

Table S1. Technical indicators of the IR / Nicolet 6700 Fourier transform infrared spectrometer

Instrument	Fourier transform infrared spectrometer
Model	IR/Nicolet 6700
Manufacturer	Thermo Fisher Scientific (USA)
Spectral range	12000-350 cm ⁻¹
Spectral resolution	≤0.09 cm ⁻¹
S/N ratio	≥50,000:1 (1 min scan, 4cm ⁻¹ resolution, KBr beam splitter, DTGS detector, peak-to-peak)
Wave number accuracy	0.01 cm ⁻¹

Table S2. Technical indicators of JEM-2100F transmission electron microscopy

Instrument	Transmission electron microscopy
Model	JEM-2100F
Manufacturer	JEOL (Japan)
Point resolution	0.24 nm
Line resolution	0.10 nm
Acceleration voltage	100, 120, 160, 200 kV
Tilt angle	0.01 cm ⁻¹ 25°
STEM resolution	0.20 nm

Table S3. Technical indicators of Zennium electrochemical workstation

Instrument	Electrochemical workstation
Model	Zennium
Manufacturer	Zahner (Germany)
Application voltage range	±10V
Current range	±2.5A
Potential accuracy	250μA
Current accuracy	0.05% (2μA~100μA); 0.5% (<2μA & >100mA)

Table S4. Technical indicators of GC-14B gas chromatograph

Instrument	Electrochemical workstation
Model	GC-14B
Manufacturer	Shimadzu
Total inlet flow setting range	0-1250mL/min
Inlet pressure setting range	0-1035kPa
Maximum inlet temperature	420°C
Carrier gas pressure range	0-1035kPa
Carrier gas flow range	0-1250mL/min
Cooling rate	300-50°C, less than 6 minutes
Heating up rate	250°C/min
Control temperature range	Room temperature+10°C ~ 420°C