Inverted Organic Solar Cell Applications of Benzodithiophene and Benzotriazole Bearing Alternating Copolymer

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Introduction

Inverted organic solar cells (IOSCs) have attracted great interest over the past few decades due to their lower cost, environmently friendly nature and ability to coat on flexible surfaces. IOSC is a solid state electronic device in which the active layer is a thin film of organic compound that absorbs light to generate electricity. Conjugated polymers having alternating single and double bonds are able to delocalize the electrons along the polymer backbone through the continuous sp^2 hybridization of carbon atom providing mobility of charge carriers, hence creating conductivity [1].

In this study, a novel alternating donor-acceptor copolymer containing benzodithiophene and benzotriazole was synthesized. Thiophene was incorporated as a π-bridge in polymer P1 and it was used as the donor material in fabrication of bulk heterojunction inverted solar cells. Electrochemical studies of the polymer were carried out with the use of cyclic voltammetry (CV) to determine the HOMO and LUMO energy levels. Photovoltaic performance of the P1 was investigated using inverted device structure of ITO/ZnO/Polymer:$PC_{71}BM$/MoO_3/Ag.

Experimental

Preparation of IOSCs

2.45 cm x 2.45 cm ITO-glass substrates were cleaned via sonication in different solvents for 15 minutes. O_2 plasma was carried out to eliminate organic impurities. ZnO which was filtered with 0.22 μm PTFE filter was spin-coated as the electron transport layer. Polymer solutions were prepared with different weight ratios, concentrations and processing additives to obtain the optimized cell construction. Solutions were stirred overnight and then filtered with 0.45 μm PTFE before spin-coating on ZnO layer. Finally, evaporation process was carried out by proper mask. MoO_3(10 nm) and Ag (100 nm) electrodes were deposited, respectively.

Results and Discussion

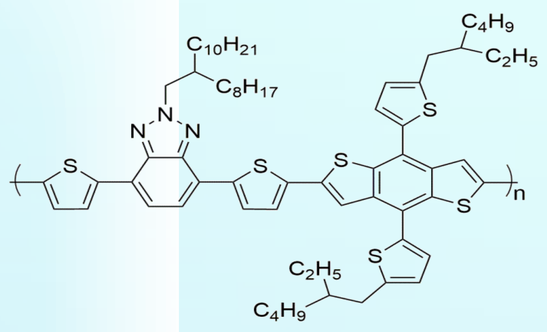

Figure 1.Chemical structure of P1

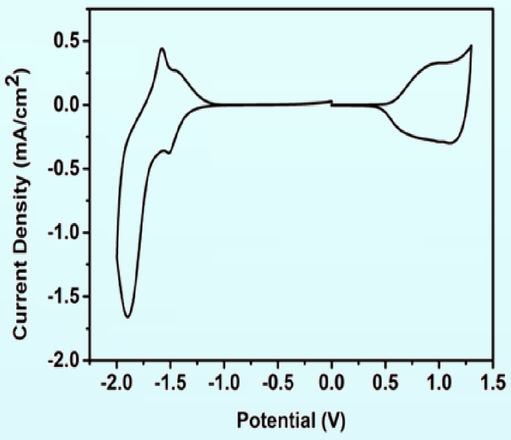

Figure 2. Single-scan cyclic voltammogram of P1 films in 0.1 M $TBAPF_6$ / ACN electrolyte solution

Table 1. Electrochemical Properties of P1

Polymer	$E_{p\text{-doping}}$ (V)	$E_{p\text{-dedoping}}$ (V)	$E_{n\text{-doping}}$ (V)	$E_{n\text{-dedoping}}$ (V)	HOMO (eV)	LUMO (eV)	E_g^{el} (eV)
P1	0.95	0.74	-1.89	-1.57	-5.30	-3.10	2.20

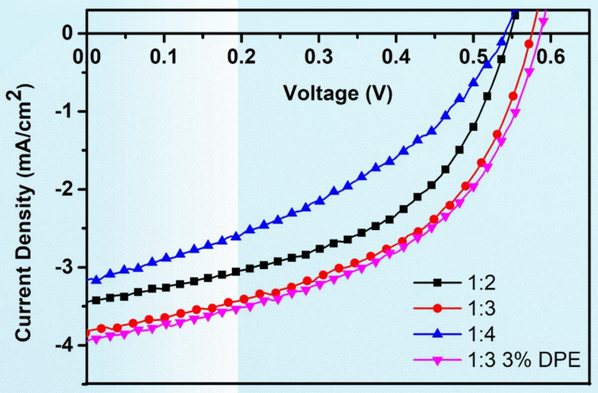

Figure 3. J-V characteristic of P1:$PC_{71}BM$ based IOSC

Table 2. Photovoltaic parameters of P1:$PC_{71}BM$ based IOSC

Polymer(P1):$PC_{71}BM$ (w:w)	J_{sc} (mA/cm²)	V_{oc} (V)	J_{max} (mA/cm²)	V_{max} (V)	FF%	Efficiency%	Solvent	RPM	Treatment
1:2 (2%)	3.4471	0.55	2.3889	0.39	49.14	0.94	cb	750	-
1:3 (2%)	3.8067	0.58	2.5439	0.43	49.54	**1.09**	cb	750	-
1:4 (2%)	3.1629	0.54	2.1214	0.31	38.50	0.65	cb	750	-
1:3 (2%)	3.8753	0.47	2.8750	0.34	53.66	0.97	o-dcb	750	-
1:3 (3%)	3.9458	0.59	2.5945	0.43	47.92	**1.13**	cb	750	-
1:3 (3.5%)	2.5988	0.61	1.6153	0.45	45.85	0.72	cb	750	-
1:3 (3%)	2.7269	0.60	2.0389	0.43	53.59	0.87	cb	500	-
1:3 (3%)	3.2486	0.55	1.9784	0.33	36.54	0.64	cb	1000	-
1:3 (3%)	3.3902	0.58	2.9038	0.37	54.64	1.06	cb	750	1.5% DIO
1:3 (3%)	3.5239	0.58	2.8899	0.38	53.73	1.10	cb	750	2% DIO
1:3 (3%)	3.1150	0.54	1.8765	0.34	37.92	0.64	cb	750	3% CN
1:3 (3%)	3.6395	0.58	2.9719	0.42	59.13	1.23	cb	750	6% CN
1:3 (3%)	3.4438	0.59	2.3284	0.40	45.84	0.93	cb	750	9% CN
1:3 (3%)	4.5103	0.52	3.4842	0.37	54.97	**1.30**	cb	750	3% DPE
1:3 (3%)	-	-	-	-	-	-	cb	750	3% DPE + MeOH

Conclusion

In this work, electrical band gap value of P1 was obtained as 2.20 eV. The inverted organic solar cell device based on **P1**:$PC_{71}BM$ (1:3, w/w) with 3% DPE exhibited the best power conversion efficiency of 1.30 % with a V_{oc} of 0.52 V, a J_{sc} of 4.51 mA cm^{-2} and a FF of 54.97 %.

References

1.A. J. Heeger, H. Shirikawa, A. G. MacDiarmid Electrical conductivity in doped polyacetylene, *Phys. Rev. Lett*. 39, 1098–1101,1977