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Supporting Materials

Promotion mechanism of CeO_2 addition on the low temperature SCR reaction over MnO_x/TiO_2: A new insight from the kinetic study

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1. Catalytic test

The ratios of NO_x and NH_3 conversion, the amount of N_2 formed, and N_2O selectivity were calculated using the following equations:

$$NO_x \text{ conversion} = \frac{[NO_x]_{in} - [NO_x]_{out}}{[NO_x]_{in}} \quad \text{(S1)}$$

$$NH_3 \text{ conversion} = \frac{[NH_3]_{in} - [NH_3]_{out}}{[NH_3]_{in}} \quad \text{(S2)}$$

$$N_2 \text{ formed} = [NO_x]_{in} + [NH_3]_{in} - [NO_x]_{out} - [NH_3]_{out} - 2[N_2O]_{out} \quad \text{(S3)}$$

$$N_2O \text{ selectivity} = \frac{2[N_2O]_{out}}{[NH_3]_{in} + [NO_x]_{in} - [NH_3]_{out} - [NO_x]_{out}} \quad \text{(S4)}$$

Where, $[NH_3]_{in}$, $[NO_x]_{in}$, $[NH_3]_{out}$, $[NO_x]_{out}$ and $[N_2O]_{out}$ were the concentrations of NH_3 and NO_x (including NO and NO_2) in the inlet, and the concentrations of NH_3, NO_x and N_2O in the outlet, respectively.

2. XPS

XPS spectra of MnO_x/TiO_2 and MnO_x-CeO_2/TiO_2 over the spectral regions of Mn 2p, O 1s, Ti 2p and Ce 3d were shown in Fig. S1. The Mn peaks on MnO_x/TiO_2 mainly centered at 642.4, 641.3 and 640.3 eV (shown in Fig. S1a), which were assigned to Mn^{4+}, Mn^{3+} and Mn^{2+}, respectively. [1] The O peak mainly centered at about 529.7 and 531.0 eV (shown in Fig. S1b), which were assigned to O in transition metal oxides and -OH. [2] The Ti peaks mainly centered at 464.3 and 458.6 eV (shown in Fig. S1c), which were assigned to Ti 2p 1/2 and Ti 2p 3/2 of Ti^{4+}.[3]

After CeO_2 addition, no obvious changes happened in the Mn, O and Ti spectra regions of MnO_x/TiO_2 (shown in Figs. S1d, e and f). The Ce 3d binding energies of MnO_x-CeO_2/TiO_2 mainly centered at 906.0, 903.3, 900.9, 898.6, 887.1, 885.2 and 881.9 eV (shown in Fig. S1g). The bands at 906.0, 900.9, 898.6, 887.1 and 881.9 eV were attributed to Ce^{4+}, and the bands at 903.3 and 885.2 eV were assigned to Ce^{3+}. [4, 5]

3. NH_3 oxidation and NO oxidation

Fig. S3 shows the effect of CeO_2 addition on NO and NH_3 oxidation over MnO_x/TiO_2. As shown in Fig. S3a, NO oxidation over MnO_x/TiO_2 did not vary after CeO_2 addition. However, NH_3 oxidation over MnO_x/TiO_2 was obviously promoted after CeO_2 addition (shown in Fig. S2b).

Meanwhile, N_2O selectivity of NH_3 oxidation over MnO_x/TiO_2 was slightly higher than that over MnO_x-CeO_2/TiO_2.

References:

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2. S. Yang, F. Qi, Y. Liao, S. Xiong, Y. Lan, Y. Fu, W. Shan and J. Li, *Ind. Eng. Chem. Res.*, 2014, **53**, 5810-5819.

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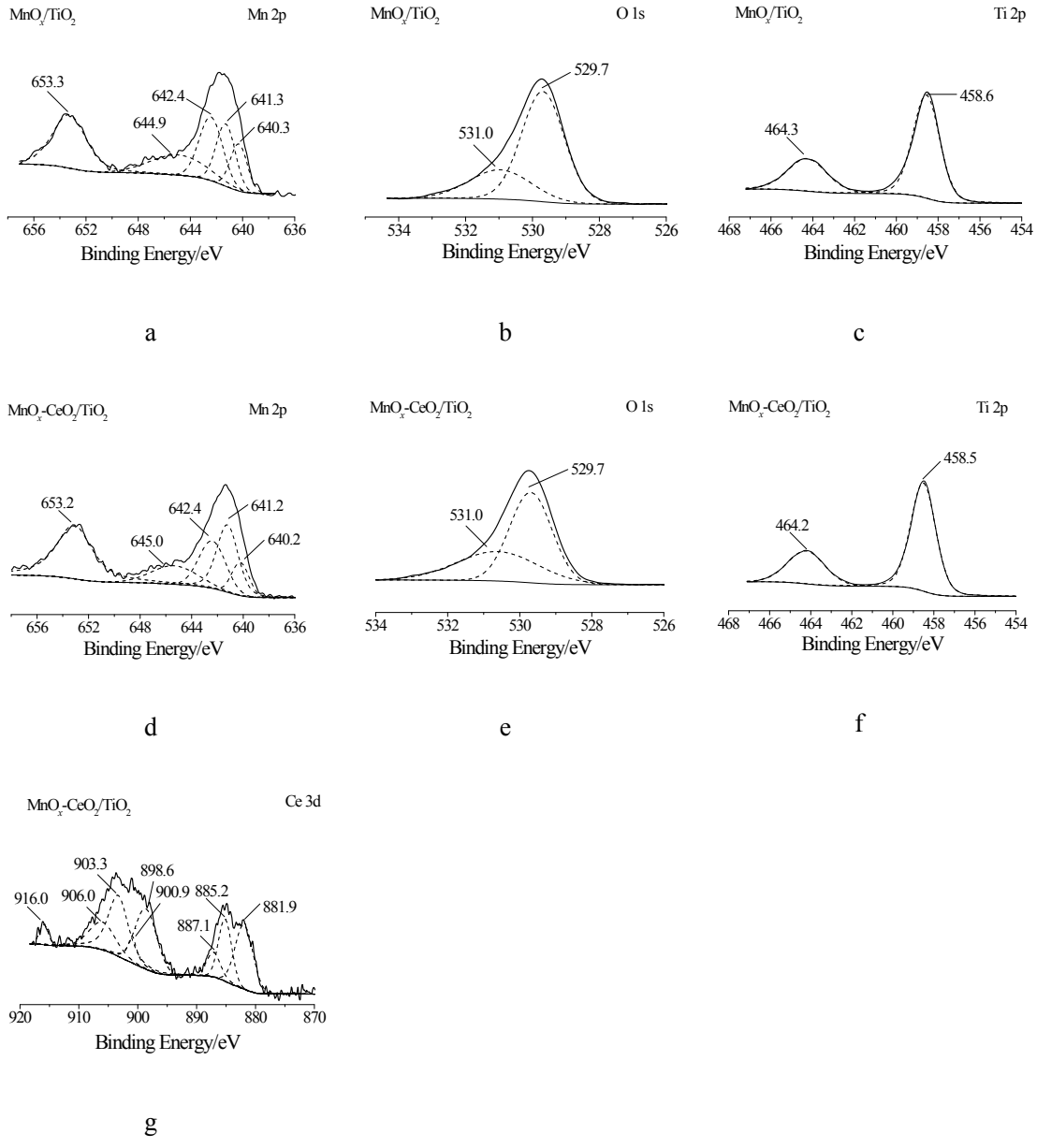
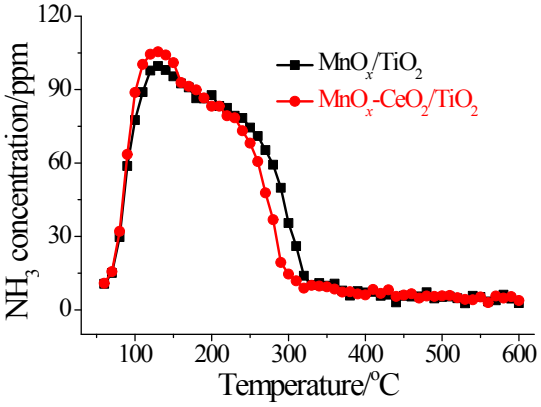
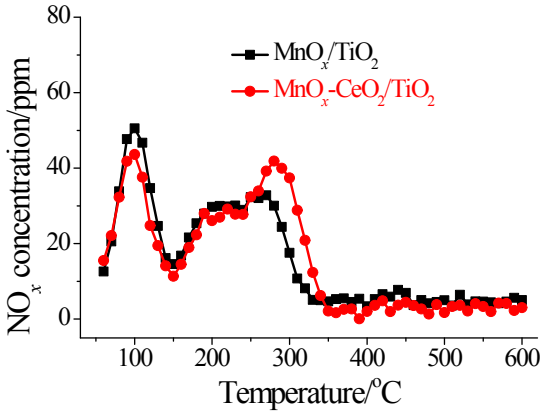


Fig. S1 XPS spectra of MnO_x/TiO_2 and MnO_x-CeO_2/TiO_2 over the spectral regions of Mn 2p, O 1s, Ce 3d and Ti 2p

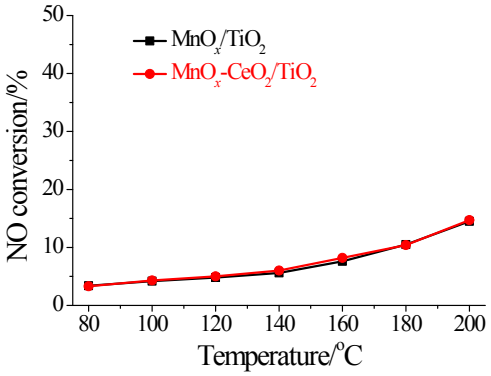


a



b

Fig. S2 The profiles of (a) NH_3-TPD and (b) NO-TPD of MnO_x/TiO_2 and MnO_x-CeO_2/TiO_2



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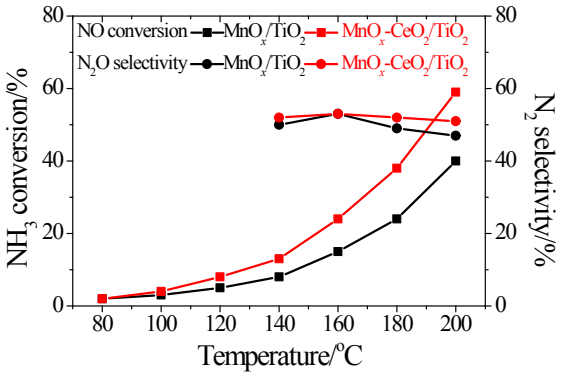

b

Fig. S3 Effect on CeO_2 addition on NO (a) and NH_3 oxidation (b) over MnO_x/TiO_2. Reaction conditions: $[NH_3]/[NO]$=500 ppm, $[O_2]$=2%, catalyst mass=250 mg, total flow rate=200 mL min^{-1} and GHSV=4.8×10^4 cm^3 g^{-1} h^{-1}.