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Solar Cells Reporting Summary

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Experimental design

Please check: are the following details reported in the manuscript?

1. Dimensions

Area of the tested solar cells	☒ Yes ☐ No	0.04 cm^2 in our lab and 0.03159 cm^2 in National Institute of Metrology (NIM), Chain.
Method used to determine the device area	☒ Yes ☐ No	Area of the tested solar cells in our lab is defined by optical microscope and area of the tested solar cells in NIM is defined by mask.

2. Current-voltage characterization

Current density-voltage (J-V) plots in both forward and backward direction	☐ Yes ☒ No	We only scan the device in forward direction. Generally there in no difference between these two direction for organic solar cell.
Voltage scan conditions *For instance: scan direction, speed, dwell times*	☒ Yes ☐ No	Forward direction, the scan voltage from -1.5 to 1.5 V with a voltage step of 10 mV and delay time of 1ms.
Test environment *For instance: characterization temperature, in air or in glove box*	☒ Yes ☐ No	Our devices were characterized at room temperature (ca. 25 Celsius degree) in glove box.
Protocol for preconditioning of the device before its characterization	☐ Yes ☒ No	No preconditioning protocol.
Stability of the J-V characteristic *Verified with time evolution of the maximum power point or with the photocurrent at maximum power point; see ref. 7 for details.*	☐ Yes ☒ No	Organic solar cells show no decay or instability during the test of J-V characteristics.

3. Hysteresis or any other unusual behaviour

Description of the unusual behaviour observed during the characterization	☐ Yes ☒ No	No hysteresis or other unusual behaviour was observed during the characterization of the solar cells. In general, organic solar cells do not have hystereisis problems.
Related experimental data	☐ Yes ☒ No	No hysteresis or other unusual behaviour was observed during the characterization of the solar cells.

4. Efficiency

External quantum efficiency (EQE) or incident photons to current efficiency (IPCE)	☒ Yes ☐ No	The EQE curves are shown in Figure 3b, which is obtained by the equipment of Enlitech (Taiwan) with a standard Si cell in air condition.
A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator	☒ Yes ☐ No	The difference between the integrated current density from EQE and the short-circuit current density from J-V is within 5%.
For tandem solar cells, the bias illumination and bias voltage used for each subcell	☐ Yes ☒ No	Our devices were only fabricated for single-junction solar cells.

5. Calibration

Light source and reference cell or sensor used for the characterization	☒ Yes ☐ No	The illumination of AM 1.5G (100mW cm-2) was achieved by a XES-70S1 solar simulator (SAN-EI Electric Co., Ltd., AAA grade, 70 mm × 70 mm photo-beam size).
Confirmation that the reference cell was calibrated and certified	☒ Yes ☐ No	The reference cell was calibrated an certified in NIM.

Calculation of spectral mismatch between the reference cell and the devices under test	☐ Yes ☒ No	The spectral mismatch factor was determined at National Institute of Metrology, China (NIM). We do not have the detailed information for the method.

6. Mask/aperture

Size of the mask/aperture used during testing	☐ Yes ☒ No	We did not use a mask during testing in our lab.
Variation of the measured short-circuit current density with the mask/aperture area	☐ Yes ☒ No	We did not use a mask during testing in our lab.

7. Performance certification

Identity of the independent certification laboratory that confirmed the photovoltaic performance	☒ Yes ☐ No	The certified PCE was obtained from the National Institute of Metrology (NIM), China.
A copy of any certificate(s) *Provide in Supplementary Information*	☒ Yes ☐ No	Supplementary Figure 14

8. Statistics

Number of solar cells tested	☒ Yes ☐ No	The average PCE of the devices is obtained from ten independent devices.
Statistical analysis of the device performance	☒ Yes ☐ No	We have given statistical data of device performance in Table 1.

9. Long-term stability analysis

Type of analysis, bias conditions and environmental conditions *For instance: illumination type, temperature, atmosphere humidity, encapsulation method, preconditioning temperature*	☐ Yes ☒ No	We did not perform the long-term stability test.