Preparation, Characterization and Fabrication of PVA based Dye sensitized solar cells (DSSC)

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Abstract- Polymer based solar cell was prepared with Basella Alba dye and polyvinyl alcohol (PVA). The absorption wavelengths were determined for different temperature from 50°C - 80°C range between 250nm – 600nm. The band gap of the solar cells is 3 eV, 2.6 eV, 2 eV, and 1.7 eV. The resultant band gap of the Tauc plot confirms the spectroscopic behavior of the solar cell. Particle size of the dye extract at various temperatures were determined from x-ray diffraction using Debye-Scherer's formula and the particle size at 50˚C, 60˚C, 70˚C, 80˚C temperature are 5.4nm, 6.1nm, 9.2nm, and 9.8nm respectively. The electrical properties of prepared samples were studied and it showed that, all samples displayed ohmic behavior. The maximum efficiency of the solar cell was obtained at 80°C with 6.7%.

Keywords: PVA, Basella Alba dye, band gap, XRD.

1. INTRODUCTION

Solar energy is the most readily available source of energy [1]. With the increasing demand of energy via greener methods and the gradual depletion of fossil fuels, solar energy conversion has regained the spotlight of the global energy activities [2]. Solar energy can be harvested and used by three basic mechanisms: solar to thermal/voltaic/chemical energy for various applications [3].

Nanoporous, dye-sensitized solar cells are promising devices to convert solar energy into electric energy, due to low fabrication cost, environmentally friendly operation and relatively high efficiency [4]. The performance of the solar cells depends on the structure of dye used as photosensitizer [5]. Polymer electrolytes have become prominent electrolyte materials in different types of electrochemical devices owing to their special properties like easy mouldability, light weight, flexibility, good electrode–electrolyte contact and adhesive property [6,7]. Photovoltaic power conversion efficiency of about ~12 % has been achieved in organic solar cells whereas it is about ~44 % in inorganic semiconductor devices [8]. A gel electrolyte is prepared by absorbing liquid electrolytes [9]. Poly(vinyl alcohol) is one of the biodegradable synthetic polymer that have good optical features, low cost, non-toxicity, hydrophilicity and high dielectric constant [10]. Polymer gel electrolytes (PGEs), a polymer matrix absorbed with liquid electrolyte, belong to a potential alternative to solid state electrolytes for the fabrication of DSSCs[11]. Conductive polymers have become an attractive components in solar cell devices based on facile tuning of materials parameters, fabrication it by using printing technique, mechanically flexible properties [12].

In this study, the solar cell was prepared by dip coating method that was characterized by UV and IV techniques. The blend polymer of PVA with basella alba organic dye solar cell was made, and electrical properties of the prepared polymers were investigated.

2. PROCEDURE AND EXPERIMENTAL WORK

2.1 Dip coating process

A glass substrate is taped with one side and another side is fully cleaned with acetone. In Dip coating Instrument the slide of the glass substrate (1.5cm x 5cm) is fixed vertically in top of the stand and the 30ml of PVA gel solution is kept in the beaker towards the substrate (Figure 5.5). PVA with organic dye coatings were deposited on glass plates with an average thickness, cut from commercially available Instruments. Glass plate coated samples were prepared by dipping the metallic substrates in the prepared mixture (gel) using a dip coater Instrument (Nima, model DC Small) at a withdrawal speed of 10 mm min^{-1}. Speed to the substrate is kept constant. Then the substrate is slowly dipped into the PVA solution contained beaker. The gel solution is uniformly spread on the one side of the substrate. Residence time was 100 Sec (Rt = 100 Sec). Samples were coated with or without R_t using one, two or three dip steps, always using the same curing conditions. Samples prepared with three consecutive dip steps without Rt. The first layer of PVA was coated in the glass plate. After 15 minutes the PVA coating dipped into the second layer of organic dye. Finally these two layers of polymer and organic dye were dried. And then tape was removed from second side.

2.2 Preparation of Polyvinyl alcohol and Organic dye
10g blend polymer of PVA was fused with 25ml of double distilled water. This mixing is continuously stirred for one hour to obtain PVA gel. Figure 5.2 shows the Basella alba Fruit. The extraction of organic dye from Basella alba plant is the first step. Usually before extraction plant samples are treated by grinding or squeezing and homogenization, which may be preceded at normal room temperature. 20ml of organic dye was mixed with 5ml of ethanol. The mixture was maintained in continuous stirring in magnetic stirrer for half an hour with 400 rpm at 50°C temperature. The final solution was prepared and it's kept at room temperature (Figure 5.3). An extract of organic dye was kept in magnetic stirrer for 60°C, 70°C and 80°C (Figure 5.4). Temperature is varied for dye and not for polymeric material.

3. RESULTS AND DISCUSSION

3.1 Spectroscopic studies

The absorption spectra of the fabricated solar cells were carried out using [Jasco V-670 made by Japan] UV Spectrophotometry instrument. Figure 3.1(a) , 3.2(a), 3.3(a), 3.4(a) shows the absorption spectra at 50°C, 60°C, 70°C, 80°C and observed the absorption peaks at 537nm, 343nm, 298nm, 342nm respectively. All the values of the maximum absorption wavelength of the solar cell are listed in Table 3.1

Figure 3.1(b), 3.2(b), 3.3(b), 3.4(b) shows that the bandgap of PVA with basella alba at different temperatures. The graph plotted between hυ and $(h\upsilon\alpha)^2$ for the prepared solar cell. In general optical energy band gap decreases with doping percentages. The doping process decreases the transmittance [13]. Adding dye to PVA leads to decrease the band gap energy of films. When the temperature is increased, the bandgap energy is decreased. Bandgap of the Tauc plot confirms the spectroscopic behavior of the solar cell. All bandgap values of fabricated solar cells are listed in table 3.1

Table 3.1: Wavelength of absorption spectra with band gap energy

Dye concentration	Absorption spectrum	Band Gap
50°C	537nm	3eV
60°C	343nm	2.6eV
70°C	298nm	2eV
80°C	342nm	1.7eV

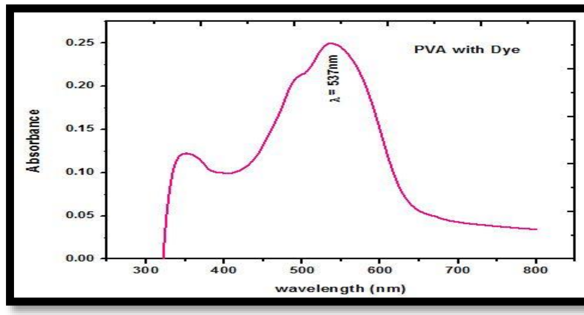


Figure 3.1 (a) UV absorption spectra for 50°C

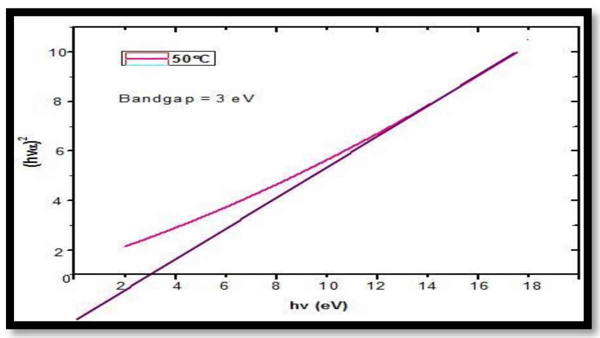


Figure 3.1(b) Tauc plot for 50°C

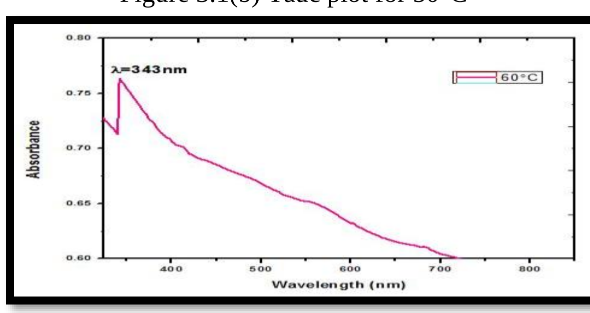
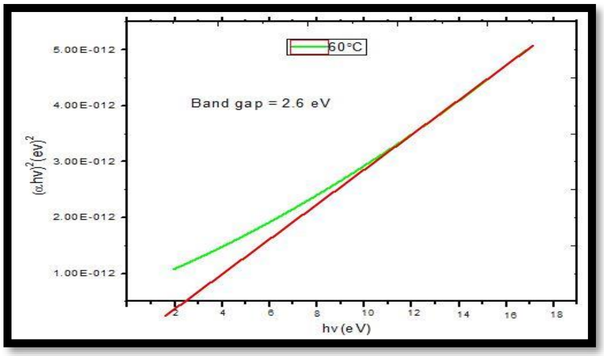


Figure 3.2 (a) UV absorption spectra for 60°C



3.2 (b) Tauc plot for 60°C

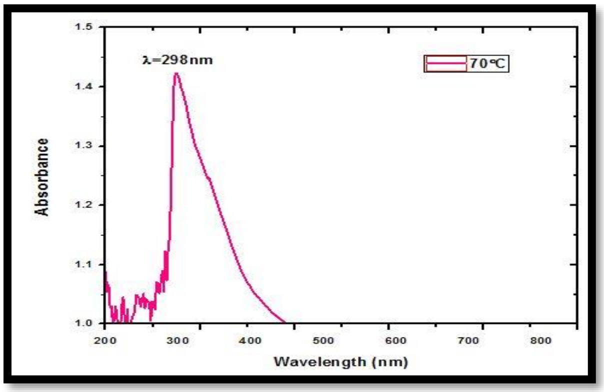


Figure 3.3 (a) UV absorption spectra for 70°C

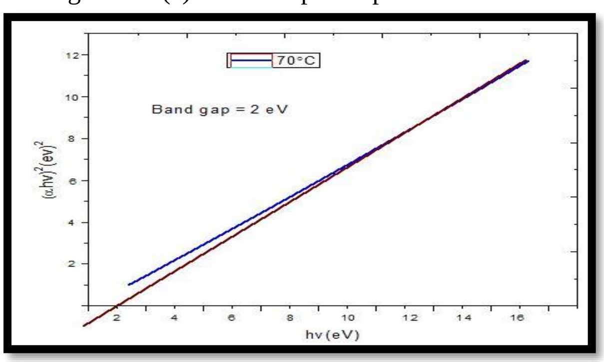


Figure 3.3 (b) Tauc plot for 70°C

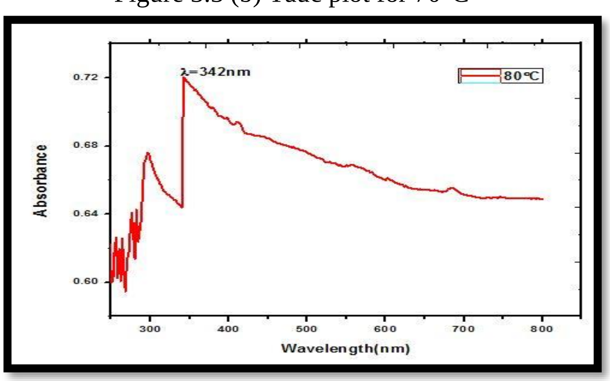


Figure 3.4 (a) UV absorption spectra for 80°C

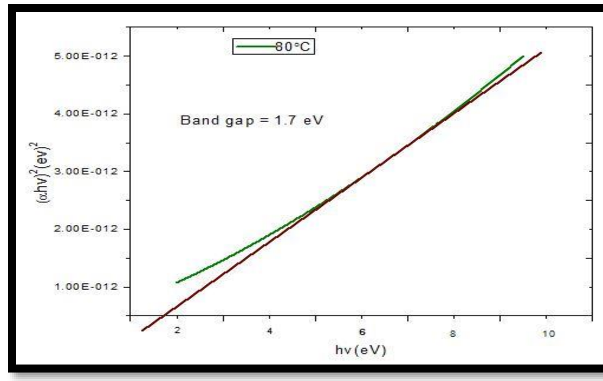
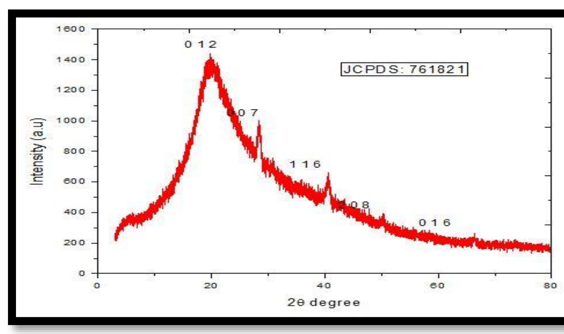
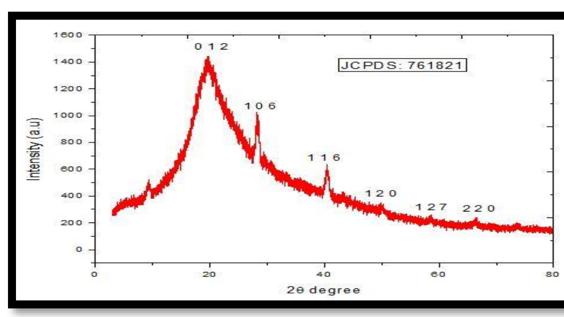


Figure 3.4 (b) Tauc plot for 80°C

3.2 X-Ray Diffraction

The XRD patterns of the dye were carried out using Rigaku miniflex 600 instruments and the diffraction patterns are shown in figure 3.5 (a) – (d). Figure 3.5 (a) shows the diffraction pattern of dye particle at 50˚C. It reveals that as synthesized dye particle are crystalline in nature. The peaks at the 2θ values 20, 28.6, 40, 50.5, 58.8, and 73.5 were fitted and their hkl planes were identified as (012), (007), (116), (120), (208) and (016) respectively, which coincides with the JCPDS card no 76-1821. The average crystallite size of the synthesized dye particle was calculated as 5.4nm.





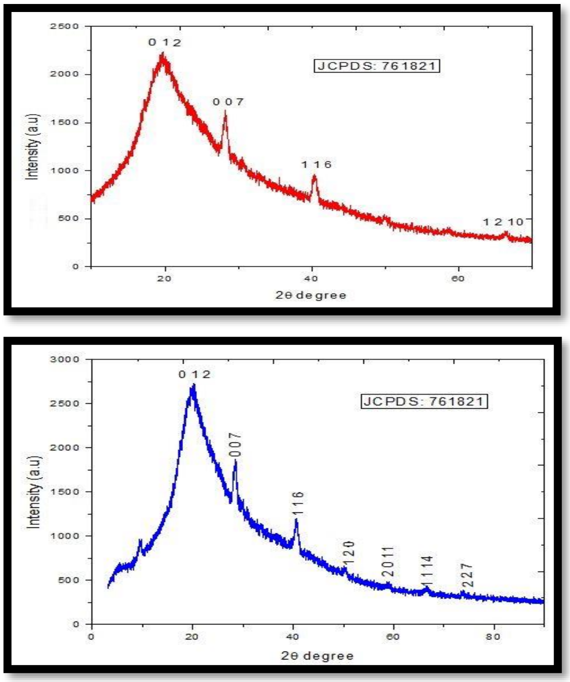


Figure 3.5 XRD patterns of the dye particles at different temperature (a) 50˚C, (b) 60˚C, (c) 70˚C, and (d) 80˚C

Figure 3.5 (b) shows the diffraction pattern of dye at 60˚C. It reveals that as synthesized dye particle are crystalline in nature. The peaks at the 2θ values 19.5, 28, 40, 50, 58 and 66 were fitted and their hkl planes were identified as (012), (106), (116), (120), (127) and (220) respectively, which coincides with the JCPDS card no 76-1821. The average crystallite size of the synthesized dye particle was calculated as 6.1nm.

Figure 3.5 (c) shows that the diffraction pattern of dye at 70˚C reveals that as synthesized dye particle are crystalline in nature. The peaks at the 2θ values 19.7, 28, 40 and 66 were fitted and their hkl planes were identified as (012), (007), (116) and (1 2 10) respectively, which coincides with the JCPDS card no 76-1821. The average crystallite size of the synthesized dye particle was calculated as 9.2 nm.

Figure 3.5 (d) shows the diffraction pattern of dye at 80˚C. It reveals that as synthesized dye particle are crystalline in nature. The peaks at the 2θ values 19.9, 28, 40.6, 50 and 66 were fitted and their hkl planes were identified as (012), (007), (116), (120), (2 0 11), (1 1 14) and (227) respectively, which coincides with the JCPDS card no 761821. The average crystallite size of the synthesized dye particle was calculated as 9.8nm.

The average crystallite size of the synthesized dye particles calculated using Scherrer formula and are give in Table 3.2.

Table 3.2: Particle size of the Basella alba dye at different temperature

S.No	Temperature	Particle size (nm)
1.	50˚C	5.4
2.	60˚C	6.1
3.	70˚C	9.2
4.	80˚C	9.8

3.3 Electrical Properties

3.3.1 I-V Characterization

The current-voltage (I-V) characteristics of prepared solar cells at various temperature of organic dye 50°C, 60°C, 70°C, 80°C are shown in Figure 3.6. The electrical properties of the prepared samples were measured by two probe method. The keithley electrometer (model 65174) was used to measure a current as a function of the applied voltage. The I-V characteristics of the films of blend polymers were recorded at various temperature which led to be linear and showed ohmic behavior at all applied voltage[14, 15]. From the table, it was found that the maximum efficiency of the solar cell was obtained at 80°C with 6.7%.

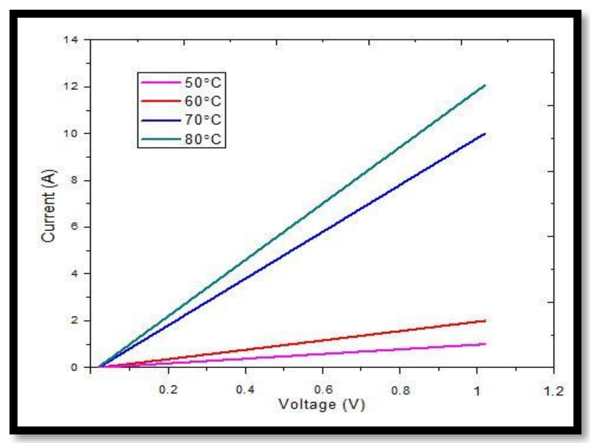


Figure 3.6 I-V characteristic curve for various temperature.

Table 3.3. Efficiencies of the solar cell at different temperatures.

Temperature of the cell	Voltage (V)	Current (A)
50°	1	1
60°	1	2
70°	1	10
80°	1	12

4. CONCLUSION

Polymer based solar cell was prepared with Basella alba dye and polyvinyl alcohol (PVA) and the following results were obtained. The absorption wavelengths were determined for different temperature from 50°C - 80°C range between 250nm – 600nm. The bandgap of the solar cells are 3 eV, 2.6 eV, 2 eV, 1.7 eV. The resultant bandgap of the Tauc plot confirms the spectroscopic behavior of the solar cell. Particle size of the dye extract at various temperatures were determined from x-ray diffraction using Debye-scherrer's formula and the particle size at 50˚C, 60˚C, 70˚C, 80˚C temperature are 5.4nm, 6.1nm, 9.2nm, and 9.8nm respectively. The electrical properties of prepared samples were studied and it showed that, all samples displayed ohmic behavior. The maximum efficiency of the solar cell was obtained at 80°C with 6.7%. The future work may be towards the fabrication of the solar cell.

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