Modern Approach of Solar Energy Conversion and Storage

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***Abstract*: All over the world are working to find out renewable source of energy. Apart from the renewable energy resources like geothermal, biomass wind, tidal and hydro energy etc. The solar energy has required characteristics for present day suitable energy source. Solar energy is not only none polluting, inexhaustible and harmless but clean, low cost and hazardless having no disposal problem.**

In this study it is proposed the conversion and storage capacity of solar energy taking different types of reductants with the photosensitizers. This field of research is still in the infant stage with respect to its viability and applicability, requires through exploration to increase the conversion efficiency and storage capacity by selecting the suitable couple of Photosensitizer and the various types of reductants.

***Keywords*: Photo potential, Photocurrent, Fill factor, Conversion efficiency, Power point, Storage Capacity.**

1. INTRODUCTION

The global warming and the rapid decrease in energy resources caused by the large-scale consumption of fossil fuels have become a serious problem. Accordingly, renewable energy resources are attracting a great deal of attention and solar energy will be one of the most promising future energy resources. In the present investigation, Ponceau-S has been used as photo sensitizer and KI as reductant for generation of electrical energy in photo galvanic cell. The photo effects in electrochemical systems were first reported by Becquerel[1, 2]. Alonso et al. reported the use of electrodeposited CdSeO-5 TeO-5 electrode for solar energy conversion[3]. Jana and Bhowmik reported enhancement in the power output of a solar cell consisting of mixed dyes[4]. Hara et al. investigated design of new coumarin dyes having thiophene moieties for highly efficient organic dye-sensitized solar cells[5]. It has been reported the use of toluidine blue nitroloacetic acid (TB-NTA) [6], in Azur A-KI[7] Bromophenol-EDTA[8]and Fluoroscein-EDTA[9] systems. Similarly, it has been reported that the photo galvanic cells for classroom investigation[10] and femto-second excited state dynamics of an iron (II) polypyridyl solar cell[11]. Schwarzhurg and Willig explored the origin of photo voltage and photocurrent in nanoporous, dye-sensitized, photo electrochemical solar cell[12]. The sensitization of nanoporous films on TiO_2 with santaline (red sandal wood pigment) and the construction of a dye–sensitized solid state photovoltaic cell were attempted by Tennakone and Kumara[13]. Yadav et al. reported use of bismarck brown-ascorbic acid (BB-AA) system in photo galvanic cell for solar energy conversion[14]. A detailed literature survey reveals that different photo sensitizers and reductant have been used in photo galvanic cell[15-19].

2. EXPERIMENTAL METHODS

All the solutions were prepared in doubly-distilled water and stored in amber-colored containers to protect them from light. A mixture of the solution of the dye, KI, sodium hydroxide and water were filled into an H-shaped glass cell. A platinum electrode (1×1 cm^2) was placed in one compartment of the cell and a reference saturated calomel electrode (SCE) in the other compartment. The platinum electrode was exposed to a 200 W tungsten lamp while the SCE was kept in the dark. The temperature of the system was maintained at 303 K (±0.1). A water filter was used to cut-off infrared radiations. A digital pH meter and a microammeter were used to measure the potential and current, respectively. The current–voltage characteristics were determined by applying extra load with the help of carbon pot (log 500 K) connected in the circuit. With this variable resistor (carbon pot), current-voltage curve was plotted.

3. RESULTS AND DISCUSSION

3.1 Effect of pH

The effect of pH on the electrical output of the cell is shown in Figure 1. Photo potential and photocurrent are increased with increasing pH until at pH 13. Further increase in pH results in a decrease in the electrical output of the cell. The dependence of photo potential and photocurrent on the concentration of the dye was studied and the results are shown in Figure 2. On increasing the concentration of Ponceau-S, both the photo potential and the photocurrent increase till a maximum is achieved at 4.8×10^{-6} M, after which both characteristics are decreased. A small output is obtained at a low concentration of Ponceau-S because a smaller number of dye molecules are available for excitation and consecutive donation of electrons to the platinum electrode. A large concentration of dye results in a decrease in photo potential because the intensity of light reaching the dye molecules (near the electrode) decreases due to the major portion of the light being absorbed by the dyes available in its path.

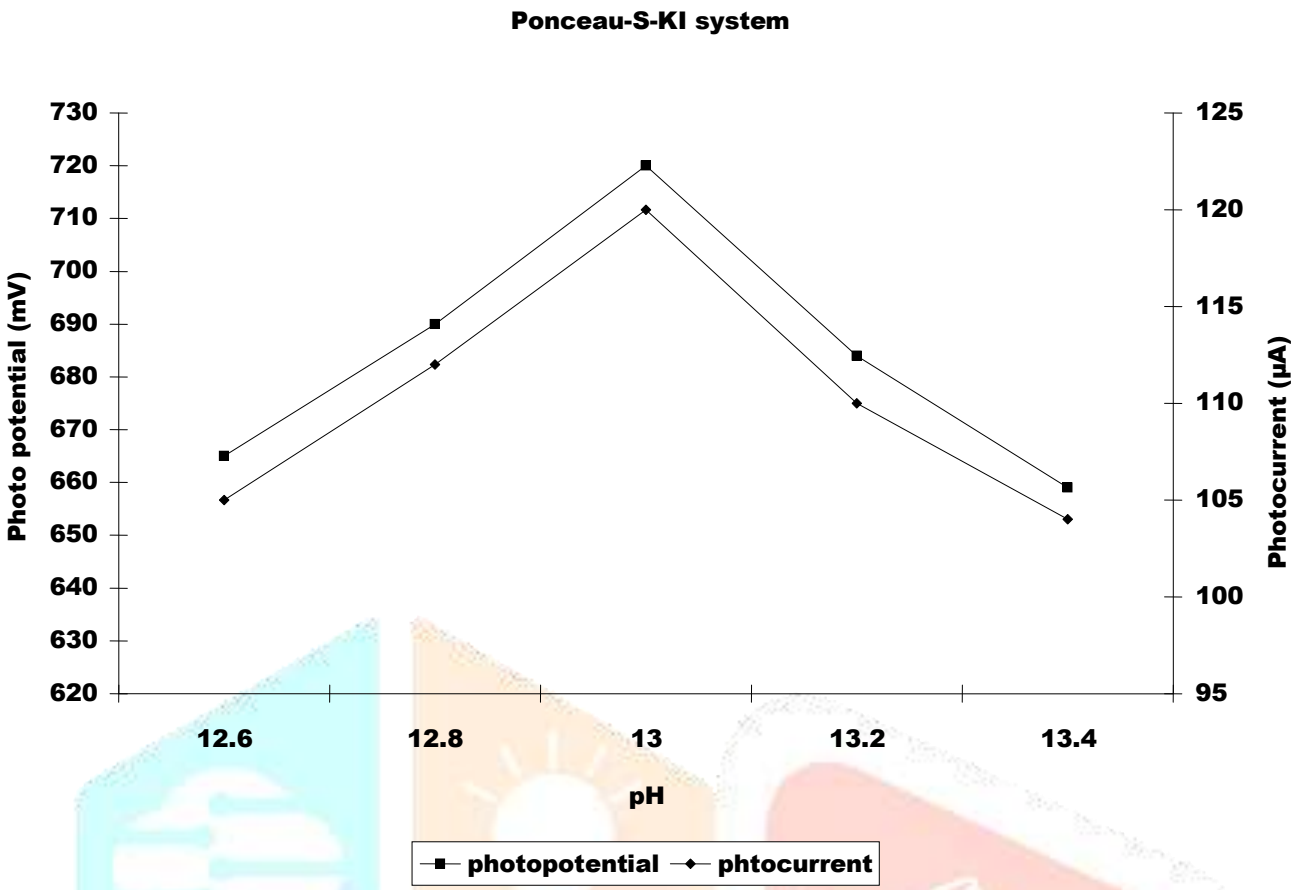

Figure-1 Variation of photo potential and photocurrent with pH.

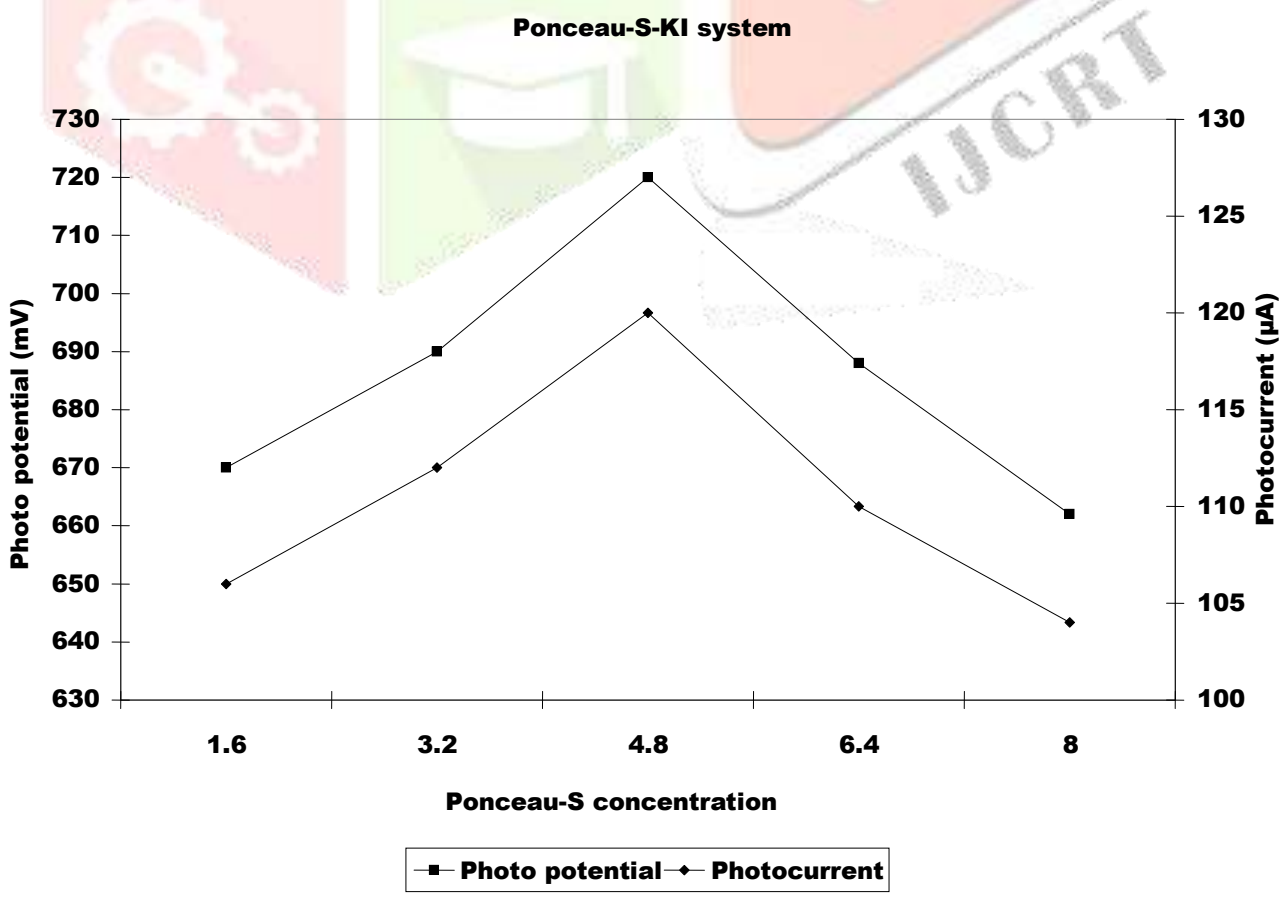

Figure- 2 Variation of photopotential and photocurrent Ponceau-S concentration.

3.2 Effect of KI concentration

The dependence of photopotential and photocurrent on the concentration of the reductant (that is, KI) was studied and the results are shown in Figure 3. Both the photopotential and the photocurrent achieve maximum values at the concentration of 2×10^{-3} M of KI. At low concentrations, the power output is small due to the fewer number of reductant molecules available for electron donation to the dye molecules, whereas a large concentration of reductant hinders the movement of dye molecules reaching the electrode in the desired time limit.

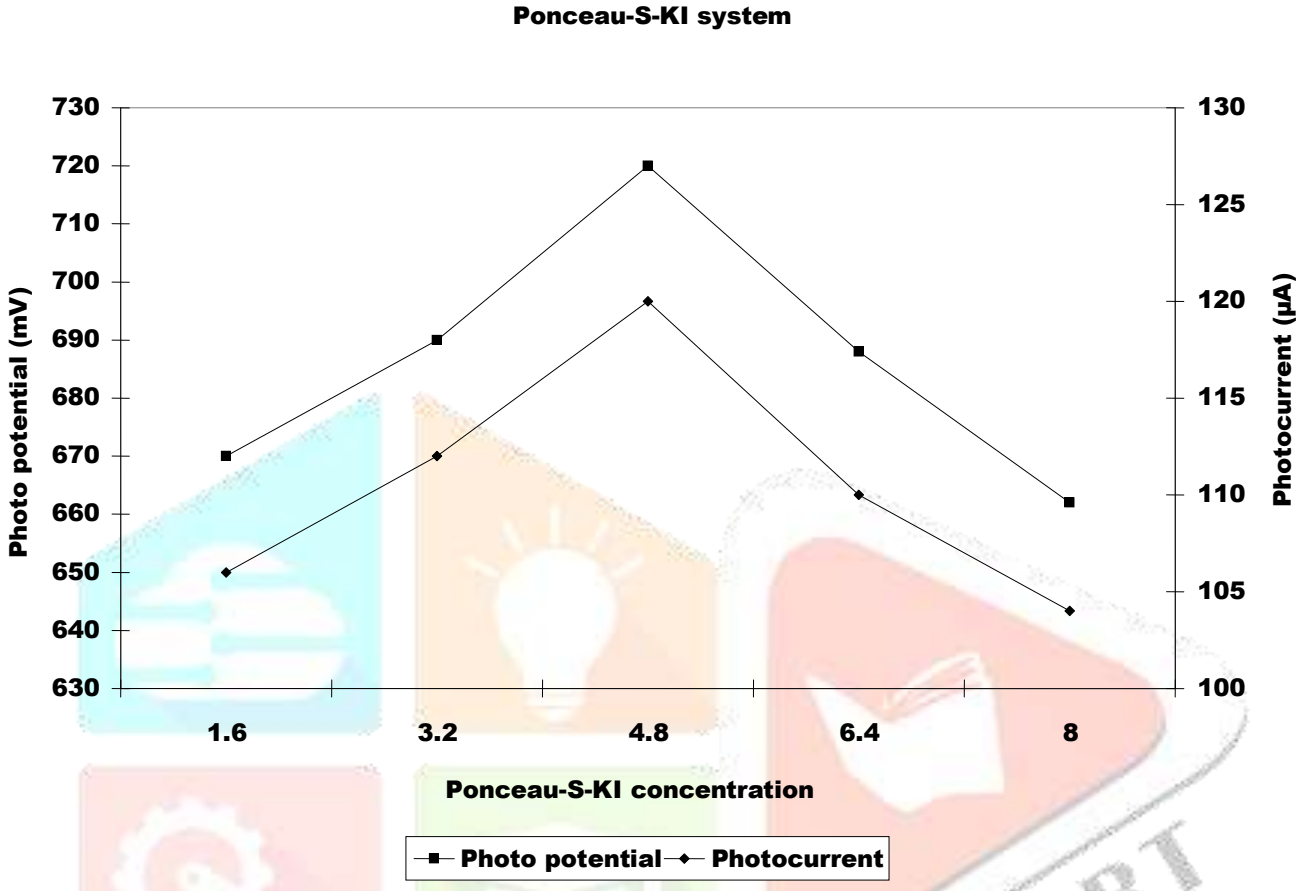

Figure- 3 Variation of photo potential and photocurrent with KI concentration.

3.3 Effect of light intensity

The variation of two electric parameters with light intensity is shown in Figure 4. The photocurrent is linearly increased with increasing in the intensity of the light, whereas the photopotential is increased in a logarithmic manner. The number of photons per unit area (incident power) that strike the dye molecules around the platinum electrode increases with the increase in the light intensity. Hence, the photocurrent and the photopotential of the photo galvanic cell are favorably increased.

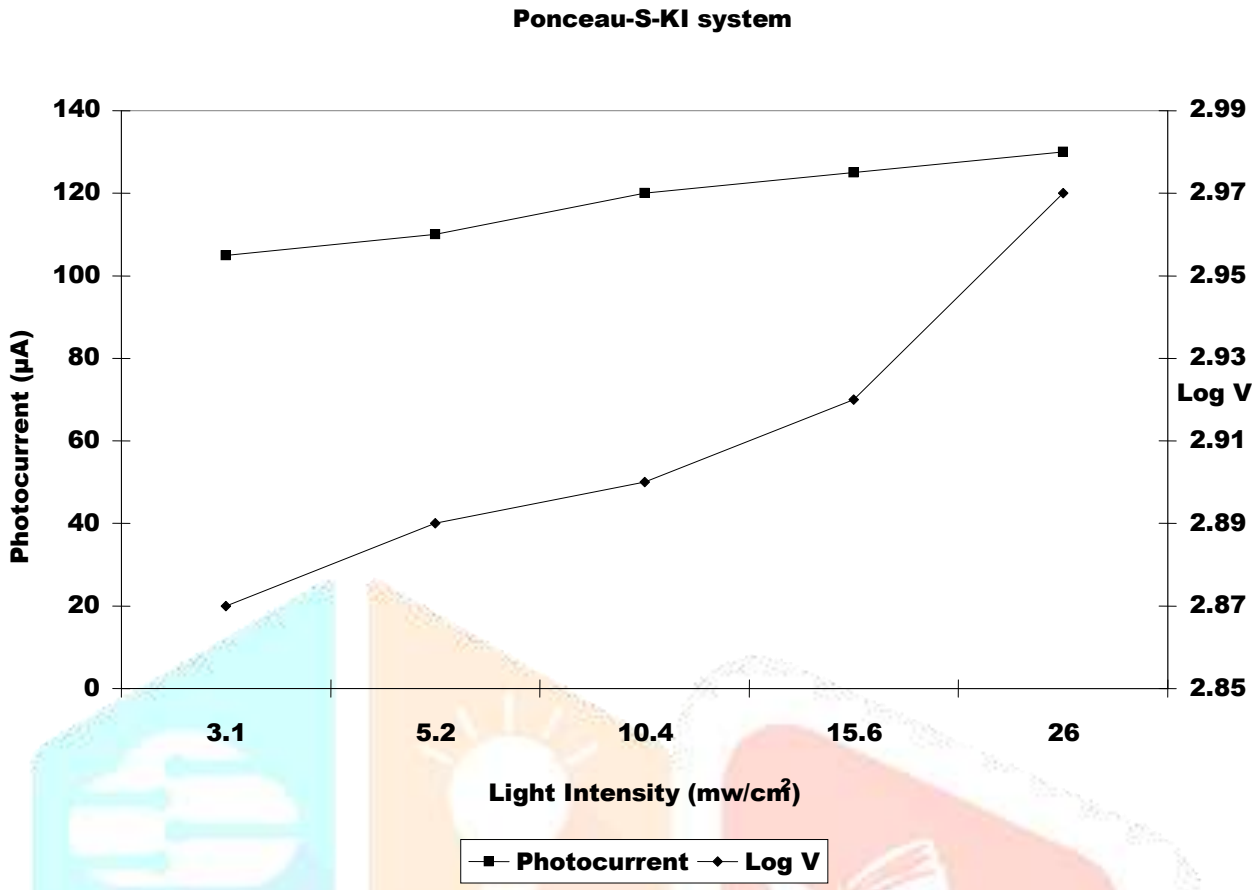

Figure- 4 Variation of photopotential and photocurrent with light intensity.

3.4 Effect of diffusion length

H-cells of different dimensions were used to study the effect of the variation of diffusion length on the current parameters of the cell (i_{max}, $\mathbf{i}_{eq}$ and initial rate of current generation). The results are shown in Figure 5. There was a sharp increase in photocurrent (i_{max}) initially. This behavior indicates an initial rapid reaction, followed by a slow rate-determining step at a later stage.

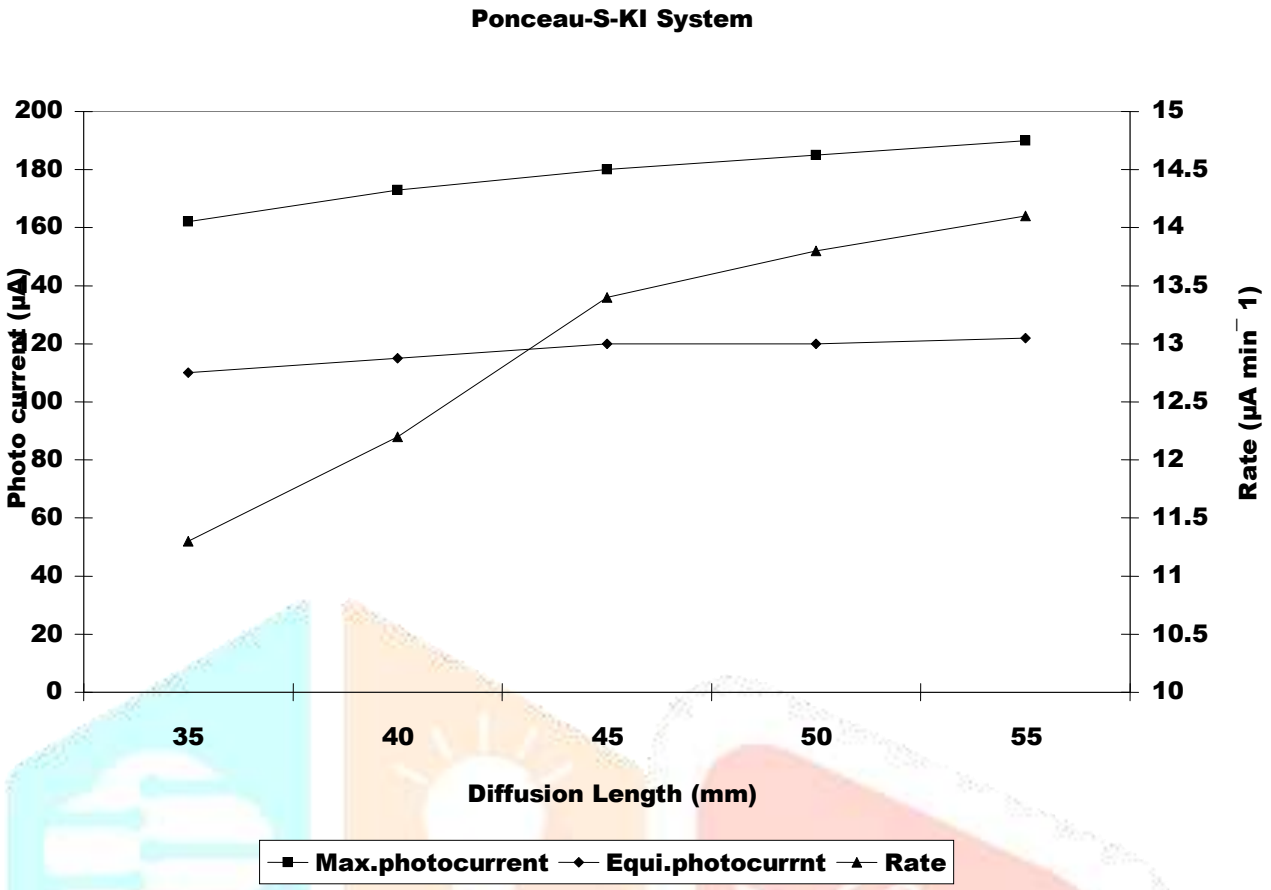

Figure- 5 Variation of current with diffusion length.

3.5 Current voltage (i–V) characteristics, conversion efficiency and performance of the cell

The open-circuit voltage (V_{oc}) and short-circuit current (i_{sc}) of the photogalvanic cell were measured by means of a digital multi-meter (keeping the circuit open) and a micro-ammeter (keeping the circuit closed), respectively. The current and potential between two extreme values (V_{oc} and i_{sc}) were recorded with the assistance of a carbon pot (linear 470 K) that was connected in the circuit of the multi-meter and through which an external load was applied.The i–V characteristic of the cell containing a Ponceau-S KI system is shown in Figure 6. With the help of the i–V curve, the fill factor and conversion efficiency of the cell are found to be 0.55 and 0.1229 %, respectively, using the formula:

$$\text{Fill Factor} = \frac{V_{pp} \times i_{pp}}{V_{oc} \times i_{sc}}$$

$$\text{Conversion Efficiency} = \frac{V_{pp} \times i_{pp}}{10.4 m W c m^{-2}} \times 100 \ \%$$

The potential and the current at the power point [A point in the i–V curve is called the power point (pp) and was determined where the product of photocurrent and photo potential is maximum] are represented by V_{pp} and i_{pp}, respectively.

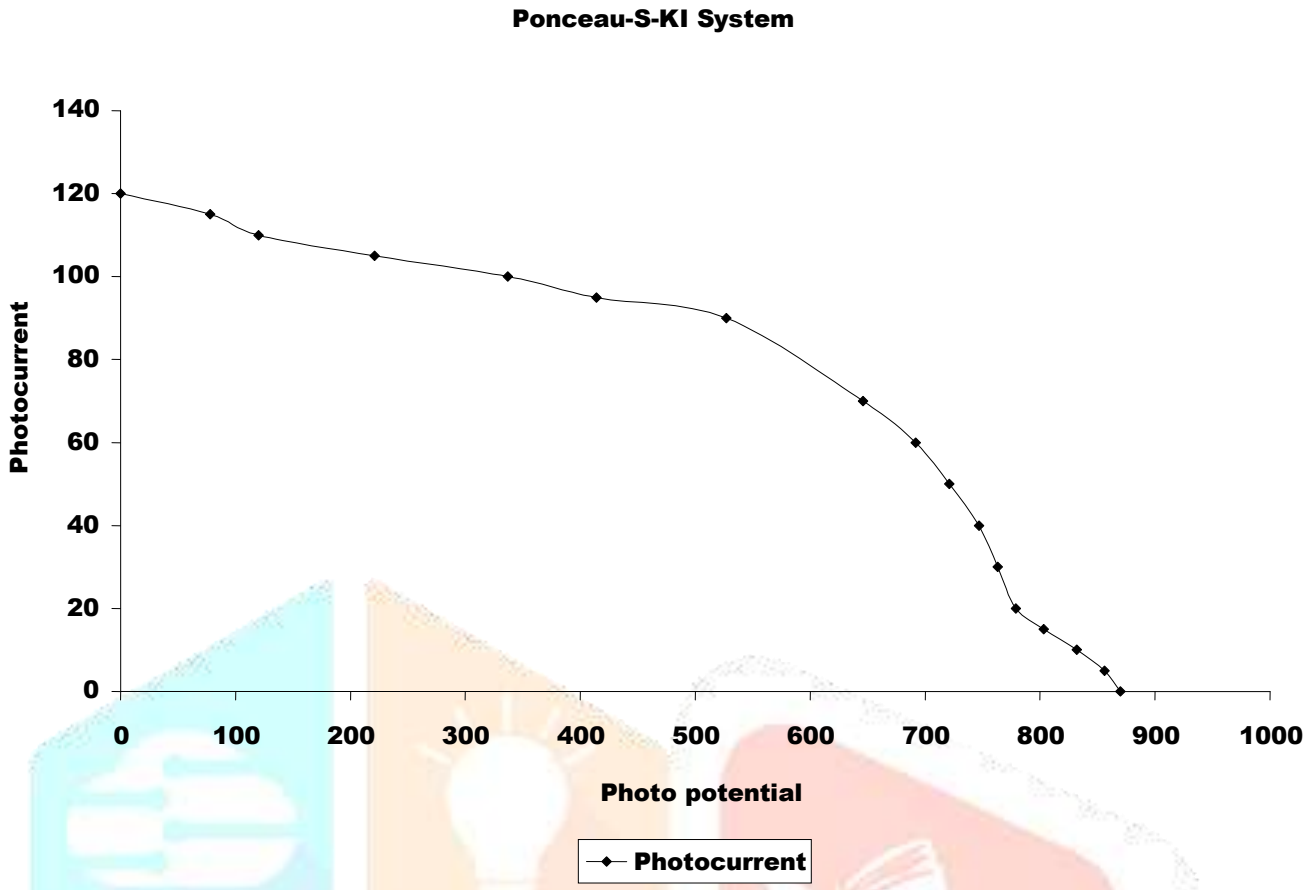

Figure- 6 Current-potential (i-V curve) of the Ponceau-S- KI cell systems

The performance of the cell was studied by applying the external load that was necessary to have the current and the potential at the power point after removing the source of light. The cell can be used in the dark at its power point for 82 min, whereas photovoltaic cell cannot be used in the dark even for a second, a photogalvanic system has the advantage of being used in the dark but at lower conversion efficiency.

3.6 Mechanism

As no reaction is observed between the Ponceau-S and KI in the dark, it may be concluded that the redox potential of KI is much higher than that of Ponceau-S. A rapid fall in potential is observed when the platinum electrode is illuminated. The potential reaches a steady value after certain period of exposure. Although the direction of the change of potential is reversed on removing the source of light, the potential does not returns to its initial value. This means that the main reversible photochemical reaction is also accompanied by some side irreversible reactions. The electro active species in this photo galvanic system is thus different from that of the well-studied thionine–iron (II) system. In the present case, the leuco- or semi reduced dye is considered to be the electrode active species in the illuminated chamber and the dye itself in dark chamber. On the basis of the information gained previously, the mechanism of photocurrent generation in the photo galvanic cell can be represented as follows:

Illuminated Chamber

Bulk solution

$$PS \xrightarrow{h\nu} PS^{*}$$

$$PS^{*} + R \rightarrow PS^{-} + R^{+}$$

At electrode

$$PS^{-} \rightarrow PS + e^{-} \quad \text{(Platinum electrode)}$$

Dark chamber

At electrode

$$PS + e^{-} \rightarrow PS^{-}$$

Bulk solution

$$PS^{-} + R^{+} \rightarrow PS + R \text{ (SCE electrode)}$$

Where, R, R+, PS, PS− are the reductant KI, its oxidized form, Ponceau-S and its leuco or semileuco forms, respectively.

4. Conclusion

On the basis of the results, it is concluded that Ponceau-S can be used successfully as a photo sensitizer in a photo galvanic cell. The conversion efficiency of the cell is 0.1229% and the cell can be used in dark at its power point for 82 min. Photo galvanic cells have the advantages of having in-built storage capacity. Thus, photo galvanic cells show good prospects of becoming commercially viable.

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