Electronic Supplementary Information (ESI)

Preparation of novel CeMo(x) hollow microspheres for low-temperature SCR removal of NOx with NH_3

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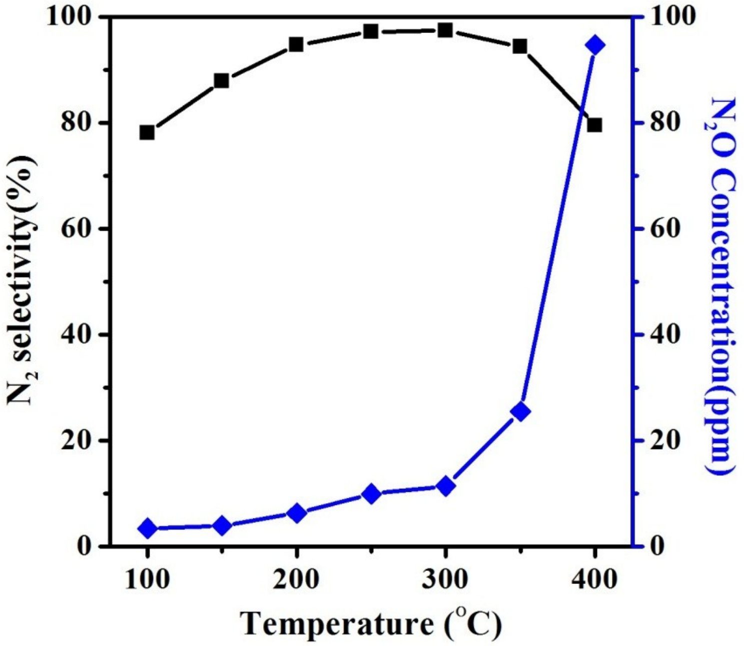

Fig. S1 N_2 selectivity of CeMo(0.3) hollow microspheres. Reaction conditions: [NO] = [NH_3]=500 ppm, [O_2] = 5%, balanced in N_2, GHSV = 30 000 h^{-1}.

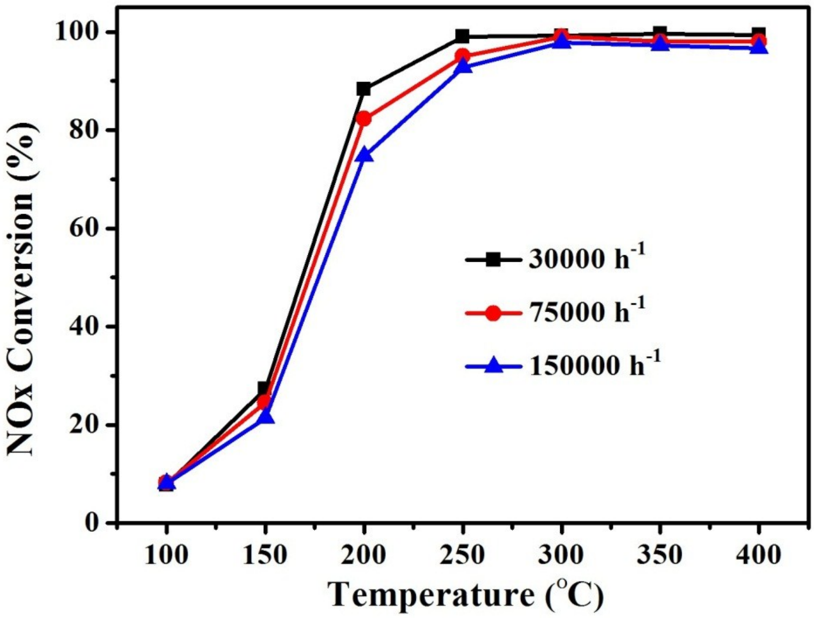

Fig. S2 NOx conversion ratio of CeMo(0.3) hollow microspheres under different GHSVs**.**

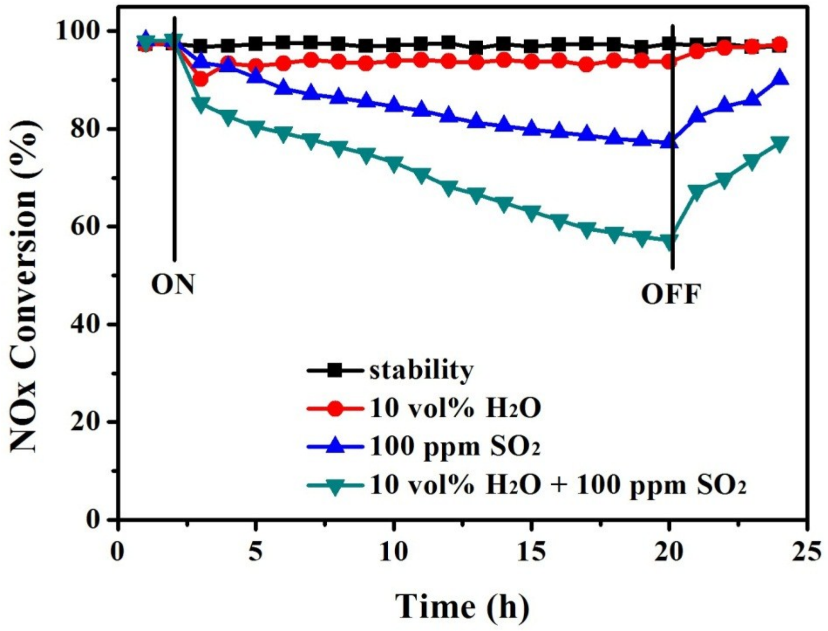

Fig. S3 The study of thermal stability, H_2O resistance and SO_2 tolerance at 250 °C on bulk CeMo(0.3) sample. Reaction conditions: [NO] = $[NH_3]$=500 ppm, $[O_2]$ = 5%, balanced in N_2, GHSV = 30 000 h^{-1}.

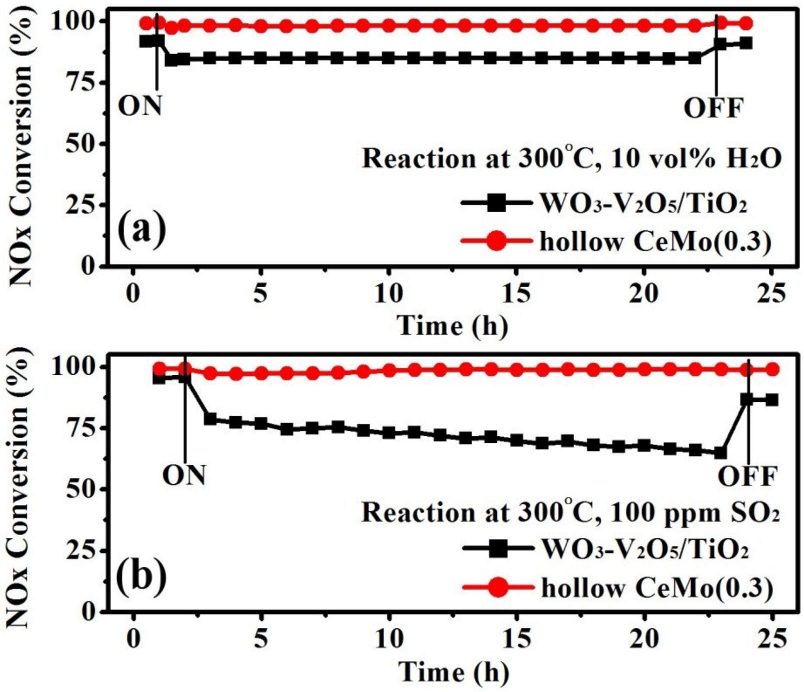

Fig. S4 The comparison of CeMo(0.3) hollow microspheres and WO_3-V_2O_5/TiO_2 on (a) H_2O resistance and (b) SO_2 tolerance at 300°C. Reaction conditions: [NO] = $[NH_3]$=500 ppm, $[O_2]$ = 5%, $[H_2O]$ = 10 vol% (while used), $[SO_2]$ = 100 ppm (when used), balanced in N_2, GHSV = 30 000 h^{-1}.

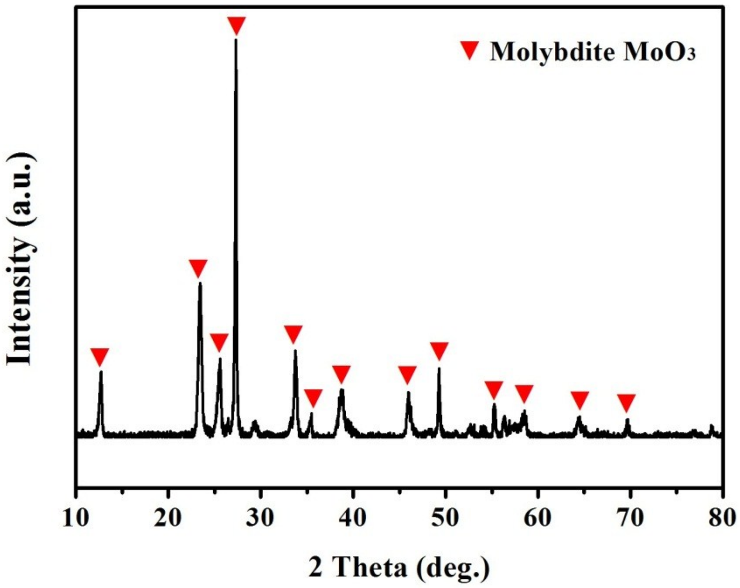

Fig. S5 The XRD pattern of pure hollow MoO_3.

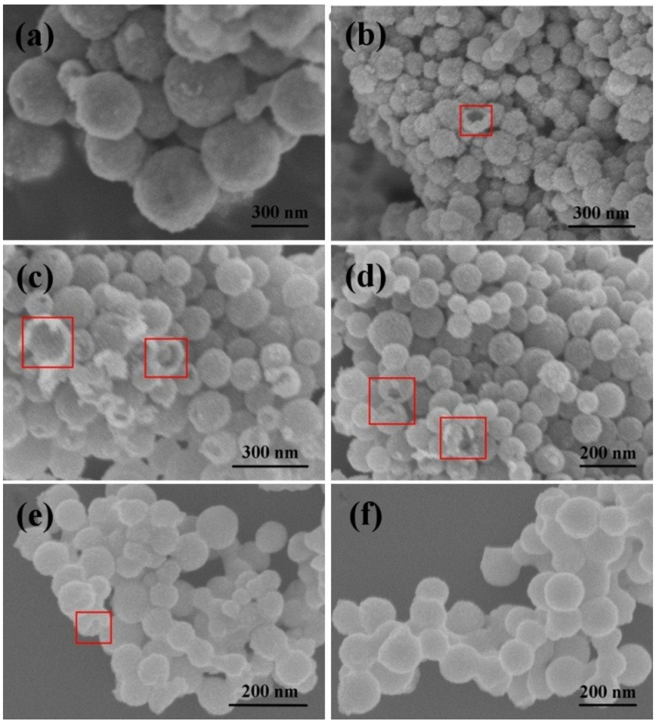

Fig. S6 Morphology and structure of CeMo(x) hollow microspheres: (a) CeO_2, (b) CeMo(0.1), (c) CeMo(0.2), (d) CeMo(0.3), (e) CeMo(0.4), (f) CeMo(0.5).

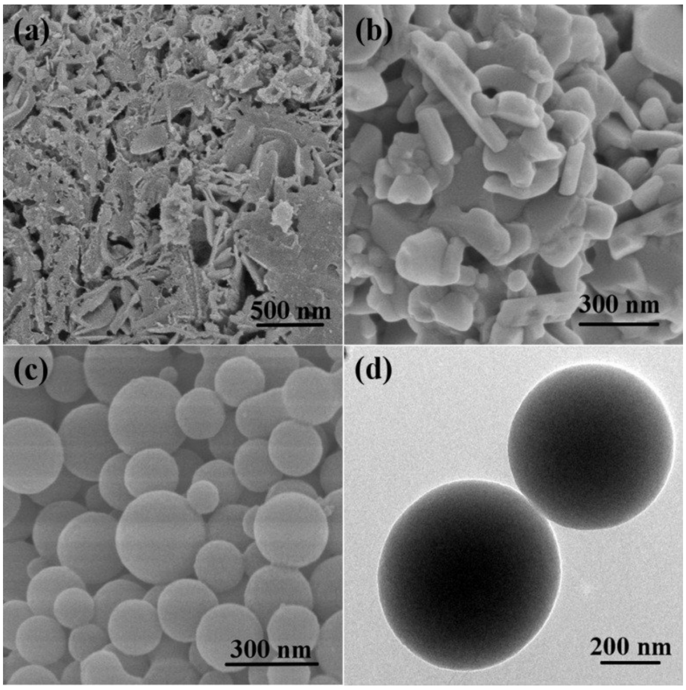

Fig. S7 SEM images of (a) bulk CeMo(0.3), (b) bulk MoO_3 and (c) carbon templates, and (d) TEM image of carbon microspheres.

It was shown in Fig. S7b that pure MoO_3 hollow microsphere cannot be obtained, which may be due to the aggregation of MoO_3。

The diameter of the hollow materials was smaller than that of carbon templates (Figure S7c and d), which was due to that the crystalline phase grew inside to occupy partial hollow space after the removal of carbon templates at about 300 °C (lower than the calcination temperature 400 °C).

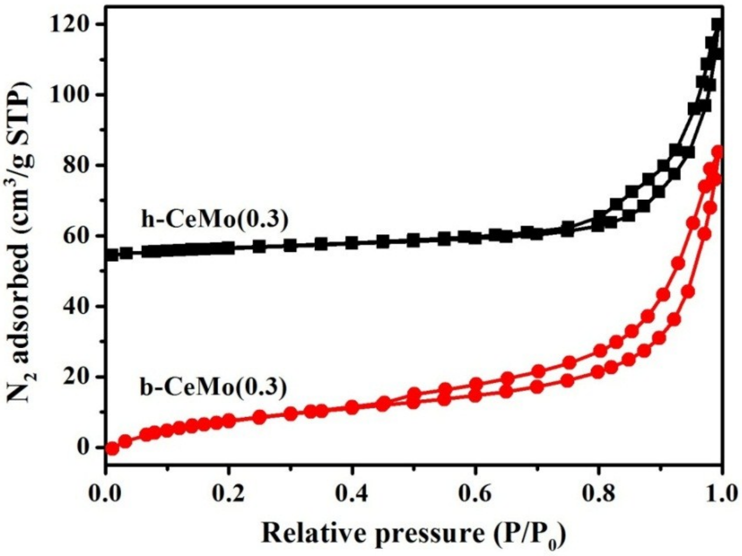

Fig. S8 N_2 adsorption-desorption isotherm of CeMo(0.3) hollow microspheres and bulk CeMo(0.3) sample.

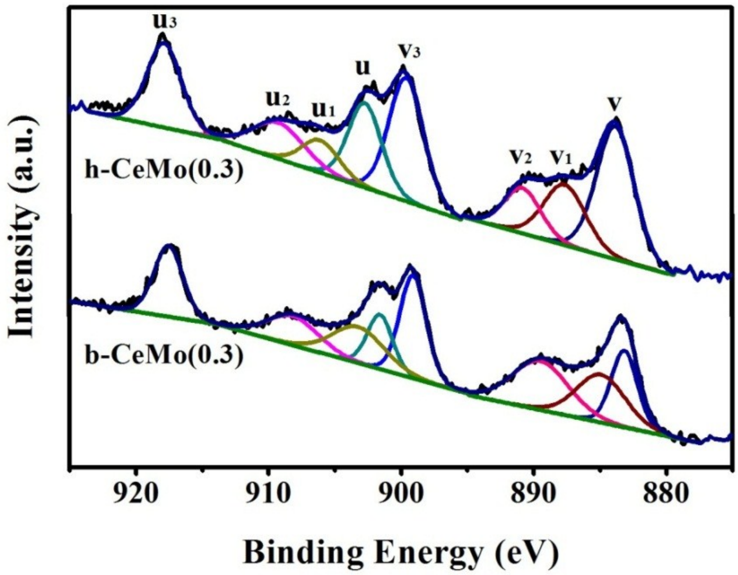

Fig. S9 Ce 3d XPS spectra of CeMo(0.3) hollow microspheres and bulk CeMo(0.3) sample.

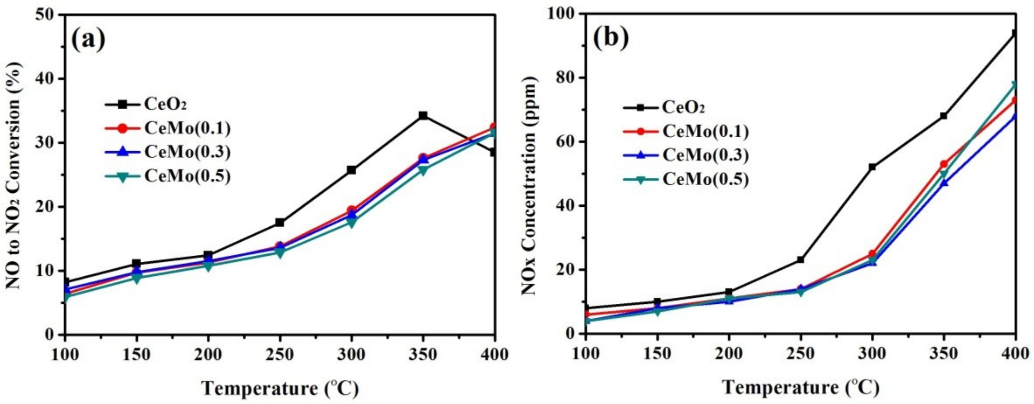

Fig. S10 (a) NO-to-NO_2 conversion during the NO oxidation reaction; (b) NOx concentration during the NH_3 oxidation reaction over CeMo(x) hollow microspheres. Reaction conditions: 500 ppm of NO or NH_3, 5 vol % O_2, N_2 as balance gas, total flow rate 200 mL/min, and GHSV = 30 000 h^{-1}.

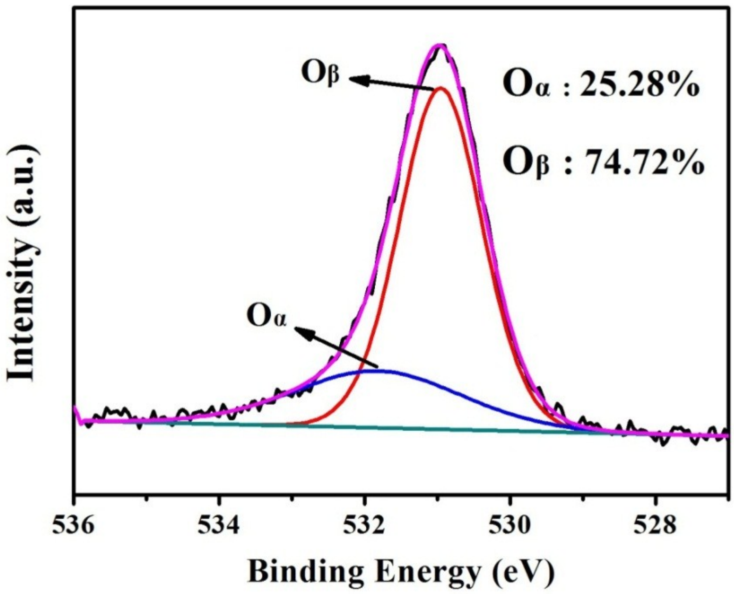

Fig. S11 O 1s XPS spectra of bulk CeMo(0.3) sample.

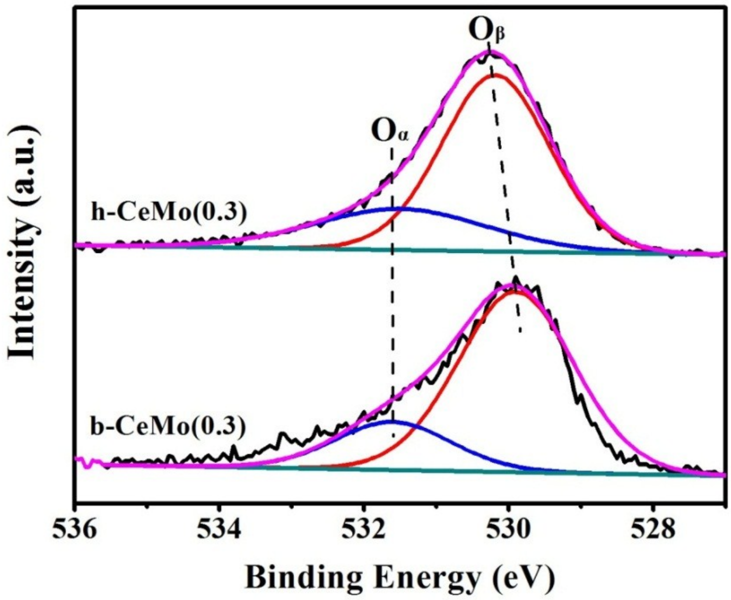

Fig. S12 O 1s XPS spectra of CeMo(0.3) hollow microspheres and bulk CeMo(0.3) sample.

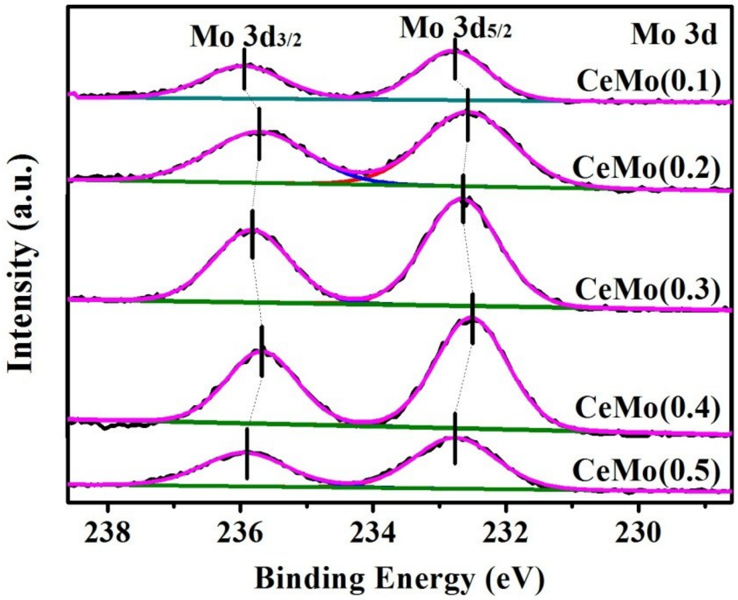

Fig. S13 XPS spectra of the prepared CeMo(x) hollow microspheres.

Fig. S13 illustrates the Mo 3d spectra of the CeMo(x) hollow microspheres. The two binding energy peaks at 232.5±0.2 and 235.9±0.2 eV represented Mo 3d$_{5/2}$ and Mo 3d$_{3/2}$.[1] The Mo 3d$_{5/2}$ peak represents Mo^{6+} surface species and the Mo 3d$_{3/2}$ peak is attributed to Mo$^{(6-\delta)+}$ species.[2]

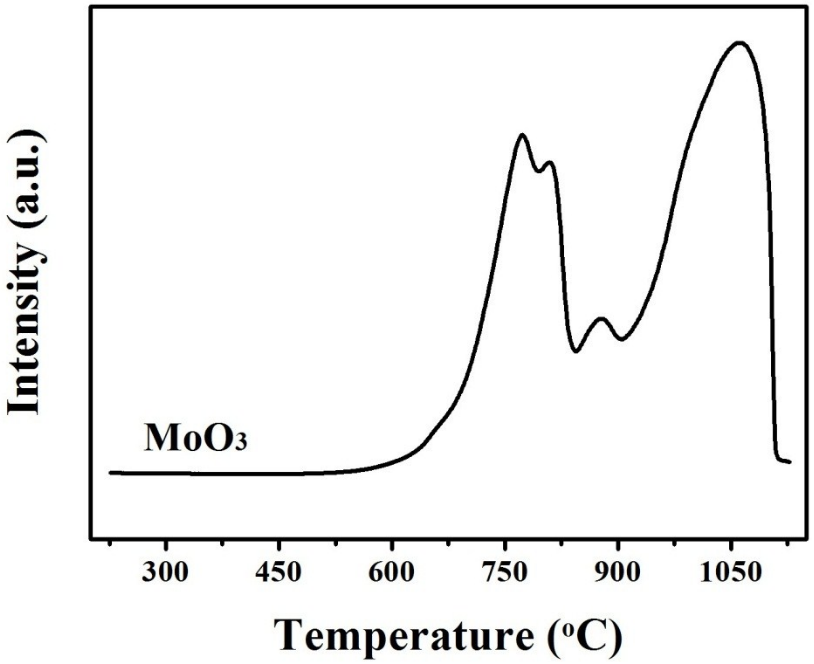

Fig. S14 H_2-TPR of pure MoO_3.

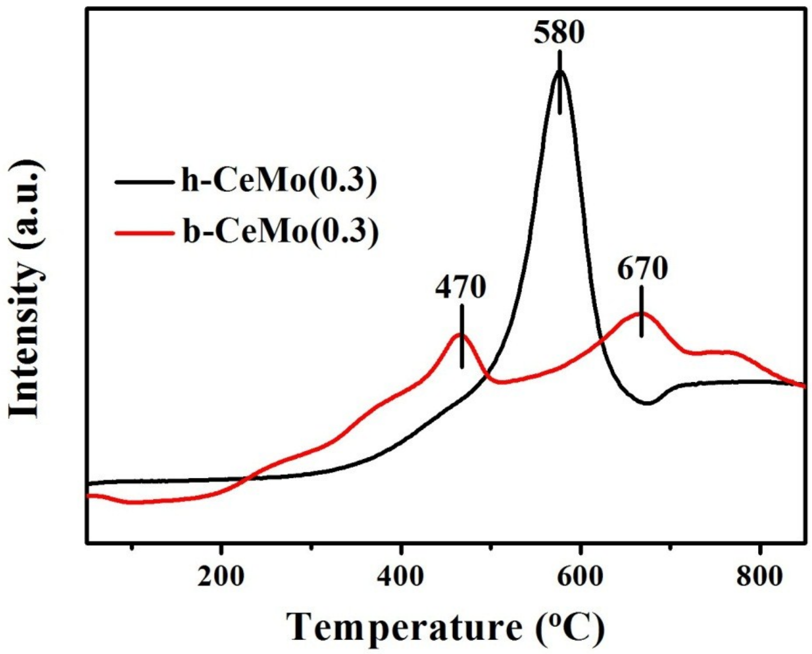

Fig. S15 H_2-TPR analysis of CeMo(0.3) hollow microspheres and bulk CeMo(0.3) sample.

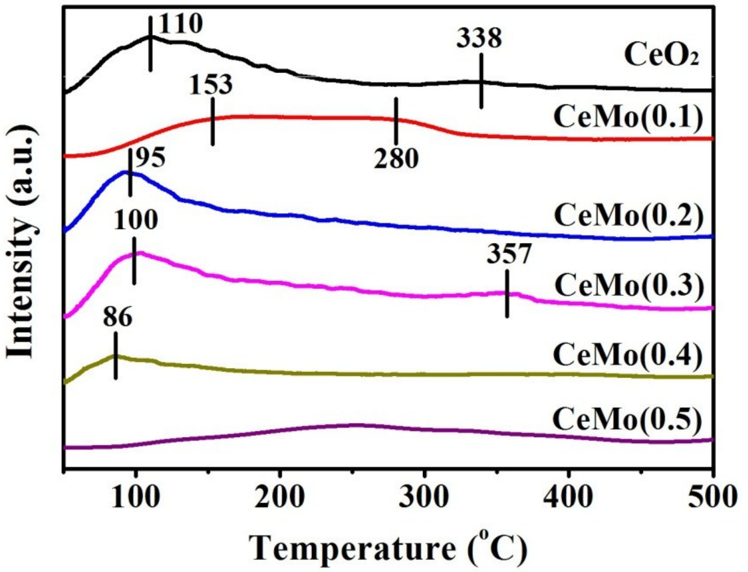

Fig. S16 NH_3-TPD analysis of CeMo(x) hollow microspheres.

NH_3-TPD data can be used to evaluate the surface acidity of samples in solid-state quantitatively.[3] As is well known, the coordinated NH_3 molecular bound to the Lewis acid sites is more thermally stable than the NH_4^+ ions fixed on the Brønsted acid sites. It is reported that NH_3 desorption peaks corresponding to Lewis acid sites occur at 200 °C or higher on CeO_2-based samples,[4] so the peaks lower than 200 °C were bound to Brønsted acid sites. Thus the amount of acid sites, shown in the form of normalized

NH_3 desorption of the sample, was calculated by integrating the peak area from NH_3-TPD curves (Fig. S16), and the results were shown in Fig. 7b.

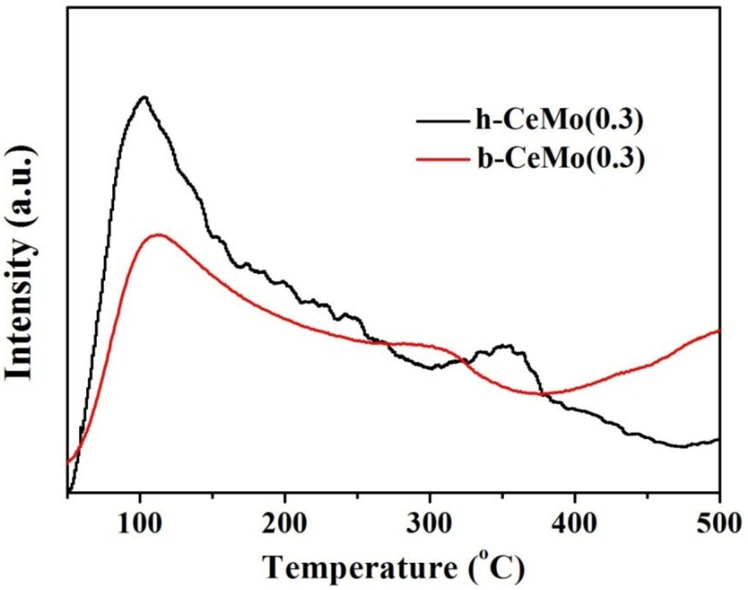

Fig. S17 NH_3-TPD analysis of CeMo(0.3) hollow microspheres and bulk CeMo(0.3) sample

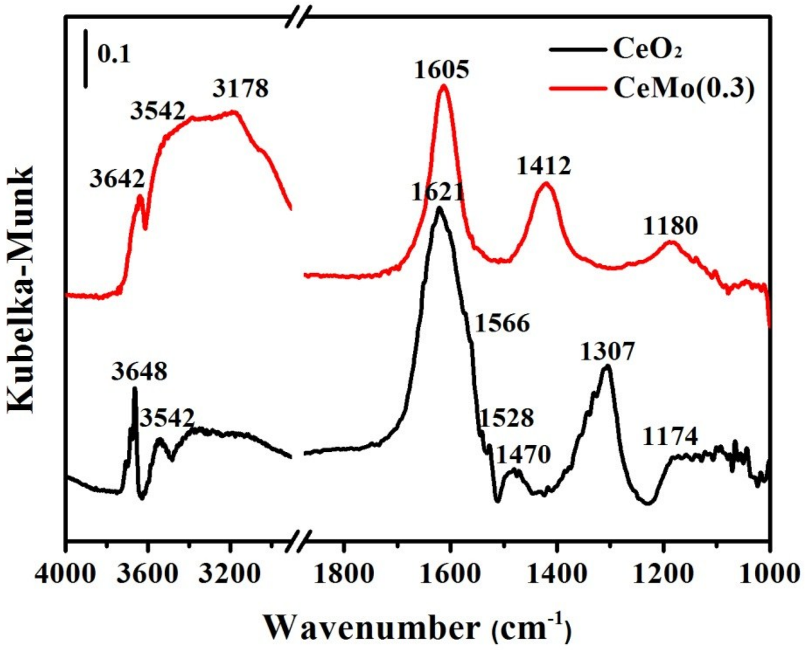

Fig. S18 In situ DRIFTS of NH_3 adsorption on CeO_2 and CeMo(0.3) hollow microspheres at 100°C.

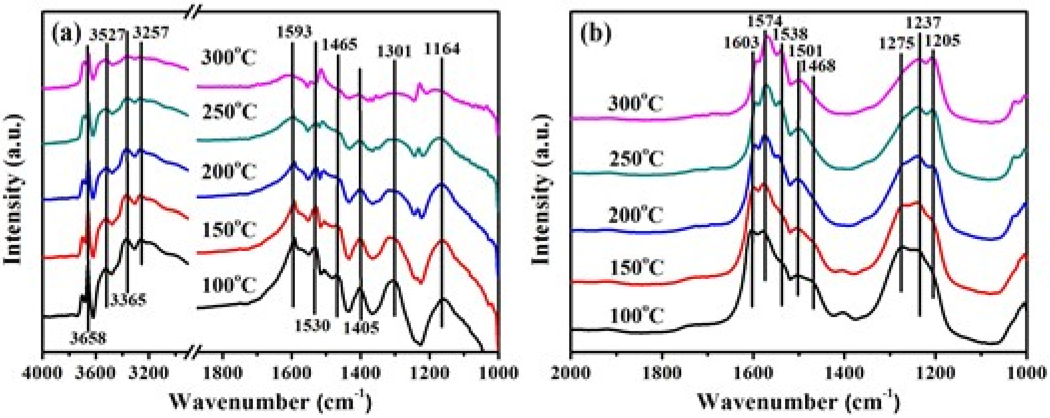

Fig. S19 *In situ* DRIFTS of bulk CeMo(0.3) under 500 ppm NH_3 (a) and 500 ppm NO (b) at different temperature.

References

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