

Solar Cells Reporting Summary

Nature Portfolio 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 the following details are reported in the manuscript, and provide a brief description or explanation where applicable.

1. Dimensions

Area of the tested solar cells	☒ Yes ☐ No	The area of the tested solar cells is 0.05 cm ² (Methods, Device Fabrication) Explain why this information is not reported/not relevant.
Method used to determine the device area	☒ Yes ☐ No	The active area was determined by the shading mask and further calculated by an optical microscope Explain why this information is not reported/not relevant.

2. Current-voltage characterization

Current density-voltage (J-V) plots in both forward and backward direction	☒ Yes ☐ No	Fig. 4d and Table 1
Voltage scan conditions	☒ Yes ☐ No	J-V curves were measured by reverse scan (1.23 V to -0.01 V) and forward scan (-0.01 V to 1.23 V) with a scanning rate of 200 mV/s (voltage step of 20 mV) Explain why this information is not reported/not relevant.
Test environment	☒ Yes ☐ No	Performance measurements were carried out in a nitrogen environment Explain why this information is not reported/not relevant.
Protocol for preconditioning of the device before its characterization	☒ Yes ☐ No	No preconditioning was used Explain why this information is not reported/not relevant.
Stability of the J-V characteristic	☒ Yes ☐ No	Maximum power point measurements were conducted (Supplementary Fig. 11) Explain why this information is not reported/not relevant.

3. Hysteresis or any other unusual behaviour

Description of the unusual behaviour observed during the characterization	☒ Yes ☐ No	The reference cells showed moderate hysteresis while the target cells showed negligible hysteresis Explain why this information is not reported/not relevant.
Related experimental data	☒ Yes ☐ No	Fig. 4d and Table 1 Explain why this information is not reported/not relevant.

4. Efficiency

External quantum efficiency (EQE) or incident photons to current efficiency (IPCE)	☒ Yes ☐ No	Supplementary Fig.12 Explain why this information is not reported/not relevant.
A comparison between the integrated response under the standard reference spectrum and the response measure under the simulator	☒ Yes ☐ No	The integrated J _{sc} from EQE spectra is consistent with the J _{sc} from J-V measurements (Main text and Supplementary Fig.12) Explain why this information is not reported/not relevant.

For tandem solar cells, the bias illumination and bias voltage used for each subcell	☐ Yes ☒ No	Provide a description of the measurement conditions. No tandem cells reported in this manuscript
5. Calibration		
Light source and reference cell or sensor used for the characterization	☒ Yes ☐ No	Enlitech IVS-KA5000 solar simulator was used for the measurements (Methods, Characterization) Explain why this information is not reported/not relevant.
Confirmation that the reference cell was calibrated and certified	☒ Yes ☐ No	The light intensity was calibrated by the reference solar cell of Hamamatsu S1133 (Methods, Characterization) Explain why this information is not reported/not relevant.
Calculation of spectral mismatch between the reference cell and the devices under test	☒ Yes ☐ No	Mismatch factor of 1 was used in measurements Explain why this information is not reported/not relevant.
6. Mask/aperture		
Size of the mask/aperture used during testing	☒ Yes ☐ No	0.04556 cm² (Main text and Methods) Explain why this information is not reported/not relevant.
Variation of the measured short-circuit current density with the mask/aperture area	☒ Yes ☐ No	We have measured the short-circuit current density using mask with various areas Explain why this information is not reported/not relevant.
7. Performance certification		
Identity of the independent certification laboratory that confirmed the photovoltaic performance	☐ Yes ☒ No	Identify the independent certification laboratory. We did not conduct PCE certification as the primary focus of this manuscript lies in the science of superoxide radical-derived spiro-OMeTAD HTL and its benefits in stability of PSCs.
A copy of any certificate(s)	☐ Yes ☒ No	Certificate copies should be provided in the Supplementary information. Please state the supplementary item number. We did not perform the PCE certification and thus no certificates.
8. Statistics		
Number of solar cells tested	☒ Yes ☐ No	40 individual devices were tested (Fig. 4a-c and Supplementary Fig. 10) Explain why this information is not reported/not relevant.
Statistical analysis of the device performance	☒ Yes ☐ No	Fig. 4a-c and Supplementary Fig.10 Explain why this information is not reported/not relevant.
9. Long-term stability analysis		
Type of analysis, bias conditions and environmental conditions	☒ Yes ☐ No	Long-term stability including humidity stability, thermal stability, operational stability and light-thermal cycling stability (detailed conditions are shown in main text and Methods, Characterization) Explain why this information is not reported/not relevant.

