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Short Communication

Photoelectrochemical cell

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Abstract

The photoresponse of chemically synthesized polyaniline (PAn) film has been studied. PAn, casted in the form of film, on ITO glass substrate formed the photoanode, 0.1 M aqueous $LiClO_4$ solution has been used as electrolyte and platinum as counter electrode. This photocell shows good performance.

Keywords: Polyaniline, Photocell.

Introduction

In recent few decades many researchers have focused their work in one of the most important source of energy i.e Solar energy. Fujishima Honda[1] was the first scientist who had suggested the applications of semiconductor polymers in liquid junction for solar energy conversion. A new field of research has been created by the generation of photocurrent due conjugated polymers in liquid junction. This field is different from the photo electrochemistry of conventional solid crystalline semiconductors. Due to low manufacturing cost of semiconductor polymers, these polymers will have a wide range of possibilities for technological application not only in photo electrochemical cell but also in photo anodes. Previously in order to resist the anodic photo corrosion of negative type semiconductors in liquid junction[2] conductive polymers were used. It is observed similar effect by covering various negative type semiconductors with PAn. I-V characteristics of such materials are studied[3].

If light with sufficient energy more than band gap is fall on conducting polymers than charge carriers are generated due to photoelectric effect. These generated charge carriers are unstable in nature. Such a way charge carriers are generated which result in photocurrent. This mechanism in poly (trans-acetylene) have been explained by Pokhodenko et al[4]. Photo response of the order 10µA was reported at a depletion layer of polyaniline of a p-type semiconductor in an aqueous $LiClO_4$ solution[4,5]. In $LiCLO_4$ reduced form of PAn shows 100µA photocurrent at saturation[6]. This type of PEC cells were explained without addition of redox species in the electrolyte solution.

It was observed that after inclusion of redox species stability of photocurrent in PAn increases under the continuous irradiation[7]of light. Fernando et al[8] had studied the rapid photoresponse current component of PAn.

Photocurrent produced by the external circuit in a reduced form of PAn having higher energy band gap is observed to be a weak signal. Thus in this situation small number of electron-hole pairs are produced due to low photocurrent density.

From the literature survey it was found that most of the photoelectrochemical studies of polyaniline have been carried out using cyclic voltametry for the synthesis of polyaniline. In the present work chemically synthesized PAn in the form of transparent and thin film has been used as a photoanode to study the photoelectrochemical response.

Materials and methods

Preparartion of photoanode: Half area of conducting ITO glass plate was covered by coating film of clear solution of polyaniline in formic acid. Conducting glass was obtained from Chemical Physics Division, TIFR, Mumbai. The film showed electrical conductivity of about $10^{-1}Scm^{-1}$. Copper wire was used to create a contact lead, with one of its end sealed over the PAn film with the help of epoxy (Araldite). The SnO_2 layer of ITO glass works as back contact for PAn – formic acid film. All the portion of ITO glass on which film was not deposited was also sealed with epoxy. Such a way photoanode with thickness of 0.2 to 0.3 µm was prepared.

Cathode: Platinum was used as counter electrode (cathode).

Reference electrode: Here we use Standard calomel electrode as reference electrode.

Electrolyte: 0.1 M aqueous solution of $LiClO_4$ was used as electrolyte to study photoelectric effect of PAn.

Fabrication of Photocell: Figure-1 shows PEC cell where semiconducting thin film of formic acid-PAn is used, 0.1 M aqueous $LiClO_4$ solution is used as an electrolyte. Tungsten halogen lamp of 150 watt has been used as a light source.

The face of photoanode was illuminated with this source of light. The intensity of illumination was varied using variac which was connected to the halogen lamp. The intensity of illumination was measured with the help of a lux meter.

Current - voltage characteristics – For studying the current – voltage characteristics of PEC cell, it is necessary to select proper intensity of light for illumination of the cell. I_{sc} and V_{oc} both depend on light intensity. In experimental observation V_{oc} and Isc reaches its maximum value as they increase with intensity of light. This maximum value attended by them is at light intensity of $70mW/cm^2$ or above.

It is also observed that I_{ph} and V_{ph} varies with R_L for a steady illumination of PEC by $70mW/cm^2$.

Results and discussion

Figure-2 shows I_{ph}-V_{ph} characteristics for the thin films of PAn-formic acid photoanode exposed to constant light intensity of $70mW/cm^2$. From these characteristics parameters like I_{sc}, V_{oc}, I_{max}, and V_{max} have been obtained.

The maximum output power of the cell (Pm) has been calculated using the relation

$$P_m = I_m \times V_m = V_{oc} \times I_{sc} \times ff$$

Where: ff is the fill factor, V_m and I_m have been calculated from I_{ph}-V_{ph} curve for maximum power.

ff has been calculated from the relation

$$ff = \frac{\text{Im x Vm}}{\text{Voc x Isc}}$$

Hence the value of fill factor decided the quality of PEC[9].

The efficiency of such a solar cell is,

$$\eta = \frac{\text{Voc x Isc x ff}}{\text{Pin}} \text{ x } 100\% \quad \text{or} \quad \eta = \frac{\text{Pm}}{\text{Pin}} \text{ x } 100\%$$

Where: P_{in} is maximum power at $70mW/cm^2$ in this case.

From the I_{ph}-V_{ph} plot the fill factor is calculated and is found to be 0.3, the efficiency (η) of the PEC cell is obtained as 1.3.

The stability of the PEC cell is also tested by plotting I_{ph} v/s time for fixed value of intensity. The plot I_{ph} versus time is shown in Figure-3. From this plot it can be observed that the photocurrent initially increases and after 2-3 minutes of illumination, the photocurrent reaches maximum value. After that the current slowly falls off and becomes almost steady after about 20 minutes. Thus using this type of PEC cell, almost steady current of about 20μA can be obtained with constant illumination with $70mW/cm^2$. Thus light intensity can be used as E.M.F. of a cell using a simple formic acid doped polyaniline thin film.

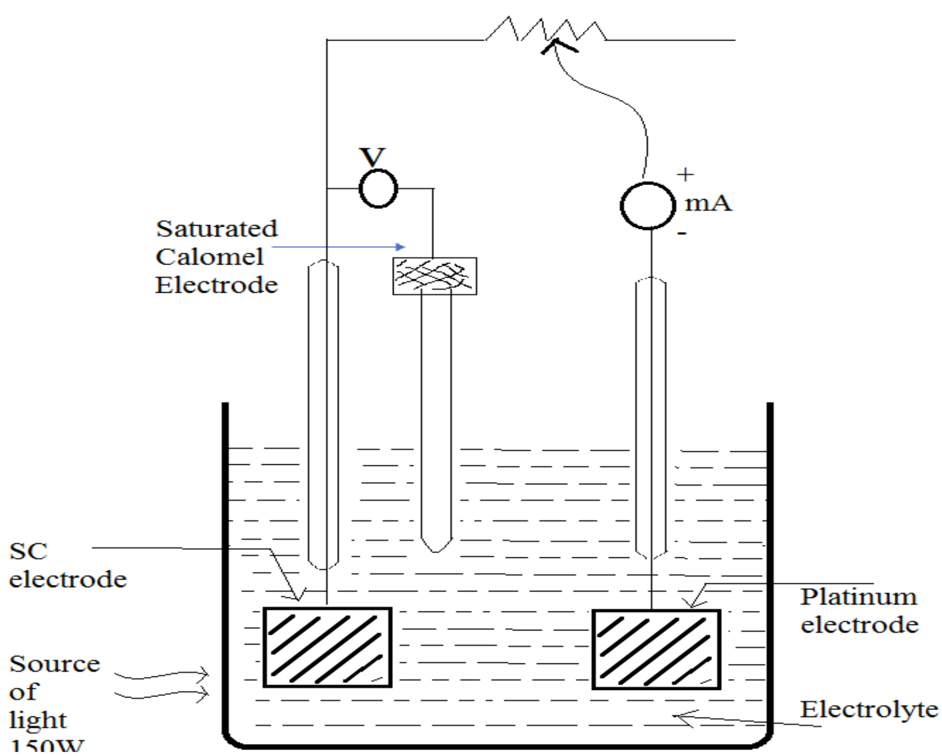

Figure-1: Photoelectrochemical Cell.

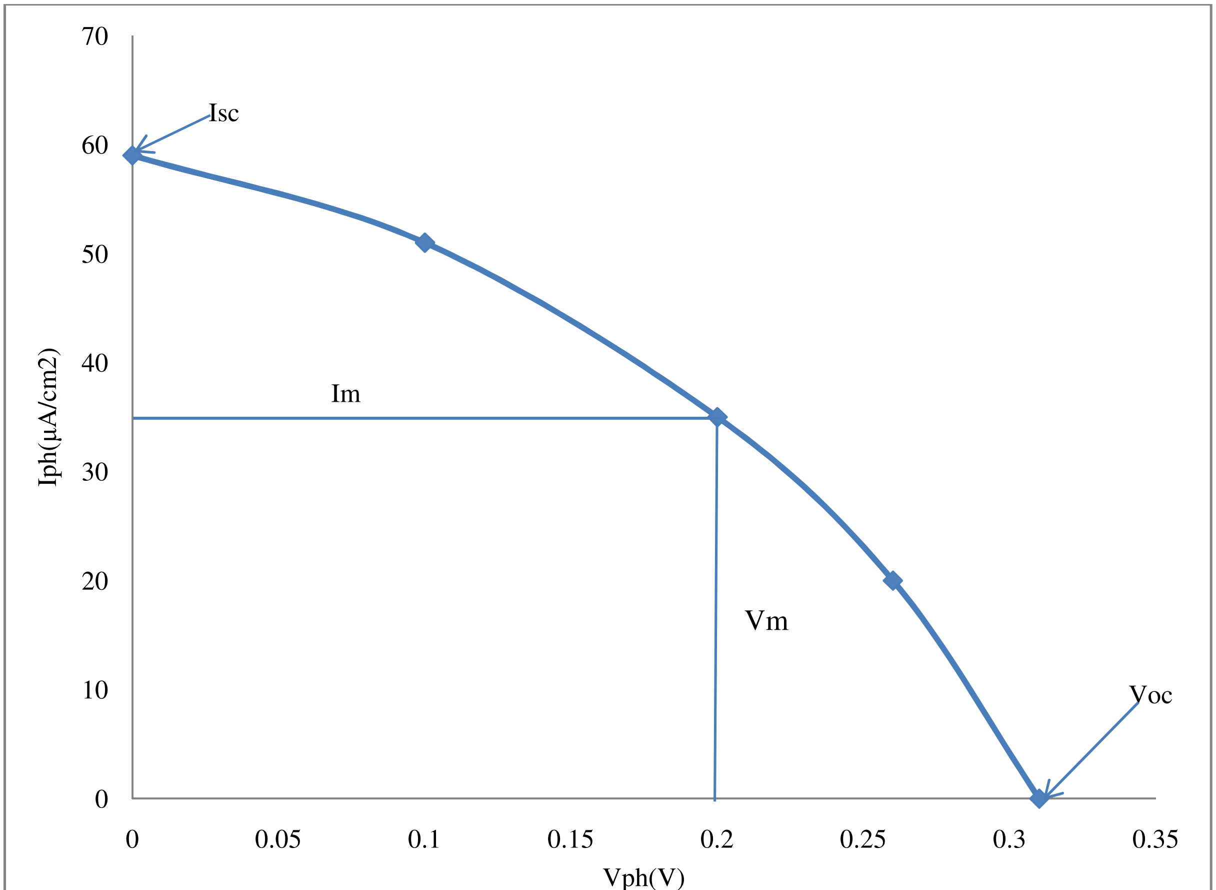

Figure-2: Photocurrent-photovoltage characteristics of HCOOH-PAn photoanode (Tungsten-halogen,70mW/cm^2 illumination at room temperature.)

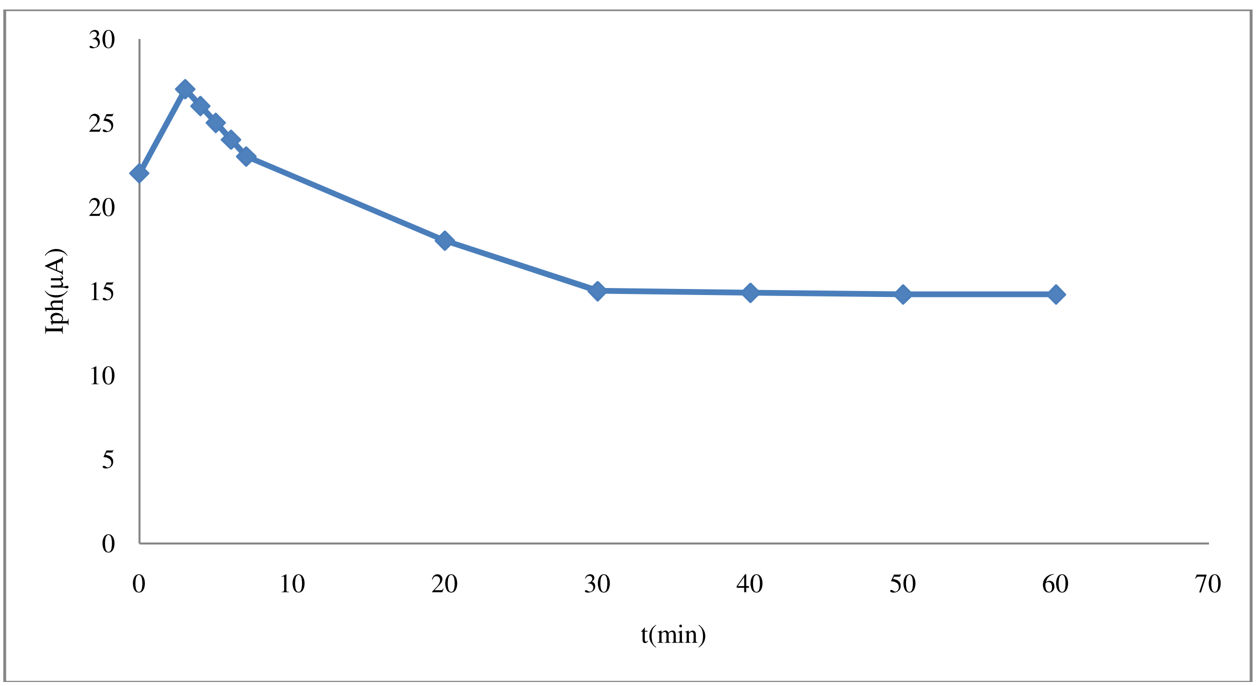

Figure-3: Photocurrent density (I_{ph}) as a function of time (t) of illumination of photoelectrochemical cell. HCOOH-PAn film/$LiClO_4$ /ITO for 1KΩ load.

Conclusion

Solar cell using PAn film shows promising results with efficiency of 1.3. With further research efficiency of PAn film can be increased.

References

1. Fujishima A. and Honda K. (1972). Electrochemical photolysis of water at a semiconductor electrode. *Nature*, 238, 37-38.

2. Frank A. and Honda K. (1982). Visible-light-induced water cleavage and stabilization of n-type cadmium sulfide to photocorrosion with surface-attached polypyrrole-catalyst coating. *J. Phys Chem,* 86(11), 1933-1935.

3. Noufi R., Nazid A.J., White J. and Warren F. (1982). Enhanced Stability of Photoelectrodes with Electrogenerated Polyaniline Films. *J. Electrochem. Soc.,* 129(10), 2261-2265.

4. Pokhodenko V.D. and Guba N.F. (1995). Photophysical properties of polymers with a system of conjugated bonds and their use in light energy conversion process. *Theoretical and Experimental Chemistry*, 30(5), 203-226.

5. Kaneko M. and Nakamura H. (1985). Photoresponse of a liquid junction polyaniline film. *J. Chem. Soc, Chem. Commun.,* 6, 346-347.

6. Kalaji M., Nyholm L., Peter L.M. and Rudge A.J. (1991). Photoelectrochemical properties of polyaniline films. *Journal of electroanalytical chemistry and interfacial electrochemistry*, 310(1-2), 113-126.

7. Shen P.K. and Tian Z.Q. (1989). Photoelectrochemical behavior of polyaniline in the presence of redox couple and electron acceptor. *Electrochimica acta*, 34(11), 1611-1613.

8. Fernando L.C., Marco A.D., Paoli D. and Eugene M.G. (1994). Photoelectrochemical response in conducting polymer films. *Synth. Met.*, 68(1), 91-96.

9. Karande V.S., Mane S.H., Pujari V.J., Deshmukh L.P. and Wadgaonkar A.R. (2004). Electrochemical studies of n-cd_1-xMnxse thin film photodetector. springer, *Journal of Material Science,* 15(7), 419-423.