Effect of Changing Solvents on Absorbance, Optical Energy Gaps and Efficiency for Zinc Oxide and Rose Bengal Dye Solar Cells

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Abstract: Zinc Oxide based Dye Sensitized Solar Cells (DSSC) with Rose Bengal were fabricated on FTO glass . Five solvents were used they are (Methanol ,Ethanol ,Acton m Chloroform and Benzene) Microstructure and cell performance of the solar cells with (FTO/ ZnO/ Rose Bengal dye /FTO+ graphite and Iodine) structures were investigated taking into account the effect of solvents. Photovoltaic devices based on the ZnO/ Rose Bengal dye hetrojunction structures provided photovoltaic properties under illumination. Absorption and energy gap measurement of the ZnO/ Rose Bengal dye 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 five (FTO/ ZnO/ Rose Bengal dye /FTO+ graphite) solar cells were produced and characterized, which provided efficiency (η) and Energy gap are (0.6795 % for Eg = 2.947 eV ,0.63901 % for Eg = 2.951 eV ,0.58821% for Eg = 2.958 eV ,0.55262 % for Eg = 2.963 eV and 0.50864 % for Eg = 2.972 eV) Fill factor (FF) average (0.89)for all cells . This means that the increase of energy gap decreases efficiency it was as shown that the increase of absorbance and distance between Nano crystal increases efficiency.

Keywords: Zinc Oxide, Rose Bengal dye, solar cell, photovoltaic property, optical energy band gap.

I. Introduction

Solar cells are devices which convert light radiation into electricity. The usage of solar energy for heat has a long history but the origin of devices which produce electricity is much more recent. [1, 2,3,4 and 5] Solar cells are considered as one of the most effective means of converting the solar energy. Solar energy is promoted as a sustainable energy supply technology because of the renewable nature of solar radiation. The active material in a photovoltaic system is a semiconductor capable of absorbing photons with energies equal to or greater than its band gap. Electrons of the valence band is promoted to the conduction band and is free to move through the bulk matter. For this free charge to be captured for current generation, decay to the lower energy state, has to be prevented through charge separation. In solar cells made of inorganic semiconductors, charge separation is driven by the electric field at the p-n junction. Their efficiency is determined by the ability of generated minority carriers to reach the p-n junction before recombining with the majority carriers. Thus, bulk properties such as crystalline and chemical purity often control the device efficiency. The operation of organic photovoltaic (OPVs) is 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.[6] 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 Lower Unoccupied Molecular Orbit(LUMO) of the acceptor to the Higher Occupied Molecular Orbit (HOMO) of the donor. [7,8]. ZnO nanoparticles are widely used in optoelectronic devices beside field-emission devices , and solar cells. ZnO nanoparticles can be synthesized using physical as well as chemical techniques. These include vapor deposition chemical vapor deposition laser ablation, and the solution method. Solution method has attracted the interest of numerous researchers worldwide. There are two main ways to prepare a ZnO seed layer: sputtering and wet coating. The former requires expensive equipment and complex conditions.

II. Materials and Methods

Five samples of Dye Sensitized Solar Cells (DSSC) with Rose Bengal were fabricated on FTO glass. A clean glass plate with a thin layer of FTO (Fluorine Tin Oxide) is needed. The FTO acts as the first part of the solar cell, the first electrode. For the purpose of the present study Zinc Oxide cells were made following the generally accepted methods. The fabrication process started by preparing the Zinc Oxide and the dye of Rose Bengal coated on FTO glass. (FTO + graphite and Iodine) electrode was used to complete the formation of Dye Sensitized Solar Cells (DSSC) .The formed sample were characterized by Ultra violet-visible spectroscopy (UV). The Dye Sensitized Solar Cells (DSSC) was made by depositing ZnO and dye on FTO glass substrate. The FTO glasses were firstly cleaned by ethanol and distilled water. Zinc acetate dehydrate was mixed in pure methanol (99%) Then 0.01 M concentration of zinc acetate (274mg) was add in

125ml of methanol and stirred and heated to 60 °C under continuous stirring one added 109mg of potassium hydroxide having (0.03M) concentration, The solution was shacked until it become transparent. One added drop-wise from potassium hydroxide solution (to heat zinc acetate) under continuous stirred, then heated to 60°C for 2hours. Some drops of solution was taken on substrate and left to be dry. The sample was cleaned by Ethanol, Then 3mg of Rose Bengal dye dissolved into 0.5ml of high pure (Methanol, Ethanol Acton, Chloroform, Benzene and Water). was deposited on Zinc Oxide .Being inserted electrical circuit the V-I characteristic was found using electric circuit containing (voltmeter, Ammeter, a light source Lamp and a solar cell) .The V-I reading were taken after exposing the solar cell to light. The UV spectrometer was used to display absorption spectrum. Five samples were prepared (FTO/ ZnO/ Rose Bengal dye /FTO+ graphite and Iodine) .by using five different solvent (Methanol , Ethanol, Acton, Chloroform and Benzene).

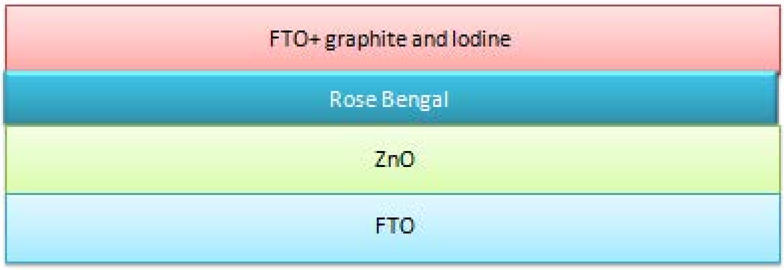


Fig (1) schematic structure of (FTO/ ZnO/ Rose Bengal /FTO+ graphite and Iodine)

III. Results and Discussion

In view of figures (2) and (4) the addition of the Rose Bengal and solvents changes the absorbance peak from about 330 nm and increase it to about 400 nm. This means that the solar cells enable to absorb more photons having wave length in the range of about 300- 400 nm. The energy gap decreases due to this addition from 0.3589eV to (2.947- 2.972 eV) which enables more electrons to enter conduction band by longer photon wave lengths as indicated by figures (3) and (6).

Table (1) shows that the decrease of energy gap increase absorbance and efficiencies as shown by figures (8) and (9) which shows that the increase of absorbance and increase efficiency while the decrease of energy gap increase efficiencies. Both processes allows more electrons to be conduction band thus increase the efficiency as shown in figure (10).

It is very clear that the solvent type affect the energy gap table (1) shows that Methanol gives high efficiency followed by Ethanol, Acetone, Chloroform than Benzene which has low efficiency.

Table (2) shows a direct relation between crystal spacing and energy gap.

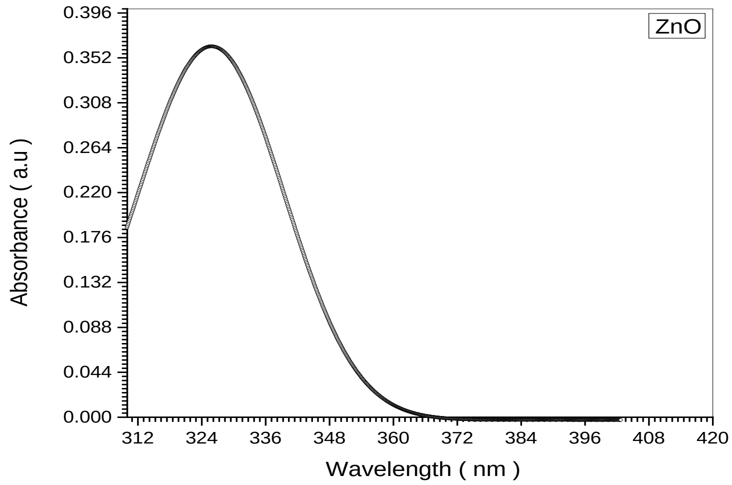


Fig (2) relation between absorbance and wavelengths of ZnO sample

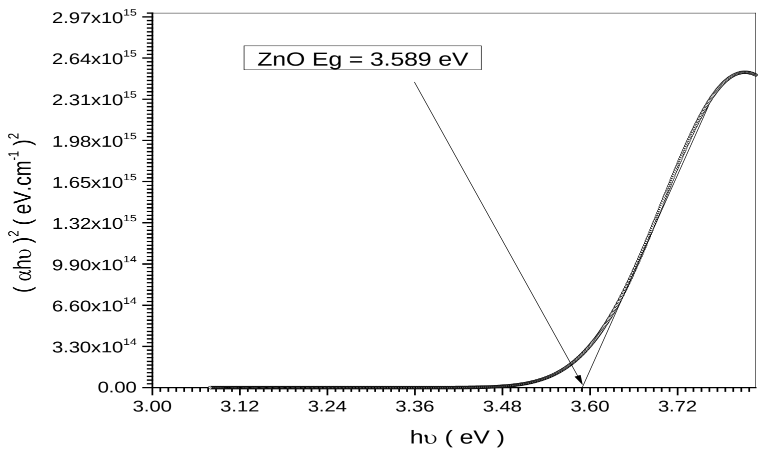
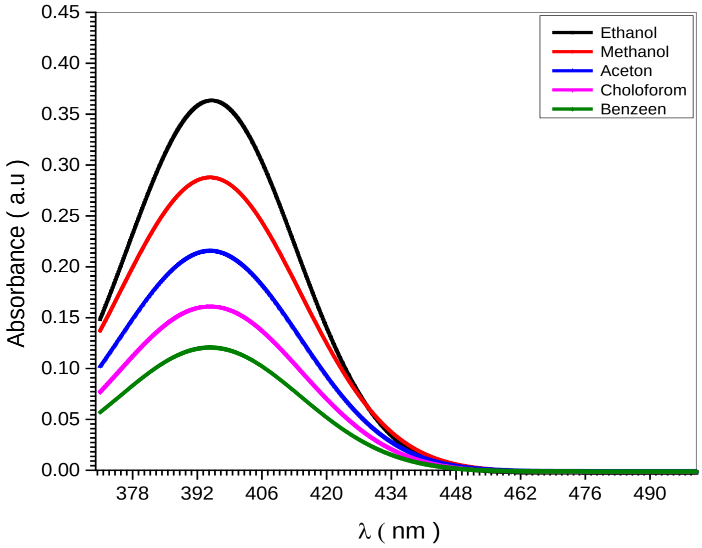
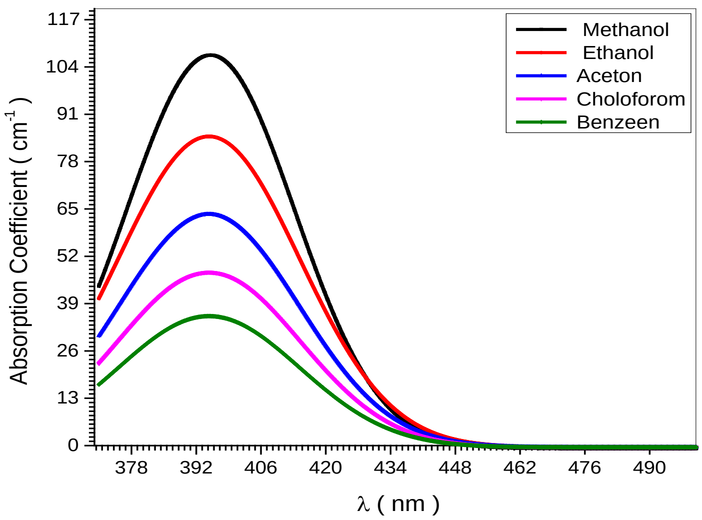


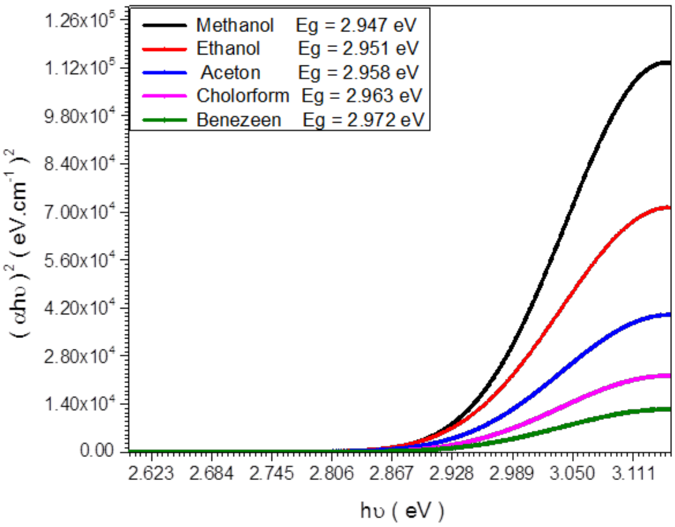
Fig (3) Optical Energy Band Gap of ZnO sample



Fig(4) Relation between absorbance and wavelengths of five sample that made by Rose Bangal dye in different solvent (Methanol, Ethanol ,Acton , Chloroform and Benzene)



Fig(5) relation between absorption coefficient and wavelengths of five sample that made by Rose Bangal dye in different solvent (Methanol ,Ethanol ,Acton m Chloroform and Benzene)



Fig(6) The optical energy band gab of five sample that made by Rose Bangal dye in different solvent (Methanol ,Ethanol ,Acton m Chloroform and Benzene)

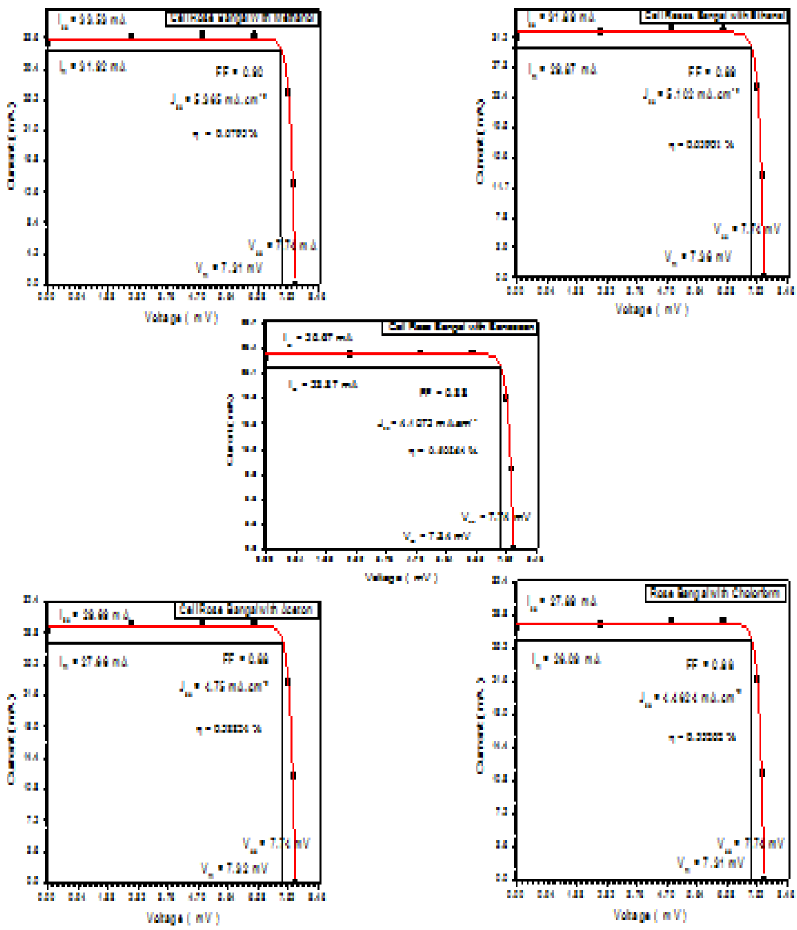


Fig (7) V-I Characteristic curves for the Five samples

Table (1) I-V readings of five samples that made by Rose Bangal dye in different solvent (Methanol, Ethanol, Acton m Chloroform and Benzene)

Sample	I_{sc}(mA)	I_m (mA)	V_m (mV)	Voc (mV)	J ($mA.cm^{-2}$)	FF	η %	Absoe	Eg (eV)
R- Methanol	33.53	31.92	7.31	7.74	5.365	0.90	0.6795	0.366	2.947
R- Ethanol	31.89	29.87	7.36	7.74	5.102	0.89	0.63901	0.289	2.951
R- Acetone	29.69	27.66	7.32	7.74	4.75	0.88	0.58824	0.217	2.958
R- chloroform	27.89	26.09	7.31	7.74	4.4624	0.88	0.55262	0.162	2.963
R- Benzene	25.67	23.87	7.34	7.74	4.1072	0.88	0.50864	0.22	2.972

Table (2) Lattice Constants and Miller Indices [Cubic Face centered] of ZnO sample

Solvent	2-Theta	d(A^o)	h	k	l	X_s (nm)
R-Methanol	17.943	2.67255	1	1	1	87.8
R-Ethanol	31.788	2.31450	2	0	0	47.8
R-Acetone	34.386	1.63660	2	2	0	53.8
R-chloroform	36.438	1.39570	3	1	1	48.8
R-Benzene	56.594	1.33628	2	2	2	62.3

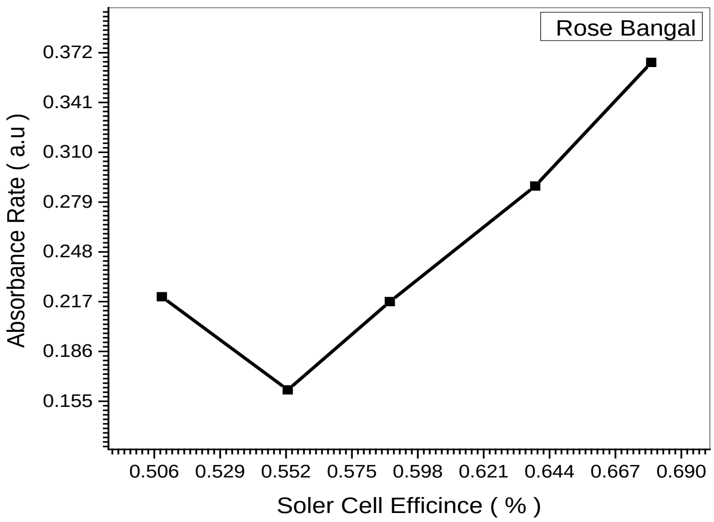


Fig (8) The relationship between Absorbance and efficiency of Dye Sensitized Solar Cells (DSSC) (ZnO+ Rose Bengal dye dye)samples

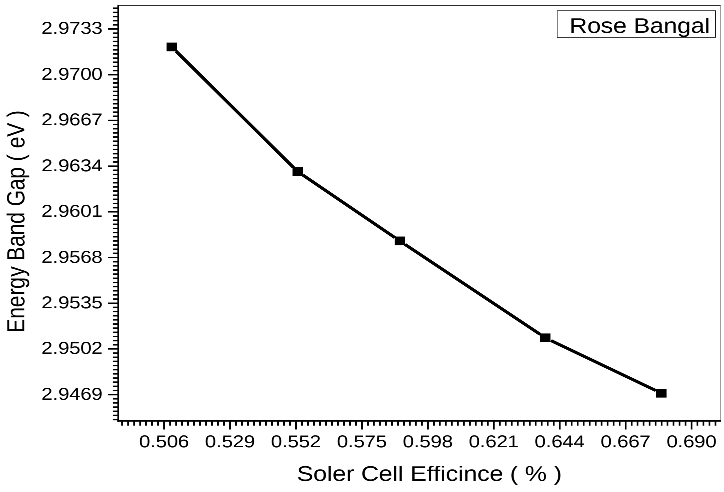


Fig (9) The relationship between Energy band gap and efficiency of Dye Sensitized Solar Cells (DSSC) (ZnO+ Rose Bengal dye dye) samples

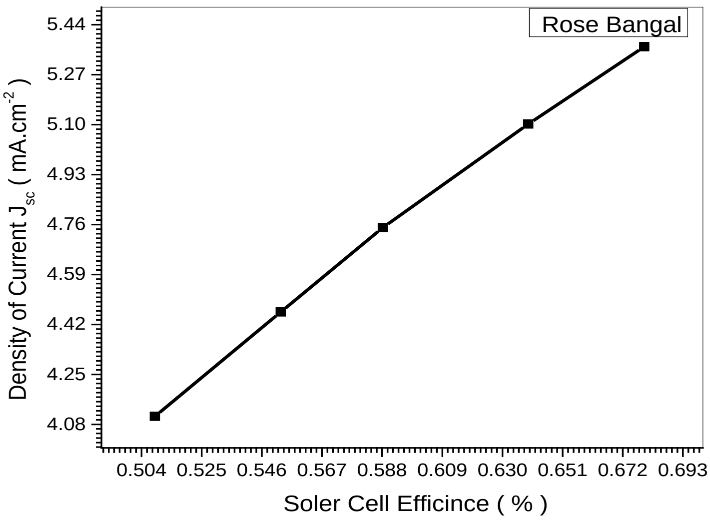


Fig (10) The relationship between Density Current and efficiency of Dye Sensitized Solar Cells (DSSC) (ZnO+ Rose Bengal dye dye) samples

V. CONCLUSION

When Rose Bengal dyes and some solvents are added to ZnO the solar cell efficiency and absorbance increase while the energy gap decreases. The solvent type affects clearly these parameters thus changing solar cell efficiency.

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