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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	Section "Device Characterization" in the Supplementary Information.
Method used to determine the device area	☐ Yes ☒ No	The area of the device was defined by a shadow mask, which is measured by microscope.

2. Current-voltage characterization

Current density-voltage (J-V) plots in both forward and backward direction	☐ Yes ☒ No	Photo-current hysteresis is not observed in organic solar cells, thus backward direction scan was not applied in this system.
Voltage scan conditions *For instance: scan direction, speed, dwell times*	☒ Yes ☐ No	The current-voltage curves were measured along the reverse scan direction from -0.2 to 1 V, yielding identical results. The scan speed and dwell times were fixed at 0.05 V/step and 10 ms, respectively. (Section "Device Characterization" in the Supplementary Information)
Test environment *For instance: characterization temperature, in air or in glove box*	☒ Yes ☐ No	The current-voltage curves were measured in a glove box at room temperature. (Section "Device Characterization" in the Supplementary Information)
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	The stability performance were shown in Supplementary Fig. 11.

3. Hysteresis or any other unusual behaviour

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

4. Efficiency

External quantum efficiency (EQE) or incident photons to current efficiency (IPCE)	☒ Yes ☐ No	As shown in Fig. 1c.
A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator	☐ Yes ☒ No	We have reported related data in former paper.
For tandem solar cells, the bias illumination and bias voltage used for each subcell	☐ Yes ☒ No	We only fabricated single-junction solar cells.

5. Calibration

Light source and reference cell or sensor used for the characterization	☒ Yes ☐ No	Section "Device Characterization" in the Supplementary Information.

Confirmation that the reference cell was calibrated and certified	☒ Yes ☐ No	Section "Device Characterization" in the Supplementary Information.
Calculation of spectral mismatch between the reference cell and the devices under test	☒ Yes ☐ No	Silicon cells were used to rectify before JV curve and EQE measurement.

6. Mask/aperture

Size of the mask/aperture used during testing	☒ Yes ☐ No	All samples were measured with a 0.0313 cm^2 mask for cells.
Variation of the measured short-circuit current density with the mask/aperture area	☐ Yes ☒ No	All the current-voltage curves were measured with a single mask.

7. Performance certification

Identity of the independent certification laboratory that confirmed the photovoltaic performance	☒ Yes ☐ No	A recorded efficiency of 18.59% was certified by Chengdu Institute of Product Quality Inspection Co., Ltd. National Photovoltaic Product Quality Inspection &Testing Center.
A copy of any certificate(s) *Provide in Supplementary Information*	☒ Yes ☐ No	See "Supplementary Fig. 10" in the Supplementary Information.

8. Statistics

Number of solar cells tested	☒ Yes ☐ No	The device performance statistics was based on around 30 devices.
Statistical analysis of the device performance	☒ Yes ☐ No	Results were included in Fig. 1d,e.

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	Supplementary Fig. 11 shows the normalized performance of encapsulated device by UV adhesive package under continuous illumination over 1200h under white light illumination of 1 sun intensity in air at room temperature.