Supporting Information

CeO_2 modified Ni-MOF as an efficient catalyst for electrocatalytic urea oxidation

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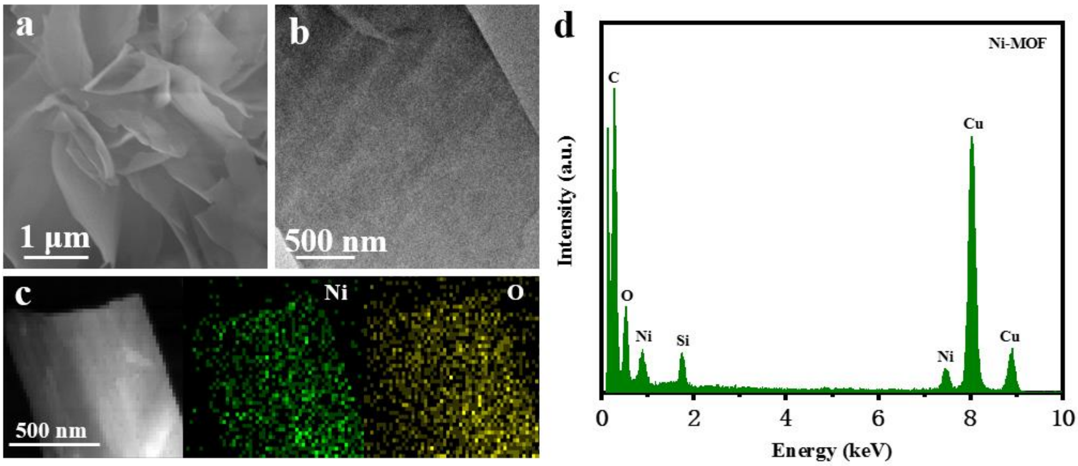

Figure S1. SEM image (a), TEM image (b), Elemental mapping images (c) and EDX spectrum (d) of Ni-MOF.

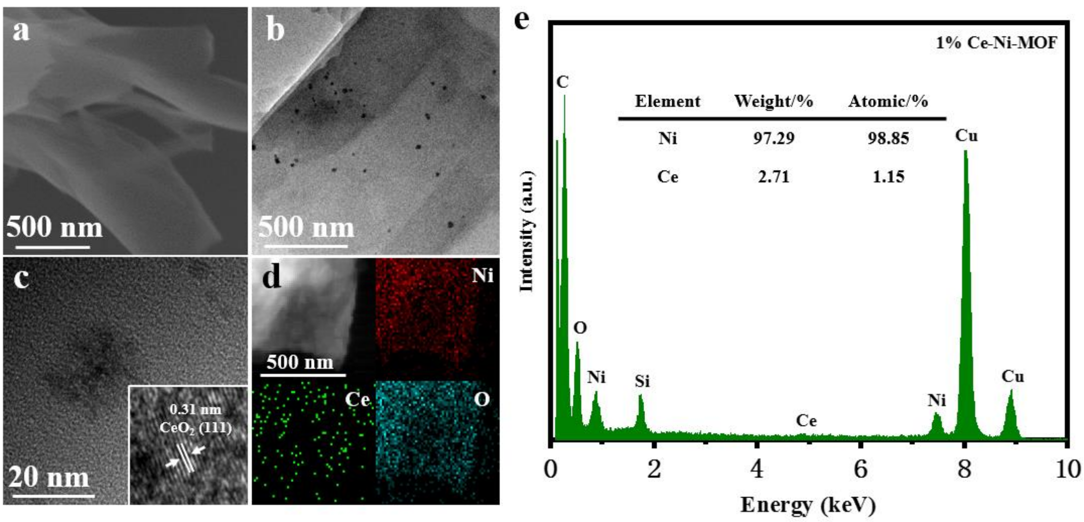

Figure S2. SEM image (a), TEM image (b), HRTEM images (c), Elemental mapping images (d) and EDX spectrum (e) of 1% CeO_2/Ni-MOF.

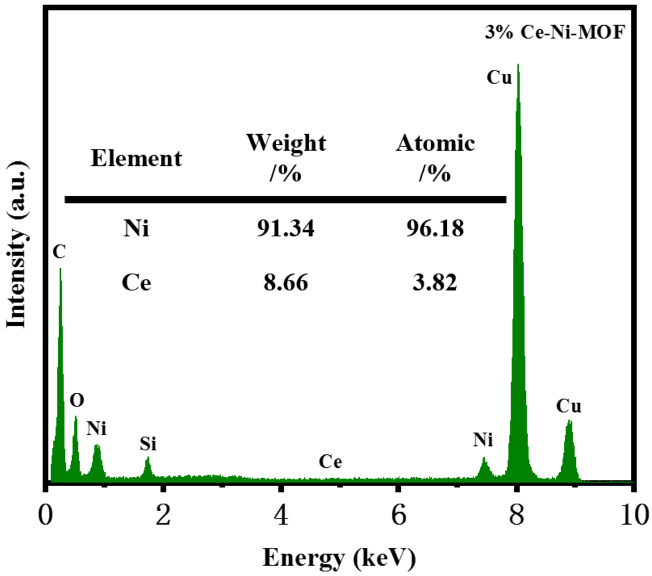

Figure S3. (a) EDX spectrum of 3% CeO_2/Ni-MOF.

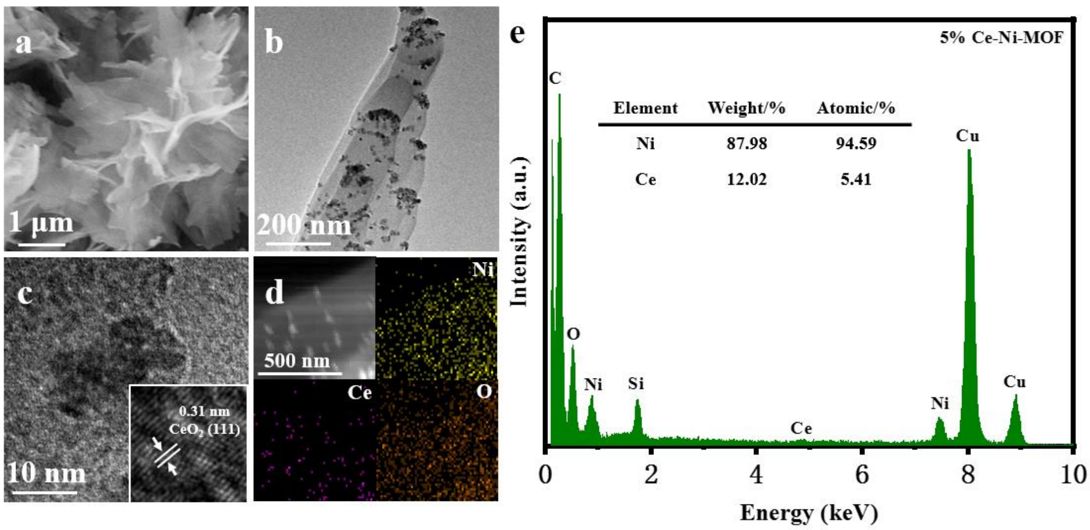

Figure S4. SEM image (a), TEM image (b), HRTEM images (c), Elemental mapping images (d) and EDX spectrum (e) of 5% CeO_2/Ni-MOF.

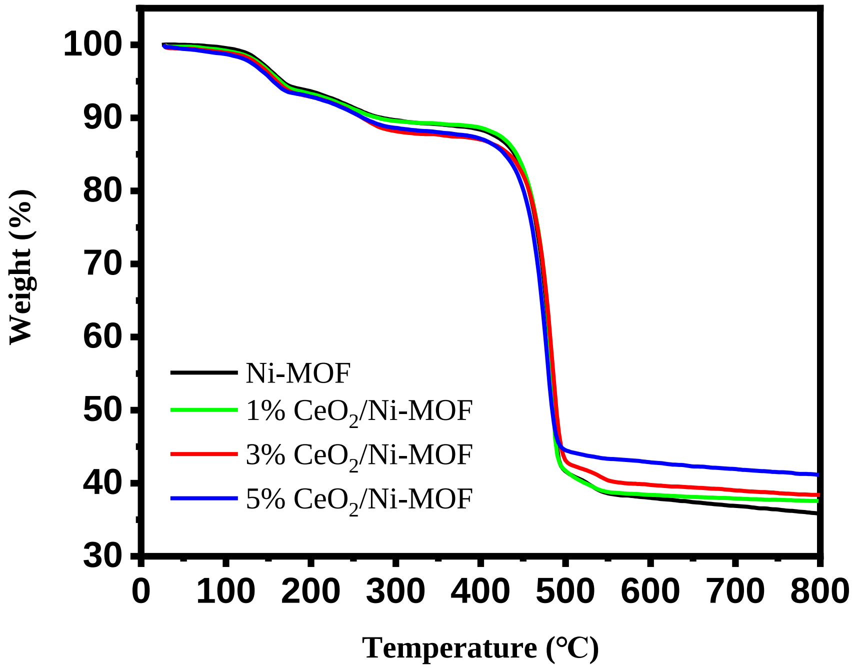

Figure S5. TGA curves of Ni-MOF, 1% CeO_2/Ni-MOF, 3% CeO_2/Ni-MOF and 5% CeO_2/Ni-MOF.

It was carried out in a nitrogen flow with a heating rate of 10 °C min-1 up to 800 °C. The curve shows three primary stages as follows: the first stage of weight loss until 180 °C mainly caused by the departure of water; the next weight loss stage ranging from 180 °C to 350 °C was ascribed to the leaving of solvated and coordinated water molecule in the Ni-MOF NSs. In the last stage ,a significant decline of this curve is due to the combustion of organic components and decomposition of the Ni-MOF NSs.

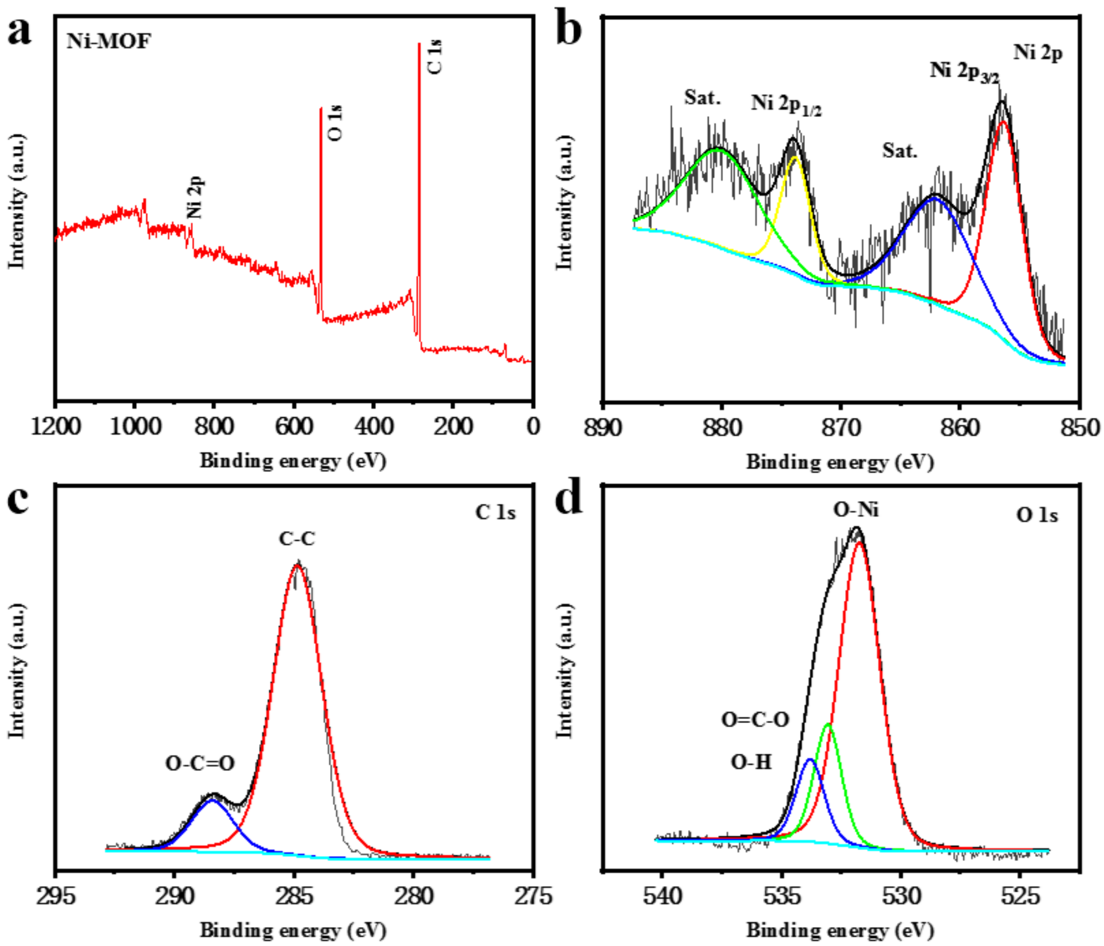

Figure S6. XPS spectra of Ni-MOF: (a) survey scan, (b) Ni 2p, (c) C 1s and (d) O 1s.

The high-resolution XPS spectrum of C 1s can be divided into two main peaks representing the two surface components. The binding energy of 284.7 eV corresponds to the C-C bond on the 1,4-BDC aromatic ring, and the binding energy is 288.2 eV corresponds to the carboxylic acid (O-C=O) group of terephthalic acid. Figure 3d shows the high-resolution XPS spectra of O 1s, which could be fitted by three peaks at binding energies of around 531.4, 532.9, and 533.8 eV attributed to oxygen atoms on the Ni-O bonds, the O-C=O of the 1,4-BDC, and -OH of absorbed water, respectively.

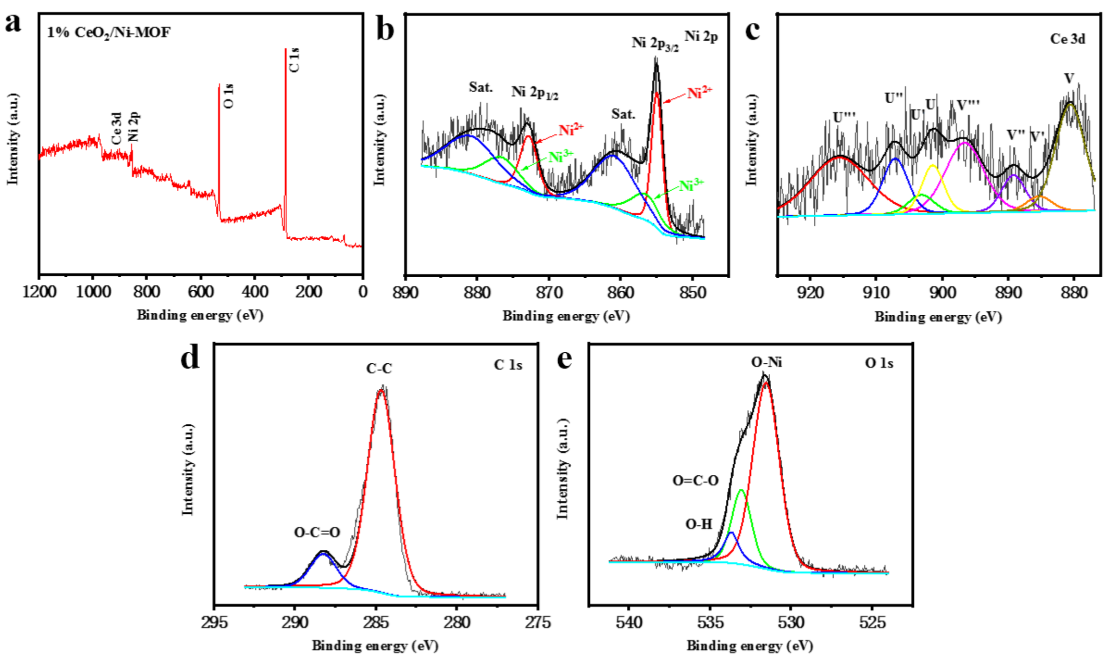

Figure S7. XPS spectra of 1% CeO_2/Ni-MOF: (a) survey scan, (b) Ni 2p, (c) Ce 3d, (d) C 1s and (e) O 1s.

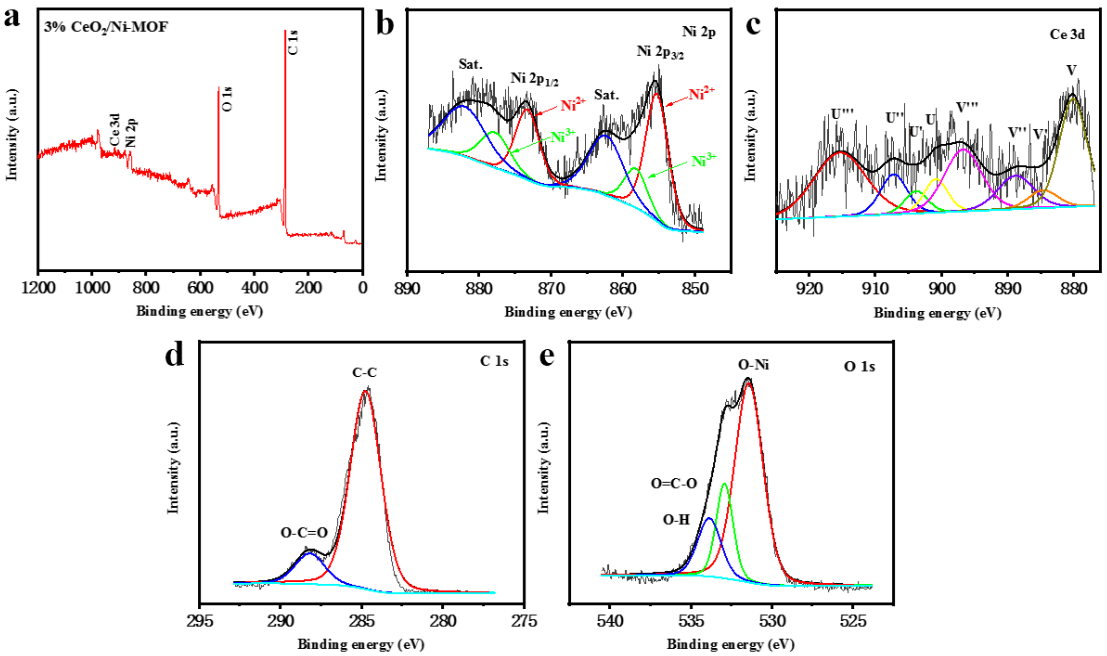

Figure S8. XPS spectra of 3% CeO_2/Ni-MOF: (a) survey scan, (b) Ni 2p, (c) Ce 3d, (d) C 1s and (e) O 1s.

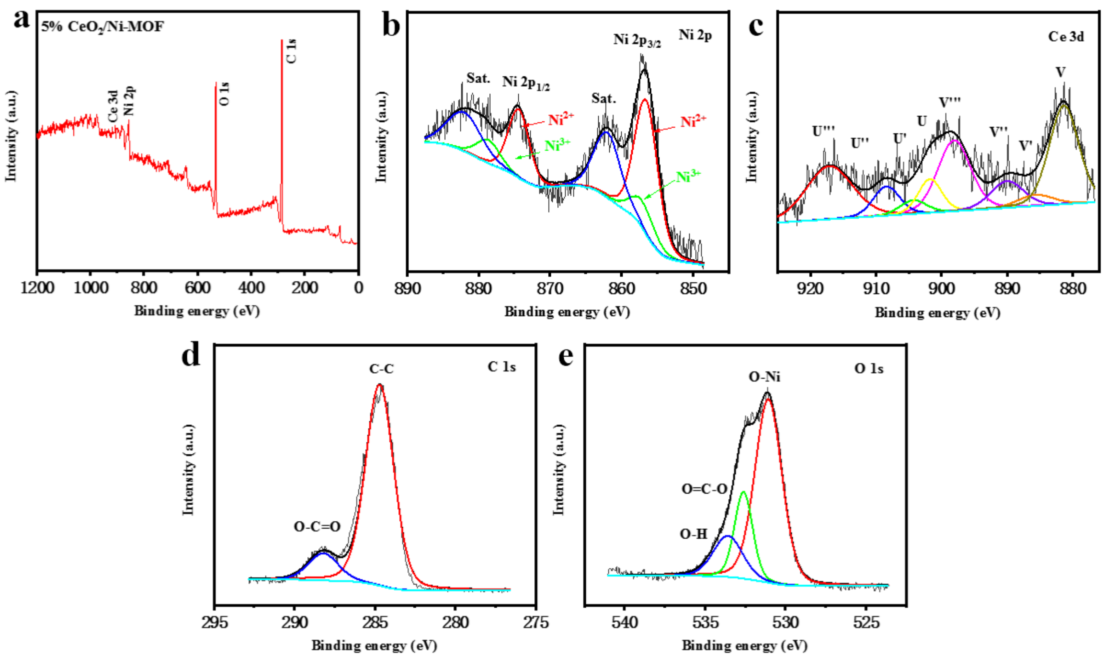

Figure S9. XPS spectra of 5% CeO_2/Ni-MOF: (a) survey scan, (b) Ni 2p, (c) Ce 3d, (d) C 1s and (e) O 1s.

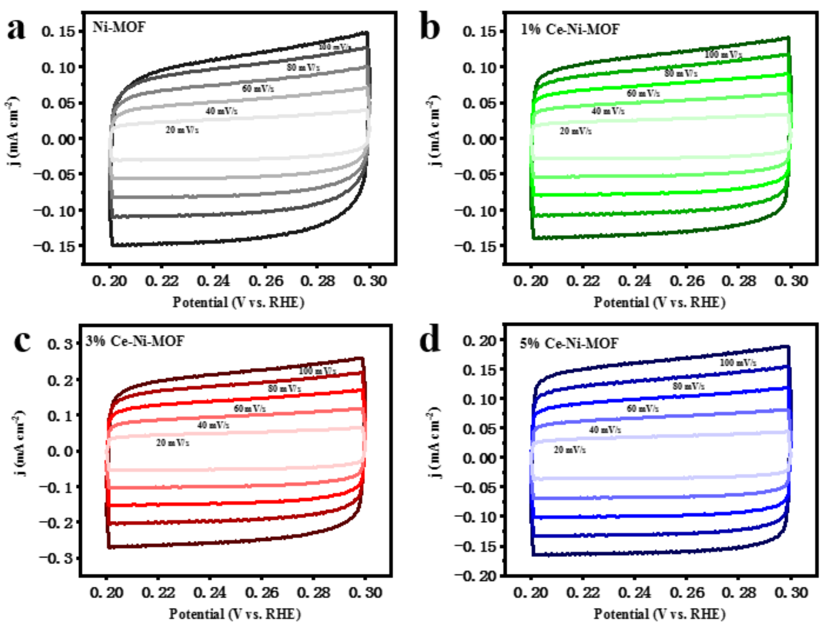

Figure S10. CV curves in potential range of 0.2-0.3 V vs RHE of (a) Ni-MOF, (b) 1% CeO_2/Ni-MOF, (c) 3% CeO_2/Ni-MOF and (d) 5% CeO_2/Ni-MOF.

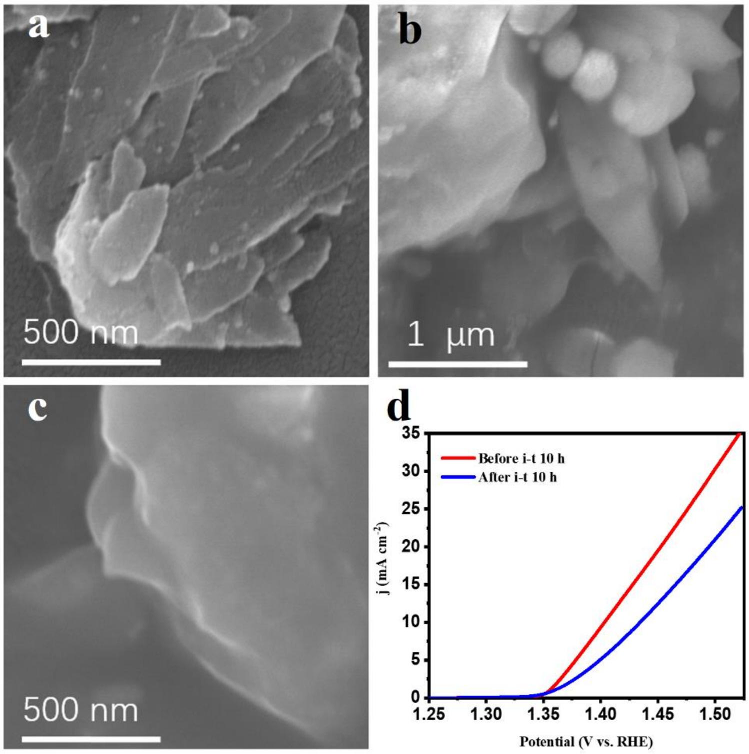

Figure S11. SEM images of 3% CeO_2/Ni-MOF for UOR: (a) after 50 cycles activation, (b and c) after 1 h, (d) LSV curves of 3% CeO_2/Ni-MOF before and after 10 h.

Table S1. BET results for the various catalysts.

Catalysts	Surface Area (m^2 g^{-1})	Pore diameter (nm)
Ni–MOF	64.9	3.83
1% CeO_2-Ni–MOF	66.2	3.94
3% CeO_2-Ni–MOF	67.5	3.93
5% CeO_2-Ni–MOF	75.1	3.46

Table S2. Fitting parameter values of the EIS data of the various catalysts for UOR.

Catalysts	Rs (Ω)	Rp (Ω)
Ni–MOF	11.08	80.73
1% CeO_2-Ni–MOF	10.35	37.91
3% CeO_2-Ni–MOF	10.46	31.57
5% CeO_2-Ni–MOF	12.10	31.94

Table S3. Comparisions of UOR electrocatalytic activity with other reported catalysts

Catalysts	Potential (V vs. RHE, at 10 mA cm^{-2})	Tafel slope (mV dec^{-1})	Ref.
Ni–MOF	1.385	28.25	This work
1% CeO_2-Ni–MOF	1.373	19.08	This work
3% CeO_2-Ni–MOF	1.356	13.83	This work
5% CeO_2-Ni–MOF	1.369	15.85	This work
Ni_2P/CFC	1.42	78.2	*Electrochim. Acta,* 2017, 254, 44
Ni-MOF	1.36	23	*ChemComm,* 2017, 53, 10906
$Ni(OH)_2$@NF	1.35	24.37	*ACS Appl. Energy Mater,* 2020, 3, 2996
Ni-WO_x	1.36	39	*Angew. Chem. Int. Ed,* 2021, 60, 10577
$NiSe_2$-NiO 350	1.33	38	*Appl. Catal. B,* 2020, 276, 119165
NiFeRh-LDH	1.344	35	*Appl. Catal. B,* 2021, 284, 119740
CoFeCr LDH/NF	1.432	83	*Appl. Catal. B,* 2020, 272, 118959
$Ni(OH)_2$-NMs	1.35	80	*Nanoscale,* 2019, 11, 1058
$Ni_{0.9}Fe_{0.1}O$	1.445	36.5	*ChemComm,* 2019, 55, 6555
VOOH-Ni	1.356	18.26	*Mater. Lett,* 2021, 291, 129593
Ni/SiO_x/NAC-900 (Y3)	1.384	108	*J. Colloid Interface Sci,* 2021, 589, 56

in 1 M KOH with 0.33 M urea.

Catalysts	Potential (V vs. RHE, at 10 mA cm^{-2})	Tafel slope (mV dec^{-1})	Ref.
NCVS-3	1.35	34.31	*ACS Catal*. 2022, 12, 569
NiClO-D	1.34	41	*Angew. Chem. Int. Ed*, 2019, 58, 16820
Ni-Mo	1.36	22	*Nano Energy*, 2019, 60, 894