Enhanced Performance of Perovskite Solar Cells with P3HT Hole-Transporting

Material via Molecularly p-Type Doping

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Figure S1. Top-view SEM of (a) perovskite film and (b) P3HT:F4TCNQ film.



Figure S2. IPCE spectra of the PSC devices based on pristine and doped P3HT HTMs.



b)



c)



Figure S3. Nyquist plots of the PSC devices with (a) P3HT and (b) 1% F4TCNQ doped P3HT as HTMs measured in the dark with varied forword biases. (c) Plot of the recombination resistance (R_{rec}) vs. bias voltages for the devices based on pristine and 1% F4TCNQ doped P3HT-based HTMs.



Figure S4. UV-Vis absorption spectra of F4TCNQ solution, P3HT solution with different dopants. Inset: Amplified spectra from 700 nm to 1000 nm.



Figure S5. Images of F4TCNQ, P3HT, P3HTdoped with LiTFSI and TBP, and P3HT doped with different concentrations of F4TCNQ solutions for UV-Vis measurement.



Figure S6. FTIR spectra of P3HT:F4TCNQ thin films with different doping concentrations. FTIR of pristine F4TCNQ is also shown.

| Dopants | V _{oc} | J_{sc} | FF | PCE |
|--------------|-----------------|-----------------------|-----------------|------------|
| | (V) | (mA/cm ²) | | (%) |
| W/O | 0.97 ± 0.03 | 18.8 ± 2.9 | 0.55 ± 0.06 | 9.9 ± 1.6 |
| 1.0% F4TCNQ | 0.98 ± 0.03 | 23.7 ± 0.89 | 0.61 ± 2.78 | 13.8 ± 1.0 |
| LiTFSI + TBP | 0.92 ± 0.03 | 21.9 ± 1.5 | 0.62 ± 0.04 | 12.7 ± 0.8 |

Table S1. Photovoltaic parameters of different dopants for P3HT-based PSCs.