

Preparation of highly dispersed metallic Pt nanoparticle catalysts for low-temperature propene combustion

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Catalyst characterization. The dispersion of platinum in the catalysts was determined by H₂-O₂ titration on VDsorb-91i apparatus equipped with a thermal conductivity detector (TCD). In a typical test, 50 mg of catalyst was placed in a quartz tube reactor and activated in 10% H₂/Ar (30 ml min⁻¹) at 200°C for 1 h; the catalyst was then purged with helium (30 ml min⁻¹) at the same temperature for another 0.5 h, after which it was cooled down to 50°C. Subsequently, the O₂ titration of the catalyst was performed by pulsing 5% O₂/He into the reactor several times at 50°C until the consumption of O₂ became negligible. Then, H₂ titration was carried out in the same way, 10% H₂/Ar was pulsed into the reactor several times to reach equilibrium adsorption. The platinum dispersion (D%) was calculated by the following equation:

$$\text{Dispersion (\%)} = 100 \times V_{\text{H}_2} \times 2/3 \times \text{MW}_{\text{Pt}} / (W_{\text{Pt}} \times 22414)$$

Where V_{H_2} is the volume of adsorbed H₂ (mL), MW_{Pt} is the atomic weight of Pt (g·mol⁻¹), and W_{Pt} is the weight of Pt supported on the sample (g).

DRIFTS was performed upon CO adsorption using a Nicolet 6700 (Thermo Scientific) equipped with a mercury-cadmium-telluride (MCT) detector. The catalyst powders were placed in an in-situ cell. The cell was purged with a stream of N₂ at 200°C for 1 h to remove water and impurities and cooled to room temperature under a stream of N₂ flow. After background collection under N₂ at 20°C, the catalysts were saturated with 5% CO/N₂ gas for 30 min, and DRIFT spectra were collected under vacuum subsequently.

Catalyst Oxidation Tests of C₃H₈, CO, NO. The same pretreatment and gas hourly space velocity conditions for light-off tests of C₃H₆ were applied in oxidation experiments of C₃H₈, CO, NO. 140 mg of samples (40–60 mesh) was used and the total gas velocity is 350 mL min⁻¹ for oxidation experiments of C₃H₈, CO, NO. For C₃H₈ oxidation test, the reactant gas is made up of 1000 ppm C₃H₈, 12 vol% O₂, and Ar as balance gas. For CO oxidation test, the reactant gas is made up of 2000 ppm CO, 12 vol% O₂, and Ar as balance gas. For NO oxidation test, the reactant gas is made up of 200 ppm NO, 12 vol% O₂, and Ar as balance gas. A Shimadzu GC-2014 instrument was utilized to determine the concentration of C₃H₈ and CO in the inlet and outlet of reactor. The online NO–NO₂–NO_x analyzer (Thermo Scientific 42i-HL) was used to determine the concentration of NO in the inlet and outlet of reactor.

Table S1 Comparison of T₅₀ and T₉₀ of Pt-RD catalysts

Catalysts	T ₅₀ (°C)	T ₉₀ (°C)
1% Pt-RD ₁	104.5	120.0
1% Pt-RD ₂	96.0	108.0
1% Pt-RD ₃	95.0	101.0
1% Pt-RD ₃ -H	104.0	109.0
1.5% Pt-RD ₃	95.5	104.0

Table S2 Comparison of some representative catalysts for propene combustion

Catalyst	Reactant composition	Space velocity/flow rate	T ₉₀ (°C)	Ref.
1% Pt/Al ₂ O ₃ (This work)	1000 ppm C ₃ H ₆ , 12% O ₂ , Ar balance	150000 mL h ⁻¹ gcat ⁻¹	100	—
1% Pt/Al ₂ O ₃ ^a	600 ppm C ₃ H ₆ , 1% O ₂ , He balance	50000 h ⁻¹	<180	1
0.8% Pd/TiO ₂	1000 ppm C ₃ H ₆ , 9% O ₂ , air balance	35000 h ⁻¹	162	2
1% Au/TiO ₂	1000 ppm C ₃ H ₆ , 9% O ₂ , He balance	35000 h ⁻¹	<275	3
2% Pt/BaO/Al ₂ O ₃	800 ppm C ₃ H ₆ , 2% O ₂ , N ₂ balance	1000 mL min ⁻¹	225	4
1% Au/CeO ₂ ^b	1200 ppm C ₃ H ₆ , 9% O ₂ , He balance	150 mL min ⁻¹	190	5

0.5% Pd–1% Au/TiO ₂	1000 ppm C ₃ H ₆ , air balance	100 mL min ⁻¹	<225	6
3% Au–3% Ir/TiO ₂	1200 ppm C ₃ H ₆ , 9% O ₂ , He balance	7800 h ⁻¹	<200	7
1% Pt/Al-PILC ^c	0.5% C ₃ H ₆ , 10% O ₂ , He balance	2000 h ⁻¹	250	8

^aCatalyst with Pt dispersion of 0.81. ^bCatalyst was first activated in a H₂ stream. ^cAl-PILC: Al-pillared montmorillonite.

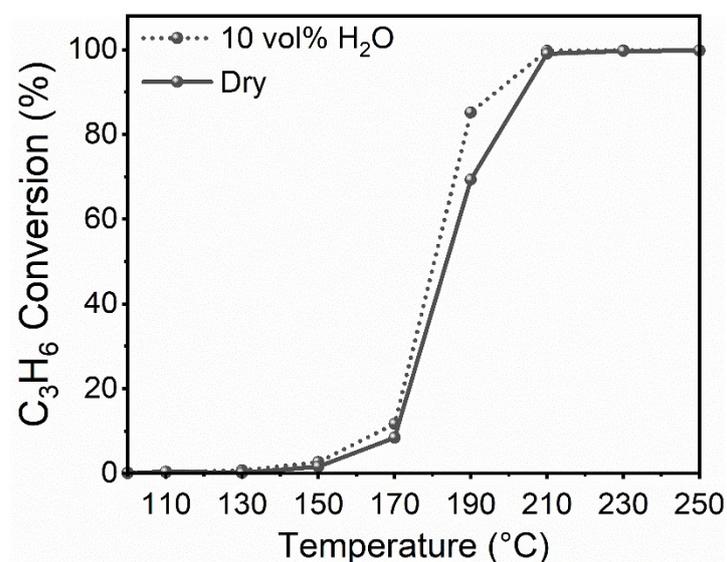


Fig. S1 Light-off curves of the 1% Pt-IW sample in dry conditions and with 10% steam.

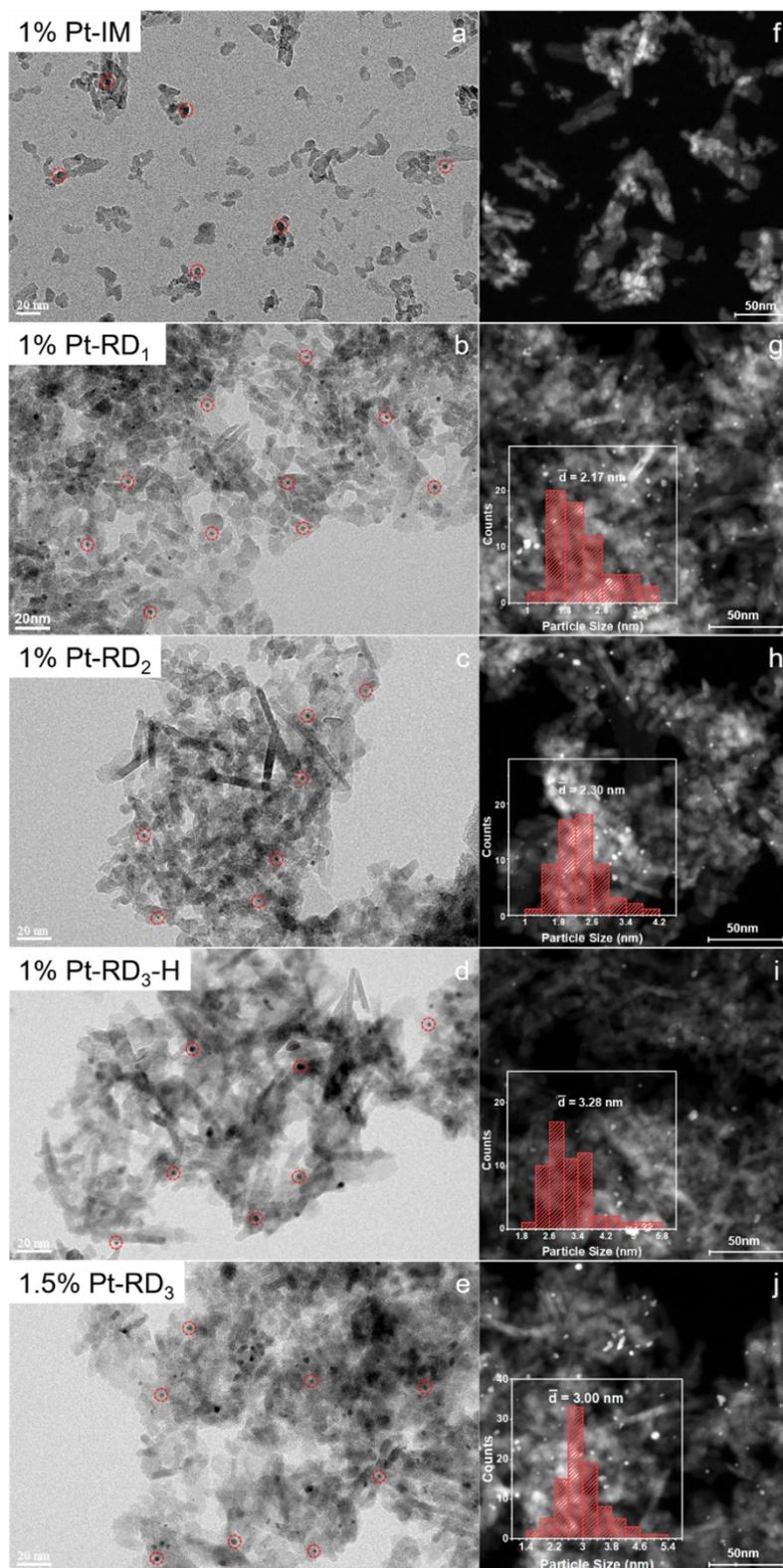


Fig. S2 (a–e) The HR-TEM and HAADF-STEM images of 1% Pt-IW, 1% Pt-RD₁, 1% Pt-RD₂, 1% Pt-RD₃-H, 1.5% Pt-RD₃ catalysts (with the images of Pt particles size distribution inserted).

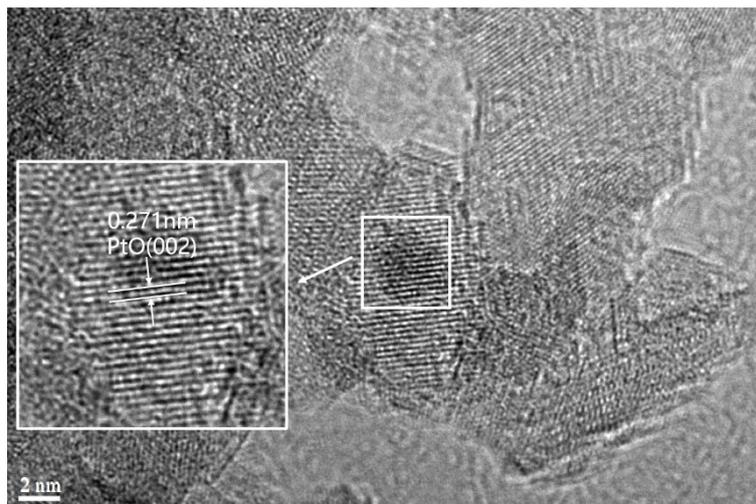


Fig. S3 The HRTEM image of 1% Pt-RD₃ catalyst.

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