

Solar Cells Reporting Summary

Nature Research wishes to improve the reproducibility of the work that we publish. This form is intended for publication with all accepted papers reporting the characterization of photovoltaic devices and provides structure for consistency and transparency in reporting. Some list items might not apply to an individual manuscript, but all fields must be completed for clarity.

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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 See "Device fabrication and characterization" in Supplementary Information.
 No
- Method used to determine the device area Yes The area of our device was certified at National Institute of Metrology, China (NIM).
 No

2. Current-voltage characterization

- Current density-voltage (J-V) plots in both forward and backward direction Yes Both forward and backward scans were conducted, which yielded identical results.
 No
- Voltage scan conditions Yes See "Device fabrication and characterization" in Supplementary Information.
For instance: scan direction, speed, dwell times
 No
- Test environment Yes See "Device fabrication and characterization" in Supplementary Information.
For instance: characterization temperature, in air or in glove box
 No
- Protocol for preconditioning of the device before its characterization Yes No preconditioning protocol.
 No
- Stability of the J-V characteristic Yes The stability were obtained by tracking the maximum output power point.
Verified with time evolution of the maximum power point or with the photocurrent at maximum power point; see ref. 7 for details.
 No

3. Hysteresis or any other unusual behaviour

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

4. Efficiency

- External quantum efficiency (EQE) or incident photons to current efficiency (IPCE) Yes The EQE measurements were conducted. The integrated response under the standard reference spectrum are quite comparable to the response measured under the simulator with a error less than 5%.
 No
- A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator Yes The EQE measurements were conducted. The integrated response under the standard reference spectrum are quite comparable to the response measured under the simulator with a error less than 5%.
 No
- For tandem solar cells, the bias illumination and bias voltage used for each subcell Yes Devices are single solar cells structure only.
 No

5. Calibration

- Light source and reference cell or sensor used for the characterization Yes See "Device fabrication and characterization" in Supplementary Information.
 No
- Confirmation that the reference cell was calibrated and certified Yes See "Device fabrication and characterization" in Supplementary Information.
 No

Calculation of spectral mismatch between the reference cell and the devices under test	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	The spectral mismatch factor has been included in testing.
6. Mask/aperture		
Size of the mask/aperture used during testing	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	See "Device fabrication and characterization" in Supplementary Information.
Variation of the measured short-circuit current density with the mask/aperture area	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Variation is small.
7. Performance certification		
Identity of the independent certification laboratory that confirmed the photovoltaic performance	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	We did not confirm the photovoltaic performance from independent certification laboratories, as our aim is not to develop new devices or break efficiency record.
A copy of any certificate(s) <i>Provide in Supplementary Information</i>	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	No copy is provided as we did not confirm the photovoltaic performance from independent certification laboratories.
8. Statistics		
Number of solar cells tested	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	For each condition, 10 devices were tested for statistics.
Statistical analysis of the device performance	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	The statistical analysis can be found in error bars of Fig. 8 and average performance data in Supplementary Table 2.
9. Long-term stability analysis		
Type of analysis, bias conditions and environmental conditions <i>For instance: illumination type, temperature, atmosphere humidity, encapsulation method, preconditioning temperature</i>	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	As our current focus is on morphology evolution of organic solar cells based on reported systems, we did not carry out systematic study on long-term stability track.