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Study the performance of photogalvanic cells for solar energy conversion and storage: Rose Bengal–D-Xylose–NaLS system

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Abstract

The Rose Bengal is used as photosensitizer with D-Xylose as reductant and sodium lauryl sulphate (NaLS) as surfactant for the enhancement of the conversion efficiency and storage capacity of photogalvanic cell for its commercial viability. The observed value of the photogeneration of photopotential was 885.0 mV and photocurrent was 460.0 μA whereas maximum power of the cell was 407.10 μW. The observed power at power point was 158.72 μW and the conversion efficiency was 1.52%. The fill factor 0.3151 was experimentally determined at the power point of the cell. The rate of initial generation of photocurrent was 63.88 μA min^{-1}. The photogalvanic cell so developed can work for 145.0 min in dark on irradiation for 165.0 min, i.e. the storage capacity of the photogalvanic cell is 87.87%. A simple mechanism for the photogeneration of photocurrent has also been proposed.

Keywords: Rose Bengal; D-Xylose; Sodium lauryl sulphate; Conversion efficiency; Storage capacity; Photocurrent

1. Introduction

The development of viable and long-term solution to meet our energy needs, that also maintains the quality of our environment which remains one of the most critical challenge is being facing by the scientific community. The solution of this challenge increasingly depend on electrochemical processes in solids. The solar energy is easily available, cheaper, environmental friendly source and has the potential to provide energy with almost zero emission. The novel approach for renewable sources of energy has led to an increasing interest in photogalvanic cells because of their reliable solar energy conversion and storage capacity. In present work, the photons of sunlight are used as driving force for the conversion and storage of sunlight in photogalvanic cell. The photogalvanic effect was first of all observed by Rideal and Williams (1925) but it was systematically investigated by Rabinowitch (1940a,b) and later on Clark and Eckert (1975), and Hall et al. (1977). Wildes (1977), Murthy et al. (1980), Suda et al. (1978), Dixit and Mackay (1982), Hamdi and Aliwi (1996) and Bayer et al. (2001) have reported the various systems in photogalvanic cell for solar energy conversion and storage. Jinting et al. (2008) have observed the performance of dye-sensitized solar cells based on nanocrystals TiO_2 film prepared with mixed template method. The performance of photogalvanic cells for the conversion of solar energy into electrical energy and storage capacity depends on the photochemistry of the cell. According to Albery and Archer (1977), the conversion efficiency of the photogalvanic cell could be as large as 18% but it is unlikely that all the necessary conditions can be met. A more reliable estimate of the maximum power conversion efficiency that could be achieved from a photogalvanic cell is between 5% and 9%. Memming (1980) and

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Bhardwaj et al. (1981) have suggested the process of solar energy conversion by photoelectrochemical process and chloroplast photoelectrochemical cells, respectively. Groenen et al. (1984) have observed micelles effect in the ferrous/thionine photogalvanic cell.

Recently the photogalvanic effects have been observed in various systems by Dube and Sharma (1994), Dube (2007), Lal (2007), Pramila and Gangotri (2007), Kumari et al. (2009), Genwa et al. (2009), Gangotri and Bhimwal (in press), Gangotri and Gangotri (2009) and Gangotri and Indora (2010) for solar energy conversion and storage in photogalvanic cells. They have used different photosensitizers, micellar species and reductants in photogalvanic system, but no attention has been paid to use of the Rose Bengal–D-Xylose–NaLS system to enhance the electrical output i.e. 460.0 μA and storage capacity i.e. 87.87% of the photogalvanic cells and to reduce the cost of the cell to gain commercial viability. Therefore, the present work was undertaken and the variation of the power output with the concentrations of the reductant, surfactant, sodium hydroxide, variation of diffusion length and other parameters of the cell is found to be quite sensitive.

2. Experimental method

A glass tube of H-shape was used containing known amount of the solutions of the photosensitizer – Rose Bengal (Merck) with reductant-D-Xylose (Loba), surfactant-sodium lauryl sulphate (s.d. fine) and sodium hydroxide (Merck) in the present work. The total volume of the mixture was always kept 25.0 ml making up by doubly distilled water. All the solutions were kept in amber coloured containers to protect them from sunlight. A platinum electrode ($1.0 \times 1.0\ cm^2$) was dipped in one limb having a window and a saturated calomel electrode (SCE) was immersed in another limb of the H-tube. The terminals of the electrode were connected to a digital pH meter (Systronics model-335) and the whole cell was placed in the dark. The potential (mV) was measured in dark when the photogalvanic cell attained a stable potential. Then, the limb containing platinum electrode was exposed to a 200 W tungsten lamp (Sylvania) as light source. Employing lamps of different wattage varies the light intensity. A water filter was placed between the illuminated chamber and the light source to cut-off infrared radiations. On illumination, the photochemical bleaching of Rose Bengal was studied potentiometrically. The photopotential and photocurrent generated by the system was measured with the help of the digital pH meter and microammeter (Ruttonsha Simpson), respectively. The current–voltage characteristics of photogalvanic 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 photogalvanic cell is given in Fig. 1.

3. Results and discussion

3.1. Effect of variation of photosensitizer (Rose Bengal) concentration on the system

With the increase in concentration of the photosensitizer (Rose Bengal) 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. The effect of variation of Rose Bengal concentration on photopotential and photocurrent are reported in Table 1.

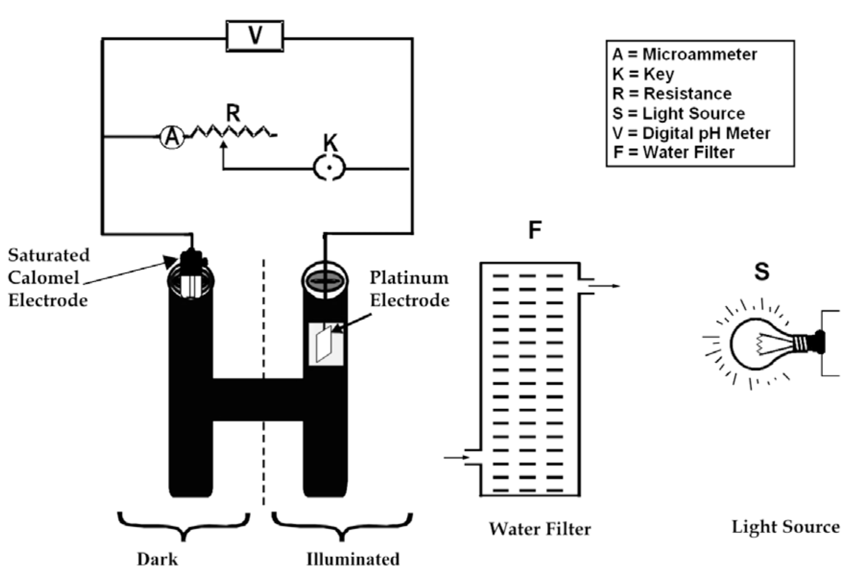

Fig. 1. Experimental set-up of photogalvanic cell.