

Supporting information

A New Insight into Catalytic Ozonation with Nanosized Ce-Ti Oxides for NO_x Removal: Confirmation of Ce-O-Ti for Active Sites

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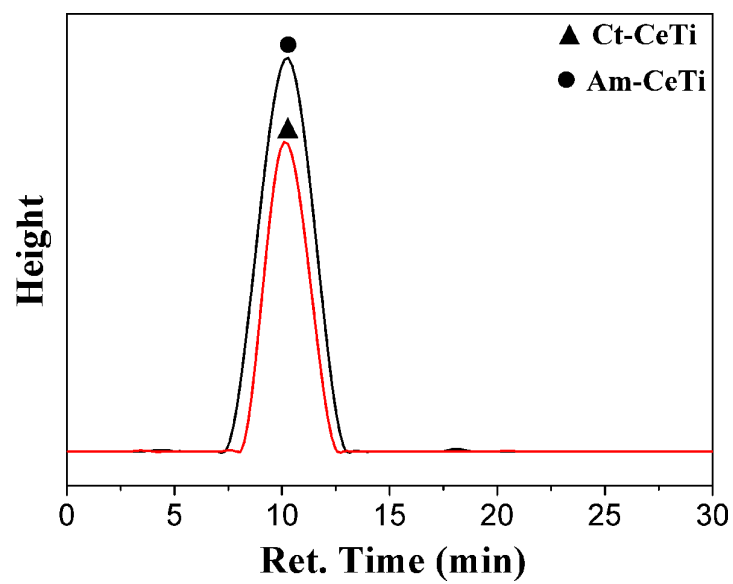
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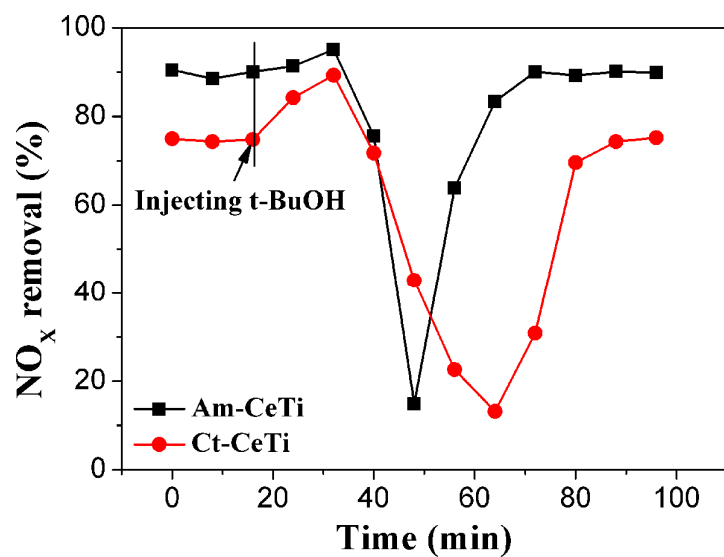
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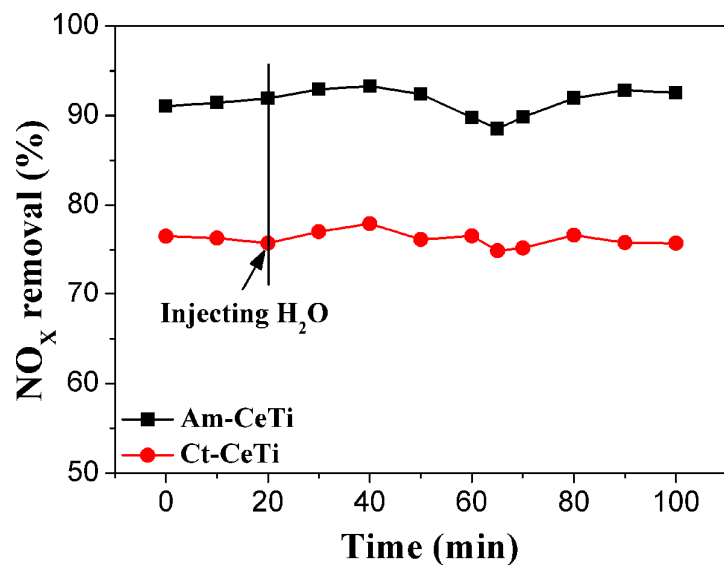
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**Figure S1 Ion chromatography of oxidation products for catalytic ozonation over
Ct-CeTi and Am-CeTi**



(a)

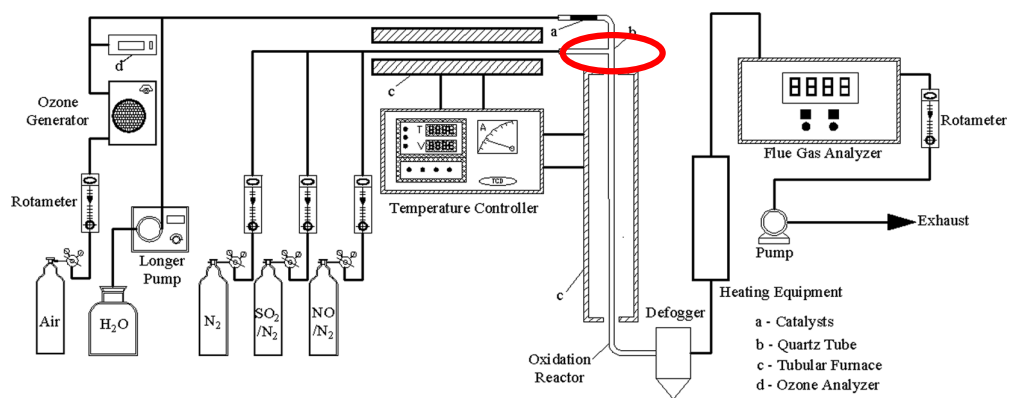


(b)

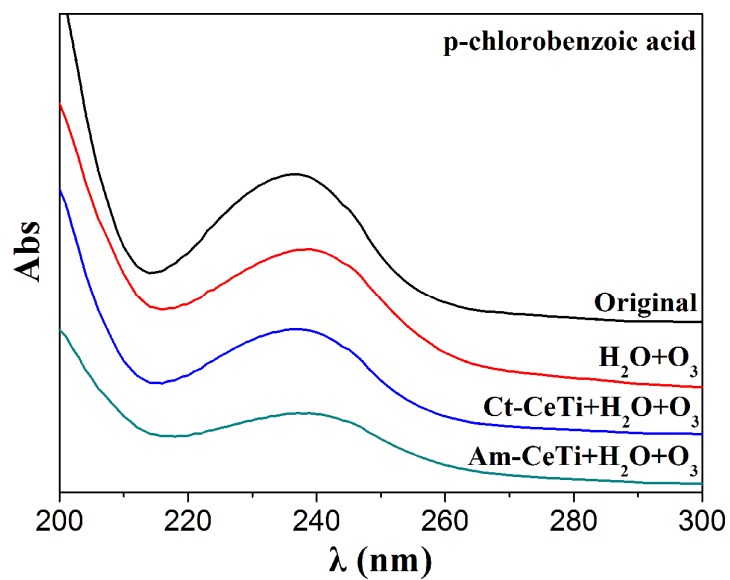
Figure S2 Effect of (a) isopropanol and (b) distilled water on NO_x removal of catalytic ozonation over Ct-CeTi and Am-CeTi

The experimental conditions are controlled as follows: The total flow of all the reactants were fixed to 400 mL·min⁻¹, including 200 mL·min⁻¹ of the O₃ flow. The initial gas concentrations used in the test were NO_x: 500 ppm, O₃: 5.2 mg·L⁻¹ appeared in different cases. In order to exclude the influence of the volume injecting

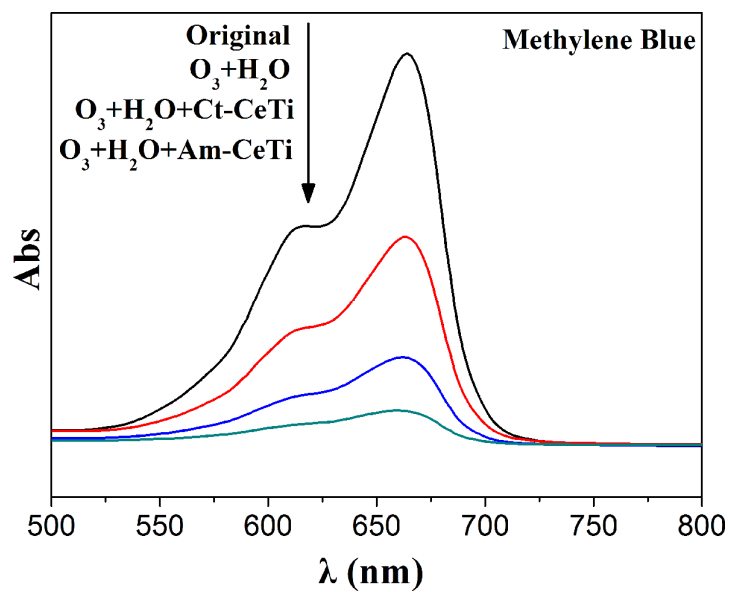
in the system. The same volume of H_2O is injecting into the system, and the results are shown in Fig. S3b. It can be observed that the NO_x removal has only a slight decrease, indicating that the injecting volume has no apparent influence on NO_x removal.



(a)



(b)



(c)

Figure S3 The oxidation point of the solutions (a) and UV-Vis spectrophotometry of p-chlorobenzoic acid oxidized by O₃-water and O₃-water with CeTi (b) and UV-Vis spectrophotometry of methylene blue in O₃-water and O₃-water with CeTi (c)

The experiments were conducted as follows:

The active mixtures were introduced into p-chlorobenzoic acid or Methylene blue solutions. The solutions were placed in the location as described in red circle in Fig. S4a. If the p-chlorobenzoic acid or Methylene blue is degraded, it can be obtained that the ·OH radicals can be introduced into duct. Because the location of solutions is placed in the same location as the duct.

It has been known that p-chlorobenzoic acid can only be oxidized by ·OH radicals, and can not be oxidized by O₃. It can be obtained from Fig. S4(b) that the characteristic absorbed peak of p-chlorobenzoic dramatically decreases in Am-CeTi + H₂O + O₃, indicating the existence of ·OH radicals and Am-CeTi has much higher ·OH radical concentration. Methylene blue (MB) has a high affinity on ·OH radicals, and easily produces hydroxylation of methylene blue (MB-OH), which is colorless. It can be obtained from Fig. S4(c) that the characteristic absorbed peak of MB decreases much more dramatically in O₃-water with CeTi catalysts comparing with that in O₃-water, further indicating the existence of ·OH radicals and Am-CeTi has much higher ·OH radical concentration.

Reaction conditions: O₃ concentration is 5.2 mg·L⁻¹, the time is 10 min.

Table S1 Material balance summary for NO_x

Category	Ct-CeTi	Am-CeTi
Time t, min	500	500
Gas flow Q, mL/min	400	400
Solution volume V _L , mL	10	10
C _{in} (NO)	513	509
C _{out} (NO)	48	152
NO removal efficiency, %	90.7	70.1
C(NO ₂ ⁻) actual value, g/L	0	0
C(NO ₃ ⁻) actual value, g/L	27.21	20.61
C(NO ₃ ⁻) calculation value, g/L	29.5	22.6
C(NO ₃ ⁻) error, %	7.76	8.81

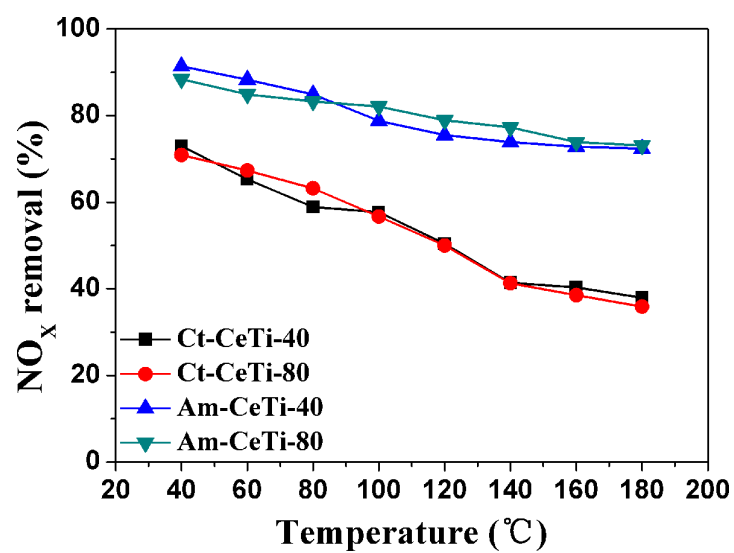


Figure S4 Catalytic activities of Ct-CeTi and Am-CeTi with the particle size of 40 and 80 mesh.

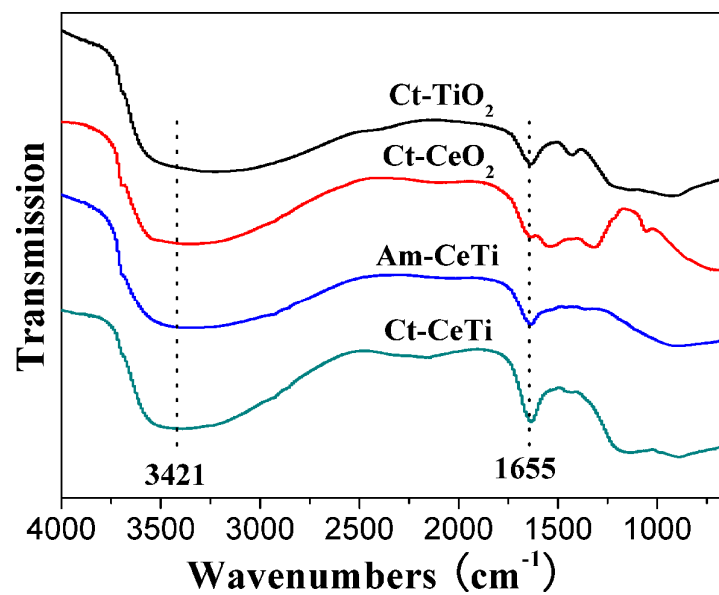


Figure S5 DRIFTS spectra of Ct-TiO₂, Ct-CeO₂, Am-CeTi and Ct-CeTi

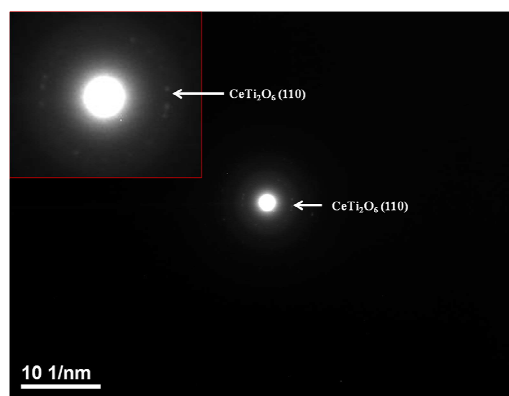
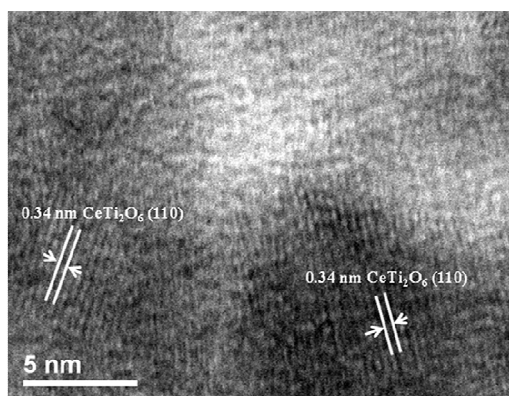
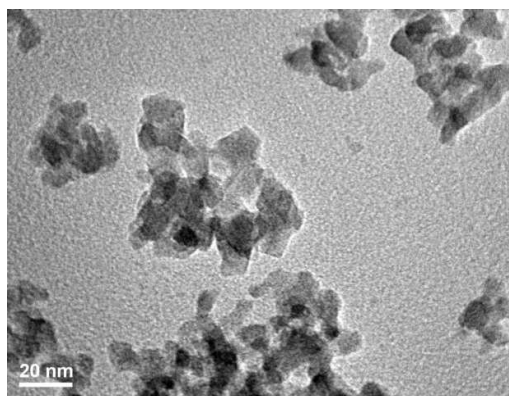
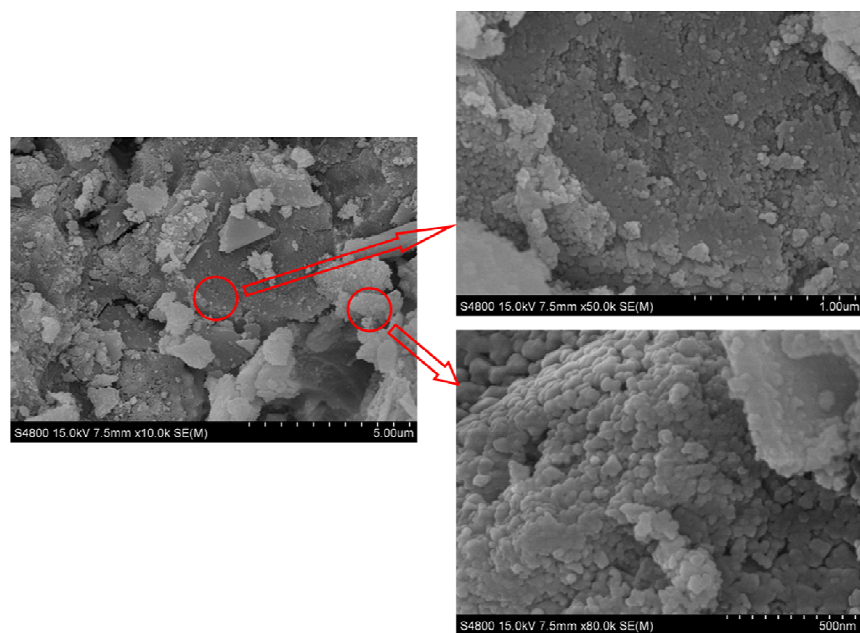
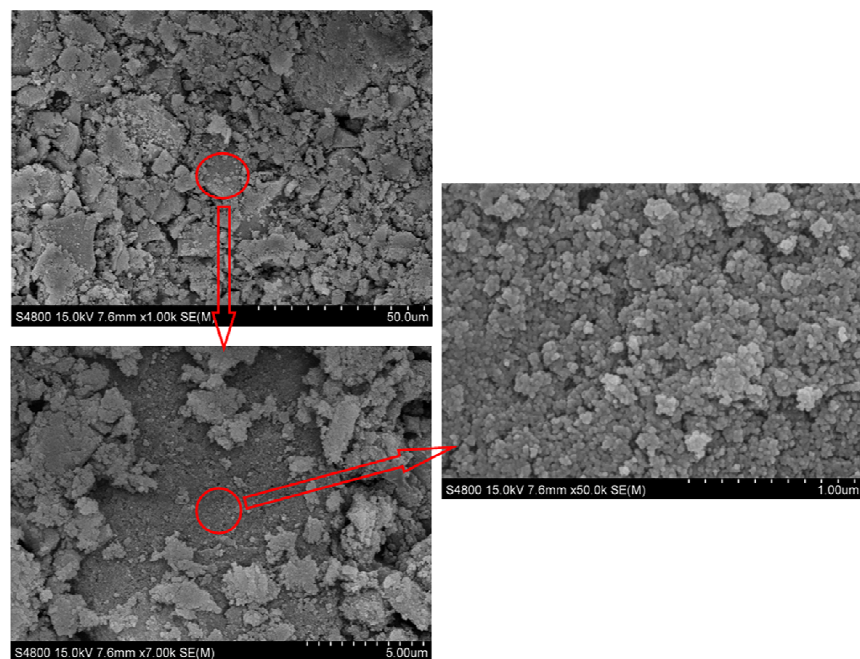


Figure S6 HRTEM and SAED images of Am-CeTi



(a)



(b)

Figure S7 SEM micrographs of (a) Ct-CeTi and (b) Am-CeTi

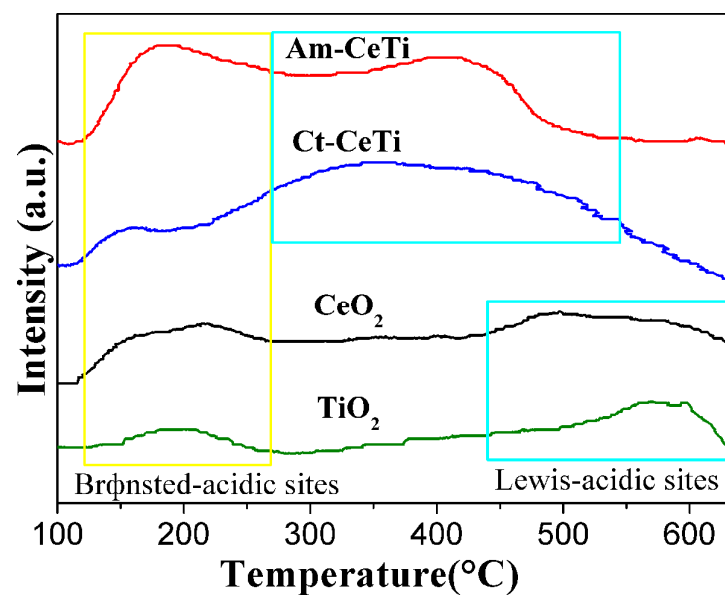


Figure S8 NH₃-TPD profiles of Am-CeTi, Ct-CeTi, CeO₂ and TiO₂

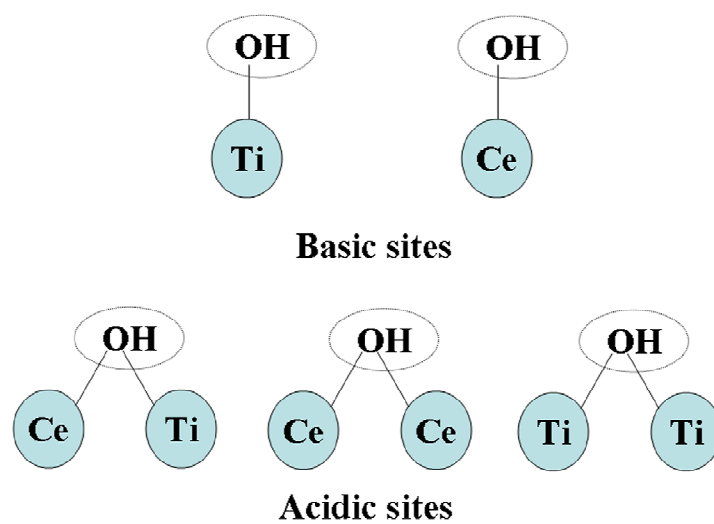


Figure S9 Acidic and Basic sites of surface hydroxyl groups

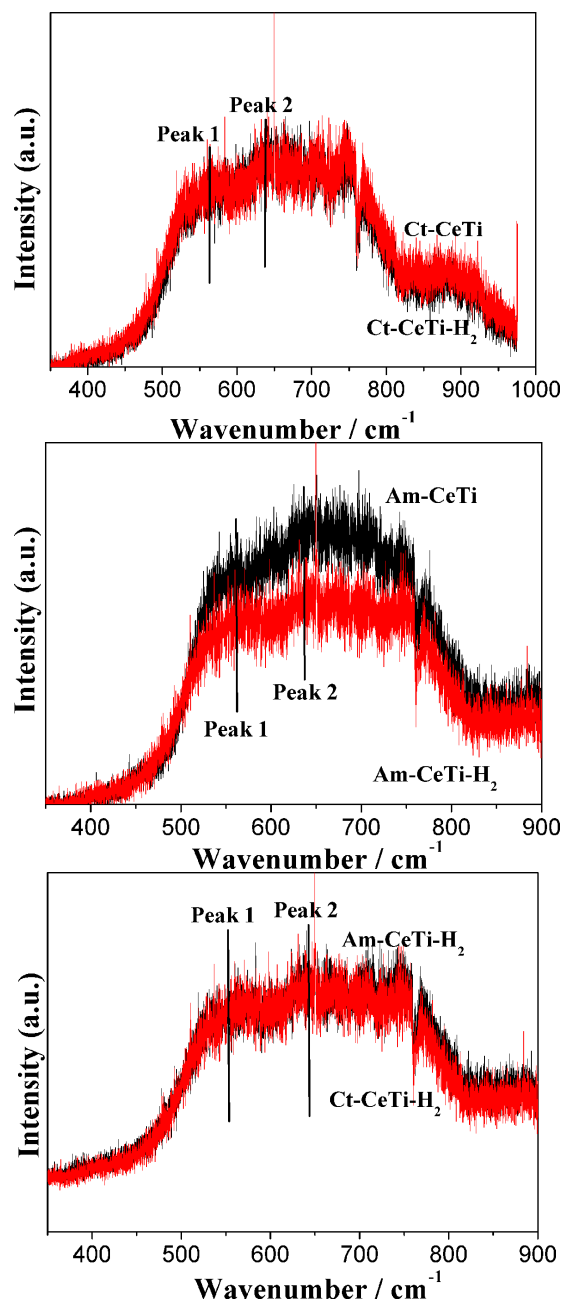


Figure S10 PL spectra of Ct-CeTi, Am-CeTi, Ct-CeTi-H₂ and Am-CeTi-H₂

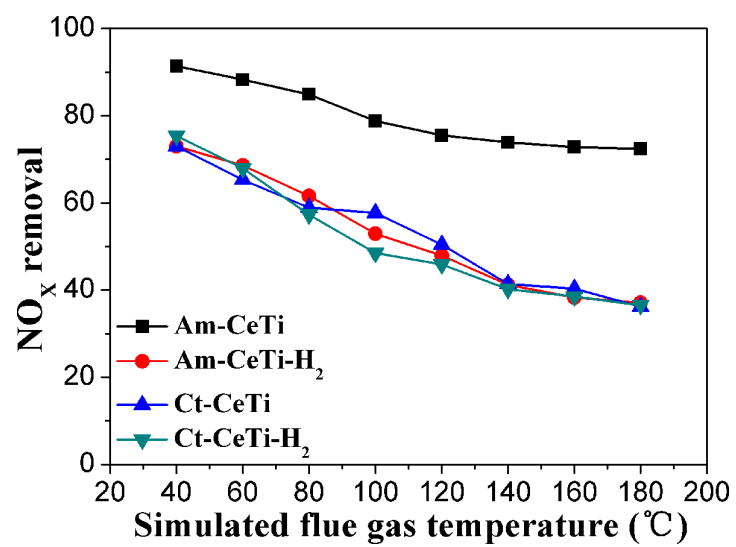
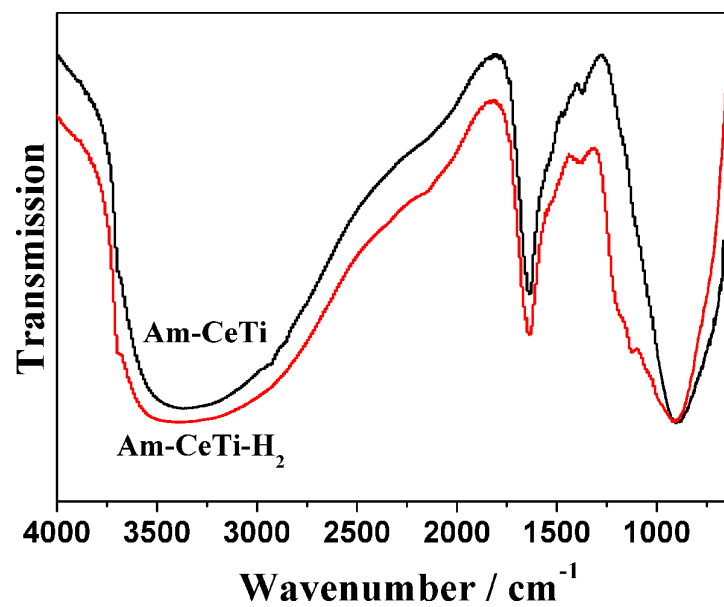
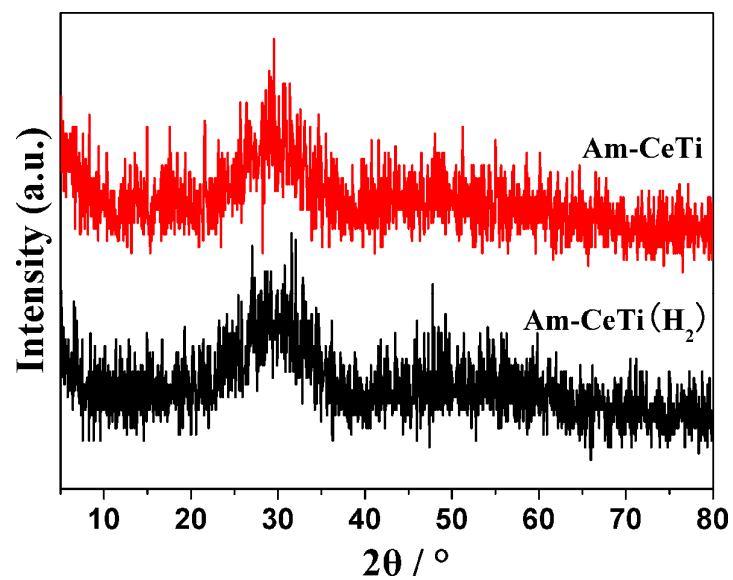


Figure S11 Catalytic activity of Am-CeTi, Am-CeTi-H₂, Ct-CeTi and Ct-CeTi-H₂



(a)



(b)

Figure S12 IR spectra (a) and XRD patterns (b) of Am-CeTi

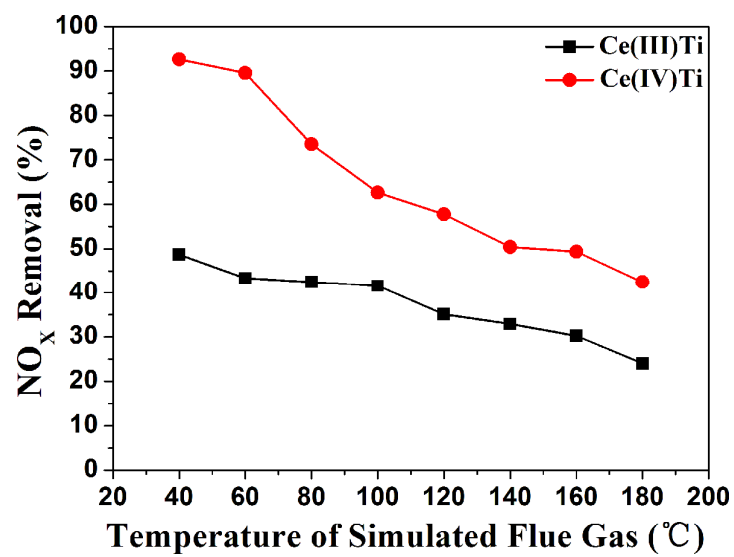


Figure S13 Catalytic activity of Ce(III)Ti and Ce(IV)Ti

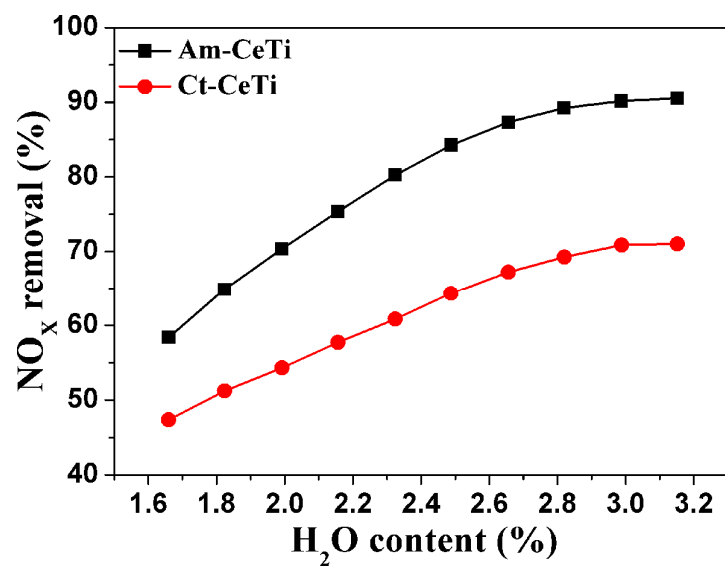


Figure S14 Catalytic activities of Ct-CeTi and Am-CeTi with the increase of H₂O content