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Photogalvanic Effect by using Natural Dye: Rose Flower Extract-Ascorbic Acid System

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ABSTRACT

Solar energy conversion and storage was studied by using Rose Flower Extract as Natural Dye (Photosensitizer) and Ascorbic acid (AA) as Reductant in Photogalvanic cell. The observed power at power point was 93.5 µW and the conversion efficiency was 0.89 %.The observed value of photopotential and photocurrent generated by this cell was 915 mV and 155 µA, respectively. The fill factor 0.54 was experimentally determined at the power point of the cell. The photogalvanic cell can be used in dark for 40 min., showing the storage capacity of the cell against charging time was 190 min. The effect of different parameters on electrical output of the cell was observed and a mechanism has also been proposed for the generation of photocurrent in photogalvanic cell.

KEYWORDS

Rose Flower Extract, Ascorbic Acid, conversion efficiency, fill factor, photopotential and photocurrent

INTRODUCTION

Solar energy is unlimited sources of energy. Solar cells convert sunlight directly to electricity with acceptable conversion efficiency. The photogalvanic effect was first observed by Rideal and Williams [1], but it was systematically investigated by Rabinowitch[2] . Ameta et al[3,4] reported use of toluidine blue nitroloacetic acid (TB-NTA) system in photogalvanic cell for solar energy conversion and also reported the use of micelles in photogalvanic cell for solar energy conversion and storage in Azur A-Glucose system. Jana and Bhowmik [5] reported enhancement in the power output of a solar cell consisting of mixed dyes. Hara et al[6] investigated design of new coumarin dyes having thiophene moieties for highly efficient organic dye-sensitized solar cells. Ameta et al [7] reported use of Bromophenol-EDTA system and Fluoroscein-EDTA system for solar energy conversion and storage. Yadav et al [8-12] reported use of Bismarck Brown-Ascorbic Acid system, Bismarck Brown-Glucose system, Bismarck Brown-EDTA system, Thionine-EDTA-CTAB, Rose Flower Extract with NTA and Mannitol system in photogalvanic cell for solar energy conversion and storage.

EXPERIMENTAL

A glass tube of H-shape was used containing known amount of the solutions of the Rose Flower Extract as Natural Dye, Ascorbic acid (Himedia) as Reductant and sodium hydroxide (Himedia) were used in the present work. The stock solutions of all chemicals were prepared by direct weighing, in doubly distilled water and were kept in colored container to protect them from light. The system was systematically set for photogalvanic studies, which consists of electrochemically treated platinum as electrode and saturated calomel electrodes as a reference electrode. A tungsten lamp was used as light source. Solutions of dye, reductant and sodium hydroxide were taken in an H type glass tube.. The whole system was first placed in dark till a stable potential was obtained and then, the arm containing the SCE was kept in the dark and the platinum electrode was exposed to a 200 W tungsten lamp. 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 generated by the system, respectively. The experimental set-up of photogalvanic cell is given in Figure 1.

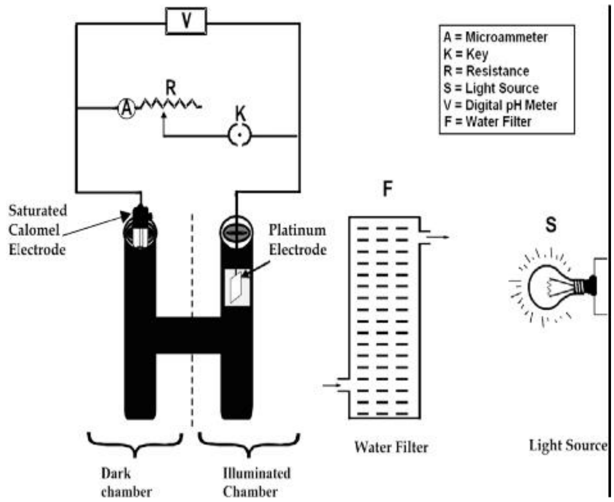

Figure 1: Experimental set up of photogalvanic cell

RESULTS AND DISCUSSIONS

1 Effect of variation of Rose Flower Extract (photosensitizer) concentration on the system

The effect of variation of Rose Flower Extract concentration on photopotential, photocurrent and power are shown in Figure 2. With the increase in concentration of the Rose Flower Extract (photosensitizer) in present system, the photopotential and photocurrent were found to increase until it reaches a maximum value. On further increase in concentration of photosensitizer a decrease in electrical output of the cell was found. At lower concentration range of photosensitizer, there are a limited number of photosensitizer molecules to absorb the major portion of the light in the path and a fewer number of electrons reach to the platinum electrode.

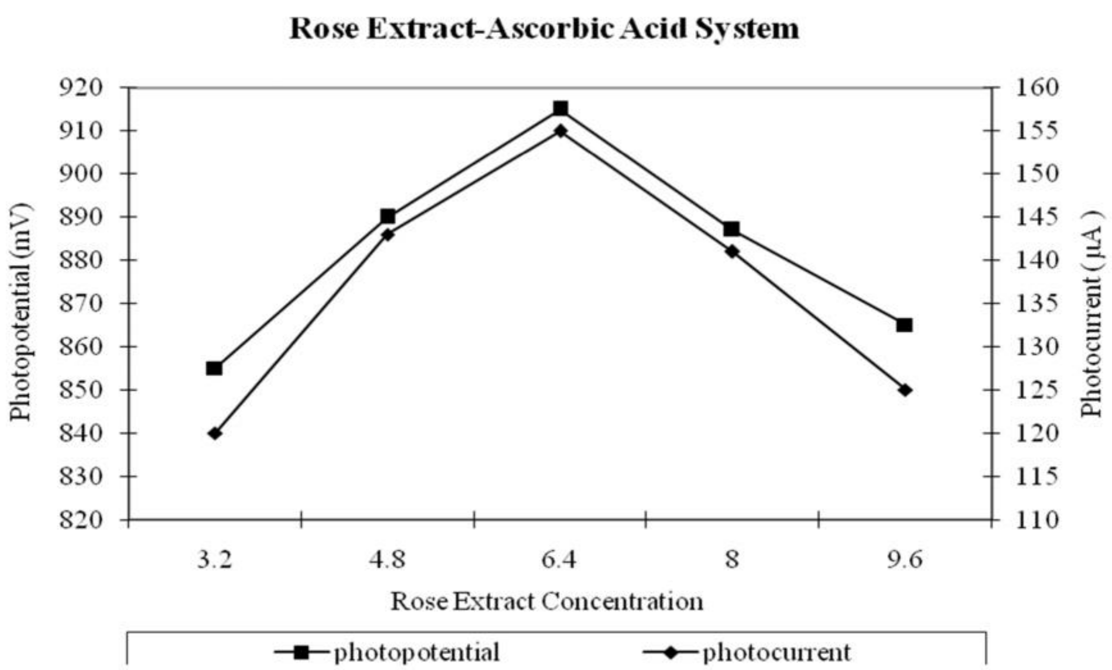

Figure 2: Variation of Photopotential and Photocurrent with Rose Flower Extract concentration

2 Effect of variation of Ascorbic Acid (reductant) concentration on the system

The effect of variation of Ascorbic Acid concentration on the photopotential and photocurrent of system is shown in Figure 3. It was observed that with the increase in concentration of the Ascorbic Acid (reductant), the photopotential was found to increase till it reaches a maximum value. On further increase in concentration of reductant, a decrease in the electrical output of the cell was observed. The fall in power output was also resulted with decrease in concentration of reductant due to less number of molecules available for electron donation to the dye.

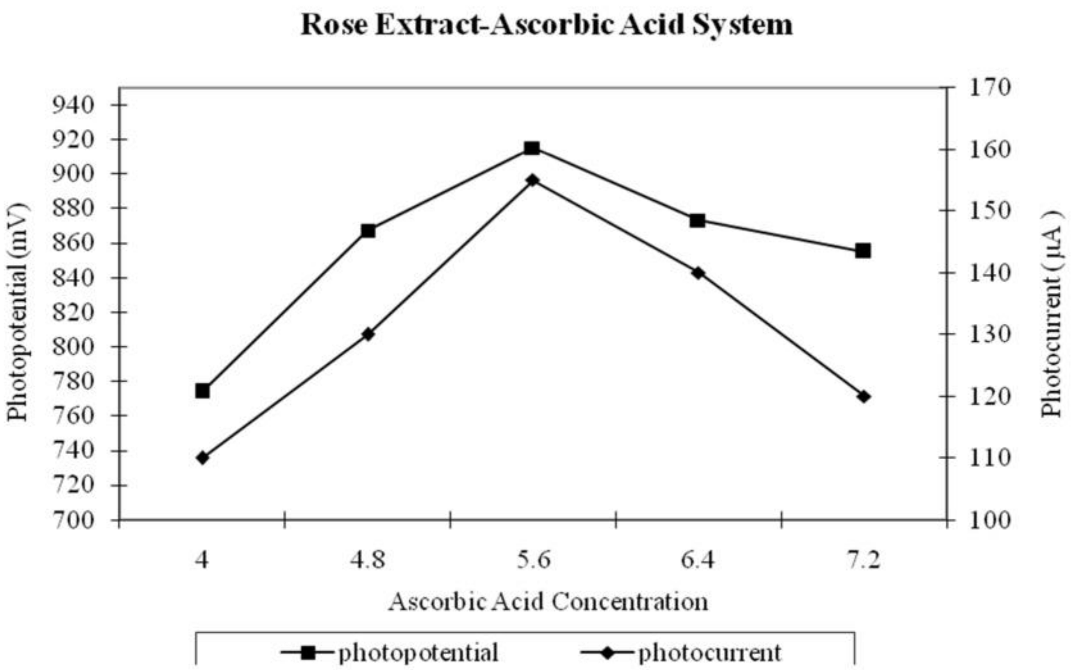

Figure 3: Variation of Photopotential and Photocurrent with Ascorbic Acid concentration

3 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 multimeter (keeping the circuit open) and a microammeter (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 multimeter and through which an external load was applied. The i–V characteristics of the cell containing Rose Flower Extract- Ascorbic Acid System are shown in Figure 4. The curve for the cell deviates from its ideal regular rectangular shape. A point in the i–V curve, called the power point (pp), was determined where the product of photocurrent and photopotential is maximum. The potential and the current at the power point are represented by V_{pp} and i_{pp}, respectively. With the help of the (i–V) curve, the Fill Factor and Conversion Efficiency of the cell are found to be 0.54%, and 0.89 %, respectively. , using the formulae:

$$\text{Fill Factor} = \frac{V_{pp} \times i_{pp}}{V_{oc} \times i_{sc}} \qquad (1.1)$$

$$\text{Conversion Efficiency} = \frac{V_{pp} \times i_{pp}}{10.4 mWcm^{-2}} \times 100 \ \% \qquad (1.2)$$

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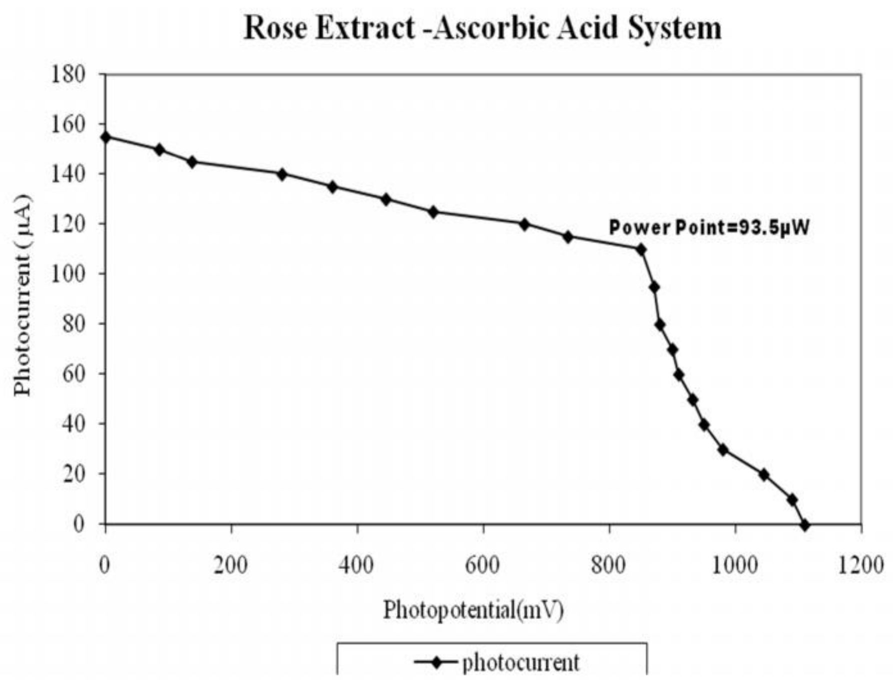

Figure 4: Current-potential (i-V characteristics) of the Cell

MECHANISM

On the basis of these observations, a mechanism is suggested for the generation of photocurrent in the photogalvanic cell as:

Dye $\longrightarrow$ Dye* (1)

Dye* + R $\longrightarrow$ Dye^- (Semi or leuco) + R^+ (2)

Dye- $\longrightarrow$ Dye + e^- (3)

Dye + e^- $\longrightarrow$ Dye^- (Semi or leuco) (4)

Dye^- + R^+ $\longrightarrow$ Dye + R (5)

Where Dye, Dye*, Dye^-, R and R^+ are the dye, excited form of dye, semi or leuco form of dye, Reductant and oxidized form of the Reductant, respectively.

CONCLUSION

Conclusively the Ascorbic Acid as Reductant and Rose Flower Extract as Natural dye can be used successfully in a photogalvanic cell. The conversion efficiency and storage capacity of the cell is 0.89 % and 40 minutes respectively, on irradiation for 190 minutes developed photogalvanic cell. It has been observed that the Natural Dye has not only enhanced the electrical parameters (i.e. Photopotential, photocurrent and power) but also enhanced the conversion efficiency and storage capacity of photogalvanic cell. The efforts are also successful because of the photogalvanic cells showed good prospects of becoming commercially viable.

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