

Supplementary information for

**Synergistic Formation of Sulfate and Ammonium Resulting from Reaction
between SO₂ and NH₃ on Typical Mineral Dust.**

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Table S1 Physical properties of mineral oxide particle used. The average particle sizes for mineral oxides were calculated over a peak of 2θ using the Scherrer equation derived from XRD.

Mineral oxides	Commercial sources	purity	BET surface area/m ² g ⁻¹	average grain size (nm)
γ -Al ₂ O ₃	SASOL	≥ 98.7 %	185.8	10.4, (2 θ = 66.9°)
TiO ₂ (anatase)	Alfa Aesar	≥ 99.5 %	165.0	12.9, (2 θ = 25.2°)
MgO	Sinopharm	≥ 98.5 %	29.1	35.5, (2 θ = 42.8°)
α -Fe ₂ O ₃	Self-made by precipitation ¹	—	24.5	27.8, (2 θ = 33.0°)

Table S2 IC results of the amount of sulfate and ammonium formed on α -Fe₂O₃ with different exposure time to SO₂ or/and NH₃ in *in situ* chamber.

Reaction time /min	SO ₄ ²⁻ (ppm)		NH ₄ ⁺ (ppm)	
	SO ₂ reaction	SO ₂ +NH ₃ reaction	NH ₃ reaction	SO ₂ +NH ₃ reaction
10	19.05	26.45	1.28	10.06
30	81.50	115.35	8.08	32.81
60	138.0	253.50	10.44	35.04

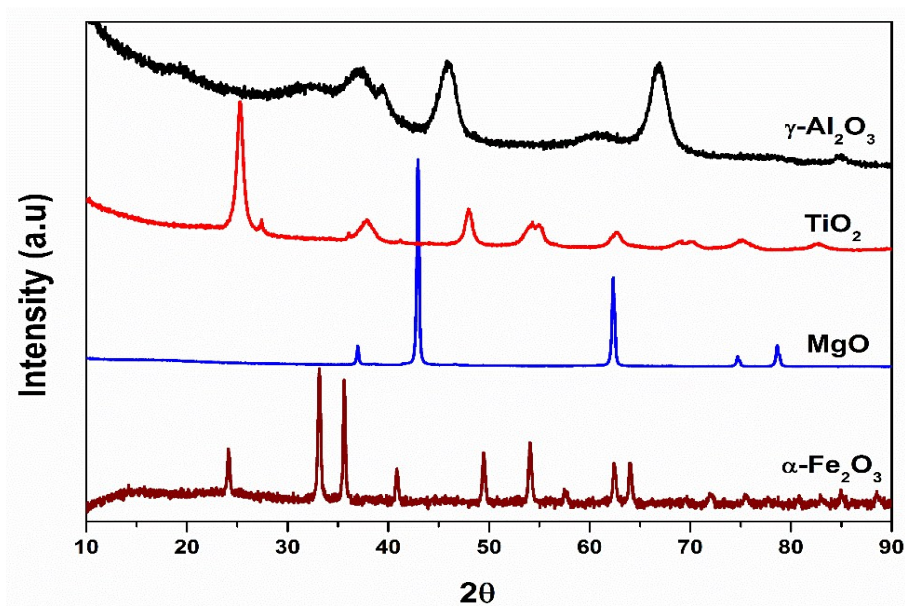


Fig. S1 XRD profile of mineral oxides

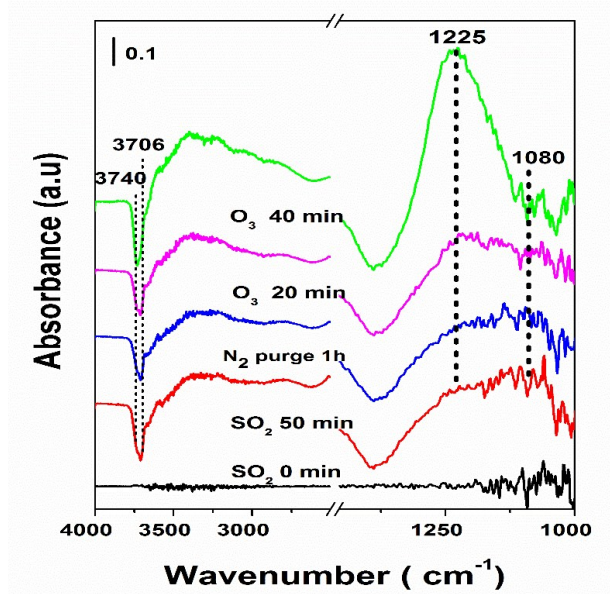


Fig. S2 DRIFTS spectra of adsorption of SO_2 on $\gamma\text{-Al}_2\text{O}_3$ followed exposure to O_3

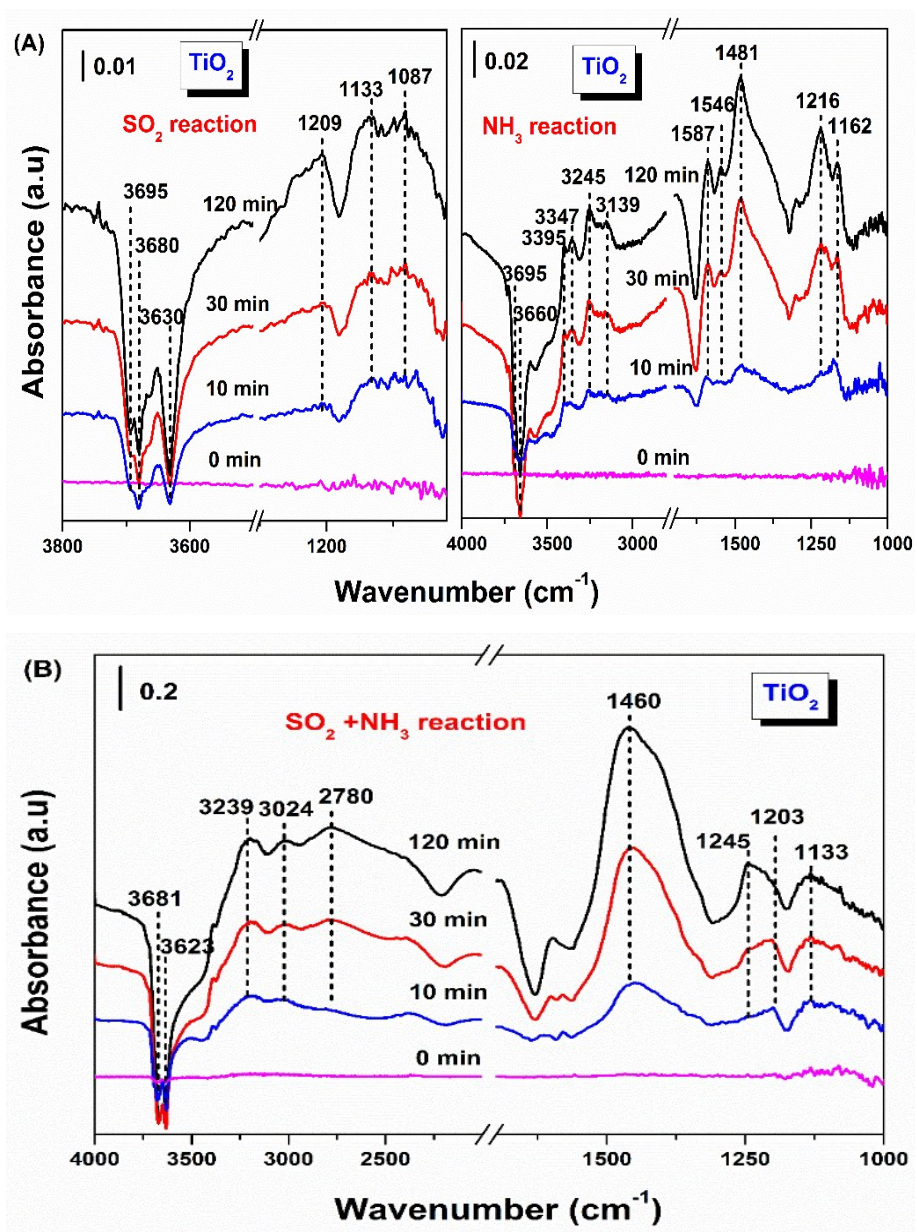


Fig. S3 *In situ* DRIFTS study of TiO_2 exposed to (A) individual 200 ppmv SO_2 or 100 ppm NH_3 , and (B) 200 ppmv SO_2 and 100 ppmv NH_3 simultaneously as a function of time in a flow of 100 mL/min synthetic air (20 % O_2 , 80 % N_2) at 303 K

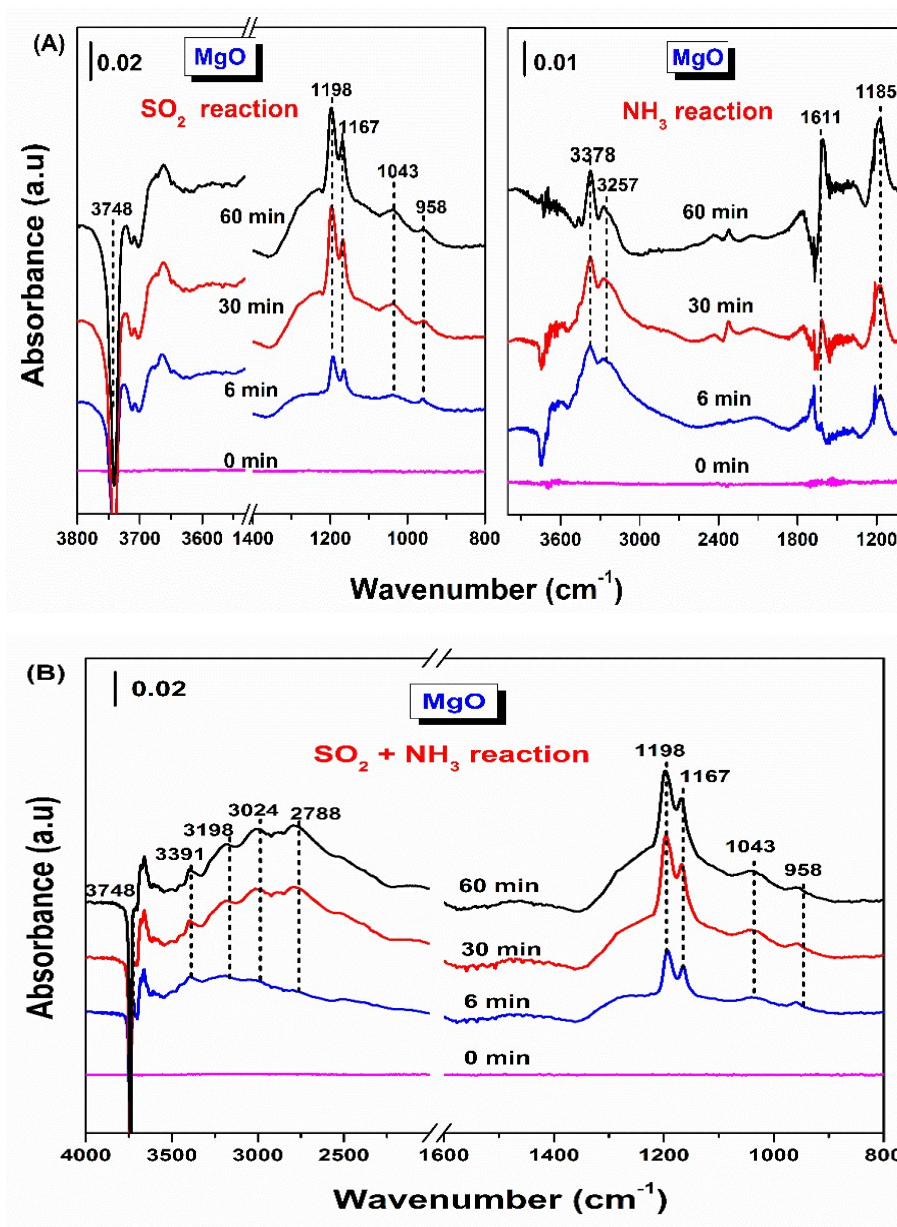


Fig. S4 *In situ* DRIFTS study of MgO exposed to (A) individual 200 ppmv SO₂ or 100 ppm NH₃, and (B) 200 ppmv SO₂ and 100 ppmv NH₃ simultaneously as a function of time in a flow of 100 mL/min synthetic air (20 % O₂, 80 % N₂) at 303 K

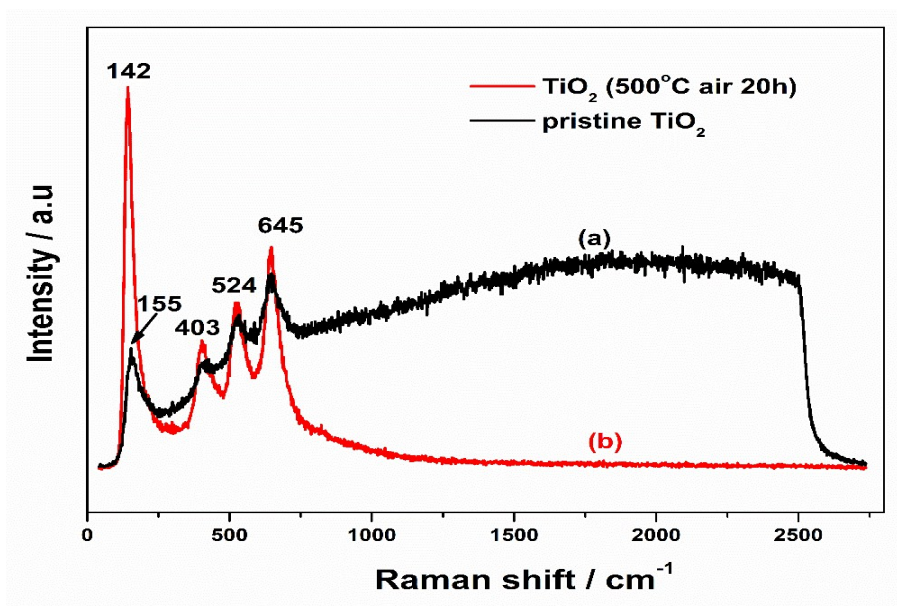


Fig. S5 Raman spectra of TiO₂ (a) pristine and (b) calcined at 500 °C for 20 h in air.

Visible Raman spectra of TiO₂ samples were collected at room temperature on a Spex 1877 D triplemate spectrograph with spectral resolution of 2 cm⁻¹. A 532 nm DPSS diode-pump solid semiconductor laser was used as the excitation source and the power output was about 60 mW. The Raman signals were collected with conventional 90 ° geometry and the time for recording each spectrum was about 1000 ms. All Raman spectra used in this paper were original and unsmoothed. The Raman lines at 142, 403, 524 and 645 cm⁻¹ are assigned to the E_g, B_{1g}, A_{1g} or B_{1g}, and E_g modes of the anatase phase, respectively.² It was suggested that Raman lines would become weak and broad when the sample was imperfect due to oxygen vacancies and a blue shift of the lowest-frequency E_g Raman mode would take place under this condition.^{3,4} In this work, the E_g Raman mode at 155 cm⁻¹ red-shifted to 142 cm⁻¹ and the peaks became clearly sharpened when TiO₂ were oxidized at 500 °C for 20 h, indicating a better crystallization of TiO₂ occur through thermal annealing treatment. It was noted that no phase transformation was observed during this process. The results implied

that the pristine TiO₂ used in this study were high-defect.

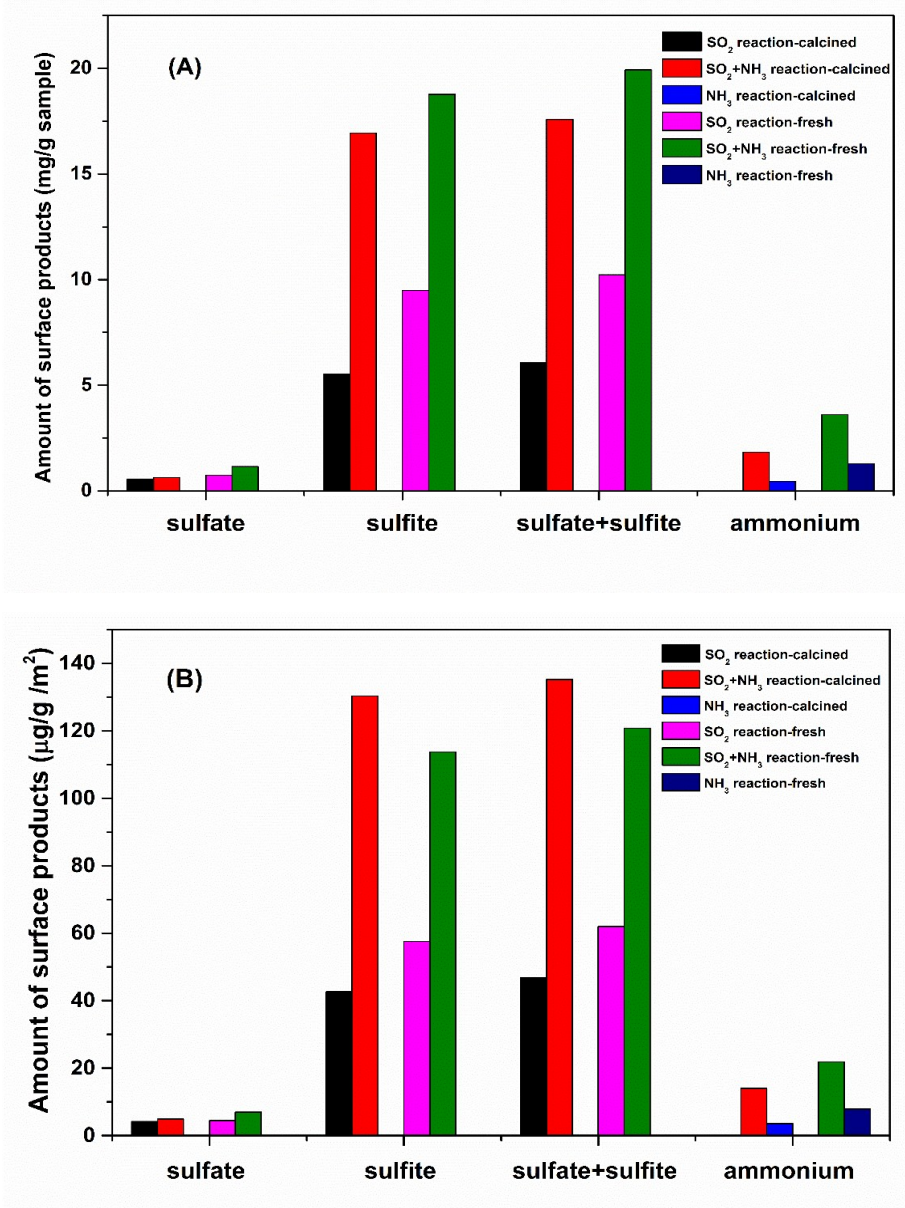


Fig.S6 Comparison of surface products between calcined-TiO₂ and fresh-TiO₂ normalized in product per unit mass (A); and in product per unit mass/surface area of sample (B).

References

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