

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	Relative information is provided in method section.
	☐ No	
Method used to determine the device area	☒ Yes	Relative information is provided in method section.
	☐ No	

2. Current-voltage characterization

Current density-voltage (J-V) plots in both forward and backward direction	☐ Yes	J-V plot in forward direction since there is no hysteresis in polymer solar cells.
	☒ No	
Voltage scan conditions <i>For instance: scan direction, speed, dwell times</i>	☒ Yes	he voltage range for single junction OSC is from -0.2 V to 1 V, and for tandem solar cell is from -0.2 V to 2.5 V. The voltage step and delay time were 10 mV and 1 ms, respectively.
	☐ No	
Test environment <i>For instance: characterization temperature, in air or in glove box</i>	☒ Yes	Devices were characterized at room temperature in In N ₂ -filled glove box.
	☐ No	
Protocol for preconditioning of the device before its characterization	☐ Yes	No preconditioning protocol.
	☒ No	
Stability of the J-V characteristic <i>Verified with time evolution of the maximum power point or with the photocurrent at maximum power point; see ref. 7 for details.</i>	☐ Yes	Organic photovoltaic devices show no decay or instability during the test of J-V characteristics. The MPP output is consistent with the J-V curve.
	☒ No	

3. Hysteresis or any other unusual behaviour

Description of the unusual behaviour observed during the characterization	☐ Yes	No hysteresis was observed in our device.
	☒ No	
Related experimental data	☐ Yes	No.
	☒ No	

4. Efficiency

External quantum efficiency (EQE) or incident photons to current efficiency (IPCE)	☒ Yes	Provided in Figures 3c and 6d.
	☐ No	
A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator	☒ Yes	The difference between the integrated current from EQE and the short-circuit current from J-V curve measured under AM 1.5G simulated sunlight is within 3% difference which is within the accuracy confidence of the measurements.
	☐ No	
For tandem solar cells, the bias illumination and bias voltage used for each subcell	☒ Yes	During EQE measurement for tandem device, light bias with 550 nm short pass filter and 800nm long pass filter were applied separately to obtain rear cell and front cell EQE value. No additional illumination and voltage bias were applied during measurements.
	☐ No	

5. Calibration

Light source and reference cell or sensor used for the characterization	☒ Yes	Relative information is provided in method section.
	☐ No	

Confirmation that the reference cell was calibrated and certified	☒ Yes ☐ No	Relative information is provided in method section.
Calculation of spectral mismatch between the reference cell and the devices under test	☒ Yes ☐ No	Relative information is provided in method section.
6. Mask/aperture		
Size of the mask/aperture used during testing	☒ Yes ☐ No	Device area is determined by a mask with area of 0.046 cm ²
Variation of the measured short-circuit current density with the mask/aperture area	☐ Yes ☒ No	The variation is within 0.3%.
7. Performance certification		
Identity of the independent certification laboratory that confirmed the photovoltaic performance	☐ Yes ☒ No	The photovoltaic performance of our devices was not confirmed from independent certification laboratories
A copy of any certificate(s) <i>Provide in Supplementary Information</i>	☐ Yes ☐ No	State where this information can be found in the text. Explain why this information is not reported/not relevant.
8. Statistics		
Number of solar cells tested	☒ Yes ☐ No	The average PCE of OSC is obtained from at least 10 different cells and of tandem cells is obtained from 30 cells
Statistical analysis of the device performance	☒ Yes ☐ No	Provided in Table 2 and Figure 6e.
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>	☒ Yes ☐ No	Relative information is provided in method section.