Supporting Information for

Pt Nanoparticle-Decorated CdS Photocalysts for CO_2 Reduction and H_2 Evolution

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Figure S1. Photo of Home-made CO_2 photoreduction reactor.

Figure S2. Photo of CdS before and after Pt deposition by polyol reduction method.

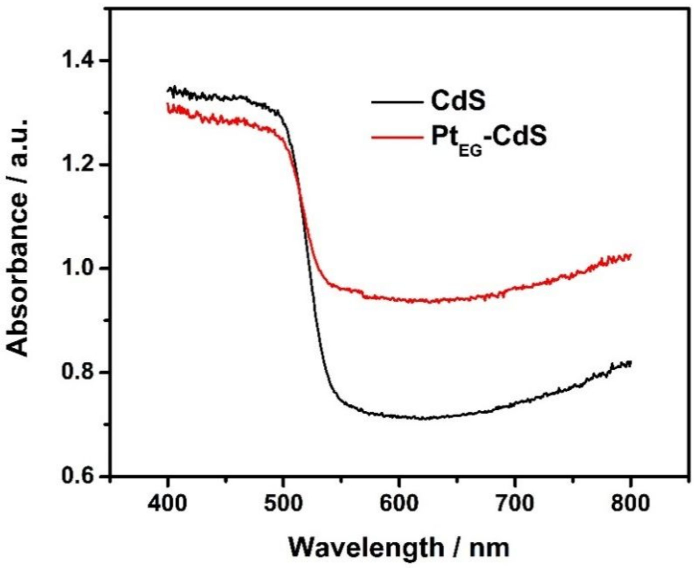

Figure S3. UV-visible diffuse reflectance spectra of pure CdS and Pt_{EG}-CdS.

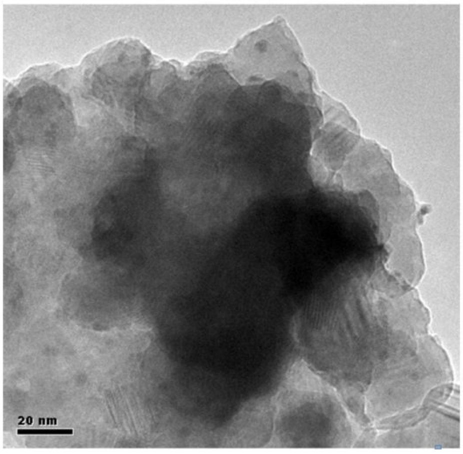

Figure S4. Transmission electron microscopic (TEM) image of Pt_{EG}-CdS.

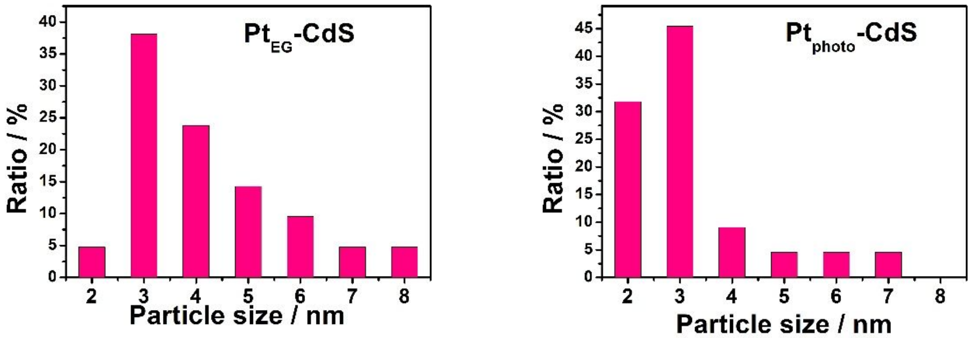

Figure S5. Distribution of Pt particle in Pt_{EG}-CdS and Pt_{photo}-CdS.

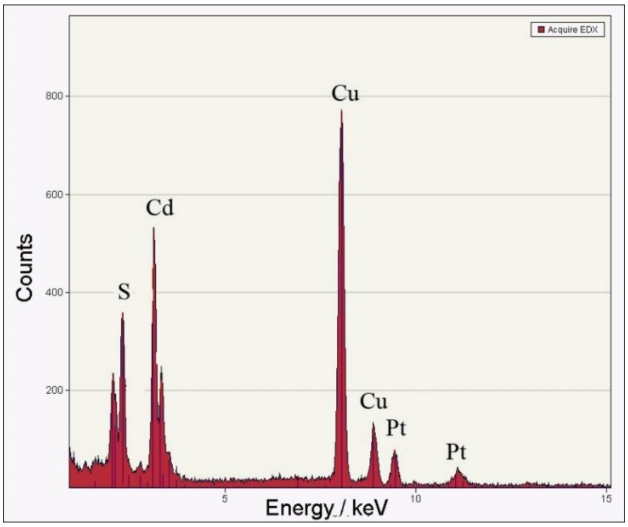

Figure S6. Energy dispersive x-ray analysis spectrum (EDS) of Pt_{EG}-CdS.

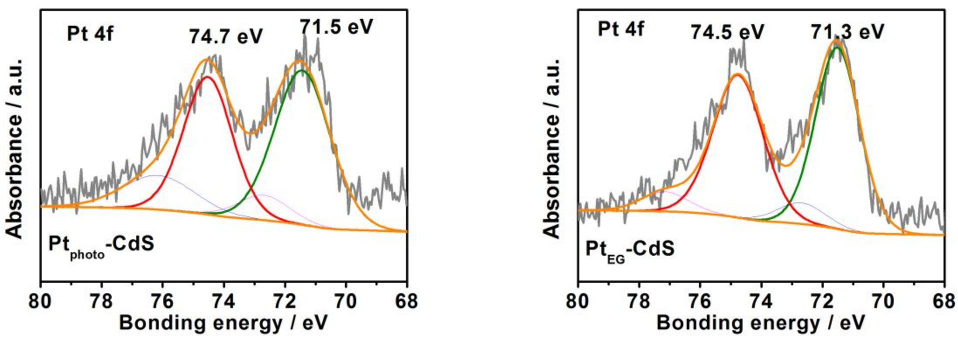

Figure S7. Fine Pt 4f XPS spectra for Pt_{photo}-CdS and Pt_{EG}-CdS.

Table S1. Loading Percentage of Pt for sample prepared with photoreduction and polyol reduction method.

Theoretical percentage (%)	0	0.1	0.5	1.0	2.0	5.0	10.0
ICP result of Ptphoto-CdS (%)	0	0.91	0.46	0.98	1.89	4.87	9.34
ICP result of PtEG-CdS (%)	0	0.93	0.48	0.98	1.92	4.96	9,76

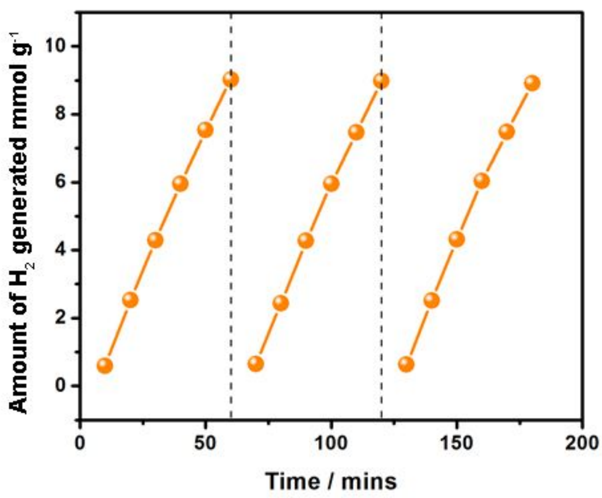

Figure S8. Cycling stability of Pt_{EG}-CdS in photocatalytic hydrogen evolution.

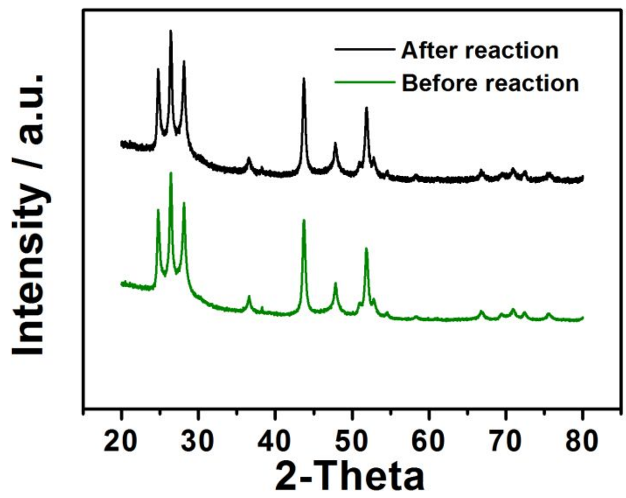

Figure S9. TEM image of Pt_{EG}-CdS before and after reaction.

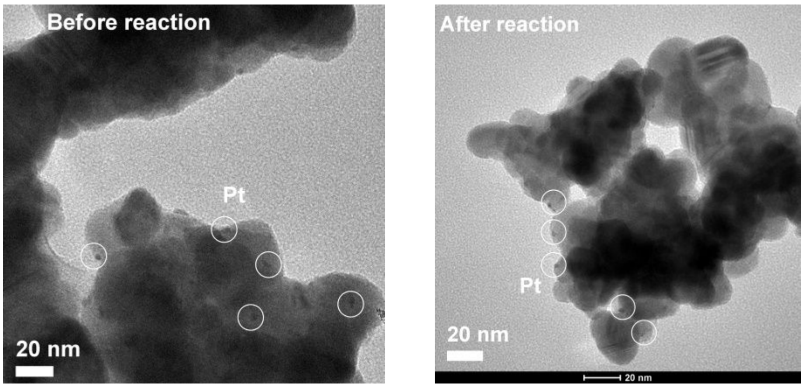

Figure S10. TEM image of sample before and after reaction.

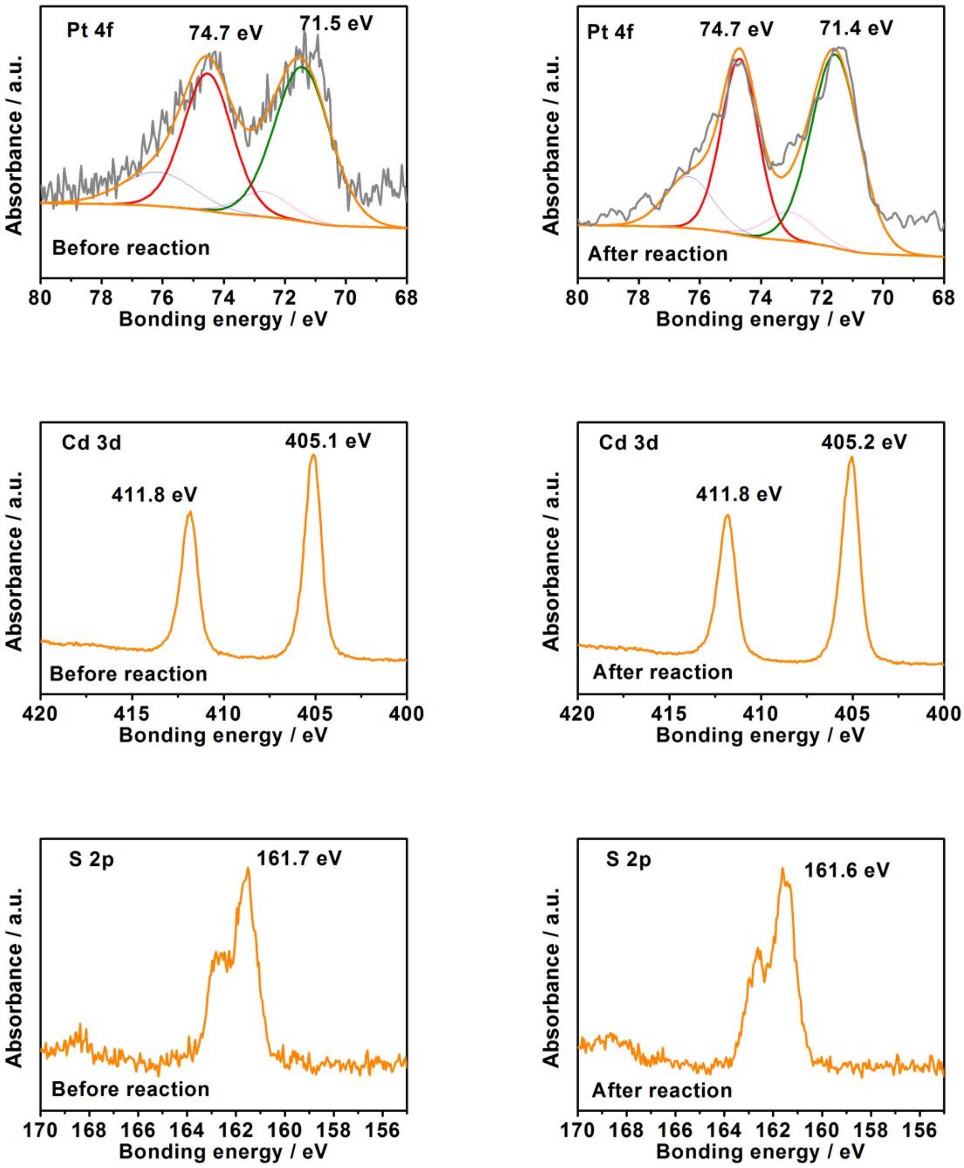

Figure S11. Fine XPS of sample before and after photocatalytic reaction.

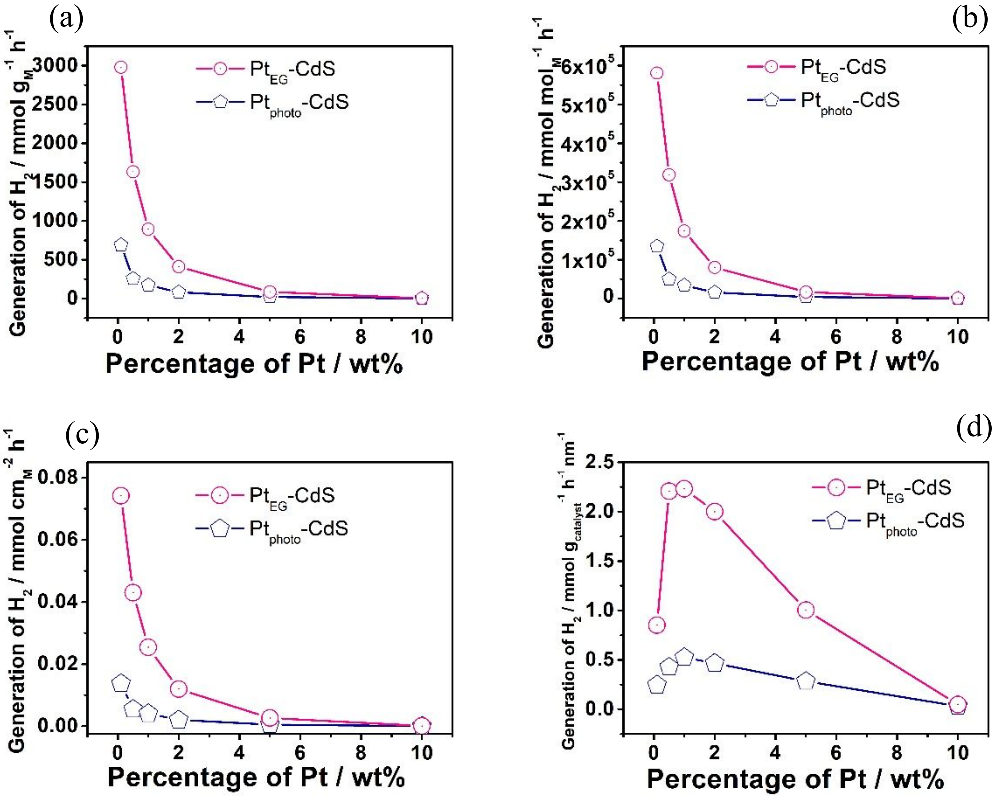

Figure S12. Normalized H_2 generation rates per (a) unit mass of metal (mmol g_M^{-1} h^{-1}); (b) mol of metal (mmol mol_M^{-1} h^{-1}); (c) unit area of metal (mmol cm_M^{-2} h^{-1}) for Pt_{EG}-CdS and Pt_{photo}-CdS and (d) unit mass of catalyst devided by avarage particle size.

Table S2. Average particle size of Pt prepared with with photoreduction and polyol reduction method.

Percentage of Pt (%)	0.1	0.5	1.0	2.0	5.0	10.0
Avarage particle size for Photoreduction (nm)	2.8	3.0	3.3	3.5	3.6	3.8
Avarage particle size for	3.5	3.7	4.0	4.1	4.3	4.8

Polyol reduction (nm)

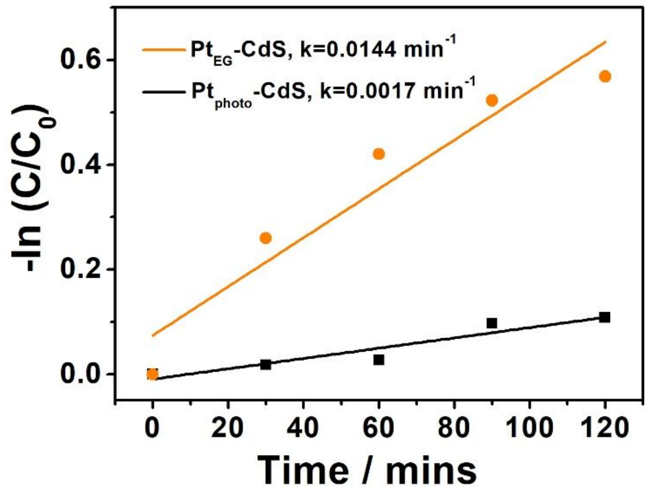

Figure S13. The plot of -ln(c/c_0) verse time for the p-Nitrophenol degradation over Pt_{photo}-CdS and Pt_{EG}-CdS.

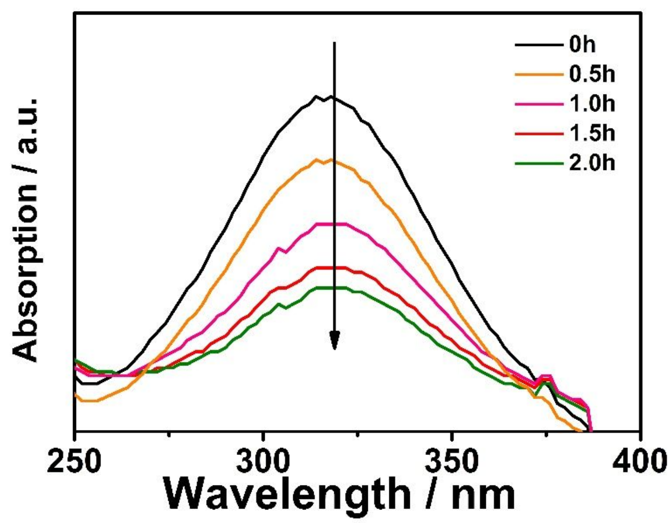

Figure S14. Time-dependent absorption spectra of p-nitrophenol solution containing 20 mg photocatalyst under irradiation.

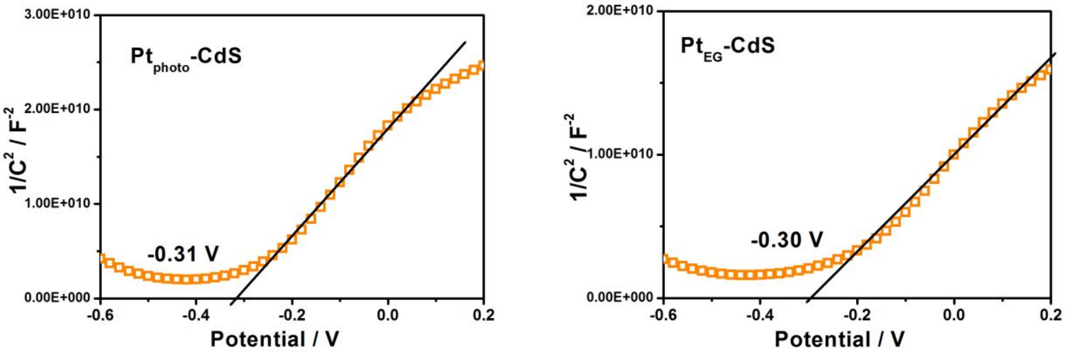

Figure S15. Mott-Schotty plot of Pt_{photo}-CdS and Pt_{EG}-CdS.

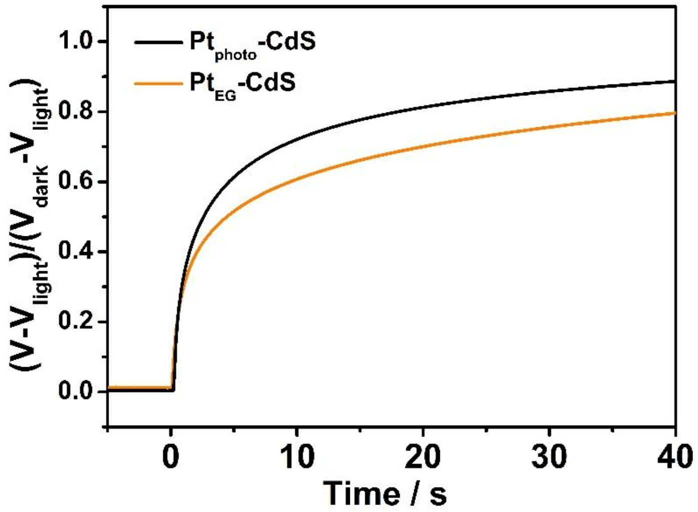

Figure S16. Open-circuit potential (OCP) decay curves after turning off the UV light (l > 320 nm).

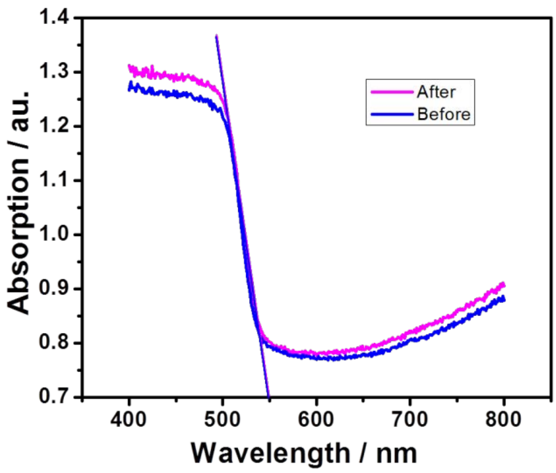

Figure S17. UV-visible diffuse reflectance spectra of CdS before (blue) and after (magenta) polyol treatment.

Table S3. Values of equivalent circuit elements obtained by fitting the experimental data.

	Rs (Ω)		Rct(Ω)		CPE-T		CPE-P	
	dark	light	dark	light	dark	light	dark	light
CdS	68.93	66.69	289390	1363	3.80E-5	1.15E-4	0.96	0.834
Pt_{photo}-CdS	68.68	59.1	1796	757.1	8.12E-5	1.82E-4	0.890	0.755
Pt_{EG}-CdS	66.58	72.65	1755	491.4	8.57E-5	4.31E-4	0.855	0.65

Table S4. Zata potential of CdS and Pt nanoparticles (prepared by EG reduction method) in a mixed solution of lactic and deionized water.

Zeta potential	1	2	3	4	5	mean
CdS	23.55	45.53	43.55	45.53	43.55	40.03
Pt	-33.52	-28.59	-26.88	-29.58	-25.64	-28.84

Section S1: Charge transfer efficiency study: open circuit potential

The open circuit potential will decay slowly in the scale of seconds when the light is turned off. According to literatures, this decay corresponds to the surface recombination between trapped electrons and reaction intermediates instead of bulk recombination that occur very fast (ns-ms domain).[1, 2] The average recombination rate (k) can be calculated by the following equation:[3, 4]

$$\frac{\mathbf{V}-\mathbf{V}_{dark}}{\mathbf{V}-\mathbf{V}_{light}} = \mathbf{1} - e^{-kt} \quad (1)$$

where V, V_{dark} and V_{light} are the open circuit potential at a certain time, in the dark and under illumination; k is the pseudo-first order recombination rate constant. Clearly, Pt_{EG}-CdS decay much slower than Pt_{photo}-CdS after light-off, the calculated k of Pt_{EG}-CdS (0.196 s^{-1}) is about 2.2 times smaller than that of its Pt_{photo}-CdS (0.429 s^{-1}), suggesting the slower charge recombination in Pt_{EG}-CdS.

REFERENCE

(1) Monllor-Satoca, D.; Gomez, R.; Choi, W., Concentration-Dependent Photoredox Conversion of As(III)/As(V) on Illuminated Titanium Dioxide Electrodes. *Environ Sci*

Technol **2012,** *46* (10), 5519-5527.

(2) Kim, J.; Monllor-Satoca, D.; Choi, W., Simultaneous production of hydrogen with the degradation of organic pollutants using TiO2 photocatalyst modified with dual surface components. *Energ Environ Sci* **2012,** *5* (6), 7647-7656.

(3) Kim, H. I.; Monllor-Satoca, D.; Kim, W.; Choi, W., N-doped TiO2 nanotubes coated with a thin TaOxNy layer for photoelectrochemical water splitting: dual bulk and surface modification of photoanodes. *Energ Environ Sci* **2015,** *8* (1), 247-257.

(4) Wang, S. B.; Pan, L.; Song, J. J.; Mi, W. B.; Zou, J. J.; Wang, L.; Zhang, X. W., Titanium-Defected Undoped Anatase TiO2 with p-Type Conductivity, Room-Temperature Ferromagnetism, and Remarkable Photocatalytic Performance. *J Am Chem Soc* **2015,** *137* (8), 2975-2983.