

**Tuning the activity of N-doped carbon for CO₂ reduction via
in-situ encapsulation of nickel nanoparticles into- nano-
hybrid carbon substrates**

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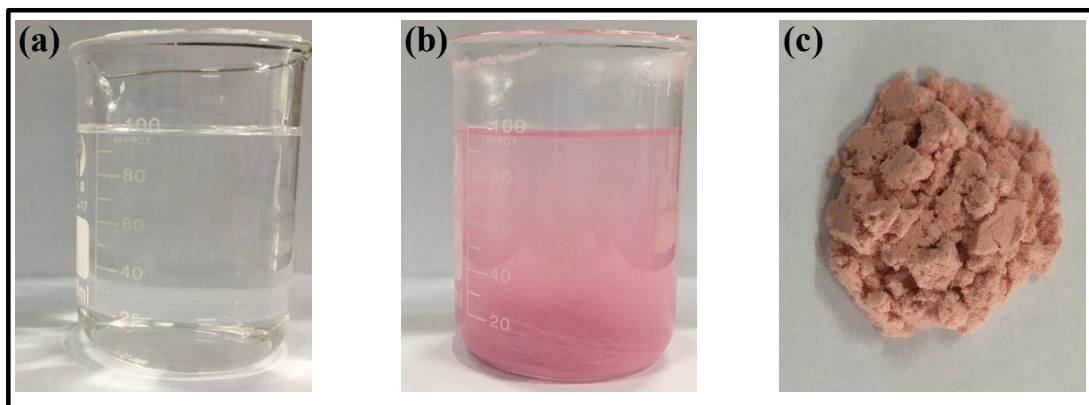


Fig. S1 The corresponding optical photographs of (a) Phen solution, (b) Ni-Phen in acetone solution and (c) Ni-Phen complex powder.

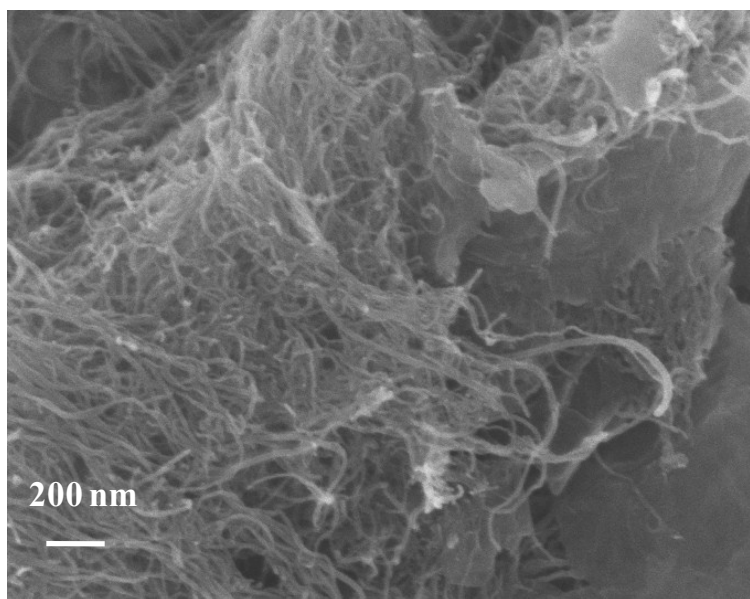


Fig. S2 The scanning electron microscope (SEM) image of obtained N-CHS.

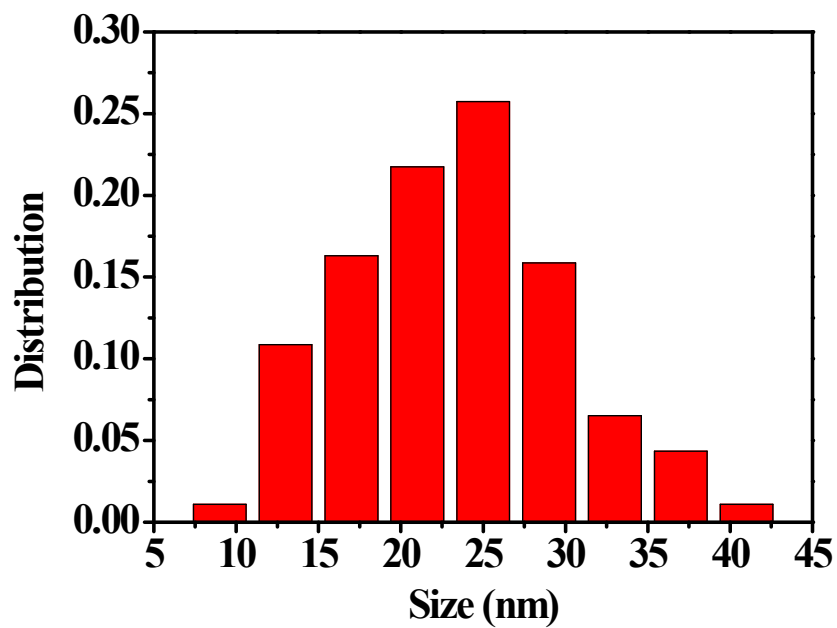


Fig. S3 The particle size distribution of the Ni NPs on the Ni/N-CHS determined from the TEM analysis.

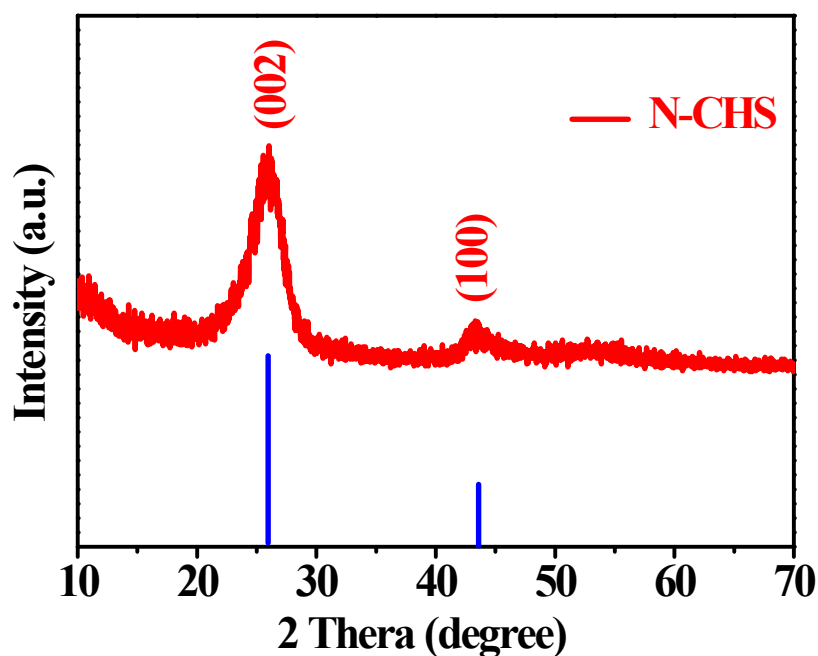


Fig. S4 X-ray diffraction (XRD) characterization of the as-synthesized N-CHS.

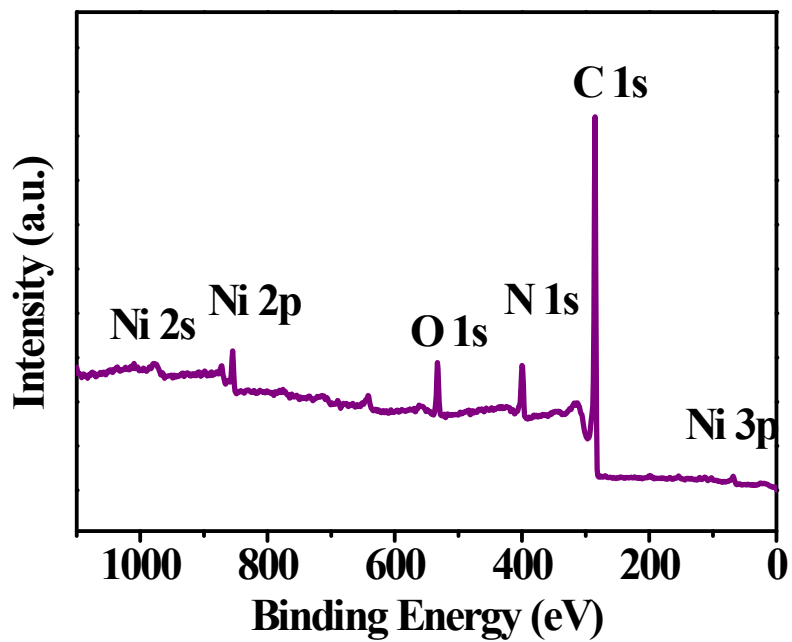


Fig. S5 The XPS survey spectrum of Ni/N-CHS sample.

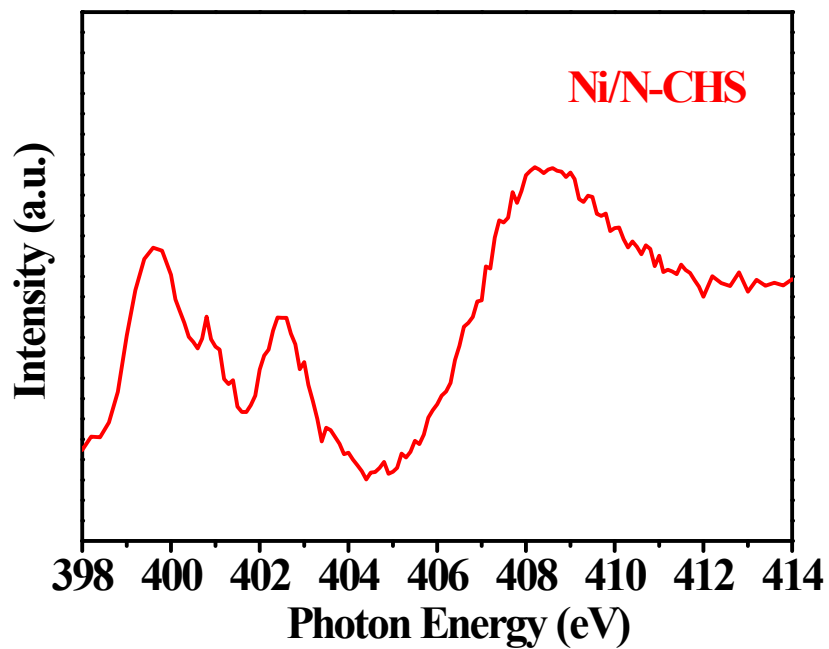


Fig. S6 The N K-edge X-ray absorption near-edge structure (XANES) spectrum of Ni/N-CHS.

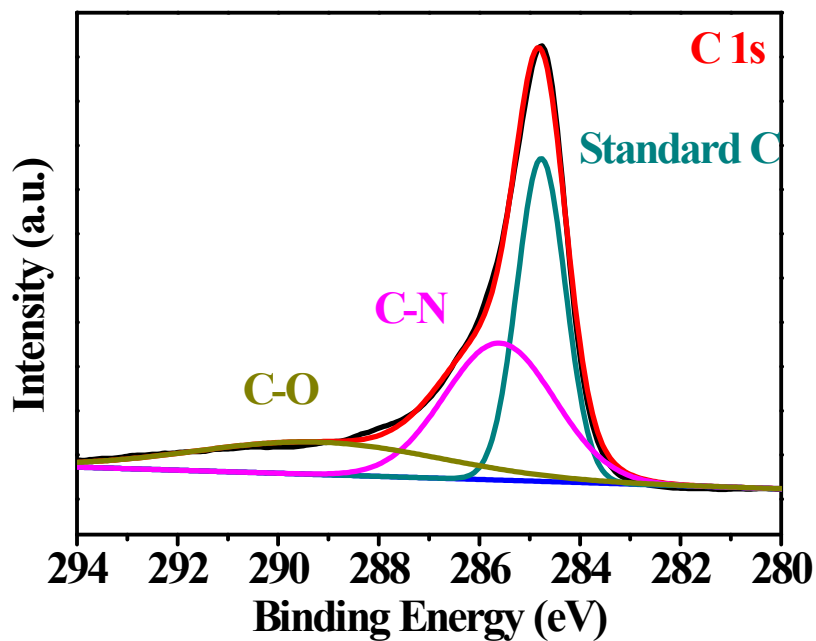


Fig. S7 The high-resolution C 1s XPS spectrum of Ni/N-CHS.

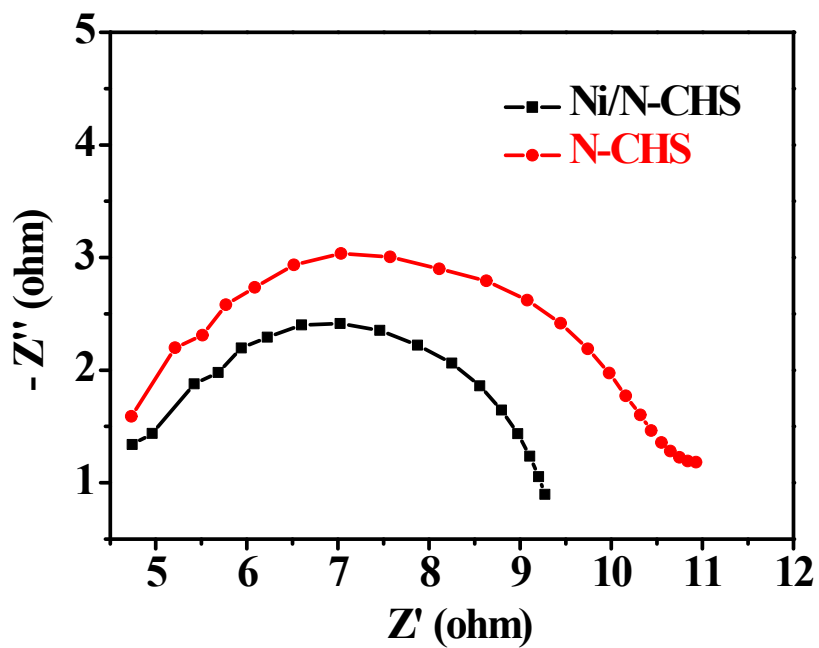


Fig. S8 The Nyquist plots of Ni/N-CHS and N-CHS catalysts.

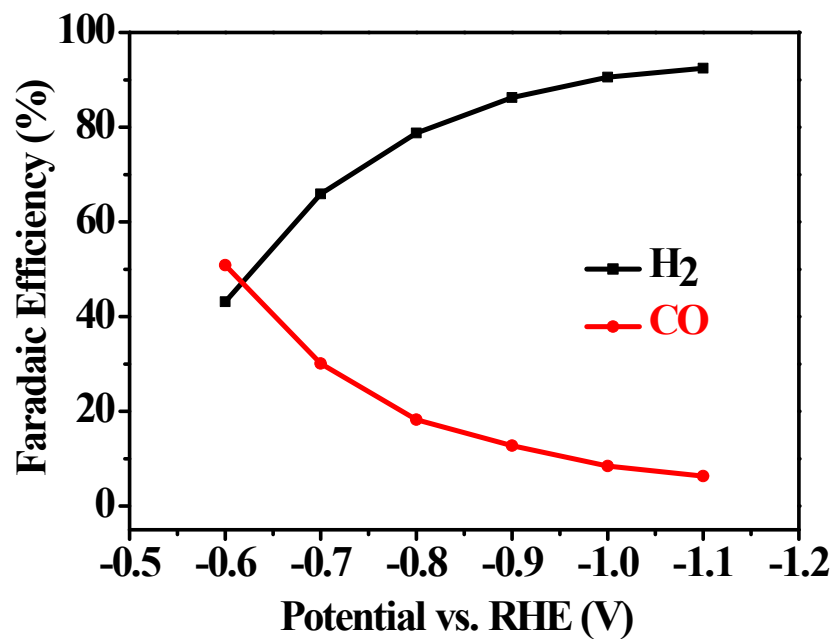


Fig. S9 The CO₂RR performances of N-C synthesized similarly without adding Ni source. The FE of CO production over N-C decreases from the potential -0.6 to -1.2 V, because the competing HER is dominant at high potential.

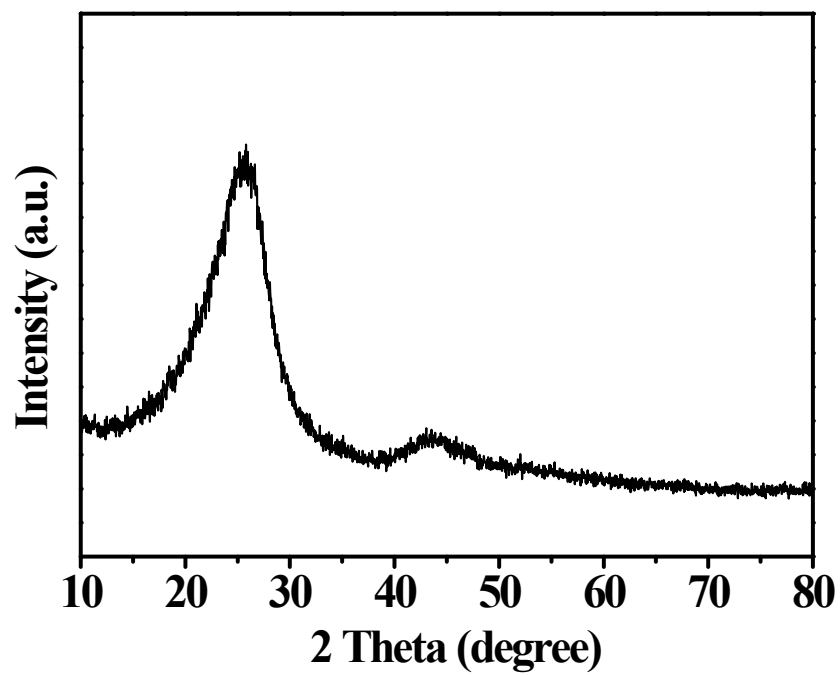


Fig. S10 The XRD pattern of obtained N-C.

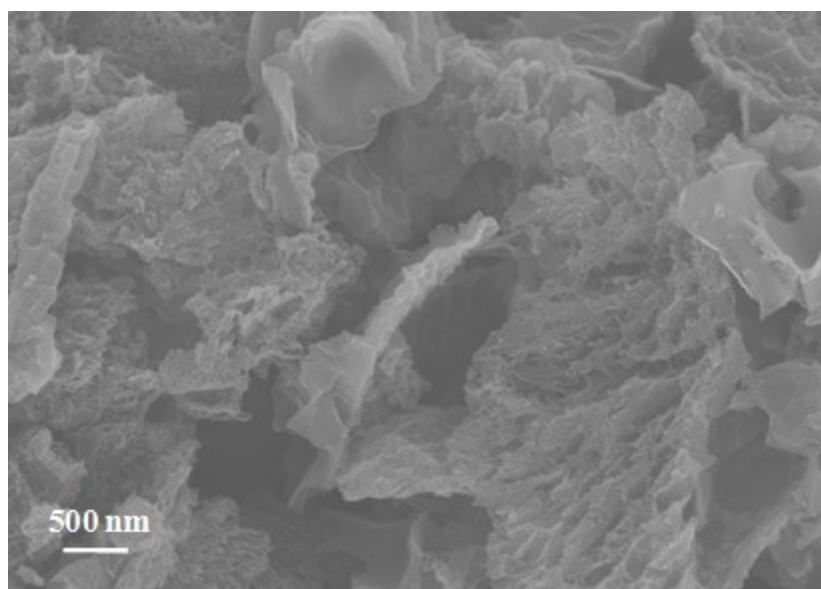


Fig. S11 The SEM image of obtained N-C.

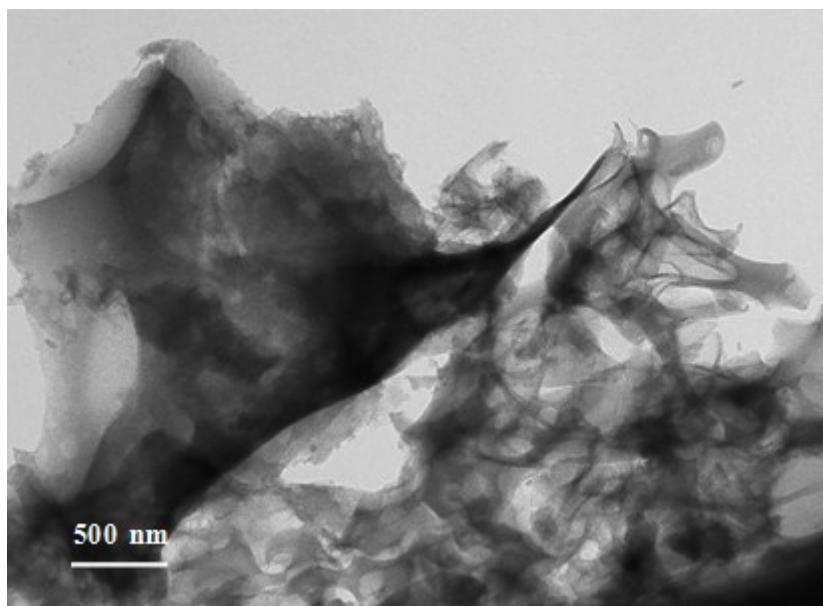


Fig. S12 The TEM image of obtained N-C.

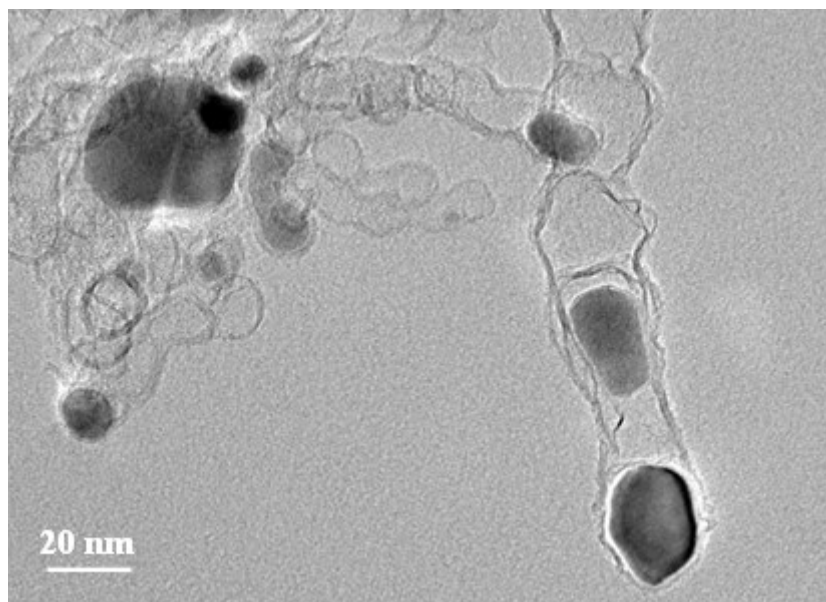


Fig. S13 The TEM image of this catalyst after electrocatalysis.

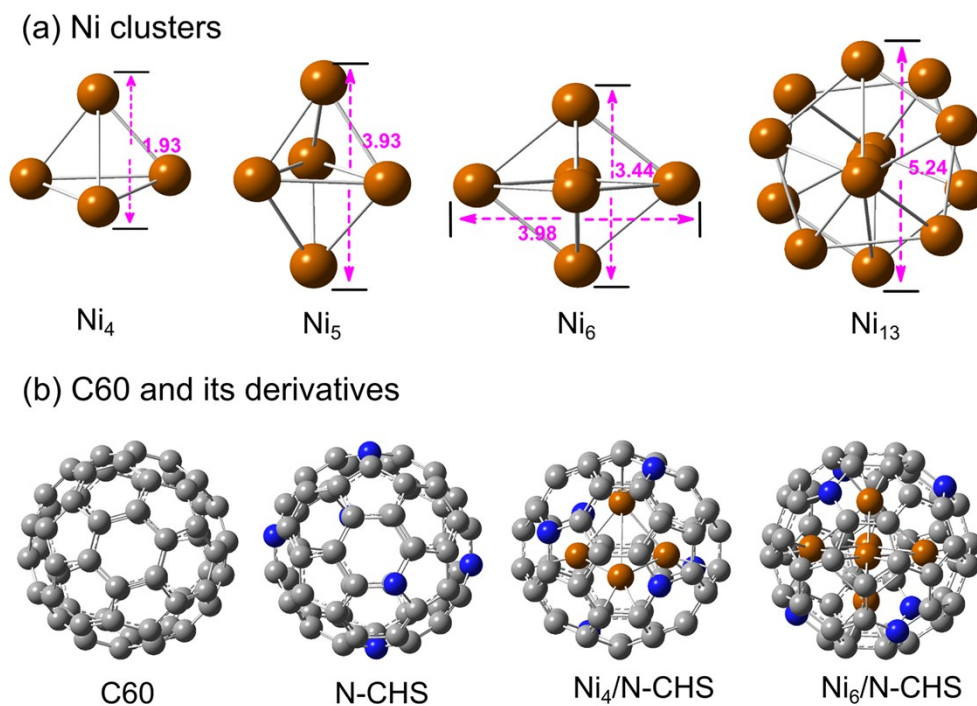


Fig. S14 (a) Structures and sizes of the optimized Ni_n clusters ($n = 4, 5, 6, 10, 13$). The distorted structure Ni_{10} was abandon. (b) C_{60} and its various derivatives: N-CHS, $\text{Ni}_4/\text{N-CHS}$ and $\text{Ni}_6/\text{N-CHS}$.

Table S1. Comparison the performances of electrochemical reduction CO₂ into CO production over some state-of-the-art materials.

Catalysts	Electrolyte	Potential (V vs. RHE)	FE _{CO} (%)	Ref.
Ni-CHS	0.5 M KHCO ₃	- 0.9	93	This work
Pd NPs	0.1 M KHCO ₃	- 0.89	91.2	1
Pd/C	0.5 M KHCO ₃	- 0.6	40	2
Au NPs	0.5 M KHCO ₃	- 0.67	90	3
Zn dendrite	0.5 M KHCO ₃	- 1.1	79	4
Ni-N-C	0.1 M KHCO ₃	- 0.75	85	5
Graphene foam	0.1 M KHCO ₃	- 0.58	85	6

References

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