

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 The laboratory sized solar cell dimension: round, diameter 0.6 cm, area 0.28 cm². Larger area solar cells: rectangular, 0.7cm x 4.0 cm, area 2.80 cm², as described in the Experimental Section (Fabrication of solar cells) in the Supplementary Information.
- Method used to determine the device area Yes No The device areas are determined by the design of the screens for printing TiO₂ films, as described in the Experimental Section (Fabrication of solar cells) in the Supplementary Information.

2. Current-voltage characterization

- Current density-voltage (J-V) plots in both forward and backward direction Yes No The J-V plots in both forward and backward direction were recorded, but not added to the publication, since we did not observe hysteresis or any other unusual behaviour during the characterization of the dye sensitized solar cells. Note that hysteresis is notorious for perovskite solar cells but is rarely seen in dye sensitized solar cells.
- Voltage scan conditions Yes No For instance: scan direction, speed, dwell times Voltage scan conditions: reverse scan, 125 mV/s, 80 ms, as described in the Experimental Section (Characterization of Solar Cells) in the Supplementary Information.
- Test environment Yes No For instance: characterization temperature, in air or in glove box Test environment: room temperature and humidity, in air, as described in the Experimental Section (Characterization of Solar Cells) in the Supplementary Information.
- Protocol for preconditioning of the device before its characterization Yes No Current-voltage characteristics were recorded in accordance with the procedure reported in the Experimental Section (Characterization of Solar Cells) in the Supplementary Information. No specific protocol for preconditioning was applied.
- Stability of the J-V characteristic Yes No Verified with time evolution of the maximum power point or with the photocurrent at maximum power point; see [ref. 7](#) for details. Our DSCs are stable under light soaking conditions.

3. Hysteresis or any other unusual behaviour

- Description of the unusual behaviour observed during the characterization Yes No We did not observe hysteresis or any other unusual behaviour during the characterization of the solar cells.
- Related experimental data Yes No Our DSCs have no hysteresis behavior.

4. Efficiency

- External quantum efficiency (EQE) or incident photons to current efficiency (IPCE) Yes No IPCE spectra were recorded, as reported in Fig. 2a and Fig. 3a of the manuscript.
- 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 IPCE spectra agrees well with the measured J_{sc} from JV measurements, as detailed in the manuscript (Fig. 2a, Fig. 3a, and Table 1). The mismatch between the J_{sc} calculated from the overlap integral of the IPCE with the standard AM1.5G emission spectrum (ASTM G173-03) and the one measured from standard AM1.5G solar simulator is very small.
- For tandem solar cells, the bias illumination and bias voltage used for each subcell Yes No We do not study tandem DSCs in the current work.

5. Calibration

- Light source and reference cell or sensor used for the characterization Yes No
As described in the Experimental Section (Characterization of Solar Cells) in the Supplementary Information, for small area solar cells (0.28 cm²): the light source was a 300-W Xenon lamp (Oriental) equipped with a SchottK113 Tempax sunlight filter (Prazisions Glas & Optik GmbH) to match the emission spectrum of the lamp to the AM1.5G standard. Before each measurement, the exact light intensity was determined using a calibrated Si reference diode equipped with an infrared cut-off filter (KG-3, Schott); For large area solar cells (2.80 cm²): indoor light sources OSRAM Warm White 930 was used and the light intensities were calibrated by the light meter (TES-1334, TES).
- Confirmation that the reference cell was calibrated and certified Yes No
The Si reference diode was certified and calibrated by Newport Corporation PV Lab, Bozeman, MT, USA.
- Calculation of spectral mismatch between the reference cell and the devices under test Yes No
The spectral mismatch between our simulator and the AM 1.5 solar source was insignificant as the integrated current densities estimated from the IPCE spectra were in good agreement with the values obtained from the current density-voltage (J-V) curves as detailed in the manuscript. Spectra mismatch factor of 1 was used.

6. Mask/aperture

- Size of the mask/aperture used during testing Yes No
For small solar cells (0.28 cm²), all measurements were conducted using a non-reflective metal mask with an aperture area of 0.158 cm² to cover part of the active area of the device and avoid stray light capturing by our devices; For the larger area solar cells (2.80 cm²) under indoor illumination, the mask with rectangular areas of 3.80 cm² was used, as detailed in the Experimental Section (Characterization of Solar Cells) in the Supplementary Information.
- Variation of the measured short-circuit current density with the mask/aperture area Yes No
We haven't measured the cells with apertures of different sizes.

7. Performance certification

- Identity of the independent certification laboratory that confirmed the photovoltaic performance Yes No
The results have not been certified yet by an independent accredited laboratory.
- A copy of any certificate(s)
Provide in Supplementary Information Yes No
Not applicable as we have not yet certified our devices by an independent accredited laboratory.

8. Statistics

- Number of solar cells tested Yes No
At least 16 devices for each condition were tested.
- Statistical analysis of the device performance Yes No
A statistical analysis of the performance is presented Fig. 3c.

9. Long-term stability analysis

- Type of analysis, bias conditions and environmental conditions Yes No
We stated the long-term stability in the Experimental Section (Characterization of Solar Cells) in the Supplementary Information.
For instance: illumination type, temperature, atmosphere humidity, encapsulation method, preconditioning temperature

