Electronic Supplementary Material (ESI) for Green Chemistry.
This journal is © The Royal Society of Chemistry 2019

Supporting Information

In-situ anchoring Co_3O_4 nanowire on nickel foam: an outstanding bifunctional catalyst for energy-saving simultaneous reactions

Zhenqiang Zhou,[a,b] Chunlin Chen,*[a,c,d] Minrui Gao,[e] Bowen Xia,[a] and Jian Zhang*[a,c,d]

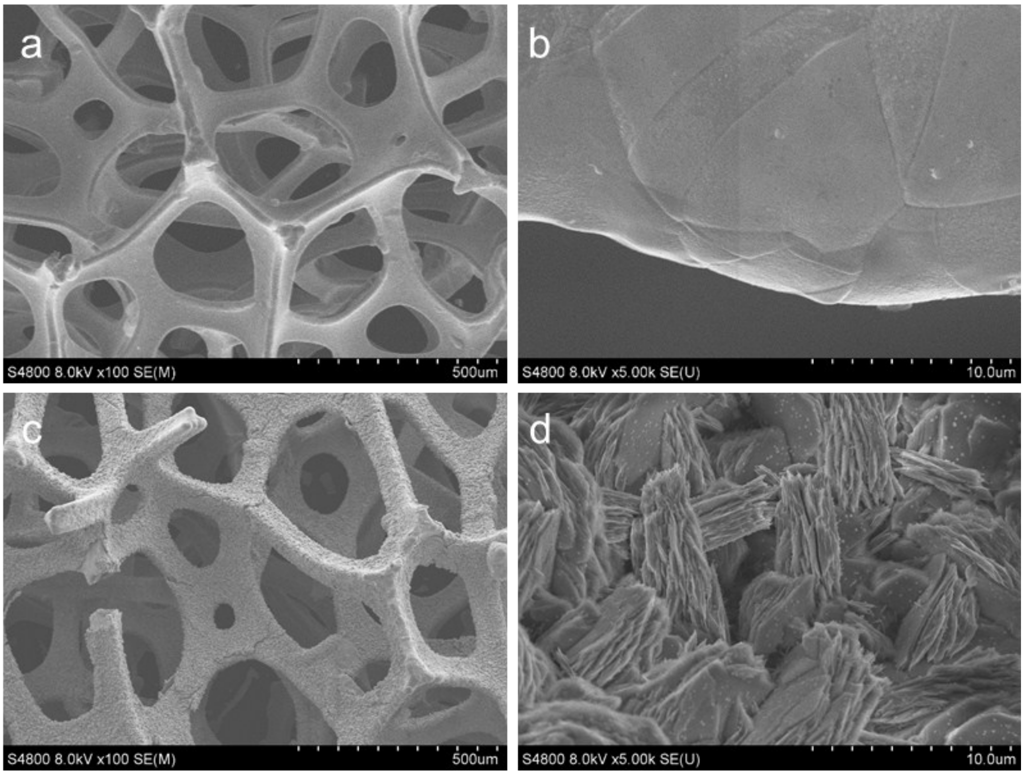


Fig. S1 SEM images of (a, b) NF washed by rare hydrochloric acid and (c, d) product obtained by the same synthesis process just without urea participation.

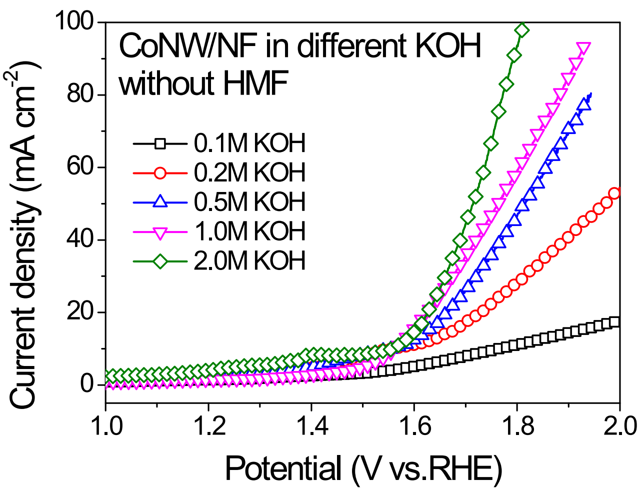


Fig. S2 Anodic LSV curves on CoNW/NF at different electrolyte without HMF presence.

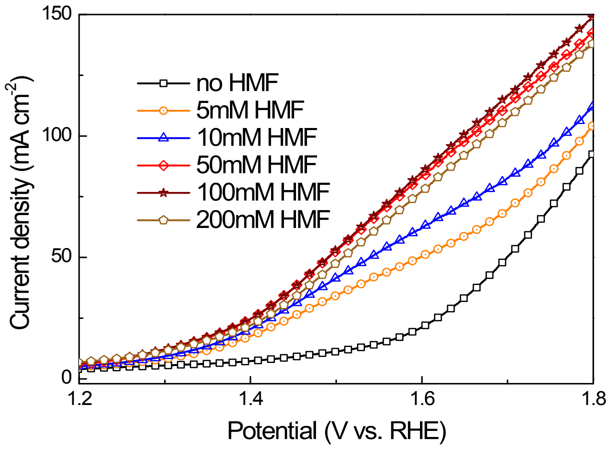
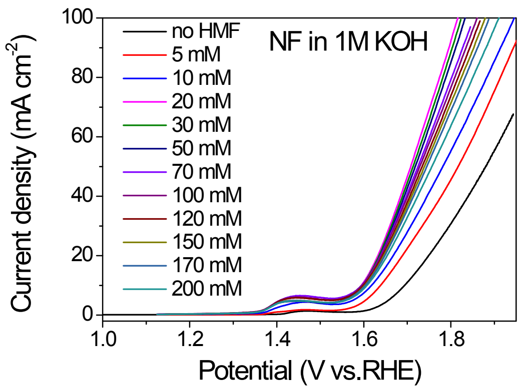


Fig. S3 Anodic LSV curves on CoNW/NF with the presence of different concentration of HMF.



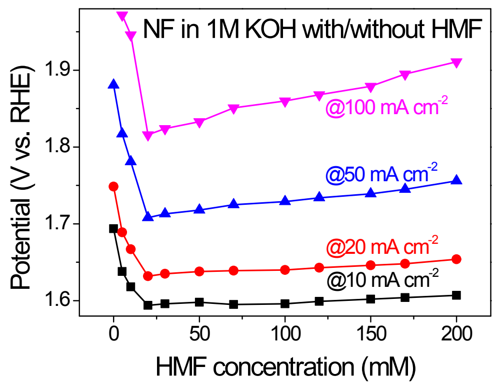
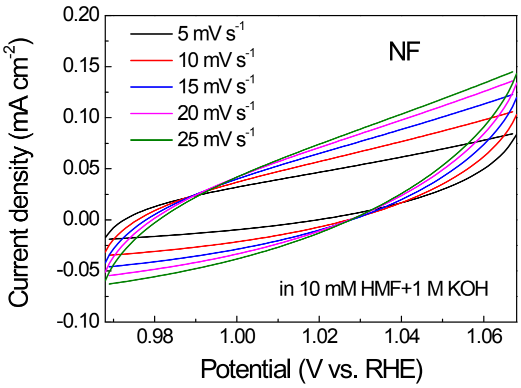


Fig. S4 Effect of concentration of HMF on electrocatalytic performance for NF.



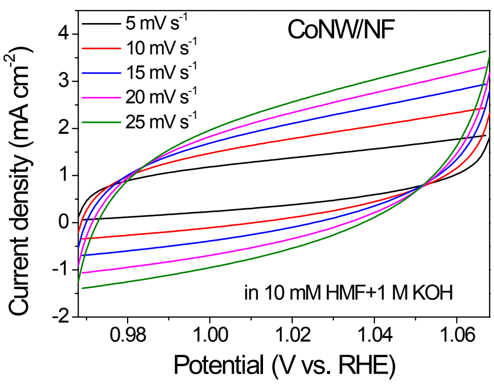


Fig. S5 Cyclic voltammograms recorded on NF and CoNW/NF in the potential range of 0.969 to 1.069 V vs RHE.

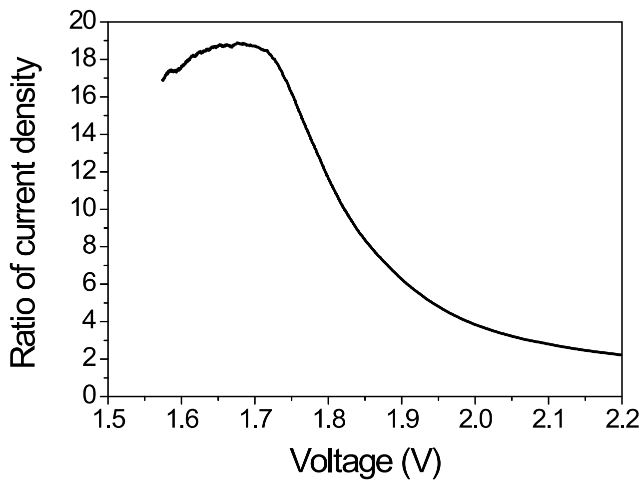


Fig. S6 Mathematical ratio of current densities of EOH and OER from Fig. 5a.

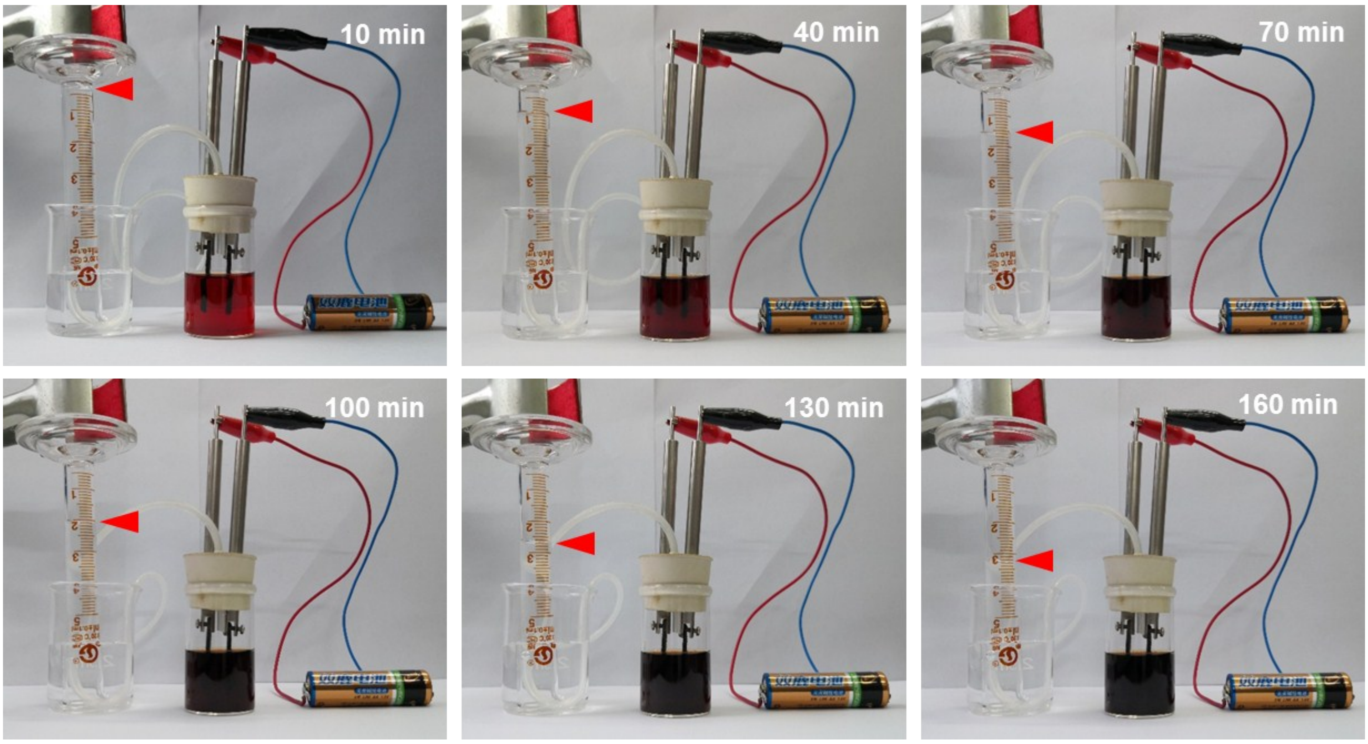


Fig. S7 Two-electrode integration electrolyser powered by a commercial AA battery. On account of only H_2 bubbles released continuously at the cathode, whereas no gas bubbles generated at the anode, we employed a water-gas displacing method to collect H_2.

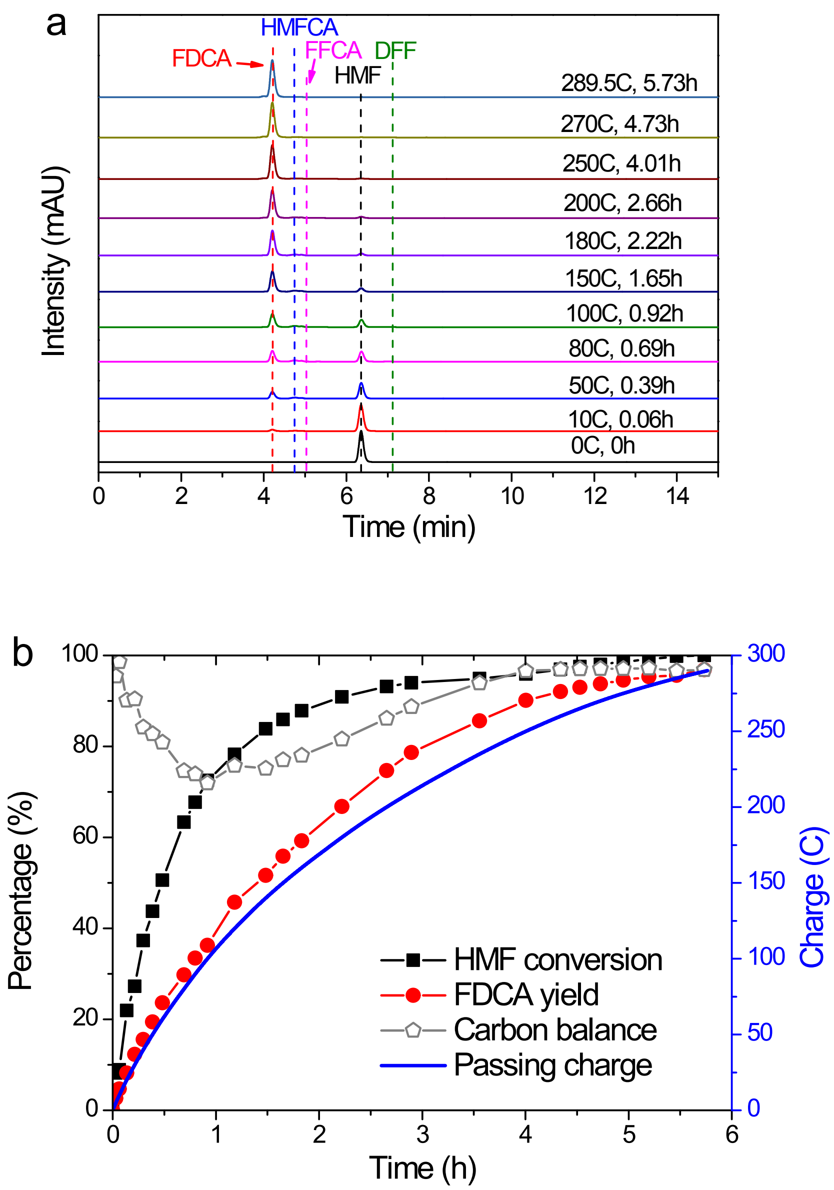


Fig. S8 (a) Representative HPLC chromatograms of integration reaction; (b) Time-course of HMF oxidation and passing charge over CoNW/NF in integration system.

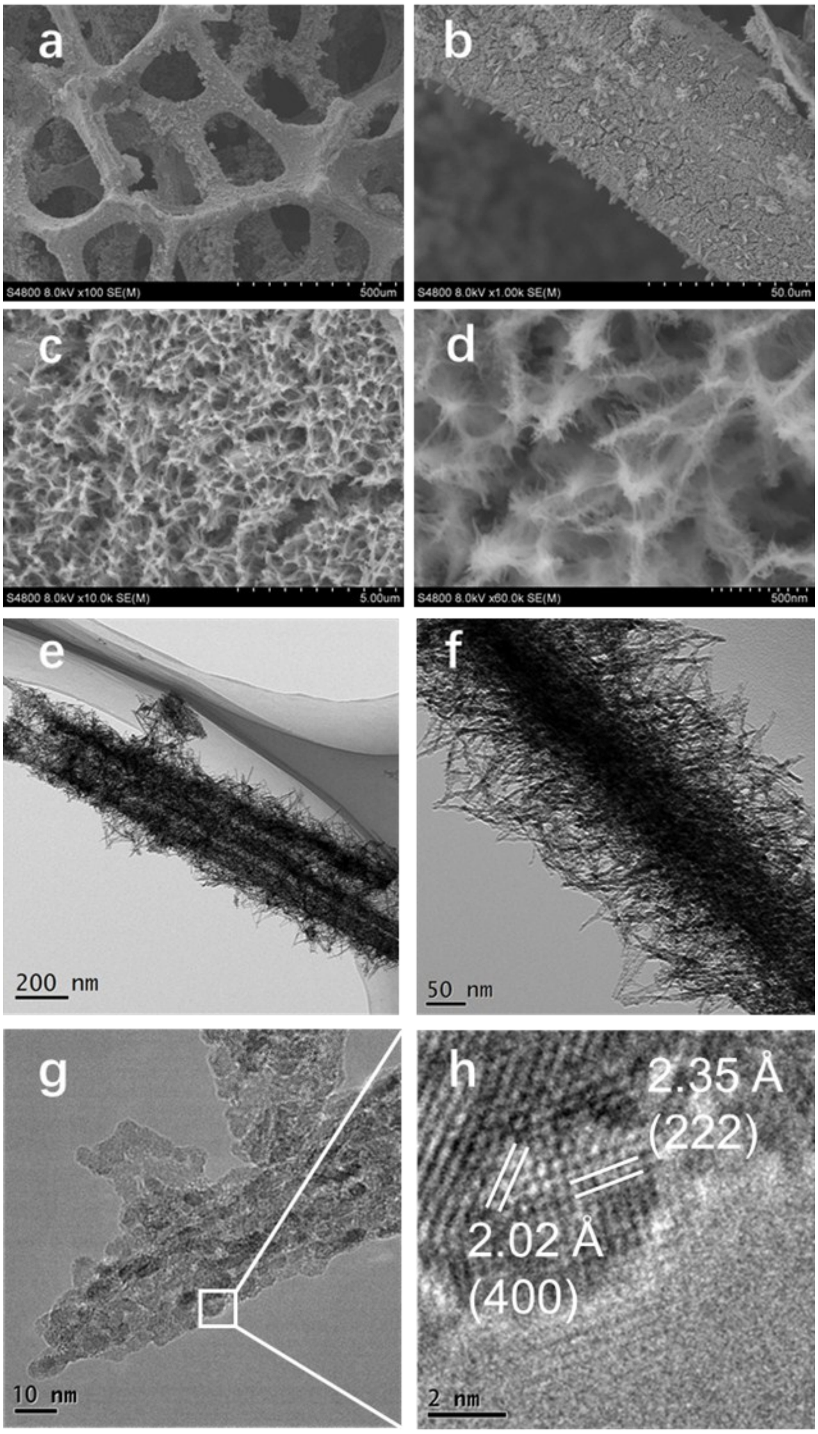


Fig. S9 SEM, TEM and HRTEM images of the used CoNW/NF after five successive chronoamperometries.

Table S1. Comparison of OER performance of CoNW/NF with references.

Catalyst	Electrolyte	Potential (OER) /V vs. RHE	Reference
CoNW/NF	1.0 M KOH	1.067 (1 mA/cm^2)	This work
		1.502 (5 mA/cm^2)	
		1.519 (the x-intercept of a tangent to the LSV curve)	
		1.563 (10 mA/cm^2)	
Ni@PIM-CF	0.1 M KOH	1.621 (10 mA/cm^2)	[1]
Nano-Cu foam	0.1 M KOH	~1.600 (onset)	[2]
Co-O@Co-Se/Cu	1.0 M KOH	1.550 (onset)	[3]
		1.570 (10 mA/cm^2)	
NCO/CT	1.0 M KOH	1.610 (10 mA/cm^2)	[4]
NCO@MO/CT	1.0 M KOH	1.567 (10 mA/cm^2)	
$NiCo_2O_4$/NF	0.1 M KOH	1.550 (10 mA/cm^2)	[5]
Ni_xB	1.0 M KOH	1.610 (10 mA/cm^2)	[6]
$Co_{0.85}Se$/NC	1.0 M KOH	1.590 (10 mA/cm^2)	[7]
hp-Ni	1.0 M KOH	~1.510 (onset)	[8]
Au-MnO_x	1.0 M KOH	1.630 (10 mA/cm^2)	[9]
$CoCr_2O_4$-700	1.0 M KOH	1.652 (10 mA/cm^2)	[10]
Ni_3S_2/NF	1.0 M KOH	~1.500 (onset)	[11]
$Co(OH)_2$	1.0 M KOH	1.590 (10 mA/cm^2)	[12]
Zn-deoped $CoSe_2$/CFC	1.0 M KOH	1.586 (10 mA/cm^2)	[13]
NiCo LDH	1.0 M KOH	1.597 (10 mA/cm^2)	[14]
Co-P film	1.0 M KOH	1.575 (10 mA/cm^2)	[15]
Ni@NC	0.1 M KOH	1.620 (10 mA/cm^2)	[16]
Ni-Co_2-O HNSs	0.1 M KOH	1.592 (10 mA/cm^2)	[17]
Co-Mn LDH	1.0 M KOH	1.555 (10 mA/cm^2)	[18]

Table S2. Comparison of anodic potentials for HMF electrooxidation.

Catalyst	Electrolyte	Potential for HMF electrooxidation /V vs. RHE			Reference
		@1 mA cm^{-2}	@5 mA cm^{-2}	@10 mA cm^{-2}	
CoNW/NF	1.0 M KOH	0.886	1.191	1.311	This work
$NiCo_2O_4$	1.0 M KOH	~1.30	~1.43	~1.47	19
Cu_3P/CFC	1.0 M KOH	~1.27	~1.37	1.43	20
Ni_2P/CFC	1.0 M KOH	~1.20	~1.28	~1.34	
NiOOH	0.1 M KOH	~1.46	—	—	21
CoOOH	0.1 M KOH	~1.60	—	—	
NiFe LDH	1.0 M KOH	1.25	~1.29	~1.32	22
Ni/NiOOH	0.1 M NaOH + 0.3 M $NaClO_4$	~1.40	~1.50	—	23
Nano-Cu foam	0.1 M KOH	~1.45	~1.79	—	2
MnO_x	0.5 M H_2SO_4	~1.50	~1.89	—	24
CoB	1.0 M KOH	~1.20	~1.33	~1.36	25
Ni_xB/NF	1.0 M KOH	~1.35	~1.37	~1.39	26
$NiCo_2O_4$/NF	0.1 M KOH	~1.14	~1.28	~1.37	5
Ni_2P/Ni/NF	1.0 M KOH	~1.33	—	~1.34	27
hp-Ni	1.0 M KOH	~1.35	~1.36	~1.37	8
Ni_2P NPA/NF	1.0 M KOH	~1.20	—	~1.36	28
Ni_3S_2/NF	1.0 M KOH	~1.30	~1.32	~1.36	11
Co-P/CF	1.0 M KOH	~1.25	~1.34	~1.37	29
NiO(OH)	1.0 M NaOH	0.6 V vs SCE (~1.66 V vs RHE) to reach 16 mA cm^{-2}			30
Pt/Fe_3O_4/rGO	0.1 M K_2SO_4	~0.42 (vs. Ag/AgCl)	—	—	31
Au	0.5 M borate buffer solution+ 7.5mM TEMPO	~1.27	—	—	32
Carbon-felt		~1.10	—	—	
Pd/C	0.1 M KOH (CV method)	~0.66	—	—	33
Pd_2Au_1/C		~0.57	~0.76	—	
Pd1Au2/C		~0.52	~0.80	—	
Au/C		~0.45	—	—	

Table S3. EIS fitted parameters of NF and CoNW/NF.

	Rs	CPE, Yo	CPE, n	Rct
	ohm	S-sec^n		ohm
NF	1.625	0.008685	0.8	13.24
CoNW/NF	1.721	0.04258	0.8234	5.01

Table S4. Comparison of catalytic performance of HMF oxidation into FDCA with references.

Catalysts (wt%)	T (ºC)	HMF (mmol/L)	solvent	t (h)	oxidant	P (Mpa)	Conv. (%)	Yield (%)	Reaction rate (mmol g-1 cat h^{-1}) HMF	Reaction rate (mmol g-1 cat h^{-1}) FDCA	Ref.
CoNW/NF electrooxidation	25	100	1 mol/L KOH in H_2O	0.92	NA	NA	72.51	36.25	8.404	4.202	This work
				1.83			87.86	59.26	5.120	3.453	
				2.89			93.97	78.65	3.467	2.902	
				4.01			95.88	90.11	2.550	2.396	
				4.95			98.64	94.54	2.125	2.037	
				5.73			100.00	96.82	1.861	1.802	
4.18% Pd/HPGS	50	200	1 equiv. NaOH in H_2O	1	O_2	0.1	29.85	5.98	7.013	1.405	34
				2			69.14	15.36	8.121	1.804	
				3			87.43	26.13	6.846	2.046	
				4			95.18	40.01	5.590	2.349	
				5			99.49	66.16	4.674	3.108	
				6			99.96	83.15	3.914	3.255	
	20			1			3.39	0.12	19.121	0.648	
	30						5.19	0.18	29.242	0.988	
	40						8.79	0.46	49.519	2.565	
	50						11.99	0.86	67.572	4.842	
	60						23.37	1.95	131.651	11.006	
1.6% Au/TiO_2	90	166.7	1 equiv. hydrotalcite in H_2O	20	O_2	0.34	100.00	99.00	0.609	0.603	35
Pt nanoparticles	80	11.6	H_2O	1	O_2	0.1	16.86	3.16	16.708	3.137	36
				2			36.64	5.69	18.156	2.820	
				3			54.32	8.86	17.945	2.925	
				4			62.54	13.69	15.495	3.393	
				6			73.07	18.96	12.069	3.132	
				8			82.11	32.44	10.171	4.019	
				12			93.91	58.13	7.756	4.800	

				14			100.43	77.27	7.109	5.470	
3.85% Pd/C@Fe_3O_4	25	50	0.5 equiv. K_2CO_3 in H_2O	4	O_2	0.1	28.60	11.90	0.724	0.301	37
	50						60.10	36.60	1.522	0.927	
	80						86.50	76.90	2.191	1.947	
				6			98.40	86.69	1.661	1.464	
	100			4			100.00	83.60	2.532	2.117	
	80		0.5 equiv. K_2CO_3 in Toluene				5.90	0.00	0.149	0.000	
			0.5 equiv. K_2CO_3 in Acetonitrile				9.70	0.00	0.246	0.000	
			0.5 equiv. K_2CO_3 in DMSO				15.50	0.00	0.393	0.000	
			0.5 equiv. K_2CO_3 in Ethanol				19.10	16.10	0.484	0.408	
			0.5 equiv. K_2CO_3 in H_2O				86.50	76.90	2.191	1.947	
			H_2O				20.60	11.90	0.522	0.301	
0.96% Au−Pd/HT（Au:Pd=1）	100	25	H_2O	12	O_2	0.5	100.00	91.00	0.527	0.480	38
0.96% Au−Pd/CNF（Au:Pd=1）							59.00	8.85	0.311	0.047	
0.96% Au−Pd/CNT（Au:Pd=1）							100.00	94.00	0.527	0.496	
0.96% Au−Pd/CNT（Au:Pd=1）		150		18			100.00	91.00	0.352	0.320	
0.97% Au−Pd/GO（Au:Pd=1）		25		12			97.00	32.98	0.517	0.176	
0.48% Au−Pd/CNT（Au:Pd=0.99）							98.00	60.76	0.454	0.281	
0.67% Au−Pd/CNT（Au:Pd=0.99）							100.00	92.00	0.463	0.426	
0.96% Au−Pd/CNT（Au:Pd=0.99）							100.00	94.00	0.463	0.435	
0.96% Au−Pd/CNT（Au:Pd=0.99）					air	1	100.00	96.00	0.463	0.444	
0.98% Au/CNT					O_2	0.5	78.00	1.09	0.323	0.005	
0.97% Au−Pd/CNT（Au:Pd=4:1							75.00	38.25	0.339	0.173	

)											
0.96% Au−Pd/CNT（Au:Pd=7:3）							90.00	47.70	0.425	0.225	
0.96% Au−Pd/CNT（Au:Pd=1）							100.00	94.00	0.527	0.496	
0.97% Au−Pd/CNT（Au:Pd=3:7）							100.00	90.00	0.605	0.545	
0.97% Au−Pd/CNT（Au:Pd=1:4）							76.00	31.92	0.493	0.207	
0.99% Pd/CNT							63.00	6.93	0.488	0.054	
0.39% $Pd/ZrO_2/La_2O_3$	90	20	5 equiv. NaOH in H_2O	8	O_2	0.1	99.00	90.00	0.454	0.412	39
0.6% $Pd/KF/Al_2O_3$							99.00	91.00	0.698	0.641	
0.45% Pd/Al_2O_3							99.00	78.00	0.523	0.412	
0.5% Pd/TiO_2							99.00	52.00	0.581	0.305	
2% γ-Fe_2O_3@HAP-Ru	110	113.3	4-chlorotoluene	2	O_2	0.1	100.00	13.90	2.643	0.367	40
	90			4			100.00	9.30	1.322	0.123	
	70			4			43.20	2.20	0.571	0.029	
				12			97.50	6.80	0.429	0.030	
				14			100.00	9.70	0.378	0.037	
	50			12			41.50	3.70	0.183	0.016	
	25			12			11.40	0.40	0.050	0.002	
3.04% Pt/C	22	150	2 equiv. NaOH in H_2O	6	O_2	0.96	100.00	79.00	3.896	3.078	41
2.9% Pd/C							100.00	71.00	6.813	4.837	
0.8% Au/C (WGC)							100.00	8.00	1.015	0.081	
0.77% Au/C (sol)							100.00	7.00	0.977	0.068	
1.6% Au/TiO_2							100.00	8.00	2.031	0.162	
0.77% Au/C (sol)		100	20 equiv. NaOH in H_2O			2	100.00	31.00	0.814	0.252	
1.6% Au/TiO_2							100.00	32.00	1.692	0.542	
0.77% Au/C (sol)				22			100.00	72.00	0.222	0.160	
1.6% Au/TiO_2							100.00	80.00	0.462	0.369	
3.3% Pt/ZrO_2	100	100	5 equiv. $NaHCO_3$ in H_2O	12	air	4	100.00	82.00	1.410	1.156	42

2.7% Pt/ZrO_2-Y_2O_3							100.00	63.00	1.153	0.727	
3.1% Pt/ZrO_2-La_2O_3							100.00	56.00	1.324	0.742	
3.3% Pt/ZrO_2							100.00	95.00	1.410	1.339	
2.7% Pt/ZrO_2-Y_2O_3							100.00	78.00	1.153	0.900	
3.1% Pt/ZrO_2-La_2O_3							100.00	75.00	1.324	0.993	
2.5% γ-Fe_2O_3@HAP-Pd(0)	100	50	Ethanol	6	O_2	0.1	10.40	6.40	0.173	0.107	43
			DMSO				14.20	7.20	0.237	0.120	
			H_2O				21.20	13.20	0.353	0.220	
			1 equiv. K_2CO_3 in H_2O				100.00	51.60	1.667	0.860	
			0.5 equiv. K_2CO_3 in H_2O				97.00	92.90	1.617	1.548	
			0.25 equiv. K_2CO_3 in H_2O				63.80	60.50	1.063	1.008	
			0.5 equiv. K_2CO_3 in H_2O		air		45.60	42.10	0.760	0.702	
			0.5 equiv. K_2CO_3 in H_2O	12			83.00	74.20	0.692	0.618	
		100	0.25 equiv. K_2CO_3 in H_2O	6	O_2		62.40	56.60	2.080	1.887	
4.17% Ru imp/AC	100	52.86	4 equiv. $NaHCO_3$ in H_2O	48	air	4	100.00	93.00	0.860	0.799	44
3.75% Ru imp/AC NaOCl							100.00	90.00	0.773	0.696	
1.85% Ru imp/AC EDA							100.00	54.00	0.381	0.206	
2.1% Ru imp/AC HNO_3-EDA							100.00	24.00	0.433	0.104	
4.93% Ru imp/CMK-3(1)							100.00	84.00	1.016	0.854	
2.81% Ru imp/pyrrole-CMK-3							100.00	78.00	0.579	0.452	
1.30% Ru@CMK-3(2)							100.00	58.00	0.268	0.155	
3.19% Ru@CMK-3 Ru^{3+}							100.00	76.50	0.658	0.503	
4.36% Ru@CMK-3 Ru							100.00	73.00	0.899	0.656	
4.9% Pt/CNT	95	25	H_2O	14	O_2	0.5	100.00	98.00	1.794	1.758	45
4.9% Au/CNT							23.00	0.10	0.409	0.002	
4.9% Pd/CNT							13.00	0.20	0.428	0.006	
4.9% Ru/CNT							47.00	0.89	1.628	0.031	
4.9% Ir/CNT							25.00	0.10	0.455	0.002	
4.9% Pt/SiO_2							74.00	0.70	1.328	0.013	
4.9% Pt/Al_2O_3							94.00	24.44	1.686	0.438	
4.9% Pt/ZrO_2							81.00	6.64	1.453	0.119	

4.9% Pt/HT							100.00	97.00	1.794	1.740	
4.9% Pt/GO							100.00	95.00	1.794	1.704	
4.9% Pt/AC							91.00	33.67	1.633	0.604	
4.9% Pt/CNF							88.00	29.92	1.579	0.537	
0.49% Pt/CNT							72.00	4.39	1.353	0.083	
0.95% Pt/CNT							77.00	6.70	1.447	0.126	
2.4% Pt/CNT							100.00	74.00	1.880	1.391	
3.2% Pt/CNT							100.00	85.00	1.880	1.598	
4.9% Pt/CNT							100.00	98.00	1.880	1.842	
				16	air	1	100.00	96.00	1.645	1.579	
6 nm Pd nanoparticles	90	20	8.75 equiv. NaOH in H_2O	7	O_2	0.1	99.00	61.00	132.897	81.886	46
2 nm Pd nanoparticles			7.5 equiv. NaOH in H_2O	6			99.00	49.00	124.037	61.392	
			8.75 equiv. NaOH in H_2O	7			99.00	81.00	132.897	108.734	
1.8 nm Pd nanoparticles							99.00	90.00	132.897	120.815	
1.95% C–Fe_3O_4–Pd	80	50	0.5 equiv. K_2CO_3 in Toluene	4	O_2	0.1	9.20	2.00	0.234	0.051	47
			0.5 equiv. K_2CO_3 in MIBK				21.90	16.20	0.557	0.412	
			0.5 equiv. K_2CO_3 in DMSO				50.60	0.00	1.288	0.000	
	100		0.5 equiv. K_2CO_3 in DMSO				52.70	45.80	1.341	1.166	
	80		0.5 equiv. K_2CO_3 in Ethanol				61.20	50.40	1.558	1.283	
			0.5 equiv. K_2CO_3 in H2O				87.20	82.30	2.219	2.094	
			H_2O				12.10	11.10	0.308	0.282	
			1 equiv. K_2CO_3 in H_2O				98.70	87.60	2.512	2.229	
			1.5 equiv. K_2CO_3 in H_2O				100.00	62.70	2.545	1.596	
			0.25 equiv. K_2CO_3 in H_2O				45.40	40.10	1.155	1.021	
			0.125 equiv. K_2CO_3 in H_2O				23.80	21.90	0.606	0.557	
	25		0.5 equiv. K_2CO_3 in H_2O				41.30	38.30	1.051	0.975	
				12			95.40	87.90	0.809	0.746	
	60			4			77.60	71.10	1.975	1.809	
	100						97.10	80.50	2.471	2.049	
	80						57.80	52.90	2.942	2.693	
							98.20	91.80	1.666	1.558	

					air		47.70	43.90	1.214	1.117	
							94.40	85.70	2.402	2.181	
graphene oxide-Fe_3O_4				12	O_2		13.00	0.00	0.074	0.000	
1% $Pt/Ce_{0.8}Bi_{0.2}O_{2-\delta}$	23	150	4 equiv. NaOH in H_2O	0.50	O_2	1	100.00	98.00	205.044	200.943	48
0.1% $Pt/Ce_{0.8}Bi_{0.2}O_{2-\delta}$		15		0.17			98.00	69.00	60.283	42.444	
				0.08			81.80	35.00	100.636	43.059	
1.02% Au/CeO_2	65	150	4 equiv. NaOH in H_2O	1	O_2	1	100.00	39.00	7.768	3.029	49
1.04% $Au/Ce_{0.95}Bi_{0.05}O_{2-\delta}$							100.00	46.00	7.920	3.643	
1.05% $Au/Ce_{0.92}Bi_{0.08}O_{2-\delta}$							100.00	73.00	7.996	5.837	
1.11% $Au/Ce_{0.9}Bi_{0.1}O_{2-\delta}$							100.00	74.00	8.453	6.255	
1.07% $Au/Ce_{0.875}Bi_{0.125}O_{2-\delta}$							100.00	75.00	8.148	6.111	
1.09% $Au/Ce_{0.85}Bi_{0.15}O2_{-\delta}$							100.00	77.00	8.301	6.392	
1.1% $Au/Ce_{0.8}Bi_{0.2}O_{2-\delta}$							100.00	74.00	8.377	6.199	
1.1% $Au/Ce_{0.5}Bi_{0.5}O_{2-\delta}$							99.00	4.00	8.293	0.335	
1.5% $Au/Mg(OH)_2$	60	543.5	4 equiv. NaOH in H_2O	6	O_2	0.3	99.00	76.00	1.382	1.061	50
1.5% Au/TiO_2							99.00	85.00	1.382	1.187	
1.5% Au/CeO_2							99.00	73.00	1.382	1.019	
1.5% Au/H-MOR							96.00	15.00	1.340	0.209	
1.5% Au/Na-ZSM-5-38							87.00	0.00	1.215	0.000	
1.5% Au/Na-ZSM-5-25							92.00	1.00	1.284	0.014	
1.5% Au/HY							99.00	99.00	1.382	1.382	
1.5% Au/HY-200							99.00	81.00	1.382	1.131	
1.5% Au/HY-400							99.00	37.00	1.382	0.517	
1.5% Au/NaY							99.00	15.00	1.382	0.209	
90-Fe_3O_4@C@Pt	90	0.119mmol	1.67 equiv. Na_2CO_3 in H_2O	10	O_2	0.1	100.00	87.10	0.966	0.841	51
100-Fe_3O_4@C@Pt				7			100.00	100.00	1.116	1.116	
110-Fe_3O_4@C@Pt				4			100.00	100.00	2.268	2.268	

1%Pd/HT-5	100	40	H_2O	7	O_2	0.1	99.00	91.30	0.566	0.522	52
2%Pd/HT-5				3			99.40	92.40	1.325	1.232	
2%Pd/HT-6				8			99.90	99.90	0.500	0.500	
2% Au-Pd(1:1)/IRA-743	100	2	1 equiv. Na_2CO_3 in H_2O	4	O_2	1	100.00	93.20	0.050	0.047	53
					air	4	100.00	82.90	0.050	0.041	
1% Au/IRA–743 +1% Pd/ IRA-743					O_2	1	100.00	52.00	0.050	0.026	
1%Au/HT-AC (HT:AC=2)	100	25	H_2O	24	O_2	0.5	100.00	99.00	0.212	0.209	54
1%Au/HT-AC (HT:AC=1)							100.00	85.00	0.212	0.180	
1%Au/HT-AC (AC:HT=2)							100.00	71.00	0.212	0.150	
1%Au/HT-AC (AC:HT=3)							93.00	59.00	0.197	0.125	
1%Au/HT-AC (AC:HT=4)							93.00	14.00	0.197	0.030	
Au/ZrO_2-dp	100	100	4 equiv. NaOH in H_2O	5	air	1	100.00	75.00	2.041	1.531	55
Ag/ZrO_2-dp							100.00	5.00	3.704	0.185	
Au/TiO_2-dp							100.00	1.00	2.041	0.020	
Ag/TiO_2-dp							100.00	3.00	3.704	0.111	
Au/CeO_2-dp							100.00	46.00	2.041	0.939	
Ag/CeO_2-dp							100.00	3.00	3.704	0.111	
Au/MgO-dp							100.00	2.00	2.041	0.041	
Ag/MgO-dp							100.00	1.00	3.704	0.037	
Au/CeO_2	140	79.2	0.2 equiv. Na_2CO_3 in H_2O	15	O_2	0.5	99.90	91.00	0.527	0.480	56
		792					99.90	28.00	0.527	0.148	
		792	2 equiv. Na_2CO_3 in H_2O				99.90	28.00	0.527	0.148	
Pt/AC-15ALD	100	39.65	H_2O	6	O_2	0.4	94.70	14.50	1.877	0.287	57
Pt-Ni/AC-5ALD							50.90	0.20	1.009	0.004	
Pt-Ni/AC-15ALD							98.10	25.10	1.945	0.498	
Pt-Ni/AC-50ALD							100.00	43.10	1.982	0.854	

Pt/rGO	95	25	H_2O	8	O_2	0.5	100.00	55.55	5.204	2.891	31
				16			100.00	99.00	2.602	2.576	
Pt/Fe_3O_4/rGO				6			100.00	47.23	6.938	3.277	
				9			100.00	99.00	4.626	4.579	
Pd-Au/HT(Pd:Au=2)	60	31.7	2 equiv. NaOH in H_2O	6	O_2	NA	89.00	10.00	4.705	0.529	58
Pd-Au/HT(Au:Pd=2)							100.00	43.00	5.286	2.273	
Pd-Au/HT(Au:Pd=4)							100.00	81.00	5.286	4.282	
							100.00	90.00	2.643	2.379	
1.64%Au/Al_2O_3	70	80	2 equiv. NaOH in H_2O	4	O_2	1	100.00	70.00	2.083	1.458	59
			4 equiv. NaOH in H_2O				100.00	99.00	2.083	2.062	

T: reaction temperature; t: reaction time; P: reaction pressure; conv.: conversion of HMF; equiv.: equivalent; NA: not available. The reaction rates over CoNW/NF were calculated on the weight of anode immersed in electrolyte (including active CoNW and NF substrate, i.e., 46.89 mg in total).

References:

1 B. Patil, B. Satilmis, M. A. Khalily and T. Uyar, *ChemSusChem*, 2019, **12**, 1469.

2 D.-H. T. Nam, Brandon J. Choi, Kyoung-Shin, *Acs Catalysis*, 2018, **8**, 1197.

3 W. Q. Yang, Y. X. Hua, Q. B. Zhang, H. Lei and C. Y. Xu, *Electrochimica Acta*, 2018, **273**, 71.

4 H. Xue, H. Yu, Y. Li, K. Deng, Y. Xu, X. Li, H. Wang and L. Wang, *Nanotechnology*, 2018, **29**, 258401.

5 L. Gao, Y. Bao, S. Gan, Z. Sun, Z. Song, D. Han, F. Li and L. Niu, *ChemSusChem*, 2018, **11**, 2547.

6 J. Masa, I. Sinev, H. Mistry, E. Ventosa, M. de la Mata, J. Arbiol, M. Muhler, B. Roldan Cuenya and W. Schuhmann, *Advanced Energy Materials*, 2017, **7**, 1700381.

7 T. Meng, J. Qin, S. Wang, D. Zhao, B. Mao and M. Cao, *Journal of Materials Chemistry A*, 2017, **5**, 7001.

8 B. You, X. Liu, X. Liu and Y. Sun, *Acs Catalysis*, 2017, **7**, 4564.

9 R. Frydendal, L. C. Seitz, D. Sokaras, T.-C. Weng, D. Nordlund, I. Chorkendorff, I. E. L. Stephens and T. F. Jaramillo, *Electrochimica Acta*, 2017, **230**, 22.

10 M. Al-Mamun, X. Su, H. Zhang, H. Yin, P. Liu, H. Yang, D. Wang, Z. Tang, Y. Wang and H. Zhao, *Small*, 2016, **12**, 2866.

11 B. You, X. Liu, N. Jiang and Y. Sun, *Journal of the American Chemical Society*, 2016, **138**, 13639.

12 M. Abu Sayeed, T. Herd and A. P. O'Mullane, *Journal of Materials Chemistry A*, 2016, **4**, 991.

13 Q. Dong, Q. Wang, Z. Dai, H. Qiu and X. Dong, *Acs Applied Materials & Interfaces*, 2016, **8**, 26902.

14 H. Liang, F. Meng, M. Caban-Acevedo, L. Li, A. Forticaux, L. Xiu, Z. Wang and S. Jin, *Nano Letters*, 2015, **15**, 1421.

15 N. Jiang, B. You, M. Sheng and Y. Sun, *Angewandte Chemie-International Edition*, 2015, **54**, 6251.

16 J. W. Ren, M. Antonietti and T. P. Fellinger, *Advanced Energy Materials*, 2015, **5**, 1401660.

17 C. Zhu, D. Wen, S. Leubner, M. Oschatz, W. Liu, M. Holzschuh, F. Simon, S. Kaskel and A. Eychmueller, *Chemical Communications*, 2015, **51**, 7851.

18 F. Song and X. Hu, *Journal of the American Chemical Society*, 2014, **136**, 16481.

19 M. J. Kang, H. Park, J. Jegal, S. Y. Hwang, Y. S. Kang and H. G. Cha, *Applied Catalysis B: Environmental*, 2019, **242**, 85.

20 X. Zhang, M. Han, G. Liu, G. Wang, Y. Zhang, H. Zhang and H. Zhao, *Appl. Catal. B*, 2019, **244**, 899.

21 B. J. Taitt, D.-H. Nam and K.-S. Choi, *Acs Catalysis*, 2019, **9**, 660.

22 W.-J. Liu, L. Dang, Z. Xu, H.-Q. Yu, S. Jin and G. W. Huber, *Acs Catal*, 2018, **8**, 5533.

23 R. B. A. A. H. v. d. M. R. v. H. M. S. Y. M. Z. M. R. M. R. Latsuzbaia, *Journal of Applied Electrochemistry*, 2018, **48**, 611.

24 S. R. Kubota and K.-S. Choi, *Chemsuschem*, 2018, **11**, 2138.

25 J. Weidner, S. Barwe, K. Sliozberg, S. Piontek, J. Masa, U. P. Apfel and W. Schuhmann, *Beilstein J Org Chem*, 2018, **14**, 1436.

26 S. Barwe, J. Weidner, S. Cychy, D. M. Morales, S. Dieckhofer, D. Hiltrop, J. Masa, M. Muhler and W. Schuhmann, *Angew Chem Int Ed Engl*, 2018, **57**, 11460.

27 X. L. Nan Jiang, Jinmei Dong, Bo You, Xuan Liu, Yujie Sun, *ChemNanoMat*, 2017, **3**, 491.

28 B. You, N. Jiang, X. Liu and Y. Sun, *Angew. Chem. Int. Ed.*, 2016, **55**, 9913.

29 N. Jiang, B. You, R. Boonstra, I. M. Terrero Rodriguez and Y. Sun, *ACS Energy Letters*, 2016, **1**, 386.

30 G. Grabowski, J. Lewkowski and R. Skowronski, *Electrochim. Acta*, 1991, **36**, 1995.

31 C. Zhou, W. Shi, X. Wan, Y. Meng, Y. Yao, Z. Guo, Y. Dai, C. Wang and Y. Yang, *Catal. Today*, 2019, **330**, 92.

32 H. G. Cha and K. S. Choi, *Nat Chem*, 2015, **7**, 328.

33 D. J. Chadderdon, L. Xin, J. Qi, Y. Qiu, P. Krishna, K. L. More and W. Li, *Green Chem.*, 2014, **16**, 3778.

34 C. L. Chen, X. T. Li, L. C. Wang, T. Liang, L. Wang, Y. J. Zhang and J. Zhang, *Acs Sustainable Chemistry & Engineering*, 2017, **5**, 11300.

35 B. N. Zope, S. E. Davis and R. J. Davis, *Top. Catal.*, 2012, **55**, 24.

36 S. Siankevich, G. Savoglidis, Z. F. Fei, G. Laurenczy, D. T. L. Alexander, N. Yan and P. J. Dyson, *J. Catal.*, 2014, **315**, 67.

37 B. Liu, Y. S. Ren and Z. H. Zhang, *Green Chem.*, 2015, **17**, 1610.

38 X. Y. Wan, C. M. Zhou, J. S. Chen, W. P. Deng, Q. H. Zhang, Y. H. Yang and Y. Wang, *Acs Catal*, 2014, **4**, 2175.

39 B. Siyo, M. Schneider, J. Radnik, M. M. Pohl, P. Langer and N. Steinfeldt, *Appl. Catal. A*, 2014, **478**, 107.

40 Z. H. Zhang, Z. L. Yuan, D. G. Tang, Y. S. Ren, K. L. Lv and B. Liu, *Chemsuschem*, 2014, **7**, 3496.

41 S. E. Davis, L. R. Houk, E. C. Tamargo, A. K. Datye and R. J. Davis, *Catal. Today*, 2011, **160**, 55.

42 H. A. Rass, N. Essayem and M. Besson, *Chemsuschem*, 2015, **8**, 1206.

43 Z. H. Zhang, J. D. Zhen, B. Liu, K. L. Lv and K. J. Deng, *Green Chem.*, 2015, **17**, 1308.

44 F. Kerdi, H. Ait Rass, C. Pinel, M. Besson, G. Peru, B. Leger, S. Rio, E. Monflier and A. Ponchel, *Appl Catal A*, 2015, **506**, 206.

45 C. M. Zhou, W. P. Deng, X. Y. Wan, Q. H. Zhang, Y. H. Yang and Y. Wang, *Chemcatchem*, 2015, **7**, 2853.

46 B. Siyo, M. Schneider, M. M. Pohl, P. Langer and N. Steinfeldt, *Catal. Lett.*, 2014, **144**, 498.

47 N. Mei, B. Liu, J. D. Zheng, K. L. Lv, D. G. Tang and Z. H. Zhang, *Catal. Sci. Technol.*, 2015, **5**, 3194.

48 Z. Z. Miao, T. X. Wu, J. W. Li, T. Yi, Y. B. Zhang and X. G. Yang, *Rsc Adv.*, 2015, **5**, 19823.

49 Z. Z. Miao, Y. B. Zhang, X. Q. Pan, T. X. Wu, B. Zhang, J. W. Li, T. Yi, Z. D. Zhang and X. G. Yang, *Catal. Sci. Technol.*, 2015, **5**, 1314.

50 J. Y. Cai, H. Ma, J. J. Zhang, Q. Song, Z. T. Du, Y. Z. Huang and J. Xu, *Chem.-Eur. J.*, 2013, **19**, 14215.

51 Y. W. Zhang, Z. M. Xue, J. F. Wang, X. H. Zhao, Y. H. Deng, W. C. Zhao and T. C. Mu, *Rsc Adv.*, 2016, **6**, 51229.

52 Y. B. Wang, K. Yu, D. Lei, W. Si, Y. J. Feng, L. L. Lou and S. X. Liu, *Acs Sustainable Chemistry & Engineering*, 2016, **4**, 4752.

53 C. A. Antonyraj, N. T. T. Huynh, S. K. Park, S. Shin, Y. J. Kim, S. Kim, K. Y. Lee and J. K. Cho, *Appl. Catal. A*, 2017, **547**, 230.

54 T. Q. Gao, T. Y. Gao, W. H. Fang and Q. E. Cao, *Molecular Catalysis*, 2017, **439**, 171.

55 O. R. Schade, K. F. Kalz, D. Neukum, W. Kleist and J. D. Grunwaldt, *Green Chem.*, 2018, **20**, 3530.

56 M. Kim, Y. Q. Su, A. Fukuoka, E. J. M. Hensen and K. Nakajima, *Angew. Chem. Int. Ed.*, 2018, **57**, 8235.

57 J. Shen, H. Chen, K. Chen, Y. Qin, X. Lu, P. Ouyang and J. Fu, *Ind. Eng. Chem. Res.*, 2018, **57**, 2811.

58 H. A. Xia, J. H. An, M. Hong, S. Q. Xu, L. Zhang and S. L. Zuo, *Catal. Today*, 2019, **319**, 113.

59 C. Megias-Sayago, A. Lolli, S. Ivanova, S. Albonetti, F. Cavani and J. A. Odriozola, *Catal. Today*, 2019, **333**, 169.