Supporting Information for

Perspective into practical solar to carbon monoxide production device with economic evaluation

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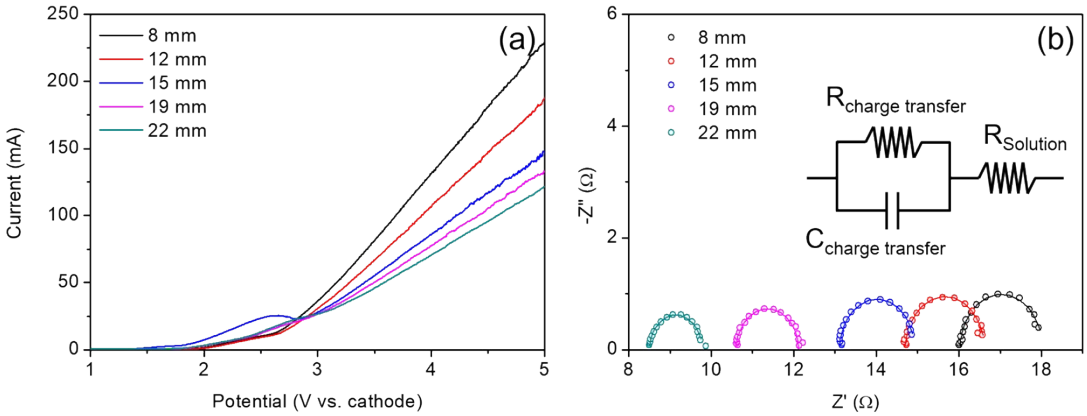

Fig. S1 (a) I-V curves of an electrochemical reactor with Ag cathode and IrO_x anode (b) Nyquist plot measured at 3.5 V.

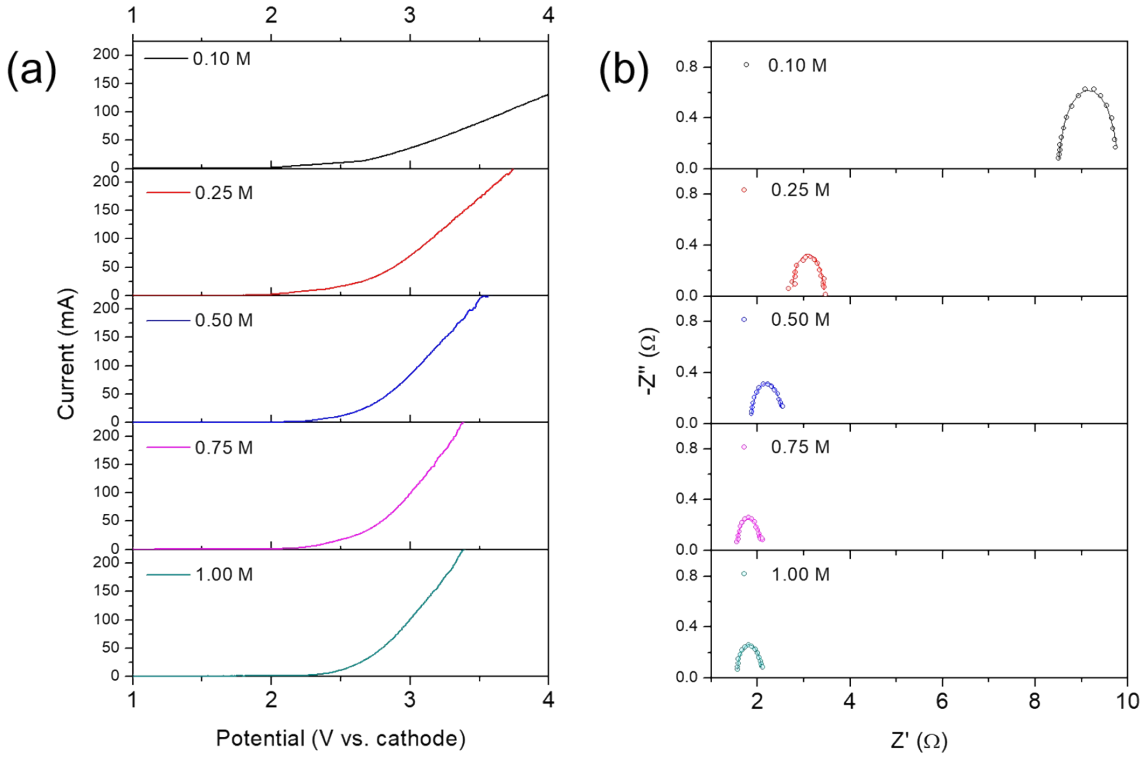

Fig. S2 (a) I-V curves of an electrochemical reactor with Ag cathode and IrO_x anode by catholyte concentration (b) Nyquist plot measured at 3.5 V.

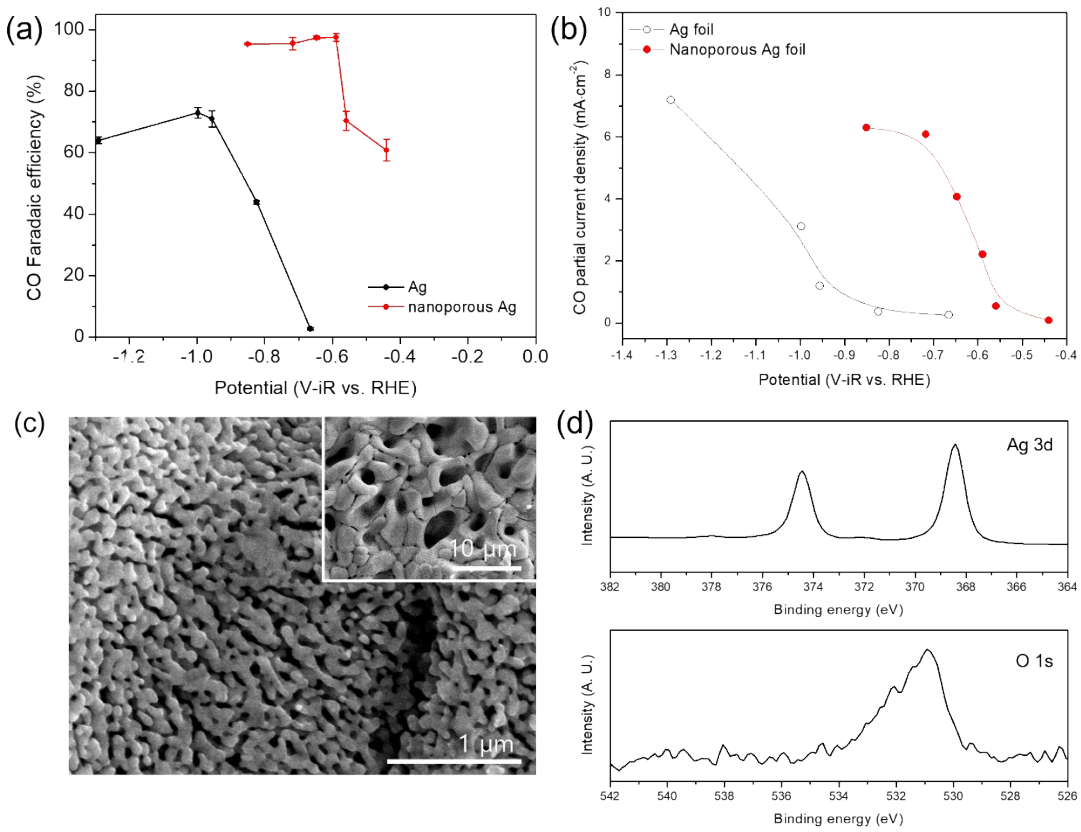

Fig. S3 Characterization of nanoporous Ag. (a) Faradaic efficiency (b) CO partial current density comparison for Ag foil and nanoporous Ag foil. (c) SEM image and (d) XPS data of nanonporous Ag foil.

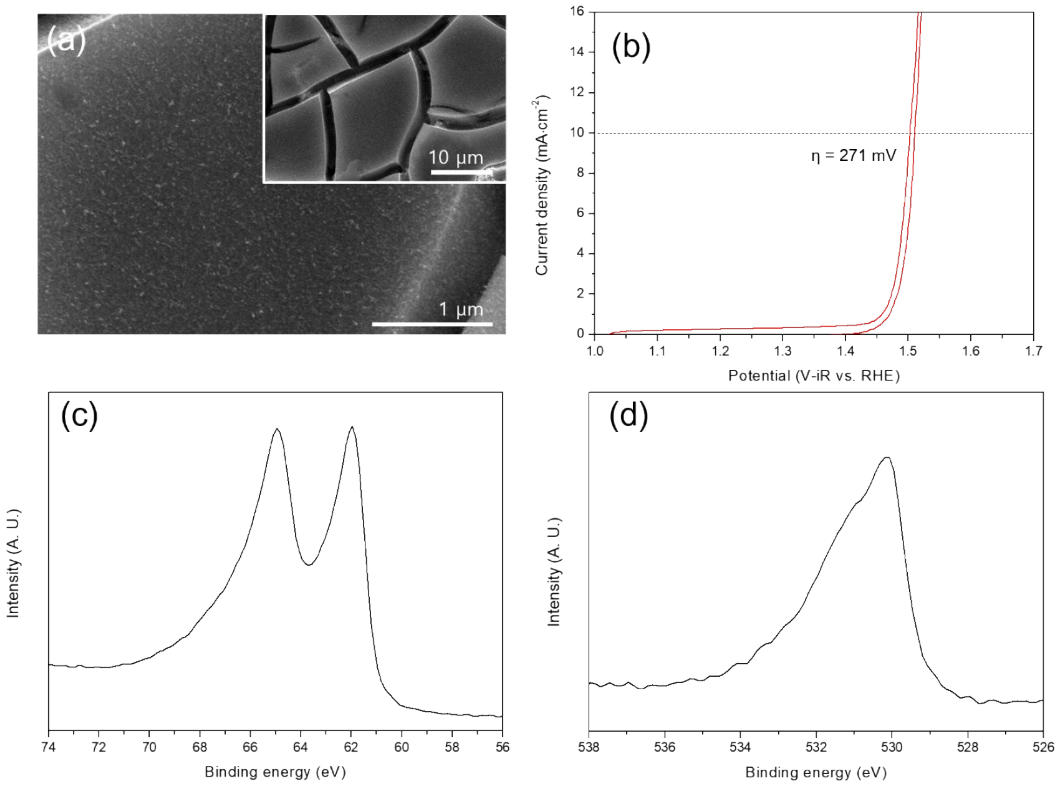

Fig. S4 Characterization of IrO_x film on Ti support. (a) SEM image (b) J-V curve. XPS spectra of (c) Ir 4f and (d) O 1S

Thermodynamic parameter regression

Herein, we applied Peng Robinson Equation of State for the precise prediction of the phase equilibrium. The equation for this model is:

$$P = \frac{RT}{V_m - b} - \frac{a}{V_m(V_m + b) + b(V_m - b)}$$

$$b = \sum_i x_i b_i$$

$$a = \sum_i \sum_j x_i x_j (a_i a_j)^{0.5} (k - k_{ij})$$

$$a_i = fnc(T, T_{ci}, P_{ci}, w_i)$$

$$b_i = fnc(T_{ci}, P_{ci})$$

$$k_{ij} = k_{ij}^1 + k_{ij}^2 T \qquad (E1)$$

where $P, R, T, V, and\ w$ respectively indicate. Pressure, gas constant, temperature, molar volume and acentric factor. The binary interaction parameter (k_{ij})of Peng-Robinson EOS is obtained by optimizing the maximum likelihood objective function (E2).

$$Q = \sum_{n=1}^{DG} \sum_{i=1}^{NP} \left[\left(\frac{T_{e,i} - T_{m,i}}{\sigma_{T,i}} \right)^2 + \left(\frac{P_{e,i} - P_{m,i}}{\sigma_{P,i}} \right)^2 + \sum_{j=i}^{NC-1} \left(\frac{x_{e,i,j} - x_{m,i,j}}{\sigma_{x,i,j}} \right)^2 + \sum_{j=i}^{NC-1} \left(\frac{y_{e,i,j} - y_{m,i,j}}{\sigma_{y,i,j}} \right)^2 \right] \qquad (E2)$$

Table S1. binary interaction parameter of CO_2 water for Peng Robinson EOS

Component i	Component j	$k^1_{i,j}$	$k^2_{i,j}$
CO_2	water	-0.141498	0

Table 1 shows Peng Robinson EOS binary interaction parameter for CO_2 water system. The Peng Robinson EOS precisely predict phase behavior of CO_2 water system around target operating conditions

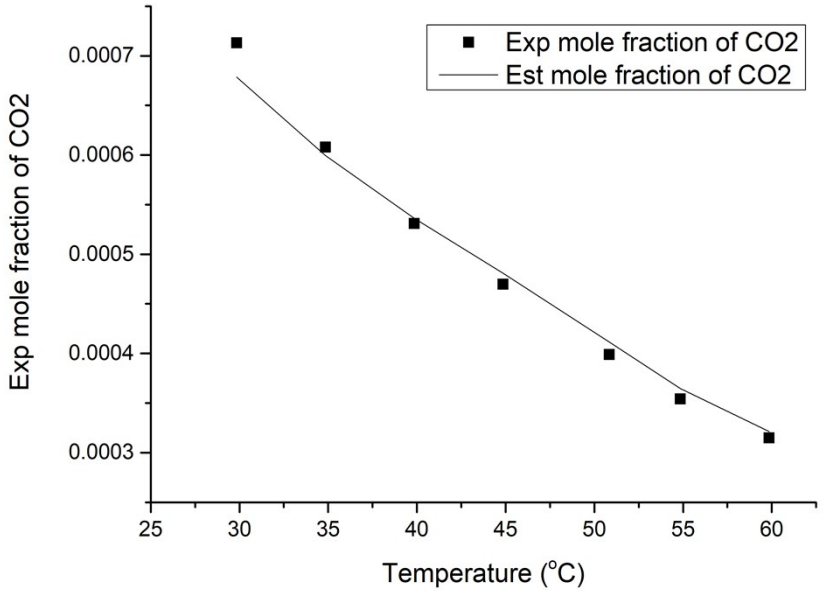

Fig. S5. Comparison of the predicted and measured CO_2 mole fraction at 1 bar

Table S2 Mass and energy balance table of CO production process

Stream Name	1	2	3	4	5	6	7	8	9	10	11	12	13
Temperature (˚C)	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2	35.2
Pressure (bar)	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0
Mass Flows (kton/hr)	0.31	0.30	0.25	482.9	482.9	482.9	482.8	0.1	482.2	482.2	482.2	0.3	0.0
Mass Fractions	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CO_2	1.000	0.000	0.980	0.001	0.001	0.001	0.001	0.873	0.000	0.000	0.000	0.000	0.000
Water	0.000	1.000	0.020	0.999	0.999	0.999	0.999	0.020	1.000	1.000	1.000	1.000	0.028
CO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.107	0.000	0.000	0.000	0.000	0.000
H_2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
O_2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.972

Table S3 Operating energy consumption of 4 MW CO production process

	Value	**Unit**
CO_2 conversion	1.4	%
PV efficiency	18.7	%
EC reaction efficiency	43	%
Solar to CO efficiency	8.04	%
Operating Energy		
Pump1	159	W
Pump2	159	W
Electrolyzer	1.72	MW