Supporting information

Insights into the Photovoltaic Mechanism of Organic Photovoltaics under Solar and Artificial Light

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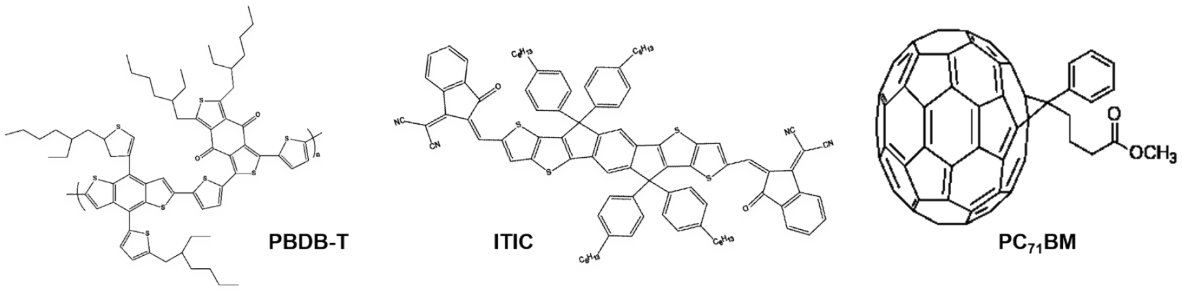

FigureS1. Chemical structures of PBDB-T, ITIC, and $PC_{71}BM$.

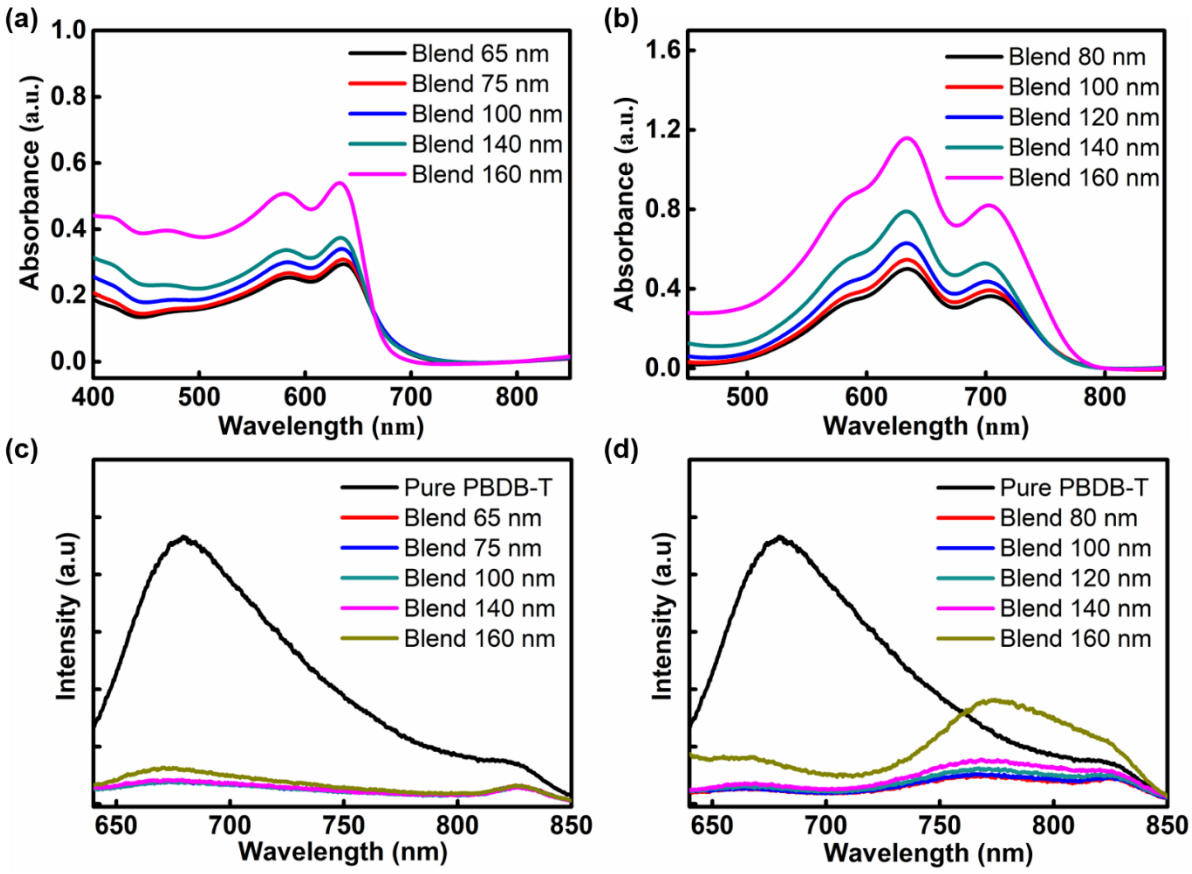

Figure S2. UV-vis spectrum of active layer thicknesses (a)PBDB-T:$PC_{71}BM$, (b)PBDB-T:ITIC. Fluorescence spectrum of active layer thicknesses (c)PBDB-T:$PC_{71}BM$, (d)PBDB-T:ITIC.

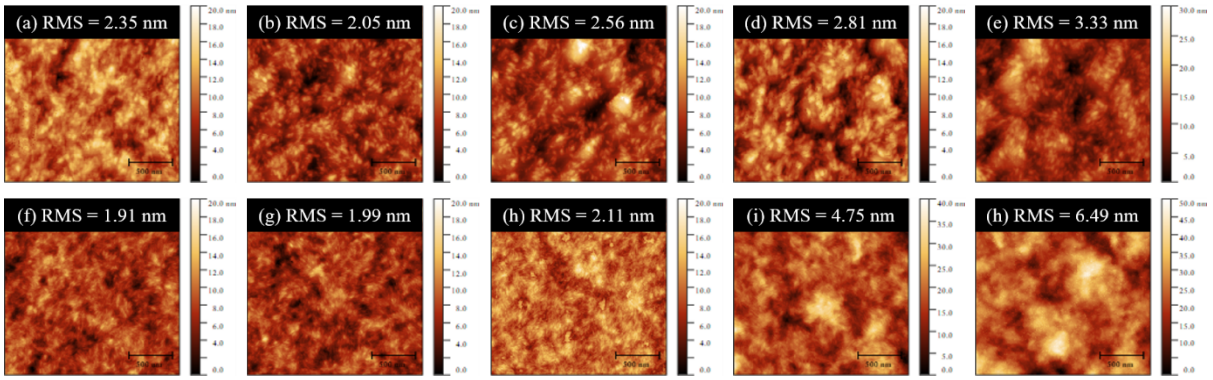

Figure S3. The morphology characterization and surface roughness. PBDB-T:$PC_{71}BM$ blend film with different thicknesses, (a)65 nm, (b)75 nm, (c)100 nm, (d)140 nm, (e)160 nm, and PBDB-T:ITIC blend film with different thickness. (f)80 nm, (g)100 nm, (h)120 nm, (i)140 nm, (j)160 nm.

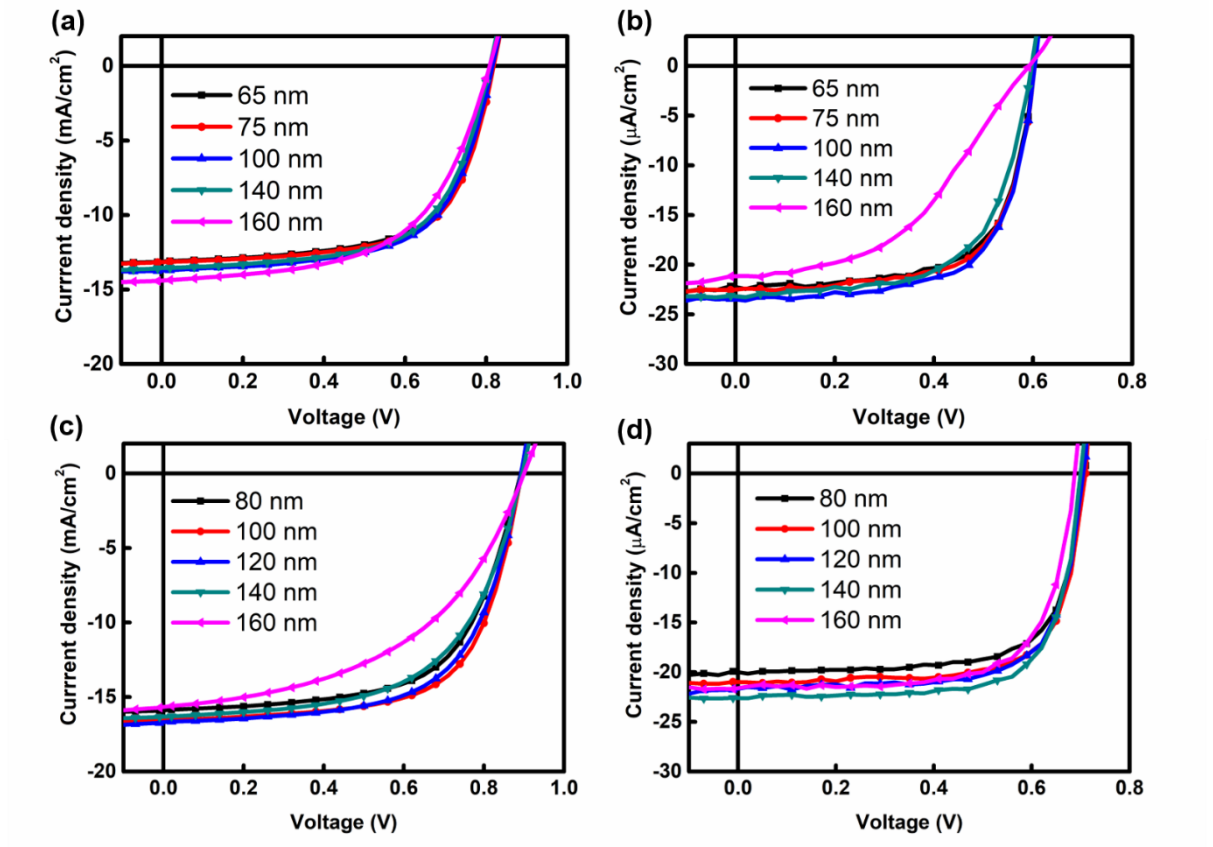

Figure S4. The J-V curve measured for device. PBDB-T:$PC_{71}BM$ different thicknesses (a)One sun, (b)200 lux TL84, and PBDB-T:ITIC different thicknesses (c)One sun, (d)200 lux TL84.

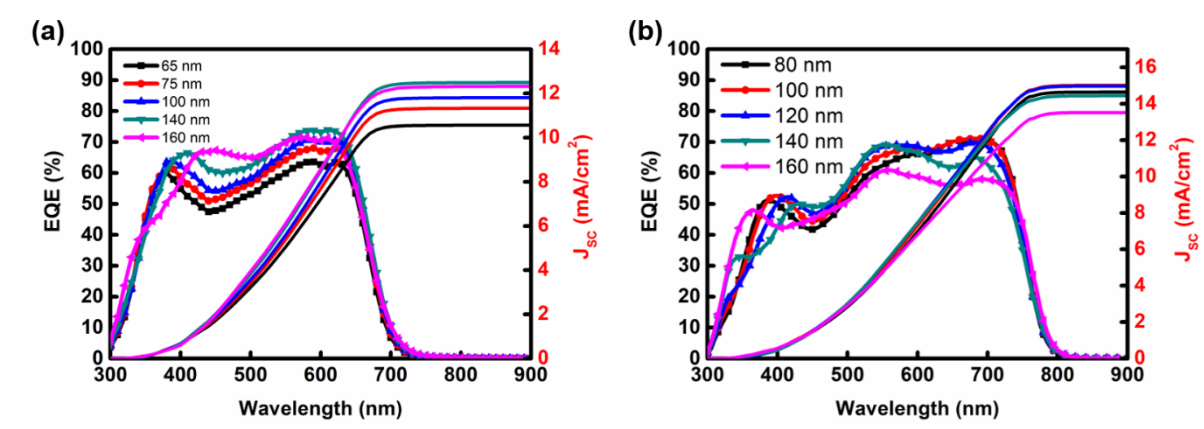

Figure S5. EQE spectra and integrated J_{SC} of device with different active layer thickness: (a) PBDB-T:$PC_{71}BM$, (b) PBDB-T:ITIC.

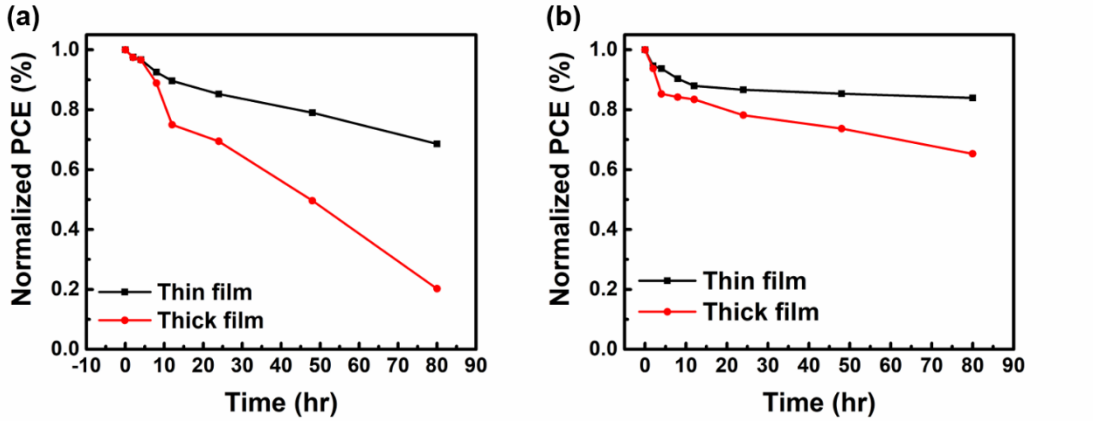

Figure S6. Photostability of the PPBDB-T:ITIC device with different thicknesses under (a)1-Sun and (b) Indoor light illumination.

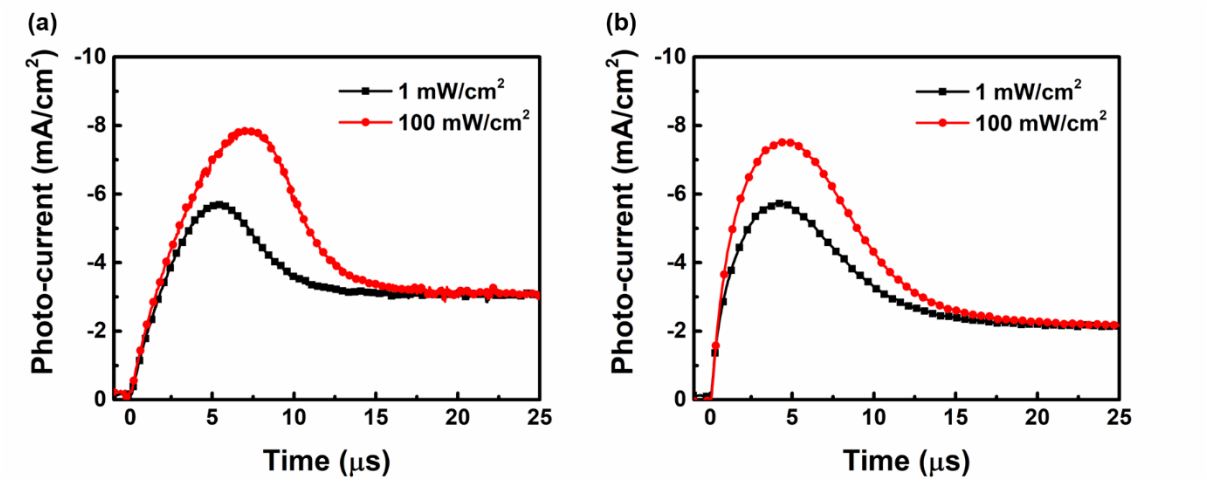

Figure S7. Photo-CELIV curves of device with different active layer under two light intensities: (a) PBDB-T:$PC_{71}BM$, (b) PBDB-T:ITIC.

Table S1. Characteristics of organic photovoltaic with different PBDB-T:$PC_{71}BM$ active layer thickness under 1-Sun and 200 lux TL84. and the data in each condition are averaged from 20 devices.

	1-sun				200 lux TL 84			
Thickness (nm)	V_{OC} (V)	J_{SC} (mA/cm²)	FF (%)	PCE (%)	V_{OC} (V)	J_{SC} (μA/cm²)	FF (%)	PCE (%)
65	0.81	13.13	64.53	6.79	0.60	22.69	65.10	15.33
	0.81 ±0.00	13.05 ±0.11	64.17 ±0.57	6.72 ±0.08	0.60 ±0.00	22.11 ±0.78	63.68 ±3.00	14.54 ±0.69
75	0.82	13.16	64.96	6.89	0.60	22.40	67.50	15.72
	0.81 ±0.00	13.23 ±0.08	64.29 ±0.41	6.83 ±0.06	0.60 ±0.00	21.81 ±1.10	65.80 ±1.21	14.86 ±0.78
100	0.82	13.72	62.89	6.93	0.60	23.64	65.96	16.22
	0.81 ±0.00	13.69 ±0.07	63.00 ±0.64	6.91 ±0.09	0.60 ±0.00	23.14 ±0.60	65.00 ±1.41	15.60 ±0.76
140	0.81	13.57	62.47	6.75	0.60	23.33	62.03	14.89
	0.81 ±0.00	13.44 ±0.10	61.06 ±1.54	6.54 ±0.19	0.59 ±0.01	22.63 ±1.10	61.09 ±0.99	14.02 ±0.66
160	0.81	14.39	57.07	6.54	0.59	21.09	45.79	9.83
	0.80 ±0.00	13.71 ±0.45	58.10 ±1.72	6.31 ±0.12	0.59 ±0.00	21.62 ±0.40	44.43 ±1.32	9.75 ±0.24

Table S2. Characteristics of organic photovoltaic with different PBDB-T:ITIC active layer thickness under 1-Sun and 200 lux TL84. and the data in each condition are averaged from 20 devices.

	1-sun				200 lux TL 84			
Thickness (nm)	V_{OC} (V)	J_{SC} (mA/cm²)	FF (%)	PCE (%)	V_{OC} (V)	J_{SC} (μA/cm²)	FF (%)	PCE (%)
80	0.89	15.89	62.39	8.71	0.71	20.11	70.44	17.27
	0.89 ±0.00	15.74 ±0.09	62.61 ±0.31	8.66 ±0.04	0.71 ±0.00	19.94 ±0.24	70.95 ±0.72	17.26 ±0.02
100	0.89	16.54	65.22	9.50	0.71	21.04	72.15	18.57
	0.89 ±0.00	16.40 ±0.21	65.32 ±0.50	9.38 ±0.09	0.70 ±0.01	20.88 ±0.15	72.03 ±0.35	18.22 ±0.32
120	0.89	16.70	62.74	9.21	0.71	21.55	71.51	18.73
	0.89 ±0.00	16.61 ±0.12	62.73 ±0.62	9.13 ±0.05	0.71 ±0.00	21.10 ±0.39	71.94 ±0.41	18.47 ±0.23
140	0.90	16.32	58.72	8.45	0.70	22.64	72.34	19.74
	0.89 ±0.01	16.30 ±0.15	58.09 ±0.66	8.31 ±0.08	0.71 ±0.01	22.23 ±0.27	71.69 ±0.60	19.43 ±0.25
160	0.90	15.66	48.24	6.70	0.69	21.41	70.55	17.90
	0.90 ±0.00	15.53 ±0.12	47.65 ±0.55	6.56 ±0.14	0.70 ±0.01	21.10 ±0.21	69.78 ±0.52	17.75 ±0.12

Table S3. Rs and Rsh of device with different PBDB-T:$PC_{71}BM$ and PBDB-T:ITIC active layer thickness under 1-Sun and 200 lux TL84.

		1-Sun		200 lux TL84	
System	Thickness (nm)	R_s (Ω cm^2)	R_{sh} (kΩ cm^2)	R_s (kΩ cm^2)	R_{sh} (kΩ cm^2)
PBDB-T:$PC_{71}BM$	65	10.76	0.76	2.35	174.30
	75	10.55	0.85	2.38	356.97
	100	10.18	1.19	2.43	547.83
	140	10.96	1.01	3.09	490.33
	160	12.77	0.59	14.29	395.98
PBDB-T:ITIC	80	10.29	0.69	3.10	466.81
	100	8.34	1.38	2.91	566.89
	120	8.91	0.89	2.65	719.68
	140	10.89	0.80	2.23	740.70
	160	16.88	0.38	2.18	894.83

Table S4. Electrical analysis of PBDB-T$PC_{71}BM$ and PBDB-T:ITIC with different thicknesses of devices under two light intensities.

system	**Light intensity (mW/cm^2)**	**Thicknesses (nm)**	**Carrier time (ms)**	**Extraction time (ms)**
PBDB-T:$PC_{71}BM$	100	100	13.74	0.89
		160	6.46	1.05
	1	100	14.43	1.05
		160	14.06	1.76
PBDB-T:ITIC	100	100	19.06	2.61
		160	15.21	3.39
	1	100	14.90	3.17
		160	14.64	4.02

Table S5. The fitted parameter of each element in the equivalent model of PBDB-T:$PC_{71}BM$ and PBDB-T:ITIC with 100 nm and 160 nm under 1-Sun condition.

System	Light source	Thickness (nm)	R_s (Ω)	R_1 (Ω)	C_1 (F)	R_2 (Ω)	C_2 (F)
PBDB-T:$PC_{71}BM$	1-Sun	100	68.26	14.50	5.02E-07	82.91	1.25E-08
		160	92.34	60.21	6.10E-09	113.50	1.81E-08
	200 lux TL84	100	56.53	162.40	1.83E-08	39.82	2.59E-09
		160	120.00	577.00	3.75E-09	50.42	1.42E-09
PBDB-T:ITIC	1-Sun	100	78.43	46.68	3.77E-08	39.79	1.16E-08
		160	115.00	75.00	3.52E-09	85.04	2.97E-08
	200 lux TL84	100	56.69	538.50	3.80E-09	31.33	3.19E-09
		160	114.50	1774.00	1.85E-09	28.63	3.30E-09

Table S6. The photo-CELIV mobility of PBDB-T$PC_{71}BM$ and PBDB-T:ITIC of devices under different light intensity.

system	Light intensity (mW/cm^2)	Carrier mobility (cm^2/Vs)
PBDB-T:$PC_{71}BM$	100	8.18×10^{-6}
	1	1.95×10^{-5}
PBDB-T:ITIC	100	1.97×10^{-5}
	1	3.05×10^{-5}