

Supporting Information

Efficient and Stable Mixed Perovskite Solar Cells using P3HT as Hole Transporting Layer

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Experimental

Materials

Lead (II) iodide (PbI_2 , >99.99%) and Methylammonium bromide (MABr, >99.5%) were purchased from Xi'an Polymer Light Technology Corp. Lead (II) bromide (PbBr_2 , >99.99%), Formamidinium iodide (FAI, >99.5%) and P3HT (MW=64815, by GPC) were purchased from Lumtec. Lithium Bis(trifluoromethanesulfonyl)imide (Li-TFSI, 99.95% trace metals basic) and Titanium diisopropoxide bis(acetylacetonate) (TAA, 75wt% in isopropanol) were purchased from Aldrich.

The substrate used for the fabrication PSCs was FTO (Fluorine-doped Tin Oxide) glass. An ETL of compact TiO_2 was deposited on the FTO glass using a precursor solution, prepared by mixing TAA and isopropyl alcohol (IPA) in a volume ratio of 1:9. A TiO_2 mesoporous layer was prepared by spin-coating of ethanol and terpinol diluted 30 NR paste (ethanol : terpinol : paste = 4:1:1 by weight). The perovskite precursor solution was prepared by dissolving 1.4 M lead salts that are composed of 0.85 PbI_2 and 0.15 PbBr_2 , and 1.3 M organic cation that are composed of 0.85 FAI and 0.15 MABr in a mixture of DMF/DMSO (4:1, by volume). The HTM layer was deposited using a pristine P3HT solution or a P3HT solution with different dopants dissolved in chlorobenzene (CB). Li-TFSI was dissolved in acetonitrile (500 mg/mL).

Fabrication of PSCs

First, the FTO glass was ultrasonically cleaned for 15 min in detergent, deionized water, and isopropyl alcohol, respectively and then blew dry. Before depositing ETL, the substrate was further cleaned in plasma cleaner for 5 min. Then the TiO_2 precursor solution mentioned above was uniformly sprayed on the FTO glass that had been heated to 450 °C and heated for 10 min. After cooling to room temperature, a m- TiO_2 slurry was spin-coated onto the uniform dense TiO_2 layer at 4000 rpm for 30 s and heated at 120 °C for 10 min. Then the substrate was

annealed at 450 °C for half an hour with a ramp time of one hour. 0.1 M Li-TFSI solution was spin-coated after cooling to room temperature at 4000 rpm for 30 s and then annealed at 450 °C for 30 min.

All the following processes were operated in a glove box filled with nitrogen. The perovskite, $\text{FA}_{0.85}\text{MA}_{0.15}\text{Pb}(\text{I}_{0.85}\text{Br}_{0.15})_3$ film was deposited on the m-TiO₂ layer (220-250 nm, by SEM) by spin-coating at 6000 rpm for 30 s with the use of 100 mL ethyl acetate as anti-solvent. Then the film was annealed at 100 °C for an hour. After cooling to room temperature, the P3HT solution was spin-coated onto the perovskite film at 3000 rpm for 30 s. Finally, a 60 nm thick Au layer was deposited onto the P3HT film through a vacuum thermal evaporation.

Measurement and Characterization

The current density-voltage curves of the devices were measured by a solar simulator (Oriel Sol3A Class AAA Solar Simulator, Newport) under 1 sun illumination (AM1.5). X-ray diffraction (XRD) patterns of the FTO substrate, FTO/P3HT, and FTO/perovskite/P3HT were examined by an X-ray Diffractometer (RU-200B, Rigaku). UV-Vis absorption spectra of the pristine P3HT and doped P3HT films were examined with a UV-Vis-NIR spectrophotometer (Lambda 750 S, PerkinElmer). FTIR spectra of the pristine P3HT and doped P3HT films were measured by a FTIR Spectrometer (Nicolet 6700, Thermo Fisher). The photoluminescence (PL) spectra of the perovskite films covered with/without P3HT were measured by a fluorescence spectrometer (AXIOS, PANalytical. B. V). Electrochemical impedance spectroscopy (EIS) of devices with pristine P3HT and doped P3HT as HTL were examined by an electrochemical workstation (SP-300, Bio-logic).

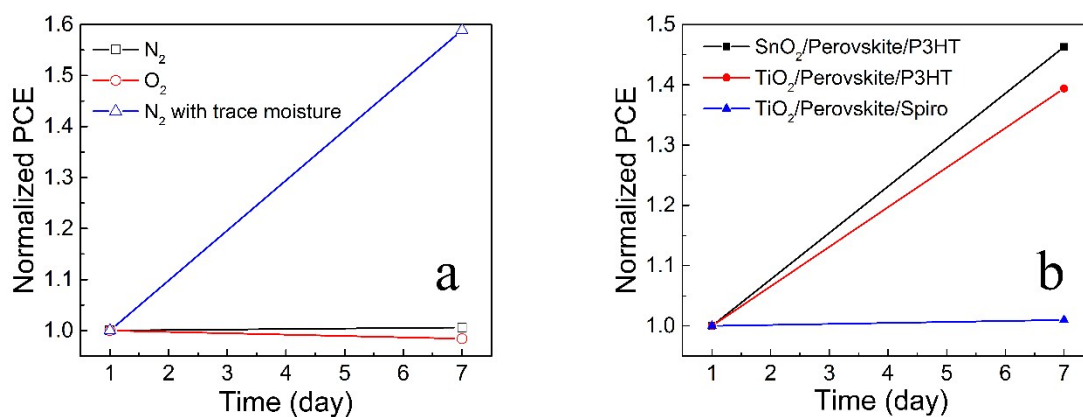


Fig. S1 The PCE change after 7-day storage (a) under different environments, and (b) with different device configurations.

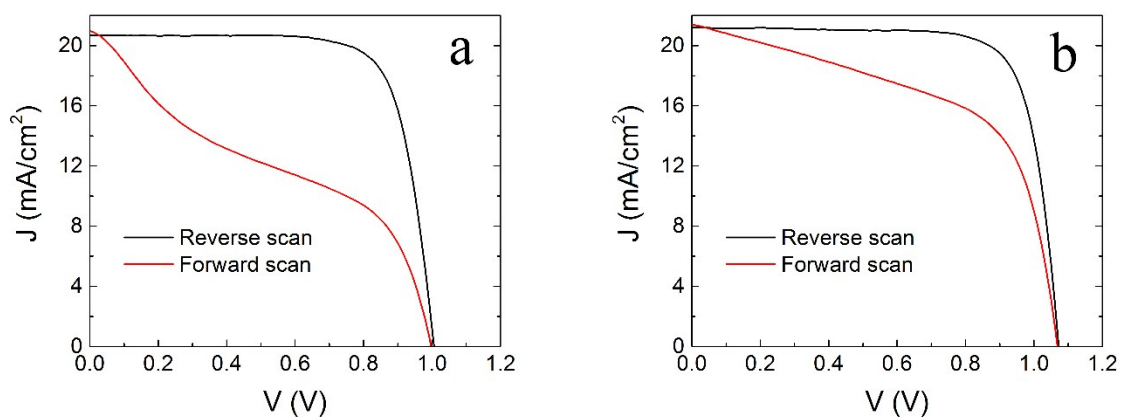


Fig. S2 The hystereses of (a) the as-made and (b) stabilized typical doped P3HT devices.

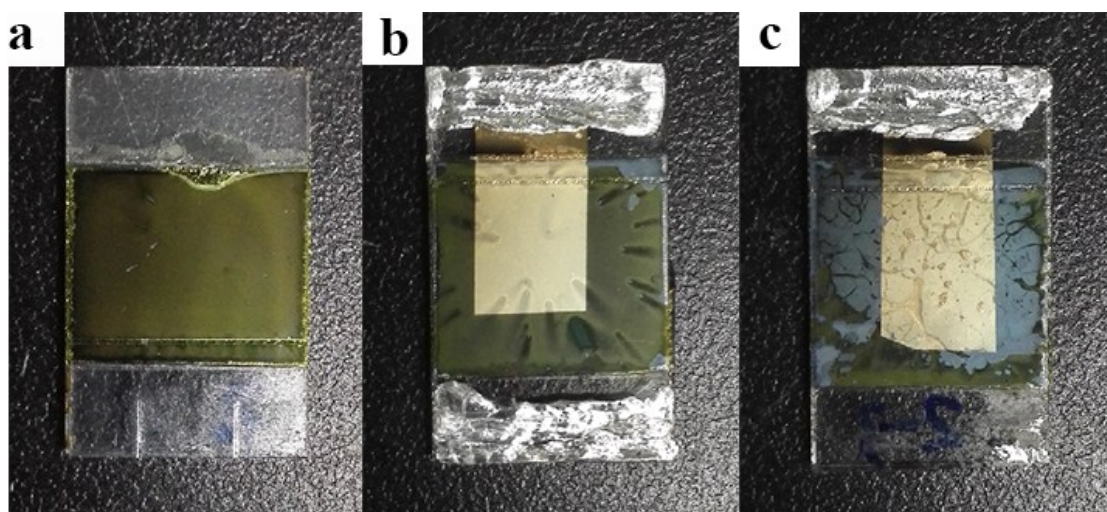


Fig. S3 Appearance of devices with (a) pristine P3HT, (b) 1.5% Li, and (c) 2% Li doped P3HT.

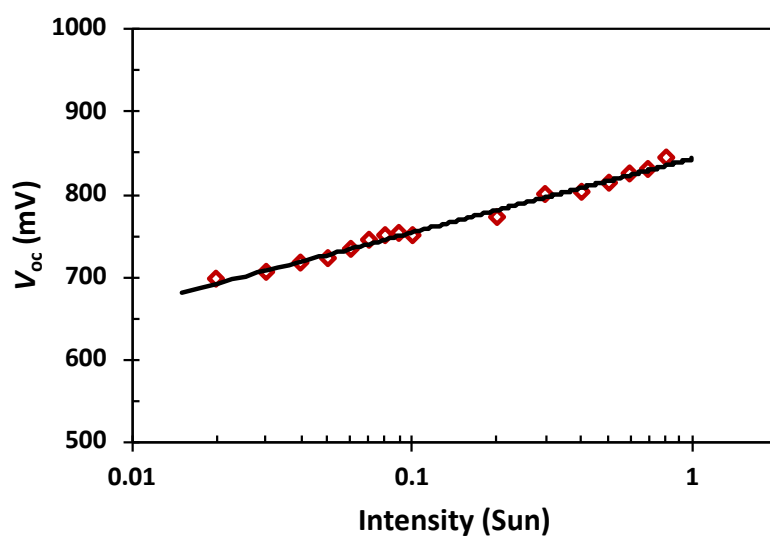


Fig. S4 V_{oc} vs. light intensity of the H2 device.

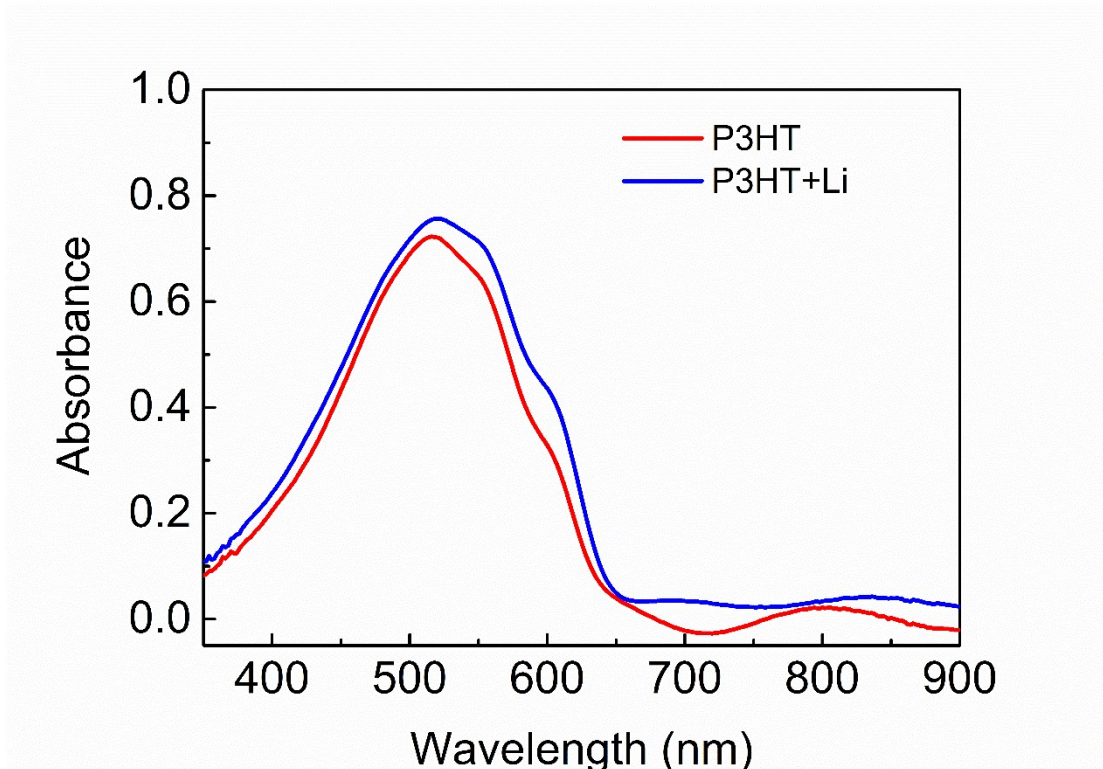


Fig. S5 UV-Vis Absorption spectra of P3HT films deposited on glass (thickness \approx 100 nm)