Supporting Information

P25@CoAl-layered double hydroxide heterojunction nanocomposites for CO_2 photocatalytic reduction

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Apparent quantum yield calculations

The apparent quantum yield (AQY) was measured using the same experimental setup, but with band-pass filters of 365 nm for UV light and 480 nm visible light to obtain monochromatic light and the equation as follows:

$$\mathrm{AQY\ /\ \%} = \frac{\text{Number of reacted electrons}}{\text{Number of incident photons}} \times 100$$

$$\text{Moles of incident photons } (\mathrm{N_{Einstein}}) = \frac{\text{Number of incident photons } (\mathrm{N_p})}{\mathrm{N_A}}$$

Number of incident photons N_p can be calculated by

$$\mathrm{N_P} = \frac{\text{Irradiance (E)}}{\text{Photon energy } (\mathrm{E_p})} \text{ ; and } \text{Photon energy } (\mathrm{E_p}) = \frac{\mathrm{hc}}{\lambda}$$

$$\mathrm{E_p} = \frac{(6.625 \times 10^{-34}\ \mathrm{J.Sec})\ (3 \times 10^{17}\ \mathrm{nm\ Sec^{-1}})}{\lambda\ (\mathrm{nm})} = \frac{19.88 \times 10^{-17}}{\lambda\ (\mathrm{nm})}$$

$$\mathrm{N_p} = \frac{\mathrm{E}}{\mathrm{E_p}} = E \times \lambda \times 5.03 \times 10^{15} (m^{-2}\mathrm{Sec^{-1}});$$

$$\mathrm{N_{Einstein}} = \frac{\mathrm{N_P}}{\mathrm{N_A}} = 0.836 \times \mathrm{E} \times \lambda\ (\mathrm{nm}) \times 10^{-8} (\mathrm{mol.\,m^{-2}.\,sec^{-1}})$$

$$\mathrm{N_{Einstein}} = 0.836 \times \mathrm{E} \times \lambda\ (\mathrm{nm}) \times 10^{-2} (\mathrm{\mu mol.\,m^{-2}.\,sec^{-1}})$$

$$\mathrm{AQY\ /\ \%} = \frac{\text{Number of reacted electrons } (\mathrm{\mu mol.\,sec^{-1}})}{0.836 \times \mathrm{E} \times \lambda \times 10^{-2}\ (\mathrm{\mu mol.\,m^{-2}.\,sec^{-1}})} \times 100$$

$$\mathrm{AQY\ /\ \%} = \frac{\text{Number of reacted electrons } (\mathrm{\mu mol.\,h^{-1}})}{0.836 \times 3600 \times \mathrm{E} \times \lambda \times 10^{-2}} \times 100$$

$$\mathrm{AQY\ /\ \%} = \frac{\text{Number of reacted electrons} (\mathrm{\mu mol.\,h^{-1}})}{30.096 \times \mathrm{E} \times \lambda\ (\mathrm{nm})} \times 100$$

where Irradiance (E) = light intensity in reactor × effective light irradiation area. Light intensity within the reactor was measured using a G & R labs intensity meter over the range 190-750 nm.

E is 0.10 $W.cm^{-2}$ at 365 nm and 0.12 $W.cm^{-2}$ at 475 nm

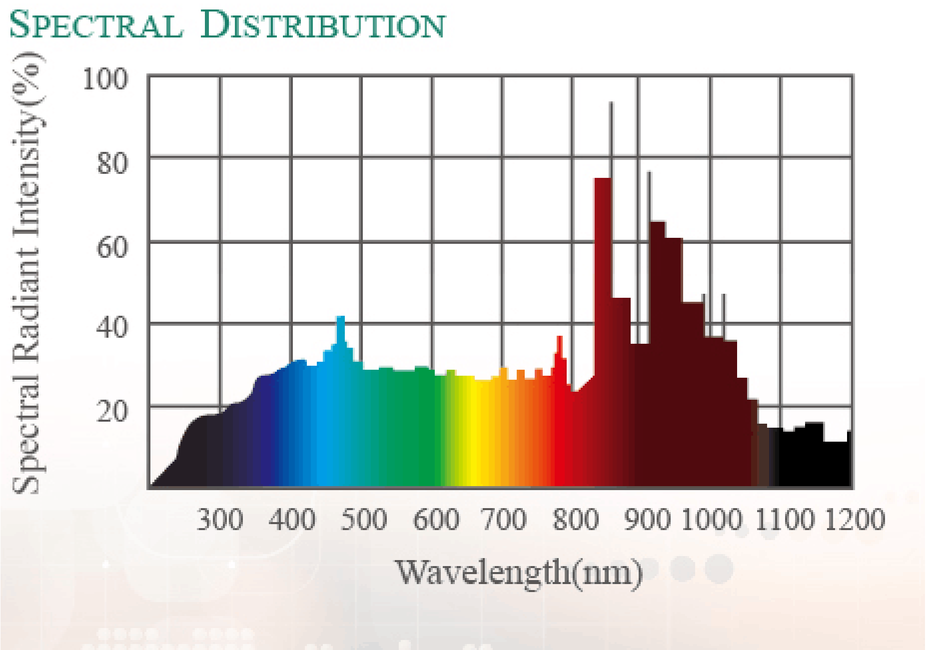

Figure S1. Spectral output of 300 W Xe light source.

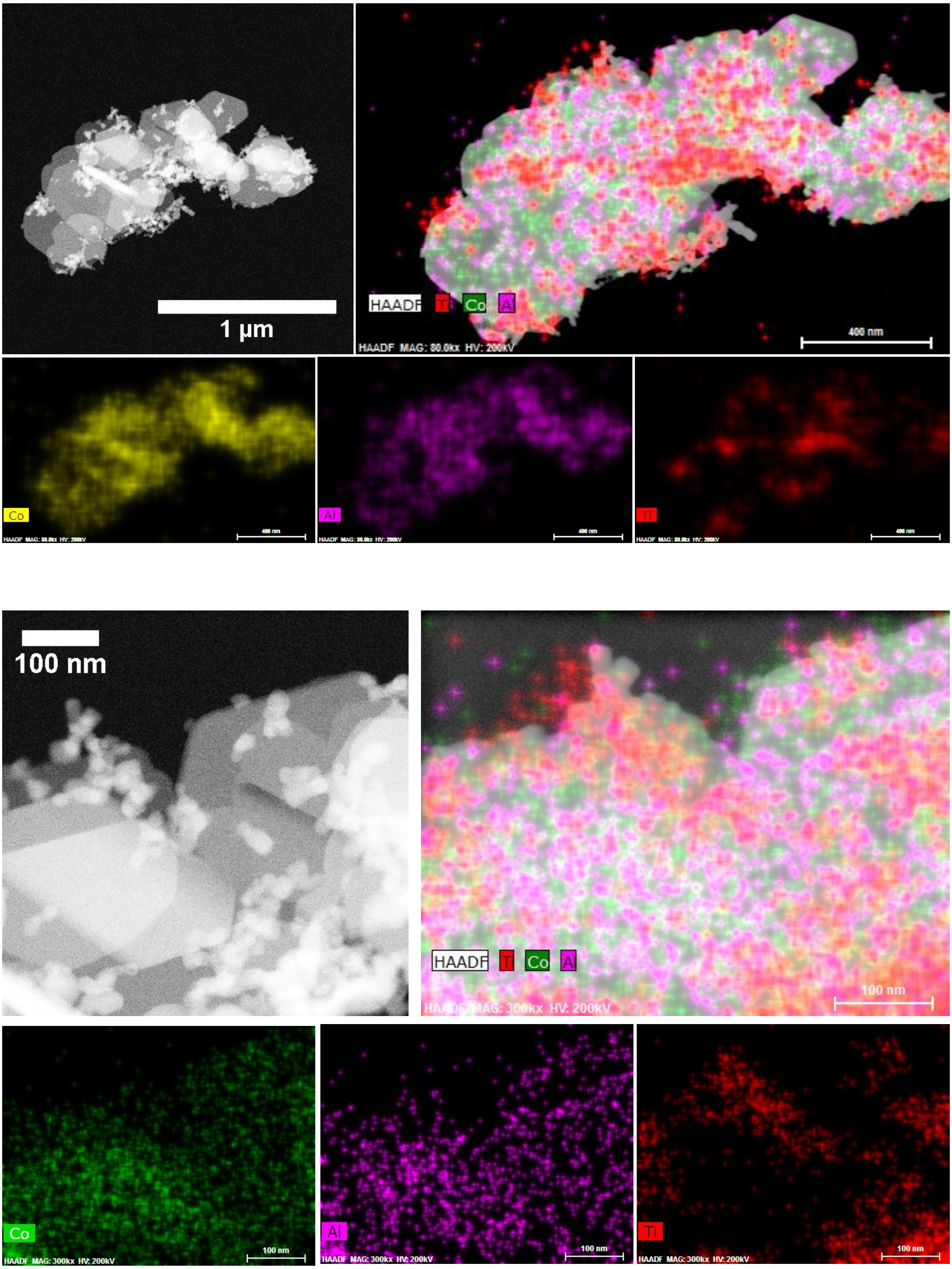

Figure S2. (top) low and (bottom) high resolution TEM images and corresponding EDX element maps of 20 wt% TiO_2@CoAl-LDH nanocomposite highlighting relatively high and uniform distribution of P25 throughout LDH matrix.

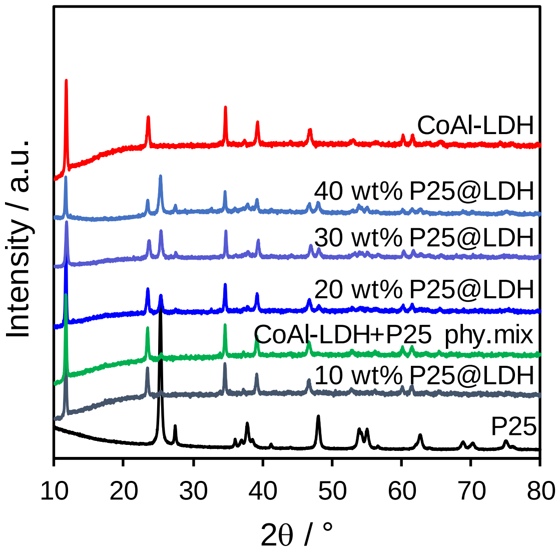

Figure S3. Powder XRD patterns of P25@CoAl-LDH nanocomposites, and reference patterns from P25, CoAl-LDH and a physical mixture of 20wt%P25+CoAl-LDH.

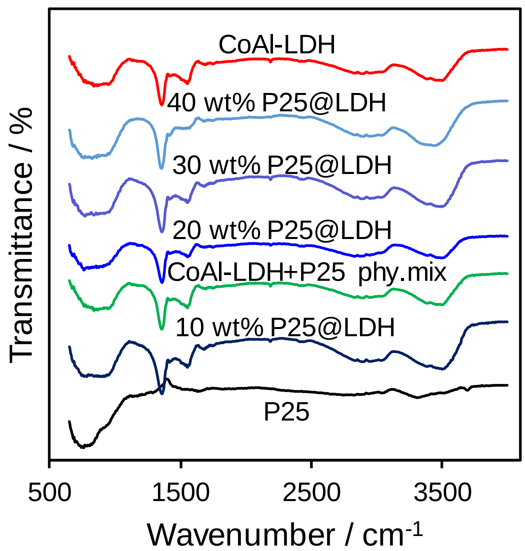

Figure S4. DRIFT spectra of P25@CoAl-LDH nanocomposites, and reference patterns from P25, CoAl-LDH and a physical mixture of 20wt%P25+CoAl-LDH.

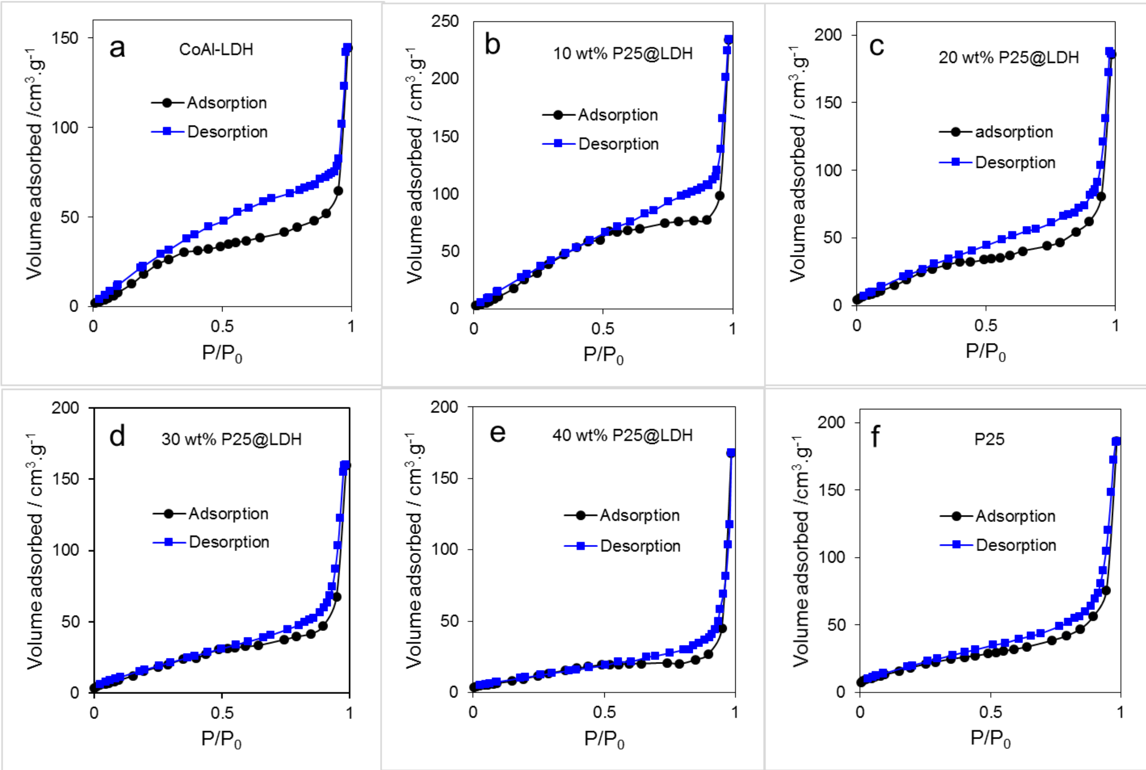

Figure S5. N_2 adsorption-desorption isotherms of CoAl-LDH, P25@CoAl-LDH nanocomposites and P25.

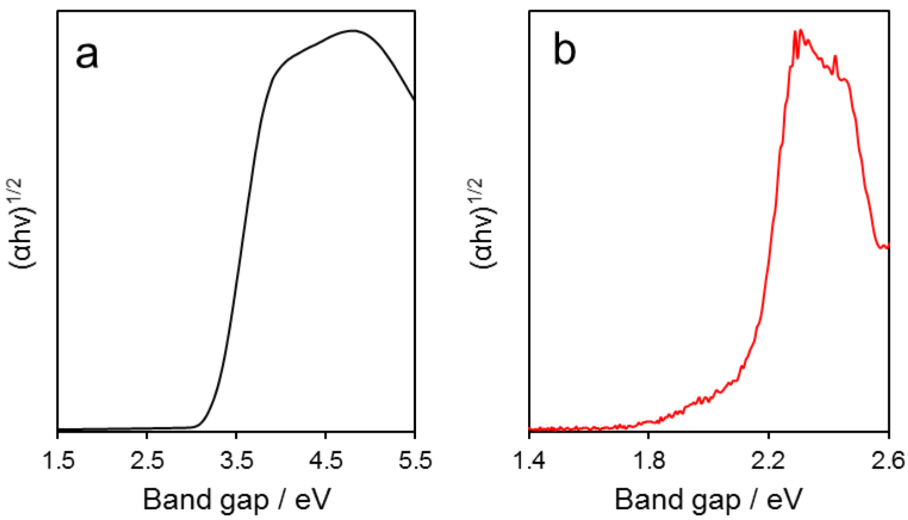

Figure S6. (a) Tauc plot to determine optical band gap of (a) CoAl-LDH and (b) P25 reference materials.

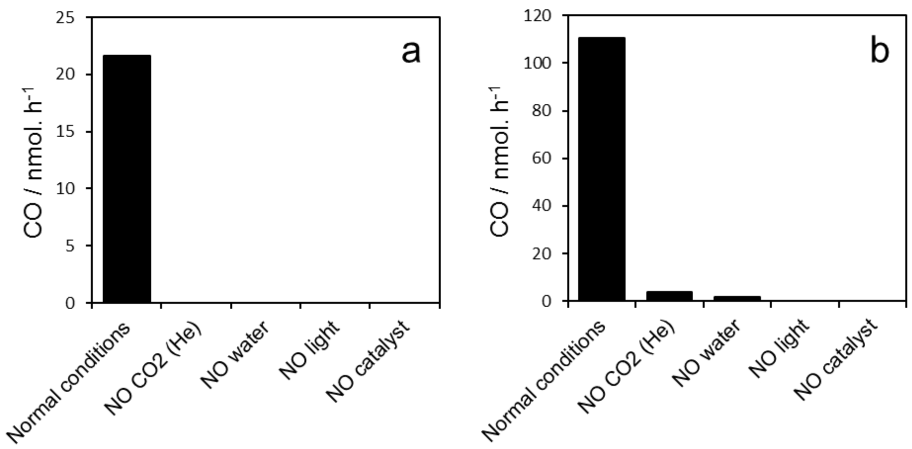

Figure S7. CO productivity during control experiments using (a) P25 and (b) 20 wt% P25@CoAl-LDH.

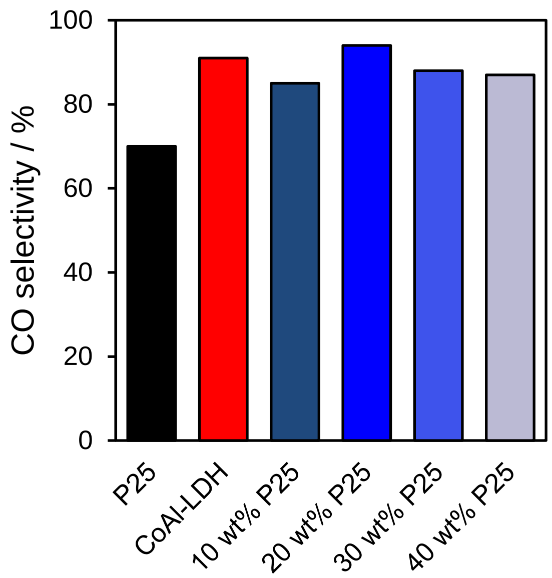

Figure S8. CO selectivity during aqueous phase CO_2 photoreduction over P25 and CoAl-LDH references and P25@CoAl-LDH nanocomposites under UV-visible irradiation.

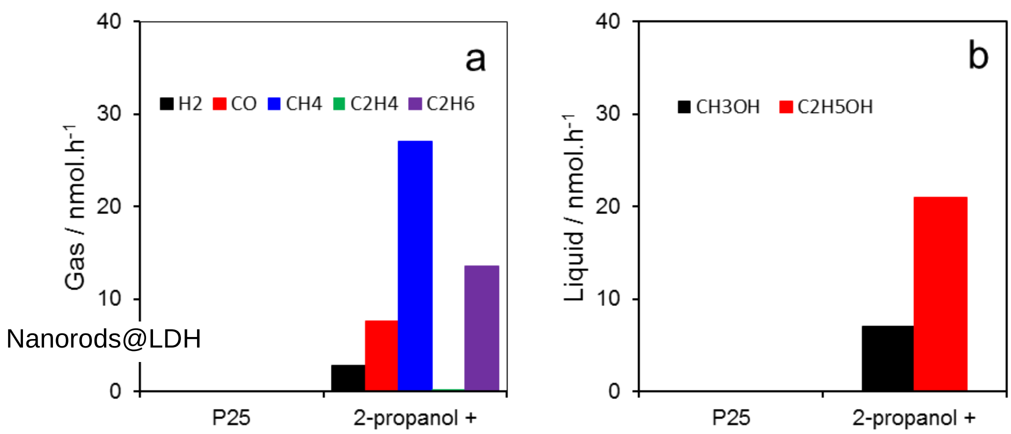

Figure S9. Effect of 2-propanol as a hole scavenger on photocatalytic production of (a) gas and (b) liquid phase carbon containing products during UV-visible irradiation under a He atmosphere.

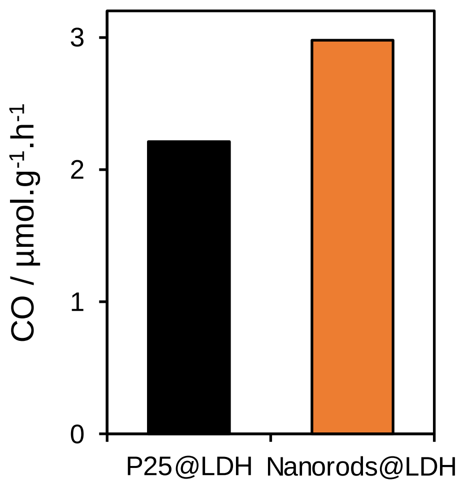

Figure S10. Effect of titania morphology on CO_2 photoreduction over 20 wt% P25@CoAl-LDH and 20 wt% anatase nanorod@CoAl-LDH nanocomposites under UV-visible irradiation. 18 nm long anatase nanorods prepared according to reference 11.

Table S1. Comparative performance of inorganic heterostructures for the photocatalytic reduction of CO_2

Material	Reaction conditions	Light source	Surface area / $m^2.g^{-1}$	Productivity / $\mu mol.g^{-1}.h^{-1}$	AQE / %	Ref.
$ZrOCo^{II}-IrO_x$ SBA-15 wafer	CO_2 and water vapor	355 nm UV light	-	CO=1.74	0.001 (355 nm)	[1]
Cu_2O/RuO_x	1 bar CO_2 and 0.7M aqueous Na_2SO_3	150 W Xe	-	CO=0.32	-	[2]
Cu^{II}-grafted Nb_3O_8 nanosheets	CO_2 and 0.5 M aqueous $KHCO_3$	Hg_Xe	-	CO=0.72	-	[3]
$Cu_xO-SrTiO_3$	CO_2 and 0.5 M aqueous $KHCO_3$	Hg–Xe	-	CO=0.35	-	[4]
Ce–TiO_2/SBA-15	CO_2 and water vapor	450 W Xe (450 $mW.cm^{-2}$)	140	0.30 (CO=0.25, CH_4=0.05)	-	[5]
Au@$SrTiO_3$	CO_2 and water vapor	300 W Xe	72	0.52 (CO=0.35, CH_4=0.17)	-	[6]
Cu-PbS-QDs/TiO_2	CO_2 and water	300 W Xe	-	1.71 (CO=0.82, CH_4=0.58, C_2H_6=0.31)	-	[7]
MgAl-LDO/TiO_2	CO_2 and water vapor <50 °C	450 W Xe	175	CO=1.5	-	[8]
Au@$NaTaO_3$	CO_2 and water vapor	200 W Hg-Xe	21	0.20 (CO=0.17, CH_4=0.03)	-	[9]
$In_2O_{3-x}(OH)_y$ Nanocrystal	CO_2 and water vapor	1000 W Hortilux Blue metal halide	159	CO=1.2	-	[10]
P25@CoAl-LDH	1 bar CO_2 and water	300 W Xe	57	CO=2.21	0.10 (365 nm) 0.03 (475 nm)	This work

References

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