

Supplementary Material

Perovskite Solar Cells Based on Hole Transporting Conjugated Polymers by Direct Arylation Polycondensation

Wei Li,^a Takehiko Mori,^a and Tsuyoshi Michinobu^{*,a}

*^a Department of Materials Science and Engineering, Tokyo Institute of Technology, 2-12-1
Ookayama, Meguro-ku, Tokyo 152-8552, Japan.*

Corresponding author:

Prof. Tsuyoshi Michinobu

E-mail: michinobu.t.aa@m.titech.ac.jp

Phone: +81-3-5734-3774, Fax: +81-3-5734-3774.

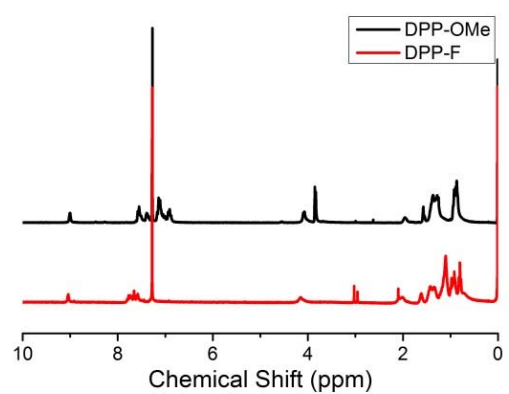
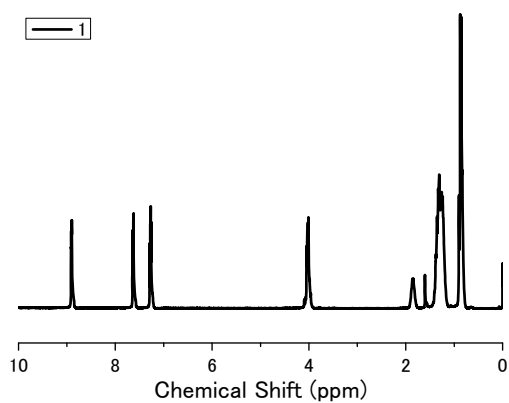


Fig. S1 $^1\text{H-NMR}$ spectra of **1**, **DPP-OMe**, and **DPP-F** in CDCl_3 .

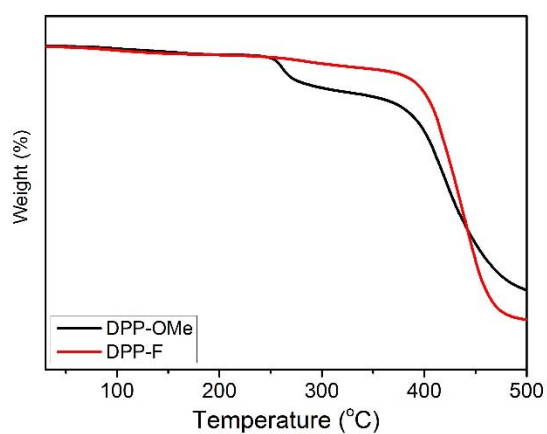


Fig. S2 Thermogravimetric analysis (TGA) curves of **DPP-OMe** and **DPP-F** under nitrogen flow (50 mL min^{-1}) at the heating rate of $10 \text{ }^\circ\text{C min}^{-1}$.

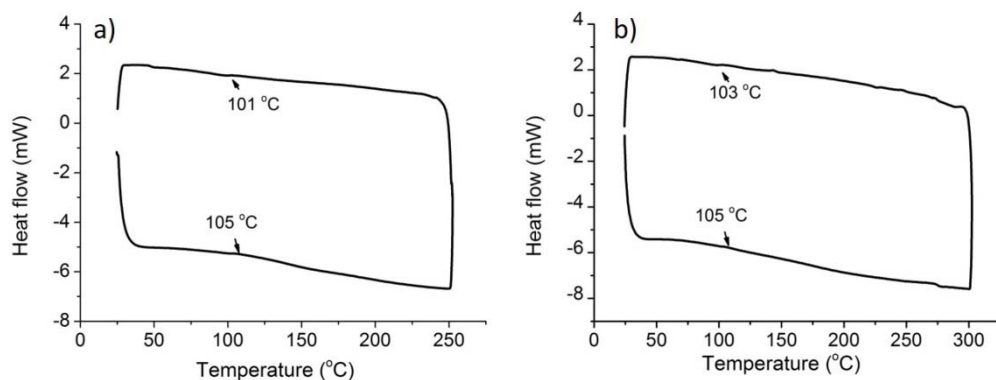


Fig. S3 Differential scanning calorimetry (DSC) curves of (a) **DPP-OMe** and (b) **DPP-F** under nitrogen flow (50 mL min^{-1}) at the scanning rate of $10 \text{ }^{\circ}\text{C min}^{-1}$ (second heating and cooling processes).

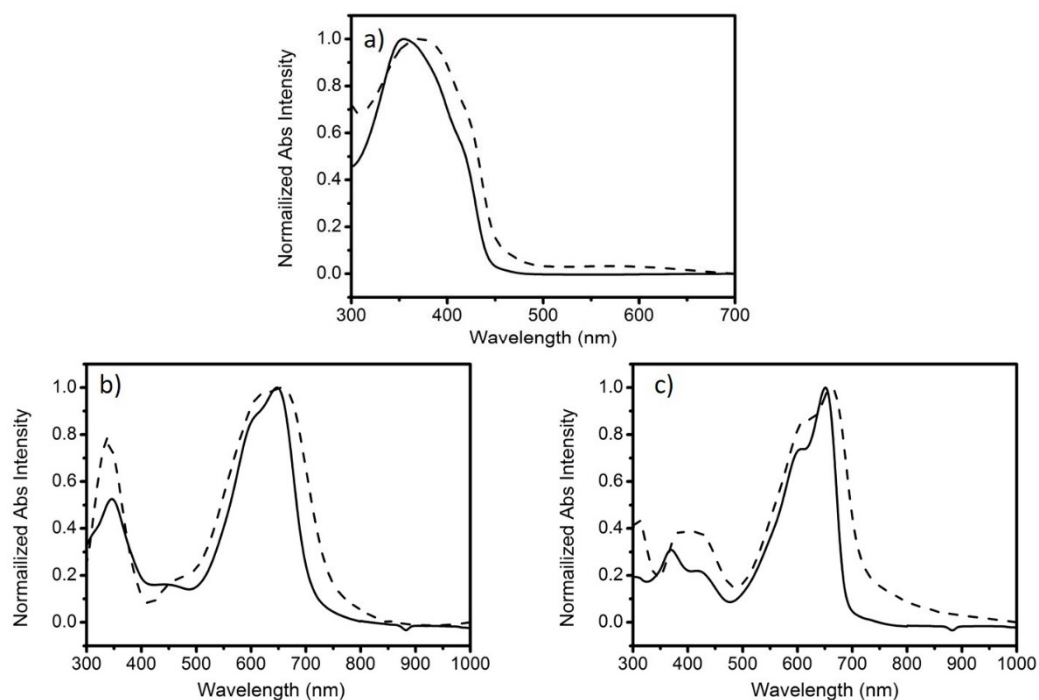


Fig. S4 Normalized UV-vis absorption of (a) **3,6-Cbz-EDOT**, (b) **DPP-OMe** and (c) **DPP-F** in CH_2Cl_2 measured at $10^{-5} \text{ M repeat unit}^{-1}$ (solid line) and film states (dash line).

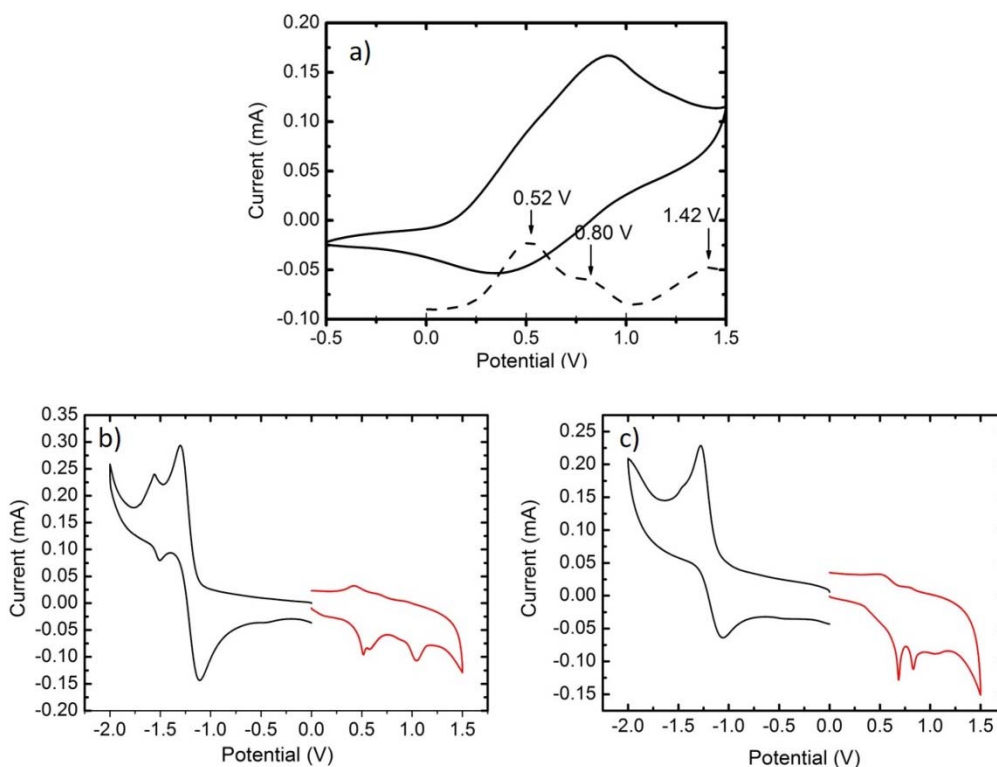


Fig. S5 Cyclic voltammetry of films of (a) **3,6-Cbz-EDOT**, (b) **DPP-OMe** and (c) **DPP-F** on a glassy carbon electrode, measured in CH_3CN with 0.1 M $(n\text{C}_4\text{H}_9\text{N})_4\text{PF}_6$ at the scanning rate of 0.1 V s^{-1} under flowing nitrogen. Potentials vs. Ag/Ag^+ .

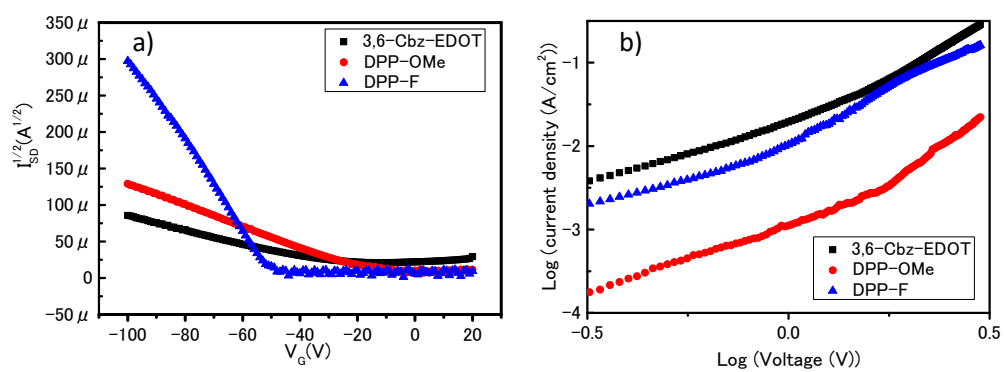


Fig. S6 (a) Transfer characteristics of the thin film transistors and (b) log-log plots of the SCLC measurements of the as-cast HTM films.

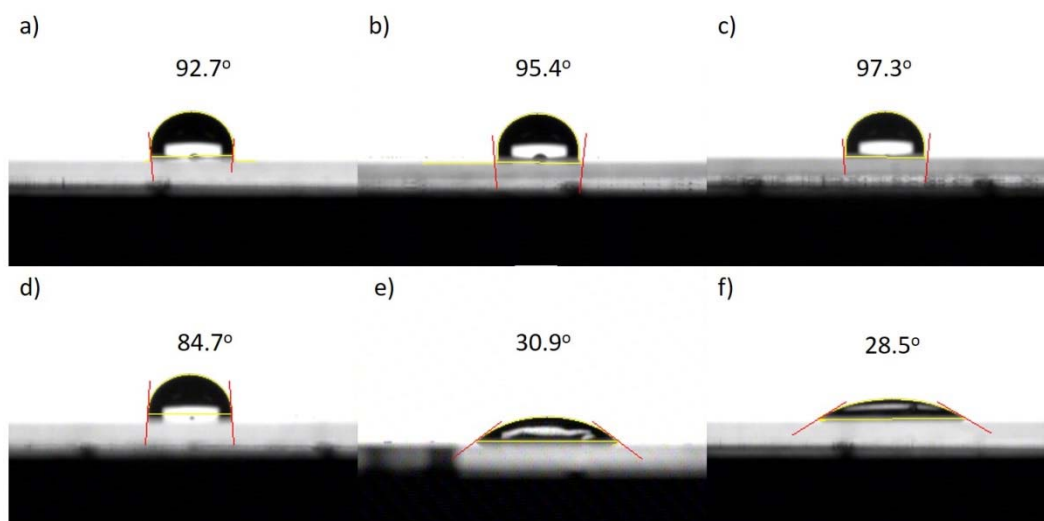


Fig. S7 Contact angles of water on the films of (a) 3,6-Cbz-EDOT, (b) DPP-OMe, (c) DPP-F, (d) TBP doped 3,6-Cbz-EDOT, (e) Li-TFSi doped 3,6-Cbz-EDOT and (f) both TBP and Li-TFSi doped 3,6-Cbz-EDOT.

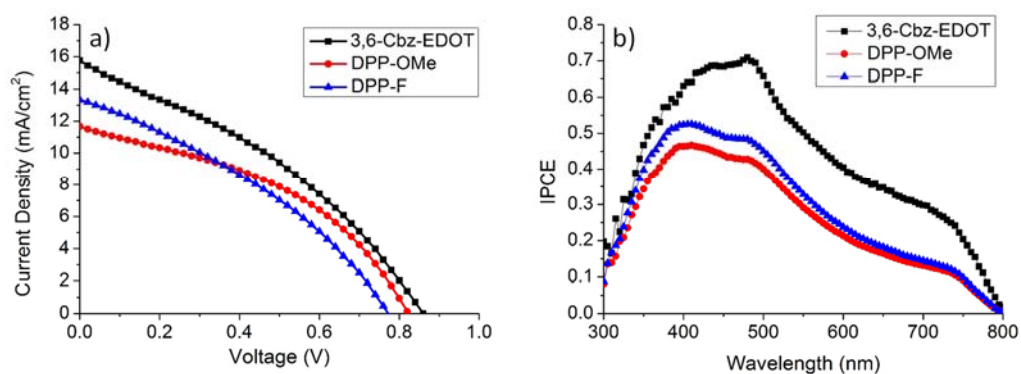


Fig. S8 (a) Current–voltage (J–V) curves and (b) IPCE spectra of the PSCs based on the polymeric HTMs without dopants.

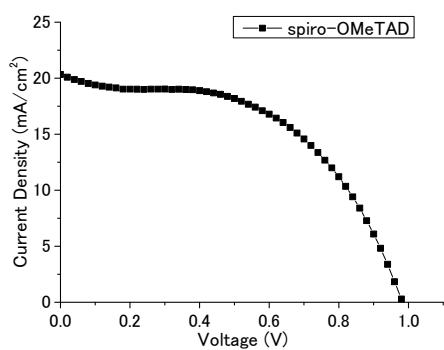


Fig. S9 Current–voltage (J–V) curve of the PSC based on spiro-OMeTAD with TBP and Li-TFSi.

Solar cell parameters

Undoped 3,6-Cbz-EDOT

No		J_{sc} (mA/cm ²)	V_{oc} (V)	FF	PCE (%)
1	average	15.76	0.86	0.35	4.70
	forward	16.31	0.86	0.34	4.77
	backward	15.21	0.86	0.36	4.67
2	average	15.35	0.83	0.30	3.83
	forward	15.21	0.83	0.30	3.82
	backward	15.49	0.83	0.30	3.84
3	average	15.10	0.78	0.37	4.39
	forward	14.83	0.73	0.39	4.31
	backward	15.35	0.83	0.35	4.47
Average		15.40	0.82	0.34	4.30

Doped 3,6-Cbz-EDOT (Li-TFSi only)

No		J_{sc} (mA/cm ²)	V_{oc} (V)	FF	PCE (%)
1	average	17.46	0.95	0.40	6.65
	forward	17.42	0.95	0.37	6.12
	backward	17.49	0.95	0.43	7.21
2	average	17.50	0.94	0.38	6.37
	forward	17.99	0.94	0.35	5.97
	backward	17.01	0.95	0.42	6.81
3	average	17.45	0.94	0.37	6.14
	forward	17.66	0.94	0.36	6.05
	backward	17.24	0.95	0.38	6.24
Average		17.47	0.94	0.38	6.39

Doped 3,6-Cbz-EDOT (TBP only)

No		J_{sc} (mA/cm ²)	V_{oc} (V)	FF	PCE (%)
1	average	15.64	0.93	0.46	6.76
	forward	15.92	0.93	0.44	6.42
	backward	15.36	0.94	0.49	7.10
2	average	15.55	0.94	0.47	6.88
	forward	15.57	0.93	0.44	6.37
	backward	15.52	0.94	0.51	7.42
3	average	15.76	0.93	0.47	6.92
	forward	15.98	0.93	0.44	6.53
	backward	15.54	0.93	0.51	7.33
Average		15.65	0.93	0.47	6.85

Doped 3,6-Cbz-EDOT (both Li-TFSi and TBP)

No		J_{sc} (mA/cm ²)	V_{oc} (V)	FF	PCE (%)
1	average	18.36	0.91	0.48	8.17
	forward	18.08	0.89	0.47	7.63
	backward	18.64	0.93	0.50	8.72
2	average	17.68	0.92	0.50	8.12
	forward	18.01	0.90	0.46	7.39
	backward	17.35	0.94	0.55	8.89
3	average	17.40	0.92	0.51	8.11
	forward	17.85	0.90	0.46	7.42
	backward	16.95	0.94	0.56	8.86
Average		17.81	0.92	0.50	8.13

Undoped DPP-OMe

No		J_{sc} (mA/cm ²)	V_{oc} (V)	FF	PCE (%)
1	average	11.37	0.83	0.39	3.70
	forward	10.91	0.74	0.31	2.48
	backward	11.84	0.90	0.50	5.30
2	average	11.67	0.82	0.41	3.97
	forward	11.30	0.82	0.40	3.74
	backward	12.04	0.83	0.42	4.19
3	average	12.02	0.83	0.43	4.32
	forward	11.79	0.83	0.43	4.19
	backward	12.26	0.84	0.44	4.47
Average		11.69	0.83	0.41	4.00

Doped DPP-OMe (both Li-TFSi and TBP)

No		J_{sc} (mA/cm ²)	V_{oc} (V)	FF	PCE (%)
1	average	11.12	0.82	0.49	4.47
	forward	11.08	0.82	0.47	4.29
	backward	11.15	0.82	0.51	4.67
2	average	11.07	0.77	0.46	3.97
	forward	11.07	0.76	0.44	3.73
	backward	11.08	0.78	0.49	4.24
3	average	11.03	0.76	0.45	3.75
	forward	10.80	0.73	0.44	3.48
	backward	11.26	0.78	0.46	4.03
Average		11.07	0.78	0.47	4.06

Undoped DPP-F

No		J_{sc} (mA/cm ²)	V_{oc} (V)	FF	PCE (%)
1	average	12.78	0.77	0.35	3.48
	forward	12.26	0.78	0.37	3.58
	backward	13.30	0.76	0.33	3.38
2	average	13.33	0.77	0.34	3.54
	forward	13.41	0.78	0.36	3.75
	backward	13.26	0.77	0.33	3.43
3	average	13.78	0.78	0.30	3.25
	forward	14.36	0.79	0.33	3.77
	backward	13.19	0.77	0.27	2.76
Average		13.30	0.77	0.33	3.42

Doped DPP-F (both Li-TFSi and TBP)

No		J_{sc} (mA/cm ²)	V_{oc} (V)	FF	PCE (%)
1	average	12.54	0.80	0.39	3.88
	forward	11.71	0.80	0.45	4.27
	backward	13.37	0.79	0.34	3.59
2	average	13.66	0.78	0.38	4.08
	forward	13.14	0.79	0.43	4.42
	backward	14.18	0.77	0.35	3.83
3	average	13.67	0.73	0.40	3.94
	forward	13.14	0.73	0.43	4.14
	backward	14.18	0.72	0.37	3.80
Average		13.29	0.77	0.39	3.97