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Photogalvanic cell for conversion of solar energy into electricity: Safranine–Arabinose–Sodium lauryl sulphate system

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Abstract

Photogalvanic cell containing safranine as photosensitizer, arabinose as electron donor and sodium lauryl sulphate (NaLS) as micelles species, has been used for conversion of solar energy into electricity. The photopotential and photocurrent generated were 827.0 mV and 117 μA, respectively. The effect of various parameters like concentration of photosensitizer, electron donor and micelles, variation of pH, light intensity and diffusion path length were observed. A current–voltage (*i–V*) characteristics of the cell was studied and the conversion efficiency and fill factor were determined at the power point of the cell. The photogalvanic cell can be used for 91.0 min in the dark due to its storage capacity. A tentative mechanism has been proposed for the generation of the photocurrent. The electrical output of the cell has also been observed for safranine and arabinose only (without micelles species) system.

Keywords: Photogalvanic cell; Safranine; Arabinose; Sodium lauryl sulphate; Conversion efficiency; Storage capacity

1. Introduction

Energy is the basic need of humanity in the modern society and the demand of energy is rising faster day by day due to increase in industrial, agricultural and developmental activities. The conventional resources like wood, coal, oil, petrol, diesel, natural gas, fuel gas, etc. are being used at very high rate leading to continuous depletion. The depletion rate of these sources brought the attention of the scientific community to search out renewable sources of energy for pressing demand of energy in future. The solar energy is one of the most promising important and practically unlimited sources of regenerative energy. It has been understood that development and implementation of cheap and functional system for efficient solar energy conversion and storage is of crucial importance for the humanity.

The photoeffects in electrochemical systems were first observed by Becquerel (1839) in his investigation on the solar illumination on metal electrodes. Thompson (1915) observed some photoactive cells with fluorescent electrolytes. The photogalvanic effect was first observed by Rideal and Williams (1925) though it was systematically investigated by Rabinowitch (1940a,b) for iron–thionine system. Later on, Albery et al. (1979), Ameta et al. (1990), Casado et al. (1989), Groenen et al. (1984), Khamesra et al. (1991), Prajuntaboribal and Chaikum (1987), Riggs and Bricker (1968), Roy and Aditya (1983), Shirotsuka et al. (1980), Zaromb et al. (1961) and Zeichner et al. (1978) have reported some interesting photogalvanic cells.

In the photogalvanic cell mixed dyes with different reductants and surfactants have been used by Gangotri

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and Lal (2000), Jana and Bhowmik (1997), Lal (2007) and Lal and Yadav (2007) whereas mixed reductants with different dyes and surfactants systems have been used by Dube (1993), Gangotri et al. (2010a) and Gangotri and Indora (2010). The various micellar species with different dyes and reducing agents have been used by Ameta et al. (1990), Gangotri and Gangotri (2009), Genwa et al. (2009), Khamesra et al. (1991) and Pramila and Gangotri (2007) in the photogalvanic cells for solar energy conversion and storage. Theoretically conversion efficiency of photogalvanic cell is about 18%, but the observed conversion efficiencies are quite low due to lower stability of dyes, back-electron transfer, aggregation of the dye molecules around electrode, etc. The problems encountered in the field of development of photogalvanic cells have been discussed time to time.

Recently Bhati and Gangotri (2011), Bhimwal and Gangotri (2011), Chandra and Meena (2011), Gangotri et al. (2010b), Gangotri and Bhimwal (2010), Gangotri and Gangotri (2010a,b), Gangotri and Solanki (2010), Genwa and Khatri (2009), Genwa and Mahaveer (2008), Koli et al. (2012) and Yadav and Lal. (2010, 2011) have developed some interesting photogalvanic cells with reasonable electrical output. They have used different photosensitizers, reductants and surfactants in photogalvanic cells but no attention has been paid to use safranine–arabinose–NaLS combination to enhance the conversion efficiency and storage capacity of the photogalvanic cell. Our study reveals that cell containing safranine–arabinose–NaLS gives higher electrical output with better storage capacity, with special attention to reduce the cost of the cell to gain commercial viability, therefore, the present work was undertaken.

2. Experimental section

Safranine (s.d. fine), arabinose (Loba chemie), NaLS (s.d. fine) and sodium hydroxide (Merck) were used in the present work. All the solutions were prepared in doubly distilled water and were kept in amber coloured containers to protect them from light. A mixture of known amounts of solution of safranine, arabinose, NaLS and sodium hydroxide were taken in an H-shaped glass tube. The total volume of the mixture was always kept at 25.0 mL with make up by doubly distilled water. A platinum electrode was immersed in one arm of the H-tube having a window and a saturated calomel electrode (SCE) was immersed in the other arm of the H-tube. The terminals of the electrodes were connected with a digital pH meter (Systronics Model-335) and a microammeter (Runttonsha, Simpson). The whole system was first placed in the dark till a stable potential was obtained. Thereafter, the arm having platinum electrode was exposed to a 200 W tungsten lamp (Sylvania) and other arm having the saturated calomel electrode was kept in dark. Lamps of different wattage were used as source of the light and a direct reading solarimeter was used to measure the intensity of light. A water filter was placed between the illuminated chamber and the light sources to avoid the effect of thermal radiations.

On illumination, the photochemical bleaching of photosensitizer was studied potentiometrically. The photopotential and photocurrent generated by the system were measured with the help of the digital pH meter and microammeter, respectively, using the key to close one circuit and open the other circuit. The current–voltage (i–V) characteristics of the cell were studied by using an external load with the help of a carbon pot (log 470 K) connected in the circuit. The experimental set up of the cell is given in Fig. 1.

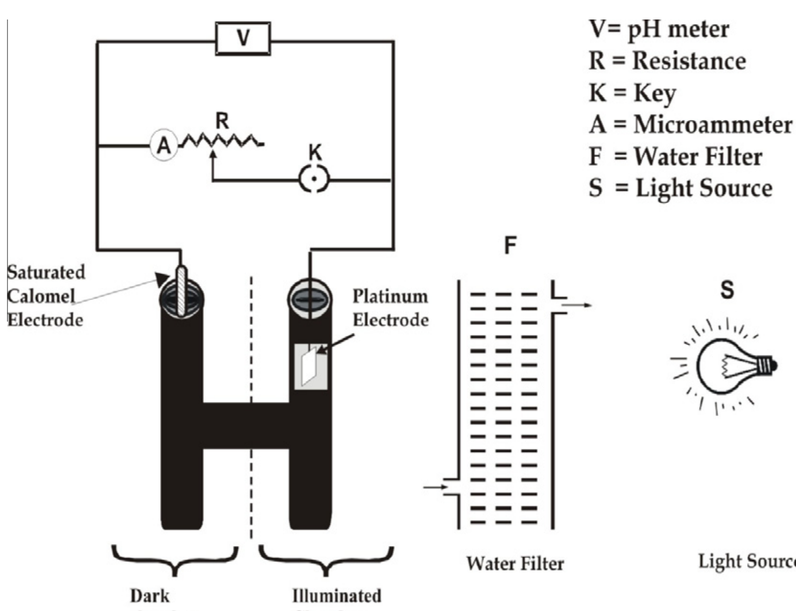

Fig. 1. Experimental set up of photogalvanic cell.