Supporting information

Angular response of photonic crystal based dye sensitized solar cells

Carmen López-López, Silvia Colodrero, Mauricio E. Calvo, Hernán Míguez*

Angular effects observed for cells containing a diffuse scattering layer (opaque) versus standard or photonic crystal based cells (transparent).

Experimental section

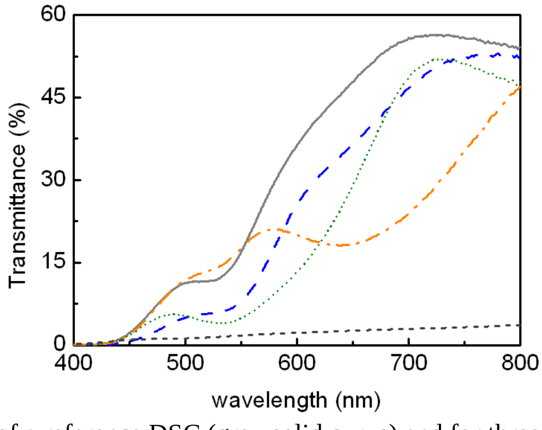
Preparation of a TiO_2 diffuse scattering layer based DSC

A paste containing TiO_2 large particles (WER2-O, Dyesol®) was used to build 4.5 µm scattering layers. This layer was deposited via screen printing on top of the transparent electrodes. The scattering layer was sintered at 450^{0}C during 30 min with heating rate of 15^{0}C/min.

Results and discussion

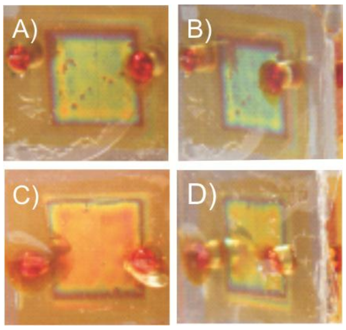
Optical properties

Transmission spectrum of a reference DSC is shown together with the spectra of different PC-DSC reflecting in different wavelength ranges as well as with that of a DSC in which a diffuse scattering layer has been coupled to the semitransparent electrode. Please notice that this latter device is practically opaque.



S1. Transmittance spectra of a reference DSC (grey solid curve) and for three DSCs coupled to different 1DPC, namely DSC-B (blue dashed line), DSC-G (green dotted line) and DSC-R (orange dash-dotted line). We also show the transmittance spectrum of a DSC with a diffuse scattering layer coupled to the electrode (black short dashed line).

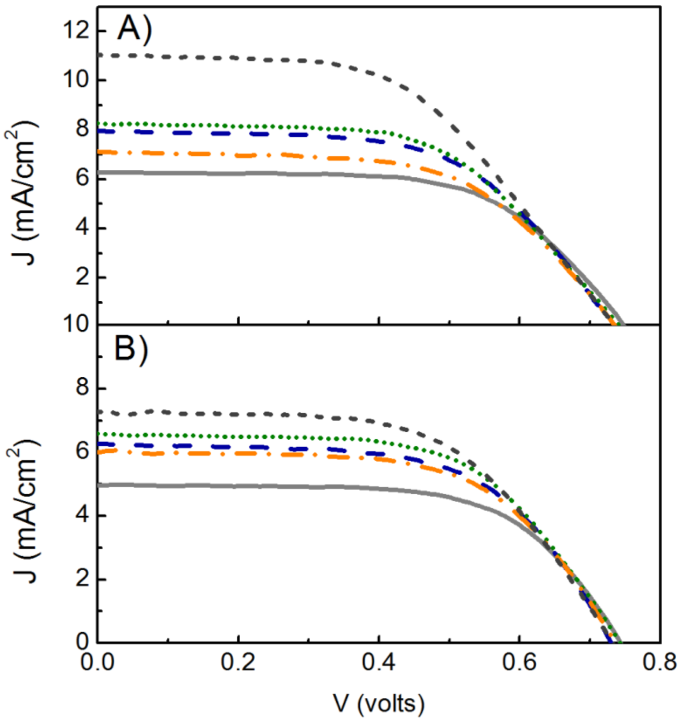
The spectral position of the Bragg reflection peak of the photonic crystals integrated in DSC depends on the light incident angle. This change is also noticeable by the naked eye. Figure S1 shows how, as the illumination angle varies, the reflected colour turns from green (Figure S1A) to blue (Figure S1B) for DSC-G, and from orange (Figure S1C) to yellow (Figure S1D) in the case of DSC-R.



S2. (A-D) Images showing the colour change when DSC-G (A-B) and DSC-R (C-D) were exposed at two different incident light angles.

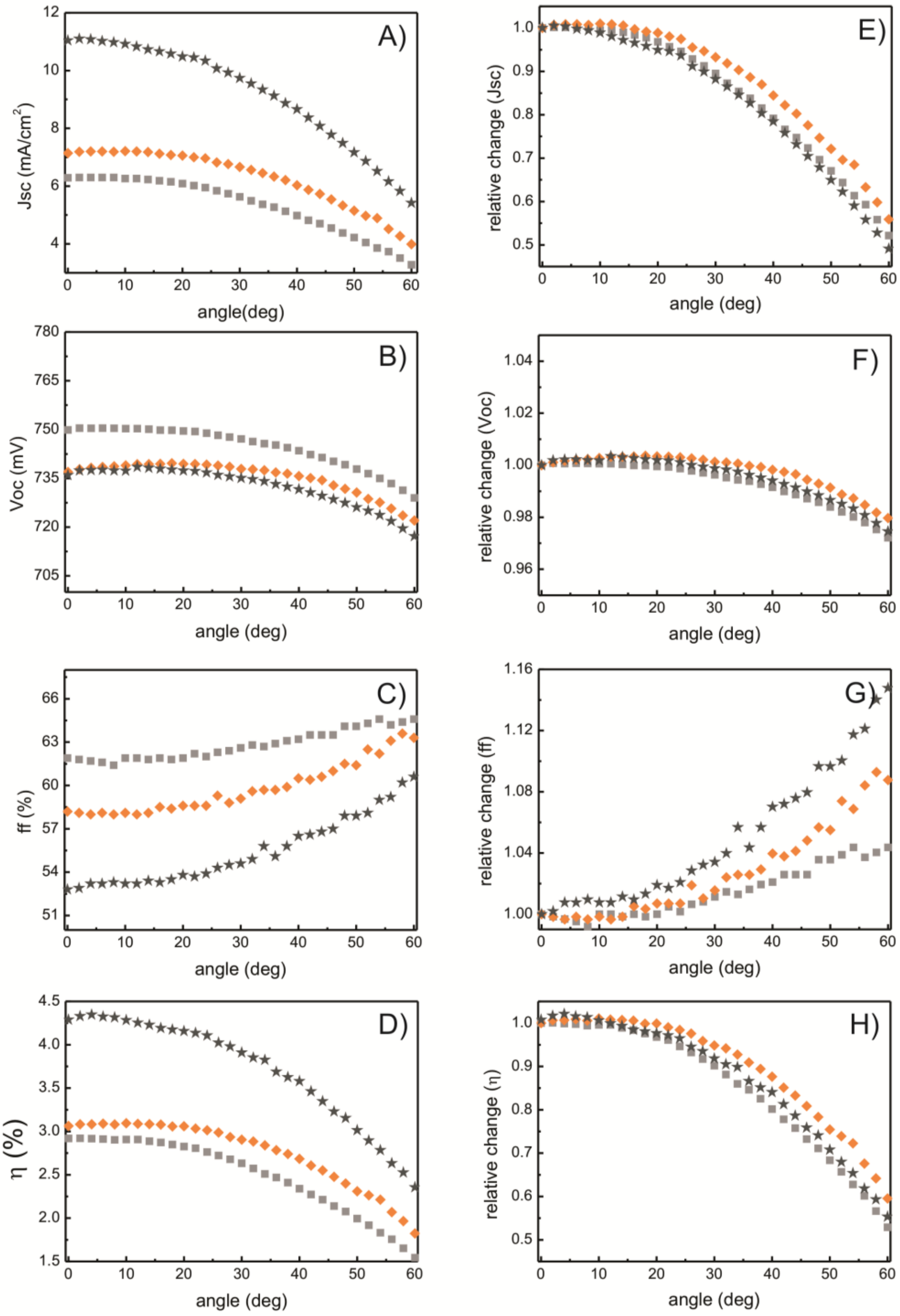
Photovoltaic properties *vs* light incident angle

The current intensity-voltage (IV) curves from PC-DSC, a reference DSC and a diffuse scattering layer based DSC were measured at different light incidence angles. An example of IV curves taken at (a) θ=0 and (b) θ=50 degrees is shown in figure S2.



S3. IV curves measured under standard illumination conditions (100 mW/cm^2, AM 1.5G) for DSC containing titania electrodes coupled to different highly porous 1DPC, namely DSC-B (blue dashed line), DSC-G (green dotted line) and DSC-R (orange dash-dotted line) as well as to a diffuse scattering layer (dashed grey line). Results for a reference cell are also plotted for the sake of comparison (grey solid line) at different illumination angles ((A) 0, (B) 50 degrees).

A detailed analysis of the variation of short circuit photocurrent density (J_{SC}), open circuit voltage (V_{oc}), fill factor (*ff*) *and* power conversion efficiency (η) of a reference cell, a red reflecting PC-DSC and a scattering layer based DSC are plotted in figure S4.



S4. Angular dependence of (A) Jsc, (B) V_{OC}, (C) ff, (D) η, (E) normalized Jsc, (F) normalized V_{OC}, (G) normalized ff, and (H) normalized η for a reference DSC (grey squares), DSC-R(orange rhombi) and scattering layer based DSC (black stars).