Effect of CdSe loading on bulk heterojunction solar cell parameters

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Hybrid solar cells based on conductive polymer poly(o-toludine) (POT) with Cadmium Selenide nanoparticles (CdSe NPs) bulk heterojunctions (BHJ) were prepared by the direct mixing method and then the optical properties of the prepared materials were analyzed. The photovoltaic response of a hybrid film is studied by I –V measurements under simulated one-sun AM 1.5 illumination (100 mW cm-2). Three different CdSe load was tested to study the effect of CdSe loading on optical properties and efficiency of solar cell. Best ratio was 1:1 were gave 0.28 % efficiency. Also no photovoltaic effect for device with 75% CdSe load.

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1. Introduction

Conjugated polymers are used in a wide variety of applications and industries because of their many useful properties, including their ease of production, low cost, and the fact that their chemical structure can be easily modified to alter their physiochemical properties, such as the size of their band gaps. All the way from metal to insulator (10^{-9} to 10^{5} S/cm), they show a wide range of conductivities. Along with low production costs and ease of manufacture, the fact that they are also somewhat poisonous makes them a competitive option [1].

Combining particles like iron oxide Fe_2O_3 [2], cadmium selenide CdSe [3], titanium dioxide TiO_2 [4], and others like them with conducting polymers enhances their properties for use in optoelectronics, catalysis, antibacterial activities, storage, and other fields [5-8].

Cadmium selenide (CdSe), one of several inorganic semiconductor materials, displays remarkable optical properties due to the quantum confinement effect and the bandgap's extensive adjustment with particle size. The bandgap is 1.74 eV. Wurtzite (Hexagonal), sphalerite (Cubic Type, Zinc-Blend), and a blend of the two are the three crystalline phases of CdSe that have been identified so far by scientists. The most stable shape is a hexagonal wurtzite [9-16].

Organic matrix with embedded semiconductor nanoparticles have attracted a lot of attention because they make it possible to create active devices that take advantage of both the rich variety of organic materials and the superior performance afforded by inorganic nanostructures. Because of their fascinating physical properties and wide range of potential applications, conductive polymer-inorganic hybrid materials consisting of different mixtures of the two have recently attracted a lot of interest [17-19].

Over the course of the past few decades, solar cells have garnered a growing amount of interest as a potentially useful alternative to the dwindling supply of fossil fuels [20]

Polymer solar cells have attracted a great interest in relation to developing low-cost, light-weight, printable and flexible renewable energy sources. However, their power conversion

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efficiency (PCE) and stability must be further enhanced before they can become successful in large-scale renewable energy production [21,22]

Bulk heterojunctions (BHJs) containing electron-donor and electron-acceptor components have received a great deal of interest, especially in comparison to more conventional donor–acceptor or p-type/n-type semiconductor heterojunctions. Because of their benefits over the more common donor–acceptor or p–n semiconductor heterojunction bilayer structure, these devices are increasingly being used [23-25].

In this study, we report on hybrid solar cells based on EDTA capped CdSe nanoparticles mixed with (POT). The effect of CdSe content in polymer matrix on solar cell parameters is the key investigation here.

2. Experimentation

The preparation and characterization of conducting polymer, CdSe and hybrid materials have been done and revealed in details in our published works [26-28]. Solar cell fabrication have been done according to our published paper [29]. Table 1 show the details of samples.

Table 1. the details of samples.

Composition	Mass Ratio	Sample name
CdSe/POT	25/75	H7
CdSe/POT	50/50	H8
CdSe/POT	75/25	H9

3. Results and discussion

Absorbance spectra behavior of H7, H8 and H9 films are shown in Figure 1. The form of the UV–Visble spectrum of absorption belong to POT-CSA/CdSe-EDTA hybrid films are analogous to POT-CSA spectrum. On the other hand, the spectra in general displayed a noticeable reduction at polaron band absorption that reduction increased with increases of CdSe content in POT matrix [30]. This point toward that the state of doping of the hybrid nanomaterials have been enhanced. Such phenomenum could be ascribed to the presence of bigger number of charges on the backbone of polymer by presenting CdSe nanocstructures into the matrix of polymer [31]. Consequently, the polymer compact coil structure would convert to an extended coil stracture [32].

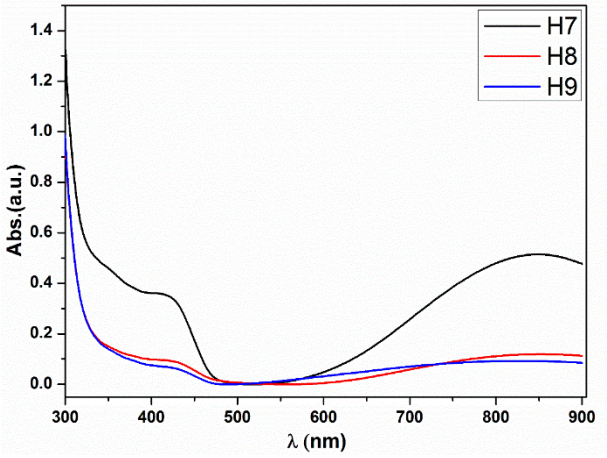

Fig. 1. absorption spectra of the prepared nanocomposites.

The peak ascribed to the benzen - transitions at 420 nm for polymer is showing red shifted and becomes broader in all the hybrid thin films. That specifies groundstate charges transference in addition to an enhancement in states of doping inside POT. peak at 826 nm come to be widened with inccrease in the CdSe NPs quantity. This peak is alsoredshifted in comparison to film of POT .the red shift in the spectra of absorption might be owing toward rise in polymer conjugations distance. That likewise proposes thatthere are complex charges transfer amongst polymers and NPs [33]. The precense of two peaks at 440 and 830 make the hybrid materials are photosensitive in a large spectral range, extending from visible to near infrared regions.

The optical energy gaps of the samples H7, H8, and H9 were calculated From the spectra of absorption the band gaps of wholly hybrid films are calculated by scheming energy of photons (hv) against $(\alpha hv)^2$ in figure 2 . Optical band gaps are found to decrease after increase the amount of CdSe NPs.

The band gap decreased continuously with increase in CdSe concentrations. The reduction in the band gaps in the current system might be due to decrease in the disarrangement of this system and the increasing in the defect states density [34].

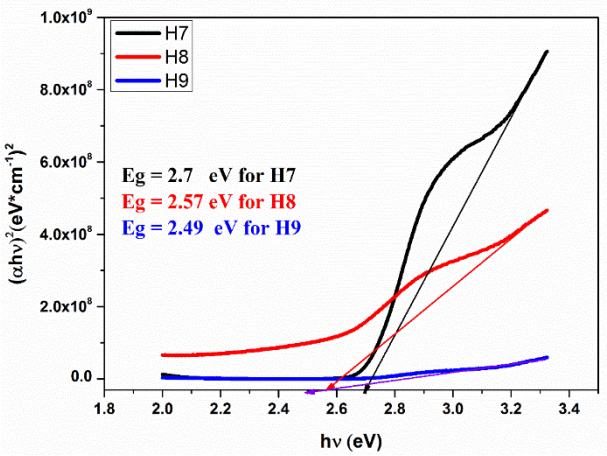

Fig. 2. Plot of (αhv)2 vs. hv for H7, H8 and H9 hybrid thin films.

The (J)-(V) properties of hybrid solar cells produced from POT-CSA/CdSe-EDTA nanocomposite are displayed in Figure 3.

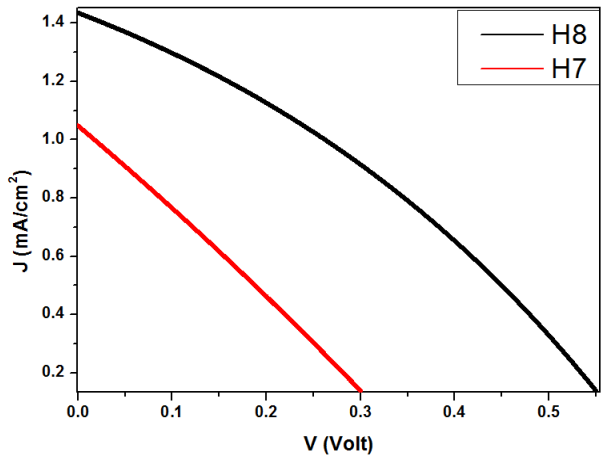

Fig. 3. J–V characteristic of fabricated devices.

These cells have a weight ratio of CdSe NPs that is 25 and 50 weight percent. It was found that the efficiency of fabricated devices varies depending on the quantity of CdSe nanoparticles in the photoactive layers. A device that was manufactured with 50 weight percent of CdSe NPs was found to have the optimal concentration of NPs. This device exhibited the highest efficiency possible, which was 0.28 percent, and it has a short current density that is equal to 1.4 milliamperes per square centimeter, in addition to an open circuit voltage that is nearly 0.55 volts. This device with 25% exhibited efficiency equal 0.1 percent, and it has a short current density that is equal to 1.04 milliamperes per square centimeter, in addition to an open circuit voltage that is nearly 0.3 volts. On the other hand, there is no photovoltaic impact (device with 75 CdSe NPs weight percent).

The performance of organic-inorganic solar cells was found to be significantly dependent on the weight ratio of electrons donor to the acceptor so the effect of the donor-to-acceptor ratio on the efficiency of the solar cell was studied and it was concluded that the best ratio between D to A is 1: 1. No photovoltaic effect in devices made from 1:3, which contain CdSe aggregates, could be due to the formation of insufficient interpenetrating network throughout the photoactive layer.

4. Conclusions

Hybrid nanocomposites material based on CdSe and POT in conjunction with three different ratio of CdSe NPs has been fabricated. The effect of the ratio of the CdSe on the optical properties and parameters of solar cell have been investigated. Best ratio was 1:1 were gave 0.28 % efficiency. Also no photovoltaic effect for device with 75% CdSe load.

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