Supporting Information

Constructing noble-metal-free Z-scheme photocatalytic overall water splitting systems using MoS_2 nanosheets modified CdS as a H_2 evolution photocatalyst

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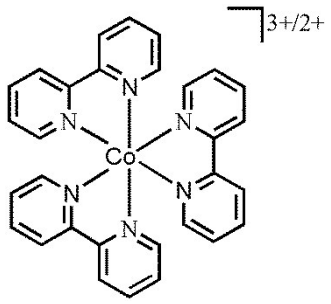

Scheme S1. Chemical structures of $[Co(bpy)_3](PF_6)_3$/$[Co(bpy)_3](PF_6)_2$ electron mediator.

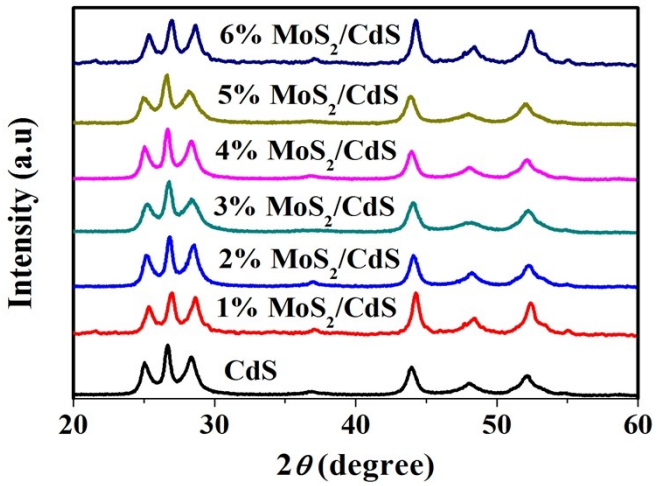

Figure S1. XRD patterns of MoS_2/CdS HERs loaded with various amounts of MoS_2.

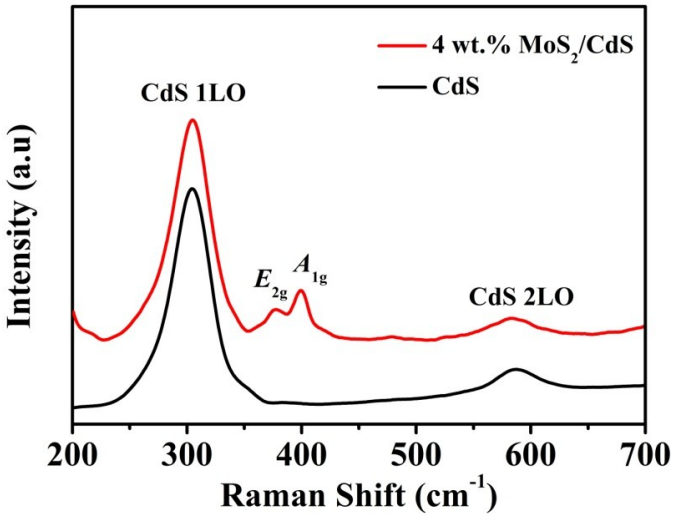

Figure S2. Raman spectra of bare CdS and 4 wt.% MoS_2/CdS composite.

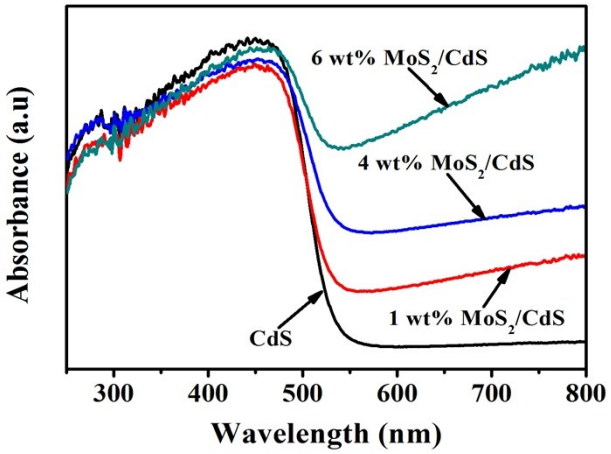

Figure S3.UV-vis spectra of MoS_2/CdS HEP loaded with various amounts of MoS_2.

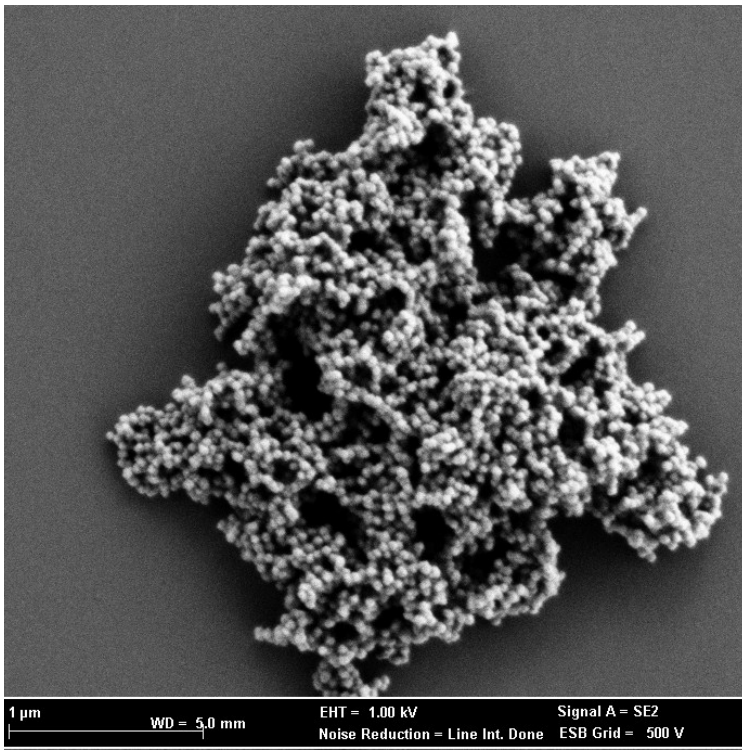

Figure S4. SEM image of pure CdS sample.

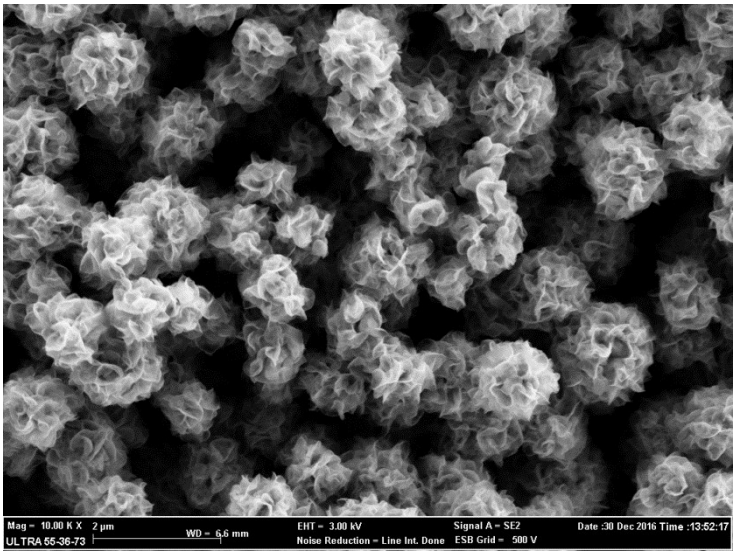

Figure S5. SEM image of pure MoS_2 sample.

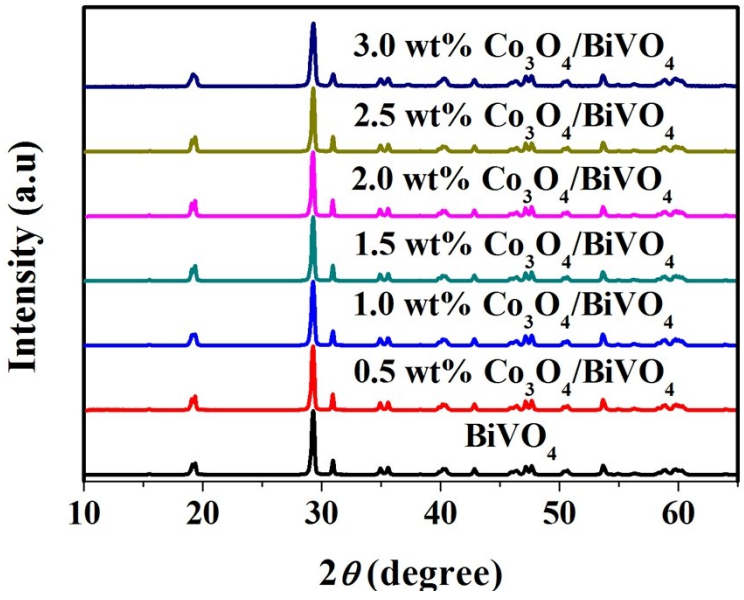

Figure S6. XRD patterns of $Co_3O_4/BiVO_4$ OEPs loaded with various amounts of Co_3O_4.

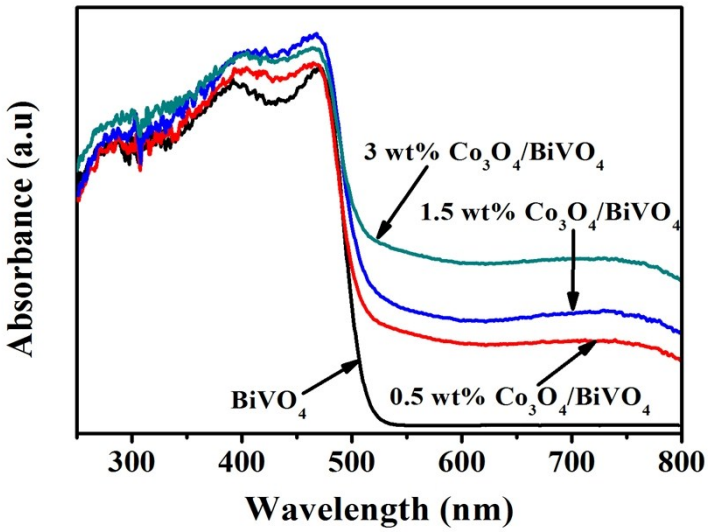

Figure S7. UV-vis spectra of $Co_3O_4/BiVO_4$ OEPs loaded with various amounts of Co_3O_4.

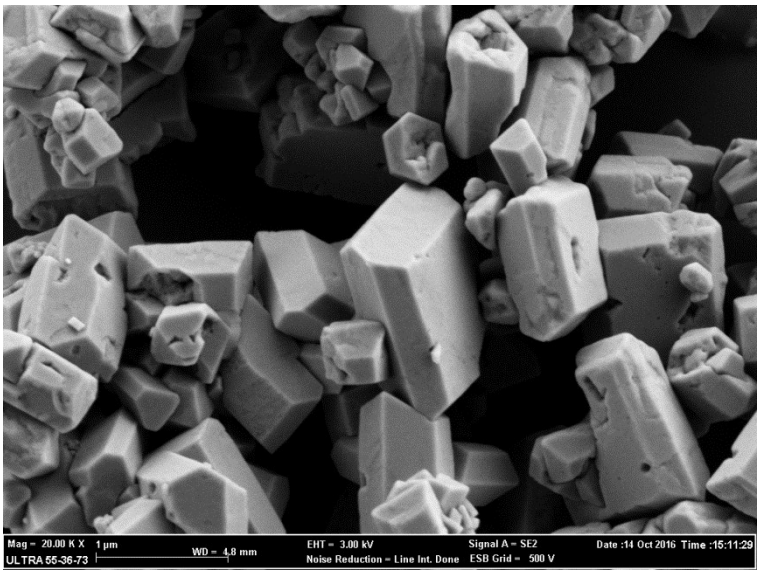

Figure S8. SEM image of pure $BiVO_4$ sample.

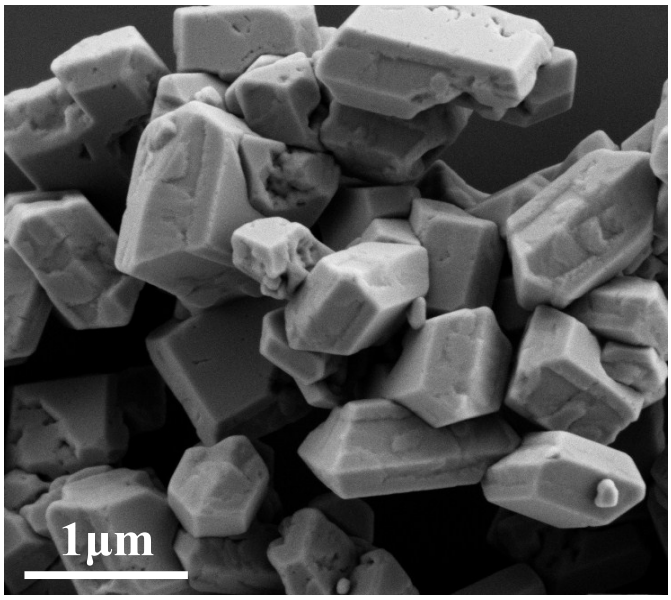

Figure S9. SEM image of 1.5 wt.% $Co_3O_4/BiVO_4$ OEP.

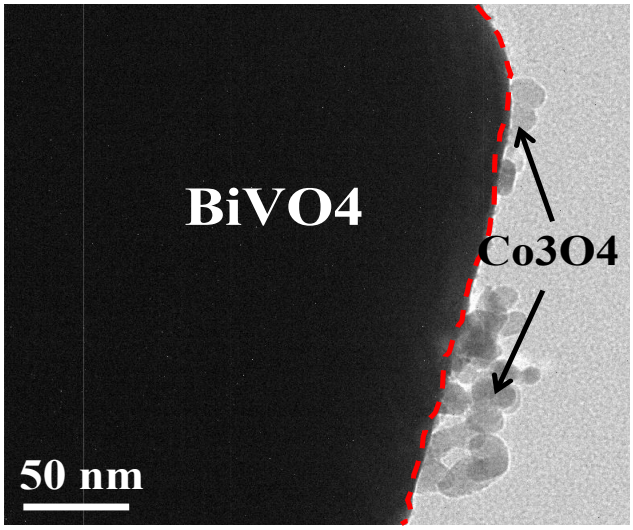

Figure S10. TEM image of 1.5 wt.% $Co_3O_4/BiVO_4$ OEP.

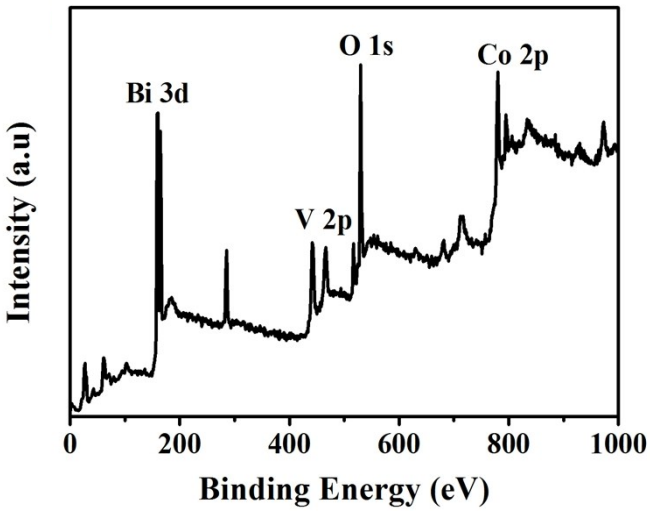

Figure S11. Survey XPS spectra of 1.5 wt.% Co_3O_4/$BiVO_4$ composite.

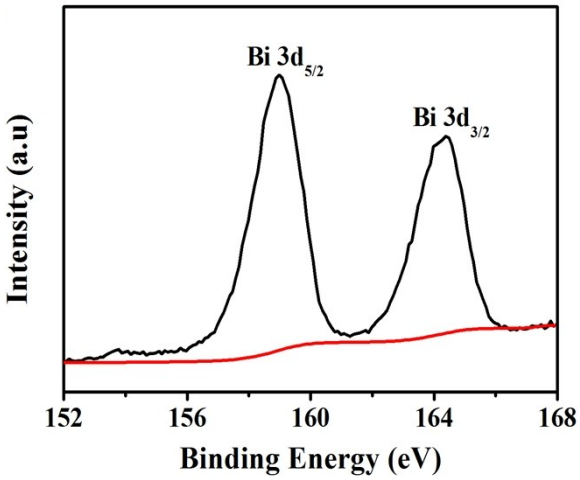

Figure S12. high resolution XPS spectra of Bi 3d.

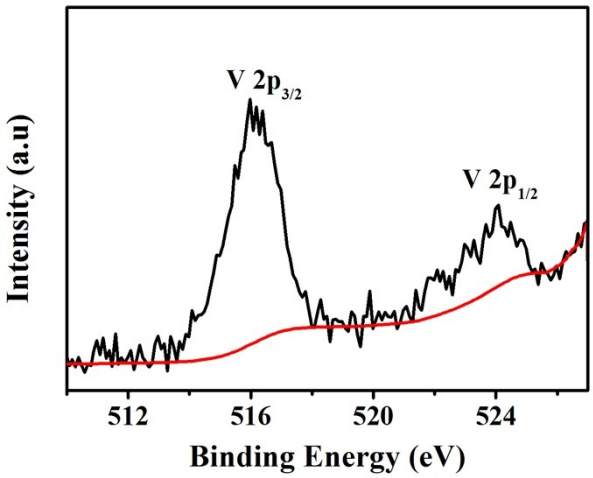

Figure S13. high resolution XPS spectra of V 2p.

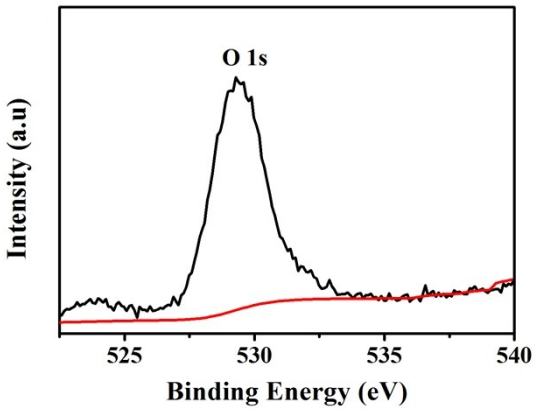

Figure S14. high resolution XPS spectra of O 1s.

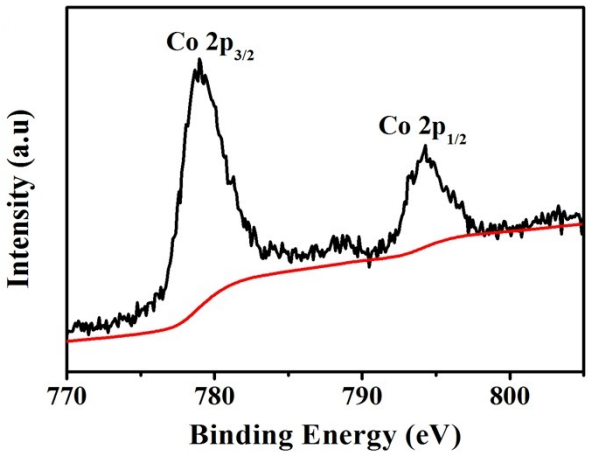

Figure S15. high resolution XPS spectra of Co 2p.

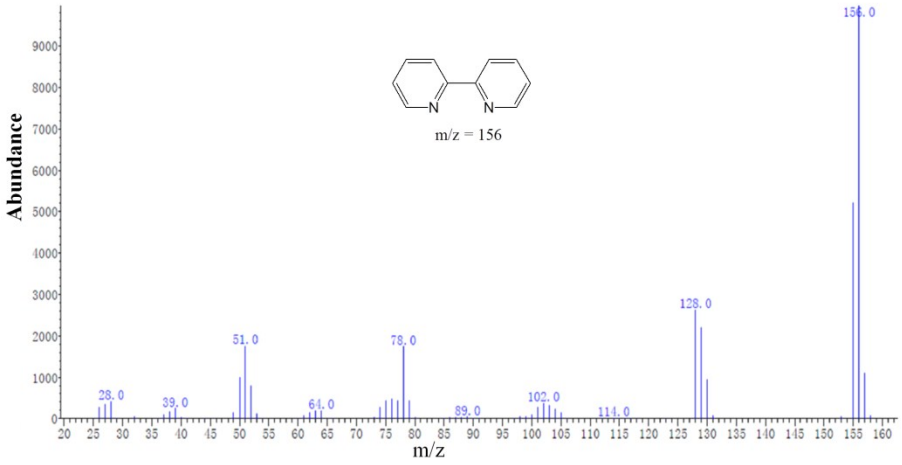

Figure S16. GC-MS of decomposition product collected from the reaction mixture after 4 h of visible light irradiation clearly reveals 2,2'-bipyridine (m/z = 156) dissociates from cobalt complexes electron mediator.

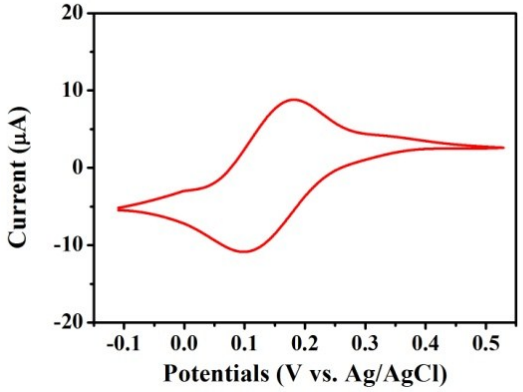

Figure 17. Cyclic voltammograms of the $[Co(bpy)_3]^{3+}/[Co(bpy)_3]^{2+}$ redox couple in saturated KCl solution (potential vs. Ag/AgCl).

$$4CdS \xrightarrow{h\nu} 4CdS(h^+ + e^-) \quad (1)$$

$$4BiVO_4 \xrightarrow{h\nu} 4BiVO_4(h^+ + e^-) \quad (2)$$

$$4CdS(h^+ + e^-) + MoS_2 \longrightarrow 4CdS\ (h^+) + 4MoS_2(e^-) \quad (3)$$

$$4MoS_2(e^-) + 4H^+ \longrightarrow 4MoS_2 + 2H_2 \quad (4)$$

$$4CdS\ (h^+) + 4[Co(bpy)_3]^{2+} \longrightarrow 4CdS + 4[Co(bpy)_3]^{3+} \quad (5)$$

$$4BiVO_4(h^+ + e^-) + 4Co_3O_4 \longrightarrow 4BiVO_4(e^-) + 4Co_3O_4((h^+) \quad (6)$$

$$4BiVO_4(e^-) + 4[Co(bpy)_3]^{3+} \longrightarrow 4BiVO_4 + 4[Co(bpy)_3]^{2+} \quad (7)$$

$$4Co_3O_4(h^+) + 2H_2O \longrightarrow 4Co_3O_4 + 4H^+ + O_2 \quad (8)$$

Scheme S2. Summarized transfer routes of photoinduced charge carriers in this Z-scheme system.

Table S1. Weight ratio of cocatalyst exhibited in 4% MoS_2/CdS and 1.5% Co_3O_4/$BiVO_4$ samples.

Sample	Sample concentration (mg/L)	Mo or Co concentration (mg/L)	MoS_2 or Co_3O_4 concentration (mg/L)	cocatalyst/photocatalyst ratio (wt%)
4% MoS_2/CdS	403	8.87	14.79	3.67
1.5 % Co_3O_4/$BiVO_4$	434	6.24	8.49	1.44

Table S2. Comparison of photocatalytic performance for water splitting between the current work and other reported studies.

Entry	H_2 evolution photocatalyst	O_2 evolution photocatalyst	Light source	Activity (μmol h^{-1})		Quantum yield (%)	Ref
				H_2	O_2		
1	Ru-$SrTiO_3$:Rh	$BiVO_4$	300 W Xe lamp (λ>420 nm)	5.0	2.2		(1)
2	Ru-$SrTiO_3$:Rh	WO_3	300 W Xe lamp (λ>420 nm)	5.7	2.4	0.4 (420 nm)	(2)
3	Ru-$SrTiO_3$:Rh	$AgNbO_3$	300 W Xe lamp (λ>420 nm)	1.9	0.7	0.1 (420 nm)	(2)
4	Ru-$SrTiO_3$:Rh	Bi_2MoO_6	300 W Xe lamp (λ>420 nm)	12	5.2	0.9 (420 nm)	(2)
5	Pt-IrO_2/$Sm_2Ti_2S_2O_5$	PtO_x/H-Cs-WO_3	300 W Xe lamp (λ>420 nm)	4.06	1.61		(3)
6	Ru-$SrTiO_3$:Rh	$BiVO_4$	300 W Xe lamp (λ>420 nm)	0.5	0.4		(4)
7	Pt/TaON	RuO_2/TaON	300 W Xe lamp (λ>420 nm)	10	4	0.1-0.2 (420 nm)	(5)
8	Pt/$CaTaO_2N$	Pt/WO_3	300 W Xe lamp (λ>420 nm)	5.5	2.5		(6)
9	Pt $BaTiO_3$:Rh	PtO_x/WO_3	300 W Xe lamp (λ>420 nm)	1.7	0.6	0.5 (420 nm)	(6)
10	Pt/$H_4Nb_6O_{17}$	PtO_2/WO_3	300 W Xe lamp (λ>420 nm)	2.2	0.9	0.05 (480nm)	(7)
11	Ru-$SrTiO_3$:Rh	$BiVO_4$	300 W Xe lamp (λ>420 nm)	7.9	3.5		(8)
12	Pt-Ba(0.3)-Ta_3N_5	PtO_x/WO_3	300 W Xe lamp	3.2	1.6		(9)
13	Pt-TaON	PtO_x/WO_3	300 W Xe lamp	15.6	7.5		(10)
14	PRGO(Ru/$SrTiO_3$:Rh)	$BiVO_4$	300 W Xe lamp (λ>420 nm)	3.5	1.4	1.03 (420nm)	(11)
15	Ru-$SrTiO_3$:Rh	Ir/CoO_x/Ta_3N_5	300 W Xe lamp (λ>420 nm)	~11.5	~5.5		(12)
16	Ru/$SrTiO_3$:Rh	$BiVO_4$	300 W Xe lamp (λ>420 nm)	13	5.8		(13)
17	Pt/$CuGaS_2$	CoO_x/$BiVO_4$	300 W Xe lamp (λ>420 nm)	3.5	1.7		(14)
21	MoS_2/CdS	Co_2O_3/$BiVO_4$	300 W Xe lamp (λ>420 nm)	14.5	7.1	1.04 (420nm)	This work

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