

Electronic Supplementary Information

Fe-modulated NH₂-CoFe MOF nanosheet arrays on nickel foam by cation exchange reaction for efficient OER electrocatalyst at high current density in alkaline water/seawater

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Number of Pages: 30

Number of Figures: 22

Number of Tables: 5

Table of Contents

Figure S1. Photograph image for measuring pH of 1M KOH electrolyte.	S4
Table S1. List of Abbreviations.	S5
Figure S2. Real images of NF, NH ₂ -Co MOF, and NH ₂ -CoFe MOF.....	S6
Figure S3. SEM images of NH ₂ -Co MOF on NF at different magnifications.....	S7
Figure S4. SEM images of NH ₂ -CoFe MOF on NF at different magnifications.....	S8
Figure S5. SEM images of (a) Co MOF, (b) CoFe MOF on a NF with BDC linker.....	S9
Figure S6. FE-TEM images of NH ₂ -Co MOF with high magnification.....	S10
Figure S7. (a) TEM-EDS mapping images of (b) Co, (c) C, (d) N, and (e) O for NH ₂ -Co MOF.	S11
Figure S8. (a) TEM-EDS mapping images of (b) Co, (c) Fe, (d) C, (e) N, and (f) O for NH ₂ -CoFe MOF-FeCl ₃	S12
Figure S9. Schematic illustration of the crystal structure of NH ₂ -Co MOF (CCDC no 1016535). The Co, C, O, N, and H atoms are marked in blue, brown, red, white, and ivory colors, respectively.	S13
Figure S10. XRD patterns of NH ₂ -Co MOF, NH ₂ -CoFe MOF-FeCl ₃ , and NH ₂ -CoFe MOF in low-angle range ($2\theta=10\sim 12^\circ$).	S14
Figure S11. FT-IR spectra of Co MOF and CoFe MOF on a NF with BDC linker.	S15
Figure S12. XPS spectra of NH ₂ -Co MOF (a) survey; (b) C 1s; (c) O 1s; (d) N 1s; (e) Co 2p.....	S16
Figure S13. XPS spectra of NH ₂ -CoFe MOF-FeCl ₃ (a) survey; (b) C 1s; (c) O 1s; (d) N 1s; (e) Fe 2p; (f) Co 2p.	S17
Figure S14. XPS spectra of NH ₂ -CoFe MOF (a) survey; (b) C 1s; (c) O 1s; (d) N 1s; (e) Fe 2p; (f) Co 2p.....	S18
Figure S15. (a) The chemical compositions, (b) The percentage of various chemical states of O in NH ₂ -Co MOF, NH ₂ -CoFe MOF-FeCl ₃ , and NH ₂ -CoFe MOF obtained by XPS.	S19
Table S2. XPS spectra results of Co 2p, Fe 2p, O 1s, N 1s, and C 1s of NH ₂ -Co MOF, NH ₂ -CoFe MOF-FeCl ₃ , and NH ₂ -CoFe MOF.	S20

Figure S16. (a) LSV curves at 2mV s^{-1} with 90% iR compensation, (b) volcano plot of $\text{NH}_2\text{-CoFe MOF}$ with different concentrations of FeSO_4 aqueous solution.	S21
Figure S17. LSV curves of Co MOF, CoFe MOF, $\text{NH}_2\text{-CoFe MOF}$ with difference linkers at 2mV s^{-1} with 90% iR compensation.	S22
Figure S18. Backward LSV curves of Bare NF, $\text{NH}_2\text{-Co MOF}$, $\text{NH}_2\text{-CoFe MOF-FeCl}_3$, and $\text{NH}_2\text{-CoFe MOF}$ at 2mV s^{-1} with 90% iR compensation.	S23
Table S3. Overpotential of OER catalyts at 100 mA cm^{-2}	S24
Figure S19. Cyclic voltammograms of (a) Bare NF, (b) $\text{NH}_2\text{-Co MOF}$, (c) $\text{NH}_2\text{-CoFe MOF-FeCl}_3$, and (d) $\text{NH}_2\text{-CoFe MOF}$	S25
Table S4. Calculated ECSA from C_{dl} values of NF, $\text{NH}_2\text{-Co MOF}$, $\text{NH}_2\text{-CoFe MOF-FeCl}_3$, and $\text{NH}_2\text{-CoFe MOF}$	S26
Figure S20. XPS spectra of $\text{NH}_2\text{-CoFe MOF}$ after stability test for 50 h, (a) survey; (b) O 1s; (c) Fe 2p; (d) Co 2p.	S27
Figure S21. Reproducibility test of the $\text{NH}_2\text{-Co MOF}$, $\text{NH}_2\text{-CoFe MOF}$	S28
Table S5. Catalytic properties for OER of the Fe, and Co-based electrocatalysts in alkaline electrolyte.	S29
Figure S22. Photographs of natural seawater of Gimnyeong sea in Jeju island, Korea, and 3 electrode cell for OER measurement in 1M KOH with sea water.	S30



Figure S1. Photograph image for measuring pH of 1M KOH electrolyte.

Table S1. List of Abbreviations.

Abbreviations	Full form
NF	Nickel foam
NH ₂ -Co MOF	Amino functionalized Cobalt-Metal organic framework with NH ₂ -BDC linker
Co MOF	Cobalt-Metal organic framework with BDC linker
CoFe MOF	Cobalt, Iron-Metal organic framework by cation exchange reaction with FeSO ₄
NH ₂ -CoFe MOF-FeCl ₃	Amino functionalized Cobalt, Iron-Metal organic framework by cation exchange reaction with FeCl ₃
NH ₂ -CoFe MOF	Amino functionalized Cobalt, Iron-Metal organic framework by cation exchange reaction with FeSO ₄

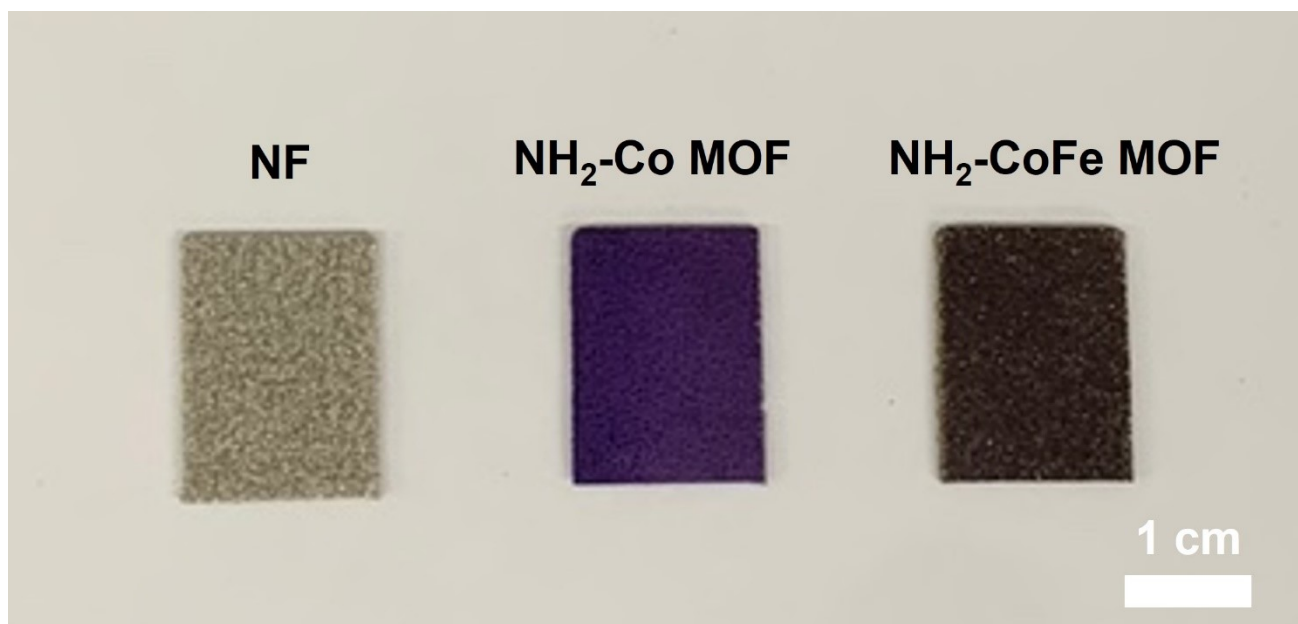


Figure S2. Real images of NF, NH₂-Co MOF, and NH₂-CoFe MOF.

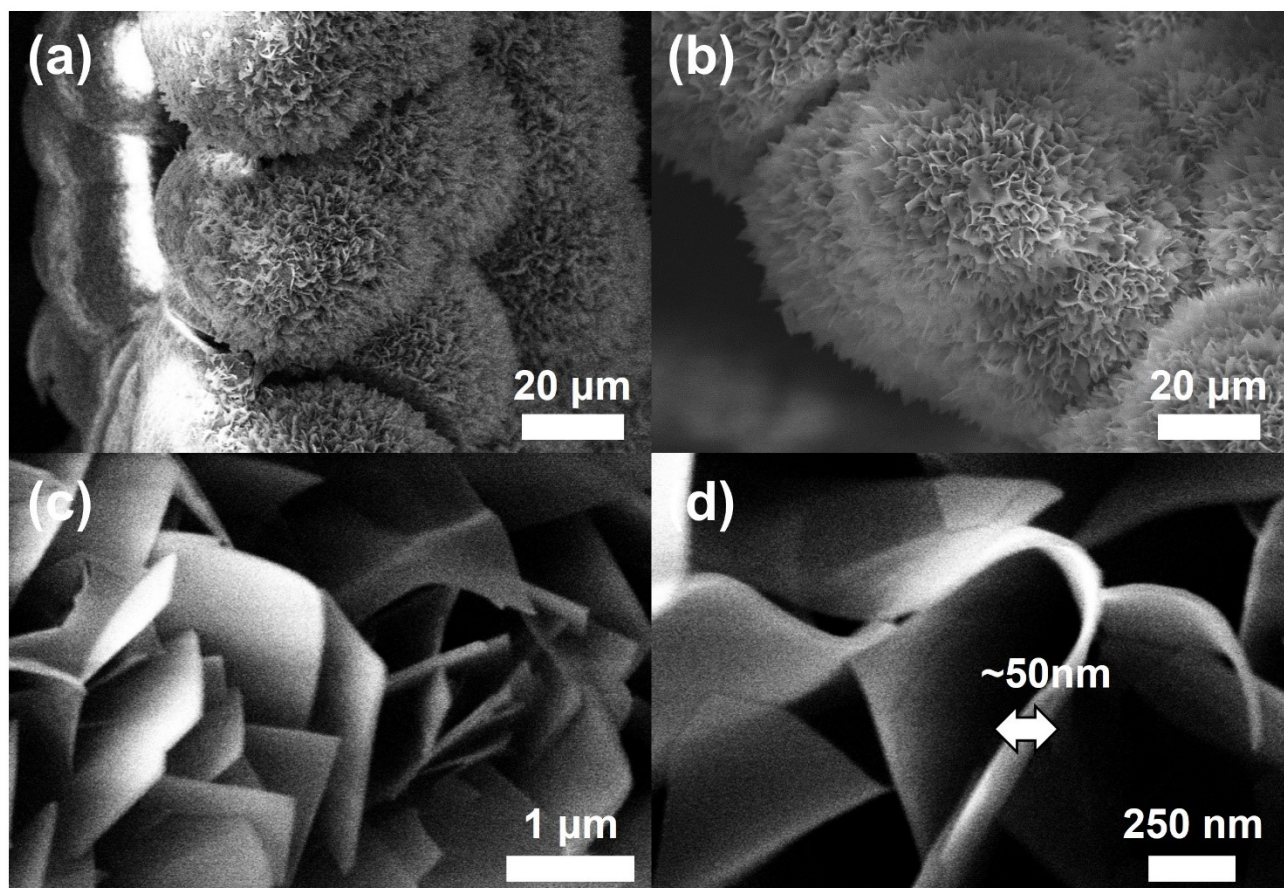


Figure S3. SEM images of $\text{NH}_2\text{-Co MOF}$ on NF at different magnifications.

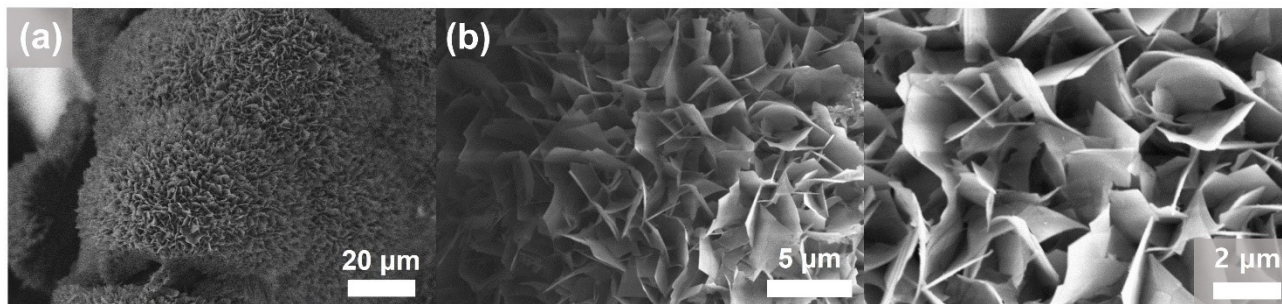


Figure S4. SEM images of NH₂-CoFe MOF on NF at different magnifications.

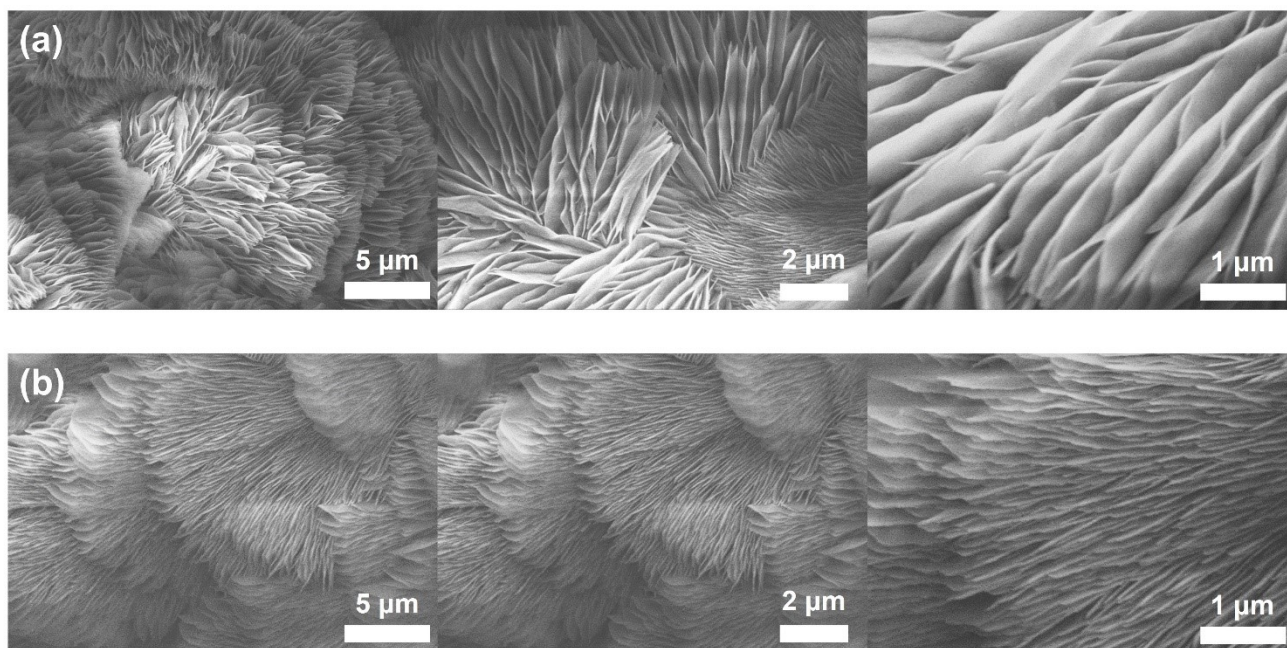


Figure S5. SEM images of (a) Co MOF, (b) CoFe MOF on a NF with BDC linker.

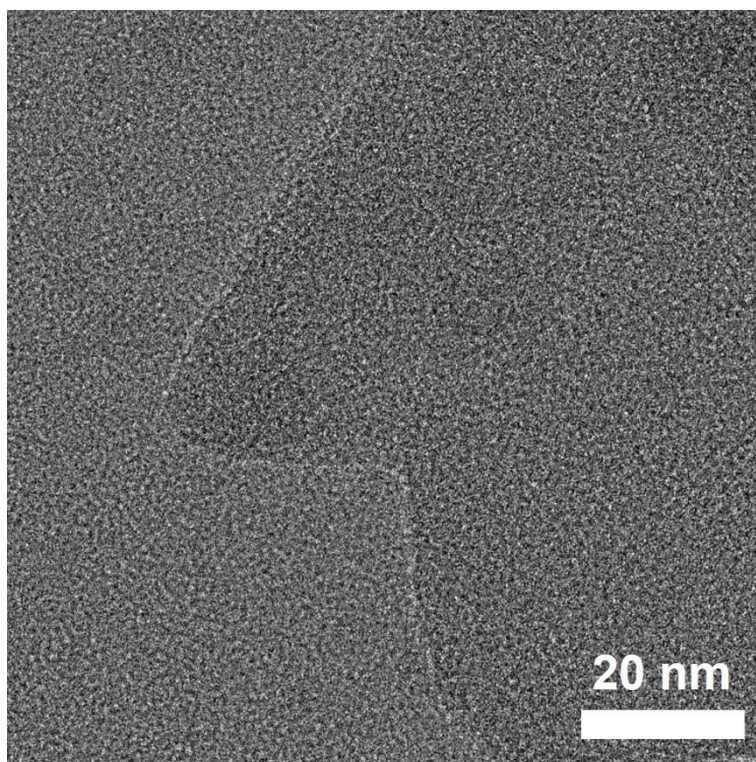


Figure S6. FE-TEM images of NH₂-Co MOF with high magnification.

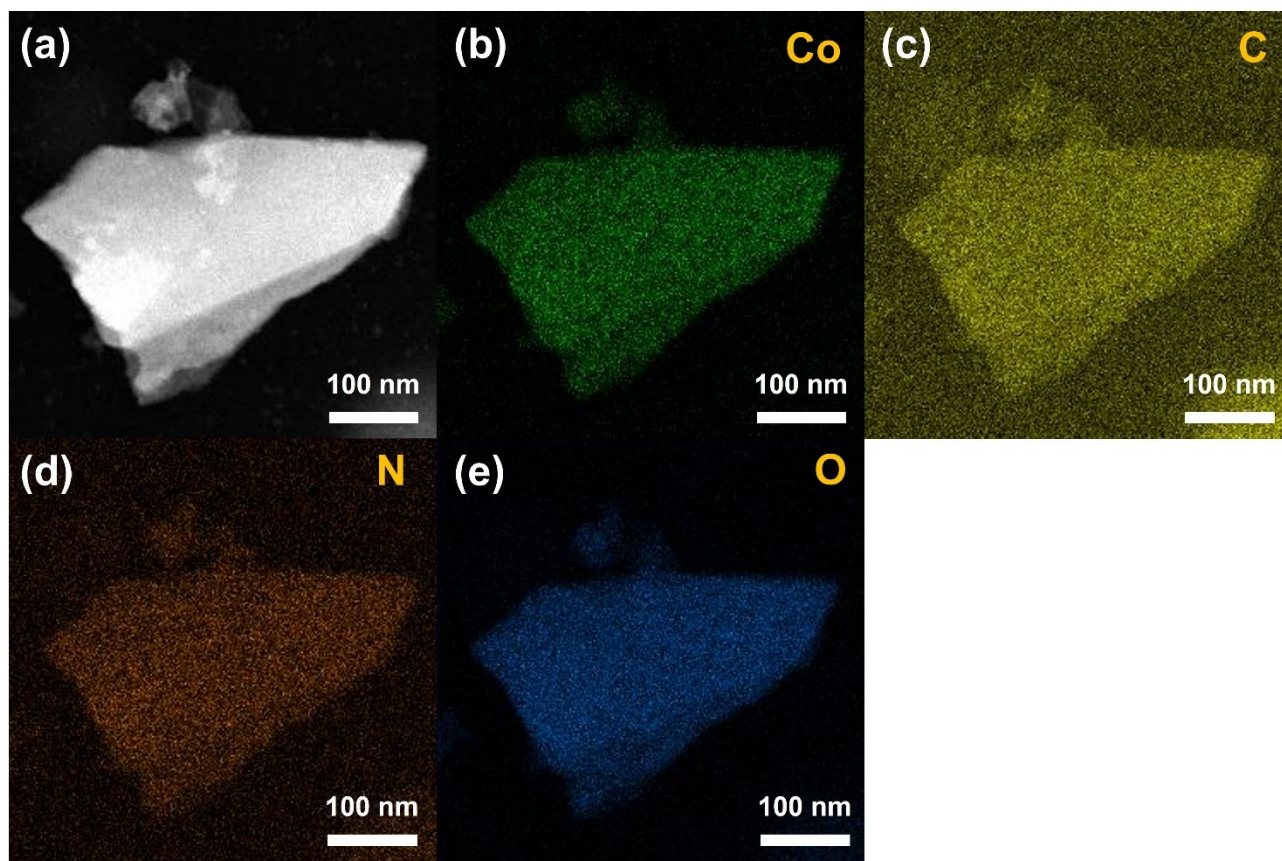


Figure S7. (a) TEM-EDS mapping images of (b) Co, (c) C, (d) N, and (e) O for NH₂-Co MOF.

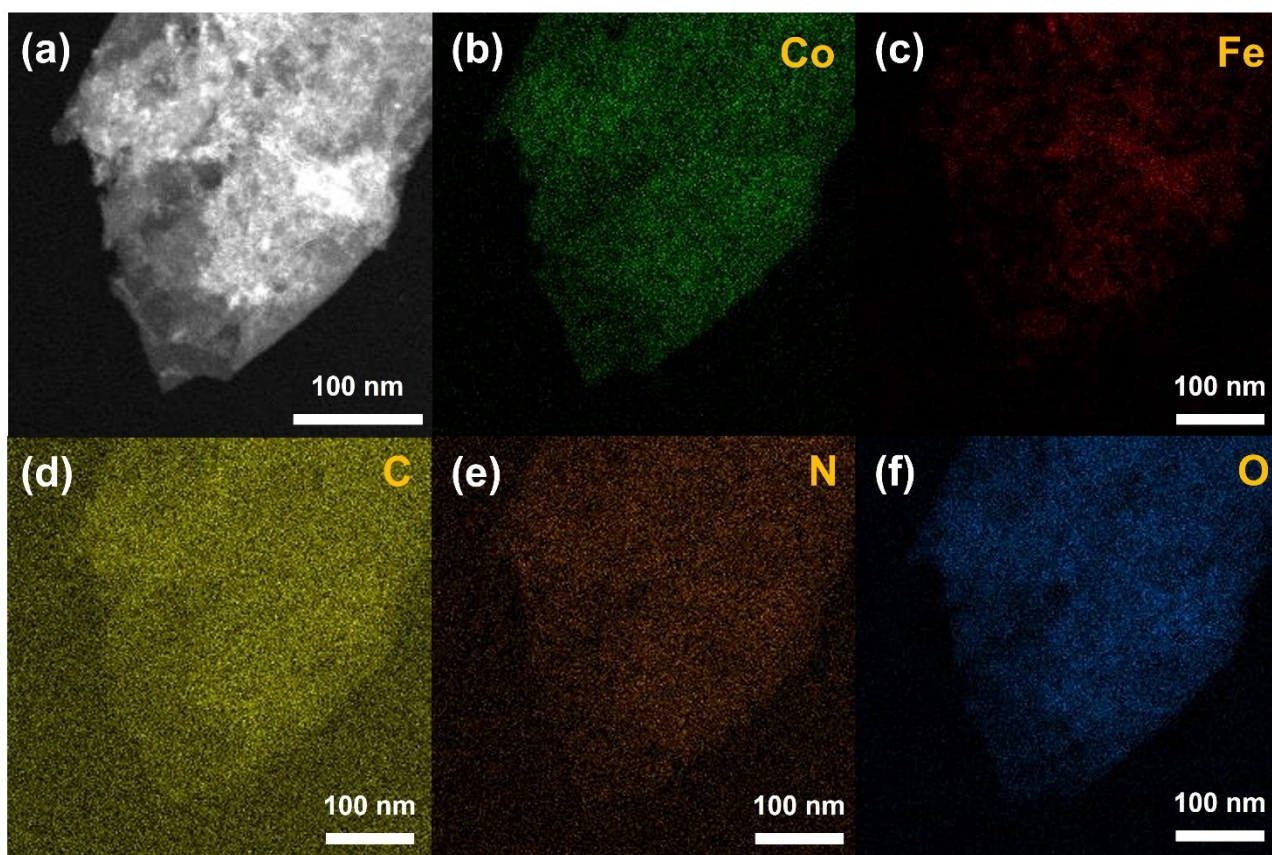


Figure S8. (a) TEM-EDS mapping images of (b) Co, (c) Fe, (d) C, (e) N, and (f) O for NH₂-CoFe MOF-FeCl₃.

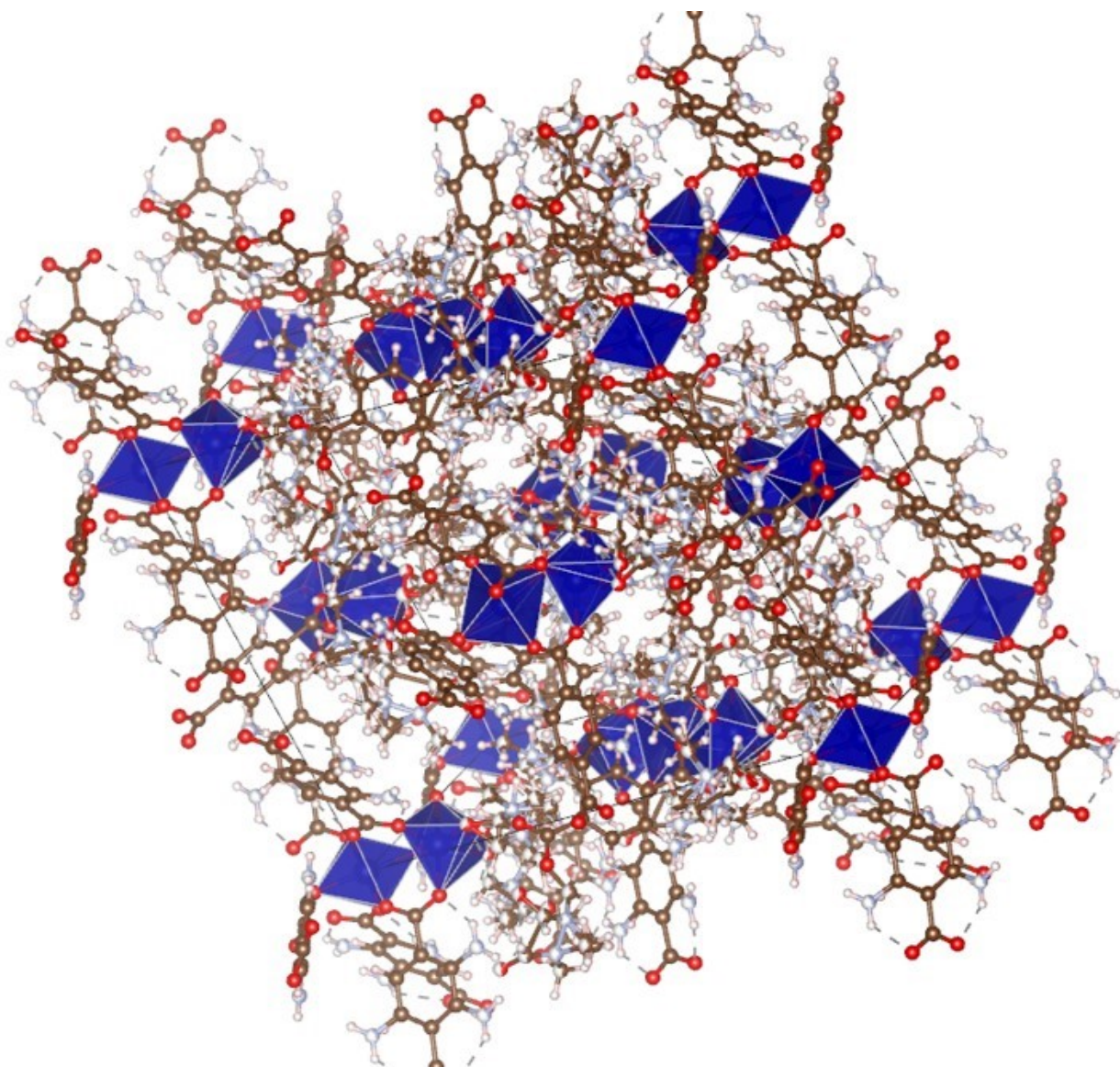


Figure S9. Schematic illustration of the crystal structure of $\text{NH}_2\text{-Co MOF}$ (CCDC no 1016535). The Co, C, O, N, and H atoms are marked in blue, brown, red, white, and ivory colors, respectively.

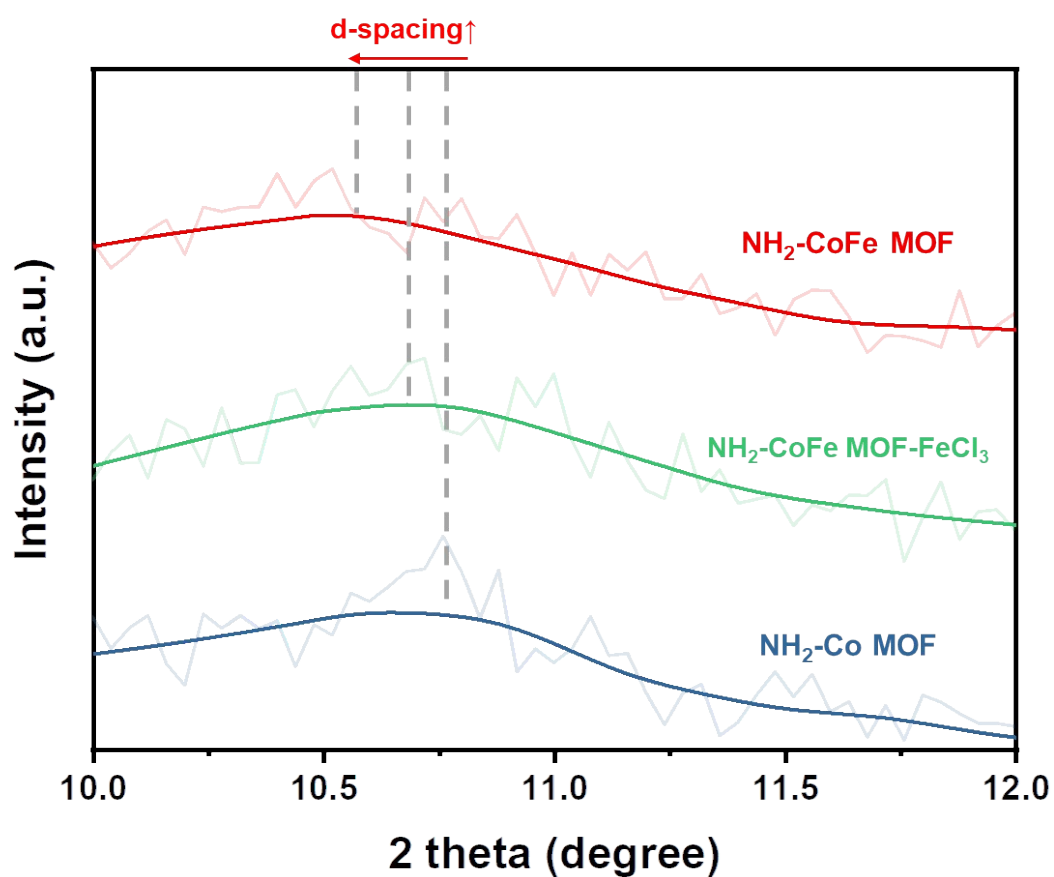


Figure S10. XRD patterns of NH₂-Co MOF, NH₂-CoFe MOF-FeCl₃, and NH₂-CoFe MOF in low-angle range ($2\theta=10\sim 12^\circ$).

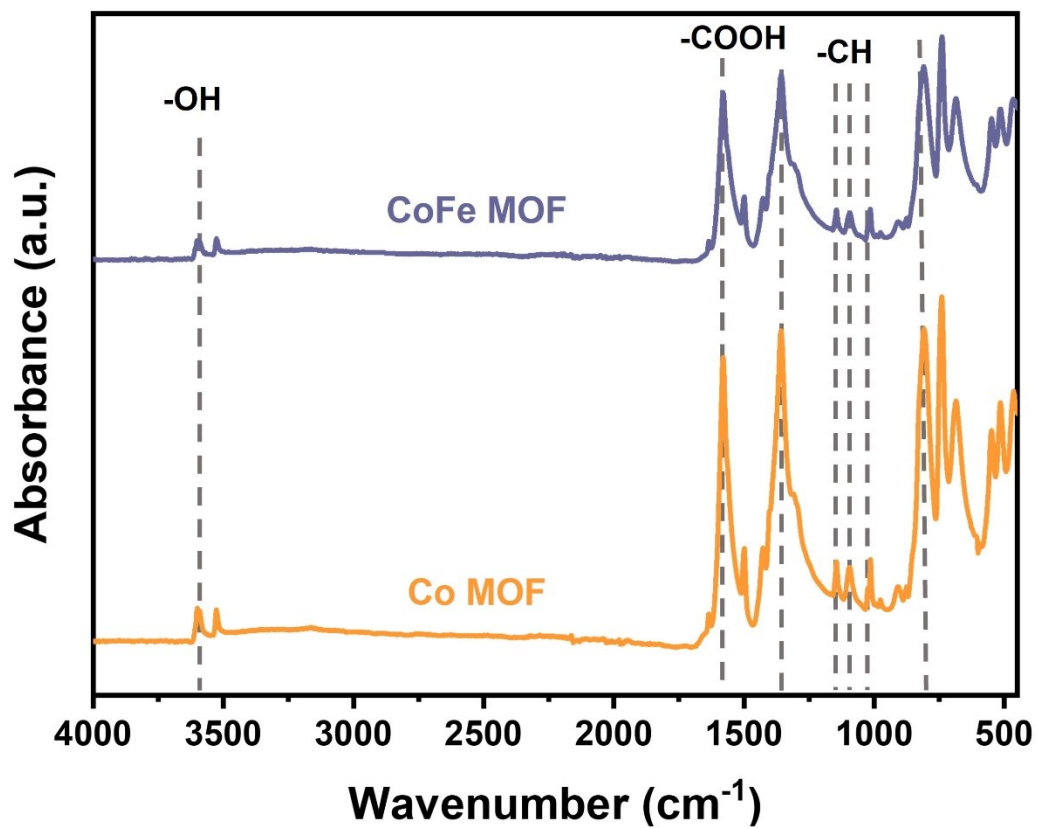


Figure S11. FT-IR spectra of Co MOF and CoFe MOF on a NF with BDC linker.

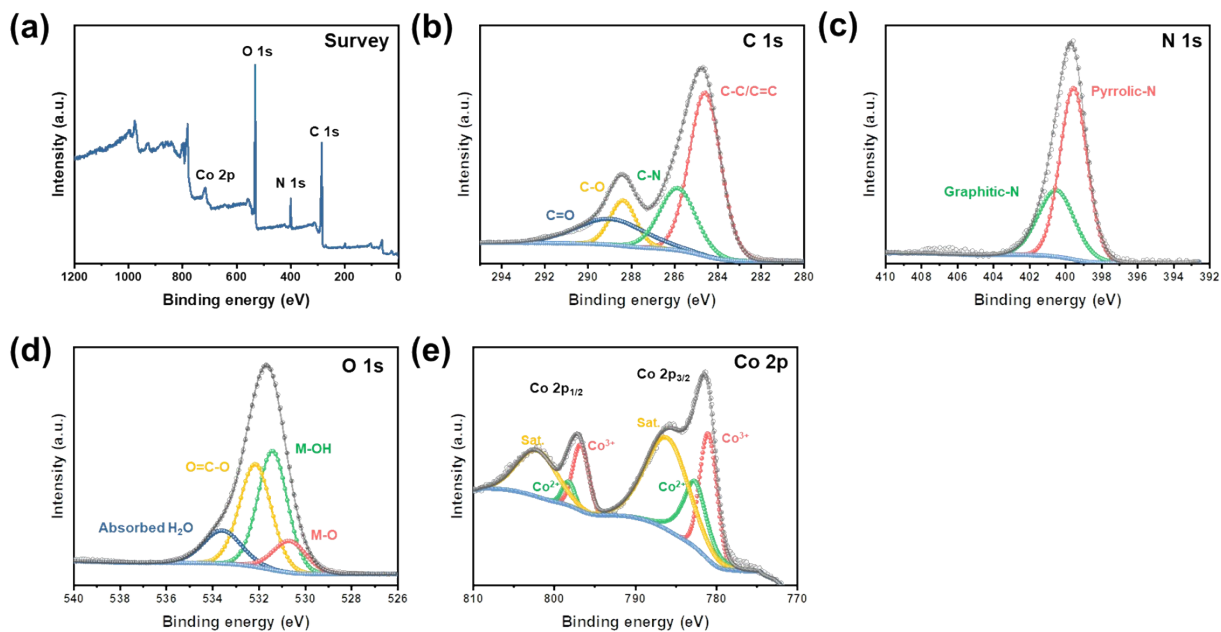


Figure S12. XPS spectra of NH₂-Co MOF (a) survey; (b) C 1s; (c) O 1s; (d) N 1s; (e) Co 2p.

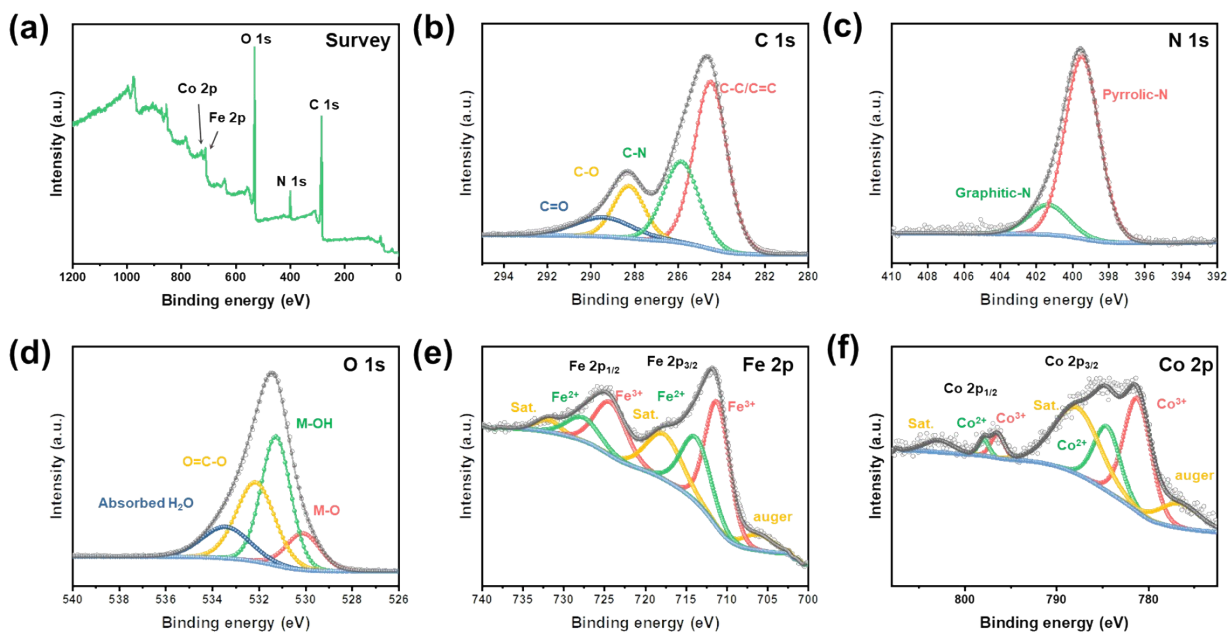


Figure S13. XPS spectra of $\text{NH}_2\text{-CoFe MOF-FeCl}_3$ (a) survey; (b) C 1s; (c) O 1s; (d) N 1s; (e) Fe 2p; (f) Co 2p.

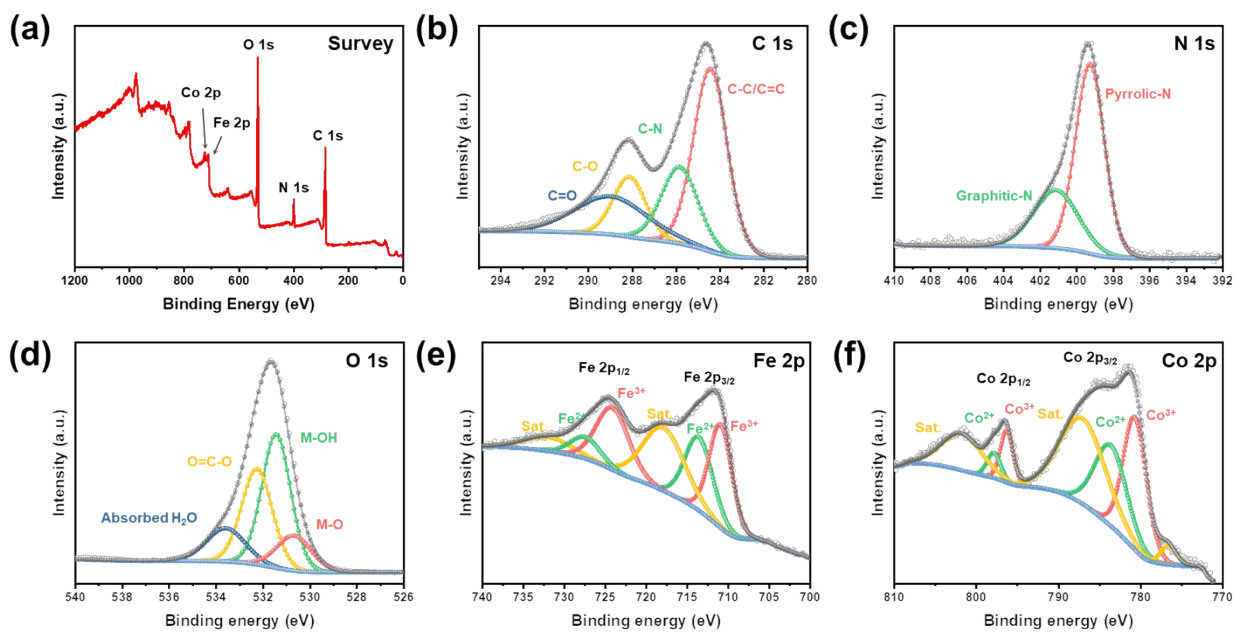


Figure S14. XPS spectra of NH₂-CoFe MOF (a) survey; (b) C 1s; (c) O 1s; (d) N 1s; (e) Fe 2p; (f) Co 2p.

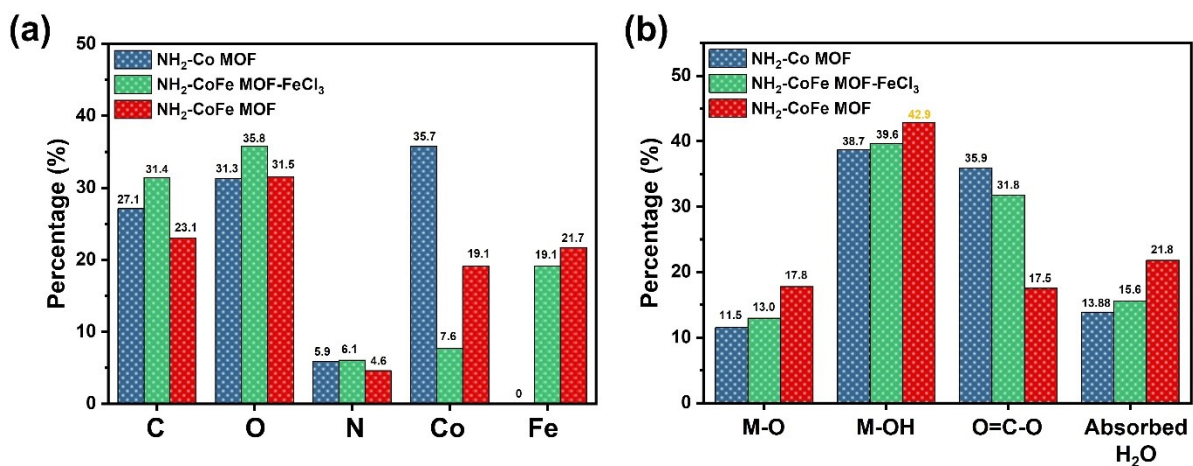


Figure S15. (a) The chemical compositions, (b) The percentage of various chemical states of O in NH₂-Co MOF, NH₂-CoFe MOF-FeCl₃, and NH₂-CoFe MOF obtained by XPS.

Table S2. XPS spectra results of Co 2p, Fe 2p, O 1s, N 1s, and C 1s of NH₂-Co MOF, NH₂-CoFe MOF-FeCl₃, and NH₂-CoFe MOF.

Peak	Assignment	NH ₂ -Co MOF	NH ₂ -CoFe MOF- FeCl ₃	NH ₂ -CoFe MOF
		Binding energy (eV)		
Co 2p	2p _{1/2}	796.7	796.4	796.3
	2p _{3/2}	781.5	781.3	781.1
Fe 2p	2p _{1/2}	-	724.7	724.6
	2p _{3/2}	-	711.7	711.7
O 1s	M-O	530.6	530.6	530.6
	M-OH	531.3	531.2	531.4
	O=C-O	532.1	532.1	532.1
	Absorbed H ₂ O	533.5	533.4	533.4
N 1s	Graphitic-N	399.5	399.5	399.3
	Pyrrolic-N	400.4	401.3	401.1
C 1s	C-C/C=C	284.5	284.4	284.4
	C-N	285.8	285.8	285.8
	C-O	288.3	288.2	288.2
	C=O	289.1	289.1	289.1

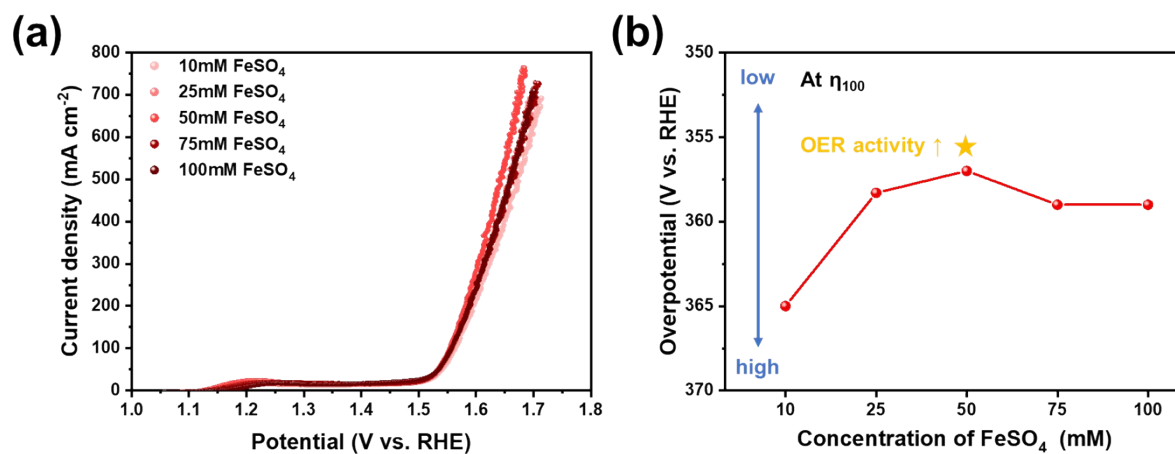


Figure S16. (a) LSV curves at 2mV s^{-1} with 90% iR compensation, (b) volcano plot of $\text{NH}_2\text{-CoFe}$ MOF with different concentrations of FeSO_4 aqueous solution.

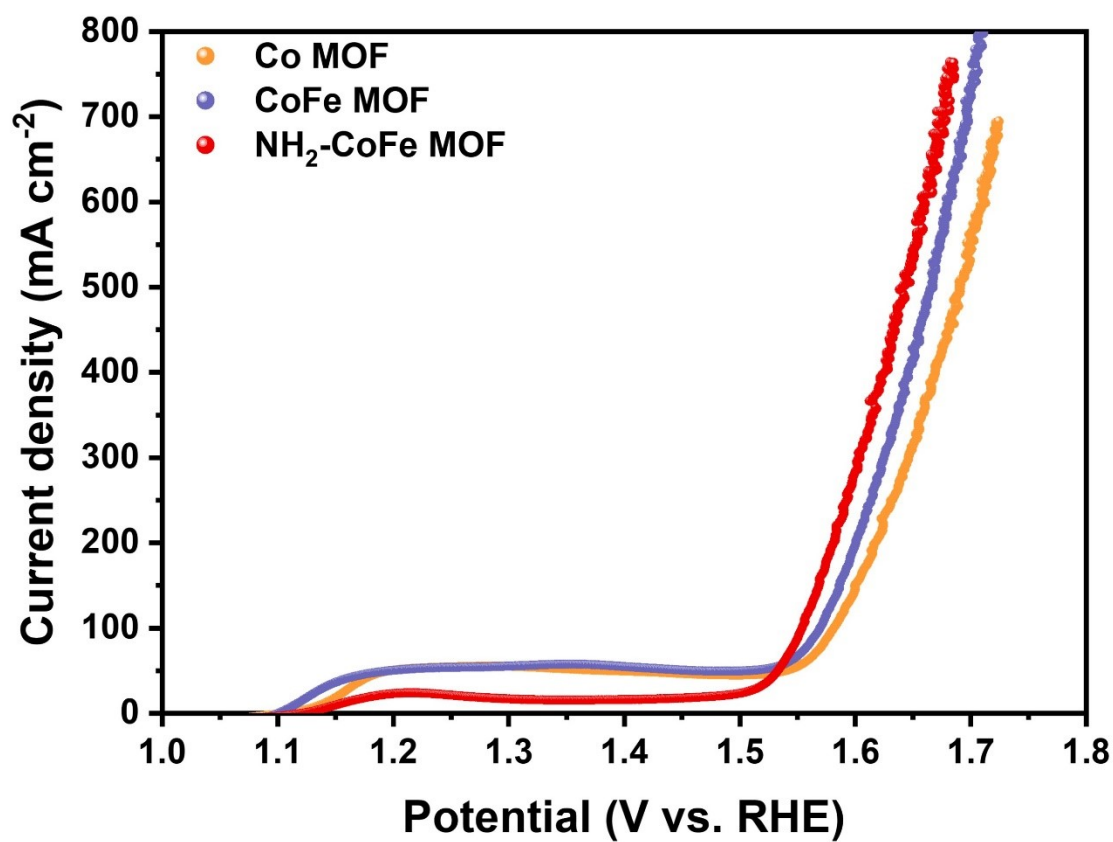


Figure S17. LSV curves of Co MOF, CoFe MOF, NH₂-CoFe MOF with difference linkers at 2mV s⁻¹ with 90% iR compensation.

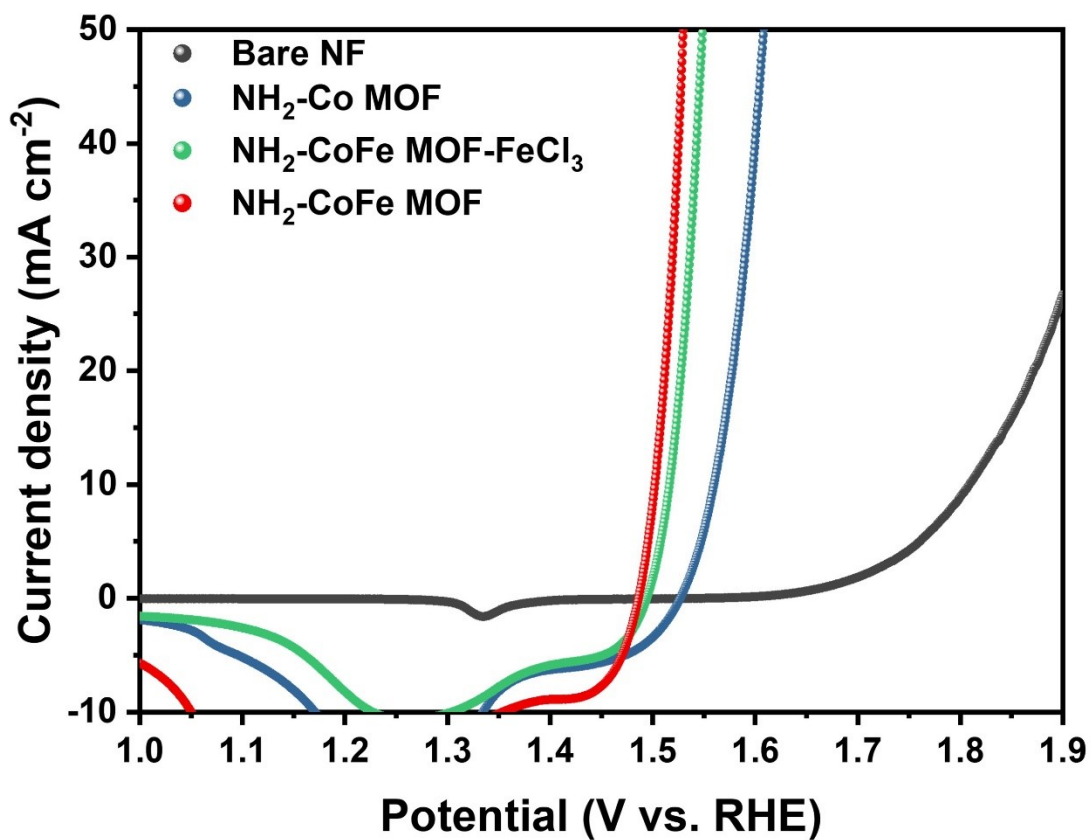


Figure S18. Backward LSV curves of Bare NF, NH₂-Co MOF, NH₂-CoFe MOF-FeCl₃, and NH₂-CoFe MOF at 2mV s⁻¹ with 90% iR compensation.

Table S3. Overpotential of OER catalysts at 100 mA cm⁻².

Sample	Overpotential at 100 mA cm ⁻²
NF	729 mV
Co MOF	351 mV
NH ₂ -Co MOF	401 mV
CoFe MOF	339 mV
NH ₂ -CoFe MOF-FeCl ₃	346 mV
NH ₂ -CoFe MOF	310 mV

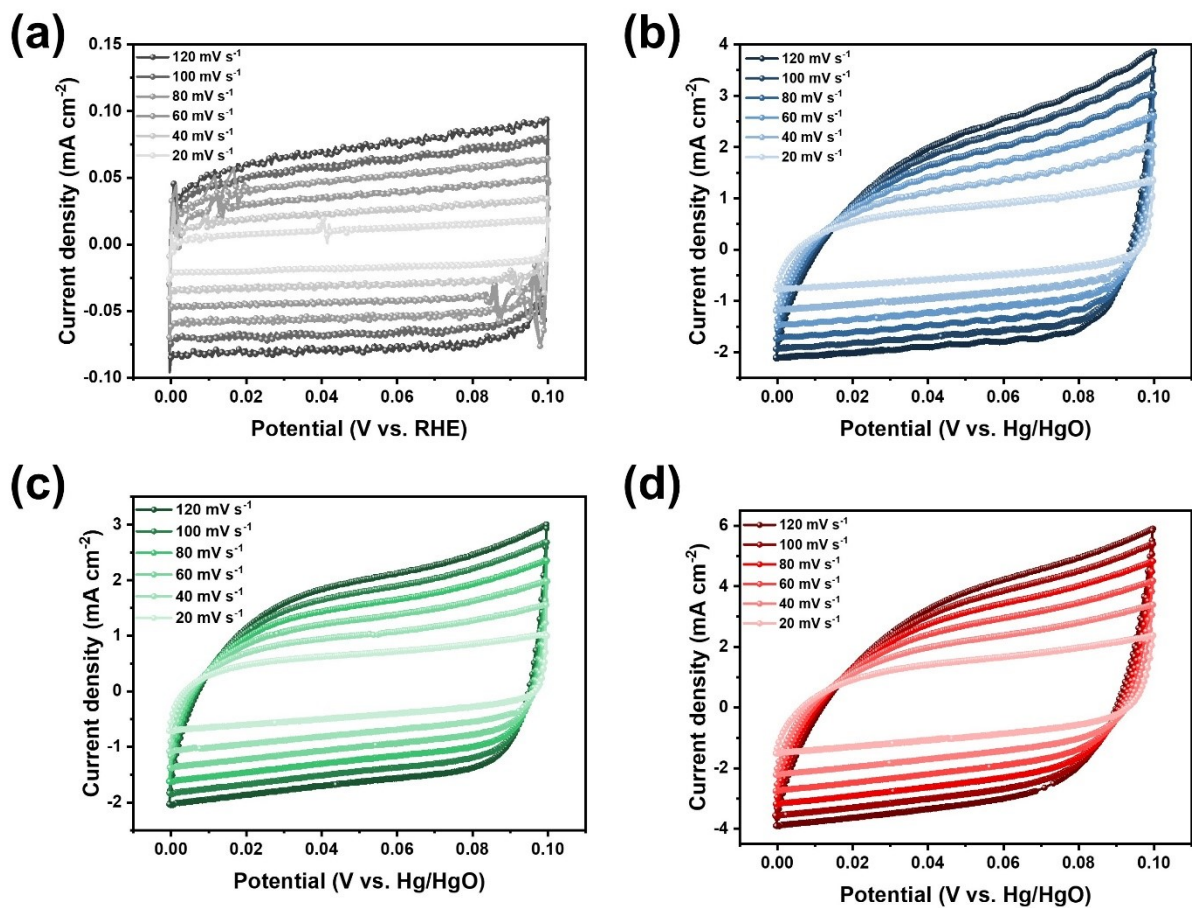


Figure S19. Cyclic voltammograms of (a) Bare NF, (b) NH₂-Co MOF, (c) NH₂-CoFe MOF-FeCl₃, and (d) NH₂-CoFe MOF.

Table S4. Calculated ECSA from C_{dl} values of NF, NH₂-Co MOF, NH₂-CoFe MOF-FeCl₃ and NH₂-CoFe MOF.

	NF	NH ₂ -Co MOF	NH ₂ -CoFe MOF-FeCl ₃	NH ₂ -CoFe MOF
ECSA (cm ²)	31.25	688.0	624.0	1113.5

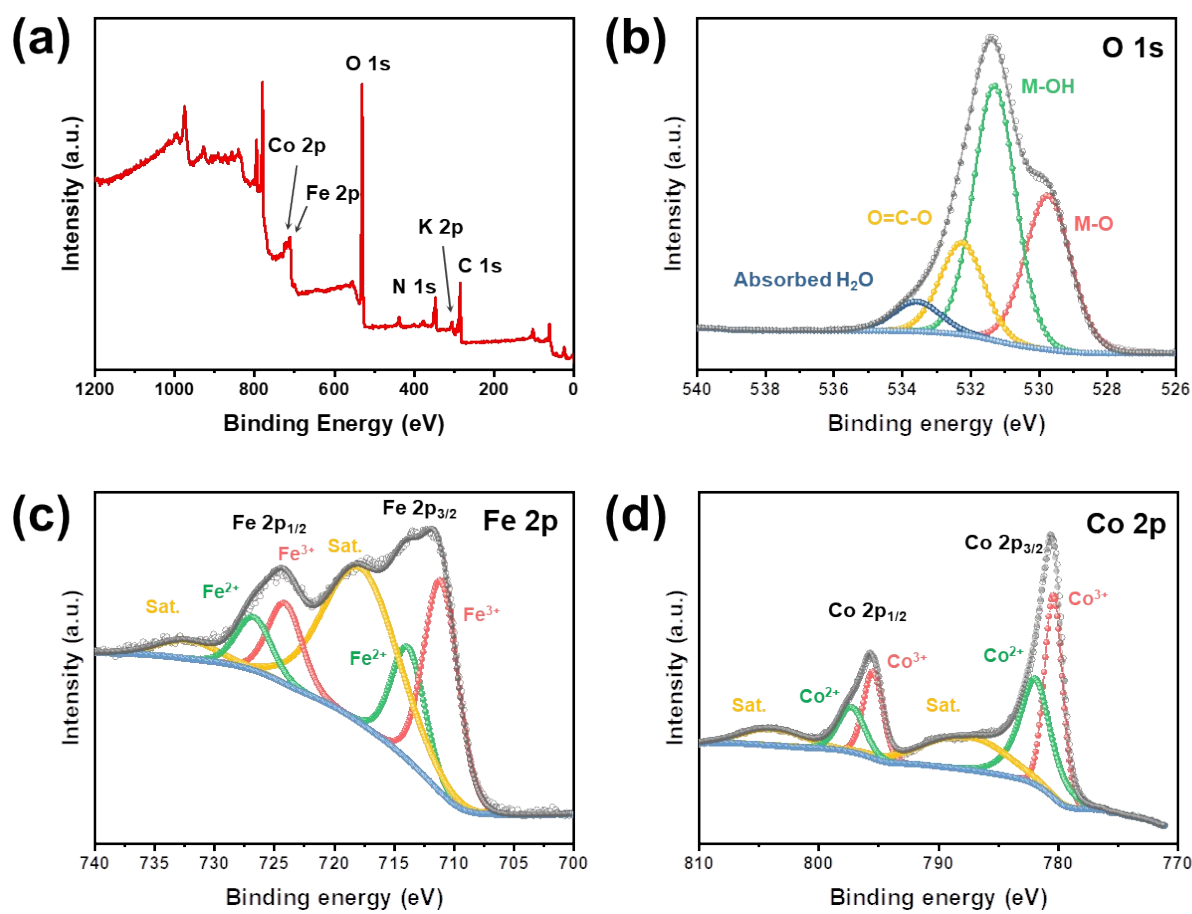


Figure S20. XPS spectra of NH₂-CoFe MOF after stability test for 50 h, (a) survey; (b) O 1s; (c) Fe 2p; (d) Co 2p.

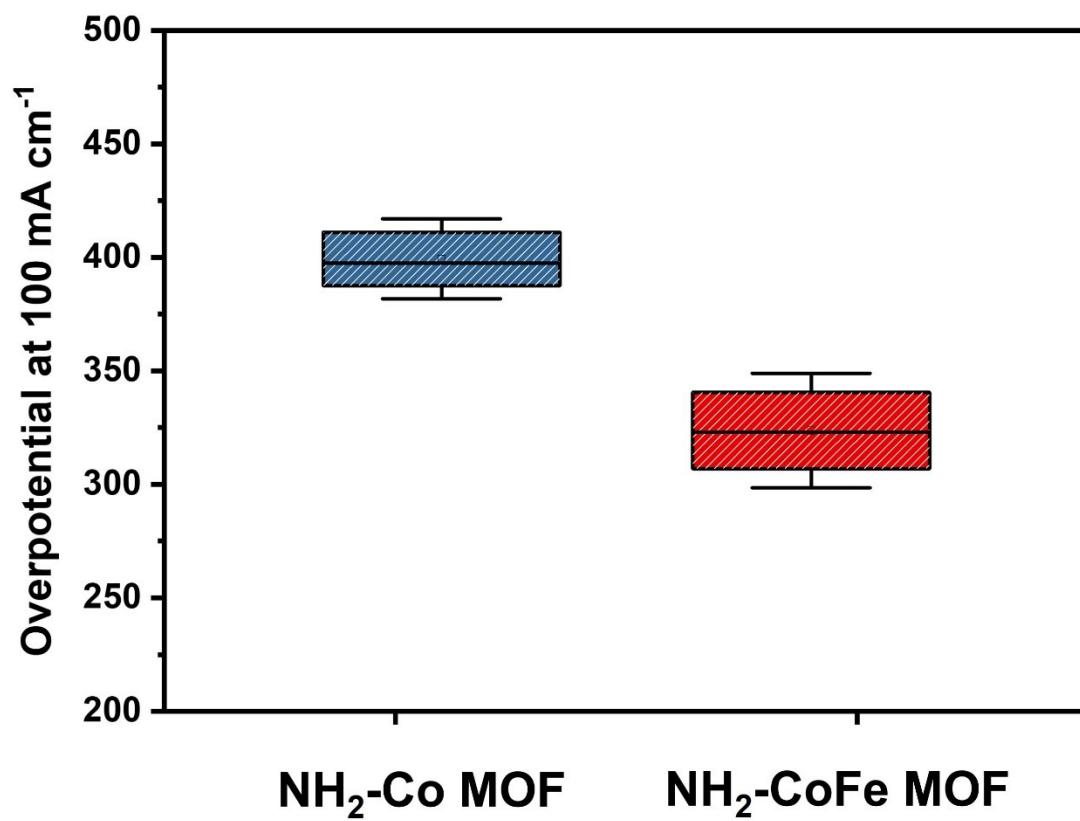


Figure S21. Reproducibility test of the NH₂-Co MOF, NH₂-CoFe MOF.

Table S5. Catalytic properties for OER of the Fe, and Co-based electrocatalysts in alkaline electrolyte.

Electrocatalysts	Electrode	Current density	Over potential	Tafel slope	Stability	Ref.
NH₂-CoFe MOF	NF	10 mA cm⁻² 100 mA cm⁻²	271 mV 310 mV	59.3 mV dec⁻¹	100 h	This work
Fe@Co-BDC NSs	GC	10 mA cm ⁻²	307 mV	34.1 mV dec ⁻¹	20000 s	[86]
CoFe LDH/MOF/CC	CC	10 mA cm ⁻²	276 mV	85 mV dec ⁻¹	60 h	[87]
Co ₄ Fe ₂ -LDHs/Co(OH) ₂ -NW	NF	10 mA cm ⁻²	276 mV	50.67 mV dec ⁻¹	60 h	[88]
Co/Fe bimetal-organic frameworks	GC	10 mA cm ⁻²	280 mV	44.7 mV dec ⁻¹	12000 s	[89]
Fe-MnO ₂ /NF	NF	20 mA cm ⁻²	330 mV	51 mV dec ⁻¹	24 h	[90]
Co _{0.1} (Hatz) _{0.1} (H ₄ bta) _{0.1} /NF	NF	50 mA cm ⁻² 100 mA cm ⁻²	294 mV 327 mV	93 mV dec ⁻¹	24 h	[91]



Figure S22. Photographs of natural seawater of Gimnyeong sea in Jeju island, Korea and 3 electrode cell for OER measurement in 1M KOH with sea water.