Construction of La/NiAl-LDO Catalyst for CO_2 Methanation Performance and Reaction Kinetics

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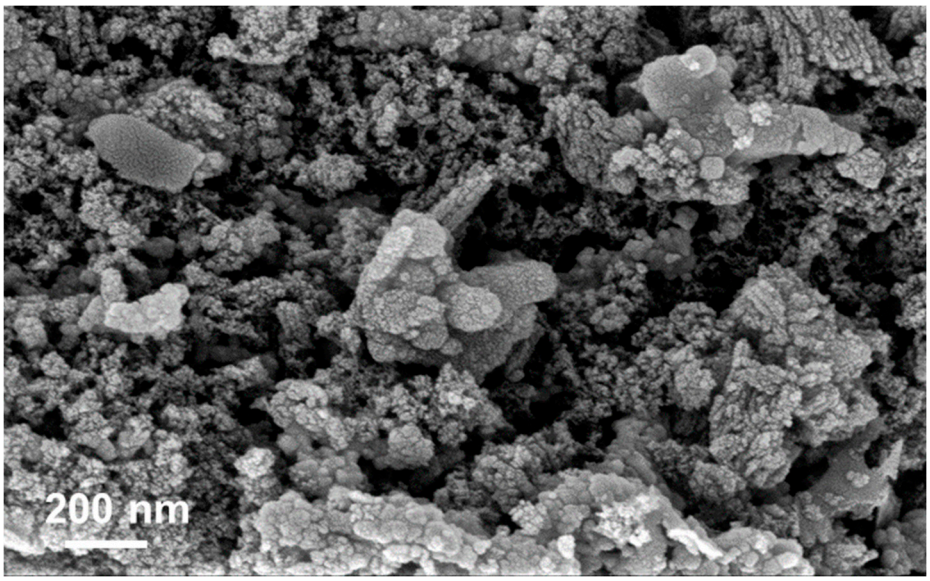


Figure S1 SEM images of the NiAl-LDO

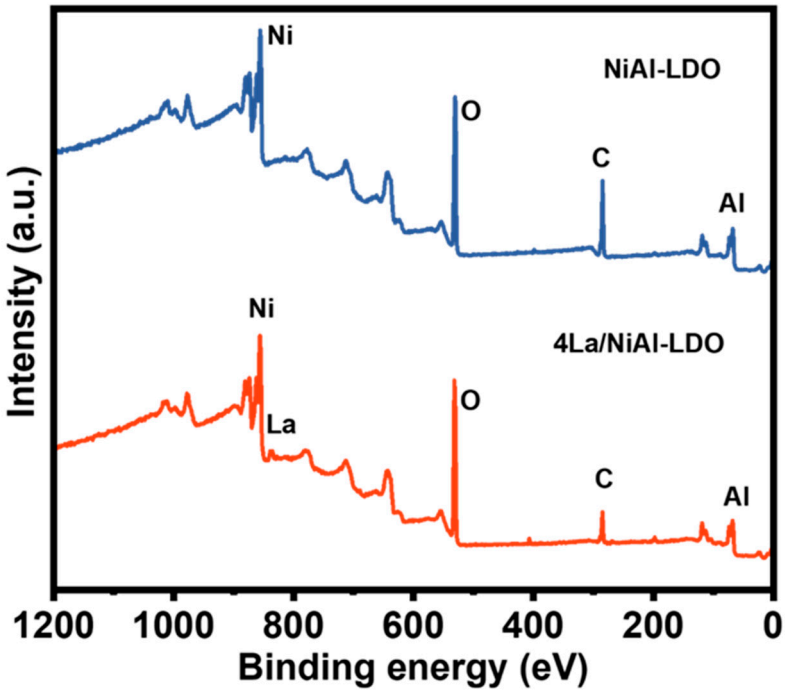


Figure S2 XPS survey spectra of NiAl-LDO, 6La/ NiAl-LDO

Table S1 Comparison of catalysts performance of CO_2 methanation over different catalysts

Type of catalyst	C (%)	S (%)	T (℃)	P (MPa)	WHSV (h^{-1})	STY (CH_4) (mmol/(g_{cat}·h))
Gd-Ni/SiO_2 [1]	9.3	100	300	1	27,015	600
Ni_{10}@γ/θ-Al_2O_3 [2]	81	>99	325	1	18,000	486
Ni–N_3 [3]	92.5	>99	350	3	320,000	1350
Ni/Al_2O_3/SiC[4]	53	>99	400	0.1	60000	180
Ni/Al_2O_3 [4]	48	>99	400	0.1	60000	163
NiAl-LDO [This work]	80.3	>99.9	300	2	8000	1692
6La/NiAl-LDO [This work]	85.6	>99.9	300	2	8000	1804

Note: $STY\ (CH4) = \frac{F_{CO_2\ (in)} \times 60 \times C_{CO_2} \times S_{CH_4}}{m_{cat}}$

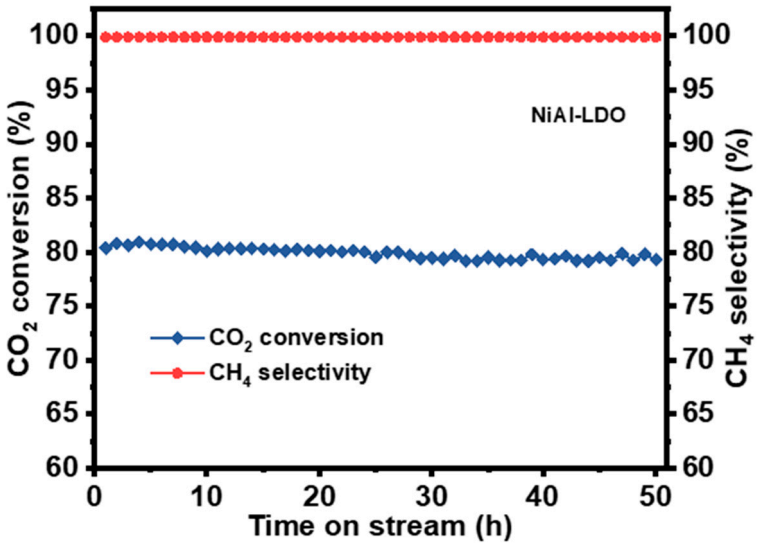


Figure S3 long-term stability evaluation in the CO_2 methanation over NiAl-LDO

Table S2 Conversion and reaction rate r over various reaction temperature and m/F

Temperature (℃)	m/F	Conversion (%)	r (mol/g·h)
250	0.30031	2.57	0.0857
265	0.30015	4.66	0.1554
275	0.30015	6.6	0.2234
285	0.30015	9.57	0.3191
300	0.1784	9.18	0.5139

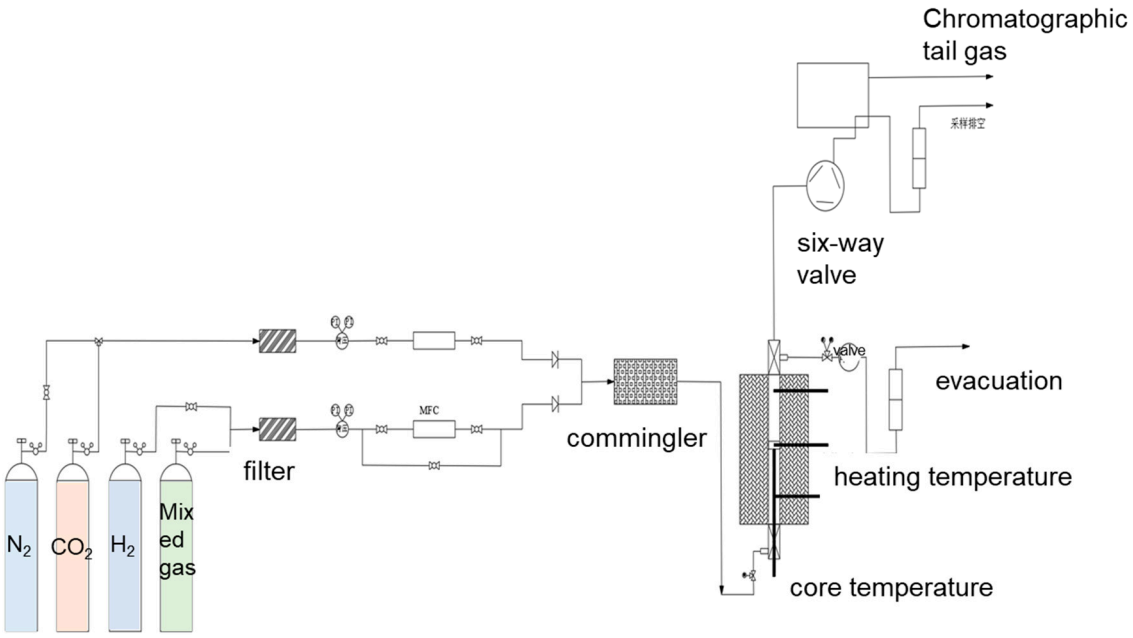
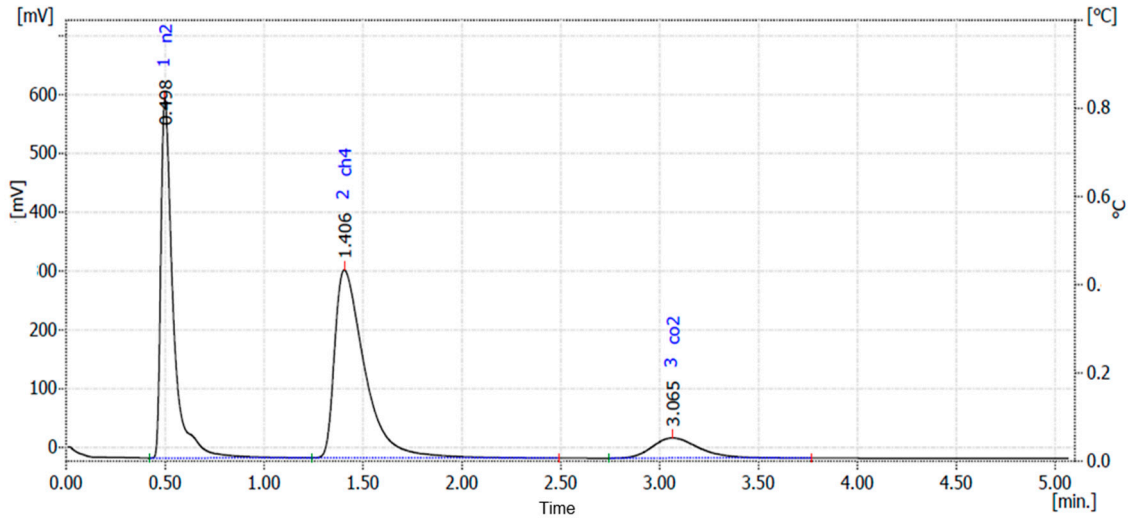


Figure S4 Diagram of catalyst performance evaluation device



NO.	Name.	Retention time (min)	Peak area	Concentration	Area percentage	Percentage concentration
1	n2	0.4983	2680.6520	25.9017	40.4395	48.9180
2	ch4	1.4059	3385.8310	23.1944	51.0776	43.8049
3	co2	3.0650	562.3188	3.8532	8.4830	7.2771
Sum			6628.8020	52.9493	100	1.0000

Figure S5 Product analysis chromatogram

1. Abir, M.A.; Phillips, R.E.; Klug, J.; Monte, G.; Harrah, J.; Schreiber, K.; Ball, M.R. Gadolinium-Modified Nickel Catalysts for Enhanced CO2 Methanation. *ACS Catalysis* **2025**, doi:10.1021/acscatal.5c06516.
2. Ni-Based Catalysts Coupled with SERP for Efficient Power-to-X Conversion Available online: https://www.mdpi.com/2073-4344/15/11/1082 (accessed on 7 December 2025).
3. Abbasi, Z.; Ren, J.; Li, Y.; Ahmed, S.M.; Ullah, I.; Lou, H.; Wu, W.; Wang, Z. Engineering a Pyridinic N–Ni Single-Atom Catalyst for Efficient Low-Temperature CO2 Methanation. *ACS Sustainable Chem. Eng.* **2025**, doi:10.1021/acssuschemeng.5c09269.
4. Liu, X.; Gao, F.; Huang, J.; Zeng, Y.; Zhong, Z.; Xing, W. Insights on the Effect of Si-Al

Interaction on Ni/Al2O3/SiC Monolithic Catalysts for CO2 Methanation. *Chinese Journal of Chemical Engineering* **2025**, *87*, 171–181, doi:10.1016/j.cjche.2025.05.031.