

Enhanced Low-Temperature CO₂ Methanation over Ni-based Catalyst Supported on La₂O₃-Al₂O₃ Composite Supports

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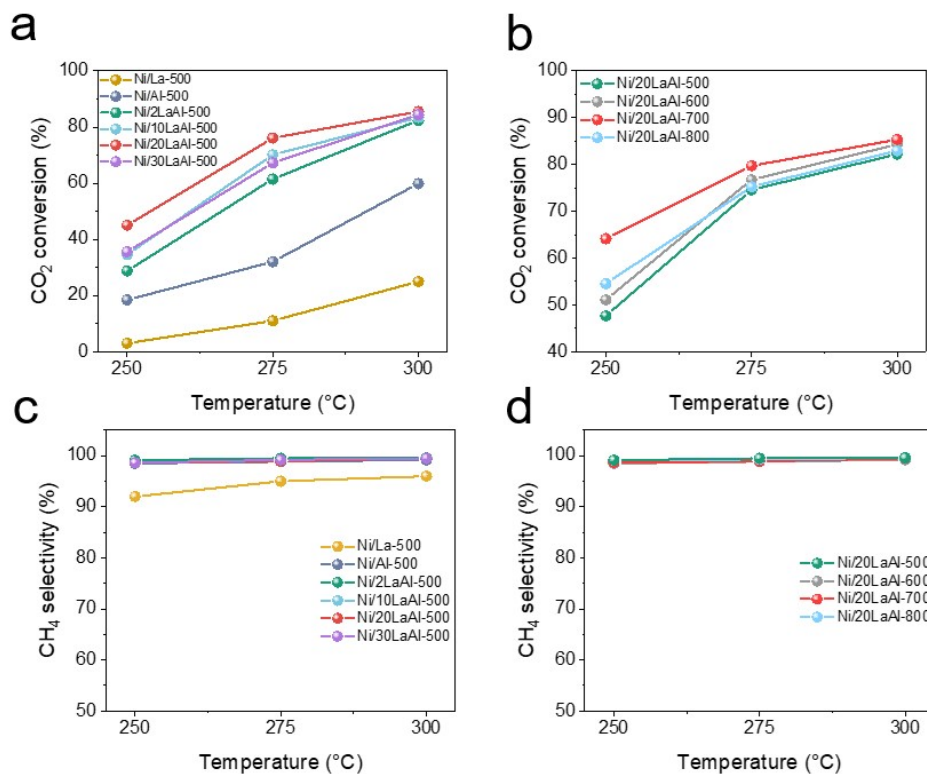


Fig. S1 CO₂ conversion and CH₄ selectivity of (a and c) Ni/30LaAl-500, Ni/20LaAl-500, Ni/10LaAl-500, Ni/2LaAl-500, Ni/Al-500 and Ni/La-500 catalysts, (b and d) Ni/20LaAl-500, Ni/20LaAl-600, Ni/20LaAl-700 and Ni/20LaAl-800 catalysts. (reaction conditions: 50 mg of catalyst, CO₂/H₂/N₂ = 15:60:25, 1 bar, WHSV = 30 L·h⁻¹·g⁻¹).

Table S1. Apparent activation energies for investigated Ni/Al-X and Ni/20LaAl-X catalysts.

Catalysts	Ea (kJ·mol ⁻¹)	
	CH ₄	CO
Ni/Al-500	121.13	91.64
Ni/20LaAl-500	100.78	60.11
Ni/Al-700	92.60	84.86
Ni/20LaAl-700	80.44	52.88

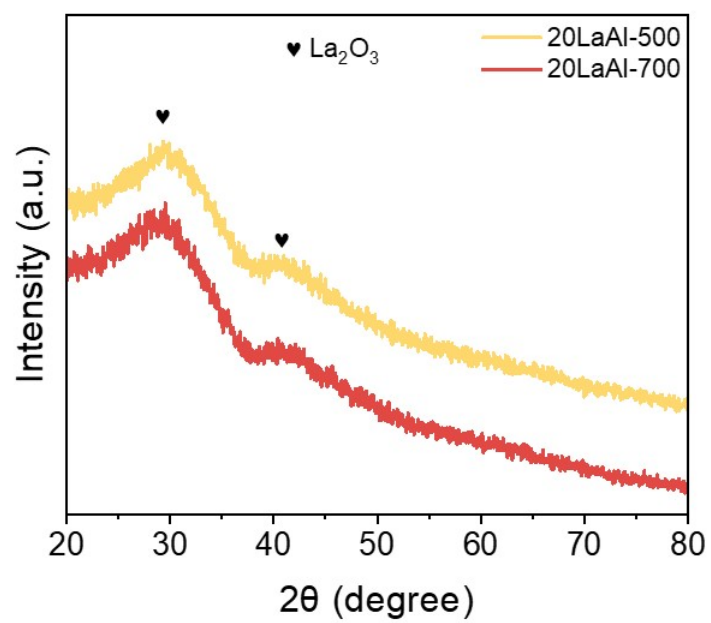


Figure S2. XRD patterns of 20LaAl-500 and 20LaAl-700 supports.

Table S2. Ni average size of the reduced Ni/Al-500, Ni/Al-700, Ni/20LaAl-500, Ni/20LaAl-700

catalysts obtained from 1. the Debye-Scherrer equation and 2. the TEM results.

Catalysts	Ni crystal size ¹ (nm)	Ni average size ² (nm)
Ni/Al-500	12.8	7.39
Ni/Al-700	15.1	7.96
Ni/20LaAl-500	6.5	6.11
Ni/20LaAl-700	8.3	4.71

Table S3. Surface atomic ratio of $\text{Ni}^0/(\text{Ni}^0+\text{Ni}^{2+})$ obtained from the XPS results.

Catalysts	$\text{Ni}^0/(\text{Ni}^0+\text{Ni}^{2+})$
Ni/Al-500	0.10
Ni/Al-700	0.13
Ni/20LaAl-500	0.19
Ni/20LaAl-700	0.21

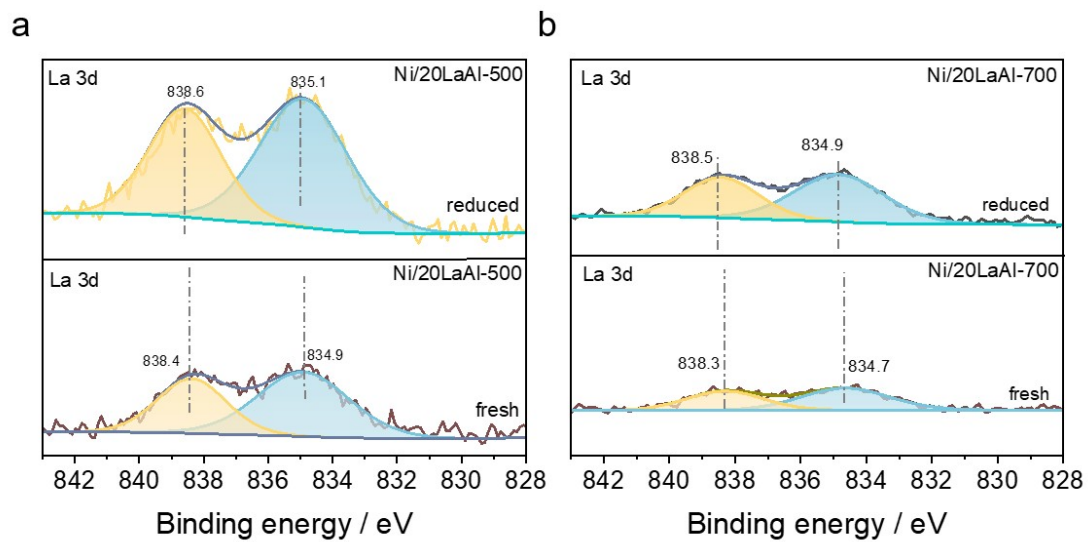


Fig. S3 Quasi *in-situ* XPS spectra of La 3d over (a) Ni/20LaAl-500 and (b) Ni/20LaAl-700 catalysts after calcination and H₂ reduction.

Table S4. Apparent reaction orders and for Ni/Al-700 and Ni/20LaAl-700 catalysts.

Catalysts	Reaction order of CH ₄ formation		Reaction order of CO formation	
	CO ₂	H ₂	CO ₂	H ₂
Ni/Al-700	0.91	0.48	1.71	-0.22
Ni/20LaAl-700	0.73	0.43	1.54	-0.11

Table S5. The basicity of the reduced catalysts (CO₂-TPD).

Catalysts	Total basicity [μmol/g]
Ni/Al-500	82
Ni/Al-700	129
Ni/20LaAl-500	249
Ni/20LaAl-700	256