Supporting Information

P-type Dye-Sensitized NiO Solar Cells: A Study by Electrochemical Impedance Spectroscopy

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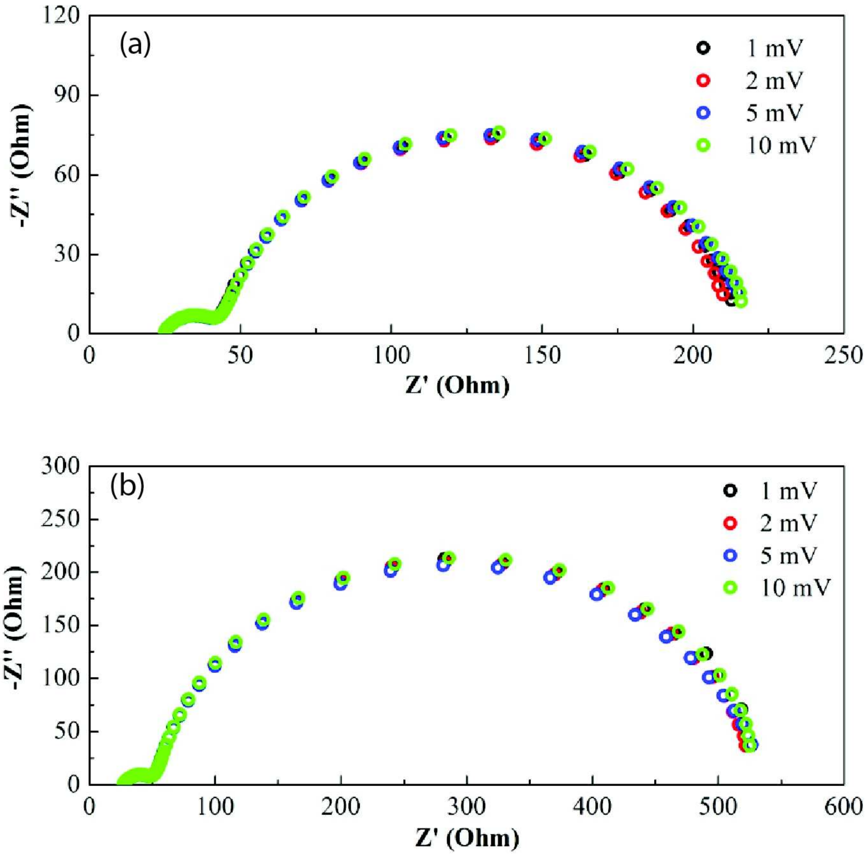

Figure S1. Nyquist plots of the NiO p-DSC using different AC amplitudes: (a) at open circuit voltage under 1 sun, (b) in the dark at 0.12 V bias.

In EIS measurements, the impedance should be independent of the amplitude of the AC perturbation. Therefore, we have first examined the choice of the AC amplitude to ensure a linear response. A NiO p-DSC was tested using different AC amplitudes (1 mV, 2mV, 5 mV and 10 mV) at open circuit under 1 sun or at 120 mV bias in the dark. As shown in Figure S1, the Nyquist plots almost remain the same when different amplitudes are applied. Also, all the data can be perfectly fitted with Kramers-Kronig transforms. Therefore, we conclude that our p-DSCs are in the linear response region with a 10 mV AC perturbation.

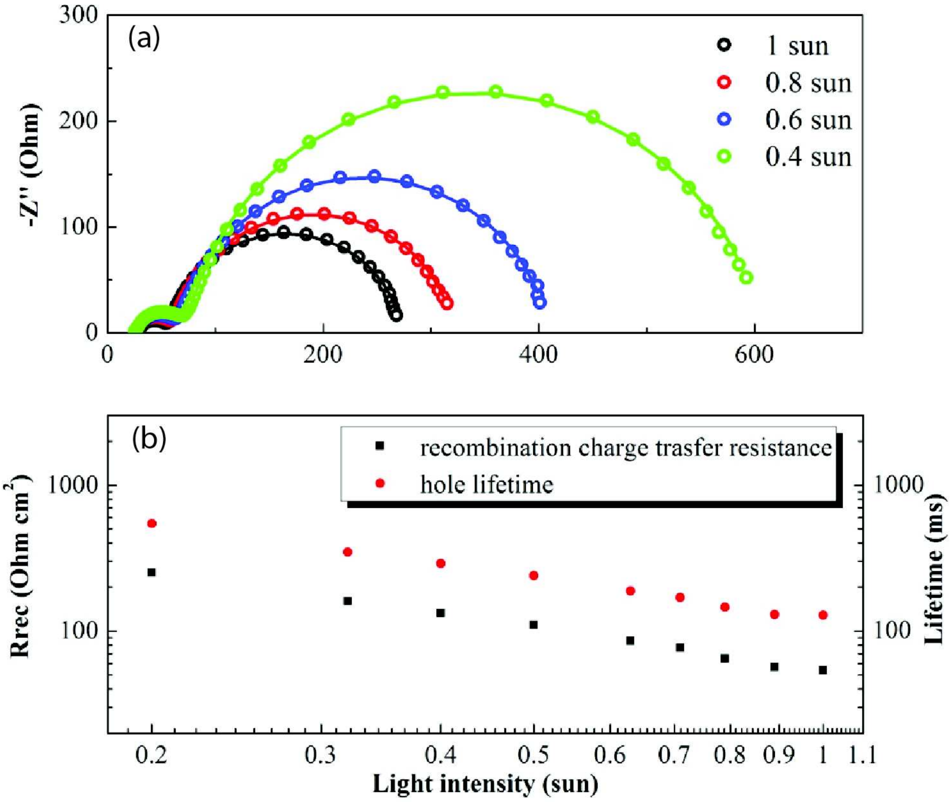

Figure S2. (a) Nyquist plots of the cell C1 at open circuit voltage under different illumination intensities (1 sun, 0.8 sun, 0.6 sun and 0.4 sun). Solid lines show the fitting curves. (b) Recombination charge transfer resistance and hole lifetime of the cell C1 under different illumination intensities (from 0.2 sun to 1 sun).

Under different illumination intensities, the first semicircle of the Nyquist plots in Figure S2a remains similar; however, the second semicircle increases significantly as the light intensity decreases. This result provides strong evidence to assign the second semicircle in the Nyquist plots to the recombination charge transfer process at the NiO/dye/electrolyte interface. The charge transfer resistance and hole lifetime under different light intensity are summarized in Figure S2b. log (R_{rec}) and log(τ) are in linear relation with log(I).

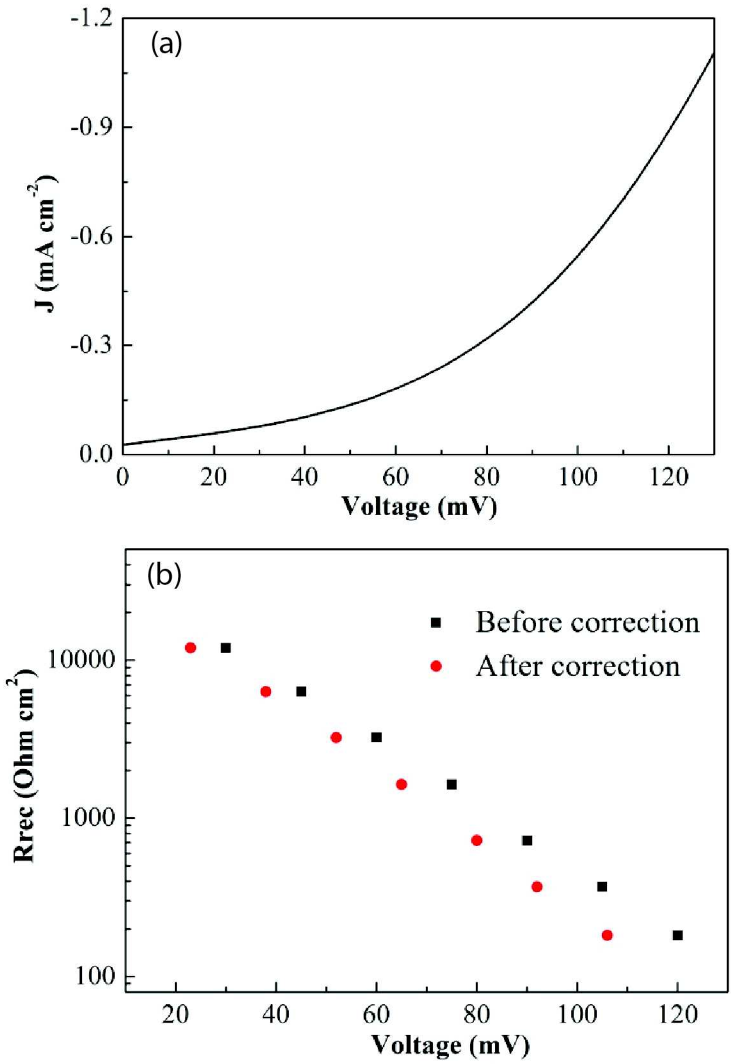

Figure S3. (a) *J-V* curve of cell N2 in the dark. (b) Recombination charge transfer resistance as a function of applied and corrected bias in the dark.

In the dark, the applied potential is divided between photoelectrode, counter electrode and series resistance. It is important to taking IR drop into consideration when analyzing p-DSCs in the dark because the dark current is quite large when applied voltage increases. The IR drop can be calculated by multiplying the total series resistance of the cell (R_s+ R_1) with the dark current (shown in Figure S2a) at specific voltage. Figure S2b shows the results before and after voltage correction. All the data shown in the paper are given after correction.

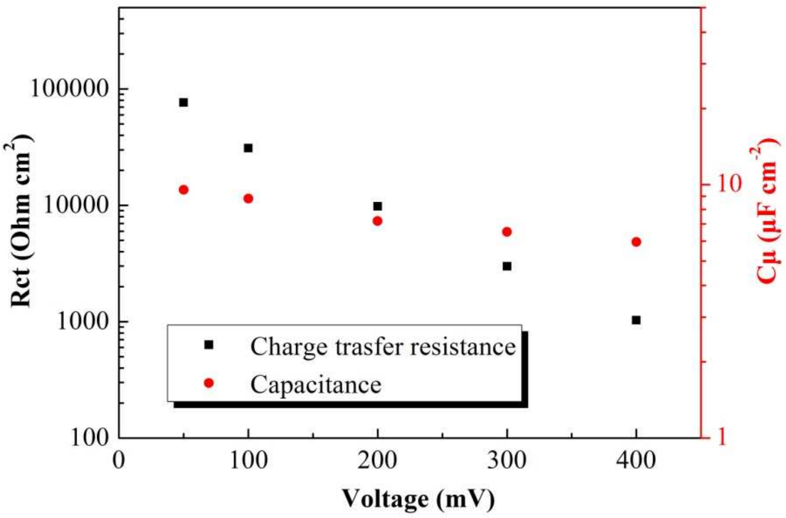

Figure S4. Charge transfer resistance and capacitance of the blank cell under different bias.

FTO-Pt blank cells were used to study the FTO/electrolyte interface. Cells with blank FTO and normal counter electrodes were made and sealed with a 60 μm thick spacer. The spacer had an opening of 0.28 cm^2 filled with the liquid electrolyte. At similar voltages, the charge transfer resistance is much larger than the R_{rec} in our paper and the capacitance is much smaller than C_{μ}. This supports the point that we are not characterizing the FTO/electrolyte instead and that the FTO/electrolyte may only play a part at very low bias.