Novel POT/CdSe blend for optoelectronic applications

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Here in this paper, we present a new hybrid design from poly (o-toluidine) doped with camphor sulfonic acid (POT-CSA) nanoparticles and CdSe capped with tri ethanolamine (TEA) nanoparticles. The structural, morphology and electrical have been examined. The XRD pattern of hybrid material analog to pattern of CdSe nanoparticles which is cubic structure. Conductivity measurements show that the hybrid films semiconducting in nature and the value of conductivity have been obtained equal to 0.1 $S.cm^{-2}$.

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1. Introduction

The development in many fields of applied science and modern technology demand us to develop new materials to keep up with this growing technological evolution. We need to manufacture and develop inexpensive, flexible and easy to handle materials. These materials are hybrid materials. The term "hybrid" denotes to the connotation of as a minimum two components that are completely dissimilar to their chemical nature either through simple blending or by bonding the components together through particular reactions [1]. These materials reveal new beneficial properties and can be very different from those of their separate counterparts. It is for that reason expected that this kind of structures would play progressively important roles in research and in many applications [2]. The most important of these hybrids are organic-inorganic hybrid nanocomposite materials. The benefit of mixing inorganic nanoparticles with polymers in organic solvents is to arrange large-area thin films by low budget processing methods like drop casting and spin coating. These methods gives easy control of the thickness of films [3]. Bulk heterojunction solar cells" made of conducting polymers denote a novel phase in the development of photovoltaic devices and this type of excitonic cells are presently the most studied solar cells [4]. They combine the exclusive properties of inorganic semiconductors with the film-forming properties of the conjugated polymers [5]. Many kinds of inorganic semiconductors and organic conductive polymers have been looked upon as possible candidates for photovoltaic hybrid materials. CdSe is the most important among the electron acceptors.

The first hybrid solar cell device using CdSe nanoparticles was reported by Greenham et al [6]. Since then, inorganic semiconducting nanostructures, such as CdSe nanostructures, with different structures, sizes, shapes, and morphological characteristics have been investigated and applied for hybrid bulk heterojunction (BHJ) solar cells [7]. Through the production of CdSe nanoparticles, electrical insulated organic structures such as TOPO or dyes have been used as stabilizers to hold the particles separated from each other and not composed into greater accumulations [8]. The presence of stabilizers in the active layers of hybrid solar cells improves the mixing between the electron donor (organic semiconductor) and the acceptor (inorganic nanoparticles), but at the same time, increases the series resistance of the cells [9]. enhances the performance of bulk heterojunction solar cells by increasing the dispersion of CdSe nanocrystals without introducing insulating surfactants [10]. Fine powders of CdSe could be obtained by using a complexing agent for the cadmium ion to slow down the reaction kinetics of cadmium and selenide. Triethanolamine (TEA) or sodium citrate have been used as cadmium complexing agents [11]. Conjugated polymers, such as poly 3-hexylthiophene P3HT, and its derivatives

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dispersed with cadmium selenide are finding applications in the development of organic solar cells.

Poly(3-hexylthiophene) (P3HT) is a type of conducting polymer that is used for flexible polymer electronic devices like organic solar cells (OSCs) [12]. But there is a problem with using P3HT especially in regioregular form, is an expensive polymer because of its complicated synthesis approach.. Getting cheap polymer instead of P3HT an interesting and attractive idea. Conducting polymer such as polypyrrole, polyaniline, polythiophene etc. exhibits good photovoltaic characteristics [13][14]. poly(o-toluidine) (POT) is one of the promising polymers in photovoltaic cell due to its tunable electrical properties, environmental stability and its ease of synthesis. The polymer (POT) is one of the most important PANI compensators containing the CH3-group at the ortho site of the aniline monomer[8]. POT is often considered supreme over poly(aniline) because of its ease in processibility, as a result of better suspension properties of POT in solvents with compare to polyaniline, and also due to good thermal and environmental suitability [3].

2. Experimental

CdSe-TEA NPs. with direct energy gap 2 eV have been synthesized according to published literature [15,16] except that the final synthesized product centrifuged at 3000 rpm for 10 min and washed two times (5 min) in ethanol. POT-CSA nanoparticles has been synthesized by chemical polymerization [17].

POT/CdSe hybrid material was prepared according to our published papers [].

3. Result and discussions

Figure 1a shows a typical transmission electron microscopy (TEM) image of such CdSe nanoparticles. the morphology exhibits spherical in shape and high aggregation was observed. Figure 1b shows the optical absorption and emission spectra of CdSe-TEA NPs. from this figure the optical band gap was equal to 2 eV.

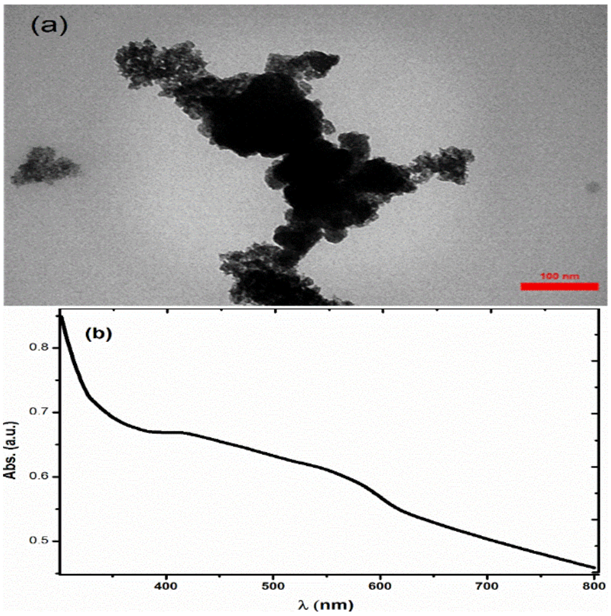

Fig. 1. (a) TEM images, (b) UV–vis absorption spectra of of CdSe nanoparticles.

Figure 2 shows and investigate the crystalline structure of CdSe-TEA nanoparticles and POT-CSA/CdSe-TEA hybrid material. The inset of figure 3 shows the XRD spectra of POT-CSA nanoparticles. The characteristics wide peak at $2\theta = 23^o$ confirms the formation polymer with amorphous or semi crystalline in nature. The peaks obtained in the fig.3 XRD spectra of CdSe-TEA at 25.4^o , 42.6^o and 49.4^o reflection from (111), (200) and (311) respectively are matched with the standard pattern of the cubic crystal of CdSe (JCPDS 19-0191); The XRD patterns with their broad bands indicate that the CdSe films involve nano-size particles[20]. No peaks resultant from impurities were detected, indicating the high purity of the mater.POT-CSA/CdSe-TEA hybrid material were presented in red color. It is evident from figure that the peaks at representing Bragg reflection from (111), (200) and (311) planes of CdSe NPs., which reflects the proper inclusion of CdSe particles in the hybrid film. It can be realized from figure below that the amorphous nature of polymer was found to be decreasing with the presence of NPs.

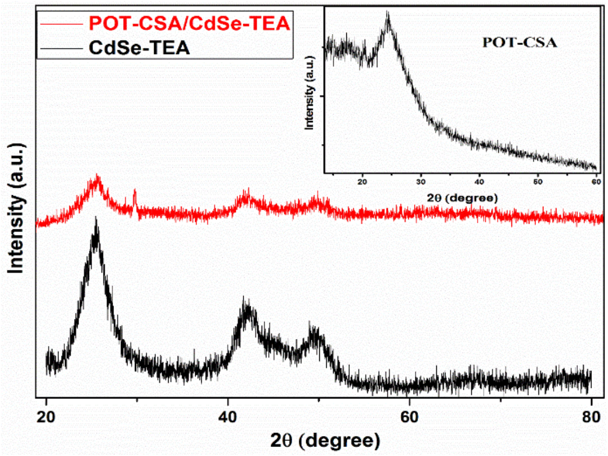

Fig. 2. X-ray diffraction patterns of hybrid films CdSe-TEA, H5 (50% CdSe) and inset POT-CSA.

Figure 3 shows the FESEM POT: CdSe thin films. The image shows a uniform distribution of the NPs in the POT matrix. Hybrid film demonstrate excellent homogeneous nanoparticles diffusion. the interface between POT chains and CdSe nanoparticles is sufficiently attractive to prevent of micro phase separation between POT and CdSe, this interaction speed up the properties of charge transport (electrons hopping) through the polymer [18]. Micrograph demonstrate that the surface of film turn into denser and rougher with the presence of nanoparticles in the hybrid films.

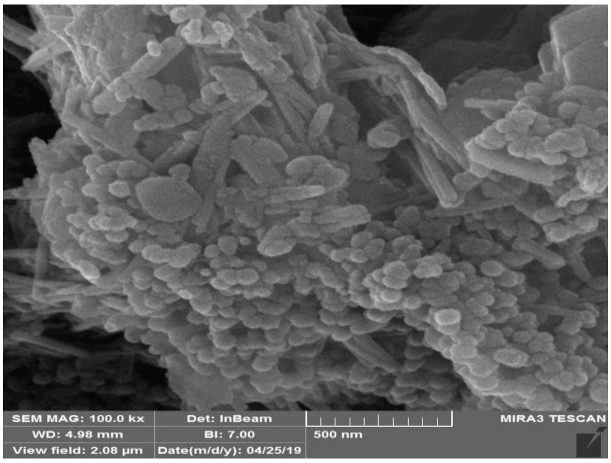

Fig. 3. FESEM analysis POT-CSA/CdSe-TEA.

Figure 4 shows the variation of current with varying voltage for of all films . The variation have been found to be symmetric and linear up to the operating range of applied voltage. dark conductivities of films were measured to study the effect of CdSe ration on the conductivity of the films. Doping (in this case presence of CdSe NPs) is responsible of electrical conductivity enhancement. The adding of CdSe might encourage the creation of more effective network for charge transport in the POT matrix, resulting in higher conductivities[19].

σ_d of the thin films as a function of temperature is plotted in Figure 5. The conductivity increased with the increasing of temperature, signifying that conduction is by means of an activated process, which is the characteristic semiconductors behavior. From the figure we can conclude that the conduction is through an activated process with single activation energy.

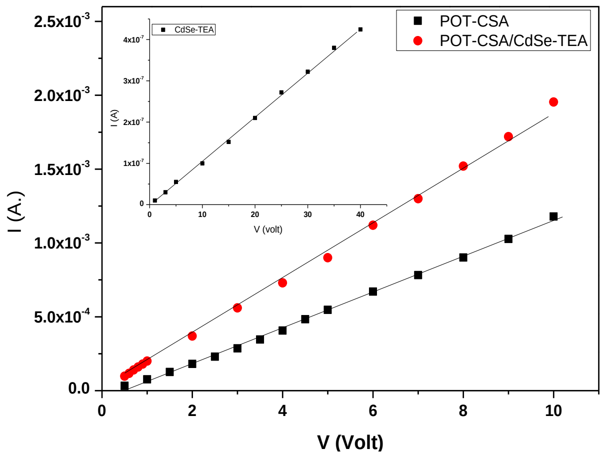

Fig. 4. I–V characteristics of hybrid devices.

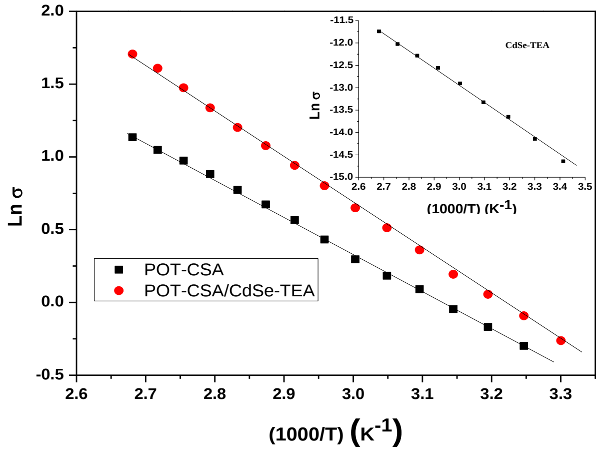

Fig. 5. The Arrhenius plot of DC conductivity vs. temperature.

4. Conclusion

We have studied the structural, omorphological and electrical properties of hybrid POT-CSA:CdSe-TEA by XRD UV–Vis spectroscopy, and field emission-scanning electron microscopy. The current density–voltage characteristics were studied. Conductivity measurements show that the hybrid films semiconducting in nature and the value of conductivity have been obtained equal to 0.1 $S.cm^{-2}$.

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