

Supporting information

Effect of calcination temperature and calcination atmosphere on the performance of Co_3O_4 catalysts for the catalytic oxidation of toluene

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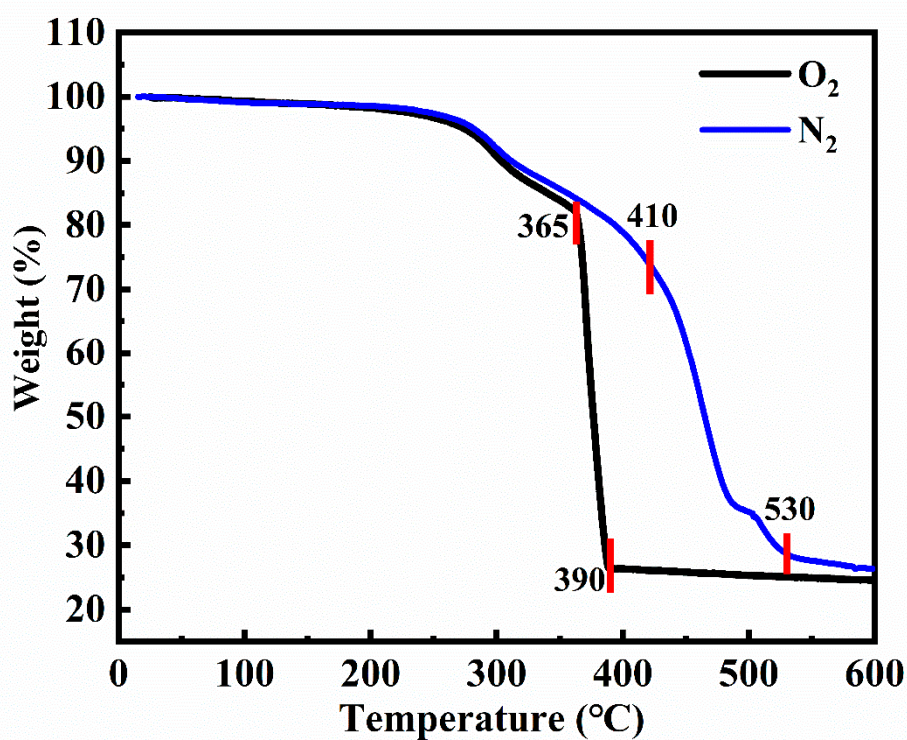
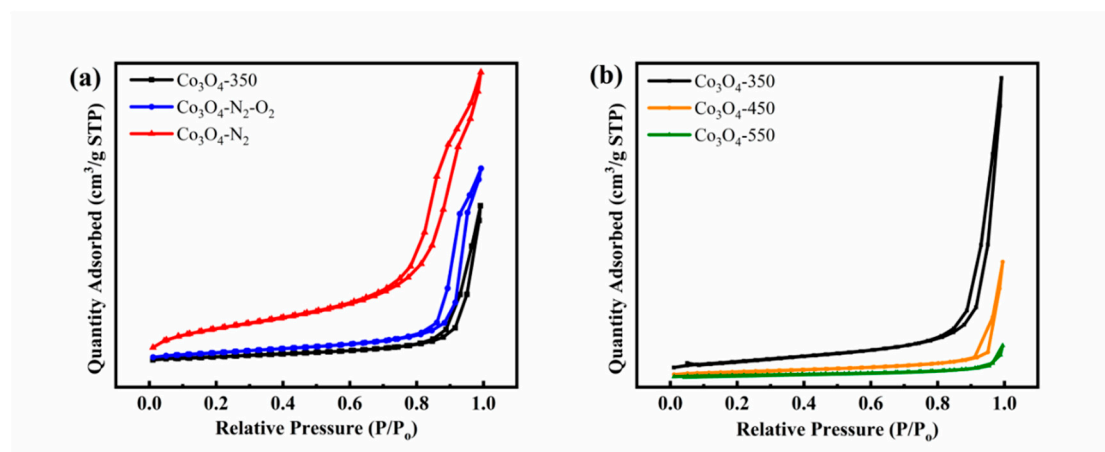


Figure S1. Thermal weight curve of Co-BTC

In order to investigate the optimum calcination temperature range for the material, air and N_2 were chosen to test the thermal stability of the material respectively, and the test results were shown in Figure S1. Under air or N_2 conditions, the thermal

decomposition of Co-BTC could be divided into two stages. The first stage in the weight loss belonged to the removal of solvent molecules ethanol, water, and DMF adsorbed in the pores of Co-BTC. The second stage was the carbonisation or decomposition of the organic ligands in the Co-BTC structure. Under air conditions, the first stage of Co-BTC weight loss before 365 °C and the second stage of Co-BTC weight loss from 366 °C to 390 °C corresponded to the decomposition of organic ligands in the structure. At N₂ conditions, the first stage of weight loss of Co-BTC before 410 °C and the second stage of weight loss of Co-BTC from 410 °C to 530 °C corresponded to the carbonisation of the organic ligands in the structure. It could be found that Co-BTC was more stable under N₂, mainly because under air conditions the organic ligand reacted rapidly with oxygen in the air to form CO₂ and H₂O, while under N₂ conditions the organic ligand was a slow carbonation process due to the lack of sufficient oxygen. To ensure complete oxidation of Co metal under air conditions and complete carbonisation of Co-BTC precursors under N₂, 350 °C, 450 °C, and 550 °C were chosen as the calcination temperatures under air conditions and 450 °C was used as the calcination temperature under N₂.



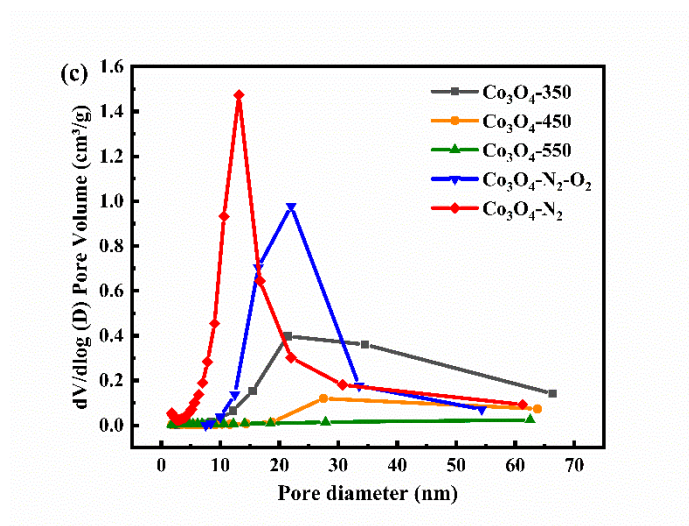


Figure S2. N₂ adsorption and desorption isotherms of samples (a) different calcination atmosphere and (b) calcination temperature in air, and (c) pore-size distributions of all samples

Table S1. Peak height of the XRD diffraction peaks of the catalysts

Catalysts	2θ								
	19°	31.3°	36.6°	36.8°	42.6°	44.8°	59.4°	61.8°	65.2°
Co ₃ O ₄ -550	435	880	-	2634	-	512	767	-	784
Co ₃ O ₄ -450	419	706	-	2096	-	391	559	-	638
Co ₃ O ₄ -350	252	438	-	1352	-	274	403	-	449
Co ₃ O ₄ -N ₂ -O ₂	211	360	-	1078	-	230	346	-	381
Co ₃ O ₄ -N ₂	-	-	181	-	195	-	-	116	-

Table S2. FWHM of the XRD diffraction peaks of the catalysts

Catalysts	2θ								
	19°	31.3°	36.6°	36.8°	42.6°	44.8°	59.4°	61.8°	65.2°
Co ₃ O ₄ -550	0.223	0.259	-	0.247	-	0.272	0.308	-	0.348
Co ₃ O ₄ -450	0.278	0.281	-	0.302	-	0.343	0.410	-	0.420
Co ₃ O ₄ -350	0.405	0.403	-	0.454	-	0.498	0.528	-	0.568
Co ₃ O ₄ -N ₂ -O ₂	0.474	0.480	-	0.500	-	0.501	0.533	-	0.595
Co ₃ O ₄ -N ₂	-	-	0.769	-	0.667	-	-	0.782	-

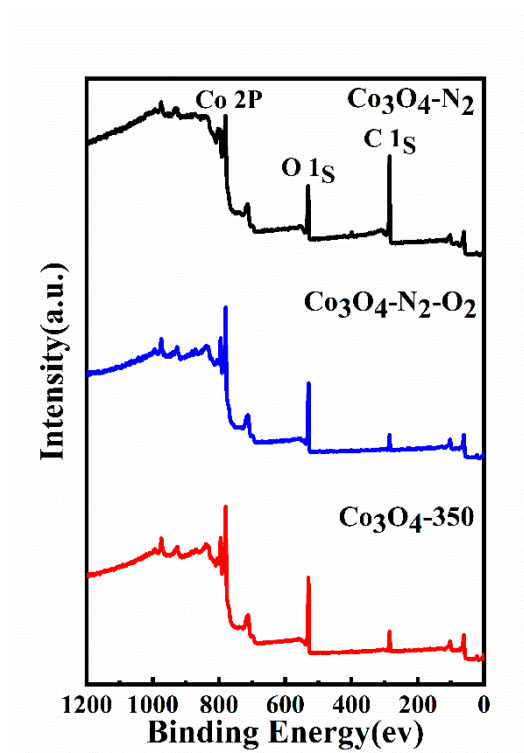


Figure S3. XPS full spectra of Co_3O_4 catalysts

Table S3. Catalytic activities of toluene and apparent activation energies (E_a) of all catalysts

Catalysts	WHSV ($\text{mL} \cdot \text{g}^{-1} \cdot \text{h}^{-1}$)	Toluene conversion ($^{\circ}\text{C}$)			Apparent activation energy ($\text{KJ} \cdot \text{mol}^{-1}$)
		T_{10}	T_{50}	T_{90}	
Co_3O_4 -550	60000	241	254	269	70.43
Co_3O_4 -450		227	239	259	47.84
Co_3O_4 -350		223	236	250	42.06
Co_3O_4 - N_2 - O_2		221	234	245	39.65
Co_3O_4 - N_2		229	246	268	67.27