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Photovoltaic application of Ti doped PANi-PTh copolymer

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Abstract: Conjugated polymers and their copolymer are promising material for efficient solar energy conversion. In this study, polymer bulk-hetero junction photovoltaic cells with the structure indium tin oxide (ITO)/copolymer/Al ware fabricated. Beneficial effects of copolymer of polythiophene (PTh) and polyaniline (PANi) layers on ITO in photovoltaic cell are observed. The PTh and PANi is chemically polymerized by the oxidation method. In this oxidation method used $TiCl_4$ as a oxidative agent. 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. Open-circuit voltage (Voc), fill factor (FF), short-circuit voltage (Vsc), dark current ware measured. The characterization was done through XRD, SEM and FTIR analysis.

Keywords -Thiophene; Aniline; indium tin oxide (ITO); open-circuit voltage (Voc); fill factor (FF); short-circuit voltage (Vsc).

Introduction:

Photovoltaic cells (PVC) are considered as the most attractive research area, because of their high performance in converting solar energy to electric energy at low cost and easy production. In PVC, so far two classes of cells such as organic metallic complexes and metal-free organic photovoltaic cells were employed in the electrical energy production from sunlight[1]. Polymer photovoltaic (PV) cells have the advantage of low-cost fabrication and easy processing. The state-of-the-art device structure is the polymer bulk heterojunction blending conjugated polymers intimately with soluble fullerene derivatives. An interpenetrating network of the donor–acceptor blend sandwitched between the anode and cathode offers large interfacial area for efficient charge separation and excellent charge transport, leading to high efficiency performance [2]. Light absorption in organic solar cells leads to the generation of excited, bound electron–hole pairs (often called exactions). To achieve substantial energy-conversion efficiencies, these excited electron–hole pairs need to be dissociated into free charge carriers with a high yield. Exactions can be dissociated at interfaces of materials with different electron affinities or by electric fields, or the dissociation can be trap or impurity assisted [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%.

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 80% $TiCl_4$ 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.

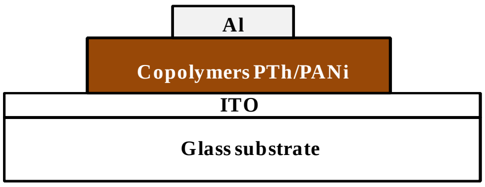

Figure 1 Side view of photovoltaic cell

Results and Discussion:

Figure 2 shows the XRD pattern of as-synthesized sample. Pattern shows some prominent peaks between 2θ=20-35°. Beyond 2θ=35°, pattern possesses noisy peaks. This confirmed the semi-crystalline nature of synthesized sample.

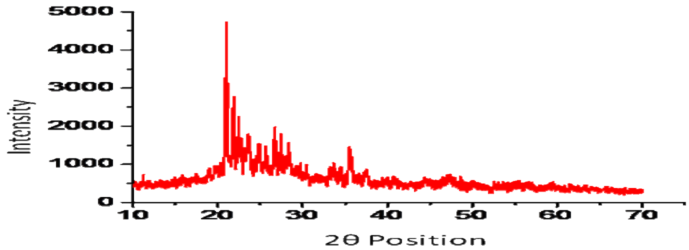

Figure 2. XRD pattern of as-synthesized sample

Polymerization of PTh-PANi can be monitored by scanning electron microscopy. The polymerization is very fast, and polymer forms sheet structure (Figure 3) some holes appeared on the sheet to fiber-like-structure . At some spaces the fiber-like structure turns shorter and shorter, 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

To establish the performance of a PV cell, I-V curves are measured, both in the dark and under irradiation. The dark current is obtained by varying the voltage without illumination. For properly operating cells typical diode behaviour is obtained. Under illumination a photocurrent (Il) is generated on top of the dark current. The I-V curve has several characteristic points. The short circuit current (I_{sc}) is obtained when the voltage is zero and the electrodes are connected externally. The open circuit voltage (V_{oc}) is obtained when the current is zero. At both points the cell does not produce power, since VI = 0. The maximum power (P_{max}) is obtained when the product VI is at a maximum (the “maximum power point”, MPP). The IV characteristics curve for the prepared photovoltaic cell is shown in Figure 4. Another indicator for the performance is the fill factor (FF). The FF of the photovoltaic cell estimated using Equation (1). The power conversion efficiency (ŋ) 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.

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

efficiency (ŋ) =((Voc×Isc)×FF)/Pin (2)

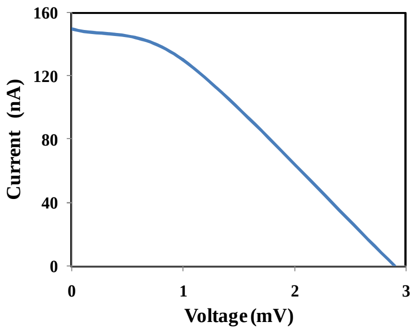

Figure 4: IV characteristics curve for the prepared photovoltaic cell.

Conclusions:

PANi, PTh and its copolymer have been successfully synthesized via in situ oxidative polymerization. XRD analysis confirmed that prepared sample has semi-crystalline nature. IV characteristics of copolymer photovoltaic cell used to measured Voc, Isc, FF and efficiency and it is found to be Voc = 2.80mV, Isc =153mA, FF=0.45 and η= 0.203%. 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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