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BET Data

Catalyst (Cu wt. %)	SSA (m²/g)
0 (Co ₃ O ₄)	26
0.33	31
0.69	27
1.02	30
1.38	30
1.83	30
2.40	33
2.71	32
2.97	29
3.62	28
4.98	29
100 (CuO)	8
Cu-ZSM5	317

Table S1. Catalyst BET specific surface areas after calcination.

Reaction Data

Table S2. NO Conversion of all catalysts at various temperatures.

Catalyst	NO Conversion (%)							
Catalyst	350 °C	375 °C	400 °C	450 °C				
1.2 CuOx/Co ₃ O ₄			7.9	9.6				
2.5 CuOx/ Co ₃ O ₄			11.2	12.5				
3.7 CuOx/ Co ₃ O ₄			14.8	16.4				
5.0 CuOx/ Co ₃ O ₄			17.4	19.9				
6.7 CuOx/ Co ₃ O ₄			18.3	21.5				
8.7 CuOx/ Co ₃ O ₄			16.7	18.9				
9.9 CuOx/ Co ₃ O ₄	13.6	16.2	17.1	19.6				
10.8 CuOx/ Co ₃ O ₄			16.5	19.5				
13.2 CuOx/ Co ₃ O ₄			16.2	19.6				
18.2 CuOx/ Co ₃ O ₄			15.4	19.5				
Cu-ZSM5	15.3	19.1	23.0	31.3				
Co ₃ O ₄				3.1				
CuO				2.1				

N ₂ Calibration Curve						
Known N₂ Concentration (ppm)	avg. m/z = 28 signal					
204	2.01					
409	2.98					
613	3.95					

Table S3. N_2 calibration data for 9.9CuOx/Co₃O₄.



Figure S1. N₂ Calibration curve for 9.9 Cu/nm² CuOx/Co₃O₄.

Sampla	N ₂ Selectivity (%)							
Sample	350 °C	375 °C	400 °C	450 °C				
1.2 CuOx/ Co ₃ O ₄			53.5	61.9				
2.5 CuOx/ Co ₃ O ₄			58.1	63.9				
3.7 CuOx/ Co ₃ O ₄			60.7	65.6				
5.0 CuOx/ Co ₃ O ₄			56.8	67.8				
6.7 CuOx/ Co ₃ O ₄			53.1	62.1				
8.7 CuOx/ Co ₃ O ₄			53.1	67.2				
9.9 CuOx/ Co ₃ O ₄	48.2	52.0	61.0	78.8				
10.8 CuOx/ Co ₃ O ₄			52.1	67.2				
13.2 CuOx/ Co ₃ O ₄			55.5	70.1				
18.2 CuOx/ Co ₃ O ₄			51.5	62.3				
Cu-ZSM5	13.7	25.3	44.1	72.5				
Co ₃ O ₄				58.6				
CuO				24.6				

Table S4. N₂ selectivity of all catalysts at various temperatures.

Catalyst	Areal Activity (µmol NO to N ₂ /m ² /s)							
Catalyst	350 °C	375 °C	400 °C	450 °C				
Co ₃ O ₄			0	2.84E-04				
1.2 CuOx/ Co ₃ O ₄			6.11E-04	8.55E-04				
2.5 CuOx/ Co ₃ O ₄			9.37E-04	1.15E-03				
3.7 CuOx/ Co ₃ O ₄			1.30E-03	1.64E-03				
5.0 CuOx/ Co ₃ O ₄			1.43E-03	1.95E-03				
6.7 CuOx/ Co ₃ O ₄			1.40E-03	1.93E-03				
8.7 CuOx/ Co ₃ O ₄			1.41E-03	2.02E-03				
9.9 CuOx/ Co ₃ O ₄	9.45E-04	1.22E-03	1.50E-03	2.24E-03				
10.8 CuOx/ Co ₃ O ₄			1.28E-03	1.85E-03				
13.2 CuOx/ Co ₃ O ₄			1.30E-03	1.98E-03				
18.2 CuOx/ Co ₃ O ₄			1.14E-03	1.76E-03				
Cu-ZSM5	9.03E-05	2.08E-04	4.38E-04	9.82E-04				
CuO			0	1.21E-04				

 Table S5. Areal activity all catalysts at various temperatures.

Table S6. Specific activity of all catalysts at various temperatures.

Catalyst	Specific Activity (μ mol NO to N ₂ /g/s)						
Catalyst	350 °C	375 °C	400 °C	450 °C			
Co ₃ O ₄			0	7.37E-03			
1.2 CuOx/ Co ₃ O ₄			1.59E-02	2.22E-02			
2.5 CuOx/ Co ₃ O ₄			2.44E-02	2.99E-02			
3.7 CuOx/ Co ₃ O ₄			3.38E-02	4.25E-02			
5.0 CuOx/ Co ₃ O ₄			3.72E-02	5.08E-02			
6.7 CuOx/ Co ₃ O ₄			3.65E-02	5.02E-02			
8.7 CuOx/ Co ₃ O ₄			3.67E-02	5.26E-02			
9.9 CuOx/ Co ₃ O ₄	2.46E-02	3.16E-02	3.91E-02	5.82E-02			
10.8 CuOx/ Co ₃ O ₄			3.32E-02	4.80E-02			
13.2 CuOx/ Co ₃ O ₄			3.37E-02	5.16E-02			
18.2 CuOx/ Co ₃ O ₄			2.97E-02	4.56E-02			
Cu-ZSM5	2.88E-02	6.64E-02	1.40E-01	3.13E-01			
CuO			0	9.60E-04			





Figure S2. Normalized XPS $Co2p_{3/2}$ spectra for $CuOx/Co_3O_4$ catalysts with varying Cu surface densities.



Figure S3. Left) Normalized XPS $Cu2p_{3/2}$ spectra for $CuOx/Co_3O_4$ catalysts with varying Cu surface densities, Right) Normalized XPS $Cu2p_{3/2}$ of 1.2 and 2.5 Cu/nm².

Band	Pos	PosSep	B_FWHM	FWHM	Height	%Gauss	Area	%Area	ChiSquared
1	932.57	0	2.68	2.68	7914	100	22581	41.87	0.79
2	935.01	2.44	2.68	2.68	4555	80	14233	26.39	
3	940.2	7.63	2.68	2.68	2859	80	8934	16.57	
4	943.04	10.47	2.68	2.68	2866	100	8176	15.16	

Table S7. 10.8 Cu/nm² CuOx/Co₃O₄ Cu $2p_{3/2}$ XPS fits (Example).

Band	Pos	PosSep	B_FWHM	FWHM	Height	%Gauss	Area	%Area	ChiSquared
1	779.37	0	2.02	2.02	31778	80	74897	56.01	5.27
2	781.05	1.68	2.48	2.2	15985	80	52078	38.94	
3	789.14	9.77	2.79	2.8	2073	80	6754	5.05	

Table S8. 10.8 Cu/nm² CuOx/Co₃O₄ Co $2p_{3/2}$ XPS fits (Example).

Table S9. XPS Co and Cu peak areas and ratios for all Cu surface densities.

Cu Surface Density (Cu/nm ²)	Cu2p _{3/2} Peak Area	Co2p _{3/2} Peak Area	Cu/Co Peak Area Ratio
1.2	4898	198957	0.025
2.5	4367	70487	0.062
3.7	16658	142198	0.117
5.0	24061	135541	0.178
6.7	36173	146757	0.246
8.7	39564	113282	0.349
9.9	57297	158563	0.361
10.8	53924	133729	0.403
13.2	62439	147664	0.423
18.2	42665	97733	0.437

Table S10. N_2O and NO_2 mass spectrometer baselines for Cu-ZSM5 and 9.9 Cu/nm² CuOx/Co₃O₄ forselectivity comparison.

Sample/Condition	N ₂ O Baseline (A.U.)	NO ₂ Baseline (A.U.)
Cu-ZSM5 (350-500 °C)	0.586	0.120
9.9 CuOx/Co ₃ O ₄ (350 and 375 °C)	0.146	0.043
9.9 CuOx/Co ₃ O ₄ (400-500 °C)	0.144	0.046

Tomporaturo	Cu-ZSM5			9.9 Cu/nm² CuOx/Co ₃ O ₄		
(°C)	N ₂ Selectivity (%)	N₂O Signal (A.U.)	NO₂ Signal (A.U.)	N ₂ Selectivity (%)	N ₂ O Signal (A.U.)	NO ₂ Signal (A.U.)
350	13.7	2.15	0.64	48.2	0.37	0.61
375	25.3	1.92	0.69	52.0	0.28	0.59
400	44.1	1.37	0.68	61.0	0.22	0.61
450	72.5	0.39	0.49	78.8	0.17	0.41
500	80.5	0.12	0.30	86.5	0.18	0.23

 $\label{eq:sigma} \begin{array}{l} \textbf{Table S11}. \ \mbox{Comparison of N_2 selectivity and N_2O and NO_2 mass spectrometer product signals from Cu-ZSM5 and $9.9 Cu/nm^2 CuOx/Co_3O_4$ at various reaction temperatures.} \end{array}$

Table S12. Comparison of NO_2 and N_2O mass spectrometer product signals over CuO and Co_3O_4 at 450 $^\circ$ C.

		N₂O		NO ₂		
Sample	Baseline (A.U.)	Signal during Reaction (A.U.)	Percent Change (%)	Baseline (A.U.)	Signal during Reaction (A.U.)	Percent Change (%)
CuO	0.0126	0.0165	+31.0	0.0040	0.0084	+110
Co ₃ O ₄	0.0250	0.0200	-20.0	0.0053	0.0220	+315