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Generation of Electrical Energy Through Dye Sensitised Solar Cell: Photogalvanic Technology

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Abstract : A device in which solar energy converts into electrical energy via DSS Cell based on PG technique. DSS cell is consisting of suitable redox-couple for electrochemical studies of dye. PG effect is studied in DSS cell containing photosensitive compound in aqueous solution of reducing agent. Electrical parameters of DSS cell is observe in terms of maximum value of photopotential, photocurrent, conversion efficiency and storage capacity. The DSS cell has the advantage of being used in the dark but at lower conversion efficiency. Photovoltaic cells based on semiconductor have better conversion efficiency than DSS cell but it cannot be used in dark whereas DSS cells are used in dark. Thus, DSS cell showed good prospects of becoming commercially viable than photovoltaic cell in the absence of sunlight.

***IndexTerms* - PG effect, redox-couple, conversion efficiency, storage capacity.**

I. INTRODUCTION:

Solar energy is our Earth's primary sources of renewable energy. It is one of the most resourceful sources of energy for the future. It is our Earth's primary sources of renewable energy. A device in which solar energy convert into electrical energy via formation of energy rich species that exhibit the solar effect. The solar effect was first of all recognized by Rideal and Williams[1] and it was systematically studied by Rabinowitch[2-3], Potter and Thaller[4] and Wolf[5]. Rohatgi-Mukherjee et al.[6], Madhwani et al.[7], Dixit and Mackay[8] and Kamet[9] were studied various photogalvanic cells for solar energy conversion and storage. Peng et al.[10] and Albery and Archer[11] have been studied on how to enhance the performance and optimum efficiency of dye sensitized solar cells for solar energy conversion and storage. Some researcher[12-14] has been uses of some reductant and photosensitizer in photogalvanic cell. Jana and Bhowmik[15] and Gangotri and Indora[16] work on enhancement in power output of solar cells consisting of mixed dyes. Many researchers and scientists[17-21] have been developed some solar cells based on photosensitive compounds. Recently some solar cells have been developed for solar energy conversion and storage based on surface active agent by Bhati and Gangotri [22], Chandra et al.[23]and Meena[24-25]. Present work is the effort to generation of electrical energy through DSS cell based on PG.

II. EXPERIMENTAL METHODS:

EXPERIMENTAL METHODS: All the solutions such as photosensitive compound (Fuchsin Basic), reducing agent (Mannitol) and NaOH are prepared in doubly distilled water and the stock solutions of all chemicals are prepared by direct weighing and are kept in coloured container to protect them from the light. The solution is bubbled with prepurified nitrogen gas for nearly twenty minutes to remove dissolved oxygen. Solutions of redox-couple (Fuchsin Basic and Mannitol) in basic medium are taken in an H-type glass tube. A platinum electrode (1.0 x 1.0 cm2) is immersed into one arm of H-tube and a saturated calomel electrode (SCE) is kept in the other. The whole cell is first placed in dark till a stable potential is obtained and then, the arm containing the SCE is kept in the dark and the platinum electrode is exposed to a 200 W tungsten lamp. A water-filter is used to cut off infrared radiations. A digital pH meter (Systronics Model-335) and a microammeter (Ruttonsha Simpson) are used to measure the potential and current generated by the cell, respectively. The current–voltage characteristics of electrochemical cell have been studied by applying an external load with the help of a carbon pot (log 470 K) connected in the circuit through a key to have close circuit and open circuit device. The experimental set-up of DSS cell is given in Figure-1. The effect of different parameters on electrical parameters has been observed. The rate of change in potential after removing the source of illumination is 1.6mVmin^{-1} in Fuchsin Basic dye in aqueous solution of Mannitol.

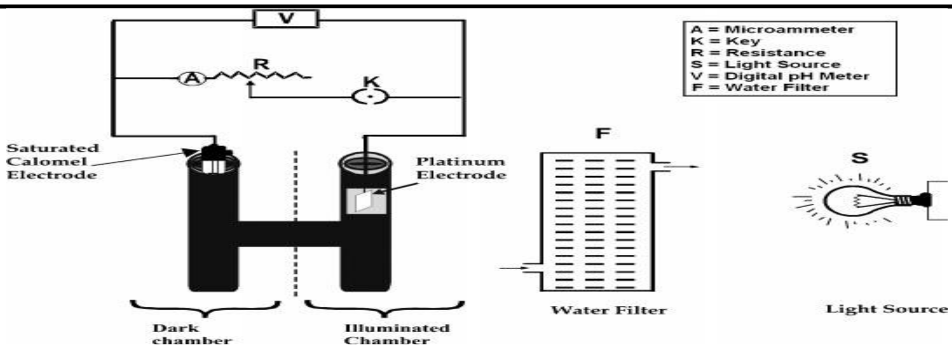


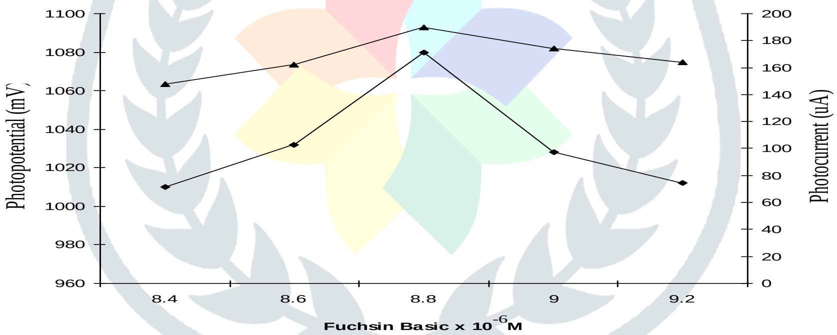
FIGURE-1 EXPERIMENTAL SET-UP OF DSS CELL

III. RESULTS AND DISCUSSION

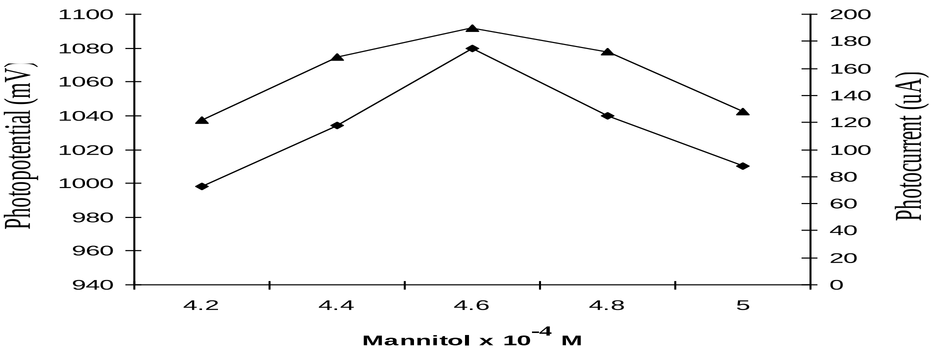
Effect of Fuchsin Basic, Mannitol Concentration, pH, Electrode Area and Light Intensity:

Fuchsin Basic is taken as photosensitive compound in DSS cell. It is observed that the photopotential and photocurrent are increasing with respect to the concentration of the Fuchsin Basic. A maximum is obtained for a particular value of Fuchsin Basic concentration. On further increase in concentration of Fuchsin Basic, a decrease in the electrical output of the cell is obtained. The reason of the change in electrical output is that lower concentration of Fuchsin Basic resulted into a fall in electrical output because fewer Fuchsin Basic molecules are available for the excitation and consecutive donation of the electrons to the platinum electrode whereas the higher concentration of Fuchsin Basic again resulted into a decrease into electrical output as the intensity of light reaching the Fuchsin Basic molecules near the electrode decrease due to absorption of the major portion of the light by Fuchsin Basic molecules present in the path. The results are graphically presented in figure 2.

Mannitol is taken as reducing agent in DSS cell. It is observed that the photopotential and photocurrent are increasing with respect to the concentration of Mannitol. A maximum is obtained for a particular concentration of Mannitol. On further increase in concentration of Mannitol, a decrease in the electrical parameters of the cell is observed. The reason of the change in electrical output is that the lower concentration of Mannitol resulted into a fall in electrical output because fewer Mannitol molecules are available for electron donation to Fuchsin Basic molecule whereas the higher concentration of Mannitol again resulted into a decrease in electrical output, because the large number of Mannitol molecules hinders the Fuchsin Basic molecules from reaching the electrode in the desired time limit. The results are graphically presented in figure 3.



▲—Photocurrent (μA) ■ — Photopotential (mV)
Figure 2: Effect of Fuchsin Basic Concentration

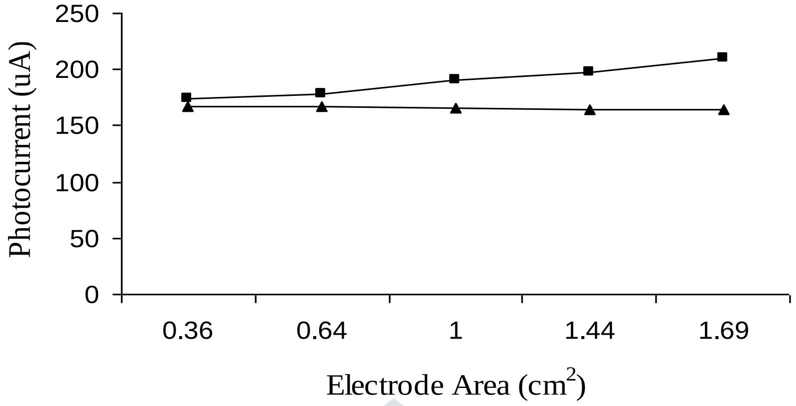


▲—Photocurrent (μA) ■ — Photopotential (mV)
Figure 3: Effect of Mannitol Concentration

It is found that the DSS cell consisting of Fuchsin Basic dye in aqueous solution of Mannitol to be quite sensitive to the pH of the solution. It is observed that there is an increase in the photoelectric parameters of this cell with the pH value (In the alkaline range). At pH 11.0 a maxima is obtained. On further increase in pH, there is a decrease in photoelectric parameters.

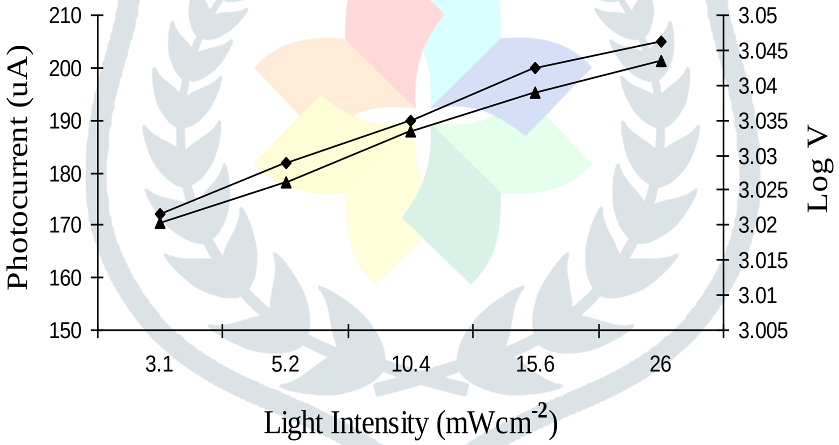
It is observed that the pH for the optimum condition has a relation with pKa of the reductant and the desired pH is higher than in pKa value (pH>pKa). The reason of the change in electrical output is that the availability of the reductant in its anionic form, which is a better donor form. The results are graphically reported in figure 4.

Figur 5 shows rate of change in photoelectric parameter with respect to electrode area. It is found that the maximum photocurrent show increasing fashion with electrode area whereas the equilibrium photocurrent (i_{eq}) show independent fashion.



▲—Photocurrent (µA) ■ — Photopotential (mV)
Figure 5: - Effect of electrode area

Figure 6 shows rate of change in photoelectric parameter with respect to light intensity. The light intensity is measured in terms of $mWcm^{-2}$ with the help of solarimeter (CEL Model SM 203). It is found that the photocurrent show linear increasing fashion with light intensity whereas the photopotential show an increment in a logarithmic fashion.



▲—Photocurrent (µA) ■ — Photopotential (mV)
Figure 6: Effect of variation of light intensity on the cell

IV. CURRENT-VOLTAGE (I-V) CHARACTERISTICS OF THE CELL:

The short circuit current (i_{sc}) and open circuit voltage (V_{oc}) of the electrochemical cell are measured with the help of a multimeter (keeping the circuit closed) and with a digital pH meter (keeping the other circuit open), respectively. The current and potential values in between these two extreme values are recorded with the help of a carbon pot (log 470 K) connected in the circuit of Multimeter, through which an external load is applied. The current-voltage (i-V) characteristic of the DSS cell containing Fuchsin Basic and Mannitol is graphically shown in Figure 7.

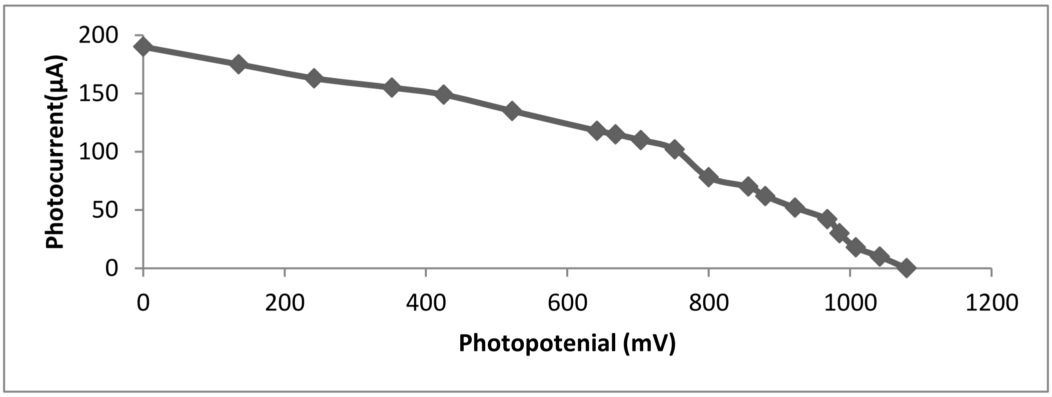


Figure 7: Current-Voltage (i-V) characteristics of the cell

V. CONVERSION EFFICIENCY AND STORAGE CAPACITY:

The storage capacity of the DSS cell is observed by applying an external load (necessary to have current at power point) after terminating the illumination as soon as the potential reaches a constant value. The storage capacity is determined in terms of $t_{1/2}$, i.e., the time required in the fall of the output (power) to its half at power point in dark. It is observed that the DSS cell can be used in dark for 90 minutes, whereas photovoltaic cell cannot be used in the dark even for a second. The results are graphically presented in Figure 8. The conversion efficiency of the cell is determined as 0.744% with the help of photocurrent and photopotential values at the power point and the incident power of radiations by using the formula.

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

$$\text{Conversion Efficiency} = \frac{V_{pp} \text{ x } i_{pp}}{10.4 \text{ mW}} \text{ x}100\% \quad (2)$$

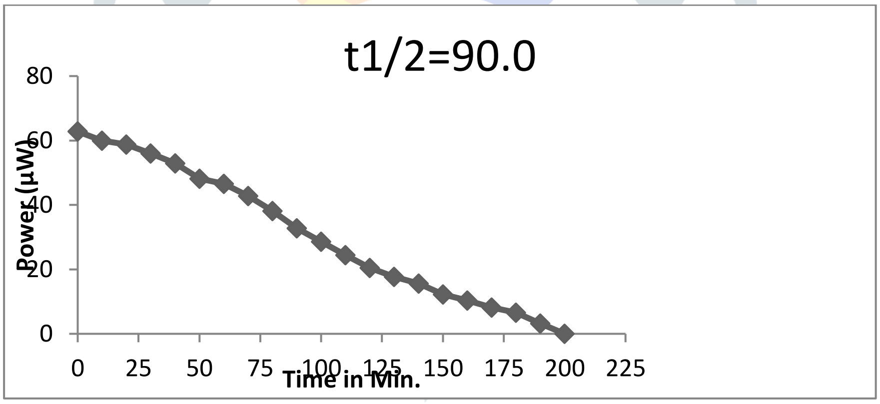


Figure 8: Performance of the Cell

[Fuchsin Basic] = 8.8×10^{-6} M, Light Intensity = 10.4 mW cm^{-2}, [Mannitol] = 4.4×10^{-4} M, Temperature = 303 K , pH = 11.0

MECHANISM

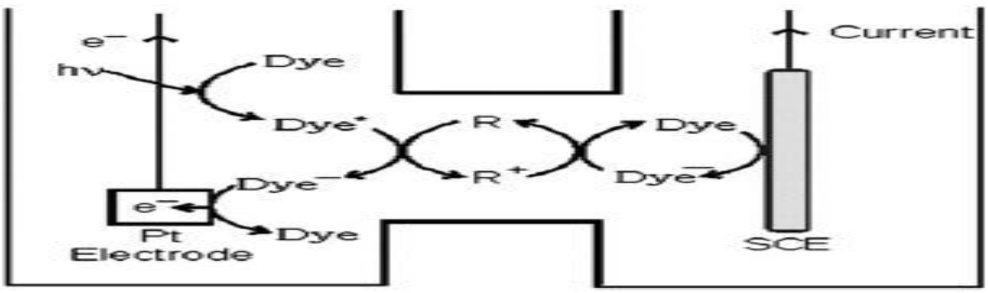


Figure 9: Mechanism in DSS Cell

CONCLUSION

On the basis of the results, it is conclude that Fuchsin Basic dye have good electrochemical properties in aqueous solution of Mannitol. Reducing properties of aqueous solution of Mannitol have profound influence on the electrical properties of Fuchsin Basic that depend fairly on the concentration of Mannitol. It has been found that the Fuchsin Basic dye is used in aqueous solution of Mannitol for better electrical output of DSS cell. DSS cell is the substituent of the photovoltaic cell in future due to it can be used in the absence of sunlight (dark).

SN.	Parameter	Observed Value
1	Dark potential	184.0 mV
2	Open circuit voltage (V_{OC})	1080.0 mV
3	Photopotential (DV)	968.0 mV
4	Equilibrium photocurrent (i_{eq})	160.0 mA
5	Maximum photocurrent (i_{max})	190.0 mA
6	Initial generation of photocurrent	56.8 mA min^{-1}
7	Time of illumination	260.0 min
8	Performance ($t_{1/2}$)	90.0 min
9	Percentage of cell performance	0.3461%
10	Work efficiency	0.744%
11	Fill factor (η)	0.44

VI. ACKNOWLEDGEMENT

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