

Supporting Information

Development of Organic Redox Couple and Organic Dyes for Aqueous Dye-Sensitized Solar Cells

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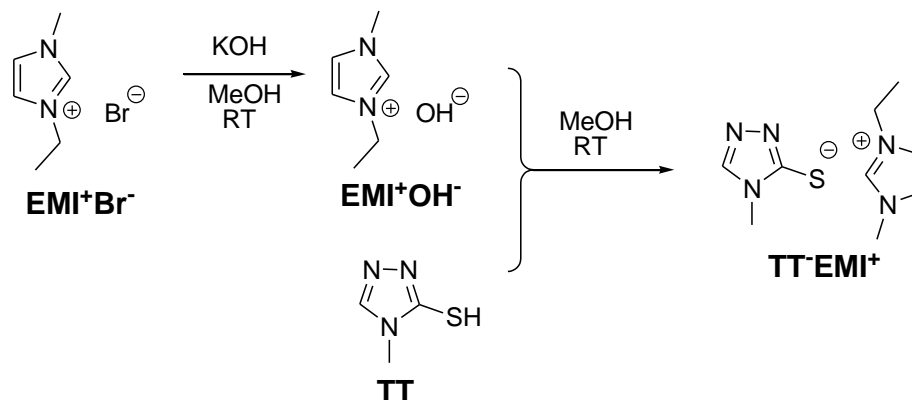
1. General

4-methyl-1,2,4-triazole-3-thiol (**TT**) was purchased from *Aldrich* and used as received. 1-ethyl-3-methyl-imidazolium bromide and 10% 1-ethyl-3-methyl-imidazolium hydroxide aqueous were purchased from *TCI* and used as received. The preparation of 5-(4-(bis(4-bromophenyl)amino)phenyl)thiophene-2-carbaldehyde (**Dx-02**) is reported elsewhere.¹ Compound **2** was provided by Karl Martin Karlsson in Dyenamo & KTH as sample. Solvents and other chemicals are also commercial available and used as received unless special stated. Chromatography was performed using silica gel 60Å (35-63 μm). HPLC was performed on an Agilent 1260 Infinity LC system. The preparative work was carried out on a Kromasil 100-10-SIL (250x10 mm I.D.) normal phase HPLC column obtained from Eka Chemicals (Bohus, Sweden). UV-Vis absorption was recorded on a Lambda 750 UV-Vis spectrophotometer. The fluorescence spectra of dye solution were recorded on Cary Eclipse fluorescence spectrophotometer. NMR spectra were recorded on a Bruker AVANCE 500 MHz spectrometer, using TMS as internal standard. *J-V* characteristics were measured using a Keithley source/meter under simulated sunlight of 100 mW·cm⁻² light intensity from a Newport 300 W solar simulator. Incident photon-to-current conversion efficiencies (IPCE) were obtained using monochromatic light from a system consisting of a xenon lamp, a monochromator, and appropriate filters. The different light intensities were calibrated with a different light filter. Both systems

were calibrated against a certified reference solar cell (IR-filtered silicon solar cell, Fraunhofer ISE, Freiburg, Germany). Electrolyte diffusion coefficient is measured by microelectrode at 25 ± 0.1 °C. The active area of the DSCs studied was $5 \text{ mm} \times 5 \text{ mm}$. A black mask ($6 \text{ mm} \times 6 \text{ mm}$) was used in the subsequent photovoltaic studies to diminish reflection light.

2. Synthesis

Synthesis of TT^-EMI^+



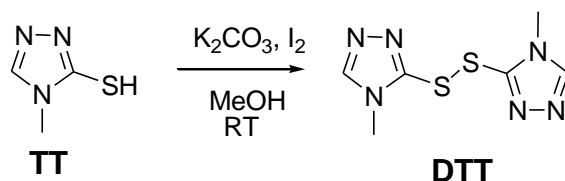
Procedure A: A methanol solution of 1 equivalent of 1-ethyl-3-methyl-imidazolium bromide (EMI^+Br^-) and 1 equivalent of KOH was stirred at room temperature for overnight to form the hydroxide ionic liquid solution (EMI^+OH^-). Then, 1 equivalent of 4-methyl-1,2,4-triazole-3-thiol compound was added into the solution. After stirring at room temperature overnight, the solvent was removed under dynamic vacuum. The remaining residue was dissolved in dry DCM or dry acetone and filtered. The organic solvent of the filtrate was again removed under vacuum to produce the crude ionic liquid, which was further purified through washing with ethyl acetate. After removing the residual organic solvent and drying at 40 °C under vacuum overnight, Pure organic 1-ethyl-3-methyl-imidazolium 4-methyl-1,2,4-triazole-3-thiolate (TT^-EMI^+), light yellow liquid, was obtained with yield more than 90%.

Procedure B: A mixture of 1.15 g (10 mmol) 4-methyl-1,2,4-triazole-3-thiol and 12.8 g (10 mmol) 10% 1-ethyl-3-methyl-imidazolium hydroxide (EMI^+OH^-) aqueous was stirred 4 h under room temperature. After removing water under vacuum condition, 10 mL toluene was added. Then the solution was treated under vacuum again in order to remove residual water. The obtained light yellow liquid was further washed with 10ml \times 2 ethyl acetate. After removing the organic solvent and drying at 40 °C under vacuum overnight, 2.2 g (9.8 mmol) 1-ethyl-3-methyl-imidazolium 4-methyl-1,2,4-triazole-3-thiolate (TT^-EMI^+), light yellow liquid, was obtained with yield 98%.

^1H NMR (500 MHz, CDCl_3 , ppm): δ 10.60 (s, 1 H), 7.87 (s, 1 H), 7.24 (m, 2 H), 4.33

(m, 2 H), 4.00 (s, 3 H), 3.50 (s, 3 H), 1.45 (t, $J = 7.4$ Hz, 3 H). ^{13}C NMR (125 MHz, CDCl_3 , ppm): δ 15.5, 31.5, 36.5, 45.1, 120.9, 122.8, 139.3, 141.6, 166.3. MS (ESI): negative ion: $m/z=114.0$ $[\text{M-EMI}]^-$, calculated 114.0; positive ion: $m/z=111.0$ $[\text{EMI}]^+$, calculated 111.1.

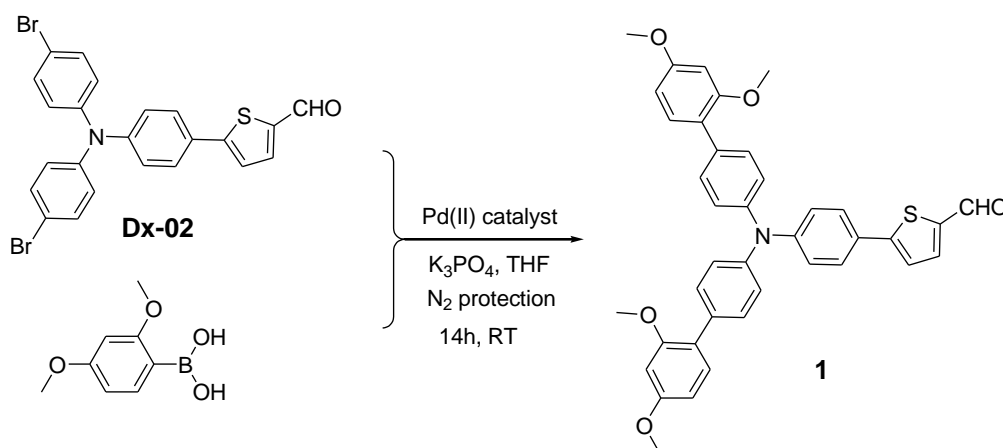
Synthesis of DTT



The mixture of 1.15 g (10 mmol) 4-methyl-1,2,4-triazole-3-thiol, 0.69 g (5 mmol) potassium carbonate and 1.24 g (5 mmol) iodine in 20 mL methanol solution was placed in an ultrasonic bath until dark red color of solution changed to near colorless. The methanol solvent was removed under vacuum and the residue was re-dissolved in 20 mL CH_2Cl_2 . After removing formed salt by filtration, the solvent was removed to obtain crude product. Column purification with silica gel and methanol as eluent give 700 mg (3 mmol) pure 3,3'-Dithiobis[4-methyl-(1,2,4)-triazole] (**DTT**), white solid, yield 60%. ^1H NMR (500 MHz, MeOD, ppm): δ 8.70 (s, 1H), 3.75 (s, 3H). ^{13}C NMR (125 MHz, MeOD, ppm): δ 32.6, 149.1, 150.0. MS (ESI): $m/z^+ = 229.0$ $[\text{M+H}]^+$, calculated 229.0; $m/z=251.1$ $[\text{M+Na}]^+$, calculated 251.0

Synthesis of

5-(4-(bis(2',4'-dimethoxy-[1,1'-biphenyl]-4-yl)amino)phenyl)thiophene-2-carbaldehyde (**1**)

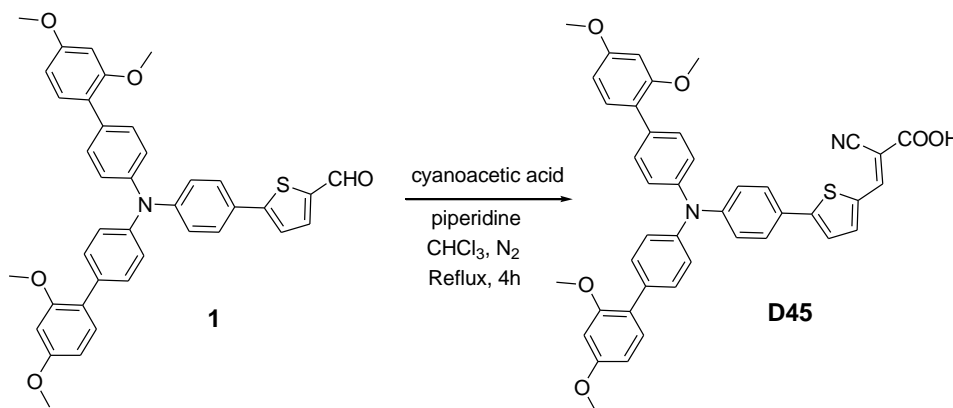


To a stirred solution of **Dx-02** (564 mg, 1.1 mmol), (2,4-dimethoxyphenyl)boronic acid (500 mg, 2.75 mmol) and Chloro(2-dicyclohexylphosphino-2',4',6'-triisopropyl-1,1'-biphenyl)[2-(2'-amino-1,1'-biphenyl)]palladium(II) (35 mg, 0.044 mmol) in THF (4 ml) under N_2 , K_3PO_4 (8.8 ml 0.5 M in H_2O) was added. The solution was stirred for 14 h, after which 100 ml H_2O

was added and the solution was extracted with DCM (100+20 ml). The organic phase was dried over anhydrous MgSO_4 before the solvent was removed by rotary evaporation. Purification by column chromatography over SiO_2 with a DCM-eluent afforded **1** (633 mg, 92%) as an orange solid. ^1H NMR (500 MHz, d_6 -Acetone) δ 9.90 (s, 1 H), 7.92 (d, 1 H, $J = 4.0$ Hz), 7.70 (d, 2 H, $J = 8.7$ Hz), 7.55 (d, 1 H, $J = 4.0$ Hz), 7.51 (d, 4 H, $J = 8.6$ Hz), 7.28 (d, 2 H, $J = 8.4$ Hz), 7.17 (d, 4 H, $J = 8.6$ Hz), 7.11 (d, 2 H, $J = 8.7$ Hz), 6.66 (d, 2 H, $J = 2.3$ Hz), 6.61 (dd, 2 H, $J = 8.4, 2.4$ Hz), 3.84 (s, $J = 5.1$ Hz), 3.83 (s). ^{13}C NMR (126 MHz, d_6 -Acetone) δ 184.48, 162.45, 159.49, 155.37, 151.10, 147.01, 143.51, 140.27, 136.33, 132.76, 132.31, 129.14, 127.89, 126.53, 125.25, 124.23, 123.89, 107.02, 100.71, 56.86, 56.67. MS (ESI): Positive ion: $m/z=628.2$ $[\text{M}+\text{H}]^+$, calculated 628.2.

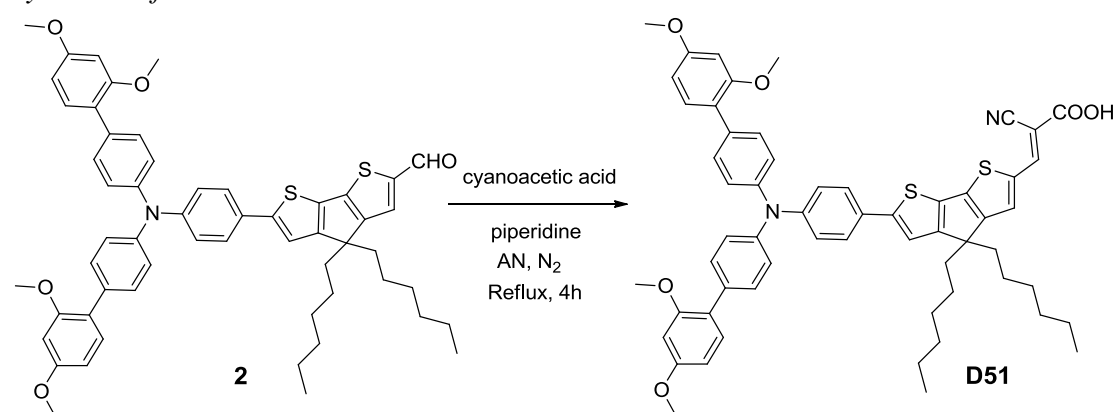
Synthesis of

(*E*)-3-(5-(4-(bis(2',4'-dimethoxy-[1,1'-biphenyl]-4-yl)amino)phenyl)thiophen-2-yl)-2-cyanoacrylic acid (**D45**)



A solution of **1** (628 mg, 1 mmol), cyanoacetic acid (255 mg, 3 mmol) and piperidine (691 μl , 7 mmol) in CHCl_3 (25 ml) was refluxed for 4 h under N_2 . The reaction mixture was allowed to cool before it was filtered through a short plug of SiO_2 and eluted with 10% MeOH in DCM. The solvent was then removed by rotary evaporation. The residue was purified (in 100 mg portions) by normal phase HPLC using a mobile phase consisting of 92% PhMe, 8% THF and 0.2% formic acid. The combined product fractions of three runs were concentrated by rotary evaporation and the remaining solvent was removed by drying the residue under high vacuum, affording **D45** (292 mg, yield n.d.) as a black solid. ^1H NMR (500 MHz, d_6 -Acetone) δ 8.42 (s, 1 H), 7.96 (d, 1 H, $J = 4.1$ Hz), 7.72 (d, 2 H, $J = 8.7$ Hz), 7.59 (d, 1 H, $J = 4.0$ Hz), 7.51 (d, 4 H, $J = 8.5$ Hz), 7.28 (d, 2 H, $J = 8.4$ Hz), 7.18 (d, 4 H, $J = 8.5$ Hz), 7.13 (d, 2 H, $J = 8.7$ Hz), 6.66 (d, 2 H, $J = 2.3$ Hz), 6.61 (dd, 2 H, $J = 8.4, 2.3$ Hz), 3.84 (s, $J = 5.5$ Hz), 3.83 (s). ^{13}C NMR (126 MHz, d_6 -Acetone) δ 147.46, 141.69, 131.78, 131.35, 128.29, 125.68, 124.43, 123.23, 122.73, 116.99, 106.05, 99.73, 98.07, 55.87, 55.69. MS (ESI): Positive ion: $m/z=695.2$ $[\text{M}+\text{H}]^+$, calculated 695.2.

Synthesis of D51



A solution of **2** (60 mg, 0.07 mmol), cyanoacetic acid (20 mg, 0.24 mmol) and 2 drops piperidine in acetonitrile (AN, 25 ml) was refluxed for 3 h. The solvent was evaporated under vacuum system. 20 mL DCM was added to dissolve the residue; then 3 drops formic acid was added to acidify the solution. 20 ml×3 H₂O was used to wash the organic phase. The finally collected DCM organic phase was dried with anhydrous Na₂SO₄. After removing DCM, the residue was purified by SiO₂ column and eluted with 10% MeOH in DCM to give **D51** (45 mg, yield 67%) as a black solid. ¹H NMR (500 MHz, *d*₆-Acetone) δ 8.41 (s, 1 H), 7.91 (s, 1 H), 7.66 (d, 2 H, *J* = 8.5 Hz), 7.54 (s, 1 H), 7.49 (d, 4 H, *J* = 8.5 Hz), 7.27 (d, 2 H, *J* = 8.4 Hz), 7.15 (d, 4 H, *J* = 8.5 Hz), 7.12 (d, 2 H, *J* = 8.6 Hz), 6.65 (d, 2 H, *J* = 2.1 Hz), 6.61 (dd, 2 H, *J* = 8.5, 2.0 Hz), 2.01-2.07 (m, 4 H, overlap with *d*₆-Acetone), 1.14-1.20 (m, 12 H). 0.97-1.04 (m, 4 H), 0.78 (t, 6 H, *J* = 6.5 Hz). ¹³C NMR (126 MHz, *d*₆-Acetone) δ 165.47, 164.54, 161.41, 158.80, 158.49, 151.31, 150.25, 148.98, 148.02, 146.27, 137.00, 134.90, 134.57, 133.34, 131.74, 131.24, 128.86, 127.30, 125.09, 123.85, 123.28, 118.24, 117.73, 105.99, 99.70, 94.66, 55.85, 55.67, 55.00, 38.36, 32.29, 25.25, 23.22, 14.27. MS (ESI): Positive ion: *m/z*=957.4 [M+H]⁺, calculated 957.4.

3. Photoelectrochemical Measurements

Hole lifetimes for the solar cells were estimated using a green-light-emitting diode (Luxeon K2 star 5 W, λ_{max}=530 nm) as the light source. Voltage and current traces were recorded by a 16-bit resolution data acquisition board (DAQ National Instruments) in combination with a current amplifier (Stanford Research SR570). The relation between potential and charge was studied using a combined voltage decay/charge extraction method. Charge extraction measurements were carried out as follows: the solar cell was illuminated for 5 s under open-circuit conditions, and then the light was switched off and the voltage was allowed to decay to a voltage *V*. At a certain voltage *V*, the cell was short-circuited, and the current was determined under 10 s and then integrated to obtain the charge, *Q*_{oc} (V). Electron lifetimes was determined by monitoring the photovoltage response after a small

perturbation of the light intensity.

4. DSCs fabrication

Fluorine-doped tin oxide (FTO) glass plates (Pilkington-TEC15) were cleaned in subsequent order of detergent solution, water and EtOH using an ultrasonic bath overnight. The conducting glass substrates were immersed into a 40 mM aqueous TiCl_4 solution at 70 °C for 30 min and washed with water and ethanol. The screen-printing procedure was used to prepare 2.5 μm or 3 μm transparent nanocrystalline film (Dyesol, 18 NR-T). Scattering layer (2 μm) was also prepared by screen-printing method using Solaronix R/SP paste. The TiO_2 electrodes were gradually heated in an oven (Nabertherm Controller P330) in ambient air atmosphere. The temperature gradient program used included two stationary plateaus at 325 °C (10 min), and 450 °C (30 min). After sintering the electrodes as described above, a post- TiCl_4 treatment was performed using 40 mM aqueous TiCl_4 solution at 70 °C for 30 min and washed with water and ethanol. A second and final sintering, at 450 °C for 30 min, was performed. The prepared electrodes were immersed into 0.2 mM organic dye or 0.3 mM Ru dye EtOH (99.5%) solutions and kept for 16~17 h in dark at room temperature. After sensitization, the electrodes were further rinsed with the EtOH and dried. The photo-electrodes were assembled with a platinized counter electrode (~13 $\mu\text{g}\cdot\text{cm}^{-2}$) using 25 μm thick hot-melt film (Surlyn, Solaronix). The redox electrolytes were introduced through a hole drilled in the back of the counter electrode. Finally, the hole was also sealed with the Surlyn film.

5. Electrochemical Measurements

Electrochemical experiments were performed with a CH Instruments electrochemical workstation (model 660A) using a conventional three-electrode electrochemical cell. For organic phase, measurement of D45 was performed with 1 mM dyes DCM solution using 0.1 M Tetrabutylammonium hexafluorophosphate (TBAPF_6) as supporting electrolyte; measurement of redox couple was carried out with 2 mM TTEMI⁺ and 1 mM DTT AN solution using 0.1 M LiClO_4 as supporting electrolyte. A glass carbon disk was used as the working electrode, a platinum wire served as a counter electrode, a Ag/Ag^+ electrode was utilized as a reference electrode, and the scan rate used was 50 $\text{mV}\cdot\text{s}^{-1}$. All redox potentials were calibrated versus a normal hydrogen electrode (NHE) by the addition of ferrocene as an internal standard taking $E(\text{Fc}/\text{Fc}^+) = 630 \text{ mV vs NHE}$. For aqueous phase, measurement of redox couple was carried out with 2 mM TTEMI⁺ and 1 mM DTT aqueous solution using 0.1 M Na_2SO_4 as supporting electrolyte. A glass carbon disk was used as the working electrode, a platinum wire served as a counter

electrode, a Saturated Calomel Electrode (SCE) was utilized as a reference electrode, and the scan rate used was $50 \text{ mV} \cdot \text{s}^{-1}$. The redox potential in water was calibrated versus a normal hydrogen electrode (NHE) by the addition of ferrocene as an internal standard taking $\text{SCE} = 240 \text{ mV vs NHE}$.

6. Electrochemical Impedance Spectroscopy (EIS)

EIS tests were carried out using an Autolab PGstat12 potentiostat with an impedance module in the frequency range 10 KHz to 0.1 Hz, using 20 mV AC amplitude under dark condition.

7. Nanosecond transient absorption spectroscopy (TAS)

Dye regeneration dynamics were monitored as described elsewhere,² using a Nd:YAG laser (Continuum Surelight II, repetition rate: 10 Hz, pulse length: 10 ns, $15 \text{ mJ pulse}^{-1} \text{ cm}^{-2}$) in combination with an OPO (Continuum Surelight) to generate pump pulses at 500 nm. The intensity of the laser output was attenuated to 1 mW cm^{-2} . Probe pulses were provided by a near-infrared LED (Osram SHF 484, λ_{max} 880 nm, FWHM 80 nm) and kinetic traces were measured with an amplified Si photodiode (Thorlabs PMA10A). In order to avoid stray light from the laser a cutoff filter (RG 715) was used in front of the detector. The samples consisted of D45 sensitized TiO_2 films ($3 \mu\text{m}$) on FTO glass. The regeneration of the dye was measured with an average of 150 laser shots and three samples were used for each electrolyte.

8. pK_a of TT

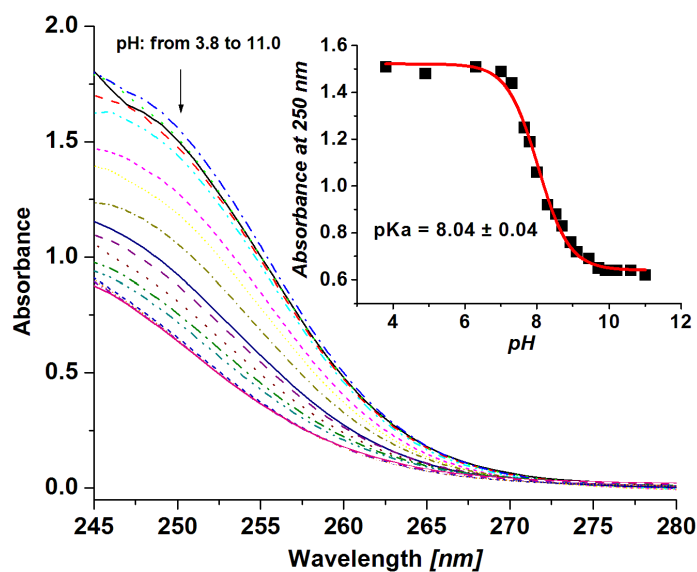


Figure S1. pH-dependent UV-Vis spectra of TT in phosphate buffer with increasing pH from 3.8 to 11.0.

The pK_a value of TT was estimated to be 8.04 ± 0.04 by nonlinear sigmoidal fits to the absorption changes at 250 nm, as shown in the inset of Figure S1. The pH value of 0.2 M TT^-EMI^+ is determined to be 9.6 in deionized water. Therefore, only less than 3% TT^- was hydrolyzed to TT in 0.2 M TT^-EMI^+ aqueous. When 0.2 M DTT was added into this solution, the pH value was changed to 8.3. However, DTT is not a proton donor compound. This change could be caused by formation of charge transfer complex between TT^-EMI^+ and DTT; the pK_b values of pure TT^-EMI^+ and charge transfer complex $TT^-EMI^+ \cdots TT^-$ probably are totally different. The pH value of electrolyte E1 is 8.0.

9. Photophysical and electrochemical data of D45

Table S1. Photophysical and electrochemical properties of D45 and D51 dyes

Dye	Absorption		Emission ^b		Potentials		
	λ_{max} ^a [nm]	ϵ [M ⁻¹ cm ⁻¹]	λ_{max} on TiO ₂ [nm]	λ_{emi} [nm]	E_{0-0} ^c [V, vs NHE]	HOMO ^d [V, vs NHE]	LUMO ^e [V, vs NHE]
D45	471	33500	461	607	2.31	0.99	-1.32
D51	505	47200	480	630	2.16	0.95	-1.21

^a 0.02 mM in EtOH; ^b 0.02 mM in EtOH, excited at λ_{max} ; ^c Calculated from the intersection between absorption and emission spectra; ^d Obtained from electrochemistry; ^e Obtained by HOMO- E_{0-0} .

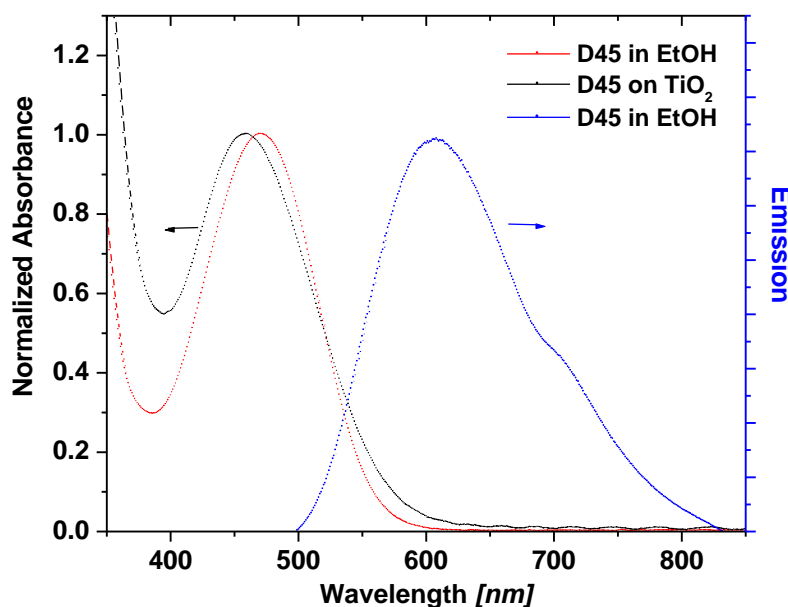


Figure S2. Absorption and emission spectra of D45

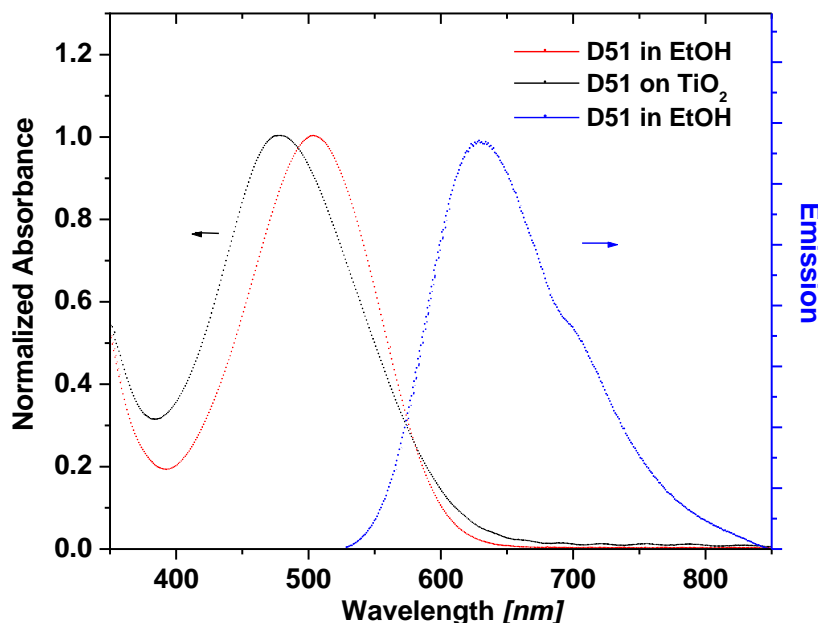


Figure S3. Absorption and emission spectra of D51

10. D45-DSCs performance based on E1 and E5

Table S2. Photovoltaic performance of D45-DSCs with E1 and E5 electrolytes.^a

Electrolyte	J_{sc} ($\text{mA}\cdot\text{cm}^{-2}$)	V_{oc} (mV)	ff	η^d (%)
E1 ^b	7.2	650	0.55	2.6
E5 ^c	5.3	590	0.57	1.8

^a TiO₂ consisting of 2.5 μm transparent layer and 2 μm scattering layer; activate area of TiO₂ film, 0.25 cm^2 ; black mask, 0.36 cm^2 ; Pt CE

^b 0.2 M TT'EMI⁺, 0.2 M DTT, 0.5 M TBP, in 1% Triton-X100 aqueous

^c 0.2 M TT'EMI⁺, 0.2 M DTT, in H₂O

^d 100 $\text{mW}\cdot\text{cm}^{-2}$ simulated sun light illumination

DSCs containing the E1 electrolyte render higher J_{sc} and V_{oc} values than those containing the E5 electrolyte due to its good wettability and the added of TBP, respectively. No differences in quasi-Fermi energy levels of TiO₂ in DSCs containing the E1 and E5 electrolytes were found (Figure S4). The addition of TBP to the electrolyte E1 makes the injected electron lifetime longer in comparison to E5 without TBP in D45-based DSCs (Figure S5). This effect is likely to be responsible for the higher photovoltage obtained with E1. No improvement in photovoltage was obtained using an electrolyte with only the addition of Triton X100

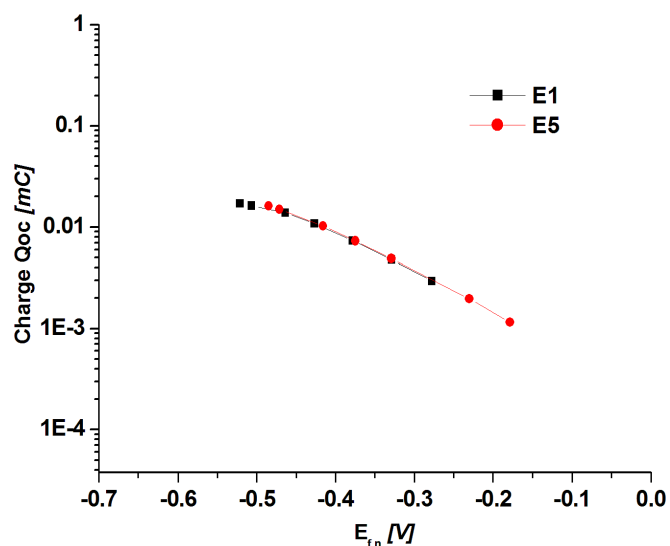


Figure S4. Charge as a function of Fermi level of TiO_2 in D45-DSCs using **E1** and **E5** electrolytes.

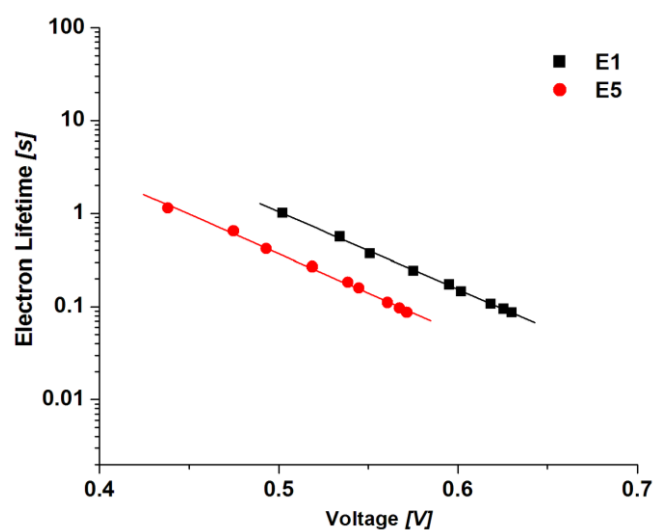


Figure S5. The injected electron lifetime of D45-DSCs using **E1** and **E5** electrolytes.

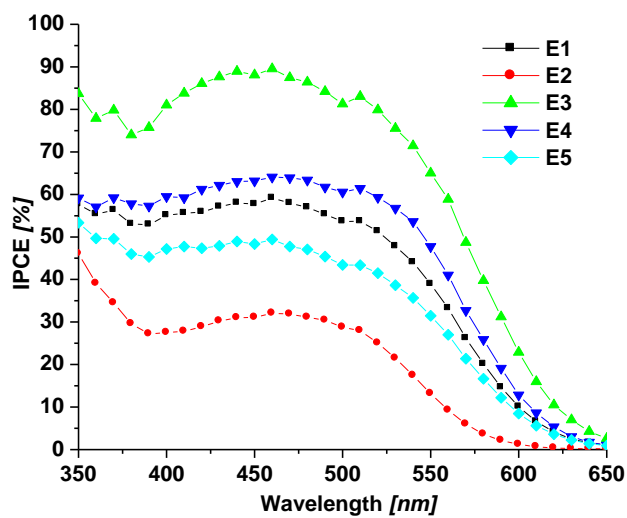


Figure S6. IPCE spectra of D45-DSCs with different electrolytes

(2.5 μm transparent layer + 2 μm scattering layer TiO_2 for **E1-3** and **E5**, 3 μm +2 μm TiO_2 for **E4**)

11. D45-DSCs with E1 under different light intensity

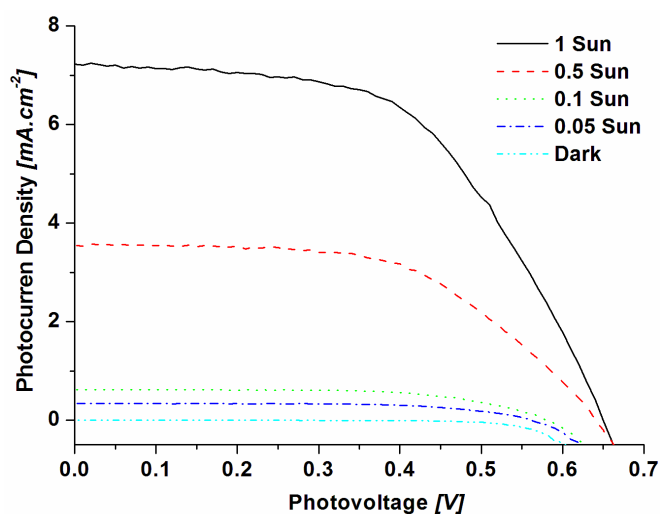


Figure S7. J-V curves of D45-DSCs with **E1** under different light intensity

Table S3. Photovoltaic properties of D45-DSCs with **E1** under different light intensity ^a

<i>Light Intensity</i>	J_{sc} ($\text{mA}\cdot\text{cm}^{-2}$)	V_{oc} (mV)	ff	η^b (%)
1 sun	7.23	650	0.55	2.6
0.5 sun	3.55	640	0.56	2.6
0.1 sun	0.62	580	0.63	2.3
0.05 sun	0.34	560	0.64	2.4

^a TiO_2 consisting of 2.5 μm transparent layer and 2 μm scattering layer; activate area of TiO_2 film, 0.25 cm^2 ; black mask, 0.36 cm^2 ; Pt CE

^b 100 $\text{mW}\cdot\text{cm}^{-2}$ simulated sun light illumination

12. D45-DSCs with different thickness of TiO_2 films using E1 electrolyte

Table S4. Photovoltaic properties of D45-DSCs with different thickness of TiO_2 films using E1 electrolyte ^a

<i>Film Thickness</i>	J_{sc} ($\text{mA}\cdot\text{cm}^{-2}$)	V_{oc} (mV)	ff	η^b (%)
Transparent+Scattering				
2.5+2 μm	7.2	650	0.55	2.6
7.5+2 μm	6.2	630	0.52	2.0
12.5+2 μm	4.0	590	0.50	1.2

^a Activate area of TiO_2 film, 0.25 cm^2 ; black mask, 0.36 cm^2 ; Pt CE

^b 100 $\text{mW}\cdot\text{cm}^{-2}$ simulated sun light illumination

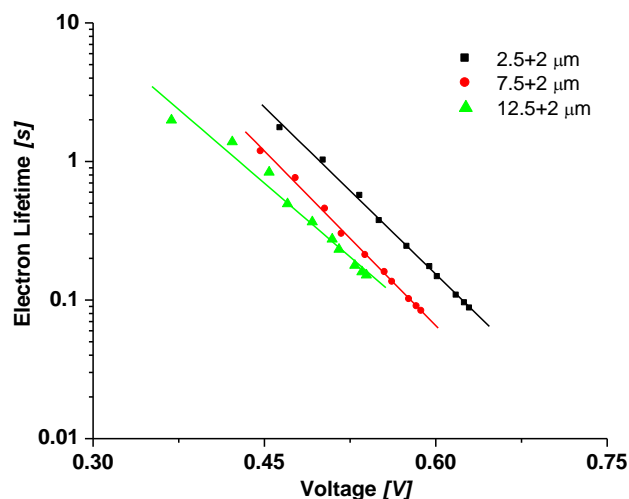


Figure S8. Electron lifetime of D45-DSCs with different thickness of TiO₂ films using E1 electrolyte

The TiO₂ films with different thickness were employed to optimize photovoltaic properties of DSCs. However, the thicker TiO₂ film rendered lower efficiency due to the faster electron recombination process.

13. DSCs performance based on different dyes and electrolyte E6

Table S5. Photovoltaic performance of D45-DSCs with E6 electrolytes.^a

<i>Dye</i>	J_{sc} (mA·cm ⁻²)	V_{oc} (mV)	<i>ff</i>	η^b (%)
D35	4.8	600	0.53	1.5
D45	5.6	620	0.52	1.8
Z907	3.1	570	0.57	1.0
N719	1.5	530	0.63	0.5

^a TiO₂ consisting of 3 μm transparent layer; active area of TiO₂ film, 0.25 cm²; black mask, 0.36 cm²; Pt CE; E6 containing 0.2 M couple tetrabutylammonium 4-methyl-1,2,4-triazole-3-thiolate (TT⁻TBA⁺, synthesis will be reported somewhere else), 0.2 M DTT, in H₂O.

^b 100 mW·cm⁻² simulated sun light illumination.

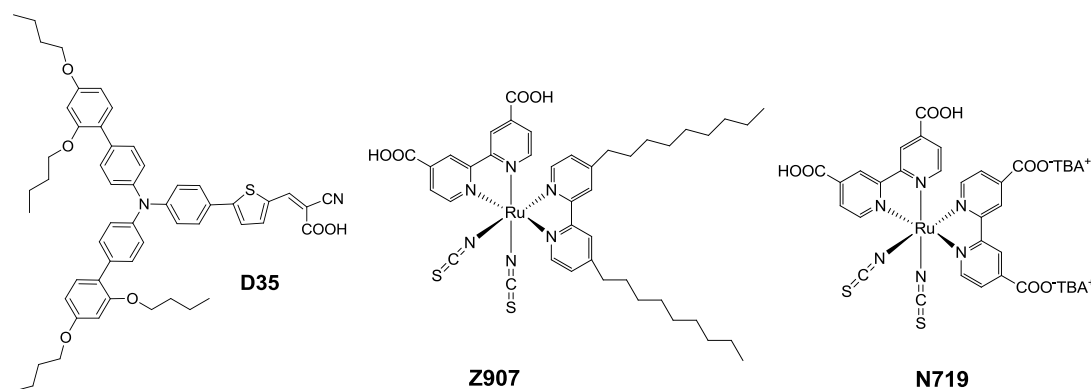


Figure S9. The structures of dyes

14. Short-term stability test of D45-DSCs with E1, E2 and E5 electrolytes

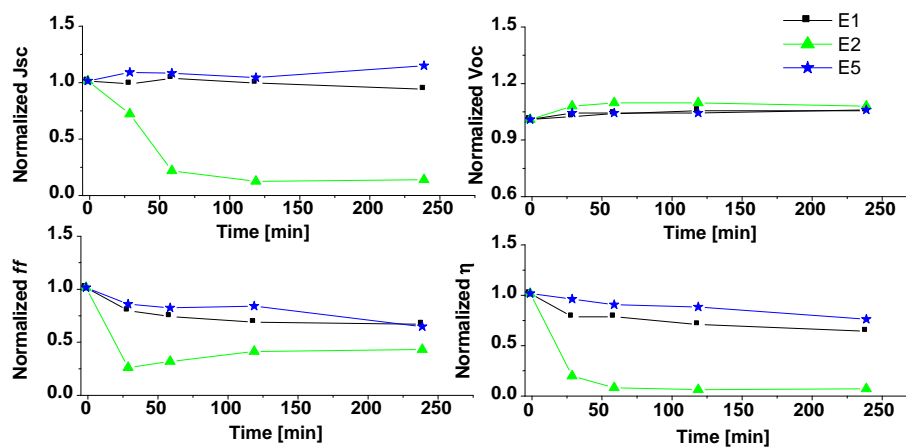


Figure S10. Electron lifetime of D45-DSCs with different thickness of TiO₂ films using E1, E2 and E5 electrolytes under 1 sun illumination at ambient temperature (25~30 °C)

15. D45-DSCs with E1 using Pt and PEDOT CEs

PEDOT CEs were prepared according to our previous publication.³

Table S6. Photovoltaic properties of D45-DSCs with different counter electrode using E1 electrolyte^a

Counter Electrode (CE)	J_{sc}	V_{oc}	ff	η^b
<i>Pt</i>	7.2	650	0.55	2.6
<i>PEDOT</i>	7.1	660	0.55	2.6

^a activate area of TiO₂ film, 0.25 cm²; black mask, 0.36 cm²

^b 100 mW·cm⁻² simulated sun light illumination

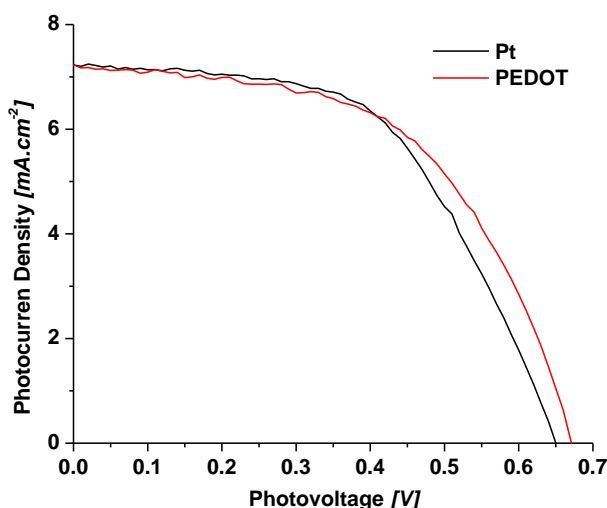


Figure S11. J-V curves of D45-DSCs with different counter electrode using E1 electrolyte.

16. EIS spectra of thin layer cell Pt//E1//Pt under different bias voltages

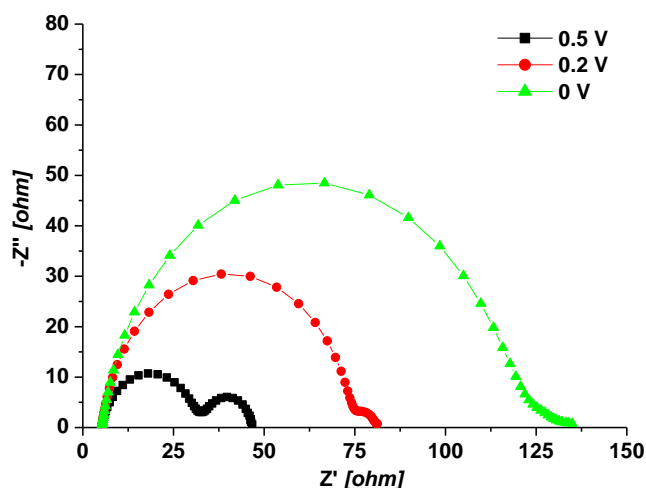


Figure S12. Nyquist plots of thin layer cell Pt//E1//Pt under different applied bias voltages.

17. Corrosion Test with Ag paste-coated FTO substrates in E1 and E3

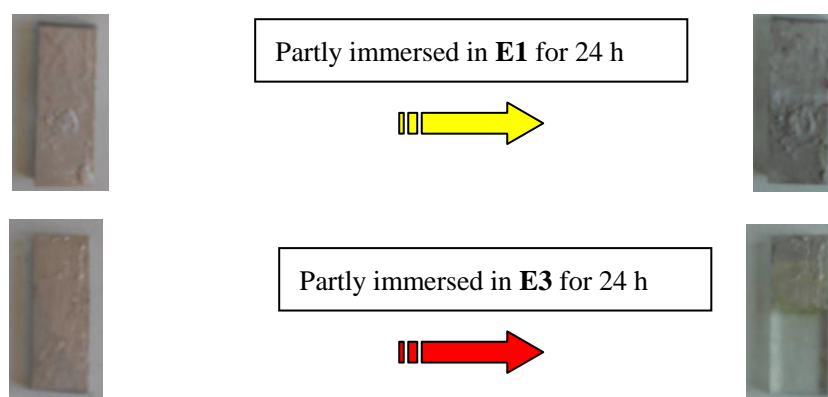


Figure S13. Corrosion test of Ag paste-coated FTO immersed into E1 and E3 in 24 h.

Referencies

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