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Characterised the PANi-PTh-Ti copolymer for Photovoltaic application

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Abstract
Conjugated polymers are promising material for efficient solar energy conversion. In this paer, organic photovoltaic cells with the structure indium tin oxide (ITO)/copolymer/Al ware fabricated. The PTh and PANi is chemically polymerized by the oxidative method. In situ polymerization enables the formation of uniform PTh and Pani layers on ITO. (ITO)/copolymer/Al PV cell photovoltaic performance examine. The results show that the copolymer interfacial layer between the ITO and active layer can increase the efficiency and stability of the prepared copolymer PV cells. V_{oc} = 0.5 V, I_{sc} =225mA, FF=0.45 and η= 1.2 %. The characterization was done through XRD, SEM-EDX.
Keywords: Thiophene, Aniline, indium tin oxide (ITO), open-circuit voltage (V_{oc}), fill factor (FF), short-circuit voltage (V_{sc})

Introduction

During the last decade, polymeric/organic composite PV materials have received intense attention for cost-effective PV cell applications. It is providing long term feasible alternatives to silicon-based solar cells. The inorganic material like TiO_2, CdS and ZnO have been attracted much attention for PV application, due to wide band gap and their extraordinary optical, electronic and magnetic properties [1]. The PTh composites have been studied extensively with considerable interest for PV material. Because of its outstanding physical properties such as good environmental stability, unique redox electrical behaviour, optical properties, stability in doped or neutral states and ease of synthesis [2]. The polymer/metal oxide composites have shown promising material for PV applications. The composites of metal oxides with PTh, extends the absorption range of the modified composite system, thereby enhancing the efficiency under UV or visible light irradiation. In composite material, the electronic properties of the polymer were modified, thereby enlarging the potential for industrial PV applications [3]. Extensive researches have been devoted to the development of alternative, efficient metal-free dyes, which offer advantages as photosensitizers in that they have high molar absorption coefficients due to intramolecular transitions and their structure scan be modified easily and economically. In recent years, whilst various metal-free dyes based on coumarins [4], indolines [5], perylenes [6], merocyanines [7], porphyrins [8], triarylamines [9] and carbazoles [10] have been reported, such compounds display overall conversion efficiencies in the range 5 to10%.

In the light of above discussion, we planned to study the PV properties of chemically synthesized Ti doped PTh composites. A literature survey of materials science shows that there are few and scattered reports present on Ti doped PTh and PANi composites for PV application. Therefore, the present work is a unique attempt to report PV properties of Ti doped PTh-PANi composites. The ITO coated glass is used as a light transparent conducting electrode for the fabrication of PV cells.

Experimental

AR grade chemicals (Merck-India), monomer of thiophene and aniline, titanium chloride, were used in the present work. The thiophene and aniline monomers were used in 1:1 M. After the rigorous stirring of solution of thiophene and aniline monomers added 1M of $TiCl_4$ in that solution. In the polymerization reaction of mixture of monomers, it was observed that as soon as the $TiCl_4$ was added to the monomer solution, the colour changed almost instantaneously and the solution became dark brown/green. There was an increase in temperature of the solution during the start of reaction, which was an indication of exothermic reaction. The reaction was carried out at room temperature, which gives rise to the formation of a brown precipitate. The copolymer and mixture of PTh/PANi so obtained was soft jet- powder, dried in a desiccator's overnight and again dried in an oven at 40 °C. Doctor blade technique used to fabricate photovoltaic cell on ITO glass plates and photovoltaic cell connected to digital ammeter and milivoltmeter in series for measurements of diode parameters. The side view of fabricated photovoltaic cell is shown in Figure 1.

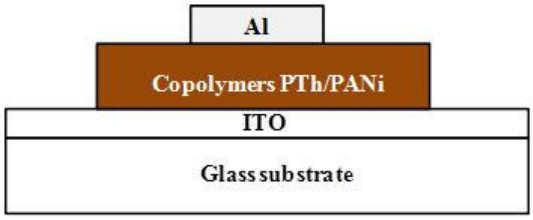

Figure 1 Side view of photovoltaic cell

Results and discussion

Figure 2 shows the XRD patterns of PTh-Ti composites. The XRD patterns of samples were recorded in 2Θ range=10-60° with a step height 0.02°. The sharp diffraction peaks appears at various 2θ positions, which clearly confirm the presence of Ti cluster in as-synthesized composites. Similarly, XRD patterns comprise the broad hump with some sharp shoulder peaks in the 2Θ range=20-30°, reflects the semi-crystalline nature of composites samples. In the XRD patterns of the PTh-PANi-Ti, lower diffraction peak intensities are suppressed by noisy pattern, which indicates the smaller inter planar spacing exists in as-synthesized materials.

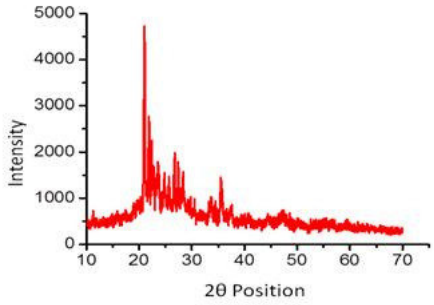

Figure 2. XRD pattern of as-synthesized sample

Polymerization of PTh-PANi can be monitored by scanning electron microscopy. At some spaces the granuals-like structure turns shorter and shorter, Form the observation of FE-SEM micrograph of all the sample of PTh-PANi-Ti composite consists of porous networks and circular microstructure rougher surface. The irregularness in particle size observed from the entire region of FE-SEM images. This also supported by XRD analysis. Chiefly smooth surface morphology of the products was observed. This would reveal a poor contact between the donor and the electron acceptor layers impairing the charge transfer between them and increasing cell reflectance [11].

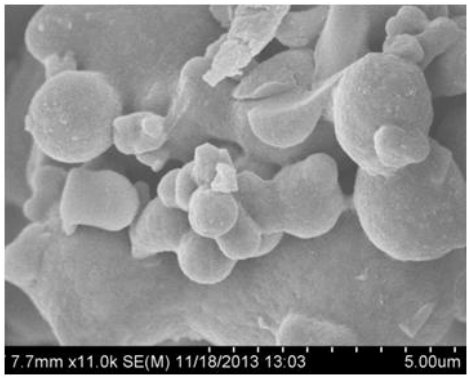

Figure 3. SEM IMAGE of copolymer of PTh-PANi-Ti

Figure 4 shows the EDX spectra of PTh-PANi-Ti with composition of 1:1:1 M ratio aniline, thiophene to TiCl4. From the spectra, it is observed that carbon, nitrogen and titanium are abundantly present in sample. EDX spectra also show the peak of oxygen, which shows that titanium present is sample undergoes for partial oxidation. The existence of nitrogen is attributed to presence of nitrogen group in PANi.

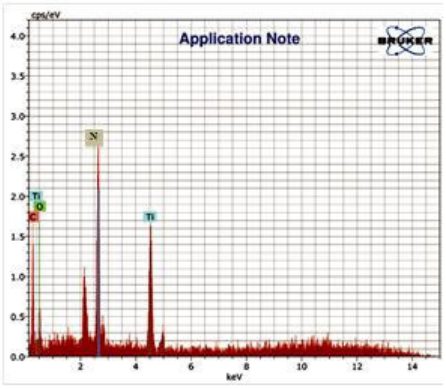

Figure4 .EDX spectra of PTh-PANi-Ti composite.

Figure 4 depict typical photocurrent–voltage (IV) curves for the as-fabricated PV cells of PTh-PANi-Ti composites same stichometric ratio of thiophene, aniline and $TiCl_4$. The PV response was taken under 100 W incandescent light bulb. From figure, the typical behaviour of semiconducting solar cell was observed in present case, at highest value of the current (I_{sc}) voltage become the zero (V_{oc}=0) and vice versa. The PV parameters like I_{sc}, V_{oc}, I_{max} and V_{max} were determined from the IV characteristics. Other PV parameters like FF and □% are estimated using the relation Eq. (1) and Eq. (2).

$$FF = V_{max} \times I_{max} / V_{oc} \times I_{sc} \quad (1)$$

□□□□ ((Voc □□Isc) □□FF)/Pin (2)

The power conversion efficiency □□of a PV device is calculated by using Equation (2), in which Pin is the power of incident radiation per cm^2 and Isc the short circuit current generated per cm^2 device area. PV parameter is found to be Voc = 0.5 V, Isc =225mA, FF=0.45 and η= 1.2 %.

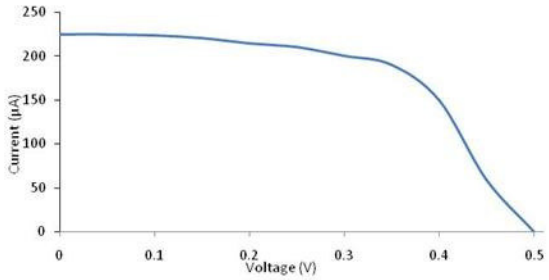

Figure 5.IV characteristics curve for the prepared photovoltaic cell.

Conclusions

PTh-PANi-Ti polymer composites were successfully synthesized by chemical oxidative polymerization route, while PV cell was fabricated by using cost effective doctor blade technique. In polymer composite material, enhancement in %η was due to the reduced band gap and its rougher morphological structure. IV characteristics of copolymer photovoltaic cell used to measured Voc, Isc, FF and efficiency and it is found to be Voc = 0.5 V, Isc =225mA, FF=0.45 and η= 1.2 %. The optimization of power conversion efficiency, fabrication of ITO, and alternating the form of devices from conventional flat to wires-based cells are needed for further study.

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