Supporting Information

## Solution-Processed Electron Transport Layer of n-Doped Fullerene for Efficient and Stable All Carbon Based Perovskite Solar Cells

Junshuai Zhou,<sup>a</sup> Jie Hou,<sup>a</sup> Xia Tao,<sup>a</sup> Xiangyue Meng\*<sup>ac</sup> and Shihe Yang\*<sup>bc</sup>

<sup>*a*</sup> State Key Laboratory of Organic-Inorganic Composites, Beijing University of Chemical Technology, Beijing 100029, China.

*E-mail: mengxy@mail.buct.edu.cn* 

<sup>b</sup> Guangdong Key Lab of Nano-Micro Material Research, School of Chemical Biology and Biotechnology, Peking University Shenzhen Graduate School, Shenzhen 518055, China.

*E-mail: chsyang@pku.edu.cn* 

<sup>c</sup> Department of Chemistry, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, China.

*E-mail: chsyang@ust.hk* 



Fig. S1 The contacting angles of DMF on the HMB-doped  $C_{60}$  film deposited on ITO substrates.



Fig. S2 AFM topographic image of (a)  $C_{60}$  and (b) HMB-doped  $C_{60}$  films.



Fig. S3 Top-view SEM images of (a) HMB-doped  $C_{60}$  and (b)  $C_{60}$  films



Fig. S4 Transmittance spectra of bare ITO substrate, HMB-doped  $C_{60}$  film and  $C_{60}$  film deposited on ITO substrates.



Fig. S5 UPS spectra of the  $C_{60}$  and HMB-doped  $C_{60}$  film.



Fig. S6 UV-Vis absorption spectra of the  $C_{60}$  and HMB-doped  $C_{60}$  film.



Fig. S7 XRD spectra of perovskite based on the HMB-doped  $C_{60}$  and  $C_{60}$  films.



**Fig. S8** (a), (b) Top-view SEM image of the perovskite film. (c), (d) Cross-sectional SEM images of the PSCs device.



**Fig. S9** J-V curves of the perovskite solar cells with different HMB dopant amount in C<sub>60</sub> ETLs measured at the reverse scan.



**Fig. S10** J-V curves of the perovskite solar cells with different spin-coating speed of HMB-doped C<sub>60</sub> ETLs measured at the reverse scan.



Fig. S11 Steady-state PL spectra of MAPbI<sub>3</sub>,  $C_{60}$ /MAPbI<sub>3</sub> and HMB-doped  $C_{60}$ /MAPbI<sub>3</sub> deposited on silica glass.



**Fig. S12** (a), (b) Corresponding EQE curves of the champion devices based on  $C_{60}$  and HMB-doped  $C_{60}$  ETLs. (c), (d) Stabilized current density and power output measured as a function of time for the  $C_{60}$  and HMB-doped  $C_{60}$  devices biased at their respective  $V_{mpp}$  0.76 and 0.80 V, respectively.



Fig. S13 Photovoltaic parameters statistics of 35 devices of all carbon-based perovskite solar cells with  $C_{60}$  or HMB-doped  $C_{60}$  ETLs measured under reverse scan.



**Fig. S14** *J-V* curves of the perovskite solar cells with PCBM or HMB-doped PCBM ETLs measured at the reverse scan under AM 1.5G 100 mW cm<sup>-2</sup> illumination.

**Table S1** Photovoltaic parameters of the best-performing perovskite solar cells with different HMB dopant amount in  $C_{60}$  ETLs measured under reverse (from  $V_{oc}$  to 0) scan.

Samples	V <sub>oc</sub> (V)	$J_{sc}$ (mA cm <sup>-2</sup> )	FF (%)	PCE (%)
W/O HMB	1.03	19.82	60.03	12.22
2.5% HMB	1.04	21.27	64.65	14.34
5.0% HMB	1.06	22.68	66.74	16.03
10.0% HMB	1.03	20.56	63.73	13.59

**Table S2** Photovoltaic parameters of the best-performing perovskite solar cells with different spin-coating speed of HMB-doped  $C_{60}$  ETLs measured under reverse (from  $V_{oc}$  to 0) scan.

Samples	V <sub>oc</sub> (V)	J <sub>sc</sub> (mA cm <sup>-2</sup> )	FF (%)	PCE (%)
1000 rpm	0.98	19.07	57.87	10.81
2000 rpm	1.01	20.27	62.91	12.88
3000 rpm	1.06	22.68	66.74	16.03
4000 rpm	1.04	21.83	64.95	14.76

**Table S3** Photovoltaic parameters statistics of 35 devices of all carbon-based perovskite solar cells with  $C_{60}$  or HMB-doped  $C_{60}$  ETLs measured under reverse (from  $V_{oc}$  to 0) scan.

Samples	V <sub>oc</sub> (V)	$J_{sc}$ (mA cm <sup>-2</sup> )	FF (%)	PCE (%)
HMB-doped C <sub>60</sub>	1.05±0.01	21.92±0.76	65.54±1.89	15.10±0.94
C <sub>60</sub>	1.01±0.02	18.19±1.59	56.59±3.44	11.04±1.62