

# USE OF TRITON X-100 IN A PHOTOGALVANIC CELL FOR SOLAR ENERGY CONVERSION AND STORAGE: THIONINE-EDTA SYSTEM

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الخلاصة :

لقد تمّ استخدام كلٍّ من : ثيونين ، وإيثيلين ثنائي أمين رباعي حمض الاسيتيك ، وترايتون (X-100) على التوالي كمواضع حساسة ضوئياً ومختزلة ومنظّفة وذلك في خلية جلفانية ضوئية لغرض تحويل الطاقة الشمسية . وأمكن توليد تيار ضوئي وجهد ضوئي في هذه الخلية مقدارهما ( ٧٠,٠ ميكروامبير ) و ( ٨٨٨,٠ ميلي فولت ) على التوالي . وتم دراسة تأثير عوامل متعددة على مردود الخلية الكهربائي وملاحظة خصائص تغيير التيار مع الجهد في هذه الخلية .

## ABSTRACT

Thionine, ethylenediaminetetraacetic acid, and Triton X-100 (Tx) have been used as photosensitizer, reductant, and surfactant, respectively in a photogalvanic cell for solar energy conversion. The photocurrent and photopotential generated by this cell were 70.0  $\mu$ A and 888.0 mV, respectively. The effect of various parameters on the electrical output of the cell was studied, and current-voltage characteristics of the cell have also been observed.

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$$\text{pH} = \text{p}K_a + \log \frac{[\text{Salt}]}{[\text{Acid}]},$$

at  $\text{pH} > \text{p}K_a$

$[\text{Salt}] \gg [\text{Acid}]$  [Ionic form]  $\gg$  [Unionized form].

### Effect of Variation of Reductant Concentration

The electrical output of the cell was affected by the variation in reductant concentration in the system. The results are summarized in Table 3.

**Table 3. Effect of Variation of EDTA Concentration.**

[EDTA] $\times 10^4$ M	Photopotential (mV)	Photocurrent ( $\mu\text{A}$ )
7.20	668.0	31.0
7.60	746.0	47.0
8.00	824.0	62.0
8.40	888.0	70.0
8.80	815.0	61.0
9.00	766.0	49.0

Lower concentration of reductant resulted into a fall in electrical output because fewer reductant molecules are available for electron donation to dye molecules. A still larger concentration of reductant again resulted into a decrease in electrical output because the large number of reductant molecules may hinder the dye molecules from reaching the electrode within the desired time limit.

### Effect of Variation of Dye Concentration

The effect of variation of dye concentration on electrical output of the cell was studied and results are given in Table 4.

A decrease in dye concentration resulted into a fall in electrical output because fewer dye molecules are available for the excitation and subsequent donation of electrons to the platinum electrode. A still larger concentration of dye resulted in a decrease in electrical output as the intensity of light reaching the dye molecule near the electrode decreased due to absorption of the major portion of the light by dye molecules present in the path.

**Table 4. Effect of Variation of Thionine Concentration.**

[Thionine] $\times 10^4$ M	Photopotential (mV)	Photocurrent ( $\mu\text{A}$ )
1.00	698.0	41.0
1.15	732.0	49.0
1.35	816.0	61.0
1.47	888.0	70.0
1.60	765.0	58.0
1.75	704.0	46.0

### Effect of Diffusion Length

The effect of diffusion length (distance between the electrodes) on the current parameters of the cell ( $i_{\text{max}}$ ,  $i_{\text{eq}}$ , and initial rate of generation of current) was studied using H-cells of different dimensions.

There are three possibilities for the combination of electroactive species:

- (i) The dye (D) itself is electrode-active in the illuminated chamber and the oxidized form of the reductant ( $\text{R}^+$ ) in the dark chamber;
- (ii) The leuco form ( $\text{D}_L$ ) or semi-leuco form ( $\text{D}_S$ ) of the dye and the oxidized form of the reductant are the main electrode-active species in the illuminated and dark chambers, respectively; and
- (iii) The dye itself is the electrode-active species in the dark chamber and its leuco or semi-leuco form in the illuminated chamber.

If the oxidized form of the reductant ( $\text{R}^+$ ) is considered to be an electrode-active species in the dark chamber, then it must diffuse from the illuminated chamber to the dark chamber to accept an electron from the dark electrode. On these grounds, the  $i_{\text{max}}$  and initial rate of photocurrent generation should decrease on increasing the diffusion length, as the oxidized form of the reductant is formed only in the illuminated chamber and the time taken by this electrode-active species to reach the other electrode will be affected by the diffusion length. However, in the present case the initial rate of photocurrent generation and  $i_{\text{max}}$  were found to be proportional to the diffusion lengths, while the value of  $i_{\text{eq}}$  was found to be independent of this variation and, therefore, the first two probabilities (i) and (ii) become invalid.

On the basis of experimental observations, it is concluded that the oxidized form of the reductant ( $R^+$ ) cannot be the electrode-active species in the dark chamber. The only possibility then is, the dye itself is the electrode-active species in the dark chamber and therefore, the corresponding electrode-active species in the illuminated chamber will be the semi-leuco ( $D_s$ ) or leuco ( $D_L$ ) form of the dye.

#### Current Voltage ( $i-V$ ) Characteristics, Conversion Efficiency and Performance of the Cell

The short circuit current ( $i_{sc}$ ) and the open circuit voltage ( $V_{oc}$ ) of the photogalvanic cell were measured with a multimeter (keeping the circuit closed) and with a digital pH meter (keeping the circuit open), respectively. The current and potential values in between these two extreme values ( $V_{oc}$  and  $i_{sc}$ ) were recorded with the help of a carbon pot (log 500 K) connected in the circuit of the multimeter through which an external load was applied.

It was observed that the  $i-V$  curve of the cell deviated from its ideal regular rectangular shape. A point in  $i-V$  curve, called the power point (pp), was determined where the product of potential and current reached a maximum. The values of potential and current at the power point is represented as  $V_{pp}$  and  $i_{pp}$ , respectively. With the help of  $i-V$  curve, the fill factor and conversion efficiency of the cell were determined as 0.26 and 0.18%, respectively.

The performance of the cell was studied by applying the external load necessary to maintain the current and potential at the power point after removing the source of light. It was observed that the cell can be used in the dark at its power point for 60 minutes.

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