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Supporting Information

Performance of nanowire-like aluminium-based organometallic complex with high activity electrocatalysis of CO_2 to CO

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The gas chromatograph (GC) uses a three-valve, three-column system to achieve simultaneous analysis of multiple components in one injection, using a column (capillary column) to separate the sample, and the separated components enter the detector in turn, a hydrogen flame ionization detector (FID), a thermal conductivity detector (TCD), with the specific conditions shown in Table S1. Qualitative analysis is to determine which substances the components are by retention time, and quantitative analysis is to determine the content of each component by peak area. The standard gases are a mixture of methane (CH_4), ethylene (C_2H_4), ethane (C_2H_6), carbon monoxide (CO), hydrogen (H_2) and oxygen (O_2) at different concentrations, and the FID detector determines the content of methane, ethylene, ethane and carbon monoxide, and the TCD detector determines the content of hydrogen and oxygen. The standard spectra are shown in Fig. S1, and the parameters are shown in Table S2. All the gas control of the inlet and detector are controlled by using electric pneumatic control (EPC), and the gas pressure control accuracy reaches 0.001 psi, so the automation degree of the equipment and the repeatability and accuracy of the experiment are guaranteed.

The products of 2-Ml/Al-F-N catalysts in this work in the electrocatalytic reduction of CO_2 were determined by gas chromatography. The Faraday efficiency (FE) of these three materials was obtained by averaging the test results of three times at each potential. Calculation formula is shown below, and only one spectrogram at -1.1 V vs. RHE potential is given (Fig. S2 and Table S3,).

Faraday efficiency (FE) calculation formula, using CO as an example:

$$FE_{CO} = \frac{n_{CO} \times Z \times F}{Q} = \frac{n_{CO} \times 2 \times 96485}{t \times I}$$

n_{co}: The amount of carbon monoxide substance;

Z: Number of transferred electrons (H_2 is 2e, CO is 2e, CH_4 is 8e, C_2H_4 is 12e, so $Z = 2$);

F: Faraday's constant ($F = 96485\ C\ mol^{-1}$);

Q: The total amount of charge ($Q = I \times t$);

I: The current on the electrochemical workstation, generally in mA, needs to be converted into A in calculation.

t: General take 1s directly ($t = 1s$).

$$n_{CO} = \frac{P \times V_{CO}}{R \times T} = \frac{101325\ Pa \times V_{CO}}{8.314 J\ mol^{-1}\ K^{-1} \times 298.15\ K}$$

$$V_{CO} = V \times C_{CO} = V_{MFC} \times t$$

P: Pressure ($P = 101325\ Pa$);

R: Gas constant ($R = 8.314 J\ mol^{-1}\ K^{-1}$)

T: Temperature ($T = 298.15K$)

V_{CO}: Carbon monoxide volume;

C_{CO}: Carbon monoxide concentration measured by GC (ppm);

V_{MFC}: The mass controller controls the gas flow rate and the unit must be converted to $m^3\ s^{-1}$, but the unit usually obtained is $mL\ min^{-1}$. (For example, the CO_2 flow rate in this paper is 20 $mL\ min^{-1}$, so $V_{MFC} = {}^{1}/_{3} \times 10^{-6}\ m^3\ s^{-1}$).

Table S1 The type of GC column and conditions

Detector	FID	TCD
Chromatographic column	HP-PLOT-Q 30m × 0.32mm × 20μm	
Column temperature (℃)	80.0	80.0
Detector temperature (℃)	250.0	160.0
Sample inlet temperature (℃)	250.0	
Column flow (mL/min) (constant flow)	3.0	3.0
Air flow (mL/min)	400.0	400.0
Hydrogen flow (mL/min)	60.0	60.0
Make-up gas (mL/min)	10.0	2.0
Split Ratio	10.0: 1	10.0: 1
Carrier gas	Ar	

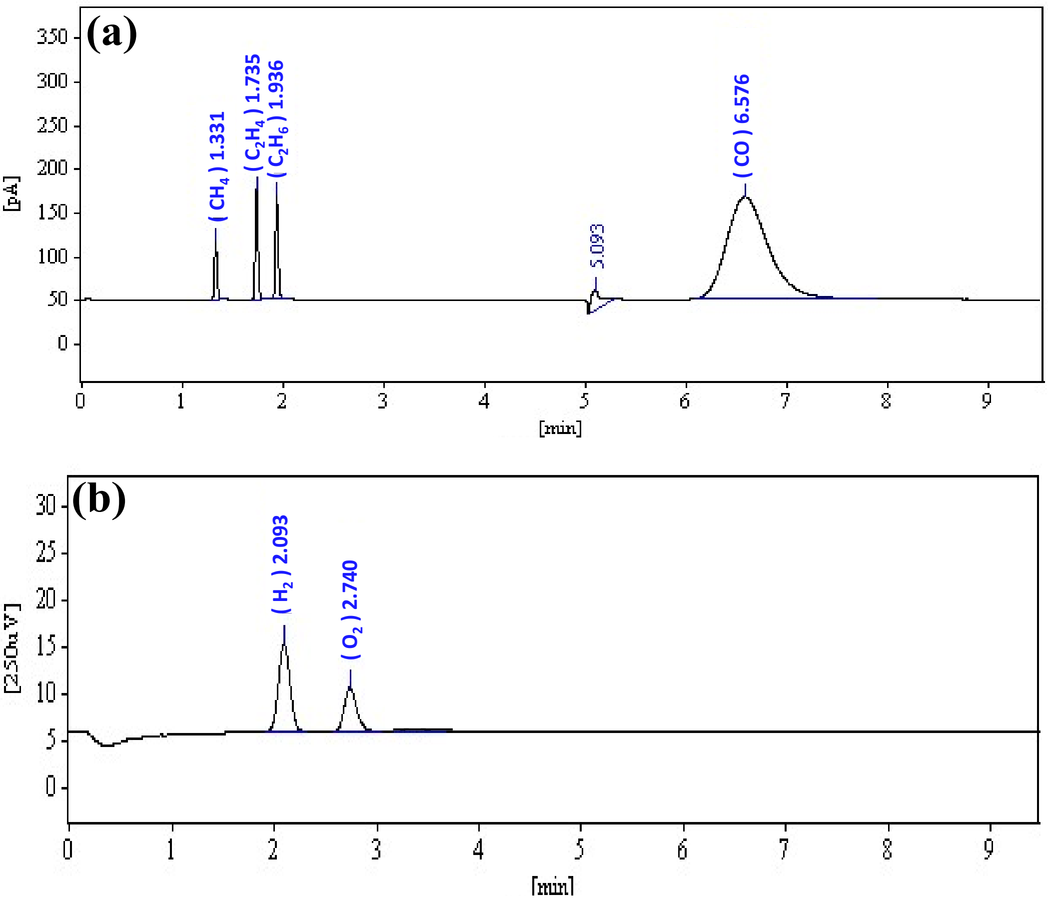

Fig. S1 Gas chromatogram for (a) FID detector and (b) TCD detector of standard gas.

Table S2 The data of each substance in the gas chromatogram of standard gas

Gas composition	CH_4	C_2H_4	C_2H_6	CO	H_2	O_2
Retention time (min)	1.331	1.735	1.936	6.576	2.093	2.740
Peak height (Pa/250uV)	67.33	125.51	118.91	116.85	9.45	4.74
Peak area (Pa*s/250uV*s)	125.54	245.94	243.71	3365.82	74.82	41.29
Concentration (ppm)	205	196	199	194	201	500

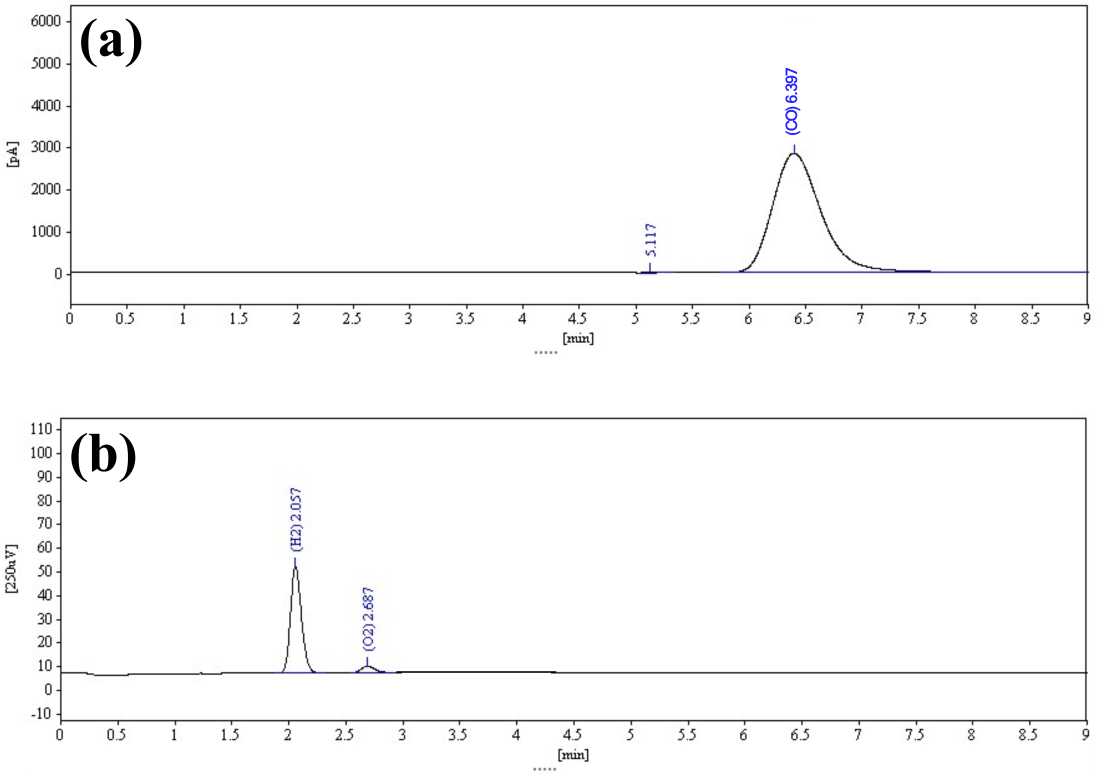

Fig. S2 Gas chromatogram for (a) FID detector and (b) TCD detector of 2-MI/Al-F-N.

Table S3 The data of each substance in the gas chromatogram of 2-MI/Al-F-N

Gas composition	CO	H_2
Retention time (min)	6.397	2.057
Peak height (Pa/250uV)	2829.00	44.95
Peak area (Pa*s/250uV*s)	85344.09	300.01
Concentration (ppm)	4072	545

Table S4 Summary of CO_2RR to CO performance on different electrocatalysts

Catalyst	j (mA cm^{-2})	V *vs.* RHE	Electrolyte (pH)	Main products	Ref.
2-MI/Al-F-N	9.51	-1.1	0.1 M $KHCO_3$ (6.8)	CO (90.1%), H_2 (9.9%)	This work
Cu-Al/LDHs	50		1 M $KHCO_3$ (8.4)	CO (42%), formate (22%)	[2]
FePc−graphene	1.7	-0.6	0.1 M $KHCO_3$ (6.8)	CO (89.7%), H_2 (10.3%)	[3]
Sn_4P_3/RGO	68.0	-1.8	0.5 M [Bmim]PF6	CO (96.6%), H_2 (3.4%)	[4]
$Ni(OH)_2$@RGO	2.3	-0.9	0.1 M $KHCO_3$ (6.8)	CO (88.2%), H_2 (11.8%)	[5]
Ni-$AlO(OH)_3$@RGO	5.1	-0.9	0.1 M $KHCO_3$ (6.8)	CO (92.2%), H_2 (7.8%)	[5]
N-NiZnAl CLDH/RGO	9.4	-0.83	0.5 M NaCl (7.0)	CO (92%), H_2 (8%)	[6]
N-doped carbon@Ni on rGO	23	-0.97	0.5 M $KHCO_3$ (7.2)	CO (90%), H_2 (10%)	[7]
Ni/NCTs	34.3	-1.0	0.5M $KHCO_3$ (7.2)	CO (98%), H_2 (2%)	[8]
N-Ta_2O_5/C	5	-0.73	0.5M $NaHCO_3$ (8.32)	CO (87.5%), H_2 (12.5%)	[9]
CN-H-CNT		-0.5	0.1 M $KHCO_3$ (6.8)	CO (88%), H_2 (12%)	[10]

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