Supplementary Material

Highly efficient and selective photocatalytic CO_2 reduction based on water-soluble CdS QDs modified by the mixed ligands in one pot

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Table S1. The shorter lifetime, longer lifetime and the average lifetime of time-resolved photoluminescence lifetime for MPA&MUA QDs, MPA QDs and MUA QDs respectively.

	Shorter lifetime (τ_1)	**Longer lifetime (τ_2)**	**Average lifetime (τ)**
MPA&MUA QDs	14.1 ns	99.4 ns	27.7 ns
MPA QDs	6.1 ns	82.1 ns	6.4 ns
MUA QDs	9.6 ns	89.8 ns	12.2 ns

The time-resolved photoluminescence spectrum curves were fitted through a biexponential function and the expression is as follow. [1]

$$I(t) = A_1 \exp(-t/\tau_1) + A_2 \exp(-t/\tau_2) \qquad (1)$$

where τ_1 and τ_2 is the shorter lifetime and the longer lifetime of the decay times respectively, and A_1 and A_2 the amplitudes of photoluminescence. The average lifetime can be calculated as follow:

$$\tau = \frac{\sum A_i \tau_i^2}{\sum A_i \tau_i} \qquad (2)$$

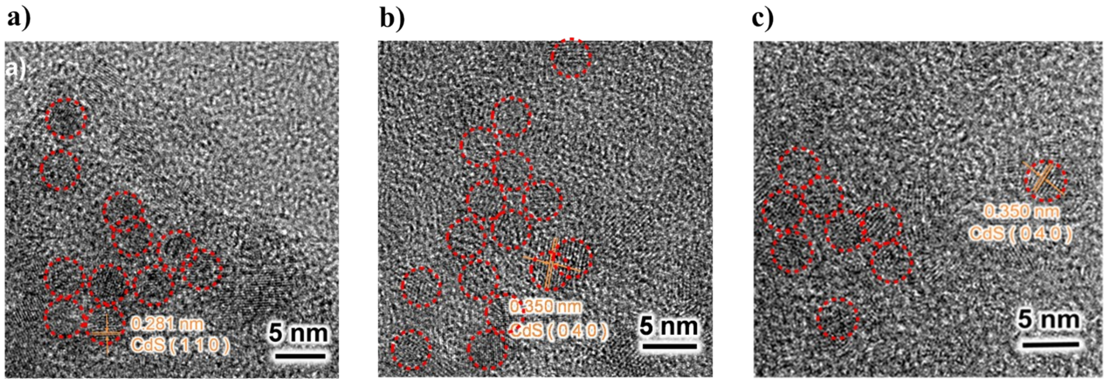
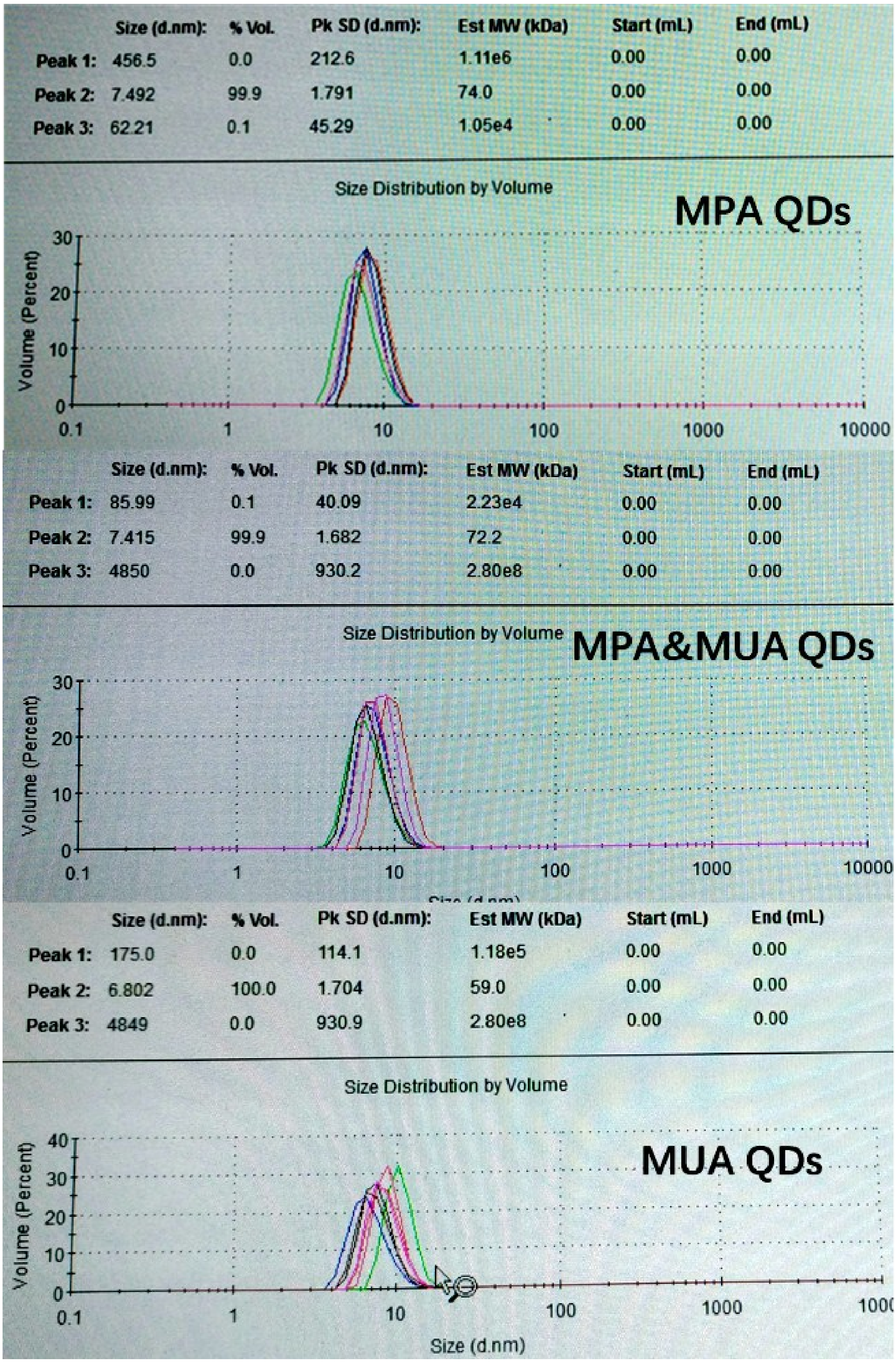


Figure S1. HRTEM image of a) MPA&MUA QDs; b) MPA QDs and c) MUA QDs.

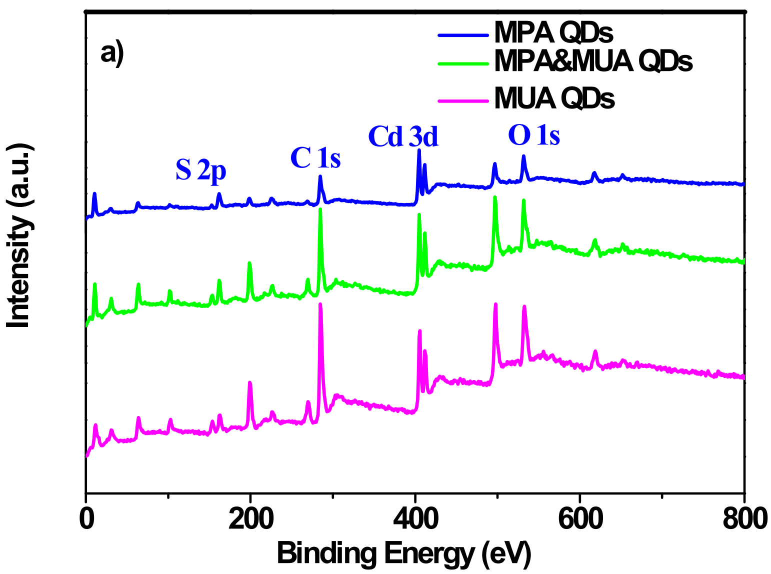


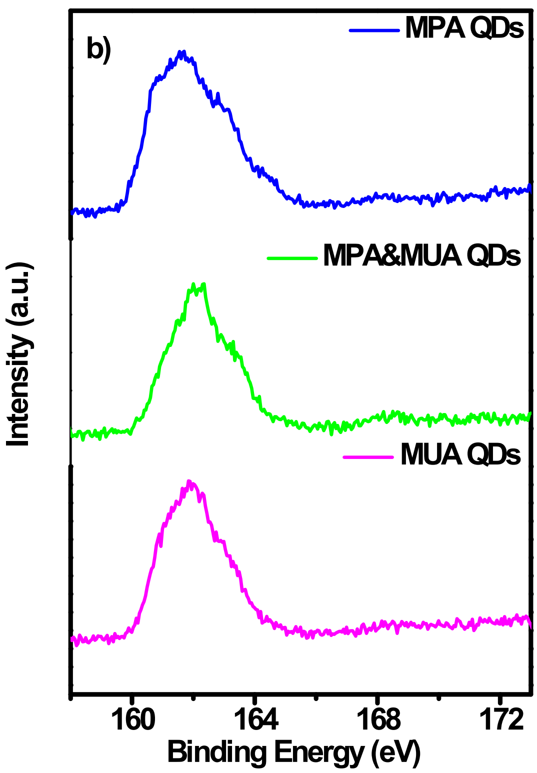
	Size (d.nm):	% Vol.	Pk SD (d.nm):	Est MW (kDa)	Start (mL)	End (mL)
Peak 1:	456.5	0.0	212.6	1.11e6	0.00	0.00
Peak 2:	7.492	99.9	1.791	74.0	0.00	0.00
Peak 3:	62.21	0.1	45.29	1.05e4	0.00	0.00

	Size (d.nm):	% Vol.	Pk SD (d.nm):	Est MW (kDa)	Start (mL)	End (mL)
Peak 1:	85.99	0.1	40.09	2.23e4	0.00	0.00
Peak 2:	7.415	99.9	1.682	72.2	0.00	0.00
Peak 3:	4850	0.0	930.2	2.80e8	0.00	0.00

	Size (d.nm):	% Vol.	Pk SD (d.nm):	Est MW (kDa)	Start (mL)	End (mL)
Peak 1:	175.0	0.0	114.1	1.18e5	0.00	0.00
Peak 2:	6.802	100.0	1.704	59.0	0.00	0.00
Peak 3:	4849	0.0	930.9	2.80e8	0.00	0.00

Figure S2. The average size of MPA QDs, MPA&MUA QDs and MUA QDs determined by DLS. Here, the size is different from that in TEM because it represents the hydrodynamic size of the suspension.


a)
MPA QDs
MPA&MUA QDs
MUA QDs
S 2p
C 1s
Cd 3d
O 1s
Intensity (a.u.)
0
200
400
600
800
Binding Energy (eV)


b)
MPA QDs
MPA&MUA QDs
MUA QDs
Intensity (a.u.)
160
164
168
172
Binding Energy (eV)

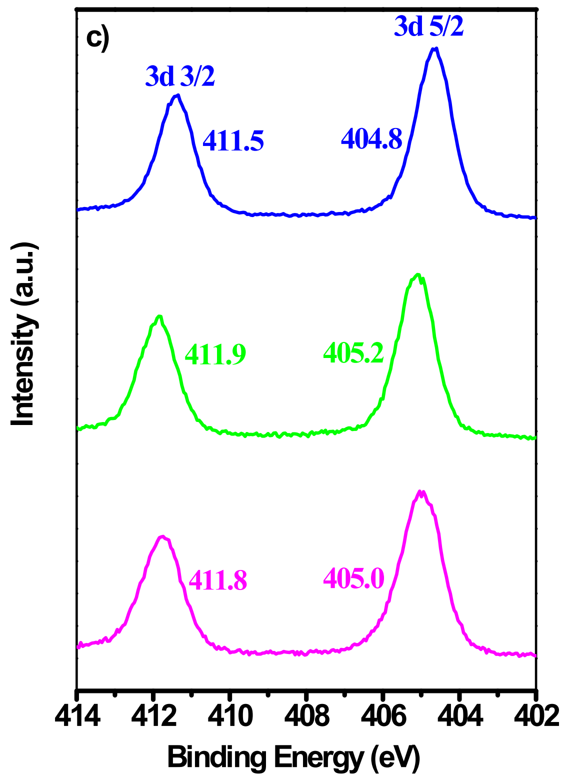


Figure S3. a) the survey scan of XPS spectrum of MAP QDs, MPA&MUA QDs and MUA QDs; the high-resolution of b) Cd 3d spectrum and c) S 2p spectrum in XPS

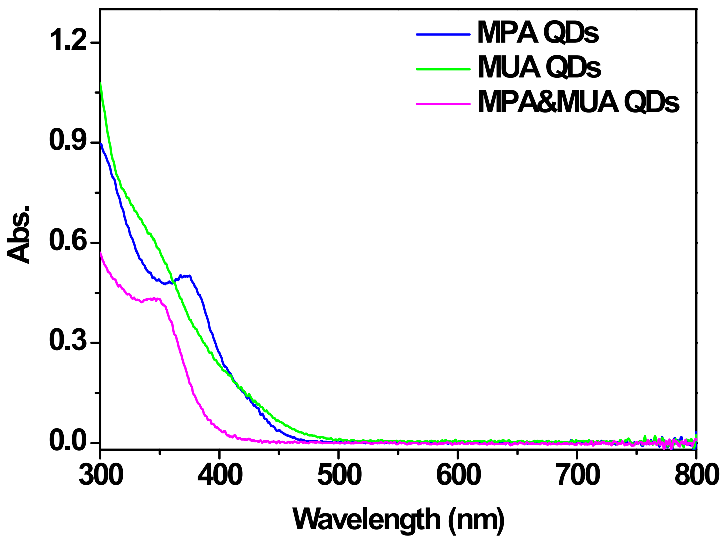
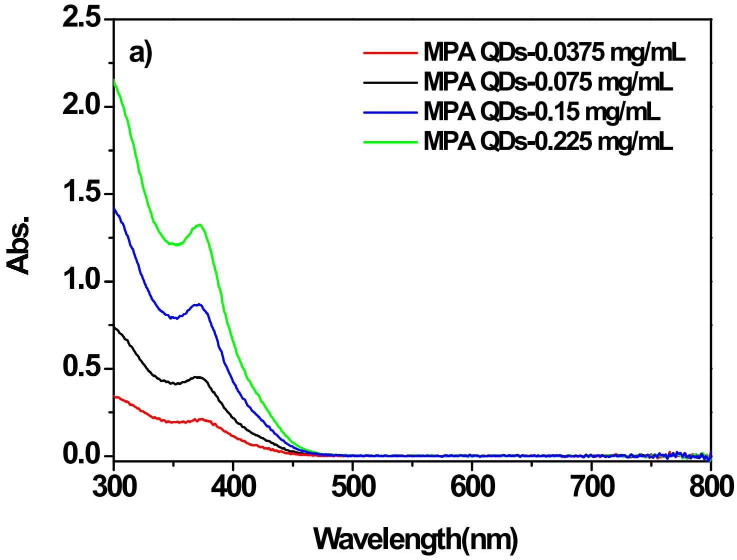
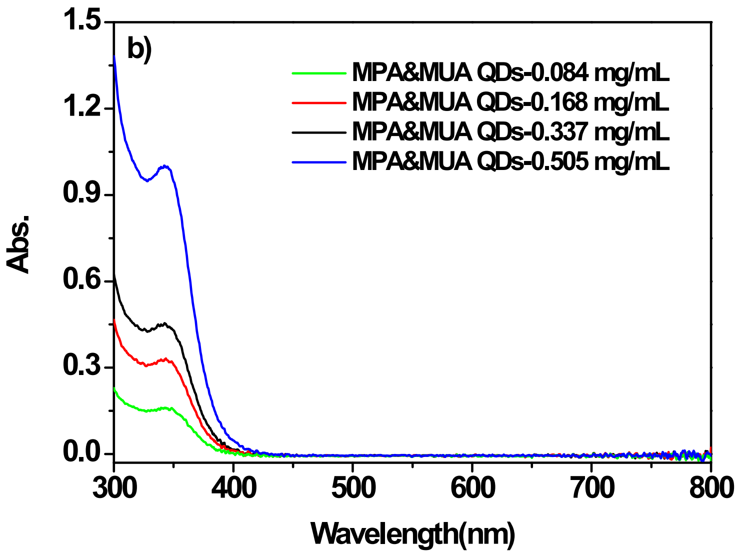


Figure S4. The UV-vis spectra of MPA QDs, MPA&MUA QDs, and MUA QDs in water.



a)
MPA QDs-0.0375 mg/mL
MPA QDs-0.075 mg/mL
MPA QDs-0.15 mg/mL
MPA QDs-0.225 mg/mL
Abs.
Wavelength(nm)



b)
MPA&MUA QDs-0.084 mg/mL
MPA&MUA QDs-0.168 mg/mL
MPA&MUA QDs-0.337 mg/mL
MPA&MUA QDs-0.505 mg/mL
Abs.
Wavelength(nm)

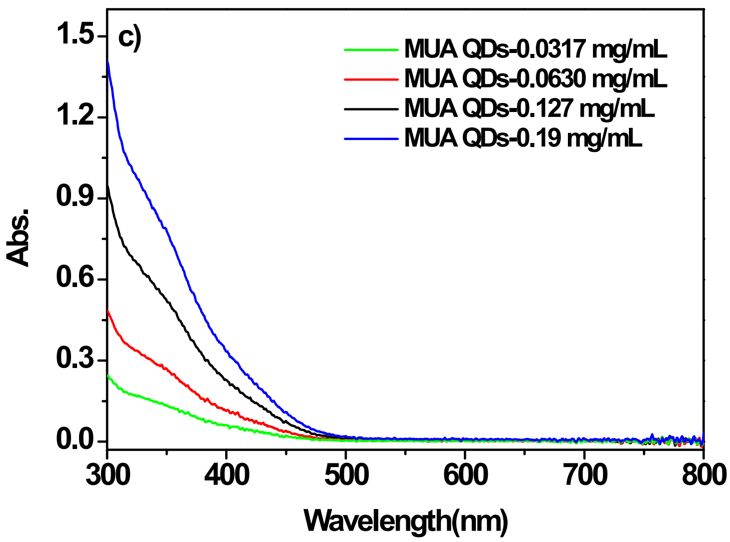


Figure S5. The UV-visible spectra of a) MPA, b) MPA&MUA, c) MUA QDs dispersed in water.

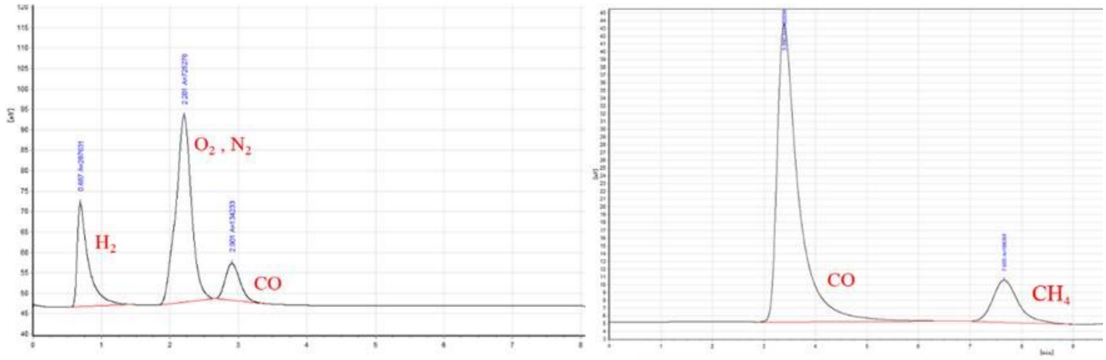
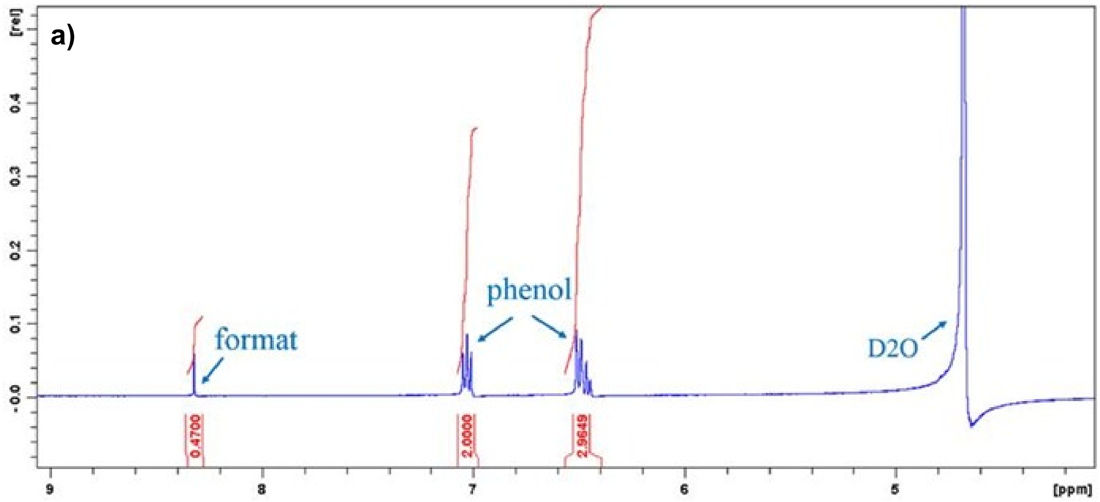


Figure S6. Gaseous products CO and CH_4, H_2 analyzed by GC



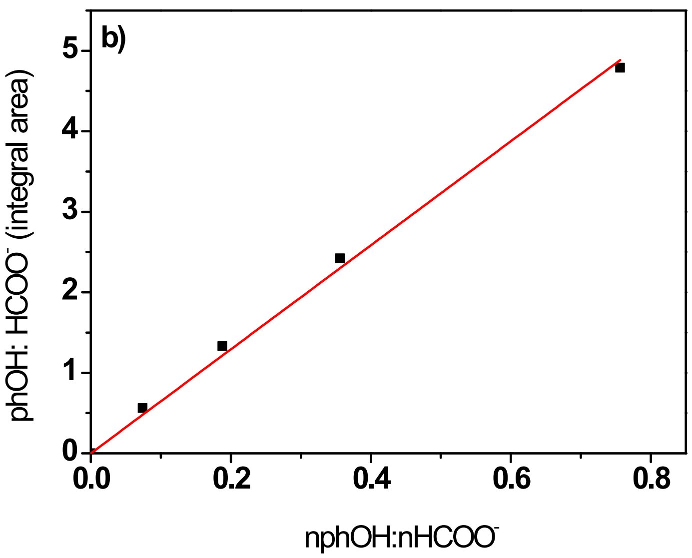


Figure S7. a) The amount of HCOOH determined by ^{1}H NMR with phenol as the internal standard; b) the job plot of the mole ratio vs. the integral area based on ^{1}H NMR (phOH is the internal standard)

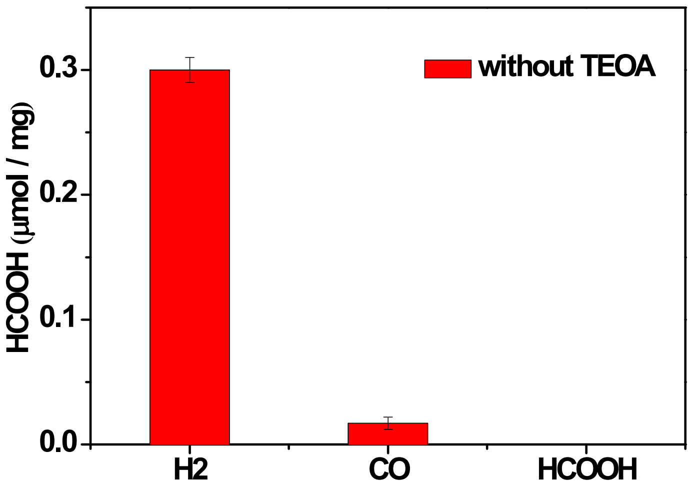


Figure S8. The controlled experiment for the photocatalysis without TEOA.

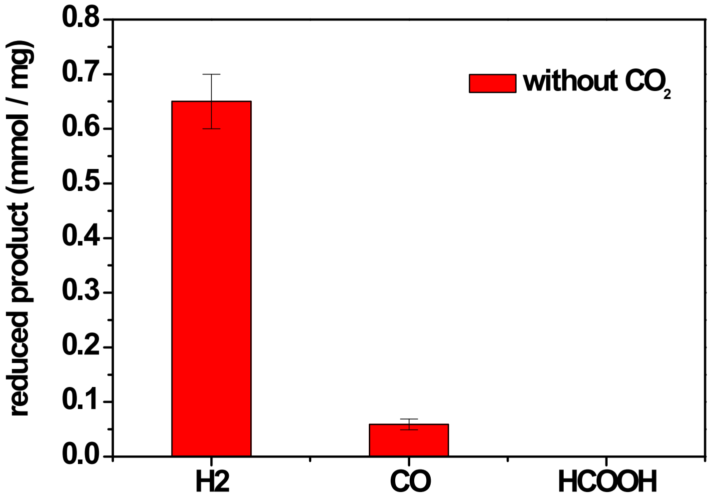


Figure S9. The controlled experiment for the photocatalysis without CO_2.

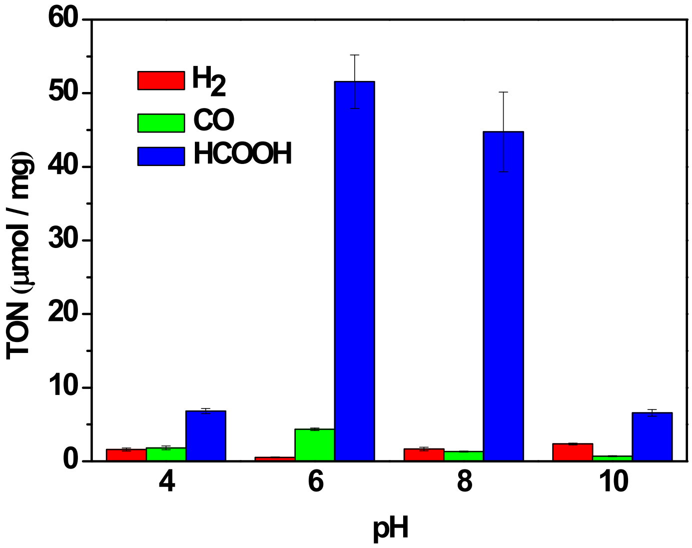


Figure S10. The amount of gas products CO and H_2 as well as the generation of liquid HCOOH varied by pH with MPA QDs as the photocatalyst.

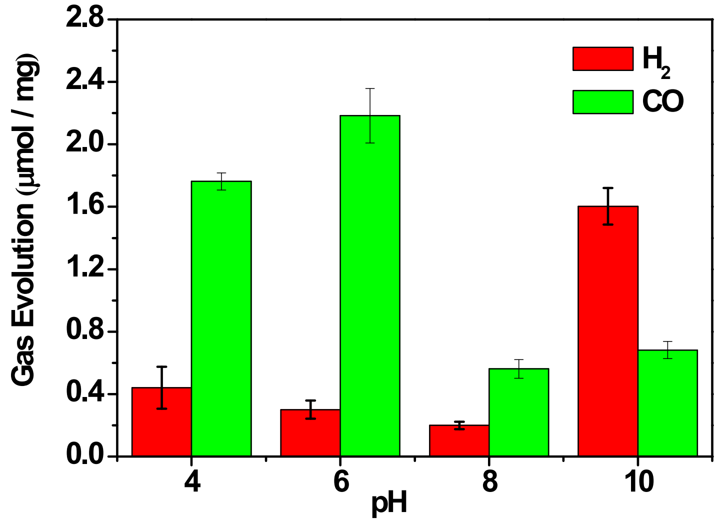


Figure S11. The amount of gas products CO and H_2 varied by pH with MUA QDs as the photocatalyst.

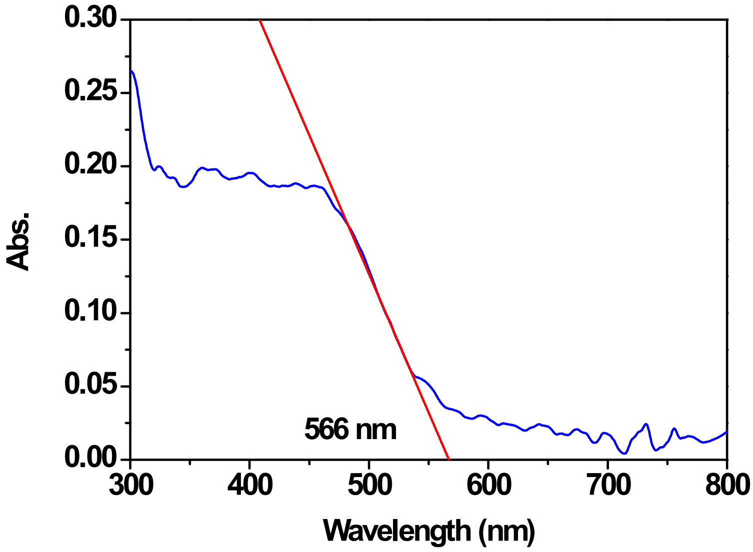
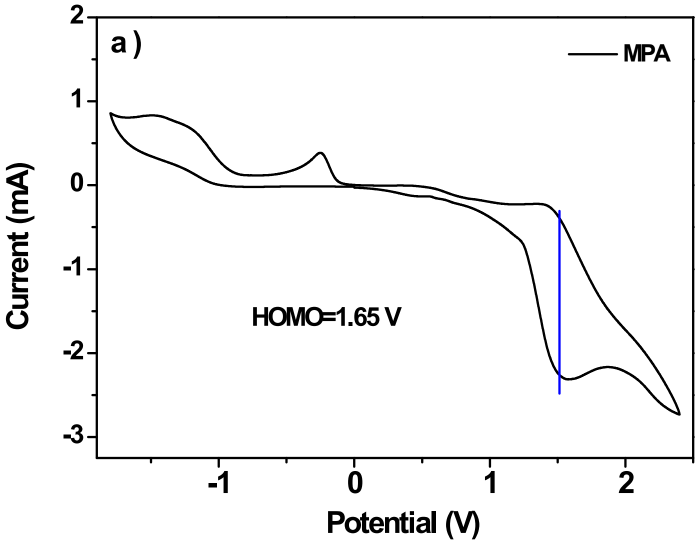


Figure S12. UV-vis DRS spectrum of mixture of MPA QDs and MUA QDs.



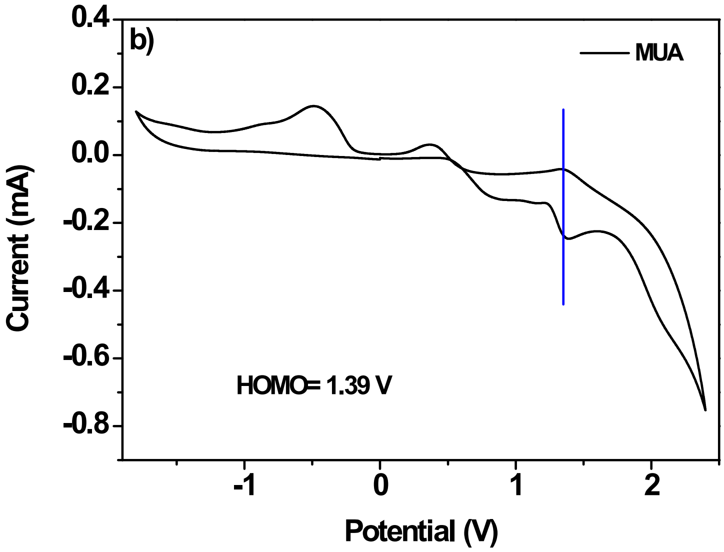


Figure S13. The electrochemistry of a) MPA and b) MUA vs.NHE.

1. M. Zhou, S. Wang, P. Yang, C. Huang and X. Wang, *ACS Catal.*, 2018, **8**, 4928; (b) F. Xing, Q. Liu, M. Song and C. Huang, *ChemCatChem*, **2018**, *10*, 5270.