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Supporting Information

Nitrogen and sulfur co-doped cobalt carbon catalysts for ethylbenzene oxidation with synergistically enhanced performance

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Materials

Melamine, $Co(OAc)_2{\cdot}4H_2O$, $C_2H_4O_2S$, glucose monohydrate ($C_6H_{12}O_6{\cdot}H_2O$), bromobenzene, 1,4-dichlorobenzene, and anhydrous ethanol were from commercial sources and were used without any further purification.

Results and discussion

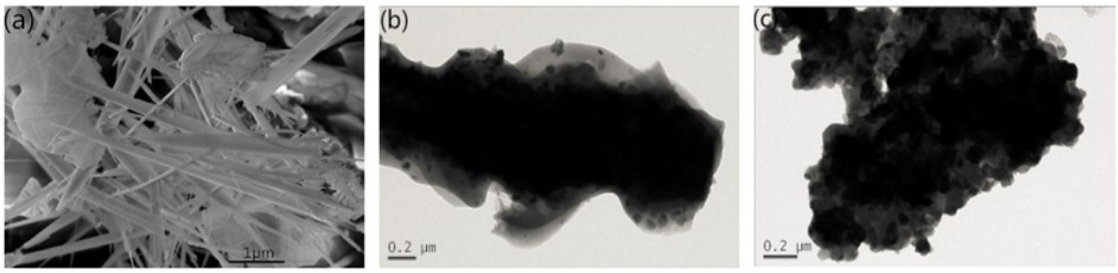

Figure S1. SEM image of (a) Co-N-S-C-700; TEM images of (b) Co-S-C-700 and (c) r-Co-N-S-C-700 (re-activated)

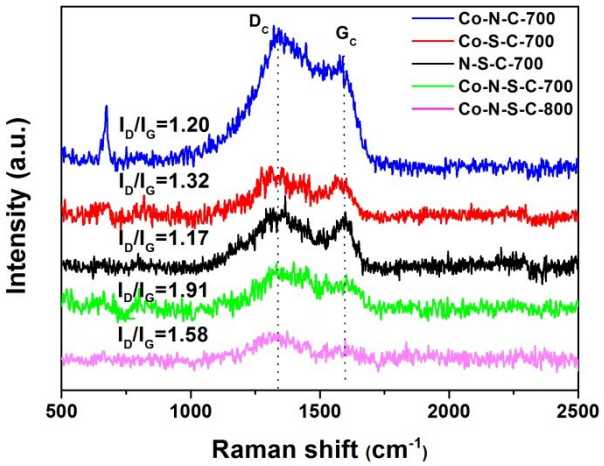

Figure S2. Raman spectra of Co-N-C-700, Co-S-C-700, N-S-C-700, Co-N-S-C-700, and Co-N-S-C-800 samples

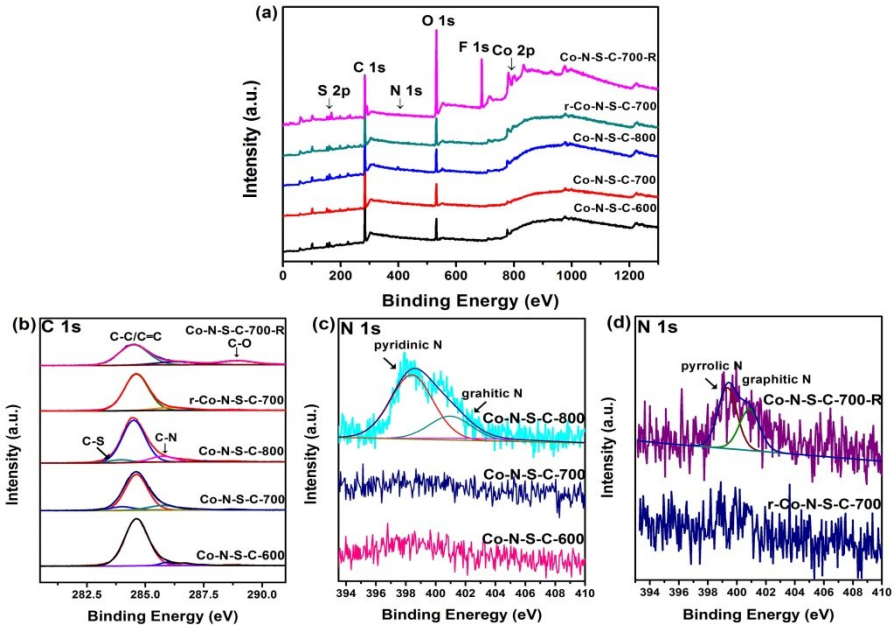

Figure S3. (a) XPS survey spectra of various Co-N-S-C-T samples; (b) High-resolution C 1s spectra of Co-N-S-C-T; High-resolution N 1s spectra of (c) Co-N-S-C-T, and (d) Co-N-S-C-700-R and r-Co-N-S-C-700 samples

Table S1. Chemical composition of different catalysts based on XPS data

Sample	Content (at%)					
	C	N	O	S	Co	F
Co-N-S-C-600	73.78	1.99	12.76	9.40	2.09	-
Co-N-S-C-700	74.81	2.63	11.81	9.43	1.32	-
Co-N-S-C-800	74.85	3.19	9.35	10.66	1.95	-
r-Co-N-S-C-700	72.77	1.17	13.24	9.29	3.52	-
Co-N-S-C-700-R	42.45	1.15	28.40	11.59	6.41	10.00

Table S2. The comparison of the work and the recently reported work

Catalysts	Dopants	Conv.(%) [a]	Select.(%)[b]	Cond.[c]	Ref.
Co-N-S-C-700	N, S	48	85	0.8 MPa O_2, 120 °C, 5h	This work
Co@GCNs-800	N	68.1	93.2	0.8 MPa O_2, 120 °C, 5h	[1]
S-CoNC	N, S	62	91	0.8 MPa O_2, 120 °C, 5h	[2]
Co-N-C-Phen	N	40	75	0.8 MPa O_2, 120 °C, 5h	[3]
Co_3O_4@GNC	N	65.8	72.6	20 bar air, 140 °C, 4h	[4]
CoNC-10	N	22	75	0.8 MPa O_2, 120 °C, 5h	[5]

[a] Conversion of ethylbenzene; [b] Selectivity to acetophenone; [c] Condition of reaction.

Table S3. Recycling performance of Co-N-S-C-700 in oxidation of ethylbenzene with O_2[a]

			Sel.(%)[c]		
Entry	Catalyst	Conv.(%)[b]	AP	PA	BA
1	Co-N-S-C-700-R	8	88	10	2
2	r-Co-N-S-C-700-2	49	86	13	1
3	r-Co-N-S-C-700-3	52	87	13	0

[a] Reaction conditions: ethylbenzene (10 ml), catalyst (28 mg), O_2 (0.8 MPa), 120 °C and 5 h.[b] Conversion of ethylbenzene. [c] Selectivity to acetophenone (AP), phenethyl alcohol (PA) and benzaldehyde (BA).

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