Supporting Information

Significant improvement of photocatalytic hydrogen evolution of diketopyrrolopyrrole-based donor-acceptor conjuagated polymers through side-chain engineering

Ruimin Diao, Haonan Ye, Zhicheng Yang, Shicong Zhang, Kangyi Kong, Jianli Hua*

Key Laboratory for Advanced Materials, Feringa Nobel Prize Scientist Joint Research Center and School of Chemistry and Molecular Engineering, East China University of Science and Technology, 130 Meilong Road, Shanghai 200237, PR China E-mail address: jlhua@ecust.edu.cn (J. L. Hua)

Experimental Section



The synthesis of diketopyrrolopyrrole (DPP)

Firstly, the Sodium particles (4.0 g, 173.9 mmol) were added into 100 mL 2methyl-2-butanol at 40 °C, and then warmed to 90 °C stirring until Sodium disappeared. After cooling down to 60 °C, 4-bromocyanobenzene was added into the solution under argon. Diisopropyl succinate was dissolved into 2-methyl-2-butanol, and dropwise added to the mixture. Subsequently, the solution was warmed to 90 °C and stirred for 12 h. Finally, the solution was cooled to room temperature, and poured into 200 mL methyl alcohol stirring intensely. PH was adjusted with hydrochloric acid, and color changed to bright red. The mixture was collected by filtration and dried at 45 °C in vacuum oven. Yield (15153 mg, 79 %).



The synthesis of DPP-C4

The preparation of monomer DPP-C4 was showed below. DPP (1.784 g, 4 mmol) and 20 mL *N*, *N*-dimethylformamide were added in flask, and then stirred for 1 h at indoor temperature. n-iodobutane (736 mg, 4 mmol) was added dropwise into the solution. The solution was heat to 100 °C and stirring overnight under Nitrogen. After cooling down to indoor temperature, the product was extracted from mixture with dichloromethane, and then DPP-C4 separated out by column chromatography. Yield (669 mg, 30 %). ¹H NMR (400 MHz, Chloroform-d) δ 7.69 (d, *J* = 5.3 Hz, 8H), 3.76 -

3.71 (m, 4H), 1.26 (d, J = 7.4 Hz, 8H), 0.85 (t, J = 7.3 Hz, 6H). ¹³C NMR (101 MHz, Chloroform-*d*) δ 162.45, 147.44, 132.25, 130.09, 126.93, 125.82, 109.94, 41.68, 31.54, 19.97, 13.60. HRMS (ESI-MS) m/z calcd. For C₃₄H₄₂N₂O₂Br₂:579.0259. [M + H⁺]. Found:579.0252.



The synthesis of DPP-C8

The preparation of monomer DPP-C8 was showed below. DPP (1.784 g, 4 mmol) and 20 mL *N*, *N*-dimethylformamide were added in flask, and then stirred for 1 h at indoor temperature. 1-bromoheptane (2.6 g, 10 mmol) was added dropwise into the solution. The solution was heat to 100 °C and stirring 12 h under Nitrogen. The product was extracted from mixture with dichloromethane, and then DPP-C8 separated out by column chromatography. Yield (759 mg, 28 %). ¹H NMR (400 MHz, Chloroform-d) δ 7.68 (d, *J* = 1.9 Hz, 8H), 3.75 - 3.69 (m, 4H), 1.20 (s, 20H), 0.91 - 0.80 (m, 10H). ¹³C NMR (101 MHz, Chloroform-*d*) δ 162.40, 147.43, 132.22, 130.09, 126.93, 125.81, 109.90, 41.84, 31.72, 29.39, 29.09, 28.98, 26.67, 22.61, 14.10. HRMS (ESI-MS) m/z calcd. For C₃₄H₄₂N₂O₂Br₂: 691.1511. [M + H⁺]. Found: 691.1517.



The synthesis of DPP-O4

The preparation of monomer DPP-O4 was showed below. 2-methoxyethan-1-ol

(3.80 g, 50 mmol), Triethanolamine (5.5g, mmol) and 50 mL dichloromethane were added in 250 mL three-necked flask at 0 °C. 4-toluene sulfonyl chloride was dissolved in 30 mL DCM, and then added into the solution drop by drop. The solution kept stirring for 30 min at 0 °C, and then stirring at room temperature overnight. The organic phase was extracted with dichloromethane/water and the mixture was purified by column chromatography on silica.

Diketopyrrolopyrrole (1.78 g, 4 mmol) and 20 mL *N*, *N*-dimethylformamide were added in flask, and then stirred for 1 h at indoor temperature. 2-methoxyethyl-4methylbenzenesulfonate (2.30 g, 10 mmol) was added dropwise into the solution. The solution was heat to 100 °C and stirring for 12 h under Nitrogen. The product was extracted from mixture with dichloromethane, and then DPP-O4 separated out by column chromatography. Yield (562 mg, 25 %). ¹H NMR (400 MHz, Chloroform-d) δ 7.89 (d, *J* = 8.6 Hz, 4H), 7.68 - 7.64 (m, 4H), 3.89 (t, *J* = 5.4 Hz, 4H), 3.64 (t, *J* = 5.3 Hz, 4H), 3.28 (s, 6H). ¹³C NMR (101 MHz, Chloroform-*d*) δ 162.77, 148.13, 132.17, 130.82, 126.74, 125.94, 109.75, 70.18, 58.98, 42.20. HRMS (ESI-MS) m/z calcd. For C₃₄H₄₂N₂O₂Br₂: 582.9844. [M + H⁺]. Found: 582.9846.



The synthesis of DPP-O8

The preparation of monomer DPP-O8 was showed below. 2-(2ethoxyethoxy)ethan-1-ol (6.0 g, 50 mmol), Triethanolamine (5.5g, mmol) and 50 mL DCM were added in 250 mL three-necked flask at 0 °C. 4-toluene sulfonyl chloride was dissolved in 30 mL DCM, and then added into the solution drop by drop. The solution kept stirring for 30 min at 0 °C. Next, the solution was stirred overnight. The organic phase was extracted with dichloromethane/water and the mixture was purified by

column chromatography on silica.

DPP (1.784 g, 4 mmol) and 20 mL *N*, *N*-dimethylformamide were added in flask, and then stirred for 1 h at indoor temperature. 2-(2-methoxyethoxy)ethyl 4methylbenzenesulfonate (2.6 g, 10 mmol) was added dropwise into the solution. The solution was heat to 100 °C and stirring 12 h under Nitrogen. After cooling down to indoor temperature, the product was extracted from mixture with dichloromethane, and then DPP-O8 separated out by column chromatography. Yield (678 mg, 25 %). ¹H NMR (400 MHz, Chloroform-d) δ 7.92 (dd, *J* = 8.8, 2.4 Hz, 4H), 7.64 (s, 4H), 3.94 (dt, *J* = 27.6, 5.3 Hz, 4H), 3.78 (dt, *J* = 19.8, 5.3 Hz, 4H), 3.58 - 3.53 (m, 4H), 3.53 - 3.49 (m, 4H), 3.46 (t, *J* = 7.0 Hz, 4H), 1.18 (td, *J* = 7.0, 3.0 Hz, 6H). ¹³C NMR (101 MHz, Chloroform-d) δ 162.78 , 148.22 , 132.09 , 130.95 , 126.76 , 125.89 , 109.73 , 70.68 , 69.68 , 68.86 , 66.69 , 42.35 , 15.17 . HRMS (ESI-MS) m/z calcd. For C₃₀H₃₄N₂O₆Br₂: 699.0681. [M + H⁺]. Found: 699.0691.

Characterization

¹H and ¹³C NMR spectra were obtained in deuterated solvents on Bruker AM-400 MHz using tetramethylsilane (TMS) as an internal standard. High-resolution mass spectra (HRMS) measurements were performed using a Waters LCT Premier XE spectrometer. UV-vis diffuse reflectance absorption spectra (DRS) were recorded at room temperature on a Varian Cary 500 spectrophotometer. Photoluminescence (PL) spectrum was obtained on a Hitachi F-4500 fluorescence spectrophotometer at room temperature. Time-resolved fluorescence spectra (TRFS) were obtained on an Edinburgh FES 920 with an excitation wavelength of 377 nm and emission wavelength as detection wavelength. The FTIR spectra were recorded on NICOLET 380 spectrometer using a standard KBr pellet technique in the frequency range of 4000 - 400 cm⁻¹. Powder XRD patterns was obtained on a RigakuD/MAX 2550 diffract meter (Cu K radiation, $\lambda = 1.5406$ Å), operated at 40 kV and 100 mA. The morphologies were characterized by Scanning Electron Microscope (SEM). Thermal gravimetric analysis (TGA) was conducted on a thermal analysis instrument (WRT-3P) under a nitrogen atmosphere at a heating rate of 10 °C min⁻¹. Dynamic light scattering (DLS)

was conducted on Malvern ZETASIZER (ZSE). The residual palladium of polymers have been detected by ICP-OES (Varian 710 ES). Molecular weight of polymers were measured via Gel Permeation Chromatography (THF/ Waters1515).

Photoelectrochemical measurement

Cyclic voltammetry (CV) curves were measured by a CHI650E electrochemical workstation in a normal three-electrode cell which using glassy carbon as the working electrode, Pt wire as counter electrode and Ag/AgCl electrode as the reference electrode. The experiments were carried out in DCM solutions with 0.1 m tetra-nbutylammonium hexafluorophosphate (TBAPF 6) as the supporting electrolyte at a scan rate of 100 mV s⁻¹. The ferrocenium/ferrocene (Fc/Fc⁺) redox couple was used as an external potential reference. Fc/Fc⁺ redox potential (0.41 V vs Ag/AgCl in the present study) was measured at the end of each experiment in order to calibrate the pseudo reference electrode. The HOMO levels were determined as follows: HOMO (eV) = $-4.8 - (E_{ox onset} - 0.41)$. The LUMO levels were then calculated from the equation of LUMO = HOMO + E_g . The transient photocurrent responses (I-t) and electrochemical impedance spectra (EIS) of composite photocatalyst samples were investigated on a CHI650E electrochemical workstation with a three-electrode (glassy carbon electrode, Pt wire, and Ag/AgCl as working, counter, and reference electrode, respectively) system. An aqueous solution of 0.5 M Na₂SO₄ was used as the supporting electrolyte and a 350 W Xe-lamp served as the light source. The films electrodes were prepared as follows: 25 mg of the as-synthesized photocatalysts was separately ground with 10 μ L of a Nafion (5%) aqueous solution and 50 μ L of ethanol to make slurry. The slurry was then coated onto FTO glass electrodes with an active area of 0.25 cm^2 , and these electrolytes were dried at 120 °C for 1 h to evaporate the solvent in muffle furnace. The photocurrent intensity of as-prepared electrodes was measured at 0 V versus Ag/AgCl with the light on and off. EIS was determined over the frequency range of $10^2 - 10^6$ Hz with an ac amplitude of 10 mV at the open circuit voltage under roomlight illumination.

Measurement of photocatalytic activity and AQY

The photocatalyst (25mg) was dispersed in the mixture of deionized

water/methanol (3:1). 240 μ l H₂PtCI₆·6H₂O aqueous solution (10 g/L) was dropped into the solution. After 5 hour of light, 3% Pt loaded photocatalyst was obtained by centrifugation and dried on under vacuum. Then 3% Pt loaded photocatalyst (25mg) was dispersed in the solution of deionized water (50 mL) and TEOA (10 mL). The mixture was stirring in a glass gas-closed-circulation system (CEL-SPH2N) under illumination with 300 W xenon lamp (CEL-HXF 300). The yield of hydrogen was detected by an online gas chromatograph (GC 2060 and TCD detector), and argon was used as the carrier gas.

In addition, a 300 W xenon lamp with monochromatic light ($\lambda = 420$ nm, 450 nm, 475 nm, 500 nm, 550 nm, 578 nm, 600 nm and 630 nm) was used as the light source. AQY for hydrogen evolution was calculated according to the following equation:

$$AQY (\%) = \frac{2 \times Number of evolved H2 molecules}{Number of incident photons} \times 100 \% = \frac{2 \times C \times NA}{S \times P \times t \frac{\lambda}{h \times c}} \times 100 \%$$

where, *C* is the hydrogen evolution amount (µmol) per hour; N_A is the Avogadro constant (6.022×10²³ mol⁻¹); S is the illumination area (12.56 cm²); P is the light intensity (20.62 W cm⁻²); t is the illumination time (3600 s); λ is the wavelength of the monochromatic light (m); h is the Plank constant (6.626 × 10⁻³⁴ J s); c is the speed of light (3 × 10⁸ m s⁻¹).



Fig. S1. TGA curves of PDPP3B-C4, PDPP3B-C8, PDPP3B-O4 and PDPP3B-O8.



Fig. S2. Cyclic voltammetry measurements of Fc/Fc⁺.



Fig. S3. FT-IR of PDPP3B-C4, PDPP3B-C8, PDPP3B-O4 and PDPP3B-O8 after reaction.



Fig. S4. XRD of PDPP3B-C4, PDPP3B-C8, PDPP3B-O4 and PDPP3B-O8 after reaction.



Fig. S5. DRS of PDPP3B-C4, PDPP3B-C8, PDPP3B-O4 and PDPP3B-O8 after reaction.



Fig. S6. The apparent quantum yields (AQY) of PDPP3B-C4 and PDPP3B-O8.



Fig. S7. Hydrogen generation of PDPP3B-O4 produced from different batches with 1 wt % Pt under visible light ($\lambda > 400$ nm).



Fig. S8. The control experiment of PDPP3B-C4, PDPP3B-C8, PDPP3B-O4 and PDPP3B-O8.



Fig. S9. The absorption spectrum and fluorescence spectra of PDPP3B-C4, PDPP3B-C8, PDPP3B-O4 and PDPP3B-O8 in DCM solution.



Fig. S10. The images of PDPP3B-C4, PDPP3B-C8, PDPP3B-O4 and PDPP3B-O8 dispersing in solution (water/TEOA/MeOH=5:1:1).



Sauter mean diameter, D[3,2], gives the diameter of a sphere that has the same volume : surface area ratio as the entire distribution.

5 C 1 <i>J</i>	-	2		
Materials	light source	Cocatalyst	H ₂ Production	AQY (%)
			$(mmol g^{-1} h^{-1})$	
COP-TP 3:1 ¹	> 400 nm	3 wt% Pt	4.2	1.5 (400 nm)
DBTD-CMP1 ²	> 420 nm	3 wt% Pt	4.6	3.3 (400 nm)
B-BT-1,4 ³	> 420 nm	3 wt% Pt	0.116	4.01 (420 nm)
SNP-BTT1 ⁴	> 395 nm	3 wt% Pt	0.632	4.5 (420 nm)
PyBT-2 ⁵	> 420 nm	3 wt% Pt	0.03	unknow
PyDOBT-2 ⁶	> 420 nm	3 wt% Pt	8.523	6.1 (400 nm)
SP-CMP ⁷	>420 nm	no Pt	0.12	0.23 (420 nm)
$F_{0.5} \operatorname{CMP^8}$	> 420 nm	no Pt	0.659	5.8 (400 nm)
S-CMP3 ⁹	>420 nm	2.1 wt% Pt	3.1	13.2 (420 nm)
HMP-3_2:3 ¹⁰	> 395 nm	5 wt% Pt	1.6	unknow
CP-CMP10 ¹¹	> 420 nm	3 wt% Pt	0.174	unknow
L-PyBT ¹²	> 420 nm	3 wt% Pt	1.674	unknow
B-FOBT-1,4-E ¹³	> 420 nm	no Pt	13.2	5.7 (420 nm)
P8-i ¹⁴	>420 nm	no Pt	0.86	0.56 (420 nm)
P7 ¹⁵	>420 nm	3 wt% Pt	3.68	2.3 (420 nm)
P28 ¹⁶	>420 nm	no Pt	0.96	6.7 (420 nm)
P12 ¹⁷	>420 nm	no Pt	0.42	1.4 (420 nm)
P7- E ¹⁸	>420 nm	no Pt	5.963	4.2 (420 nm)
P10 ¹⁹	>420 nm	no Pt	3.26	11.6 (420 nm)
FSO-FS ²⁰	>420 nm	no Pt	3.4	6.8 (420 nm)

Table S1. Recent representative photocatalytic H_2 evolution activities of D-Aconjugated polymer-based photocatalysts.





Fig. S11. ¹H NMR spectrum of DPP-C4 in CDCl₃.





Fig. S12. ¹H NMR spectrum of DPP-C8 in CDCl₃.

Fig. S13. ¹H NMR spectrum of DPP-O4 in CDCl₃.



Fig. S14. ¹H NMR spectrum of DPP-O8 in CDCl₃.



Fig. S15. ¹³C NMR spectrum of DPP-C4 in CDCl₃.



Fig. S16. ¹³C NMR spectrum of DPP-C8 in CDCl₃.



Fig. S17. ¹³C NMR spectrum of DPP-O4 in CDCl₃.



Fig. S18. ¹³C NMR spectrum of DPP-O8 in CDCl₃.



Fig. S19. ¹H NMR spectrum of PDPP3B-C4 in CDCl₃.



Fig. S20. ¹H NMR spectrum of PDPP3D-C8 in CDCl₃.



Fig. S21. ¹H NMR spectrum of PDPP3B-O4 in CDCl₃.



Fig. S22. ¹H NMR spectrum of PDPP3B-O8 in CDCl₃.

Reference

(1) Liu, Y.; Liao, Z.; Ma, X.; Xiang, Z. Ultrastable and Efficient Visible-Light-Driven Hydrogen Production Based on Donor-Acceptor Copolymerized Covalent Organic Polymer. *ACS Appl. Mater. Interfaces.* **2018**, *10*, 30698–30705.

(2) Wang, Z.; Yang, X.; Yang, T.; Zhao, Y.; Wang, F.; Chen, Y.; Zeng, J.; Yan, C.; Huang, F.; Jiang, J. Dibenzothiophene Dioxide Based Conjugated Microporous Polymers for Visible-Light-Driven Hydrogen Production. *ACS Catal.* **2018**, *8*, 8590–8596.

(3) Yang, C.; Ma, B. C.; Zhang, L.; Lin, S.; Ghasimi, S.; Landfester, K.; Zhang, K.
A.; Wang, X. Molecular Engineering of Conjugated Polybenzothiadiazoles for Enhanced Hydrogen Production by Photosynthesis. *Angew.Chem.Int. Ed.* 2016, 55, 9202–9206.

(4) Kochergin, Y. S.; Schwarz, D.; Acharjya, A.; Ichangi, A.; Kulkarni, R.; Eliasova,
P.; Vacek, J.; Schmidt, J.; Thomas, A.; Bojdys, M. J. Exploring the "Goldilocks Zone" of Semiconducting Polymer Photocatalysts by Donor-Acceptor Interactions. *Angew.Chem. Int. Ed.* 2018, *57*, 14188–14192.

(5) Xu, Y.; Mao, N.; Zhang, C.; Wang, X.; Zeng, J.; Chen, Y.; Wang, F.; Jiang, J. Rational design of donor-π-acceptor conjugated microporous polymers for photocatalytic hydrogen production. *Appl. Catal. B: Environ.* **2018**, *228*, 1–9.

(6) Zhao, Y.; Ma, W.; Xu, Y.; Zhang, C.; Wang, Q.; Yang, T.; Gao, X.; Wang, F.; Yan, C.; Jiang, J. Effect of Linking Pattern of Dibenzothiophene-S,S-dioxide-Containing Conjugated Microporous Polymers on the Photocatalytic Performance. *Macromolecules*. **2018**, *51*, 9502–9508.

(7) Sprick, R. S.; Bonillo, B.; Sachs, M.; Clowes, R.; Durrant, J. R.; Adams, D. J.; Cooper, A. I. Extended Conjugated Microporous Polymers for Photocatalytic Hydrogen Evolution from Water. *Chem. Commun.* **2016**, *52*, 10008–10011.

(8) Mothika, V. S.; Sutar, P.; Verma, P.; Das, S.; Pati, S. K.; Maji, T. K. Regulating Charge-Transfer in Conjugated Microporous Polymers for Photocatalytic Hydrogen Evolution. *Chem. Eur. J.* **2019**, *25*, 3867–3874.

(9) Sprick, R. S.; Bai, Y.; Guilbert, A. A. Y.; Zbiri, M.; Aitchison, C. M.; Wilbraham,

L.; Yan, Y.; Woods, D. J.; Zwijnenburg, M. A.; Cooper, A. I. Photocatalytic Hydrogen Evolution from Water Using Fluorene and Dibenzothiophene Sulfone-Conjugated Microporous and Linear Polymers. *Chem. Mater.* **2018**, *30*, 5733–5742.

(10) Kailasam, K.; Mesch, M. B.; Möhlmann, L.; Baar, M.; Blechert, S.; Schwarze, M.; Schröder, M.; Schomäcker, R.; Senker, J.; Thomas, A. Donor-Acceptor-Type Heptazine-Based Polymer Networks for Photocatalytic Hydrogen Evolution. *Energy Technol.* 2016, *4*, 744–750.

(11) Sprick, R. S.; Jiang, J. X.; Bonillo, B.; Ren, S.; Ratvijitvech, T.; Guiglion, P.; Zwijnenburg, M. A.; Adams, D. J.; Cooper, A. I. Tunable Organic Photocatalysts for Visible-Light-Driven Hydrogen Evolution. *J. Am. Chem. Soc.* **2015**, *137*, 3265–3270.

(12) Cheng, C.; Wang, X.; Lin, Y.; He, L.; Jiang, J.-X.; Xu, Y.; Wang, F. The Effect of Molecular Structure and Fluorination on the Properties of Pyrene-Benzothiadiazole-Based Conjugated Polymers for Visible-Light-Driven Hydrogen Evolution. *Polym. Chem.* **2018**, *9*, 4468–4475.

(13) Xiang, Y.; Wang, X.; Rao, L.; Wang, P.; Huang, D.; Ding, X.; Zhang, X.; Wang, S.; Chen, H.; Zhu, Y. Conjugated Polymers with Sequential Fluorination for Enhanced Photocatalytic H₂ Evolution via Proton-Coupled Electron Transfer. *ACS Energy Lett.* **2018**, *3*, 2544–2549.

(14) Woods, D. J.; Sprick, R. S.; Smith, C. L.; Cowan, A. J.; Cooper, A. I. A Solution-Processable Polymer Photocatalyst for Hydrogen Evolution from Water. *Adv. Energy Mater.* **2017**, 1700479.

(15) Sprick, R. S.; Bonillo, B.; Clowes, R.; Guiglion, P.; Brownbill, N. J.; Slater, B.
J.; Blanc, F.; Zwijnenburg, M. A.; Adams, D. J.; Cooper, A. I. Visible-Light-Driven
Hydrogen Evolution Using Planarized Conjugated Polymer Photocatalysts. *Angew Chem* 2016, *128*, 1824–1828.

(16) Sprick, R. S.; Wilbraham, L.; Bai, Y.; Guiglion, P.; Monti, A.; Clowes, R.;
Cooper, A. I.; Zwijnenburg, M. A. Nitrogen Containing Linear Poly(phenylene)
Derivatives for Photo-catalytic Hydrogen Evolution from Water. *Chem. Mater.* 2018, 30, 5733–5742.

(17) Sprick, R. S.; Aitchison, Catherine M.; Berardo, E.; Turcani, L.; Wilbraham, L.;

Alston, B. M.; Jelfs, K. E.; Zwijnenburg, M. A.; Cooper, A. I. Maximising the Hydrogen Evolution Activity in Organic Photocatalysts by Co-polymerisation. *J. Mater. Chem. A*, **2018**, 6, 11994–12003.

(18) Zhang, X.; Wang, X.; Xiao, J.; Wang, S.; Huang, D.; Ding, X.; Xiang, Y.; Chen,
H. Synthesis of 1,4-Diethynylbenzene-Based Conjugated Polymer Photocatalysts and
their Enhanced Visible/Near-Infrared-Light-Driven Hydrogen Production Activity. *Journal of Catalysis.* 2017, 350, 64–71.

(19) Sachs, M.; Sprick, R. S.; Pearce, D.; Hillman, S. A. J.; Monti, A.; Guilbert, A. A. Y.; Brownbill, N. J.; Dimitrov, S.; Shi, X.; Blanc, F.; Zwijnenburg, M. A.; Nelson, J.; Durrant, J. R.; Cooper, A. I. Understanding Structure-activity Relationships in Linear Polymer Photocatalysts for Hydrogen Evolution. *Nat. Commun.* 2018, 9, 4968.

(20) Lan, Z. A.; Zhang, G.; Chen, X.; Zhang, Y.; Zhang, K. A. I.; Wang, X. Reducing the Exciton Binding Energy of Donor-Acceptor-Based Conjugated Polymers to Promote Charge-Induced Reactions. *Angew. Chem. Int. Ed.* **2019**, 58, 10236–10240.

(21) Dai, C.; Xu, S.; Liu, W.; Gong, X.; Panahandeh-Fard, M.; Liu, Z.; Zhang, D.; Xue, C.; Loh, K. P.; Liu, B. Dibenzothiophene-S,S-Dioxide-Based Conjugated Polymers: Highly Efficient Photocatalyts for Hydrogen Production from Water under Visible Light. *Small.* **2018**, 1801839.