

Supplementary Information for

A facile one-pot synthesis of hyperbranched carbazole hole-transporting material for efficient perovskite solar cells

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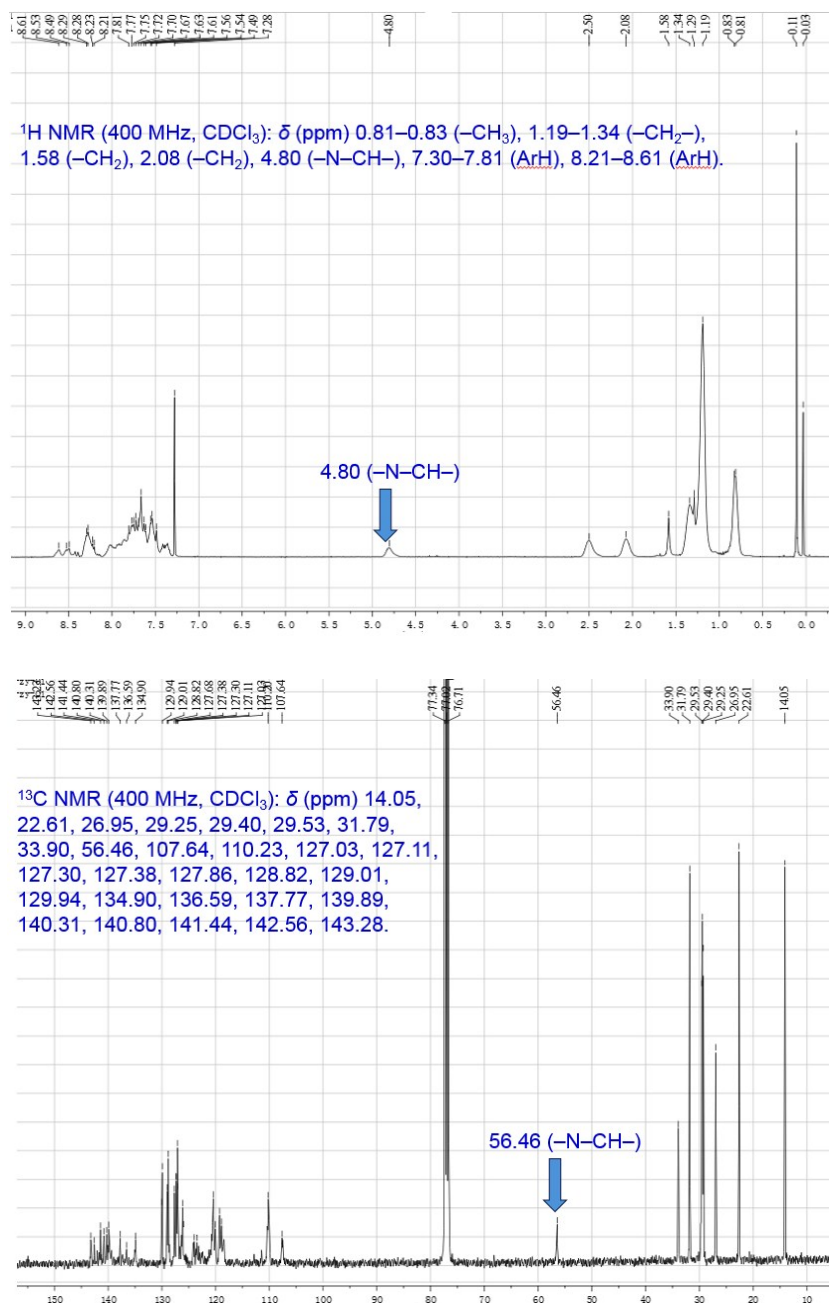


Figure S1. The ^1H and ^{13}C NMR spectra of HB-Cz

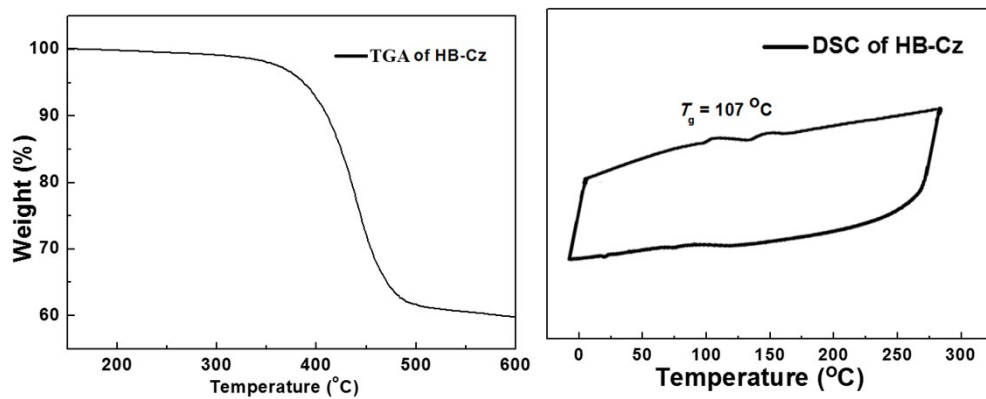


Figure S2. Thermogravimetric analysis and differential scanning calorimetry curve of HB-Cz with scan rate of $10^\circ\text{C}/\text{min}$ under N_2 .

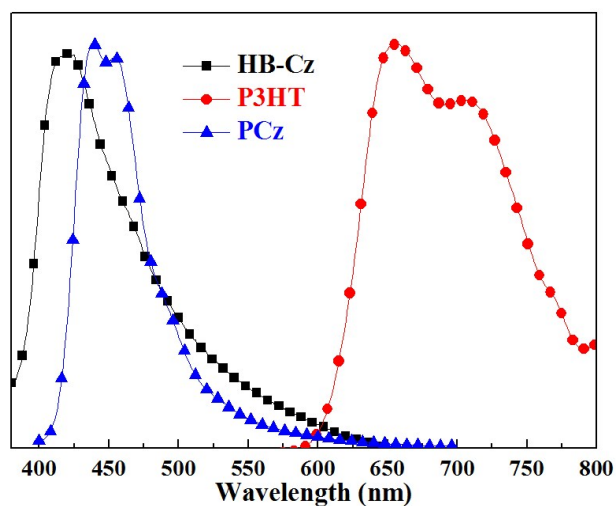


Figure S3. The photoluminescence spectra of the HB-Cz, P3HT and PCz films.

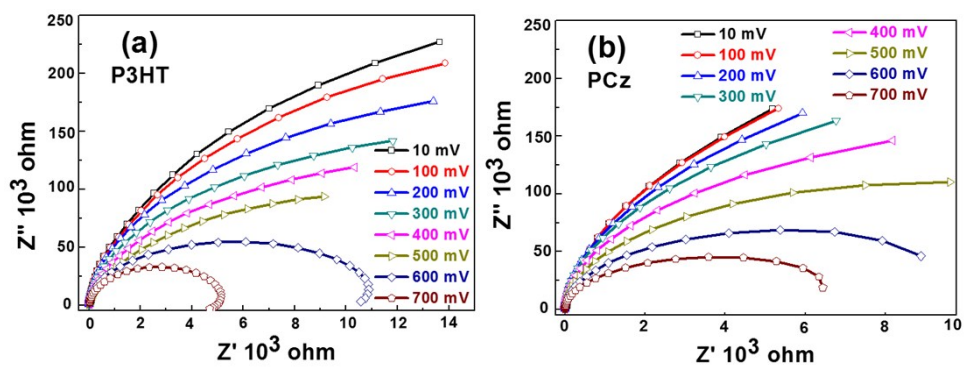


Figure S4. (a, b) Nyquist plots of PVSCs based on P3HT and PCz under dark at various bias voltages.

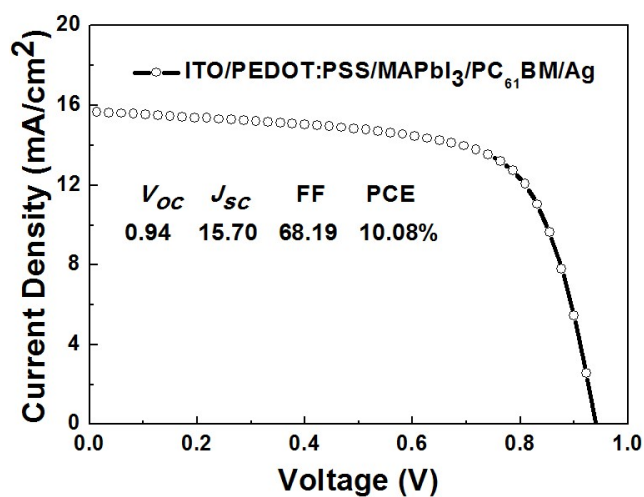


Figure S5. The J - V curves of the device with the structure of ITO/PEDOT:PSS/MAPbI₃/PC₆₁BM/Ag under the standard AM 1.5G illumination.

Table S1. Summary of optical, electrochemical, and photoelectrical properties of the HTMs used in this work.

HTM	λ_{abs} (nm)	Mw	HOMO (eV)	LOMO (eV)
HB-Cz	350	6.4×10^3	-5.32	-2.42
P3HT	525	2.7×10^5	-5.18	-3.18
PCz	380	2.3×10^5	-5.60	-2.66

Table S2. Summary of device parameters obtained from ITO/compact TiO₂/MAPbI₃/HTM/Ag.

Entry	HTM	Spin speed of HTM (rpm)	V_{oc} (V)	J_{sc} (mA·cm ⁻²)	FF (%)	PCE (%)
1	HB-cz	800	0.86	19.52	53.37	8.95
2	HB-cz	1000	0.85	20.54	54.99	9.60
3	HB-cz	1500	0.93	19.77	64.93	11.93
4	HB-cz	2000	0.97	20.80	69.91	14.07
5	HB-cz	2500	0.94	20.13	66.85	12.62
6	HB-cz	3000	0.90	19.86	58.08	10.41
7	PCz	1500	0.83	8.46	55.67	3.90
8	PCz	2000	0.82	13.20	61.00	6.60
9	PCz	2500	0.83	8.11	57.40	3.87
10	PCz	3000	0.83	7.40	59.51	3.66
11	P3HT	1500	0.87	16.97	61.32	9.05
12	W/O	-	0.67	12.23	38.62	3.78