Supplementary Information

Gas phase photocatalytic CO_2 reduction, “A brief overview for benchmarking”

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Calculation of AQY:

Photocatalytic reaction with Pt/TiO_2 mesoporous photocatalyst from [1]:

Main product: **CH_4**
Reactor type: Batch reactor (quartz tubular reactor)
Product yield: 5.7 µmol g_{cat}^{-1} after 120 mins
Apparent Light input (H): 348 W/m^2
Area of irradiation (A): computed from tubular reactor dimensions
(length: 28.0 cm × diameter: 3.0 cm) A = 0.0084 m^2
Band gap: 3.18 eV

The number of reacted electrons is computed by

$$\text{number of reacted electrons} = \begin{bmatrix}\text{mole of product} \\ \text{produced in time, t}\end{bmatrix} \times \begin{bmatrix}\text{number of electrons} \\ \text{required to produce} \\ \text{1 mol of product}\end{bmatrix} \times N_A$$

Since $CO_2 + 8H^+ + 8e^- \rightarrow CH_4 + 2H_2O$, there are 8 electrons required to produce 1 mol of CH_4 product

$$\text{number of reacted electrons} = \left[\frac{5.7\times10^{-6}}{2}\ \frac{\text{mol}}{\text{g}\cdot\text{h}}\right] \times [8] \times 6.022\times10^{23} \text{ per mol}$$

$$\text{number of reacted electrons} = 1.37\times10^{19}$$

The number of incident photons is computed by

$$\text{effective number of incident photons} = \frac{\text{light absorbed by the photocatalyst}}{\text{average photon energy}} \times t$$

Wherein light absorbed by the photocatalyst and average photon energy is found to be

$$\text{light absorbed by the photocatalyst} = H \times A = 348\ \frac{W}{m^2} \times 0.0084\ m^2 = 2.92\ W$$

$$\text{average photon energy} = \frac{hc}{\lambda}$$

Where λ is the average wavelength of the absorption range of the photocatalyst. We first computed the maximum wavelength from the band gap by using the formula:

$$\lambda_{max} = \frac{hc}{E_g} = \frac{(6.626\times10^{-34}\ J\cdot s) \times (3\times10^{8}\ m/s)}{3.18\ eV} \times \frac{1\ eV}{1.6\times10^{-19}\ J} \times 10^{9} = 390\ nm$$

Therefore, the average wavelength would be

$$\lambda = \frac{\lambda_{min} + \lambda_{max}}{2} = \frac{250 + 390}{2} = 320\ nm$$

The average photon energy is then computed to be

$$\text{average photon energy} = \frac{(6.626\times10^{-34}) \times (3\times10^{8})}{320 \times 10^{-9}\ m} = 6.21\times10^{-19}\ J$$

$$\text{number of incident photons} = \frac{2.92\ \text{W}}{4.91\times10^{-19}\ \text{J}} \times \frac{3600\ \text{s}}{\text{hr}}$$

$$\text{number of incident photons} = 1.69\times10^{22}$$

AQY computation:

$$\text{AQY (\%)} = \frac{\text{number of reacted electrons}}{\text{effective number of incident photons}} \times 100\%$$

$$\text{AQY (\%)} = \frac{1.37\times10^{19}}{1.69\times10^{22}} \times 100\% = 0.081\%$$

Table S1: Computation of AQY performance of photocatalysts by In et al.

Photocatalyst	Product	Product Yield (μmol/g/h)	Light input (W/m^2)	Area of irradiation (m^2)	Band gap (eV)	Wavelength λ_{min}	Wavelength λ_{max}	Ave. λ (nm)	No. of reacted electrons	Average photon energy (J)	No. of incident photons	AQY (%)
Degussa P25 [2]	**CH_4**	0.021	1200	0.00071	-	250	365	308	1.01×10^{17}	6.46×10^{-19}	4.74×10^{19}	0.0021
CZTS [3]	**CH_4**	0.082	1000	0.00071	1.5	250	828.3	539	3.95×10^{17}	3.69×10^{-19}	6.93×10^{21}	0.0057
CZTS-ZnO [4]	**CH_4**	0.095	1000	0.00041	1.74	250	714	482	4.58×10^{17}	4.12×10^{-19}	3.58×10^{21}	0.0128
Cu_xO–TiO_2 [5]	**CH_4**	0.152	1000	0.00071	3.15	250	394.4	322	7.32×10^{17}	6.17×10^{-19}	4.14×10^{21}	0.0177
Pt-X-RT [6]	**CH_4**	1.13	1000	0.00071	2.85	250	435.9	343	5.44×10^{18}	5.8×10^{-19}	4.41×10^{21}	0.1234
C,N-TNT06 [7]	**CH_4**	9.75	1000	0.00071	2.8	250	443.7	347	4.7×10^{19}	5.73×10^{-19}	4.46×10^{21}	1.0532
Pt-XG/RBT [8]	**CH_4**	37	1000	0.00049	2.41	250	515.5	383	1.78×10^{20}	5.19×10^{-19}	3.4×10^{21}	5.2479
	C_2H_6	11	1000	0.00049	2.41	250	515.5	383	9.27×10^{19}	5.19×10^{-19}	3.4×10^{21}	2.7303
Pt-BT-X [9]	**CH_4**	80.35	1000	0.00049	2.73	250	455.1	353	3.87×10^{20}	5.63×10^{-19}	3.13×10^{21}	12.36
$Cu_{x\%}$–$Pt_{y\%}$–BT [10]	**CH_4**	500	1000	0.00049	2.85	250	435.9	343	2.41×10^{21}	5.8×10^{-19}	3.04×10^{21}	79.14
	C_2H_6	25	1000	0.00049	2.85	250	435.9	343	2.11×10^{20}	5.8×10^{-19}	3.04×10^{21}	6.92

Table S2: Computation of AQY performance of photocatalysts from other research works

Photocatalyst	Product	Product Yield (μmol/g/h)	Light input (W/m^2)	Area of irradiation (m^2)	Band gap (eV)	Wavelength		Ave. λ (nm)	No. of reacted electrons	Average photon energy (J)	No. of incident photons	AQY (%)
						λ_{min}	λ_{max}					
$Cd_{1-x}Zn_xS$ [1] [11]	**CH_4**	0.22	2850	0.00091	2.33	400	510	455	1.06×10^{18}	4.37×10^{-19}	2.14×10^{22}	0.0049
	CO	2.9	2850	0.00091	2.33	400	510	455	3.49×10^{18}	4.37×10^{-19}	2.14×10^{22}	0.0163
Co-ZIF-9/TiO_2 [1] [12]	**CO**	17.58	4940	0.00081	-	200	900	550	2.12×10^{19}	3.61×10^{-19}	3.98×10^{22}	0.053
Pt/TiO_2 [1] [1]	**CH_4**	2.85	348	0.0084	3.18	250	391	320	1.37×10^{19}	6.21×10^{-19}	1.69×10^{22}	0.081[3]
In_2O_3–C_3N_4 [1] [13]	**CH_4**	7.991	12000	0.00063	2.8	250	444	347	3.85×10^{19}	5.73×10^{-19}	4.71×10^{21}	0.082[3]
TiO_{2-x}/CoO_x [1] [14]	**CH_4**	0.0903	200	0.00139	-	*ave*	365	365	4.35×10^{17}	5.45×10^{-19}	1.84×10^{21}	0.0237
	CO	1.2473	200	0.00139	-	*ave*	365	365	1.50×10^{18}	5.45×10^{-19}	1.84×10^{21}	0.0817
HCP-TiO_2-FG [1] [15]	**CH_4**	27.62	4330	0.00031	2.34	420	531	475	1.33×10^{20}	4.18×10^{-19}	1.17×10^{22}	1.14
	CO	21.63	4330	0.00031	2.34	420	531	475	2.61×10^{19}	4.18×10^{-19}	1.17×10^{22}	0.2227
Pd_xCu_1-TiO_2 [1] [16]	**CH_4**	19.6	20	0.0064	-	250	400	325	9.44×10^{19}	6.12×10^{-19}	7.53×10^{20}	12.53[3]
In/TiO_2 [1] [17]	**CH_4**	244	400	0.0012	3.2	250	388	319	1.18×10^{21}	6.23×10^{-19}	2.77×10^{21}	42.39[3]
	CO	81	400	0.0012	3.2	250	388	319	9.76×10^{19}	6.23×10^{-19}	2.77×10^{21}	3.52[3]
ZnV_2O_4 [1] [18]	**CH_3OH**	100	200	0.0012	2.1	250	592	421	3.61×10^{20}	4.72×10^{-19}	1.83×10^{21}	19.75[3]
	CO	485	200	0.0012	2.1	250	592	421	5.84×10^{20}	4.72×10^{-19}	1.83×10^{21}	31.92[3]
Cu/GO-2 [2] [19]	**CH_3OH**	2.94	1000	0.00442	2.51–3.09	402	495	449	1.06×10^{19}	4.43×10^{-19}	3.59×10^{22}	0.0296
	CH_3CHO	3.88	1000	0.00442	2.51–3.09	402	495	449	2.34×10^{19}	4.43×10^{-19}	3.59×10^{22}	0.065

[1] Batch reactor

[2] Continuous flow reactor

[3] 250 nm was used as the minimum wavelength (λ_{min}) if the light wavelength range was not specified by the reference paper.

**All other AQYs not included here have been computed by the respective authors of the reference paper.

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