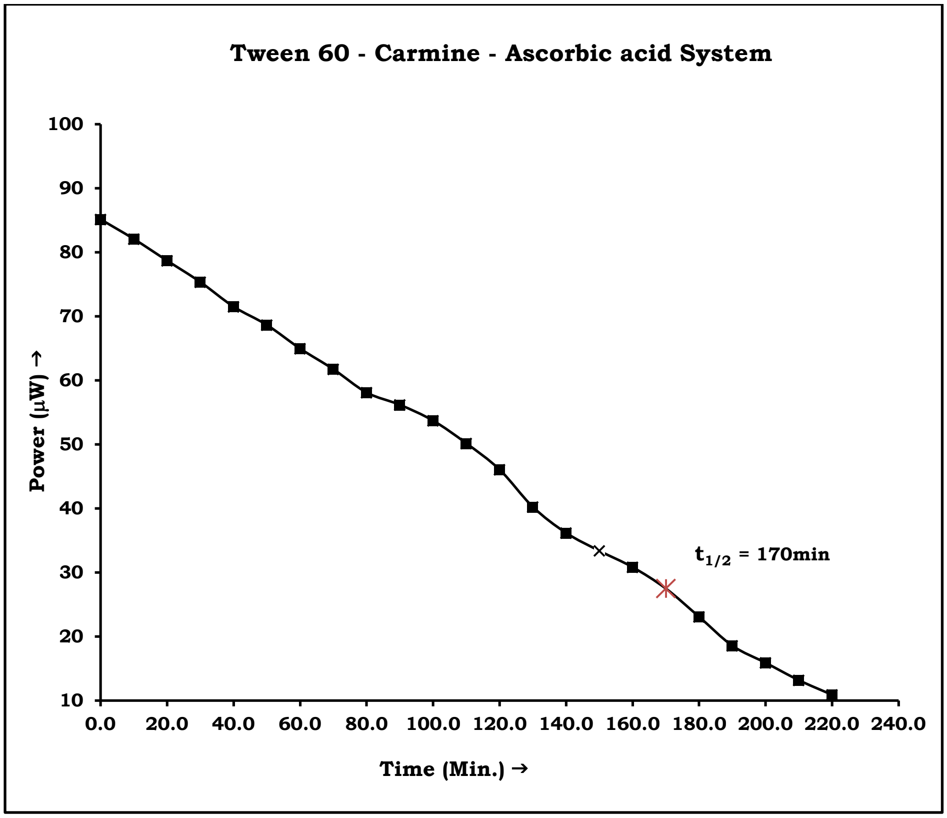

Figure-3
Time - power curve of the cell

Current – voltage (i-V) characteristics of the cell: The open circuit voltage (V_{oc} 1040.0 mV) and short circuit current (i_{sc} 190.0 µA) of the photogalvanic cell were measured under the continuous illumination of light, with the help of digital pH meter (keeping the circuit open) and a micro ammeter (keeping the circuit closed), respectively. The external parameters (photopotential and photocurrent) of the photogalvanic cell in between this two extreme values (V_{pp} and i_{pp}) were recorded with the help of a carbon pot (log 407K) connected in the circuit of micro ammeter, through which an external load applied on it. i-V curve is shown in figure-2 i-V curve deviated from its regular rectangular shape. A point in the i-V curve, called power point(pp), was determined where the product of current and potential was maximum and the fill-factor was calculated as 0.43 and conversion efficiency of the cell was determined as 0.8184% using the following relationship

$$\text{Fill-factor (f f)} = V_{pp} \times i_{pp} / V_{oc} \times i_{sc} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

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

Where V_{pp}, i_{pp} and A are photopotential at power point, Photocurrent at power point and electrode area respectively.

Storage capacity (Performance) of the cell: The performance of photogalvanic cell containing tween 60 – carmine - ascorbic acid system have current and potential corresponding to the power point after removing illumination. The power output is observed to half of its original value of the power point in the dark. It was observed that the cell can be used in dark for 170 minutes using Tween 60 - carmine – ascorbic acid system in photogalvanic cell. Performance of the cell observed graphically in time – power curve shown in figure-3.

Conclusion

Renewable energy can be used again and again without duplication they are free and they are abundant. The use of nonrenewable energy source like sunlight not only limited to the production of electricity. The sunlight is directly converted into the electricity by photogalvanic and photovoltaic cells. The photovoltaic cell are wildly used in the hilly and desert place, but saying to there storage capacity and commercial viability, the photogalvanic cell are edge over the others because they are cost effective, economic and have added advantage of inherent storage capacity. The power conversion efficiency of photogalvanic cell containing a tween 60 – carmine – ascorbic acid was calculated as 0.8184% and storage of light energy in this system recorded 75.0 min. These results are encourage to present effort toward applicably of economically and cost effective photogalvanic technology.

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