

## Supporting Information

### **TiO<sub>2</sub>-modified CeVO<sub>4</sub> catalyst for the selective catalytic reduction of NO<sub>x</sub> with NH<sub>3</sub>**

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**Table S1** Physical properties of the catalysts.

Sample	S <sub>BET</sub> (m <sup>2</sup> /g) <sup>a</sup>	V <sub>p</sub> (cm <sup>3</sup> /g) <sup>b</sup>	D <sub>p</sub> (nm) <sup>c</sup>	Crystallite size (nm) <sup>d</sup>
CeVO <sub>4</sub>	20.3	0.14	28.4	25.0
CeVTi <sub>2.5</sub>	33.6	0.12	14.4	16.8
CeVTi <sub>5</sub>	50.6	0.14	10.2	4.9
CeVTi <sub>10</sub>	88.9	0.23	8.6	6.3
CeVTi <sub>20</sub>	105.3	0.27	8.7	6.5
TiO <sub>2</sub>	106.8	0.19	5.0	9.1

<sup>a</sup> BET surface area

<sup>b</sup> BJH desorption pore volume

<sup>c</sup> BJH adsorption pore size

<sup>d</sup> Scherrer equation from XRD data

**Table S2** The results of H<sub>2</sub> consumption.

Sample	H <sub>2</sub> consumption ( $\mu\text{mol/g}$ ) <sup>a</sup>		
	Below 600 °C	Above 600 °C	Total
CeVO <sub>4</sub>	102	3763	3866
CeVTi <sub>2.5</sub>	2375	1206	3581
CeVTi <sub>5</sub>	2463	186	2620
CeVTi <sub>10</sub>	1835	160	1995
CeVTi <sub>20</sub>	1079	79	1158
TiO <sub>2</sub>	28	-	28
V <sub>2</sub> O <sub>5</sub>	-	11878	11878
CeO <sub>2</sub>	1008	937	1945

<sup>a</sup> quantified by the H<sub>2</sub>-TPR

**Table S3** The surface atomic concentration of CeVTi<sub>x</sub> catalysts obtained from XPS.

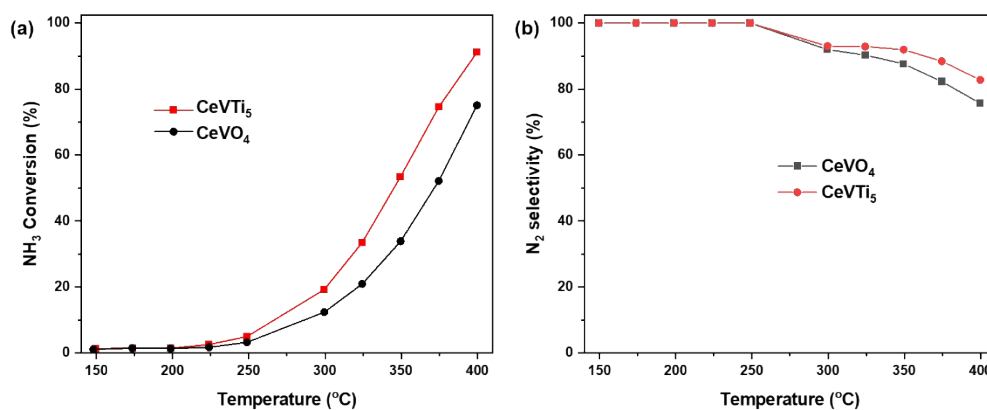
Sample	Surface atomic concentration (%)				
	Ce	V	Ti	O	Surface V/Ce molar ratio
CeVO <sub>4</sub>	15.08	15.25	-	69.67	1.01
CeVTi <sub>2.5</sub>	5.82	7.80	18.06	68.32	1.34
CeVTi <sub>5</sub>	4.01	5.57	22.43	67.99	1.39
CeVTi <sub>10</sub>	2.50	4.22	26.81	66.47	1.69
CeVTi <sub>20</sub>	1.44	2.77	29.47	66.32	1.92
TiO <sub>2</sub>	-	-	25.70	74.30	-

**Table S4** The XPS results on Ce-V-Ti catalysts.

Sample	$O_{\alpha}/(O_{\alpha} + O_{\beta} + O_{\gamma})$ (%)	$Ce^{4+}/(Ce^{3+} + Ce^{4+})$ (%)	$V^{4+}/(V^{4+} + V^{5+})$ (%)
CeVO <sub>4</sub>	9.4	35.2	4.6
CeVTi <sub>2.5</sub>	15.3	53.9	22.6
CeVTi <sub>5</sub>	19.5	54.9	26.0
CeVTi <sub>10</sub>	15.9	46.1	20.5
CeVTi <sub>20</sub>	15.0	43.9	16.7
TiO <sub>2</sub>	12.5	-	-

**Table S5** Amounts of NH<sub>3</sub> adsorption over Ce-V-Ti catalysts.

Samples	NH <sub>3</sub> adsorption (μmol/g)
CeVO <sub>4</sub>	41.3
CeVTi <sub>2.5</sub>	68.1
CeVTi <sub>5</sub>	124.5
CeVTi <sub>10</sub>	221.9
CeVTi <sub>10</sub>	252.2
TiO <sub>2</sub>	313.4

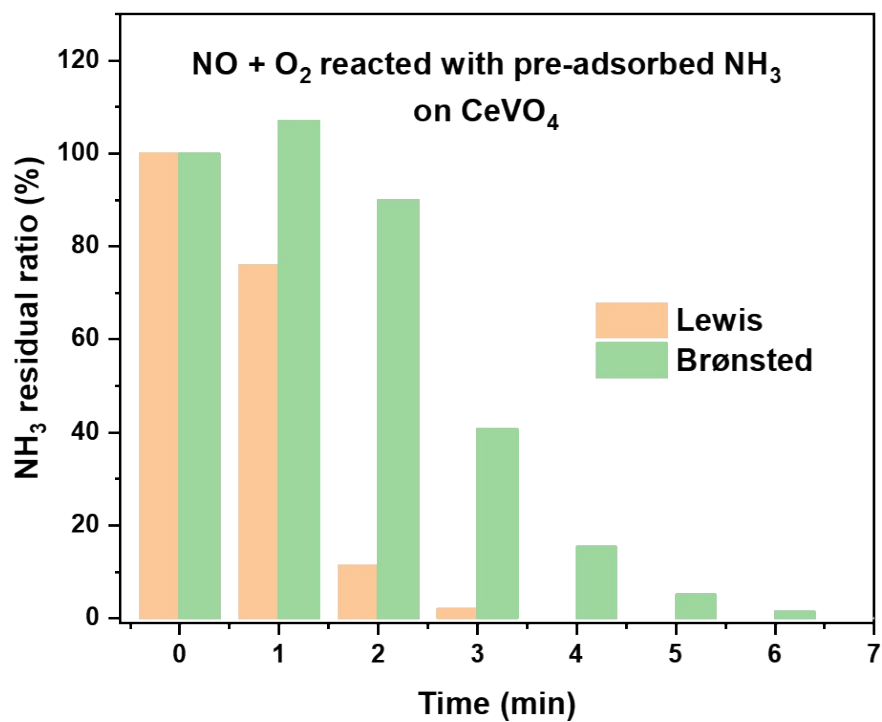


**Fig. S1** NH<sub>3</sub> conversion in NH<sub>3</sub> oxidation reactions over CeVO<sub>4</sub> and CeVTi<sub>5</sub> catalysts. NH<sub>3</sub> oxidation efficiency (a), selectivity for N<sub>2</sub> (b). Reaction conditions: 500 ppm NH<sub>3</sub>, 5% O<sub>2</sub> and N<sub>2</sub> balance, under a GHSV of 200,000 h<sup>-1</sup>.

In the oxidation of NH<sub>3</sub> reaction, the NH<sub>3</sub> conversion and the selectivity for the formation of N<sub>2</sub> were defined by the following equations:

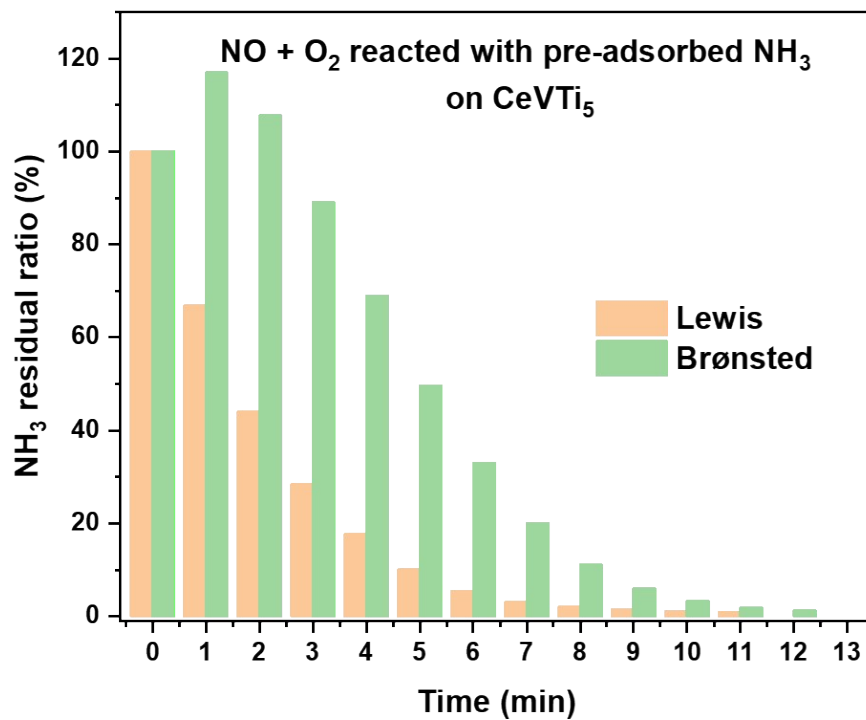
$$\text{NH}_3 \text{ conversion} = \left( \frac{[\text{NH}_3]_{\text{in}} - [\text{NH}_3]_{\text{out}}}{[\text{NH}_3]_{\text{in}}} \right) \times 100\% \quad (1)$$

$$\text{N}_2 \text{ selectivity} = \left( 1 - \frac{[\text{NO}]_{\text{out}} + [\text{NO}_2]_{\text{out}} + 2[\text{N}_2\text{O}]_{\text{out}}}{[\text{NH}_3]_{\text{in}} - [\text{NH}_3]_{\text{out}}} \right) \times 100\% \quad (2)$$



**Fig. S2** The NH<sub>3</sub> residual ratio by calculating integral area at Lewis acid site (1187 cm<sup>-1</sup>) and Brønsted acid site (1423 cm<sup>-1</sup>) with the reaction time under the reaction between NO + O<sub>2</sub> and pre-adsorbed NH<sub>3</sub> on CeVO<sub>4</sub> catalyst.





**Fig. S3** The NH<sub>3</sub> residual ratio by calculating integral area at Lewis acid site (1228 cm<sup>-1</sup>) and Brønsted acid site (1423 cm<sup>-1</sup>) with the reaction time under the reaction between NO + O<sub>2</sub> and pre-adsorbed NH<sub>3</sub> on CeVTi<sub>5</sub> catalyst.