Electronic Supplementary Material (ESI) for RSC Advances.

Supplementary Information

Enhanced plasma-catalytic decomposition of toluene over Co-Ce binary metal oxide catalysts with high energy efficiency

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Table S1. An overview on the decomposition of toluene with various catalysts in IPC[1].

Catalysts	m (g)[2]	Q (L min^{-1})	GHSV (mL g^{-1} h^{-1})[3]	c_{in} (ppm)	SIE (J L^{-1})	$\eta_{toluene}$(%)	S_{CO_2} (%) Bc (%)	η_{energy} (g kWh^{-1})	Ref
Co_3O_4/Al_2O_3/nickel foam	-	0.1	-	50	500	96	~72 -	1.32	[1]
MnO_x/alumina/nickel foam	-	0.1	-	50	756	95.9	81 -	0.88	[2]
MnO_x/γ-Al_2O_3	-	2	-	186	700	96	-	3.52	[3]
TiO_2/γ-Al_2O_3/nikel foam	-	0.2	-	50	1527	94	99 -	0.42	[4]
Cu/OMS-2	0.2	0.06	18000	800	-	80	-	-	[5]
MnO_x/ Al_2O_3/nickel foam	0.45	0.2	26666.67	100	651	87	37 48	1.84	[6]
Ag/Mn-SBA-15	0.2	0.1	30000	21	317	88	- 36	0.80	[7]
Co-MCM-41	0.1	0.2	120000	100	226	~100	- 75%	6.11	[8]
CeO_2-MnO_x	-	0.25	-	1500	24 W	95.94	90.73 -	3.45	[9]
MnO_x-MCM41	0.5	1	120000	110	500	99.4	73 99.5%	3.02	[10]
Co-Ce	**0.2**	**0.5**	**150000**	**210**	**401**	**98.5**	**87.3** **97.8**	**7.12**	**This work**

[1] Conditions: room temperature; atmospheric pressure; IPC; DBD reactor.

[2] m: catalyst mass.

[3] GHSV: gas hourly space velocity. $\mathrm{GHSV\ (mL\ g{-}1\ h{-}1)} = 60000 \times Q / \mathrm{m}$.

Table S2. Physicochemical properties of Co-Ce catalysts.

Sample	Crystallite size (nm)[1]	Specific surface area ($m^2\ g^{-1}$)	Total pore volume ($cm^3\ g^{-1}$)	Average pore size (nm)
CoO_x	-	12.1	0.048	18.1
$Co_{0.75}Ce_{0.25}O_x$	9.6	56.0	0.138	4.7
$Co_{0.5}Ce_{0.5}O_x$	11.9	51.1	0.108	6.7
$Co_{0.25}Ce_{0.75}O_x$	12.6	46.0	0.124	5.2
CeO_x	14.2	25.6	0.077	7.3
used $Co_{0.75}Ce_{0.25}O_x$	10.7	53.7	0.131	5.1

[1] The crystallite size is calculated from the characteristic peak of CeO_2 (111) crystal face located at 2ϑ = 28.7°.

Table S3. XPS analysis of Co-Ce binary metal oxide catalysts.

Sample	Ce^{3+} / (Ce^{3+} + Ce^{4+})	O_s / (O_s + O_l)
$Co_{0.75}Ce_{0.25}O_x$	19.2%	31.0%
$Co_{0.5}Ce_{0.5}O_x$	16.2%	26.9%
$Co_{0.25}Ce_{0.75}O_x$	12.7%	20.6%
used $Co_{0.75}Ce_{0.25}O_x$	17.6%	29.1%

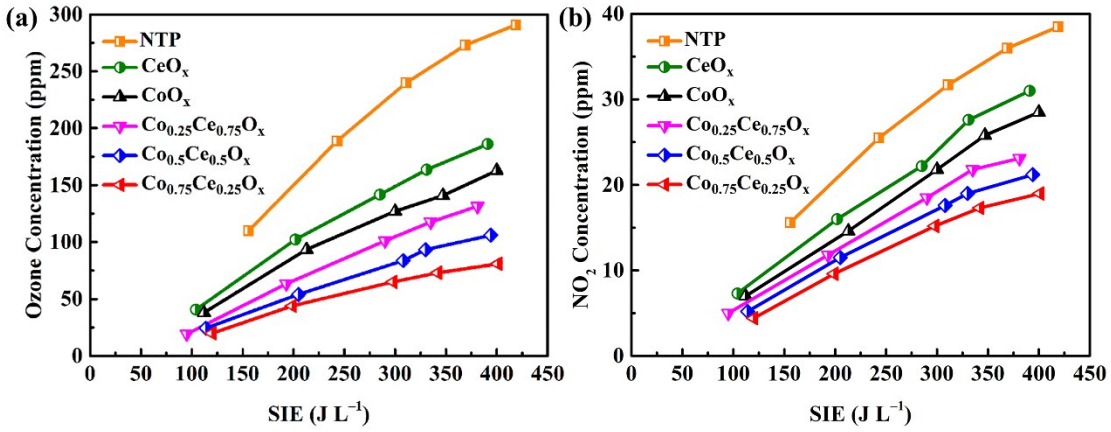

Fig. S1 (a) O_3 and (b) NO_2 concentrations of Co-Ce catalysts as a function of SIE.

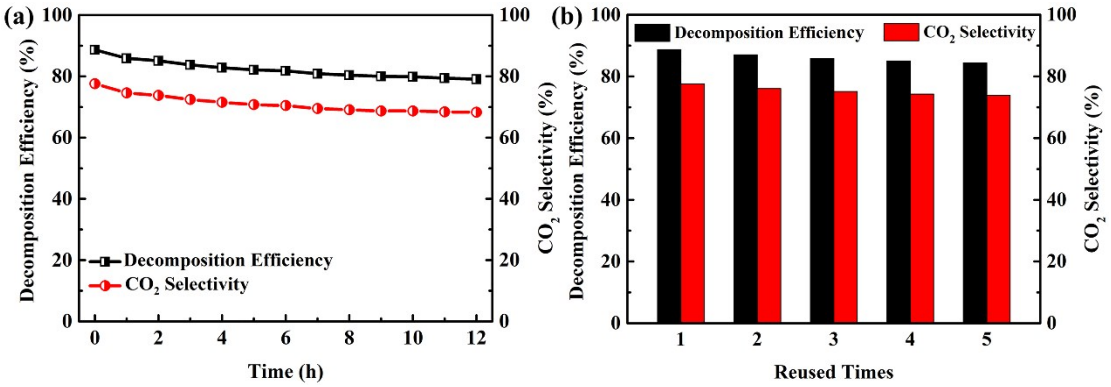

Fig. S2 (a) The durability and (b) reusability tests of the $Co_{0.75}Ce_{0.25}O_x$ catalyst at 298 J L^{-1}.

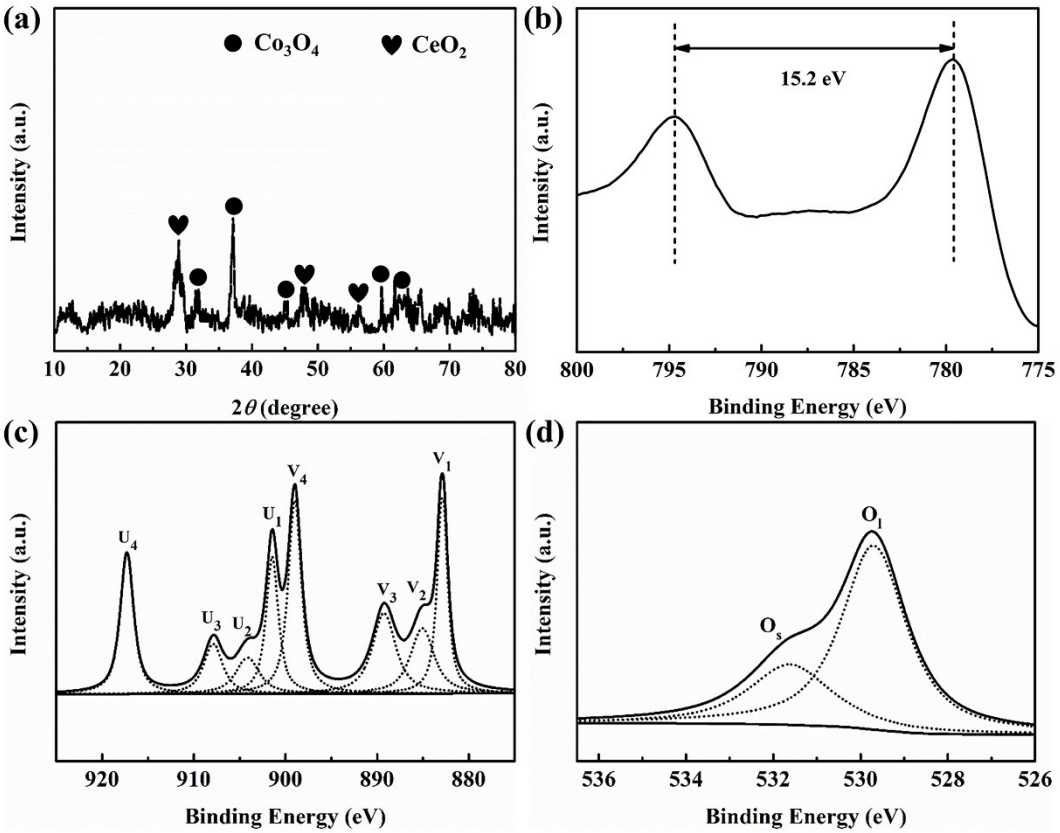

Fig. S3 (a) XRD and (b-d) XPS characterization of the used $Co_{0.75}Ce_{0.25}O_x$ catalyst.

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