Supporting Information

A Cost-Device Efficiency Balanced Spiro Based Hole Transport Material for Perovskite Solar Cells

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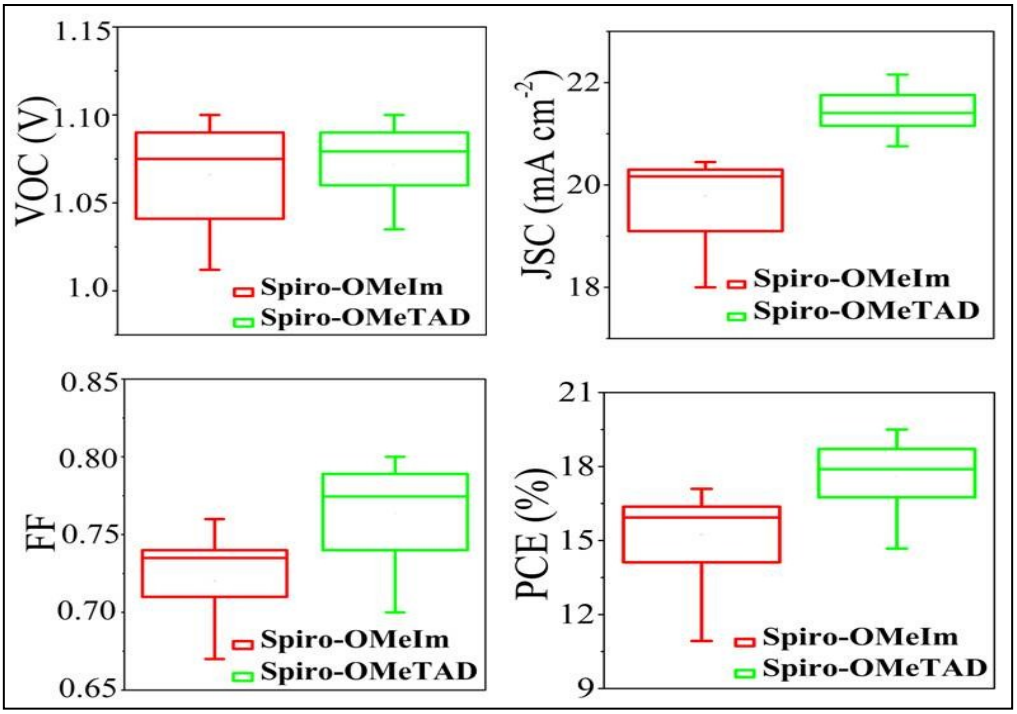


Figure S1. Statistical distribution of the performance of 20 perovskite solar cells.

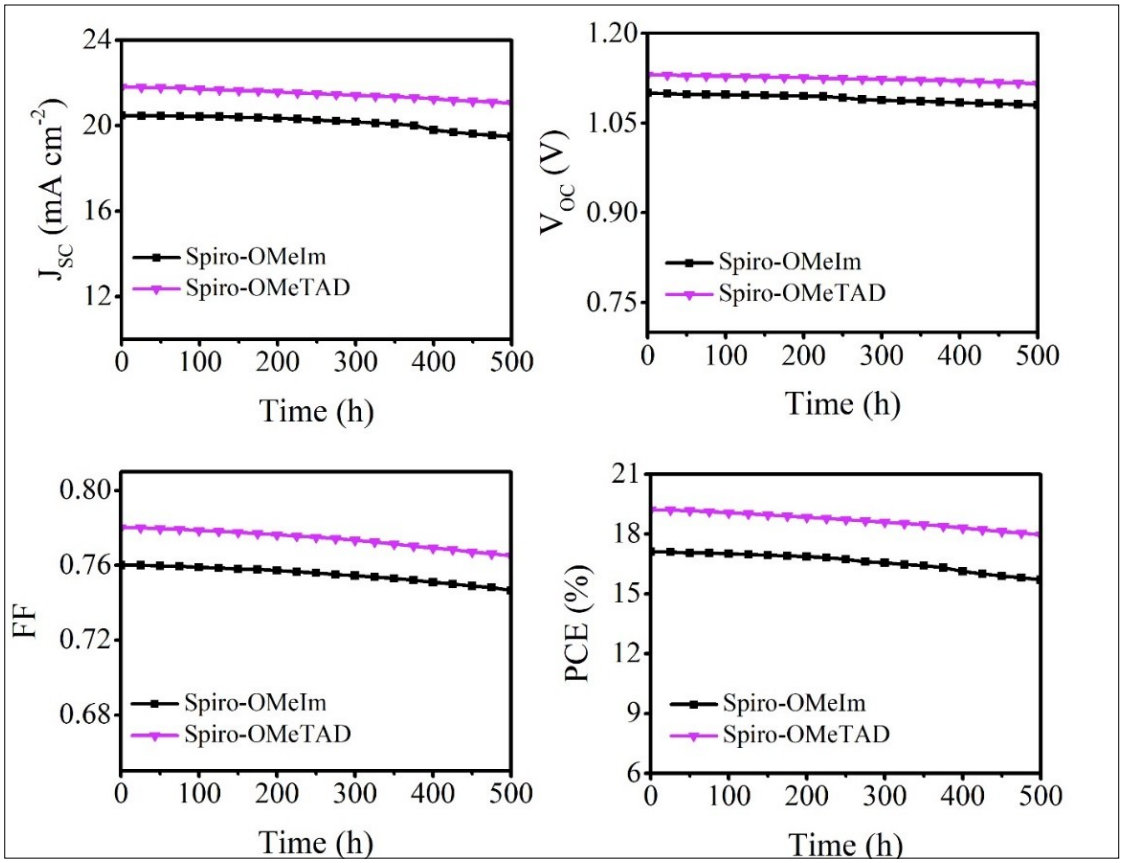


Figure S2. Stability of the photovoltaic characteristics over time for the PSCs based on Spiro-OMeIm and Spiro-OMeTAD. The stability test of devices are done under during exposure to full AM 1.5 simulated sunlight for 500 hours (humidity ≈ 40%).

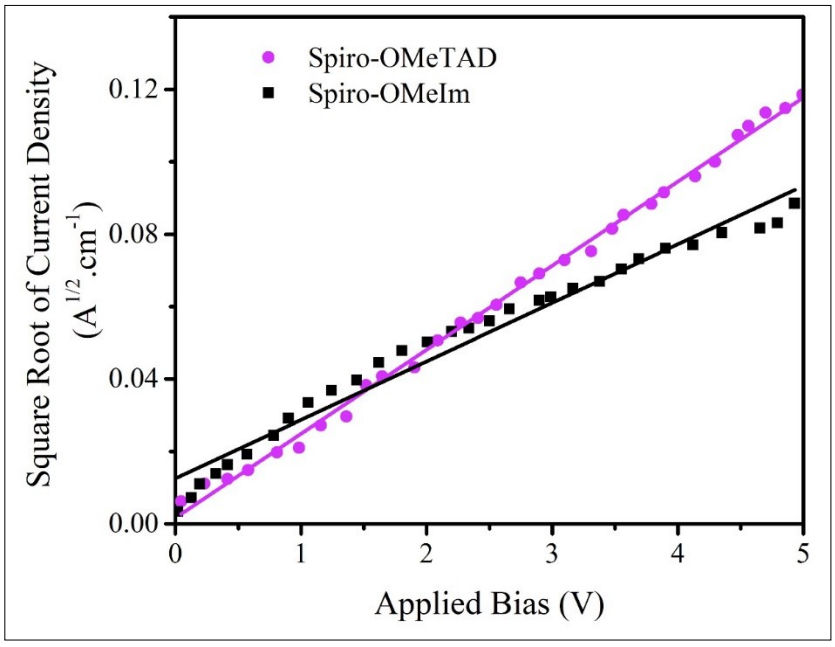


Figure S3. J–V characteristic of thin films in hole-conducting only devices based on Spiro-OMeTAD and Spiro-OMeIm (pristine state).

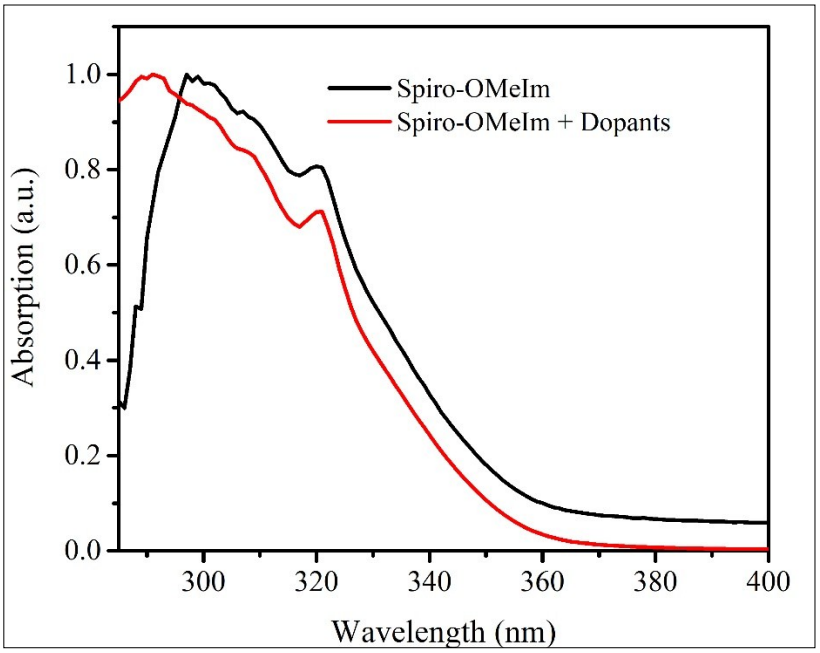
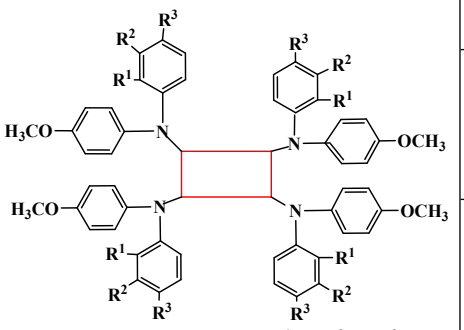
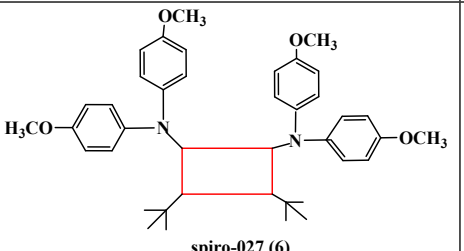
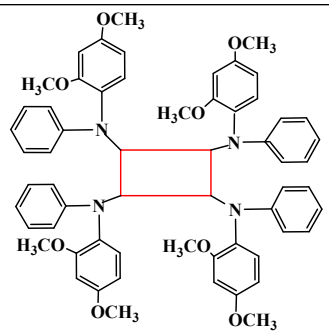
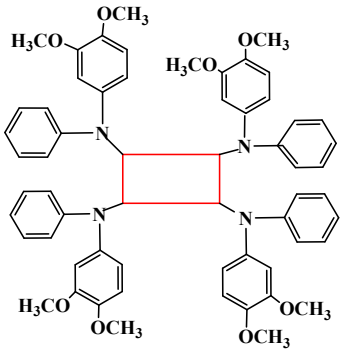


Figure S4. UV-Vis spectra of Spiro-OMeIm without and with dopants in $CHCl_3$.

Table S1. The photovoltaic performance of previously reported spiro-cyclic HTMs.

HTMs	HTMs	V_{oc} [V]	J_{sc} [mA cm^{-2}]	FF [%]	PCE [%]	Ref.
 pp-spiro-OMeTAD (1a) : R^1=H, R^2=H, R^3=OCH_3 pm-spiro-OMeTAD (1b): R^1=H, R^2=OCH_3, R^3=H po-spiro-OMeTAD (1c): R^1=OCH_3, R^2=H, R^3=H	**pp–spiro–OMeTAD(1)**	1	20.7	71.1	14.9	[1]
	Pm–spiro–OMeTAD(2)	1.01	21.1	65.2	13.9	
	po–spiro–OMeTAD(3)	1.02	21.2	77.6	16.7	
 spiro-027 (6)	**Spiro-027 (4)**	1.07	22.07	70	16.6	[2]

 2,4-Spiro-OMeTAD (7)	**2,4-Spiro-OMeTAD (5)**	0.956	25.6	70.1	17.2	[3]
 3,4-Spiro-OMeTAD (8)	**3,4-Spiro-OMeTAD (6)**	0.752	20.1	59.9	9.1	

References

[1] N. J. Jeon, H. G. Lee, Y. C. Kim, J. Seo, J. H. Noh, J. Lee and S. I. Seok, *J. Am. Chem. Soc.*, 2014, **136**, 7837.

[2] Y. Shi, Y. Xue, K. Hou, G. Meng, K. Wang, R. Chi, F. Chen, H. Ren, M. Pang and C. Hao, *RSC Adv.*, 2016, **6**, 96990.

[3] M.-D .Zhang, D.-X. Zhao, L. Chen, N. Pan, C.-Y. Huang, H. Cao and M.-D. Chen, *Sol. Energy Mater. Sol. Cells*, 2018, **176**, 318.