Electronic Supplementary Material (ESI) for Catalysis Science & Technology.

Supplementary Data

MOF-derived metal oxide composite $Mn_2Co_1O_x$/CN for efficient formaldehyde oxidation at low temperature

Xi Wang ,*[a] Jiawei Ying ,[a] Yuliang Mai,[a] Junjie Zhang ,[a] Jiazhi Chen, [a] Mingtong Wen[a] and Lin Yu *[b]

[a] Guangdong Provincial Key Laboratory of Industrial Surfactant, Guangdong Research Institute of Petrochemical and Fine Chemical Engineering, Guangzhou 510665, China

[b] School of Chemical Engineering and Light Industry, Guangdong University of Technology, Guangzhou 510006, China

* Corresponding author. Email: wangxi@gdcri.com (X. Wang); gych@gdut.edu.cn (L. Yu)

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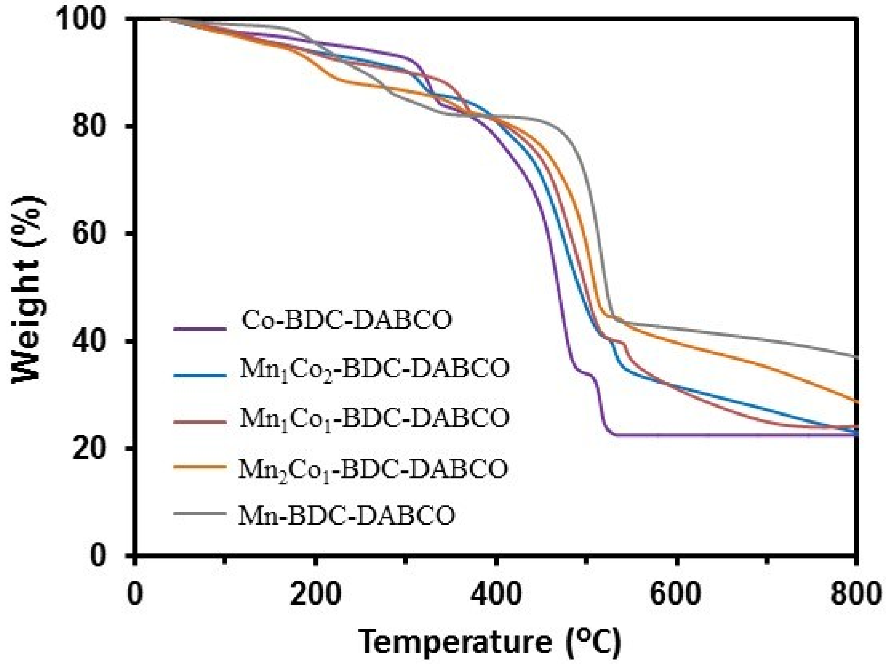

Figure S1. TGA curves of the MnCo-BDC-DABCO.

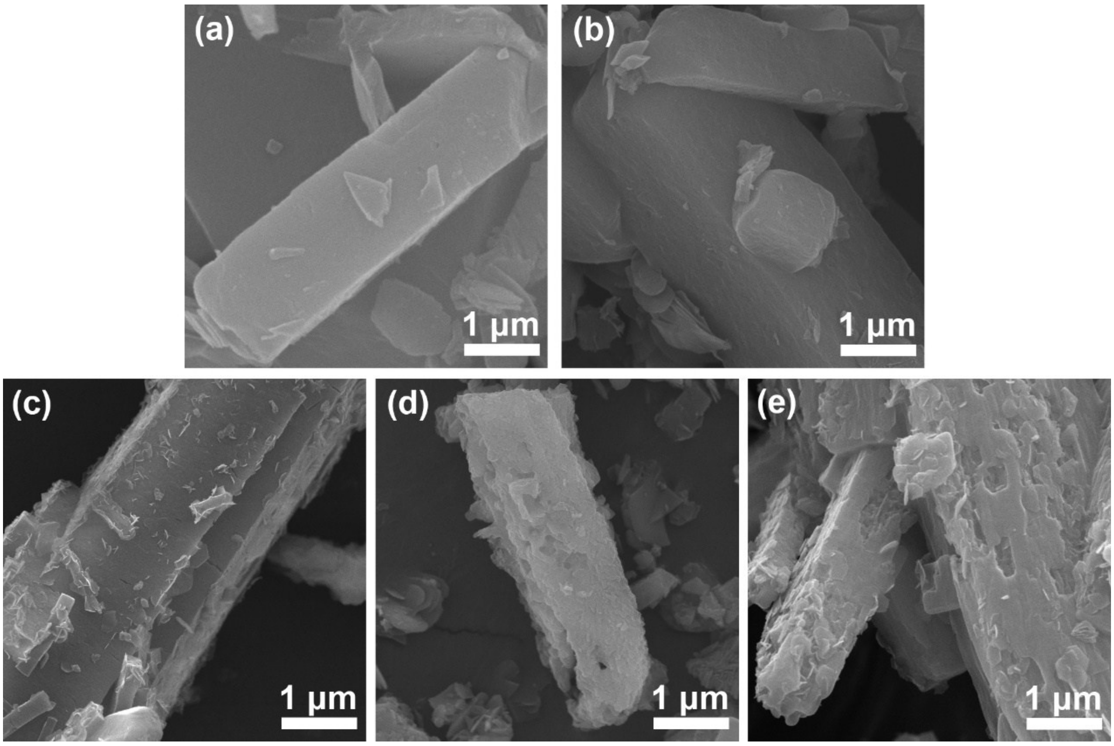

Figure S2. The SEM images of (a) Co-BDC-DABCO, (b) Mn_1Co_2-BDC-DABCO, (c) Mn_1Co_1-BDC-DABCO, (d) Mn_2Co_1-BDC-DABCO and (e) Mn-BDC-DABCO.

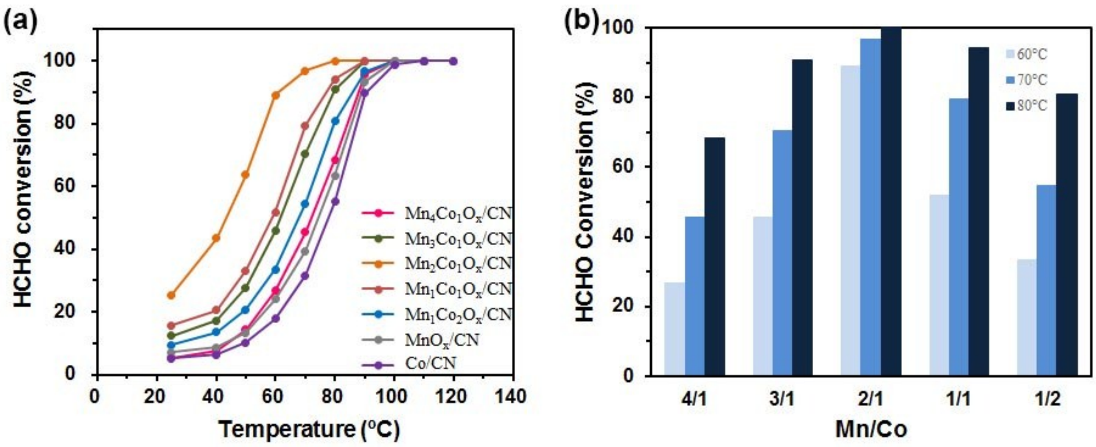

Figure S3. (a) Catalytic activity test for HCHO oxidation over $MnCoO_x$/CN catalysts. (b) Effect of Mn/Co ratios on HCHO oxidation over $MnCoO_x$/CN catalysts.

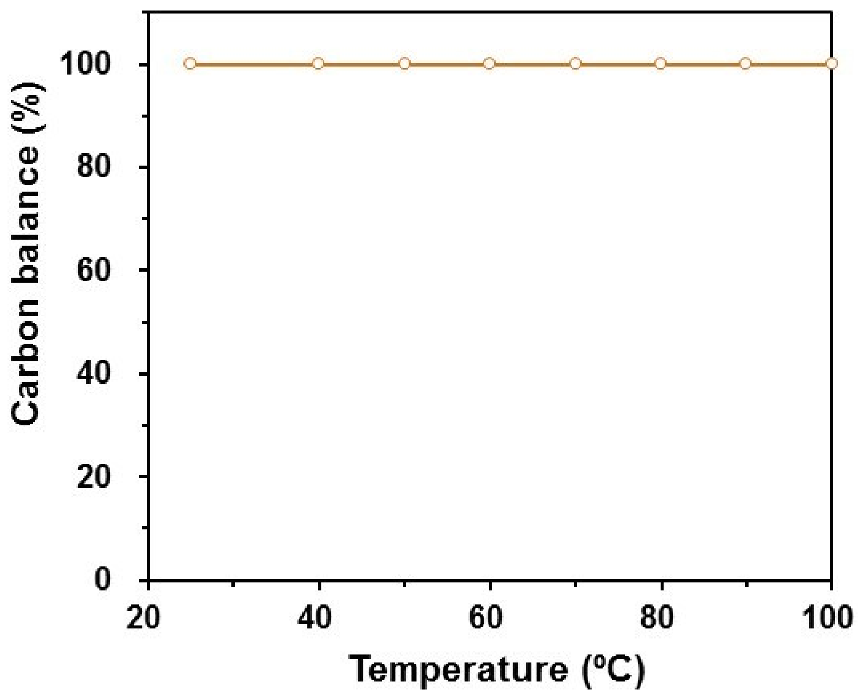

Figure S4. Carbon balance plotted as a function of the reaction temperature for $Mn_2Co_1O_x$/CN.

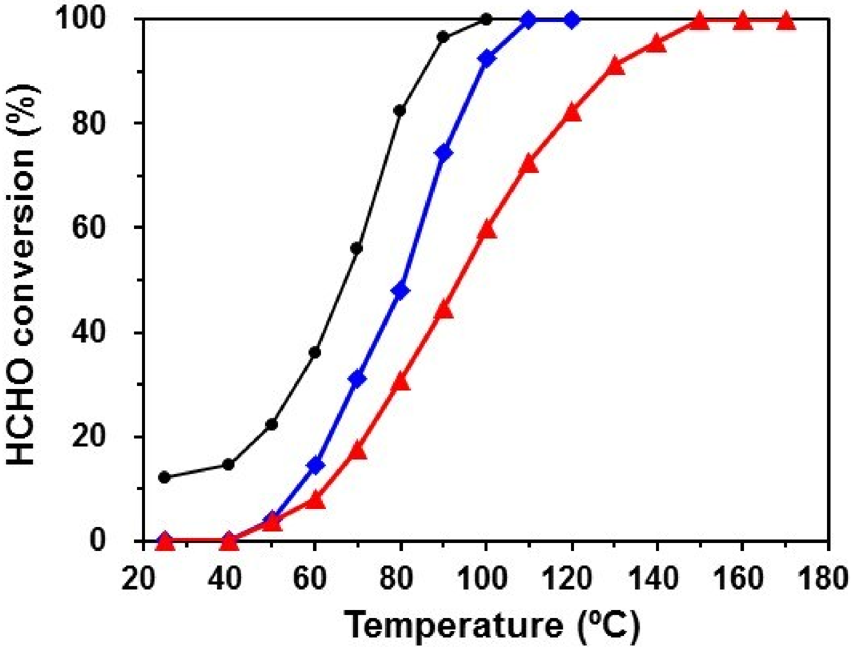

Figure S5. Activity profile of $Mn_2Co_1O_x$/C (black), $Mn_2Co_1O_x$/AC-N (blue) and $Mn_2Co_1O_x$ (red).

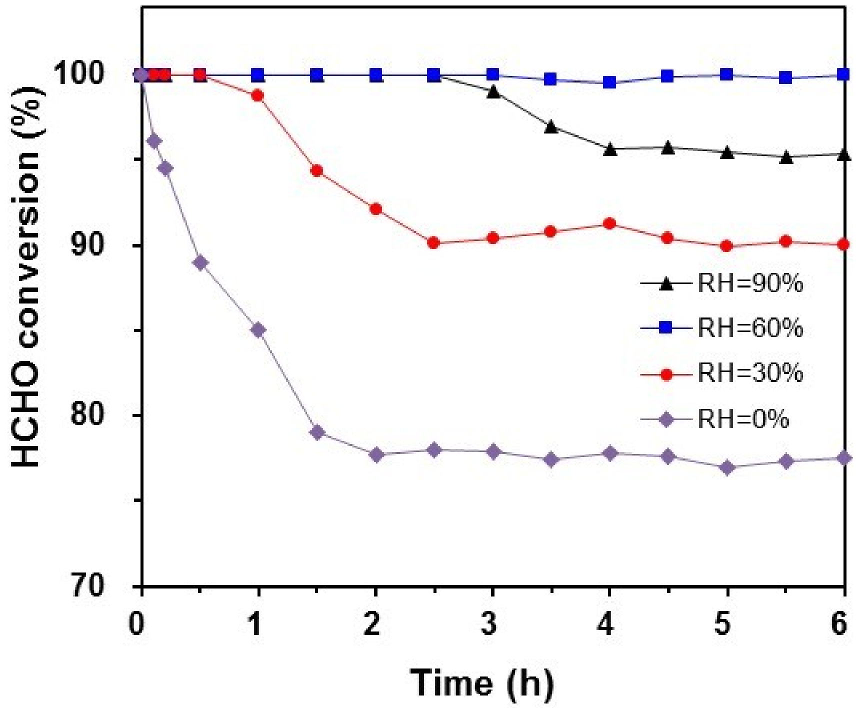

Figure S6. Effect of relative humidity on catalytic performance of $Mn_2Co_1O_x$/CN. Reaction condition: HCHO concentration = 100 ppm, GHSV = 60000 $mL/g_{cat}\cdot h$, T = 80°C.

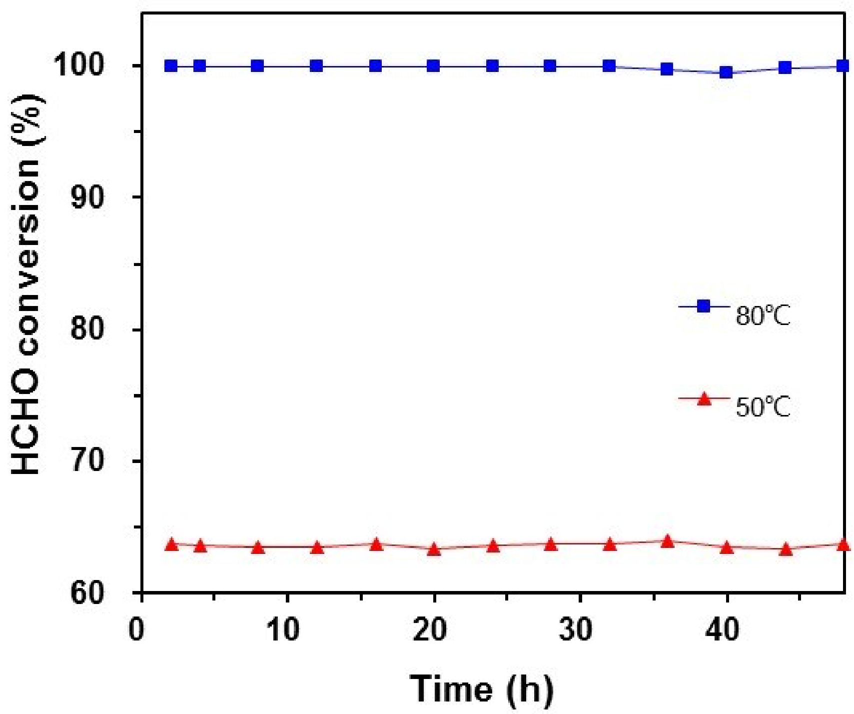

Figure S7. Catalytic stability test of $Mn_2Co_1O_x$/CN at 80°C and 50°C. Reaction condition: HCHO concentration = 100 ppm, GHSV = 60000 mL/g_{cat}·h, RH = 60%.

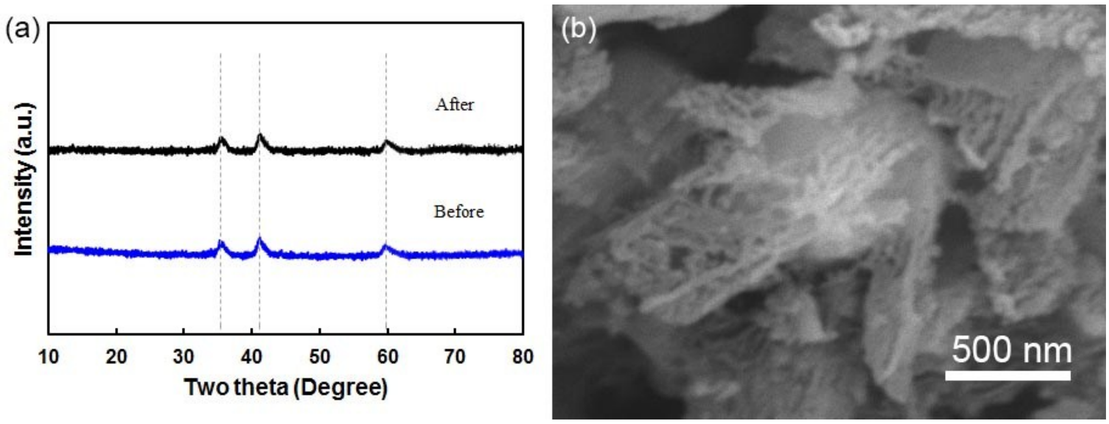

Figure S8. (a) XRD pattern of $Mn_2Co_1O_x$/CN before and after the reaction at 80°C. (b) SEM images of $Mn_2Co_1O_x$/CN after the reaction at 80°C.

Table S1. Surface areas and pore distribution of the materials.

Materials	S_{BET} (m^2g^{-1})	Pore volume (cm^3g^{-1})	Pore size (nm)
Mn-BDC-DABCO	1311	0.60	0.56
Mn_2Co_1- BDC-DABCO	1389	0.66	0.57
Mn_1Co_1- BDC-DABCO	1467	0.69	0.57
Mn_1Co_2- BDC-DABCO	1524	0.70	0.56
Co-BDC-DABCO	1585	0.71	0.56
MnO_x/CN	79	0.14	4.12
$Mn_2Co_1O_x$/CN	129	0.18	4.02
$Mn_1Co_1O_x$/CN	170	0.20	4.01
$Mn_1Co_2O_x$/CN	176	0.21	4.00
Co/CN	193	0.22	4.01

Table S2. Surface element molar ratios for $MnCoO_x$/CN catalysts.

Catalysts	Mn^{3+}/Mn^{4+}	Co^{3+}/Co^{2+}	O_{ads}/O_{total}
MnO_x/CN	0.45	-	0.28
$Mn_2Co_1O_x$/CN	0.53	0.67	0.42
$Mn_1Co_1O_x$/CN	0.49	0.63	0.39
$Mn_1Co_2O_x$/CN	0.46	0.60	0.33
Co/CN	-	0.59	0.31

Table S3. The main element contents of various MOFs and catalysts

Materials	C content (wt%)[a]	N content (wt%)[a]	H content (wt%)[a]	Co content (wt%)[b]	Mn content (wt%)[b]
Mn-BDC-DABCO	46.4	9.5	5.8	/	20.5
Mn_2Co_1- BDC-DABCO	47.0	9.6	5.5	6.9	13.8
Mn_1Co_1- BDC-DABCO	46.5	9.8	5.6	10.5	10.2
Mn_1Co_2- BDC-DABCO	45.6	9.3	5.2	13.7	7.1
Co-BDC-DABCO	46.8	9.4	5.7	20.6	/
MnO_x/CN	42.6	0.9	0.8	/	40.3
$Mn_2Co_1O_x$/CN	43.5	1.0	0.9	13.5	27.1
$Mn_1Co_1O_x$/CN	44.4	1.2	0.9	20.3	19.9
$Mn_1Co_2O_x$/CN	45.9	1.3	1.0	26.7	13.8
Co/CN	51.1	1.5	1.0	41.4	/
$Mn_2Co_1O_x$/AC-N	44.1	1.5	0.4	13.7	25.2

[a] Measured by elemental analysis.

[b] Measured by AAS.

Table S4. Survey of manganese oxides and cobalt oxides catalysts for the oxidation of formaldehyde

Catalysts	Mass (mg)	Reaction conditions	GHSV	$T_{100\%}$ (°C)	Ref.
Birnessite	100	460 ppm HCHO, purified air	30,000 ml/g·h	100	[1]
Birnessite	100	40 ppm HCHO, air, 80% RH	120,000 ml/g·h	100	[2]
Birnessite	100	200 ppm HCHO, air, 45% RH	120,000 ml/g·h	100	[3]
Todorokite	200	400 ppm HCHO, 10.0% O_2	18,000 ml/g·h	160	[4]
K-OMS-2 nanorods	100	460 ppm HCHO, 21% O_2	30,000 ml/g·h	200	[5]
OMS-2	200	500 ppm HCHO, 10% O_2	30,000 ml/g·h	120	[6]
3D-MnO_2 mesoporous	200	400 ppm HCHO, 20% O_2	30,000 ml/g·h	130	[7]
Birnessite nanospheres	50	100 ppm HCHO, 20% O_2	50,000/h	140	[8]
δ-MnO_2	60	170 ppm HCHO, 20% O_2, 25% RH	100,000 ml/g·h	80	[9]
Spinel Co_3O_4	100	100 ppm HCHO, 21% O_2	69,000/h	90	[10]
3D- Co_3O_4	200	400 ppm HCHO, 20% O_2	30,000 ml/g·h	130	[11]
3D- Co_3O_4	200	100 ppm HCHO, 20% O_2	30,000/h	110	[12]
Co_3O_4 nanofibers	100	400 ppm HCHO, 20% O_2	30,000 ml/g·h	98	[13]
Co-Mn	150	80 ppm HCHO, 21% O_2, 50% RH	60,000/h	75	[14]
3D-Co-Mn	250	80 ppm HCHO, 21% O_2, 50% RH	36,000/h	70	[15]
MnO_x-Co_3O_4-CeO_2	50	200 ppm HCHO, 21% O_2	36,000 ml/g·h	100	[16]
$Mn_2Co_1O_x$/CN	100	100 ppm HCHO, air	60,000 ml/g·h	80	This work

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