Supplementary Materials

A Membrane Reactor with Microchannels for Carbon Dioxide Reduction in Extraterrestrial Space

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1. Evaluation of FE

The FE for gas products was calculated as follows:

$$FE = \frac{Q_{gas}}{Q} = \frac{v \times y \times \alpha \times F \times P_0}{I \times R \times T_0} \quad (1)$$

where FE is the Faradaic efficiency of the gas product; Q is the total number of the charge consumed during the reaction; Q_{gas} is the charge corresponding to gas products; v represents the flow rate of CO_2; y is the measured concentration of the gas product; α is the number of electrons required to form a molecule of the gas product; F is the Faraday constant (96485 C mol^{-1}); P_0 is the standard atmosphere; R is the universal gas constant (8.314 J Mol^{-1} K^{-1}); T_0 is the absolute temperature; I is the total current.

2. Evaluation of SPCE

The single-pass carbon efficiency (SPCE) of CO_2 in each product was calculated as follows:

$$SPCE = \frac{\dfrac{j_x \times 60\ (\text{second})}{\alpha \times \text{F}}}{\dfrac{v(L/min) \times 1(\text{min})}{22.4(L/mol)}} \quad (2)$$

where j_x is the partial current density of specific products from CO_2 reduction, α is the electron transfer for every product molecule, and F is the Faradaic constant.

3. Evaluation of EE

The energy efficiency (EE) for C_2H_4 was calculated as follows:

$$EE_{C2H4} = \frac{(1.23 - E_{C2H4}) \times FE_{C2H4}}{E_{app}} \quad (3)$$

where E_{C2H4} is the thermodynamic potential (vs RHE) for CO_2RR to C_2H_4 species, which is 0.08 V for C_2H_4. E_{app} is the cell voltage in a two-electrode setup.

Citation: Feng, D.; Jiang, W.; Zhang, C.; Li, L.; Hu, B.; Song, J.; Yao, W. A Membrane Reactor with Microchannels for Carbon Dioxide Reduction in Extraterrestrial Space. *Catalysts* **2022**, *12*, 3. https://doi.org/10.3390/catal12010003

Academic Editors: Shangqian Zhu, Qinglan Zhao and Yao Yao

Received: 19 November 2021
Accepted: 19 December 2021
Published: 21 December 2021

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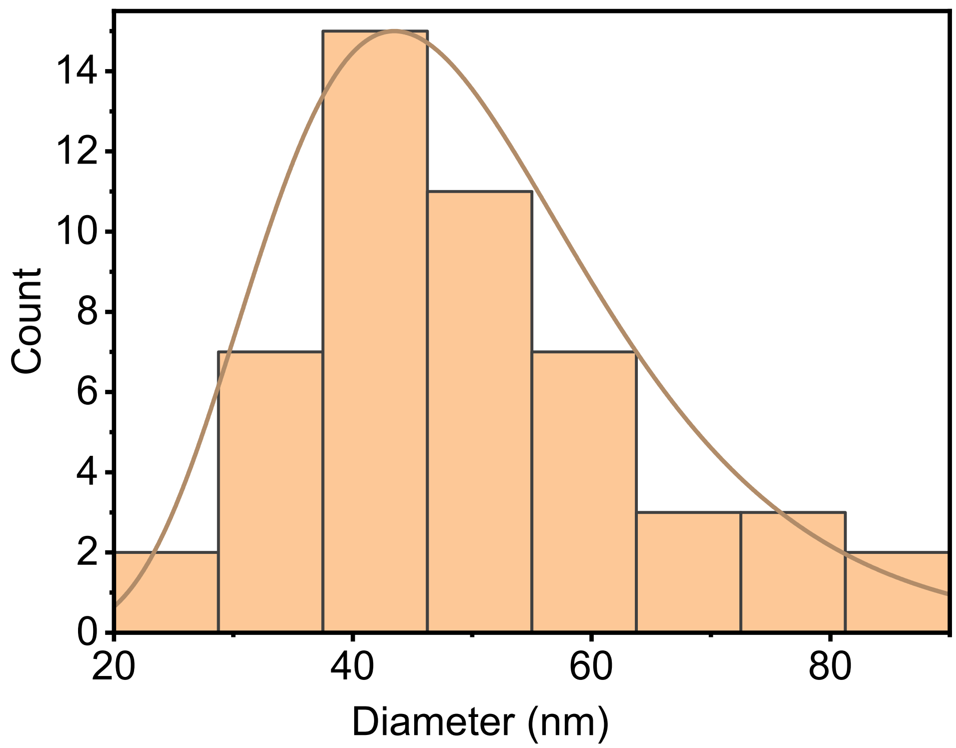

Figure S1. Diameter distributions of CuNWs.

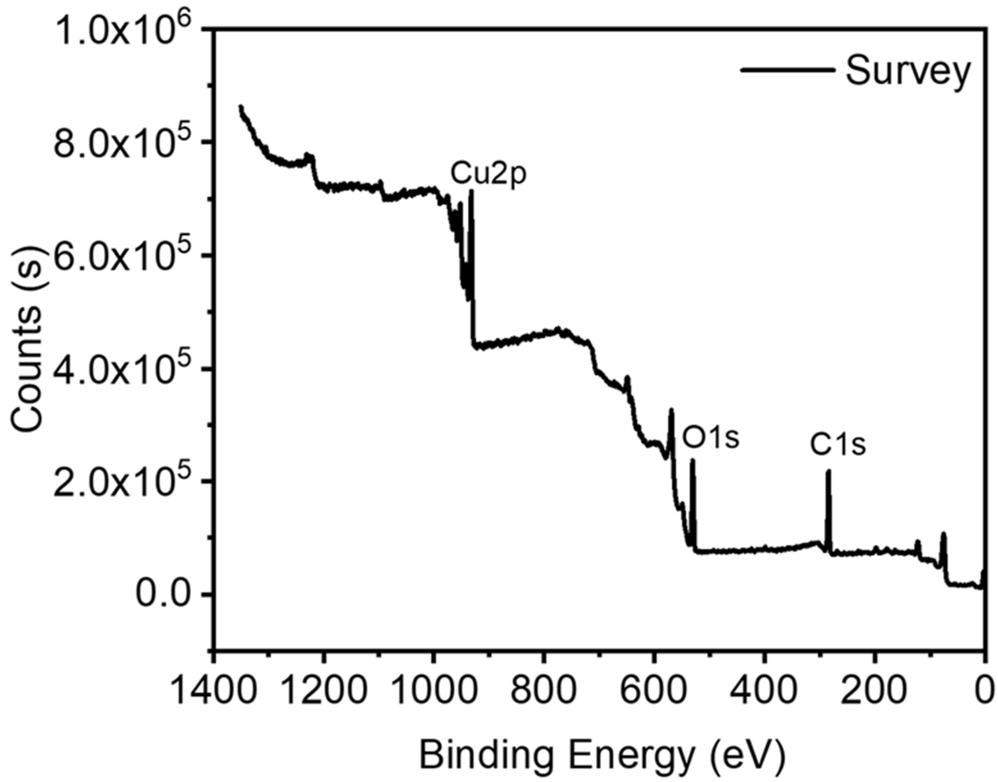

Figure S2. XPS of survey spectra of CuNWs.

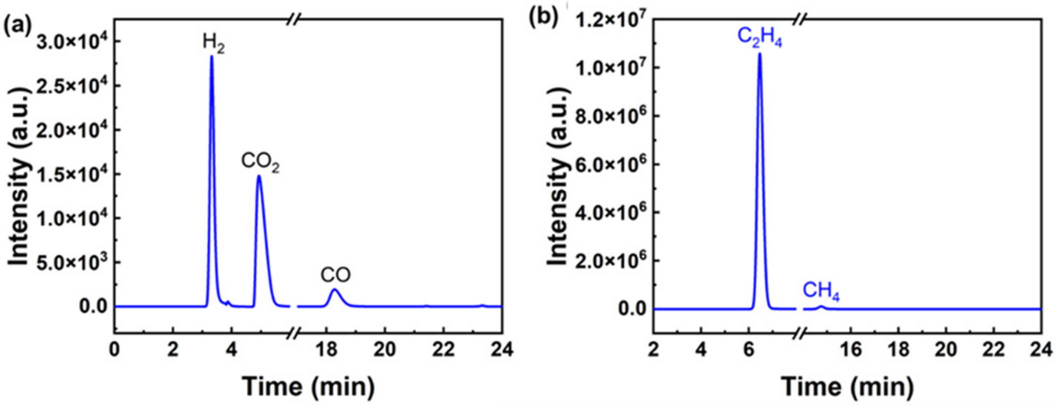

Figure S3. Typical (**a**) TCD and (**b**) FID chromatograms of cathodic gas products measured under the condition of CO_2 gas flow rate of 10 sccm, anolyte flow rate of 10 sccm, the voltage of 4.2 V, with the anion exchange membrane using Sustainion X37-50 Grade 60, and the channel type of series microchannel structure.

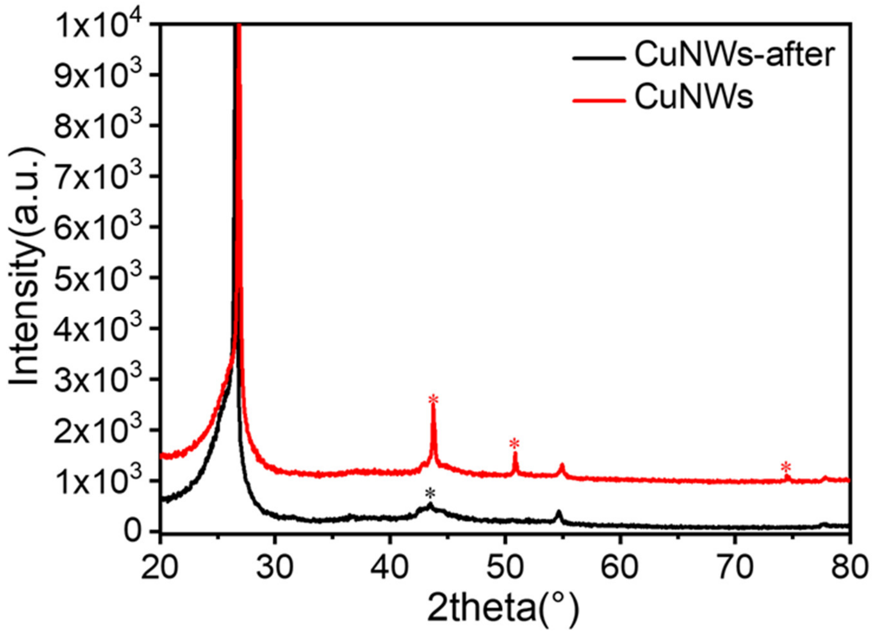

Figure S4. XRD patterns of CuNWs before and after reaction.

Table S1. The single-pass carbon efficiency (SPCE) of CO_2 in each product at 4.2 V.

	SPCE-CO (%)	SPCE-CH_4 (%)	SPCE-C_2H_4 (%)	SPCE-gas (%)
Grade 60	6.78	0.19	4.64	11.61
Grade T	7.20	0.19	4.14	11.54
FAA-3-30	5.34	0.17	3.17	8.68

Table S2. The energy efficiency (EE) of CO_2 in C_2H_4 at 4.2 V.

Membrane	Grade 60	Grade T	FAA-3-30
Energy Efficiency (%)	19.9	17.8	13.4

Table S3. Concentrations of Cu and Ir in the anodic solution before and after the reaction.

Reaction time (min)	Cu (%)	Ir (%)
0	0	0
30	3523.2	1422.7
60	3985.5	3255.5