The effect of adding conductive polymers to the efficiency of silicon solar cells

Morooj A. Abood¹, Ashwaq A. Jabor¹, Khansaa khuder Abbas², Eman Sapte²
¹Solar Energy Research Centre, Renewable Energy Directorate, Ministry of Science and Technology, Baghdad, Iraq
²Directorate of Materials Research, Ministry of Science and Technology Baghdad, Iraq

Abstract. Poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) (BEDOT:PSS) and Poly Aniline (PANI) thin films was grown onto silicon solar cells by Dip-coating deposition method at thickness (100 nm). The optical properties were studied by using UV-V is absorption spectra. The surface morphology of the films was characterized by a scanning electron microscope SEM and the current–voltage characteristics of solar were measured. Values from 8.64, 7.21 by type of conductive polymers.

Keywords. Conductive polymers, silicon solar cells

1. Introduction
Polymers have several advantages, such as easy processing, low cost, flexibility, high strength, and good mechanical properties. In the microelectronic fabrication industry, polymers are used in the photolithography process just like metals have high conductivity due to the free movement of electrons through their structure, for polymeric systems to be electronically conductive they must possess: A, charge carriers doping. B, An orbit that allows the charge carriers to move conjugation.

PANI is widely used in various industrial fields due to its attractive properties compared to other conducting polymers such as polyacetylene (PA) [1, 2] polypyrrole (PPy) [3] and polythiophene (PT) [4]. Researchers are interested in improving properties such as the electrical conductivity, stability and process ability of PANI through the choice of appropriate dopants. Furthermore, the properties of conducting polymers can be modified depending on the type of monomer; researchers have been successful in the preparation of PANI possessing highly desirable properties by blending it with polymers that have excellent physical and mechanical properties.16, 25 The influence of dopants on the synthesis and properties of PANI have previously been studied. The charge transport mechanism in the case of PEDOT: PSS can be generally explained within the framework of the charging-energy limited tunneling model, originally proposed for highly disordered conducting polymers. In this model conduction is supposed to proceed from tunneling between small conducting grains separated by insulating barriers. This model is an extension of Sheng’s model of granular metals; it focuses on the disorder present in the polymer and the polaronic ground state characteristic in many conducting polymers. According to this model, the conducting clusters are highly doped ‘polaronic islands’ generated by heterogeneities in the doping distribution.

The dopant centers act as bridges between neighboring chains and therefore improve the charge carrier transport. The conductivity of PEDOT: PSS film can be enhanced by more than two orders of magnitude by adding compounds with two or more polar groups, like ethyleneiglycol, into an aqueous solution of PEDOT: PSS. The additive induces a conformational change in the PEDOT chains in the PEDOT: PSS film. Both coil and linear or expanded–coil conformations exist in untreated PEDOT: PSS films, whereas the linear or expanded–coil conformation becomes dominant in high conductivity PEDOT: PSS films. This conformational change results in an increase in the intra chain and inter chain charge-carrier mobility, so that the conductivity is enhanced [5]. Dip-coating is one way of coating polymers, a substrate is dipped into a liquid coating solution and then is withdrawn from the solution at
a controlled speed. Coating thickness generally increases with faster withdrawal speed. The thickness is determined by the balance of forces at the stagnation point on the liquid surface. A faster withdrawal speed pulls more fluid up ion to the surface of the substrate before it has time to flow back down into the solution. The thickness is primarily affected by fluid viscosity, fluid density, and surface tension (fig 1). Dip-coating, while excellent for producing high-quality, uniform coatings, requires precise control and a clean environment. The applied coating may remain wet for several minutes until the solvent evaporates. This process can be accelerated by heated drying. In addition, the coating may be cured by a variety of means including conventional thermal, UV, or IR techniques depending on the coating solution formulation. Once a layer is cured, another layer may be applied on top of it with another dip-coating / curing process.

Figure 1. Dip-coating

2. Experimental
Si solar cell was etching by HF acid concentration of 0.4 for a ten minutes then was cleaning by acetone and alcohol. The films of PANI and PEDOT: PPSS thickness of 100 nm, were deposited by Dip-coating over Si solar cell an area of 8cm². The optical measurement include UV-Visible SEM is used to examine the morphology of the formed blend. The morphology and structures of the films are very important to determine the properties of the PANI and PEDOT: PPSS nano structure size. The Furrier Transform-Infra Red (FTIRTENSOR 27) (400-4000 cm⁻¹) to find out the nature of the bonds with the compound. The characteristics of current-voltage under dark and light condition was measured by Solar cell efficiency measurement system (C100AAA).

3. Results and Discussion
The transmission spectra for PEDOT: PSS and PANI are given in the Figure 2, show high transmission of the PEDOT: PSS in Vis-Near Infrared than PANI, shows in Figure 3 and 4, the FT-IR spectrum for PANI & PEDOT: PSS, shows the bond stretching represented by the range (2000-4000) icm⁻¹. The spectrum shows a weak peak in the range (600-400) cm⁻¹ which indicate the presence of (metal-Nitrogen) bond vibration at (466-578) cm⁻¹ have been assigned for (Nickel– Nitrogen). A number of well-defined bands assigned to PEDOT: PSS vibrations are found in the region of500 cm⁻¹ to2000 cm⁻¹ as depicted and 1400ito 1500 cm⁻¹ associated with C=C symmetrical stretching has been employed to distinguish PEDOT being in its benzoid and quinoid [203,204]. The band at (1400-1100) cm⁻¹ is for bond of C-Oi stretching, the peak (1431) cm⁻¹ indicates to Stretching vibration band (C–Ni) and the peak (1600-1500) cm⁻¹ indicates C=C bond. The band at (2900-2700) cm⁻¹ is for bond of C-H stretching. Show table 1, the FT-IR absorptions bands are shown in Table (2). The morphology of PEDOT: PSS prepared by dip-coating, observed that the shapes of grain is nano fiber as shown in figure 6 FESM test appear. The nano fiber structure of polymer particle size with average nearly 47nm.
Figure 2. The transmittance spectra of PANI & PEDOT:PSS

Figure 3. 4 FT-IR spectra for PEDOT:PSS

Figure 4. FT-IR spectra for PANI

Table 1. Shows the bond of PEDOT: PSS.

| Bonds Type                     | Wave number (cm$^{-1}$) |
|--------------------------------|-------------------------|
| metal-Nitrogen (weak peak)     | 600-400                 |
| Nickel–Nitrogen                | 466-578                 |
| C= C stretching                | 1400 - 1500             |
| C-O stretching                 | 1400-1100               |
Table 2. The absorption bands of Polyaniline.

| Vibration groups                                      | Absorption bands(Cm⁻¹) |
|-------------------------------------------------------|-------------------------|
| Stretching vibration band (N-H)                       | 3410                    |
| Stretching vibration band (C-H) aromatic              | 2924                    |
| Stretching vibration benzoid (C − N)                  | 1597                    |
| Stretching vibration band (C=C) to the benzene ring   | 1307                    |
| Bending band (C-H ) to the benzene ring               | 1134                    |

Figure 5. Scanning Electron Microscope (SEM) of PEDOT: PSS thin films.

Figure 6. Scanning Electron Microscope (SEM) of PANI thin films.
Figure 8 shows the current-voltage measurements of the solar silicon cell without additives. Figure 8.9 shows the current-voltage measurements of PANI and PEDOT: PSS on the silicon solar cell. The best efficiency of the models is PEDOT: PSS on solar silicon cell and equal (8.64%). This is due to the high permeability of PEDOT: PSS compared to PANI, as well as the high electrical conductivity of the PEDOT: PSS.

Figure 7. The current-voltage measurements of the solar silicon cell without additives

Figure 8. The current-voltage measurements of PANI on the silicon solar cell.
4. CONCLUSION
In this paper, studied the effects of adding conductive polymers to the efficiency of solar cells. We have increased the efficiency by 2% for solar cell area of 8 cm. conductive polymers just like metals have high conductivity due to the free movement of electrons through their structure, for polymeric systems to be electronically conductive they must possess: Charge carriers (Doping)and orbit that allows the charge carriers to move (Conjugation).

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