

Electronic Supplementary Information (ESI):

**Sc promoted and aerogel confined Ni catalysts for coking- resistant
dry reforming of methane**

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Preparation details of Ni/Al₂O₃-I and NiSc/Al₂O₃-I catalysts

All chemicals purchased by Sinopharm Chemical Reagent Company were used without any further purification, except for spherical alumina (γ -Al₂O₃, Shanghai Emperor Yang Co. Ltd.), and scandium nitrate (Sc(NO₃)₃·6H₂O, 99%, Shanghai Emperor Yang Co. Ltd.). deionized water (H₂O), nickel nitrate (Ni(NO₃)₂·6H₂O, 98%), aluminum chloride hexahydrate (AlCl₃·6H₂O, 99%). Deionized water was used throughout the experiment.

The NiSc/Al₂O₃-I catalyst was prepared by incipient wetness impregnation. In a typical synthesis, γ -Al₂O₃ (1.0 g), Ni(NO₃)₂·6H₂O (0.56 g) and Sc(NO₃)₃·6H₂O (0.084 g) were added into deionized water (60 mL). After stirring for 6 h, the solution was dried in hot air at 70 °C for two days. Powder obtained after the drying was heated to 600 °C at a heating rate of 1 °C /min. Then, it was calcined at the same temperature (600 °C) in air for 3 h. The NiSc/ Al₂O₃-I catalyst was obtained by reduction in a flow of H₂/N₂ (having 10% H₂ in N₂ gas with a flow rate of 40 mL/min) at 900 °C for 1 h.

The Ni/Al₂O₃-I catalyst was synthesized by a method similar to that employed for synthesizing the NiSc/Al₂O₃-A catalyst, except in the absence of Sc(NO₃)₃·6H₂O.

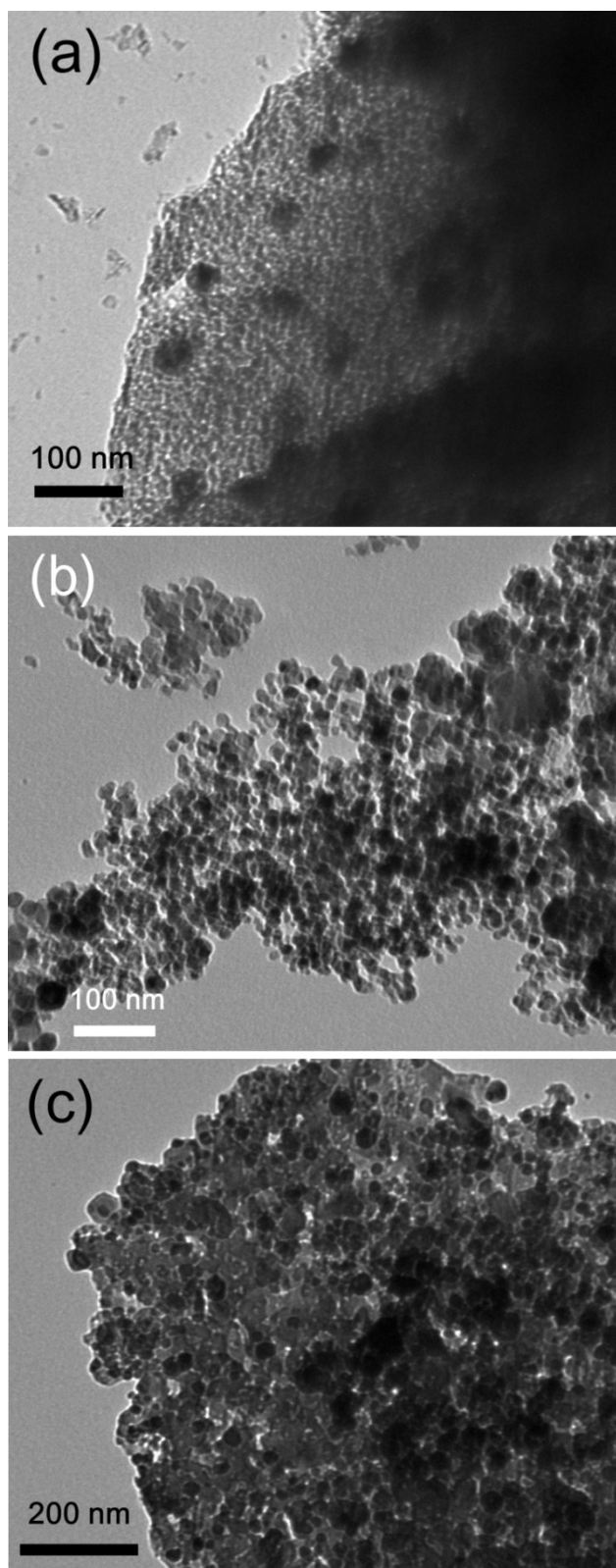


Fig. S1 TEM images of various catalysts: (a) Ni/Al₂O₃-A; (b) NiSc/Al₂O₃-I; and (c) Ni/Al₂O₃-I.

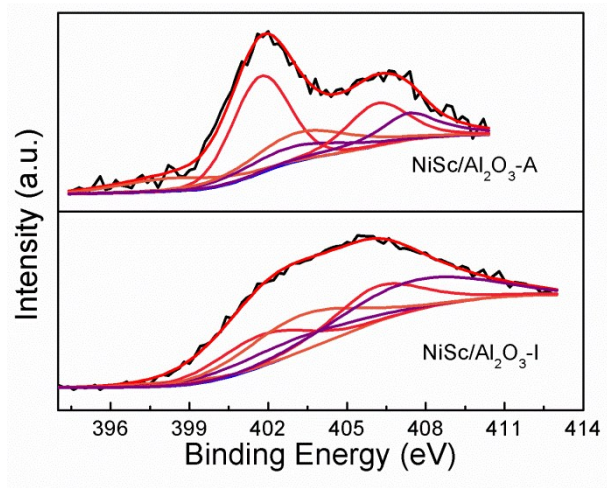


Fig. S2 Sc 2p XPS spectra of the NiSc/Al₂O₃-A and NiSc/Al₂O₃-I catalysts.

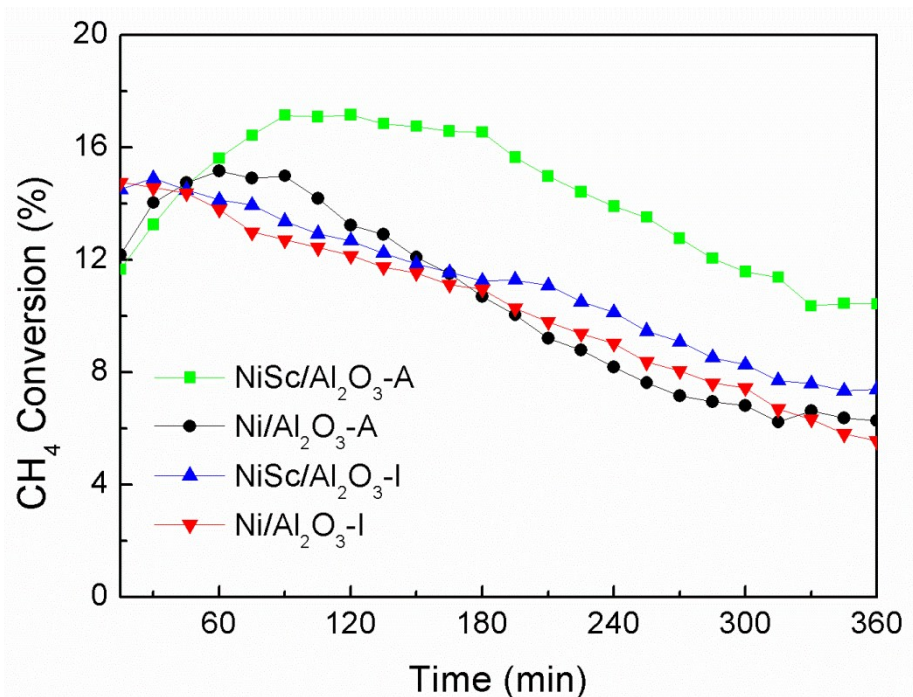


Fig. S3 Catalytic stability test of various catalysts for methane dry reforming at 500 °C for 1800 min. (Catalytic conditions: CH₄:CO₂ = 1:1, 45 mL/min per reactor ; 50 mg of catalysts.)

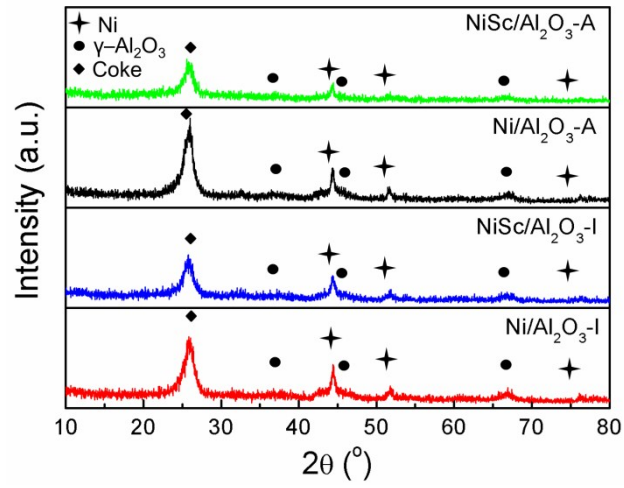


Fig. S4 XRD of the various catalysts stability tests for 1800 min.

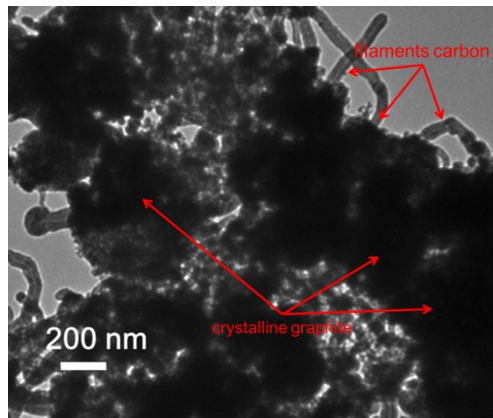


Fig. S5 TEM images of the Ni/Al₂O₃-A catalyst stability tests for 1800 min.

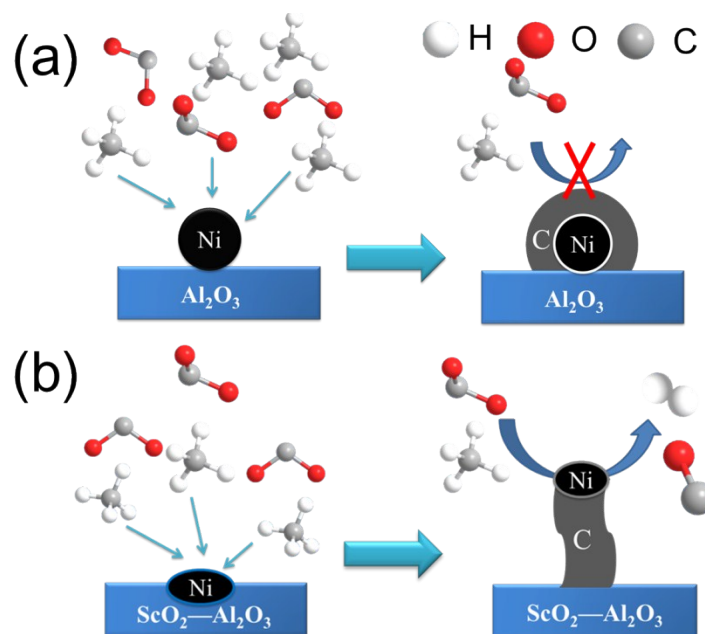


Fig. S6 Schematic representation of methane dry reforming over (a) $\text{Ni}/\text{Al}_2\text{O}_3\text{-A}$; and (b) $\text{NiSc}/\text{Al}_2\text{O}_3\text{-A}$ catalysts.

Table S1 The Ni dispersion of various catalysts during dry reforming of methane at 550 °C was determined by H₂ chemisorption.

| Catalysts | Ni dispersion (%) | |
|--|-------------------|----------|
| | t=10min | t=360min |
| Ni/Al ₂ O ₃ -I | 0.40 | 0.18 |
| NiSc/Al ₂ O ₃ -I | 0.45 | 0.29 |
| Ni/Al ₂ O ₃ -A | 0.52 | 0.26 |
| NiSc/Al ₂ O ₃ -A | 0.56 | 0.55 |

The Ni dispersion of various catalysts was determined by H₂ chemisorption. The Ni dispersion is low compared with other Ni-based catalysts which is consistent with the reported values of core shell catalysts due to the confinement effect.^{1,2}

Reference:

1. Z. Li, L. Mo, Y. Kathiraser and S. Kawi, ACS Catal., 2014, 4, 1526-1536.
2. L.H. Yao, Y.X. Li, J. Zhao, W.J. Ji, C.T. Au, Catal. Today, 2010, 158, 401-408.