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Manufacture of a new Polymeric Photovoltaic Cell

*Ali H. Al-Mowali** , Ziad T. Falik* ,Roza Abdul Rzak** , Hameed A.hamdi* , Khansa'a F.Abdullah*, A.A.Dia`a**

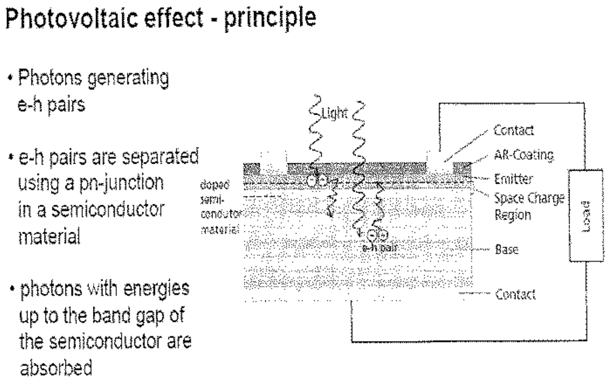
** Basrah Uiversity, Polymer Research Center*
*** Basrah Uiversity , Collage of Science , Chemistry Department*

Abstract

In this study , a polymeric unilayer photovoltaic cell has been prepared by using aniline polymer grafted with azo and rodamine – B dies and molded on positive silicon (P-Si) base forming a positive charge source which was used instead of the normal source of most voltaic cells such as ITO electrode and also precipitating an aluminium upper electrod which produced negative charge (electrons) . The results of the electrical properties of the prepared cell which were obtained by measuring different radiation intensities at constant wavelength showed good efficiency at radiation intensity equal to (295 m^2 / lux) . The new prepared azo dye was characterized by U.V-visible spectrophotometric technique . The molded method used in this research appeared efficient for preparing the new polymeric photovoltaic cell and the positive silicon with high dopping appeared to be very succeful as compared with ITO electrode.

Introduction

The construction of electrical conducting polymeric materials continues to attract attension due to potential applications in manufacture of electrical batteries , transistors , electrical capacitors , screen displays and others (1-8) . Progress in the field has been reviewed in recent years (8-16) . In modern literature many types of photovoltaic cells have been manufactured due to the availability of starting materials , high flexibility and easy manufacture and to control the electrical properties (9,10,12) . All the above properties enabled us to use these cell as solar energy cells at any atmospheric conditions . Figure (1) shows Schemalic diagram of typical polymeric photovoltaic cell and its energy band .



Photovoltaic effect - principle

- Photons generating e-h pairs
- e-h pairs are separated using a pn-junction in a semiconductor material
- photons with energies up to the band gap of the semiconductor are absorbed

Figure (1) Schematic diagram for typical polymeric unilayer photovoltaic cell and its energy band .

In our own attempts in achieving new design of polymeric unilayer photovoltaic cell , aniline polymer was grafted with azo and rodamine – B dies and molded on positive silicon base forming positive charge source which was used instead of normal source and an aluminum negative electrod was used . The results of the electrical properties of this new photovoltaic cell have been discussed in detail .

EXPERIMENTAL :

Spectroscopic measurements:

The Infra-red spectra were recorded in KBr disc by using SP_3-300 Pye-Unicam spectrometer . Ultra-violet / Visible spectra of the prepared compounds in DMSO were recorded by using SP_8-100 Pye Unicam Spectrometer .

Circuit for measuring electrical properties

The electrical circuit was build up in material science department , polymer research centre , which was composed of the following :

1- Power supply LIY 130LD-Heraeus .
2- Avometer Digital DT890C+ .
3- Phyew-DC amplifier .
4- Tungsten lamb .
5- Green gelatine filter .

Figure (2) shows the major electrical circuit of photovoltaic cell used in this study .

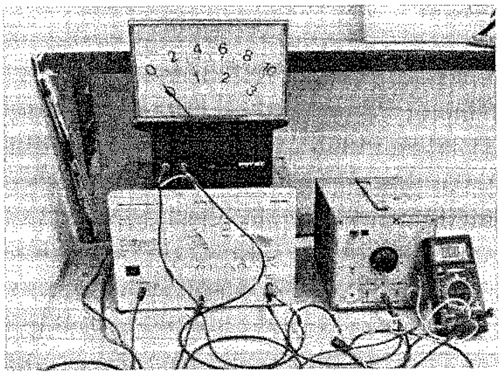
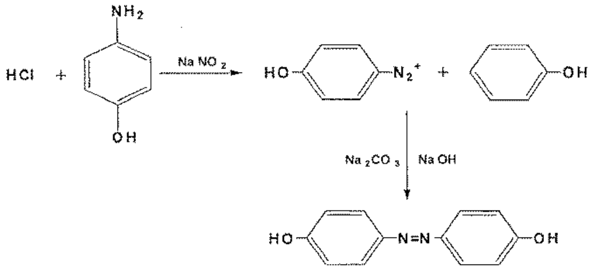


Figure (2) The manufacture polymeric photovoltaic cell

Preparation of p-dihydroxy phenyl azo benzene

(25 ml) of heated concentrated HCl (70°C) was added to (0.005 mole) of p-hydroxy aniline and the mixture was left to cool to (0°C) . To this mixture , (50 ml) of distilled water and (50 g) of ice were added and the temperature of the mixture was kept at (5°C) . (12.5 ml) of (5 N) sodium nitrite $NaNO_2$ was added to the mixture during (30 minutes) and pale yellow solution of diazonium salt was immediately formed . To the above solution , (0.008 mole) of urea dissolved in distilled water was added and the resultant mixture was added gradually in turn to a solution composed of (0.05 mole) phenol , (0.1 mole) of sodium hydroxide and (0.15 mole) of sodium carbonate dissolved in (150 ml) of distilled water and the mixture was mechanically stirred for four hours at temperature between (10°C – 15°C) . The solid product was filtred and left to dry under atmospheric pressure for (24) hours .



p - dihydroxyphenyl azobenzen

Yield = 65%
m.p. = 152 - 153° C

Figure (3) and (4) show the infra-red and U.V-Visible spectra of the azo compound .

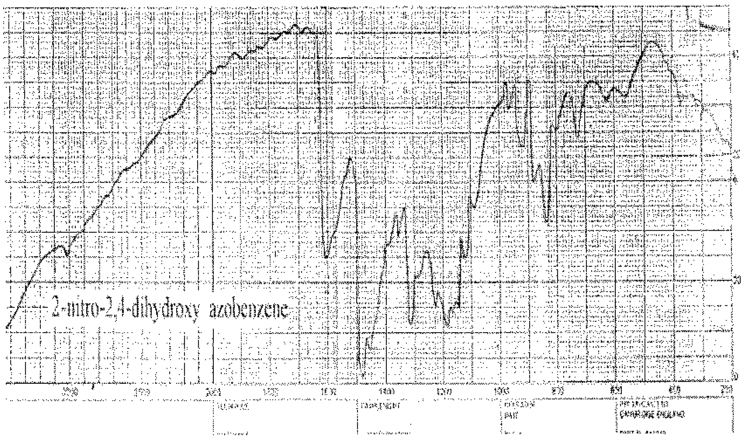


Figure (3) IR spectrum of azo compound.

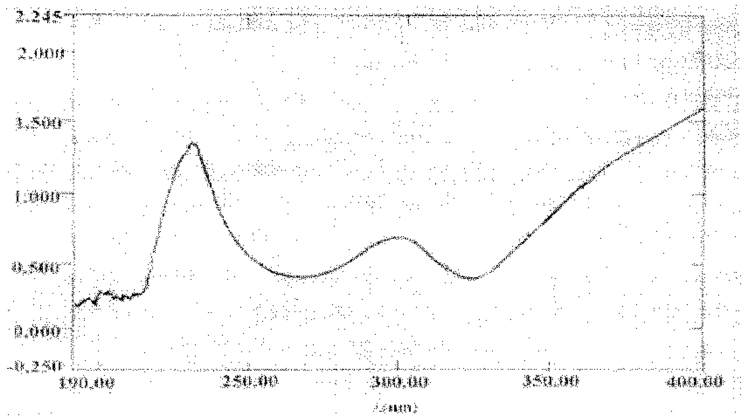


Figure (4) u.v-visible spectrum of azo compound.

Synthesis of aniline polymer

This polymer was synthesized by two stages :-

A) Preparation of Aniline Formaldhyde Condensates (AFC) .

A mixture of (9.3 g) of aniline and (3 ml) of 36% hydrochloric acid was added gradually to (5 ml) of 37% formaline . The mixture was concentrated at (100° C) for two hours and then the temperature gradually lowered to (60°C) and kept for two hours at this temperature . The formed mixture was neutralized by (4 ml) of 3% sodium hydroxide and the formed oily resin was washed three times with hot water and the formed resin was separated and kept to dry at (80°C) and (0.1 mm) mercury pressure for about one hour in order to evaporate unreacted aniline and formaldehyde .

B) (0.15 gm) of (AFC) prepared in the first step (A) was mixed with (3 gm) of dissolved aniline in (100 ml) of (1M) hydrochloric acid and then trace of ferric sulphate was added to the mixture . The solution was mixed mechanically and (3 ml) of 30% hydrogen peroxide was added and then the reaction mixture was left for six hours at room temperature in order to complete the polymerization process . The solution was filterd and a black powder of polyaniline was obtained , washed with (1M) hydrochloric acid and several time with acetonitrile and then dried under reduce pressure (0.1 mm mercury) at (80°C)for one hour . The obtained polymer was characterized by IR and U.V-visible spectroscopic technique.

RESULTS AND DISCUSSION

The prepared polymer was characterized by Infra-red and UV-Visible spectroscopy . The appearance of Infrared absorptions at (3200cm^{-1}) and at (1720 cm^{-1}) indicates the appearance of (N-H) and (C=N) groups , respectively . The absorption at wave number of (1390 cm^{-1}) indicates the appearance of (C-N) group also . Figure (5) shows the IR spectrum of the aniline polymer .

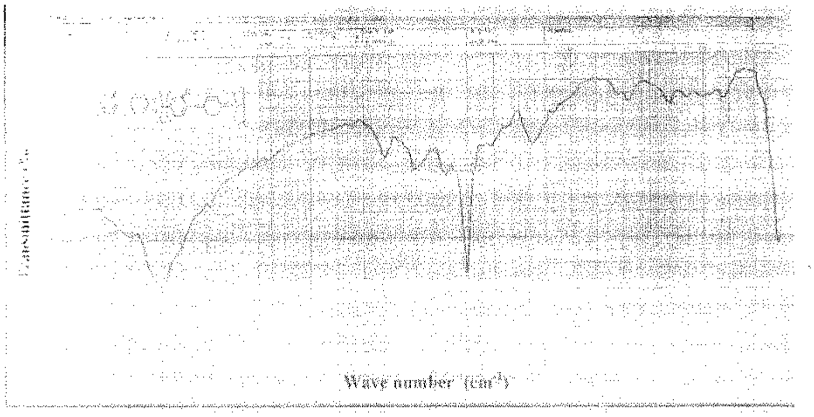


Figure (5) : Infra-red spectrum of prepared polymer

The UV-Visible spectrum of the prepared polymer in DMSO show two absorptions . The first one appeared at visible range of the spectrum with λ_{max} at (633 nm) and A= 0.443 and the second band appeared at ultra violet region of the spectrum with λ_{max} at (308 nm) and A= 0.939 . The above result indicates that the polymeric aniline has very high nature of conjugated double bonds . Figure (6) shows the UV-Visible spectrum of aniline polymer .

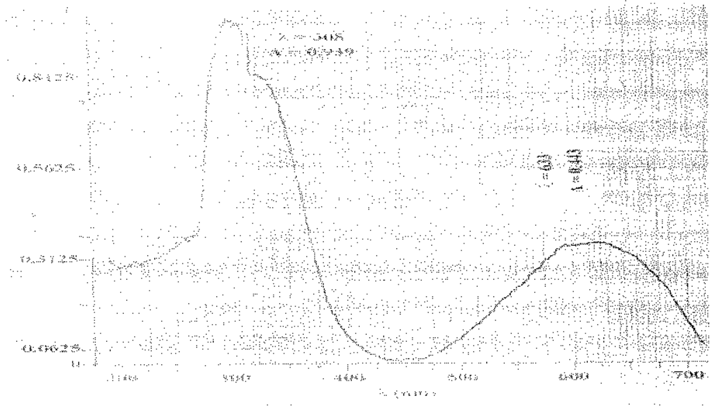


Figure (6) : U.V-Visible spectrum of the prepared polymer

The polymeric photovoltaic cell was manufactured on the form of unilayer basis which consists of three layers . The first in the semiconductive middle one in which absorption of light and formation of positive and negative carriers are observed . The aniline polymer grafted by azo and rodamine-B dyes was used and it was found that the azo dye increased the light absorbed by the cell , while , the rodamine-B dye generated a negative charge . The second layer composes from aluminium which is precipitated on aniline polymer . The third layer consists of highly dopped silcon holding the polymer aniline and also in this case the silicon was used instead to ITO in order to supply the middle layer by gabs . It is also important to mention here that the permeability of the applied light on the cell proceeded through aluminum electrode . The substrates of highly dopped p-silicon of dimension (1.5 x 1)cm were cleaned by acetone and distilled water many times . At the same time , a solution of aniline polymer in DMSO containing azo and rodamin-B of (0.01 M) concentration was poured on silicon base and the poured mixture was left for 72 hours in air and the cell was dried by vacuum disicator for 24 hours . The aluminium electrode of $1cm^2$ area was allowed to evaporate on the upper surface of aniline polymer membrane and finally the cell was subjected to electrical field through its upper aluminum electrode and lower silicon electrode for one hour in order to complete polymerization process and to getrid of solvents .

Figure (7) explains the change of current – voltage character for polymeric photovoltaic manufactured in this research in which the incident light falls on the photovoltaic cell in a perpendicular maner on the upper face of the cell producing lightening by aluminium electrode deposited on aniline polymer film . It is noted from Figure (7) that the use of three different values of light intensity applied on the prepared photovoltaic cell causes changes in the area under the carve (current – voltage) accordingly which reaches maximum intensity at (295 lux / cm^2) . This indicates that the prepared cell has high efficiency and good ability to convert incident light to electrical energy by absorping great amount of incident light energy and to librate negative and positive charges carrier enough to generate potential difference across the two ends of the prepared photovoltaic cell while the area decreases on both sides of this intensity in which we have seen from the Figure that the area under the curve decreases greatly with the increase of light intensity falling on the cell . This could be explained by two assential reasons , the first is related to thickness of aniline polymer membrance grafted by the azo and rodamine –B dyes which is large enough to reach (20) micrometer and this in turn leads to the absorption of indcident photons on the cell before reaching to the active space inside the aniline polymer .

This in turn librates negative and positive charges carrier in less number and this leads to decrease the efficiency of photovoltaic cell as explained in Figure (8) . The second reason is related to fact that the less intensity of light generates less number of the carriers and the high intensity of heat generated inside the aniline polymer leads to opposite results which decreases the cell efficiency . Figure (9) explains the change of filling factor with the change of intensity of incident light and shows the acute fall of value of filling factor with high intensity .

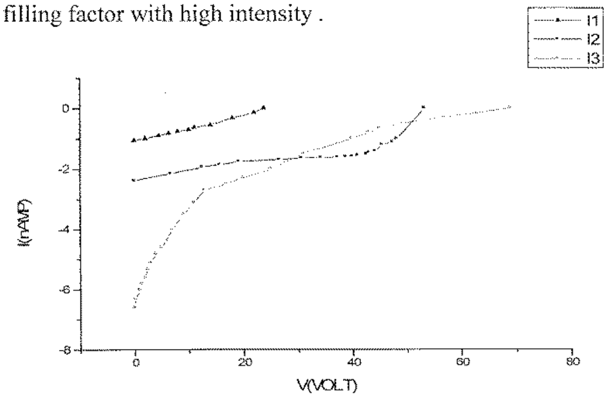


Figure (7) relation between current and voltage of the prepared photovoltaic cell .

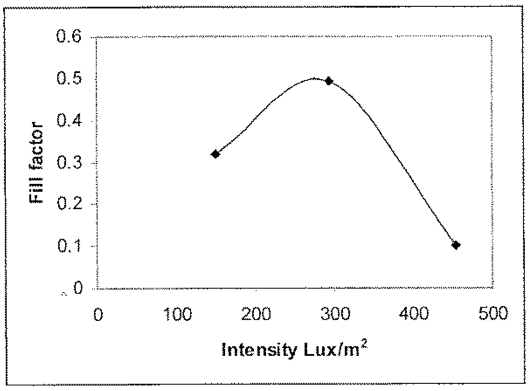


Figure (8) change of filling factor for the photovoltaic cell as a function of radiation intensity .

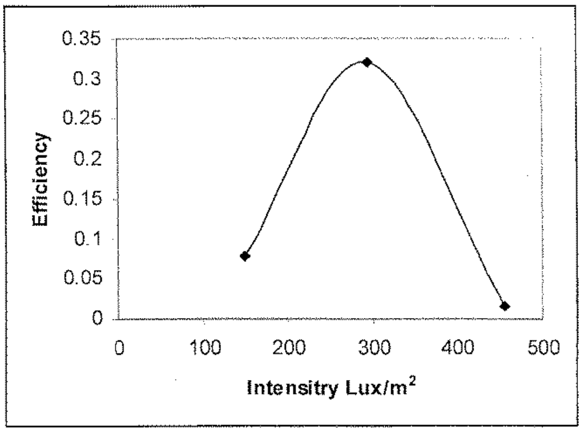


Figure (9) change of filling factor of photovoltaic cell as a function of radiation intensity .

From the above results it may be concluded that the molding and dopping of the aniline polymer with azo and rodamine-B dyes increase the incident light absorption and the positive high dopping silicon electrode (p-Si) may be considered to be an excellent electrode as compared with ITO electrode used in most photovoltaic cells and this in turn leads to decrease the cost of the manufacturing of these cells because the precipitation process of ITO electrode is the most difficult and costy .

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الخلاصة

تم في هذا البحث تحضير خليه فوتوفولتائيه بوليمريه احاديه الطبقه باستخدام بوليمر الانلين المطعم بصبغتي الازو وصبغه رودامين- B وباسنخدام طريقه الصب على قاعده من السليكون الموجب (p-Si) مكونا مصدرا للشحنات الموجبه (الفجوات) حيث استعيض به عن المصدر الاعتيادي المستخدم في معظم الخلايا الفوتوفولتائيه وهو قطب ITO وترسيب قطب علوي من الالمنيوم مكوناً مصدراً للشحنات السالبة (الالكترونات) ومن النتائج المستحصله للخواص الكهربائيه للخليه المحضره في هذا البحث والتي تم قياسها باستخدام طول موجي ثابت وشده اشعاع مختلفه فانه تم الحصول على أحسن كفاءة واعلى عامل ملء عند شده اشعاع مساويه الى (lux/m^2 295) وتقل العوامل اعلاه على جانبي هذه الشده وكذلك تم تشخيص صبغه الازو الجديده المحضره في هذا البحث باعتماد مطيافيه الاشعه فوق البنفسجيه لكون طيف امتصاصها واقع ضمن المدى المرئي للطيف وان طريقه الصب طريقه فعاله في تحضير هذا النوع من الخلايا الفوتوفولتائيه البوليمريه ويمكن القول ان السليكون الموجب عالي التشويب يعتبر بديلاً ناجحاً لقطب ITO .