Supplementary Material

An S-scheme heterojunction constructed from α-Fe_2O_3 and In-doped carbon nitride for high-efficiency CO_2 photoreduction

Jiaming Wu[a], Keyan Li[a,*], Jiahui Li[a], Jun Du[a], Xiangyang Li[a], Chunshan Song[a,b], Xinwen Guo [a,*]

[a]*State Key Laboratory of Fine Chemicals, PSU-DUT Joint Center for Energy Research, School of Chemical Engineering, Dalian University of Technology, Dalian 116024, China.*

[b]*Department of Chemistry, Faculty of Science, The Chinese University of Hong Kong, Shatin, Hong Kong 999077, China*

**Corresponding Author. E-mail address: keyanli@dlut.edu.cn; guoxw@dlut.edu.cn.*

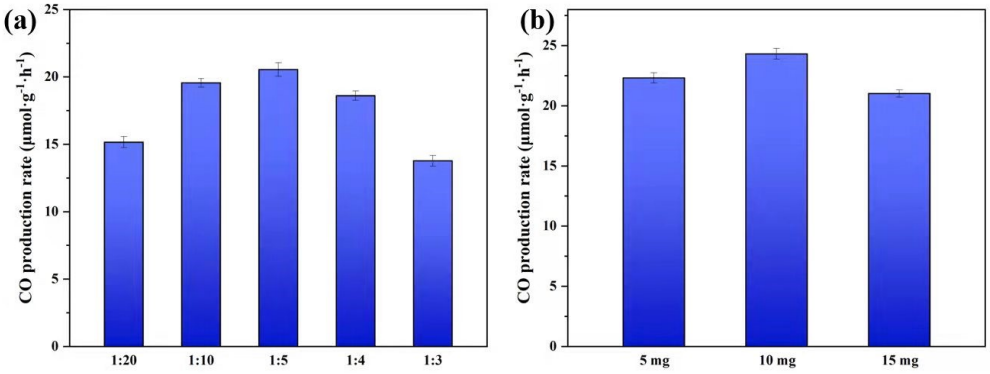

Fig. S1 Photocatalytic CO_2 reduction activity of (a) α-Fe_2O_3/PCN with different mass ratios of α-Fe_2O_3 to PCN and (b) α-Fe_2O_3/In-CN for which In-CN are prepared with different dosages of In-MOF. The corresponding In contents are 0.24 wt%, 0.41 wt% and 0.70 wt%, respectively.

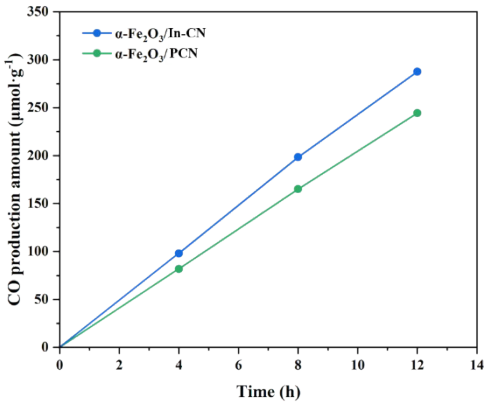

Fig. S2 Time-dependent CO yield of α-Fe_2O_3/PCN and α-Fe_2O_3/In-CN heterojunctions.

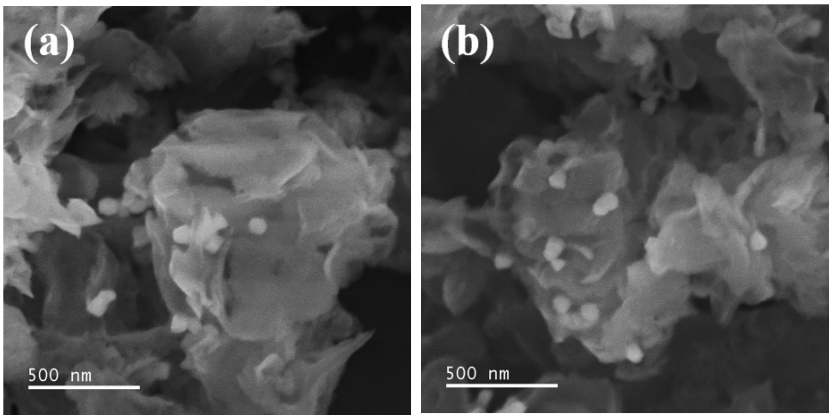

Fig. S3 SEM images of α-Fe_2O_3/In-CN (a) before reaction and (b) after continuous reaction for 12 h.

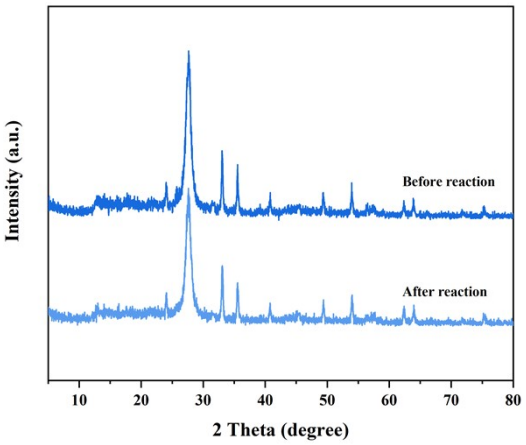

Fig. S4 XRD patterns of α-Fe_2O_3/In-CN before reaction and after continuous reaction for 12 h.

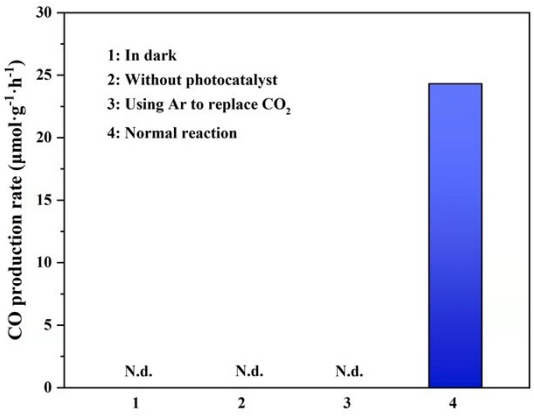

Fig. S5 CO production rate over α-Fe_2O_3/In-CN under various conditions (N.d.: not detected).

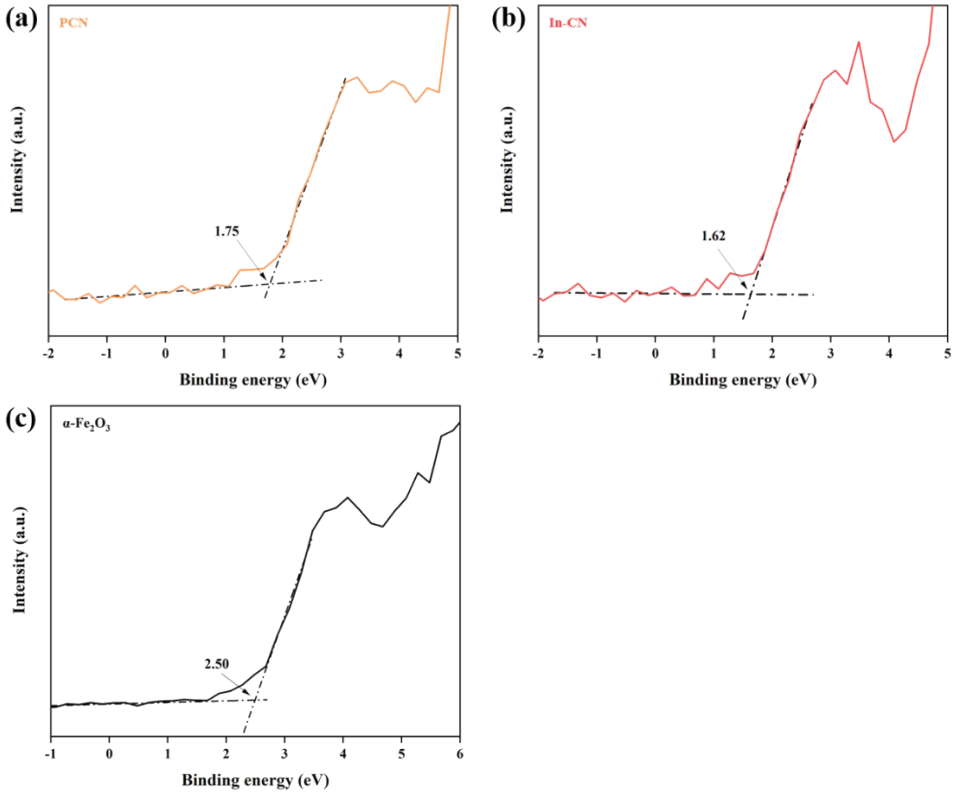

Fig. S6 Valence band (VB)-XPS spectra of (a) PCN, (b) In-CN and (c) α-Fe_2O_3.

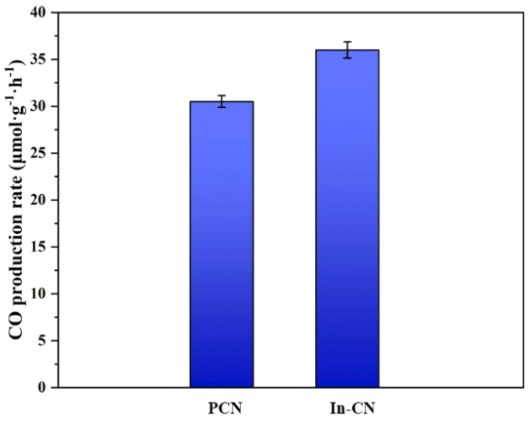

Fig. S7 Comparison of the photocatalytic activity of PCN and In-CN in the presence of TEOA as hole sacrificial agent.

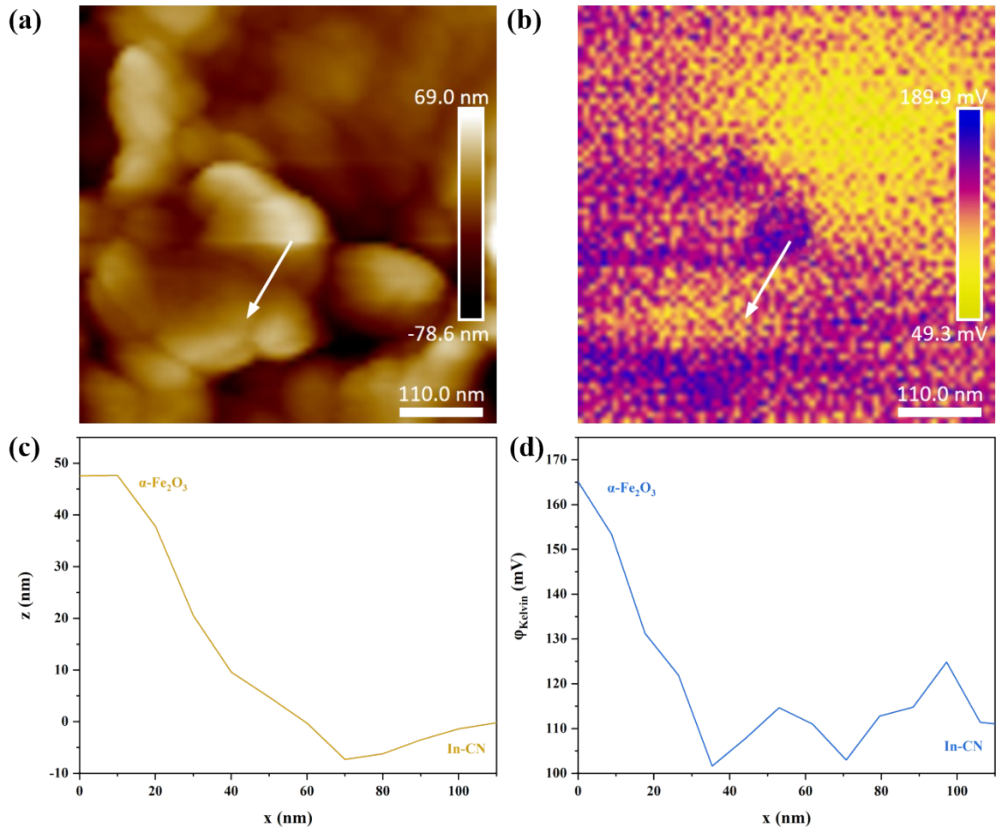

Fig. S8 (a) Topography image and (b) surface potential of α-Fe_2O_3/In-CN, (c,d) line-scanning profile and the corresponding Kelvin probe signal through one α-Fe_2O_3 nanoparticle.

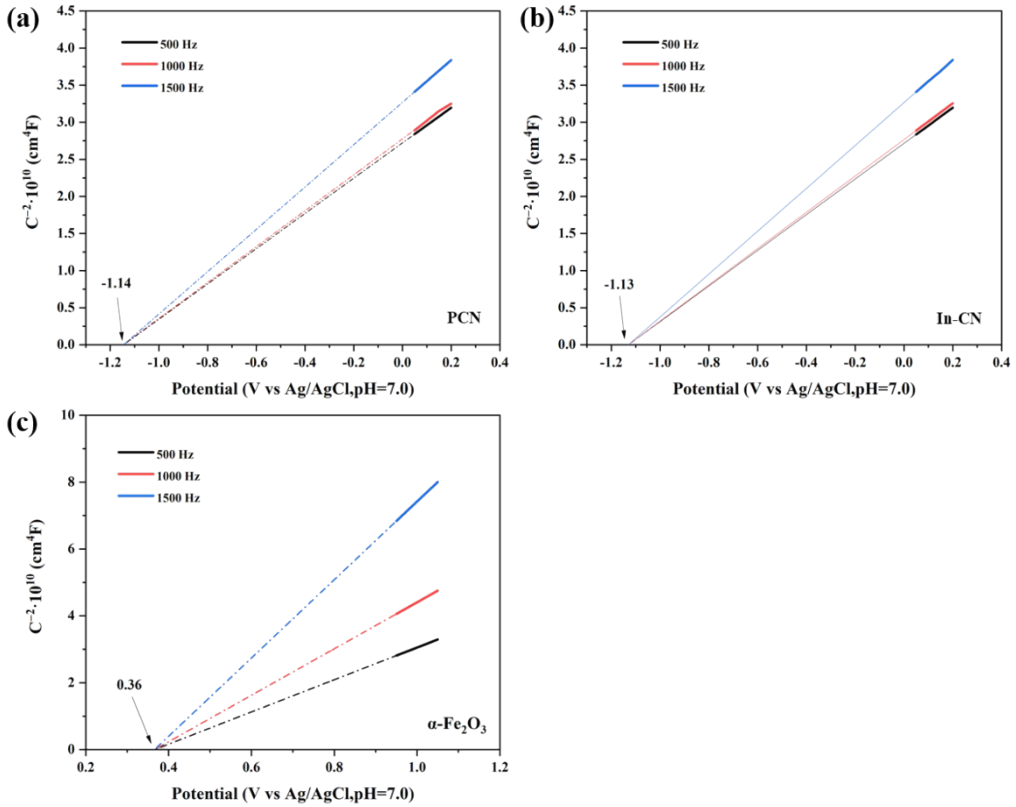

Fig. S9 Mott-Schottky plots of (a) PCN, (b) In-CN and (c) α-Fe_2O_3.

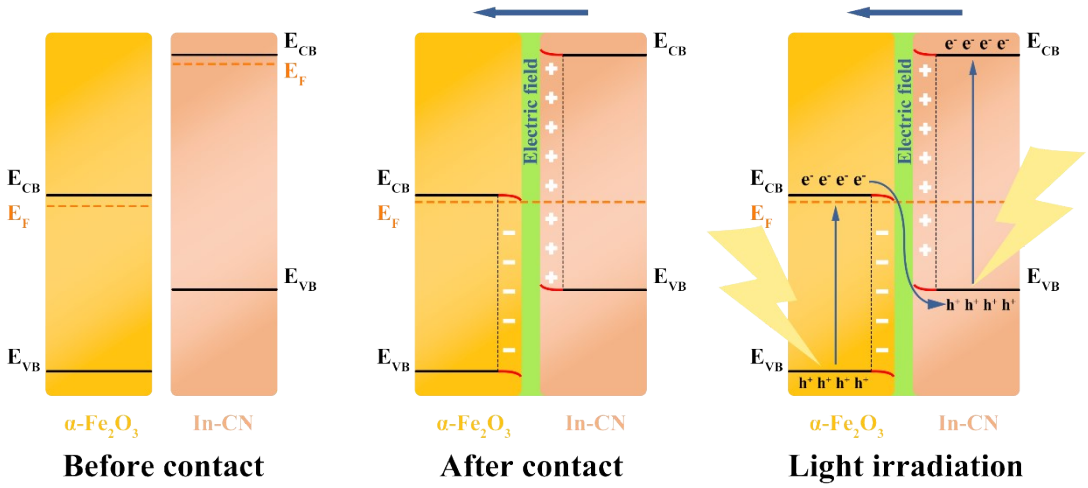

Fig. S10 Energy band positions of α-Fe_2O_3 and In-CN (a) before contact, (b) after contact, and (c) S-scheme charge transfer mechanism under light irradiation.

Table S1 Comparison of the CO_2 photoreduction performance of α-Fe_2O_3/In-CN with those of other photocatalysts reported in the literature.

Photocatalyst	Light source	Reaction medium	Product	Product generation rate ($\mu mol \cdot g^{-1} \cdot h^{-1}$)	Ref.
α-Fe_2O_3/In-CN	300W Xe lamp	Gas-solid, H_2O	CO	24.3	This work
MoS_2/TiO_2	300W Xe lamp	Gas-solid, H_2O	CO CH_4	2.83 1.45	[1]
NH_2-MIL-101(Fe) /g-C_3N_4	300W Xe lamp λ>400 nm	Gas-solid, TEOA	CO	22.13	[2]
Bi_3TiNbO_9	300W Xe lamp with AM1.5 G filter	Gas-solid, H_2O	CO	20.91	[3]
Mo/C_3N_4	300W Xe lamp λ>420 nm	Gas-solid, H_2O	CO H_2	18.0 37.0	[4]
Urchin-like α-Fe_2O_3/g-C_3N_4	300W Xe lamp	Gas-solid, H_2O	CO	27.2	[5]
$InVO_4$/β-$AgVO_3$	300W Xe lamp λ>420 nm	Gas-solid, H_2O	CO	12.61	[6]
$ZnFe_2O_4$/RGO/In_2O_3	300W Xe lamp	Gas-solid, H_2O	CO CH_4	8.85 1.95	[7]
Co_1-C_3N_4@α-Fe_2O_3	300W Xe lamp	Gas-solid, H_2O	CO	25.2	[8]
NiAl-LDH/Ti_3C_2	300W Xe lamp	Gas-solid, H_2O	CO	11.82	[9]
$LaPO_4$/g-C_3N_4	300W Xe lamp	Gas-solid, H_2O	CO	14.4	[10]

Table S2 The fitted parameters of time-resolved PL spectra.

Sample	τ_1 (ns)	f_1 (%)	τ_2 (ns)	f_2 (%)	τ (ns)
α-Fe_2O_3/In-CN	3.87	72.35	16.50	27.65	11.69
In-CN	4.03	81.13	17.44	19.77	10.76
α-Fe_2O_3/PCN	2.05	82.35	8.50	17.65	5.09
PCN	1.90	80.24	7.53	19.76	4.68

References

[1] Y. Li, J. Tang, Y. Wei, W. He, Z. Tang, X. Zhang, J. Xiong and Z. Zhao. *J. CO_2 Util.*, 2021, **51**, 101648.

[2] X.-Y. Dao, X.-F. Xie, J.-H. Guo, X.-Y. Zhang, Y.-S. Kang and W.-Y. Sun. *ACS Appl. Energy Mater.*, 2020, **3**, 3946-3954.

[3] H. Yu, F. Chen, X. Li, H. Huang, Q. Zhang, S. Su, K. Wang, E. Mao, B. Mei, G. Mul, T. Ma and Y. Zhang. *Nat. Commun.*, 2021, **12**, 4594.

[4] R. Zhang, P. Li, F. Wang, L. Ye, A. Gaur, Z. Huang, Z. Zhao, Y. Bai and Y. Zhou. *Appl. Catal. B: Environ*, 2019, **250**, 273-279.

[5] Z. Jiang, W. Wan, H. Li, S. Yuan, H. Zhao and P. K. Wong. *Adv. Mater.*, 2018, **30**, 1706108.

[6] J. Yang, J. Hao, S. Xu, Q. Wang, J. Dai, A. Zhang and X. Pang. *ACS Appl. Mater. Inter.*, 2019, **11**, 32025-32037.

[7] J. Li, F. Wei, C. Dong, W. Mu and X. Han. *J. Mater. Chem. A*, 2020, **8**, 6524-6531.

[8] B.-C. He, C. Zhang, P.-P. Luo, Y. Li and T.-B. Lu. *Green Chem.*, 2020, **22**, 7552-7559.

[9] Q. Shi, X. Zhang, Y. Yang, J. Huang, X. Fu, T. Wang, X. Liu, A. Sun, J. Ge, J. Shen, Y. Zhou and Z. Liu. *J. Energy Chem.*, 2021, **59**, 9-18.

[10] M. Li, L. Zhang, X. Fan, M. Wu, M. Wang, R. Cheng, L. Zhang, H. Yao and J. Shi. *Appl. Catal. B: Environ*, 2017, **201**, 629-635.