## The effect of water on the heterogeneous reactions of SO<sub>2</sub> and NH<sub>3</sub> on the surfaces of $\alpha$ -Fe<sub>2</sub>O<sub>3</sub> and $\gamma$ -Al<sub>2</sub>O<sub>3</sub>

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Fig. S1 XRD patterns of  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub> and  $\gamma$ -Al<sub>2</sub>O<sub>3</sub>.



Fig. S2 Linear mass dependence for  $\gamma_{obs}$  on oxides at different RH.



Fig. S3 DRIFTS spectra of α-Fe<sub>2</sub>O<sub>3</sub> exposed to 200 ppmv SO<sub>2</sub> and 100 ppmv NH<sub>3</sub> as a function of time at (a) 20% RH, (b) 60% RH; and (c) Gaussian-Lorentzian peak fitting of typical spectra shown in (a) and (b).



**Fig. S4** Integrated areas of fitting-peaks with reaction time at low RH (a) and at high RH (b).



Fig. S5 Individual reactions of SO<sub>2</sub> and NH<sub>3</sub> on (a) (b) α-Fe<sub>2</sub>O<sub>3</sub>, and (c) (d) γ-Al<sub>2</sub>O<sub>3</sub> at different RH. The reaction conditions are as follows: 200 ppmv SO<sub>2</sub> or 100 ppmv NH<sub>3</sub> balanced with synthetic air in a flow of 100 mL/min.



**Fig. S6** DRIFTS spectra of water adsorption as a function of RH on (a) SO<sub>2</sub>+NH<sub>3</sub> aged-Fe<sub>2</sub>O<sub>3</sub> and (b) SO<sub>2</sub>+NH<sub>3</sub> aged-Al<sub>2</sub>O<sub>3</sub>.

To investigate the influence of water on the stability of adsorbates on oxides,  $SO_2$  and  $NH_3$  mixture aged  $-\alpha$ -Fe<sub>2</sub>O<sub>3</sub> and  $\gamma$ -Al<sub>2</sub>O<sub>3</sub> were exposed to water vapor as a function of RH. The oxides were first exposed to 200 ppmv SO<sub>2</sub> and 100 ppmv NH<sub>3</sub> simultaneously for 1h followed purge by nitrogen for 2h to remove physisorbed species, and then exposed to water vapor at elevated RH. The exposure process was

kept for 30 min at each RH.

On  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub> (Fig. S6a), the absorption bands of sulfate at 1225 and 1131 cm<sup>-1</sup> and ammonia species at 1429 cm<sup>-1</sup> corresponded with 3214, 3035, 2842 cm<sup>-1</sup> changed slightly with increasing RH, indicating they sticking strongly to the surface. In contrast, for Al<sub>2</sub>O<sub>3</sub> (Fig. S6b), the intensities of the bands at 960 cm<sup>-1</sup> and 1180 cm<sup>-1</sup> that are assigned to sulfite and sulfate species, respectively, increased significantly accompanied with the increase of absorption of water at 1635 cm<sup>-1</sup>.<sup>1, 2</sup> However, no SO<sub>2</sub> or NH<sub>3</sub> was introduced to the gas flow during this process, indicating that surface-coordinated sulfite at 1080 and 960 cm<sup>-1</sup> may convert to water-solvated sulfate species;<sup>3</sup> meanwhile, the adsorption of NH<sub>4</sub><sup>+</sup> at band of 1456 cm<sup>-1</sup> decreased remarkably, suggesting loss of this species. The results show that the sulfurcontaining and nitrogen-containing species resulting from the adsorption of SO<sub>2</sub> and NH<sub>3</sub> are less stable under the disturbance of water.

## Notes and references

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