All-Solid-State Dye-Sensitized Solar Cells with Alkyloxy-Imidazolium Iodide Ionic Polymer/SiO$_2$ Nanocomposite Electrolyte and Triphenylamine-Based Organic dyes

Jifu Shi, Ling Wang, Yanliang Liang, Shengjie Peng, Fangyi Cheng and Jun Chen*

Institute of New Energy Material Chemistry and Key Laboratory of Nanomaterials and Advanced

Batteries/Cells (Ministry of Education), Chemistry College, Nankai University, Tianjin 300071,

People's Republic of China

*Corresponding author; Fax: (86) 22-2350-6808; E-mail: chenabc@nankai.edu.cn

Table S1. Absorption, Emission, and Electrochemical Properties of TPAR14 and TC15 Dyes

Dye	Adsorption			Emission	Oxidation potential		
	λ_{max} [nm][a]	ε_{max} [M^{-1} cm^{-1}][a]	λ_{max} [nm] (on TiO$_2$)[b]	λ_{em} [nm][a]	$E_{0\text{-}0}$ [V] (Abs/Em)[c]	$E_{S+/S}$ [V] (vs. NHE)[d]	$E_{S+/S*}$ [V] (vs. NHE)[e]
TPAR14	486	39200	487	616	2.34	1.15	-1.19
TC15	486	34100	451	571	2.33	1.11	-1.22

[a] Absorption and emission spectra measured in dichloromethane solution (5×10^{-5} M) at room temperature. [b] Absorption spectra of dye-adsorbed TiO$_2$ films sensitized from dichloromethane

solution. [c] The zero-zero transition E_{0-0} estimated from the intersection of the normalized absorption and emission spectra. [d] Cyclic voltammogram of the oxidation behavior of the dyes measured in dry dichloromethane solution containing 0.1 M tetrabutylammonium perchlorate (TBAP) as supporting electrolyte (scanning rate: 100 mV/s; working electrode: glassy carbon; reference electrode: Ag/AgCl calibrated with ferrocene/ferrocenium (Fc$^+$/Fc) as an internal reference; counter electrode: Pt wire). [e] $E_{S+/S*}$ gained from the difference of the $E_{S+/S}$ and E_{0-0} values.
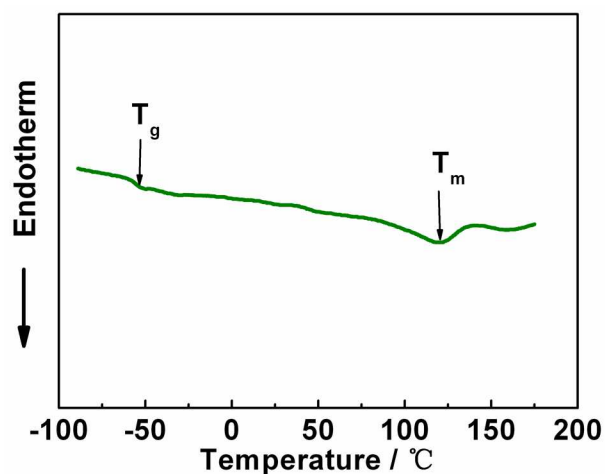

Figure S1. Differential scanning calorimetry thermogram of the optimal electrolyte, which is composed of I_2 (with mole ratio of $I_2/O = 0.9$), DMPImI (with mole ratio of DMPImI/O = 0.6), and SiO_2 (1 wt %) in AIIP.
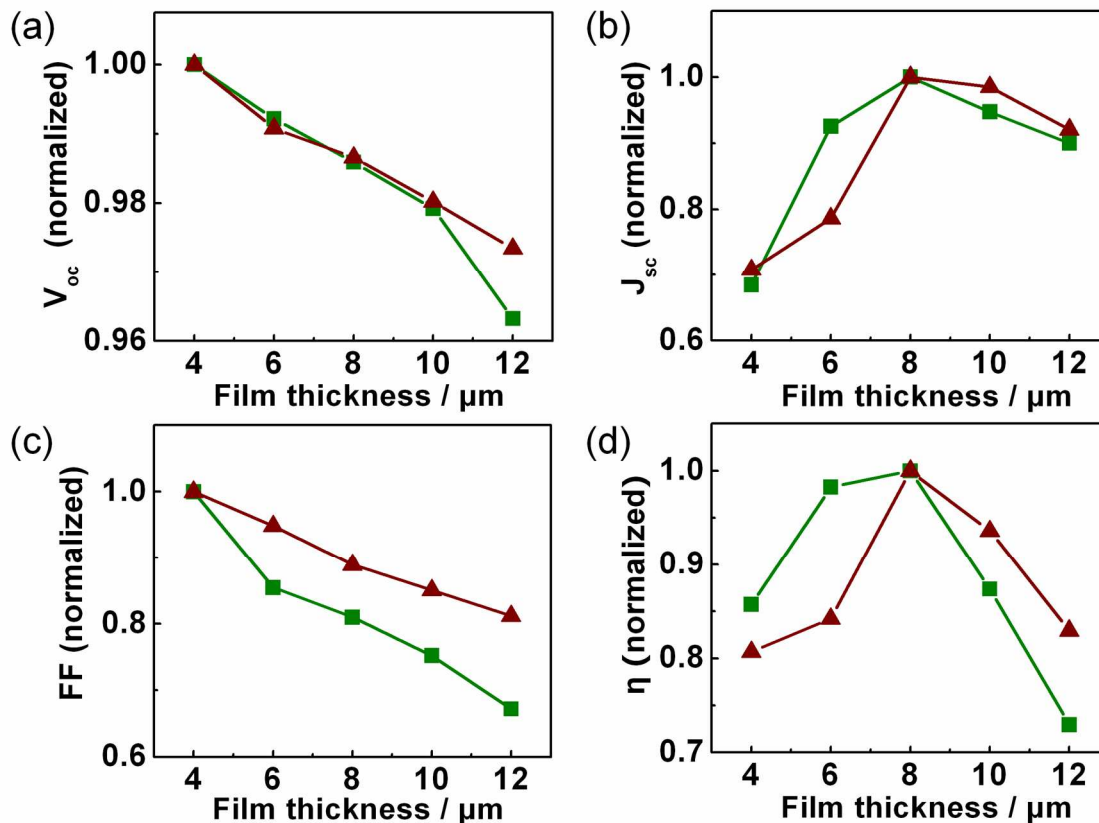
Figure S2. Normalized photovoltaic performance of all-solid-state solar cells sensitized by TPAR14 (red triangles) and TC15 (green squares) as a function of the nanocrystalline TiO_2 film thickness: (a) open-circuit voltage, V_{oc}; (b) short-circuit photocurrent density, J_{sc}; (c) fill factor, FF; (d) energy conversion efficiency, η.

The correlation between the nanocrystalline TiO_2 film thickness and the photovoltaic performance of the all-solid-state solar cells sensitized by TPAR14 or TC15 is depicted in Figure S2. The changes of V_{oc} (Figure S2a), J_{sc} (Figure S2b), FF (Figure S2c), and η (Figure S2d) for both the TPAR14- and TC15-based cells as a function of thickness of the TiO_2 film are similar. The J_{sc} increases firstly and peaks at 8 μm. The V_{oc} gradually decreases as the film thickness is increased. The increase of the film thickness can augment the surface area of the photoanode and provide additional charge-recombination sites, consequently lowering their quasi-Fermi level and reducing V_{oc}.[S1] In the mean time, the transport resistance of electrons in the TiO_2 particles is increased with increasing thickness of film, leading to the

decrease of FF.[S1] The TiO$_2$ film thickness of these all-solid-state DSCs is optimized to be 8 μm because the maximum η value is attained at this thickness.
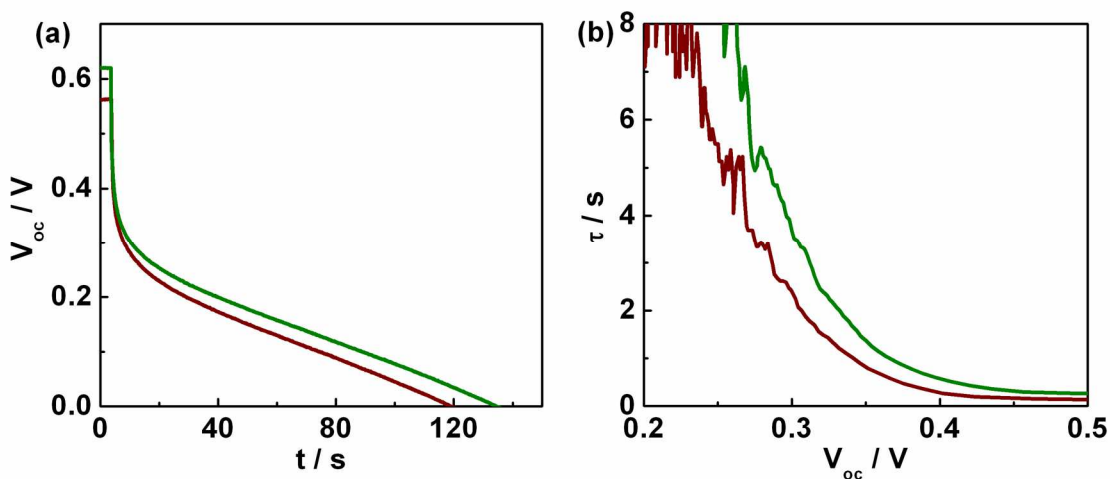

Figure S3. (a) Open-circuit voltage-decays of cell A (red line) and cell B (green line) after switching off the light. (b) Calculated electron lifetime vs V_{oc}.

The electron lifetime τ can also be measured by the open-circuit voltage-decays (OCVD) of DSCs. Figure S3a shows the decay of V_{oc} that follows after witching off the light.[S2] The electron density falls when the illumination is interrupted due to the back reaction between the injected electrons and I$_3^-$ ions at the TiO$_2$/electrolyte interface, leading to the decay of the photovoltage. The electron lifetime, τ, can be calculated from eq :[S3,S4]

$$\tau = -\frac{k_B T}{e}\left[\frac{dV_{oc}}{dt}\right]^{-1} \qquad (1)$$

The electron lifetime as a function of the V_{oc} is displayed in Figure S3b, in which, the lifetime increases approximately exponentially with decreasing V_{oc}. The electron lifetime of cell B is larger than that of cell A.

References

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