Bulk-heterojunction Solar Cells Based on Mixed Donors of P3HT and Phenylene–Thiophene Oligomer Derivative

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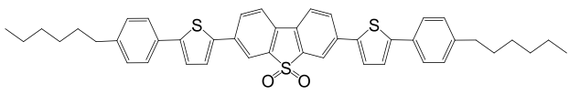
1. Introduction

Each of the materials used for organic solar cells has different spectral sensitivity characteristics. The spectral distribution of sunlight has a maximum intensity at a wavelength of approximately 450 nm. Therefore, solar cells are expected to have a maximum incident photon to charge carrier efficiency (IPCE) at approximately 450 nm. Bulk-heterojunction solar cells fabricated using poly(3-hexylthiophene) (P3HT): [6,6]-phenyl C61 butyric acid methyl ester (PCBM) have a maximum IPCE at approximately 500 nm.[1)] On the other hand, Duan et al. reported that a bulk-heterojunction solar cell based on dibenzothiophene 5,5-dioxide core, 3,7-bis [5-(4-n-hexylphenyl)-2-thienyl] dibenzothiophene-5,5-dioxide (37HPTDBTSO) (Fig. 1) has a maximum IPCE at approximately 400 nm.[2)] In this research, bulk-heterojunction solar cells were fabricated using a mixed solution of two donors, P3HT and 37HPTDBTSO, and an accepter, PCBM, to investigate whether the maximum sensitivity at 450 nm could be realized.



37HPTDBTSO

Fig. 1 Molecular structure of 37HPTDBTSO.

2. Experimental results

37HPTDBTSO was synthesized according to the previously reported procedures.[3)] Bulk heterojunction solar cells were fabricated using a spin-coating technique. After patterned indium tin oxide (ITO) glass substrates were cleaned, spin coating at 3000 rpm for 180 s in air was used to deposit an aqueous solution of poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) onto the cleaned ITO glass. The substrates were baked at 150 °C for 10 min. The chloroform blend solution of PCBM, 37HPTDBTSO, and P3HT was then spin coated on the top of the PEDOT:PSS layer. The weight ratio of the PCBM:P3HT:37HPTDBTSO was 3:1:1. Finally, a 100-nm-thick aluminum (Al) top electrode was evaporated. The active area of the solar cells was 4 mm^2.

The measured IPCE spectra indicated that the solar cell based on the two donors showed a maximum sensitivity at approximately 450 nm, and it had a wide sensitivity range (Fig. 2). The open circuit voltage V_{oc} was also improved, as shown in Fig. 3. The solar cell showed a V_{oc} of 0.62 V, a saturation current J_{sc} of 3.90 mA/cm^2, and a power conversion efficiency (PCE) of 0.90%. The solar cell performances are summarized in Table 1.

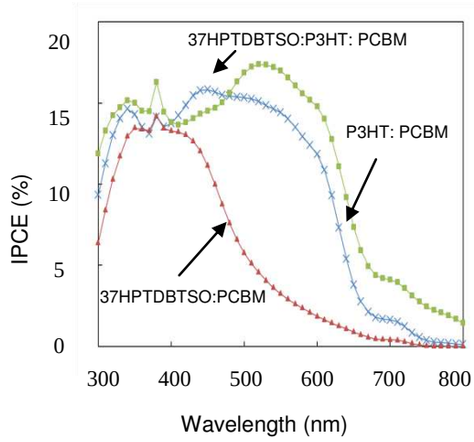


Fig. 2 ICPE spectra of fabricated solar cells.

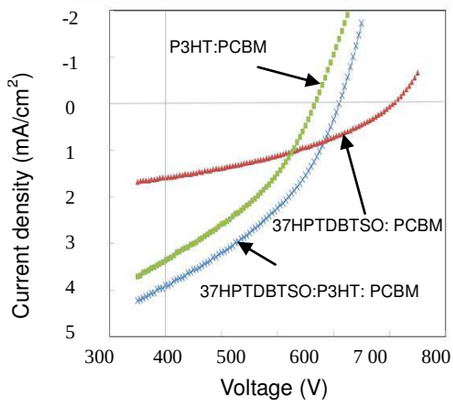


Fig. 3. Current-voltage characteristics.

Table 1. Summary of solar cell performances.

Active layer	J_{sc} (mA/cm^2)	V_{oc} (V)	FF	PCE (%)
37HPTDBTSO :PCBM	1.59	0.81	0.36	0.47
P3HT:PCBM	3.36	0.53	0.36	0.65
Mixed donors: PCBM	3.90	0.62	0.37	0.90

3. Summary

Bulk-heterojunction solar cells were fabricated using a mixed solution of two donors, P3HT and 37HPTDBTSO, and an accepter, PCBM. The IPCE spectra indicated that these solar cells based on two donors showed a maximum sensitivity at approximately 450 nm. The solar cells showed an improved V_{oc} of 0.62 V, a short circuit current density J_{sc} of 3.90 mA/cm^2, and a PCE of 0.90%. These results suggest that the IPCE of bulk-heterojunction solar cells based on mixed donors can be adjusted to the sunlight spectra.

References

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