

## 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	<input checked="" type="checkbox"/> Yes	Section "OSC device fabrication and measurement"
	<input type="checkbox"/> No	<i>Explain why this information is not reported/not relevant.</i>
Method used to determine the device area	<input checked="" type="checkbox"/> Yes	The electronic active area of the cell is defined by the overlap of the ITO electrode and metal electrode.
	<input type="checkbox"/> No	<i>Explain why this information is not reported/not relevant.</i>

## 2. Current-voltage characterization

Current density-voltage (J-V) plots in both forward and backward direction	<input type="checkbox"/> Yes	<i>State where this information can be found in the text.</i>
	<input checked="" type="checkbox"/> No	Generally, organic photovoltaic devices do not have forward and backward problems. And we only scan the device in forward direction.
Voltage scan conditions <i>For instance: scan direction, speed, dwell times</i>	<input checked="" type="checkbox"/> Yes	Section "OSC device fabrication and measurement"
	<input type="checkbox"/> No	<i>Explain why this information is not reported/not relevant.</i>
Test environment <i>For instance: characterization temperature, in air or in glove box</i>	<input checked="" type="checkbox"/> Yes	Our devices were characterized at room temperature (ca. 25 Celsius degree) in glove box.
	<input type="checkbox"/> No	<i>Explain why this information is not reported/not relevant.</i>
Protocol for preconditioning of the device before its characterization	<input type="checkbox"/> Yes	<i>State where this information can be found in the text.</i>
	<input checked="" type="checkbox"/> No	No preconditioning protocol
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 <a href="#">ref. 7</a> for details.</i>	<input type="checkbox"/> 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.
	<input checked="" type="checkbox"/> No	We only tested the long-term stability.

## 3. Hysteresis or any other unusual behaviour

Description of the unusual behaviour observed during the characterization	<input type="checkbox"/> Yes	<i>State where this information can be found in the text.</i>
	<input checked="" type="checkbox"/> No	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.
Related experimental data	<input type="checkbox"/> Yes	<i>State where this information can be found in the text.</i>
	<input checked="" type="checkbox"/> 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)	<input checked="" type="checkbox"/> Yes	The external quantum efficiency (EQE) spectra of OSCs are recorded using Enli QE-R3011 (Enli Technology Co., Ltd Taiwan).
	<input type="checkbox"/> No	<i>Explain why this information is not reported/not relevant.</i>
A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator	<input checked="" type="checkbox"/> Yes	There are less than 5% errors between the integrated response under the standard reference spectrum and the response measure under the simulator. We give details in the manuscript.
	<input type="checkbox"/> No	<i>Explain why this information is not reported/not relevant.</i>

For tandem solar cells, the bias illumination and bias voltage used for each subcell	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	<input type="text" value="State where this information can be found in the text."/> <input type="text" value="We only fabricated single junction solar cells."/>
<b>5. Calibration</b>		
Light source and reference cell or sensor used for the characterization	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Section 'OSC device fabrication and measurement'"/> <input type="text" value="Explain why this information is not reported/not relevant."/>
Confirmation that the reference cell was calibrated and certified	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Section 'OSC device fabrication and measurement'"/> <input type="text" value="Explain why this information is not reported/not relevant."/>
Calculation of spectral mismatch between the reference cell and the devices under test	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="The relative expanded uncertainty resulting of the relative combined standard uncertainty multiplied with a coverage factor k = 2 is specified. It corresponds to a level of confidence of 95%."/> <input type="text" value="We do not have the detailed information for the method."/>
<b>6. Mask/aperture</b>		
Size of the mask/aperture used during testing	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	<input type="text" value="State where this information can be found in the text."/> <input type="text" value="We did not use a mask during testing and the device effective area was obtained by its crossed area of the bottom and top electrodes."/>
Variation of the measured short-circuit current density with the mask/aperture area	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	<input type="text" value="State where this information can be found in the text."/> <input type="text" value="We did not use a mask during testing."/>
<b>7. Performance certification</b>		
Identity of the independent certification laboratory that confirmed the photovoltaic performance	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="The PCE was certified by NIM, China, using a 3.152 mm2 mask."/>
A copy of any certificate(s) <i>Provide in Supplementary Information</i>	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="See 'Supplementary Fig. 5'."/>
<b>8. Statistics</b>		
Number of solar cells tested	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="We have tested ten solar cells for each type of OSCs, and the average PCE of OSCs are obtained from ten independent cells."/> <input type="text" value="Explain why this information is not reported/not relevant."/>
Statistical analysis of the device performance	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="Statistical results of the devices are listed in Table 1,2 and Supplementary Table 1-9."/> <input type="text" value="Explain why this information is not reported/not relevant."/>
<b>9. Long-term stability analysis</b>		
Type of analysis, bias conditions and environmental conditions <i>For instance: illumination type, temperature, atmosphere humidity, encapsulation method, preconditioning temperature</i>	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input type="text" value="See 'Supplementary Figure 6.'"/> <input type="text" value="Explain why this information is not reported/not relevant."/>