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Using Gum Arabic in Making Solar Cells by Thin Films Instead Of Polymers

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Abstract : *Gum Arabic based solar cells with Rhodamine 6G were fabricated on indium tin oxide by a spin coater position. Microstructure and cell performance of the solar cells with ITO/ Rhodamine 6G/ Gum Arabic structures were investigated. Photovoltaic devices based on the Rhodamine 6G / Gum Arabic hetrojunction structures provided photovoltaic properties under illumination. Absorption and energy gap measurement of the Rhodamine 6G / Gum Arabic hetrojunction were studied by using UV-VS mini 1240 spectrophotometer and light current-voltage characteristics. The energy levels of the present solar cells were also discussed. The three ITO/Gum/Rhodamine/Au solar cells were produced and characterized, which provided efficiency (η) is (3.8 - 5.1 and 5.2) %. Fill factor (FF) is (0.964 - 0.9462 and 0.973), current density (Jsc) is (2.22 - 4.31 and 4.4) mAcm^{-2} and Open – circuit voltage (Voc) is (1.22 -1.25 and 1.209) V. This could be used at larger scale in promoting efficiency of solar cells.*

Keywords: *Gum Arabic, thin film, solar cell, photovoltaic property, optical property*

I. Introduction

The direct conversion of light into electricity is done by solar cells. The usage of solar energy for heat has a long history but the origin of devices which produce electricity is much more recent, it is closely linked to modern solid-state electronics. Indeed, the first usable solar cell was invented at Bell Laboratories – the birthplace of the transistor - in the early 1950's. The first solar cells found a ready application in supplying electrical power to satellites. Terrestrial systems soon followed, these were what we would now call remote industrial or professional applications, providing small amounts of power in inaccessible and remote locations, needing little or no maintenance or attention. Examples of such applications include signal or monitoring equipment, or telecommunication and corrosion protection systems. Since then, numerous photovoltaic systems have been installed to provide electricity to the large number of people on our planet that do not have (nor, in the foreseeable future, are likely to have) access to mains electricity. [1, 2]

Solar cells are considered as one of the most effective means of converting the solar energy .And to make use of it in eighties and sisal areas solar energy is classified as clear, sustainable renewable and cheap energy especially in the countries which are famous for the long day hours. Solar energy is promoted as a sustainable energy supply technology because of the renewable nature of solar radiation and the ability of solar energy conversion systems to generate greenhouse gas-free electricity during their lifetime. Photovoltaic devices allow the direct production of electricity from light absorption. The active material in a photovoltaic system is a semiconductor capable of absorbing photons with energies equal to or greater than its band gap. Upon photon absorption, an electron of the valence band is promoted to the conduction band and is free to move through the bulk of the semiconductor. In order for this free charge to be captured for current generation, decay to the lower energy state, i.e. recombination with the hole in the valence band, has to be prevented through charge separation. In photovoltaic devices made of inorganic semiconductors, charge separation is driven by the built-in electric field at the p-n junction. As a consequence, their efficiency is determined by the ability of photo generated minority carriers to reach the p-n junction before recombining with the majority carriers in the bulk of the material. Thus, bulk properties such as crystalline and chemical purity often control the device efficiency. The operation of organic photovoltaic's (OPVs) is fundamentally different. The optical and electronic properties of organic semiconductor materials are determined by the molecular orbital's that are built up from the summation of individual atomic orbital's in the molecule.[3]

The efficiency of these devices is determined by the requirement that exactions reach the donor-acceptor interface, charges are transferred before recombination occurs, and charges are subsequently transported to the electrodes before electrons back-transfer from the LUMO of the acceptor to the HOMO of the donor. [4]

Gum Arabic, also known as gum acacia, char goo, is a natural gum made of hardened sap taken from two species of the acacia tree; Acacia Senegal and Acacia seyal. The gum is harvested commercially from wild trees throughout the Sahel from Senegal and Sudan to Somalia, although it has been historically cultivated in Arabia and West Asia. Gum Arabic is a complex mixture of polysaccharides and glycoprotein's that is used primarily in the food industry as a stabilizer. It is perfectly edible and has E number E414. Gum Arabic is a key ingredient in traditional lithography and is used in printing, paint production, glue, cosmetics and various industrial applications, including viscosity control in inks, although cheaper materials compete with it for many of these roles. Chemical properties effect on surface tension in liquids .Gum Arabic reduces the surface tension of liquids, which leads to increased fizzing in carbonated beverages this can be exploited in what is known as a Diet Coke and Mantes. [5]

Solar cell technology for future energy resources has been progressed recently. Silicon is used as the semiconductor material for conventional solar cells, and the cost reduction of the solar cells is one of the most important issues. This research aims to develop the conversion of the solar radiation into electrical energy in sunny country like Sudan .In this study using the local natural resources. Gum Arabic to produce solar cell, and the Gum Arabic was chose to be used because its availableitity in SUDAN. To prepare of Solar cells thin films and study Solar cells thin films optical band gab and light current-voltage properties. And investigate the energy levels of the present solar cells and discussed.

II. Materials And Methods

Were 3 sample of Gum solar cells made by depositing the Gum Arabic solution on ITO a glass manner Spin Coating, and another layer was deposited from day on a layer of Gum Arabic .Gold was fabricated on the layers to represent the anode and ITO Cathode. A clean glass plate with a thin layer of ITO (Indium Tin Oxide) is needed. The ITO acts as the first part of the solar cell, the first electrode. However a bit of the ITO has to be removed, to avoid short-circuiting

For the purpose of the present study Arabic Gum devices were made following the generally accepted methods. The fabrication process started by preparing the Arabic Gum and the dye of interest then spin coated on indium tin oxide glass. Silver electrode was used to complete the formation of organic Arabic Gum solar cell. The formed devices were characterized by Ultra violet-visible spectroscopy. The Arabic Gum solar cell was made on ITO glass. The ITO glasses were firstly cleaned by ethanol and distilled water. 10mg of Arabic Gum was dissolved into 0.5ml of chloroform and add 0.24 mg ZnO and added drop of acetic acid glacial. Then 3mg of Rhodamine 6G dye dissolved into 0.5 of high pure chloroform was deposited on Arabic Gum .Being inserted electrical circuit containing the (voltmeter and Ammeter and a light source Lamp with the intensity radiological" and a solar cell).Cell was offered to light and fulfilled taking the results of the current and voltages were recorded the UV spectrometer in as as to display absorption spectrum . Three samples were prepared.

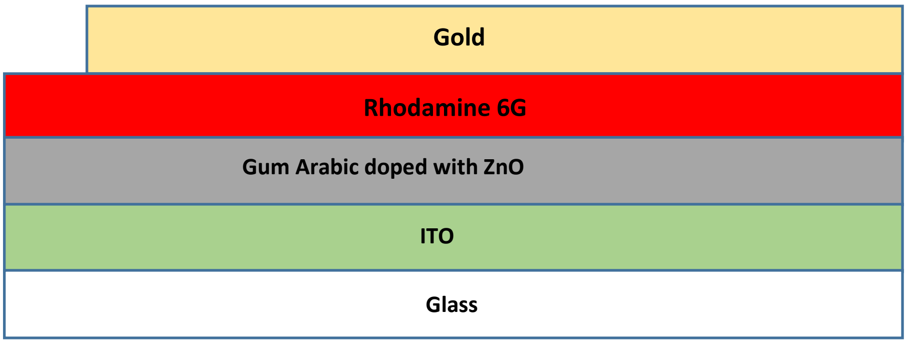

Fig (1) schematic structure of Arabic Gum solar cell formed with a single organic layer of Gum Arabic

III. Results And Discussion

The results and curves obtained by the Ultra-Violet device and curve.

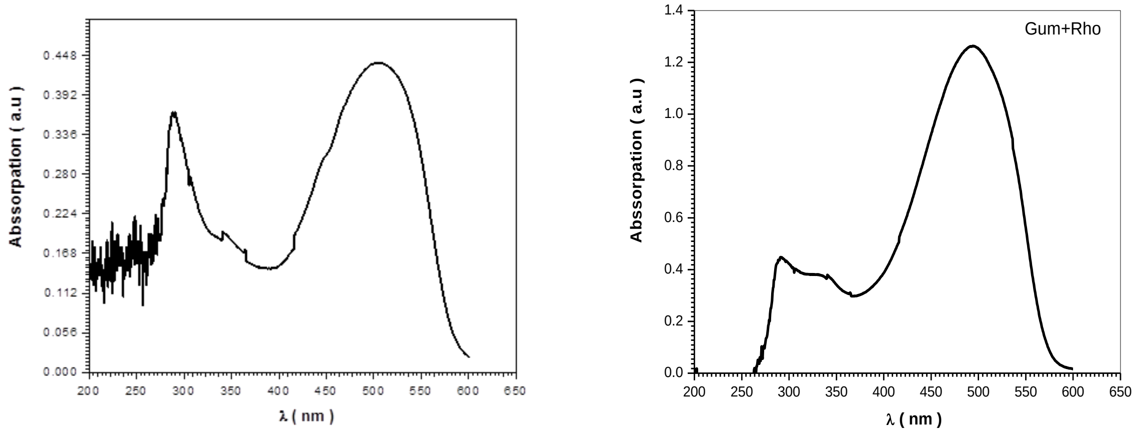

Fig (2) the UV Vis spectra optical absorption of ArabicGum in room temperature and Arabic Gum doped with Rhodamine 6 G

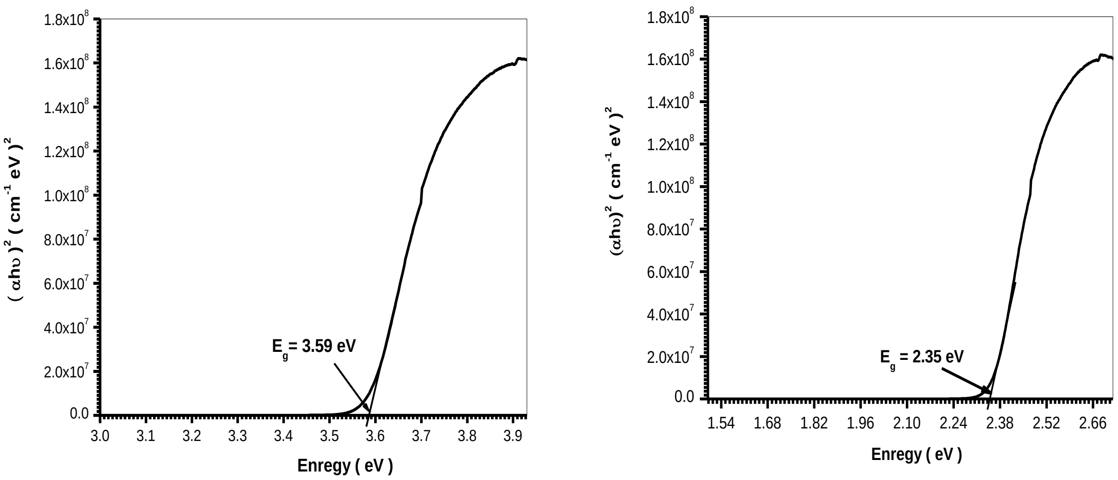

Fig (3) optical band gap energy (Eg) of Arabic Gum and Rhodamine 6 G in room temperature.

The I-V reading for the three sample are fabricated in the three tables below. I-V reading are displayed graphically in the figures ( ) below

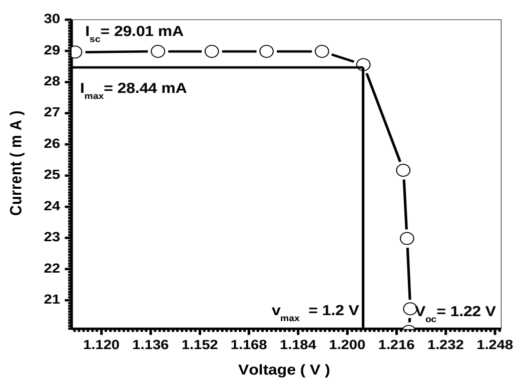

Fig (4) several factors for characterization of samples

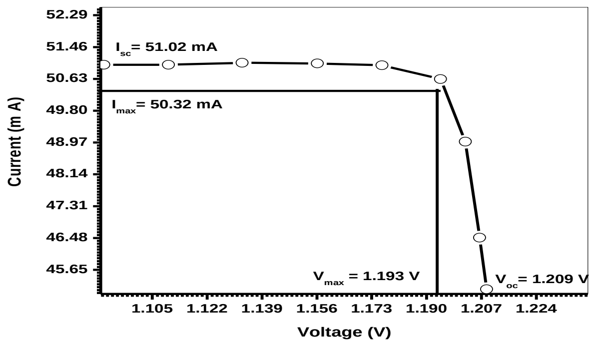

Fig (5) several factors for characterization of samples 2

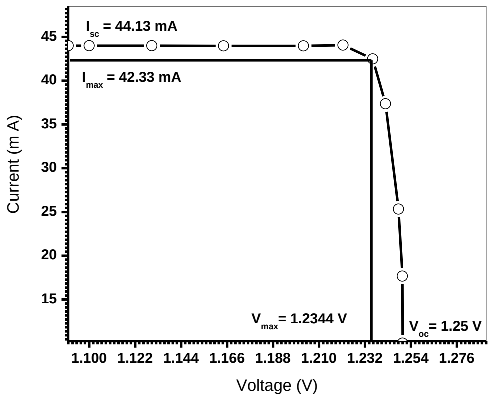

Fig (6) several factors for characterization of samples 3

Table (1) I-V reaction for sample1

Current (mA)	Voltage (V)
1.11	28.96
1.14	28.98
1.15	28.98
1.17	28.98
1.19	28.98
1.21	28.56
1.22	25.17
1.22	22.98
1.22	20.72
1.22	20.00

Table (2) I-V reaction for sample2

Current (mA)	Voltage (V)
1.09	44.00
1.10	44.00
1.13	44.00
1.16	43.97
1.20	43.97
1.22	44.06
1.24	42.48
1.24	37.36
1.25	25.33
1.25	17.67
1.25	10.00

Table (3) I-V reaction for sample2

Current (mA)	Voltage (V)
1.09	51.00
1.11	51.00
1.13	51.05
1.16	51.03
1.18	50.98
1.19	50.63
1.20	48.99
1.21	46.49
1.21	45.14

IV. Discussion

Fig (2) shows the pure Arabic Gum absorption the absorption beak wavelengths was obtained at300 nm and 500 nm respectively. The range of absorption for Arabic Gum for ultra-violet spectrum and absorption of visible radiation is in the range (200-600nm). The Arabic Gum after being doped with Rhodamine 6G cases the highest absorption peak to change from 300 nm to 520 nm, although the difference is not large, it can't be ignored. The Rhodamine 6G dye rang of absorption (250-600nm) cause this peak shift for 50 nm reason the polymer solar cell is better than silicon cells since it absorb in wide wavelength range .Despite the fact that there is no significant shift in the peak that characterizes the UV-Vis spectra of Arabic Gum, there is clear change in full width at half maximum which increases with doping concentration.

Determination of the optical band gap energy (Eg) was made in fig (3). The method is based on the relation of $\alpha h\nu = A\,(h\nu - Eg)^2$ [6, 7, 8]. The intersection of the straight line with the hν-axis determines the optical band gap energy Eg. It was found to be 2.35 eV for Rhodamine 6G and 3.59 eV for Arabic Gum.

Fig (4) is used to find (I_{sc}) , (V_{0c}) , (I_{max}) and (V_{max}) . It is found that these parameters have the

$I_{SC} =$ 29.01 m A $J_{sc} = I_{sc} \div active\ aera = 3.22$ mA cm^{-2}

Open – circuit voltage (V_{oc})

V_{oc} = 1.22 V

Fill factor (FF)

The fill factor (FF) is found by dividing maximum out power (P_{max}) by the product of short-circuit current and the open-circuit voltage. The maximum power is given by max volt (V_{max}) and max current (I_{max}) to be.

$P_{max} = I_{max} \times V_{max} = 0.0003413$ W

$FF = P_{max} \div I_{sc} \times V_{oc}$ =0.9643

Power conversion efficiency

The power conversion efficiency (η) of the Arabic Gum -sensitized solar cell is determined by the photocurrent density measured at short-circuit, V_{oc}, the FF of the cell, and the open-circuit and J_{sc} as shown in follow equation. [9 – 10 and 11]

$\eta = V_{oc} \times I_{sc} \times FF \div P_{in} =$ 3.8%

These results for the three samples are recorded in table (4).

Table (4) are Factors for characterization of Arabic Gum solar cells performance for three samples

No of sample	I_{sc}mA	I_{max} mA	V_{oc}Vol	V_{max}vol	FF	J_{sc}mA/cm^2	AreaCm^2	η%
Sample 1	29.01	28.44	1.22	1.2	0.9643	3.22	0.00090	3.8
Sample 2	44.13	42.33	1.25	1.234	0.9462	4.31	0.001024	5.1
Sample 3	51.02	50.32	1.209	1.193	0.9730	4.40	0.00116	5.2

Table (4) show that the efficiency range from (3.8 % to 5.2 %), The maximum efficiency is 5.2 %.

V. Conclusions

The application of conducting Arabic Gum to optoelectronic devices such as solar cell, light emitting diodes, and electrochemical sensors are of practical significance, because the Arabic Gum mixture can be easily prepared and modified by rich chemical procedures to meet optical and electronic requirements .This solar cell is cheap can be easily fabricated. It efficiency is relatively large.

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