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SUPPLEMENTAL INFORMATION

Selective aerobic oxidation of 5-hydroxymethylfurfural to 2,5-furandicarboxylic acid over nanojunctions of cobalt–ceria binary oxide in water

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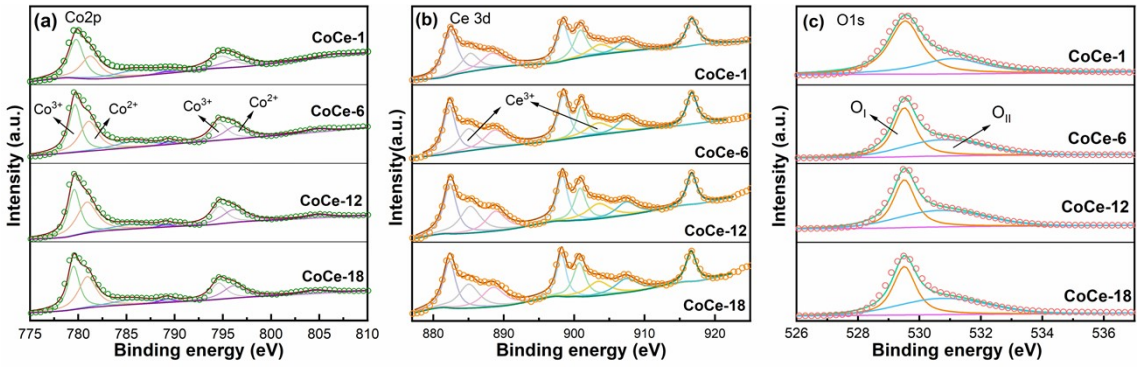

Fig. S1 XPS spectra of Co 2p (a), Ce 3d (b) and O 1s (c) for various catalysts

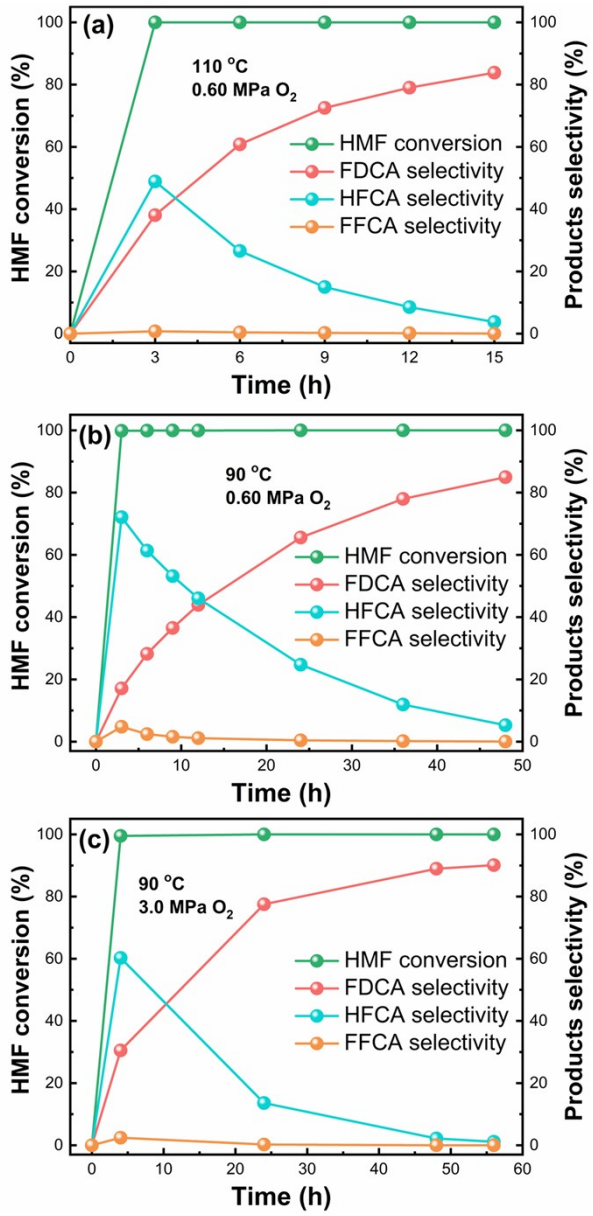

Fig. S2 Influence of reaction time on the aerobic oxidation of HMF over the CoCe-15 catalyst at different reaction conditions

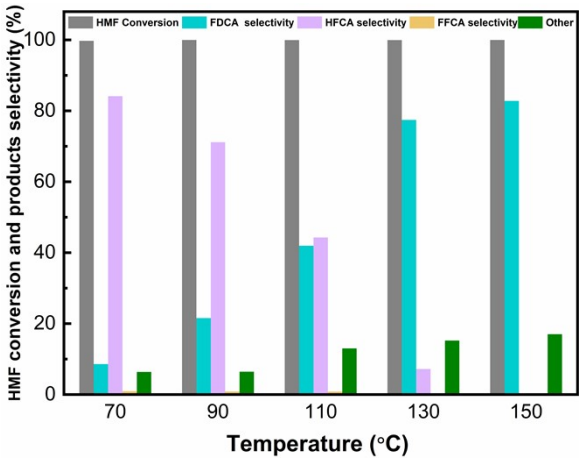

Fig. S3 Influence of reaction temperature on the aerobic oxidation of HMF over the CoCe-15 catalyst at 0.6 MPa O_2 pressure and various temperature for 4 h

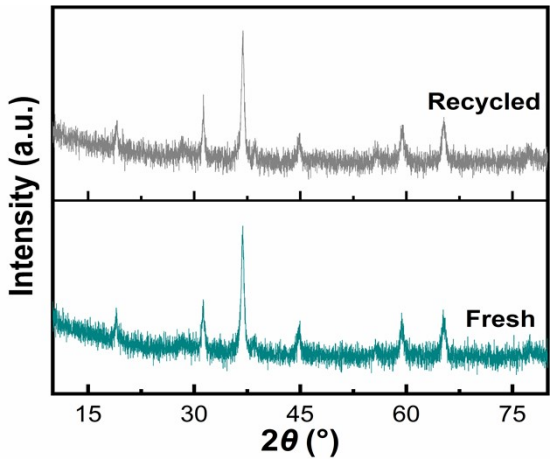

Fig. S4 XRD patterns for the fresh and recycled CoCe-15

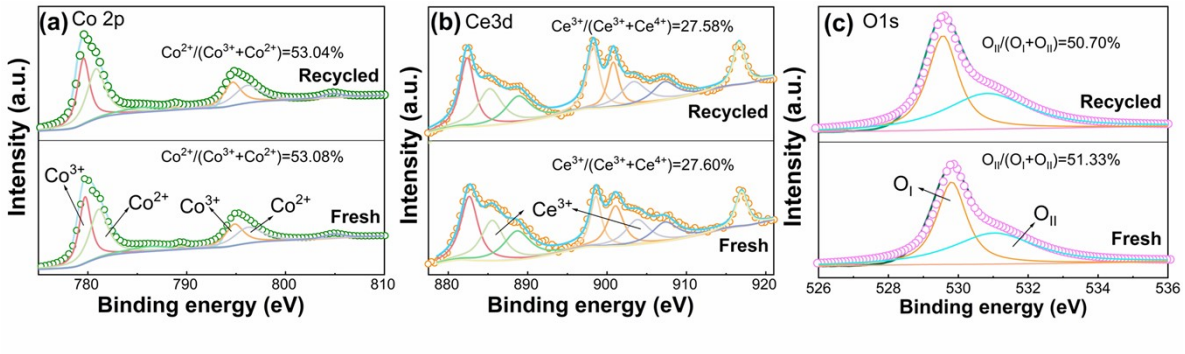

Fig. S5 XPS spectra of Co 2p (a), Ce 3d (b), and O 1s (c) for the fresh and recycled CoCe-15

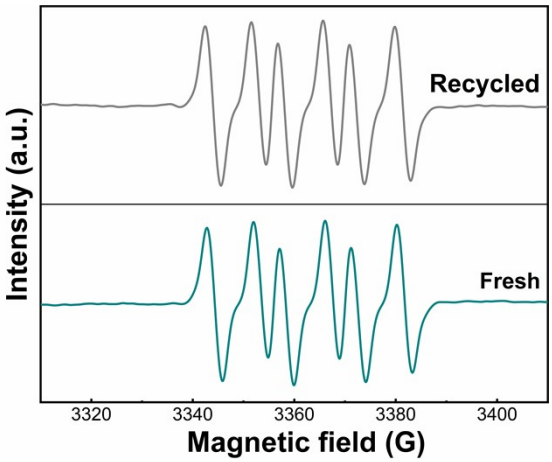

Fig. S6 EPR spectra for the fresh and recycled CoCe-15

Table S1 The relative surface proportion of Co, Ce and O species at their different valence states in various catalysts.

Catalyst	$O_{II}/(O_I+O_{II})$	$Co^{2+}/(Co^{3+}+Co^{2+})$	$Ce^{3+}/(Ce^{3+}+Ce^{4+})$
Co_3O_4	45.54%	48.71%	—
CoCe-21	46.00%	50.79%	18.68%
CoCe-18	48.40%	52.11%	24.79%
CoCe-15	51.33%	53.08%	27.60%
CoCe-12	49.59%	52.76%	26.85%
CoCe-9	47.15%	51.39%	25.49%
CoCe-6	46.27%	48.79%	23.72%
CoCe-1	38.92%	43.26%	18.96%
CeO_2	37.96%	—	15.06%

All data were calculated from the relative intensities of the corresponding XPS peaks.

Table S2 Comparison on catalytic performances of cheap metal oxide catalysts for the aerobic oxidation of HMF to FDCA in basic system

Catalyst	Oxidant	Additive		Temp. (°C)	Time (h)	Conv. (%)	FDCA Yield (%)	Apparent reaction rate ($mmol_{FDCA}\ g_{cat}^{-1}\ MPa_{O_2}^{-1}\ h^{-1}$)	Ref.
		Dosage	Concentration						
CoCe-15	0.6 MPa O_2	4 equiv. NaOH	0.027 M	130	4	100	77.4	0.143	This work
Co-Mn-0.25	1 MPa O_2	2 equiv. $NaHCO_3$	0.10 M	120	5	99	95.2	0.950	S1
Ni-MnO_x	0.8 MPa O_2	4 equiv. $NaHCO_3$	0.40 M	100	28	100	93.8	0.419	S2
MOF-Mn_2O_3	1.4 MPa O_2	3 equiv. $NaHCO_3$	0.15 M	100	24	100	99.5	0.197	S3
MnO_x-CeO_2	2.0 MPa O_2	2 equiv. $KHCO_3$	0.10 M	110	12	98.5	88.7	0.185	S4
β-MnO_2−HS	1 MPa O_2	3 equiv.$NaHCO_3$	0.12 M	100	24	99	86	0.143	S5
$Mn_{0.75}Fe_{0.25}$	0.8 MPa O_2	4 equiv. NaOH	0.40 M	100	24	93	29.8	0.310	S6
Activated MnO_2	1 MPa O_2	3 equiv. $NaHCO_3$	0.12 M	100	24	99	74	0.123	S5
$Ce_{0.5}Bi_{0.5}O_{2-\delta}$	1 MPa O_2	4 equiv. NaOH	0.10 M	65	1	100	8	0.120	S7
MnO_2	1 MPa O_2	3 equiv. $NaHCO_3$	0.12 M	100	24	99	91	0.076	S8
$MnCo_2O_4$	1 MPa O_2	3 equiv. $KHCO_3$	0.12 M	100	24	99.5	70.9	0.059	S9
$SrMnO_3$	1 MPa O_2	3 equiv. $NaHCO_3$	0.12 M	100	24	99	58	0.048	S8

Table S3 Properties of the recycled catalyst of CoCe-15

Catalyst	BET surface area (m^2 g^{-1})	Pore volume (cm^3 g^{-1})	Average pore size (nm)	Crystallite size[a] (nm)	
				Co_3O_4	CeO_2
CoCe-15-recycled	42.8	0.28	26.2	21.4	—

[a] Calculated by Scherrer equation based on the XRD principal peak at 36.8 ° and 28.5 ° for Co_3O_4 and CeO_2, respectively.

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