SPECTRALLY TUNED P- N JUNCTION BLEND FOR PLASTIC SOLAR CELL

ISHWAR NAIK, RAJASHEKHAR BHAJANTRI

Abstract: Poly [2-methoxy-5-(2-ethylhexyloxy)-1-4-phenylenevinylene] (MEH-PPV) is a P-type organic semiconductor that can be combined with an N-type material to form a photoactive blend for plastic solar cells. Photoactive blend exhibiting a broad spectral absorption is the primary requisite of an efficient solar cell. We have prepared P-N junction blends of the P-type polymer MEH-PPV and N-type organic semiconductor Perylene -3,4,9,10 - tetracarboxylic- dianhydride (PTCDA) with weight ratios 3:1, 1:1 & 1:3 in chloro-benzene (CB) as the common solvent and glass coated samples are prepared by solution cast method. Samples are analyzed by UV-VISIBLE spectroscopy using JASCO UV Vis NIR V 670 spectrometer which indicated that the absorption spectra can be tuned or modulated with P: N weight ratios. Among the samples prepared, 1:1 blend of MEH-PPV with PTCDA shows a broad spectral response for absorption. The onset wavelength for pure MDMO-PPV film is 581nm with a band gap of 2.13 eV whereas that for 1:1 MEH--PPV: PTCDA film, the onset wavelength is 714.28nm with a band gap of 1.73 eV. A red shift of 133 nm or a band gap reduction of 0.4 eV is observed for the photoactive film with respect to that of pure MEH-PPV film. We conclude that 1:1 blend of MEH-PPV: PTCDA can be the best photoactive material to be used for construction of a plastic solar cell. Solar absorption can be further enhanced by either dye sensitization or by doping the active material with gold or silver nanoparticle.

Keywords: MEH-PPV, PTCDA, CB, LSPR.

Introduction: Harvesting the solar energy through organic solar cells is the powerful solution to energy crisis due to which the organic photovoltaics has become a highly popular research topic of the present day [1]. The first generation silicon based cells suffer from material cost, installation cost and fabrication complications. Even the second generation thin film solar cells are also not economical [2]. Organic solar cells are promising because of their low cost, simple processing and flexibility. They are widely investigated at scientific and industrial level [3]. Low efficiency is the main drawback of these solar cells but can be increased by designing a photoactive material having a broad spectral absorption for incident light. The solution processed bulk hetero-junction organic photovoltaic cells have gained serious attention in this regard[4].The present work is focused on optimizing the photoactive blend of P- type donor MEH-PPV & N- type acceptor PTCDA for broad spectral absorption The MEH-PPV is blended with PTCDA at 3:1, 1:1 & 1:3 weight ratios ,their films are coated on glass by solution cast method and Samples are characterized by UV-visible spectroscopy and the spectra are analyzed for maximum absorption of solar energy by the photoactive material.

Experimental Details: The P-type donor polymer MEH-PPV (mol.wt.40000-70000, HOMO 5.3 eV & LUMO 3.0 eV) & N-type acceptor PTCDA (HOMO 6.8eV & LUMO 4.7eV) are purchased from Sigma Aldrich Corporation. The solvent Chloro-benzene (mol.wt.112.56) is procured from (Rankem Chemicals) RFCL limited, India. All chemicals are used as received without further purification. 10mg of MEH-PPV and 10mg of PTCDA are dissolved in 100cm^3 & 20cm^{3}of chloro-benzene respectively in separate beakers, magnetically stirred for 48 hrs at room temperature until clear solutions are formed. The resulting solutions are of concentrations 0.1 mg/cm^3 & 0.5 mg/cm^3 respectively. The solutions are mixed at MEH- PPV: PTCDA weight ratios of 3:1, 1:1 & 1:3 and magnetically stirred again for 48 hours at room temperature to ensure the optimum blending. Blended solutions are transferred to 3cm diameter petri-plates, dried at room temperature and then at about 70^{o}C in an oven to get the glass coated samples. Absorption spectra are as shown below.

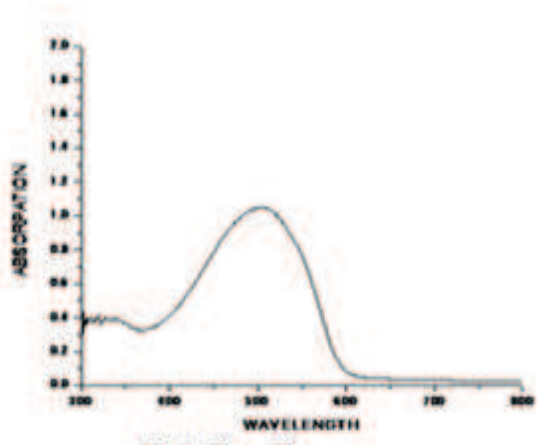

Fig1 Pure P

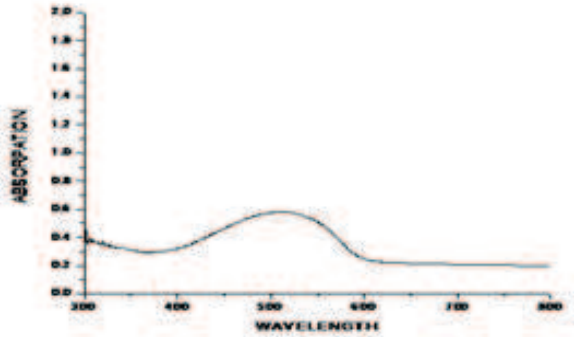

Fig2 3:1 P: N

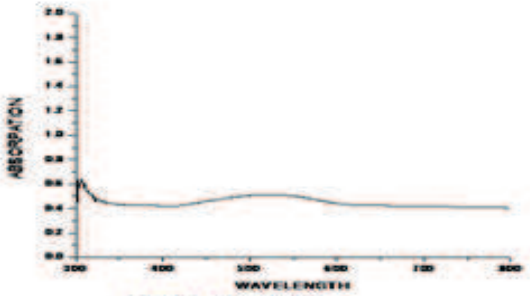

Fig3 1:1 P:N

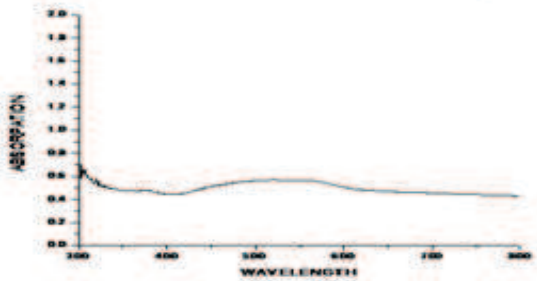

Fig4 1:3 P:N

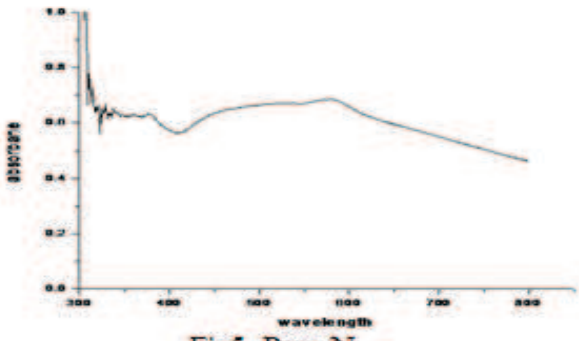

Fig5 Pure N

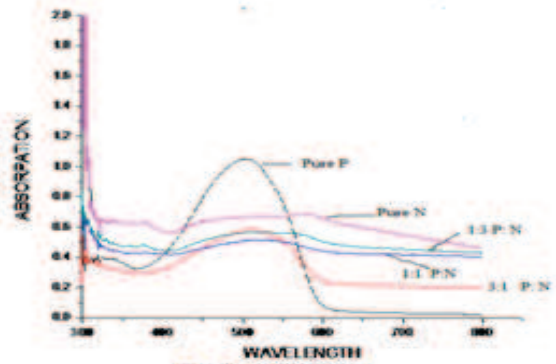

Fig6 Overlay

Tauc's Plot:

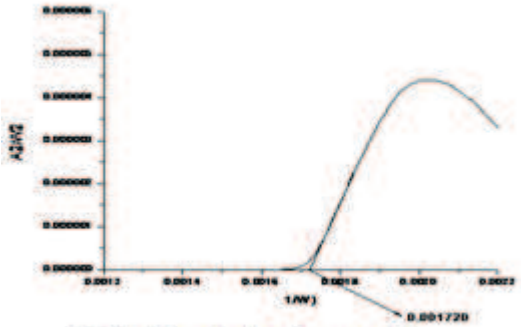

Fig7 Tauc's plot for pure P

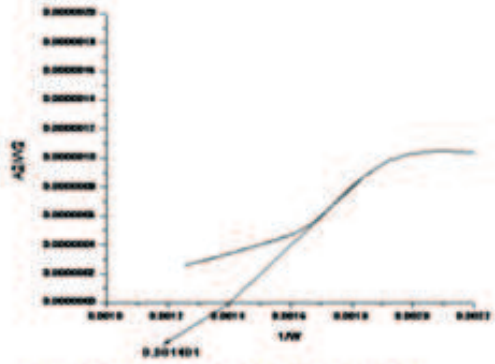

Fig8 Tauc's plot for 1:1 P:N

Result and discussion: Samples are characterized by UV-visible spectrometer JASCO UV Vis NIR V-670. Fig 1 shows the absorption spectrum of pure MEH-PPV film coated on glass which has λ_{max} = 503nm and onset of absorption λ_{onset} = 581nm. The band gap corresponding to this onset wavelength is 2.13eV which agrees with the results quoted in the literature. PTCDA is an acceptor and well known for high spectral selective absorption with good semiconducting property. It is a highly conjugated system with broad band of absorption with selective peaks between 400nm to 600nm having optical band

gap of about 2.2eV. Optical band gap of PTCDA is comparable to Poly Para Penylene Vinylene and also substituted PPVs. The molecule is almost as delocalized as the polymer and their π- π* transitions are similar [5]. Addition of PTCDA into MEH-PPV polymer matrix generates multiple donor-acceptor P-N junctions. Fig 2 is the spectrum for 3:1 blend of MEH-PPV: PTCDA indicating that PTCDA has reduced the absorbance of MEH-PPV in its spectral region. Fig 3 represents the spectrum for 1:1 MEH-PPV: PTCDA with relatively flattened absorption peak indicating the absorption beyond the spectral region of pure MEH-PPV film. Similar effect can be observed in fig 4 for 1:3 composition but 1:1 blend contains maximum PN junctions due to equal amount of MEH-PPV and PTCDA and hence preferred. The result is well predicted in the fig 6 showing the overlay of the spectra for all samples. The onset wavelength of the 1:1 blend is about 714.28nm (λ_{onset} = 714.28nm) which corresponds to an energy gap of 1.73 eV. Finally we conclude that presence of perylene in MEH- PPV can tune the spectral response of MEH-PPV and maximum tuning occurs in 1:1 composition to be the best photoactive blend for constructing the solar cell. The absorption can be further enhanced by either dye sensitization of the blend or by exploiting the Localized Surface Plasmon Resonance (LSPR) of doped metal oxide nano particles without increasing the thickness of the film. [6]

Conclusion: In the present work we have investigated UV- Visible absorption spectra for 3:1, 1:1, 1:3 blends of MEH-PPV: PTCDA photoactive material along with their pristine glass coated films. Spectral analysis indicated that presence of PTCDA in the blend can effectively tune the spectral response. Among these samples, 1:1 blend of MEH–PPV with PTCDA shows a broad spectral absorption extending from UV region to the region beyond the visible range. A red shift of 133 nm or band gap reduction by 0.4 eV is observed for the active material compared to pure MEH-PPV film. Although 1:3 blend is equally probable blend for solar cell, 1:1 blend is preferred due to the presence of large number of P-N junctions relative to 1:3 blend. We conclude that 1:1 blend of MEH-PPV: PTCDA can be used as the best photoactive material for constructing a plastic solar cell. The solar absorption can be further enhanced either by dye sensitization or by doping the blend with gold or silver nano particles that can exploit LSPR [6].The construction of the solar cell using the same photoactive blend is our work under progress.

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