Supporting information

Controllable Synthesis of Magic Cubelike Ce-MOFs-Derived Pt/CeO₂ Catalyst for Formaldehyde Oxidation

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1. Experimental

1.1 Etching experiment of NH₂-Ce-BDC

In this procedure, 100 mg of the as-prepared c-NH₂-Ce-BDC was dispersed in 40 mL deionized water and heated it to 35 °C in a water bath, then the required acid (0.5 mL 1 g•100 mL⁻¹ H₂PtCl₆•6H₂O, 20 μ L 1.2 M HCl, 0.5 mL 1.2 M HCl, HNO₃ or H₂SO₄) was added to the system and maintained for 40 minutes. Finally, the precipitate was obtained after centrifugation, washing and drying at 70 °C. The obtained samples were denoted as E-Pt, E-20Cl, E-0.5Cl, E-0.5N and E-0.5S, respectively.

1.2 In-situ etching experiment of NH₂-Ce-BDC

In this procedure, 250 mg NH₂-BDC was dispersed in 50 mL deionized water, following with adjusting pH to 5.6 by 0.1 M NaOH aqueous solution. Then 220 mg CeCl₃•7H₂O was added to the solution, and 0.5 mL 1.2 M HCl was added after keeping at room temperature for 20min, then heated it to 35 $^{\circ}$ C in a water bath and stood for another 20 min. Finally, the precipitate was obtained after centrifugation, washing and drying at 70 $^{\circ}$ C. The obtained sample was denoted as IE-0.5Cl.



Fig. S1. (a) FT-IR and (b) TGA curves of mc-NH₂-Ce-BDC and c-NH₂-Ce-BDC.



Fig. S2. SEM images of the samples synthesized at different temperatures: (a, b) 25, (c, d) 30, (e, f) 35, (g, h) 40, (i, j) 50 and (k, l) 60 °C. In this part, 0.5 mL $H_2PtCl_6\bullet 6H_2O$ (1 g•100 mL⁻¹) was used instead of 20 µL HCl (1.2 M) to synthesize the sample.



Fig. S3. Size distribution of the samples synthesized at different temperatures: (a) 25, (b) 30, (c) 35, (d) 40, (e) 50 and (f) 60 °C. The statistics were carried out according to the SEM images of the corresponding samples. The abscissa in the figure represents the size distribution range of the sample.



Fig. S4. SEM images of the samples synthesized at different pH: (a, b) 5.0, (c, d) 5.4, (e, f) 5.8, (g, h) 6.9, (i, j) 10.0 and (k, l) 11.3. In this part, 0.5 mL H₂PtCl₆•6H₂O (1 g•100 mL⁻¹) was used instead of 20 μ L HCl (1.2 M) to synthesize the sample.



Fig. S5. Size distribution of the samples synthesized at different pH: (a) 5.0, (b) 5.4, (c) 5.8, (d) 6.9, (e) 10.0 and (f) 11.3. The statistics were carried out according to the SEM images of the corresponding samples.



Fig. S6. SEM images of the samples synthesized at different time: (a, b) 5, (c, d) 80, (e, f) 120 and (g, h) 240 min. In this part, 0.5 mL H₂PtCl₆•6H₂O (1 g•100 mL⁻¹) was used instead of 20 μ L HCl (1.2 M) to synthesize the sample.



Fig. S7. Size distribution of the samples synthesized at different time: (a) 5, (b) 80, (c) 120 and (d) 240 min. The statistics were carried out according to the SEM images of the corresponding samples.



Fig. S8. SEM images of the samples synthesized at different temperatures and different times: (a) T_{15} - $t_{0.1}$, (b) T_{15} - t_1 , (c) T_{15} - t_5 , (d) T_{25} - $t_{0.1}$, (e) T_{25} - t_1 , (f) T_{25} - t_5 , (g) T_{30} - $t_{0.1}$, (h) T_{30} - t_1 , (i) T_{30} - t_5 , (j) T_{35} - $t_{0.1}$, (k) T_{35} - t_1 and (l) T_{35} - t_5 . "T" represents the reaction temperature (°C) and "t" represents the reaction time (min). In this part, 0.5 mL H₂PtCl₆•6H₂O (1 g•100 mL⁻¹) was used instead of 20 µL HCl (1.2 M) to synthesize the sample.



Fig. S9. Size distribution of the samples synthesized at different temperatures and different times: (a) T_{15} - $t_{0.1}$, (b) T_{15} - t_1 , (c) T_{15} - t_5 , (d) T_{25} - $t_{0.1}$, (e) T_{25} - t_1 , (f) T_{25} - t_5 , (g) T_{30} - $t_{0.1}$, (h) T_{30} - t_1 , (i) T_{30} - t_5 , (j) T_{35} - $t_{0.1}$, (k) T_{35} - t_1 and (l) T_{35} - t_5 . The statistics were carried out according to the SEM images of the corresponding samples.

	Pt loading (wt %)
Temperature-25 °C	0.0093
Temperature-35 °C	0.0049
Temperature-50 °C	0.0058
pH-5.0	0.0066
pH-6.9	0.0082
pH-9.96	0.0068
time-2 h	0.0053

Table S1. The Pt loading of the metal oxide that derived from the correspondingsample. The theoretical Pt loading is about 1.8 wt %.



Fig. S10. SEM images of the samples related to etching experiment: (a, b) E-Pt, (c, d) E-20Cl, (e, f) E-0.5Cl, (g, h) E-0.5N, (i, j) E-0.5S, (k, l) IE-0.5Cl.



Fig. S11. XRD patterns of the as-prepared samples.



Fig. S12. The (a) CO adsorption and (c) N_2 purging spectra of mc-Pt/CeO₂, and (b, d) the corresponding results of c-Pt/CeO₂.

Table S2. The particle size distribution and average particle size of Pt, concentrations of Pt-O-Ce and Pt-O, percentages of different surface Pt and O species, Ce^{3+}/Ce^{4+} values in mc-Pt/CeO₂ and c-Pt/CeO₂ catalysts.

eO ₂
.9 nm
m
)7
51
57
%
%
%
5
5 2 2

Samples	Pt content (wt%)	HCHO concentration (ppm)	Temperature (°C)	R _{s-catal} ^a	R _{s-Pt} ^b	Reference
mc-Pt/CeO ₂	3.10	190	20	0.0074	0.2387	Our work
c-Pt/CeO ₂	3.20	190	20	0.0063	0.2313	Our work
Pt/CeO ₂	0.17	100	20	0.0023	1.3529	S 1
Pt/ZrO ₂	0.88	100	25	0.0035	0.3973	S2
Pt/TiO ₂	1.00	100	25	0.0041	0.4100	S 3
Pt/γ - Al_2O_3	1.00	80	25	0.0049	0.4900	S4
Pt/SiO ₂	1.00	300	25	0.0013	0.1300	S 5
Pt/FeOOH	0.77	50	25	0.0010	0.1273	S 6
Na ⁺ -Pt/MnO ₂	1.55	200	25	0.0010	0.0619	S 7
Pt/MnO _x -CeO ₂	3.00	200	25	0.0025	0.0833	S 8
Pt-Ni/Fe layered double oxides	1.00	100	25	0.0003	0.0300	S 9
Pt-Ni/ZSM-5	0.1	50	30	0.0002	0.1800	S10

Table S3. The comparison of catalytic activity between the as-prepared catalysts in this work and the reported catalysts.

The reaction rates ($R_{s-catal}$ and R_{s-Pt}) were calculated using the following expression:^{S2}

$$\label{eq:Rs-catal} \begin{split} ^{a}R_{s\text{-catal}} &= X_{HCHO}QC_{f}\!/mS_{BET} \;(mmol \; h^{-1} \; g_{catal}^{-1} \; m^{-2}) \\ ^{b}R_{s\text{-catal}} &= X_{HCHO}QC_{f}\!/mS_{BET}W_{Pt} \;(mmol \; h^{-1} \; g_{Pt}^{-1} \; m^{-2}) \end{split}$$

where X_{HXHO} is the HCHO conversion, Q is the volumetric flow rate (mL h⁻¹) and C_f is the inlet concentration of HCHO (mol mL⁻¹). m is the mass of the catalyst employed (g), S_{BET} is the BET surface area of the catalyst (m² g⁻¹) and W_{Pt} is the Pt content (wt%).

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