Supplementary Material

Constructing a composite catalyst containing amorphous nickel hydroxide/crystalline lanthanum carbonate hydroxide for urea electrolysis

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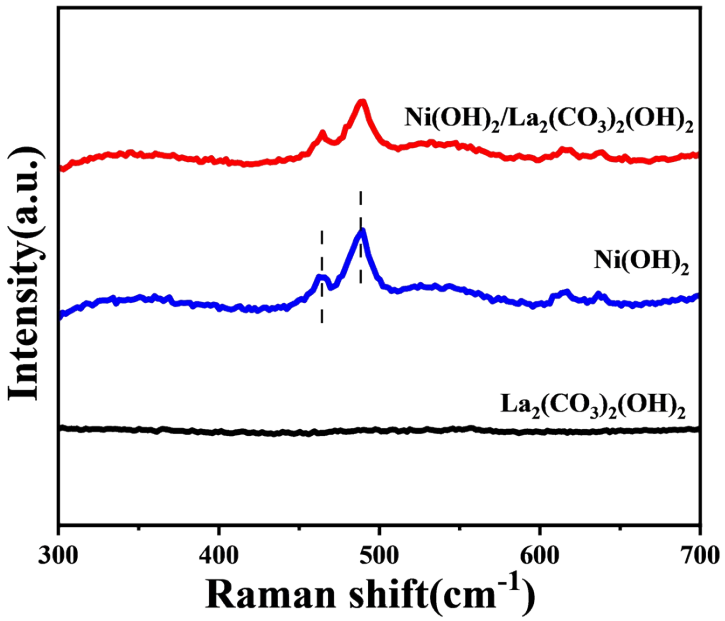

Fig. S1 Raman spectra of $Ni(OH)_2/La_2(CO_3)_2(OH)_2$, $Ni(OH)_2$ and $La_2(CO_3)_2(OH)_2$.

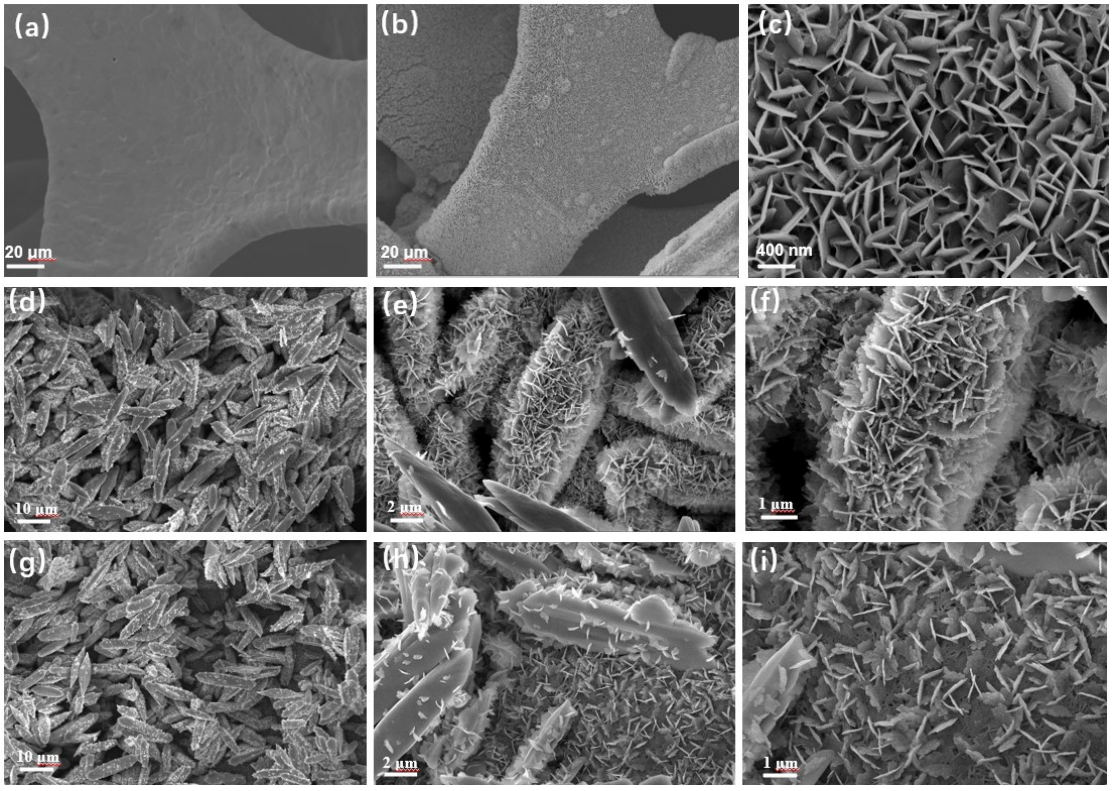

Fig. S2 FE-SEM images of catalysts at different magnifications：(a) NF, (b-c) $Ni(OH)_2$/NF, (d-f) $La_2(CO_3)_2(OH)_2$/NF and (g-i) $Ni(OH)_2/La_2(CO_3)_2(OH)_2$/NF.

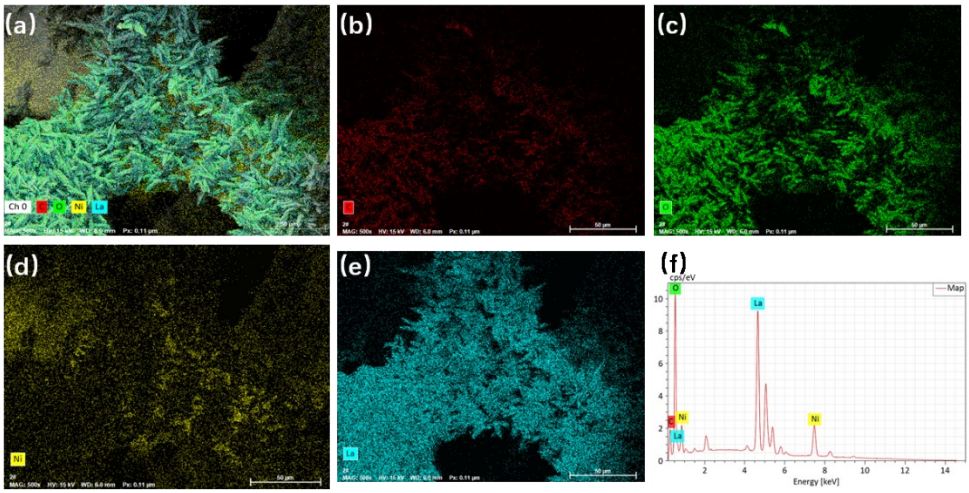

Fig. S3 EDS mapping images of the $Ni(OH)_2/La_2(CO_3)_2(OH)_2/NF$.

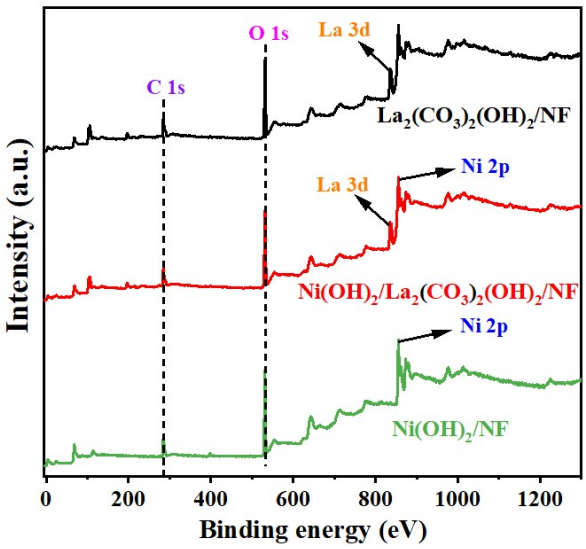

Fig. S4 XPS survey spectra of the $Ni(OH)_2/NF$, $La_2(CO_3)_2(OH)_2/NF$, and $Ni(OH)_2/La_2(CO_3)_2(OH)_2/NF$

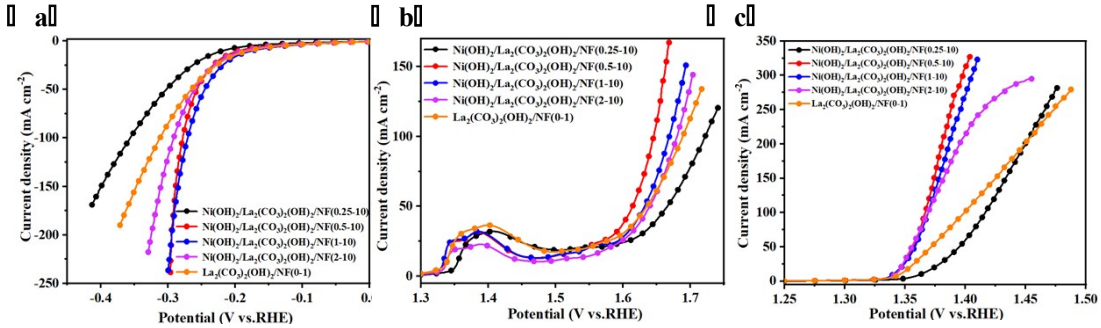

Fig. S5 LSV curves of the $Ni(OH)_2/La_2(CO_3)_2(OH)_2/NF$ under different Ni-to-La ratios: (a) HER, (b) OER and (c) UOR.

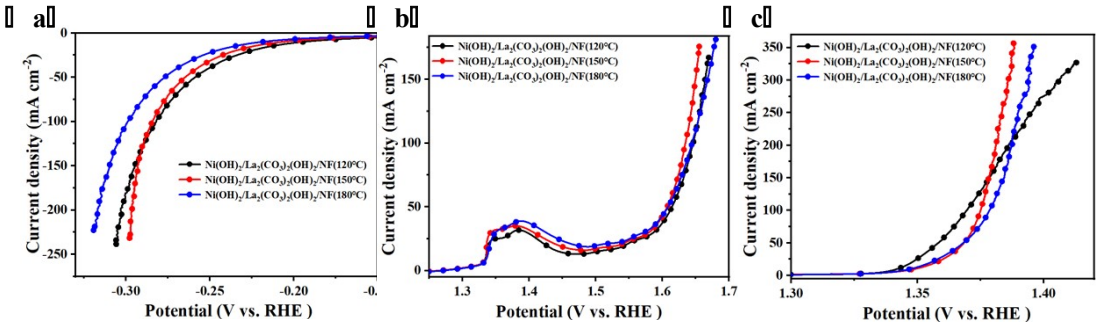

Fig. S6 LSV curves of the $Ni(OH)_2/La_2(CO_3)_2(OH)_2$/NF under different hydrothermal temperatures: (a) HER, (b) OER and (c) UOR.

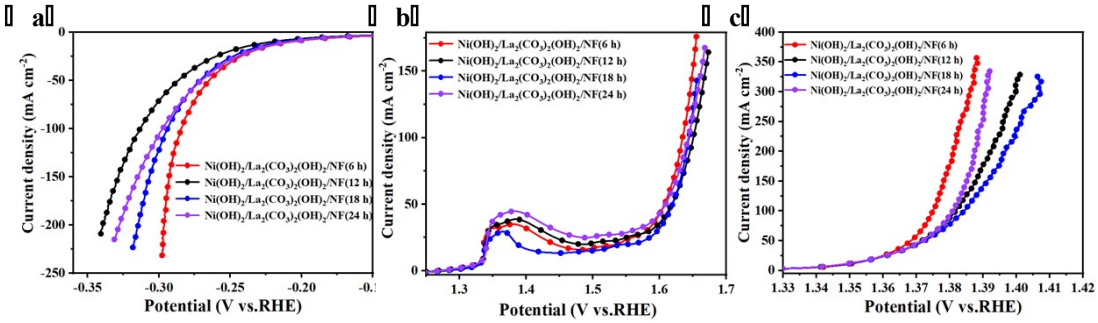

Fig. S7 LSV curves of the $Ni(OH)_2/La_2(CO_3)_2(OH)_2$/NF under different hydrothermal time: (a) HER, (b) OER and (c) UOR.

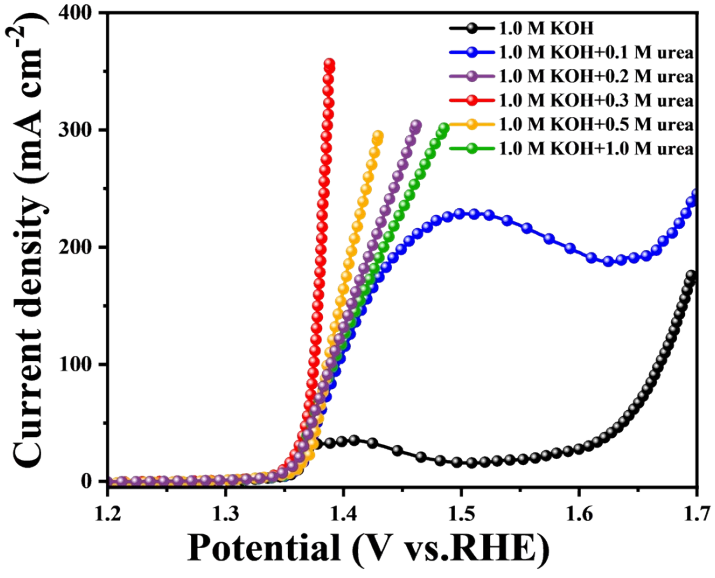

Fig. S8 LSV curves measured for $Ni(OH)_2/La_2(CO_3)_2(OH)_2$/NF in 1.0 M KOH with different concentrations (X=0.1, 0.2, 0.3, 0.5, and 1.0 M) of urea.

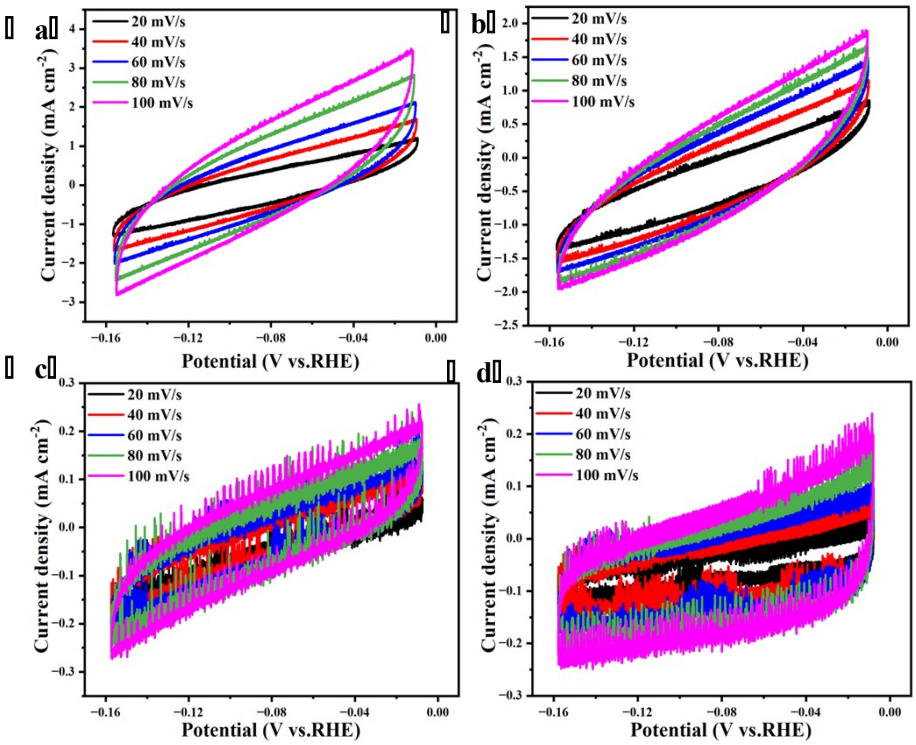

Fig. S9 Cyclic voltammograms were taken in a potential range where no faradic processes were observed to measure the capacitive current from double layer charging. CV curves at different scan rate from 20 mV s^{-1} to 100 mV s^{-1}: (a) $Ni(OH)_2/La_2(CO_3)_2(OH)_2$/NF, (b) $La_2(CO_3)_2(OH)_2$/NF, (c) $Ni(OH)_2$/NF, and (d) NF.

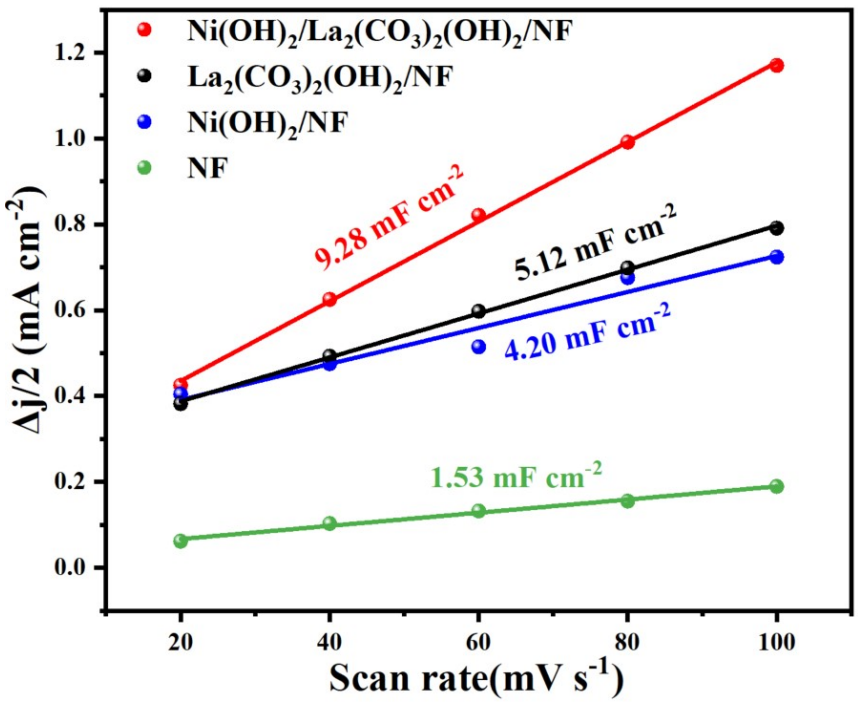

Fig. S10 The HER performance of the as-prepared catalysts: C_{dl}

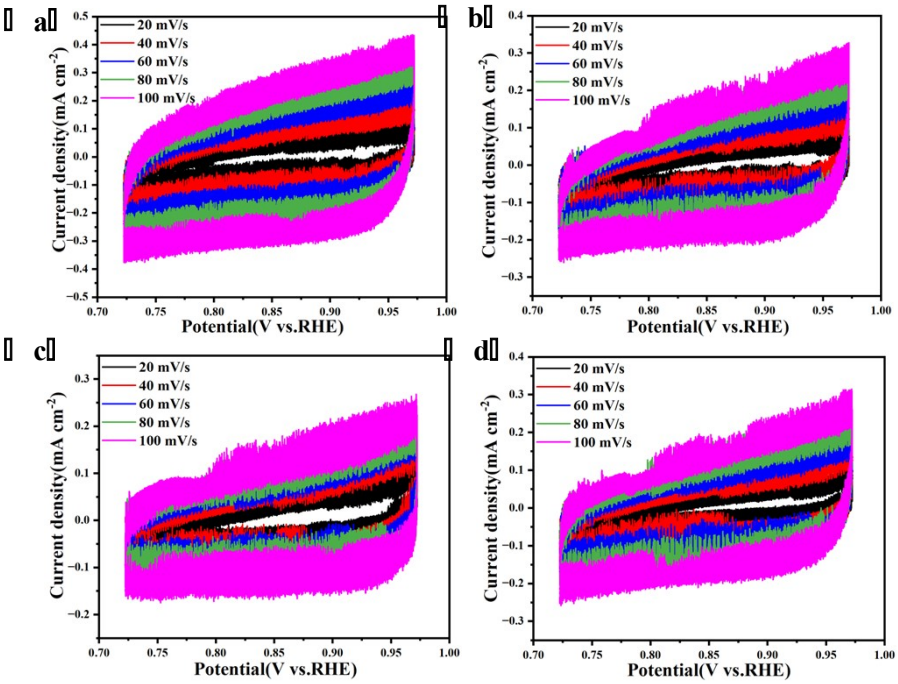

Fig. S11 CV curves at different scan rate from 20 mV s^{-1} to 100 mV s^{-1}: (a) $Ni(OH)_2/La_2(CO_3)_2(OH)_2/NF$, (b) $La_2(CO_3)_2(OH)_2/NF$, (c) $Ni(OH)_2/NF$, and (d) NF.

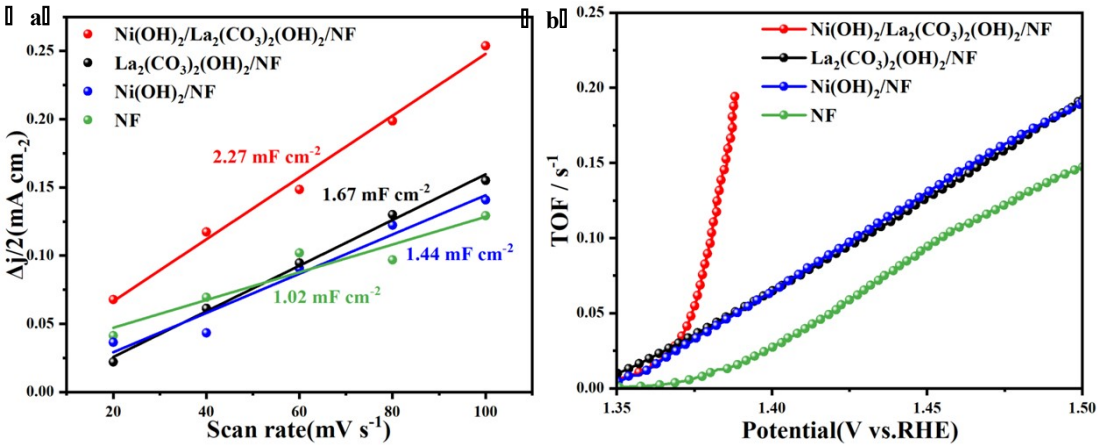

Fig. S12 The UOR performance of the as-prepared catalysts: (a) C_{dl}, (b) TOF curves.

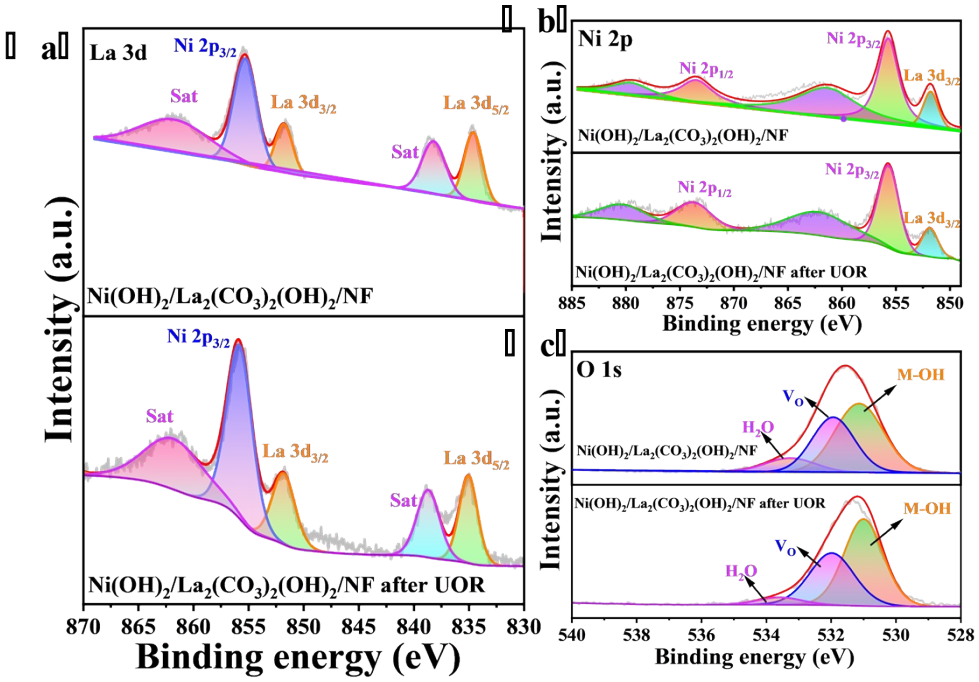

Fig. S13 Comparison of XPS spectra of $Ni(OH)_2/La_2(CO_3)_2(OH)_2$/NF catalyst before and after UOR stability testing.

Table S1. comparison of HER performance in alkaline electrolytes used for water splitting.

Electrolysts	Electrolyte	overpotential @10 mA cm^{-2}	References
$Ni(OH)_2/La_2(CO_3)_2(OH)_2$/NF	1 M KOH	0.201 V	This work
$Ni(OH)_2$/ NF	1 M KOH	0.252 V	[4]
$NiCo_2S_4$/NF	1 M KOH	0.210	[5]
Ni_2P/CNS	1 M KOH	0.315 V	[6]
$Ni_2P/Ni_{12}P_5$	1 M KOH	0.234 V	[7]
Ni_2P	1 M KOH	0.258 V	[7]
$Ni_{12}P_5$	1 M KOH	0.270 V	[8]
NiS_2/NF	1 M KOH	0.255 V	[9]
NiS	1 M KOH	0.474 V	[10]
h-NiS	1 M KOH	0.205	[11]
Ni-CoCHH/NF	1 M KOH	0.248 V	[12]

Table S2. comparison of UOR performance in alkaline electrolytes used for water splitting.

Electrolysts	Electrolyte	Potential @10 mA cm^{-2}	References
$Ni(OH)_2/La_2(CO_3)_2(OH)_2$/NF	1 M KOH + 0.3 M urea	1.348 V	This work
1% La:α-$Ni(OH)_2$	1 M KOH + 0.33 M urea	1.567V	[13]
Ni/NiP	1 M KOH + 0.33 M urea	1.350V	[14]
Ni/NiS@CP	1 M KOH + 0.33 M urea	1.350V	[15]
Ce-Ni_2P/NF	1 M KOH + 0.3 M urea	1.406V	[16]
NiFeMo	1 M KOH + 0.33 M urea	1.380V	[17]
Fc-NiCo-BDC	1 M KOH + 0.33 M urea	1.350	[18]
CoFe LDH/MOFs	1 M KOH + 0.33 M urea	1.450V	[19]
Ni-MOF-0.5	1 M KOH + 0.5 M urea	1.381V	[20]
Ni_2P/Fe_2P/NF	1 M KOH + 0.5 M urea	1.36V	[21]
N-NiO	1 M KOH + 0.5 M urea	1.390V	[22]

Table S3. comparison of overall urea splitting performance in alkaline electrolytes

Electrolysts	Electrolyte	Potential	References
$Ni(OH)_2/La_2(CO_3)_2(OH)_2/NF$	1 M KOH + 0.3 M urea	1.536 V@10 mA cm^{-2}	This work
$Ni(OH)_2/La_2(CO_3)_2(OH)_2/NF$	1 M KOH + 0.3 M urea	1.689 V@100 mA cm^{-2}	This work
CoS_2-Ti	1 M KOH + 0.3 M urea	1.590 V@10 mA cm^{-2}	[23]
Ni/C	1 M KOH + 0.3 M urea	1.600 V@10 mA cm^{-2}	[24]
Co_3O_4/CC	1 M KOH + 0.3 M urea	1.710 V@10 mA cm^{-2}	[25]
Ni@NCNT	1 M KOH + 0.5 M urea	1.560 V@10 mA cm^{-2}	[26]
HC-NiMoS/Ti	1 M KOH + 0.5 M urea	1.590 V@10 mA cm^{-2}	[27]
$MnO_2/MnCo_2O_4$/Ni	1 M KOH + 0.5 M urea	1.550 V@10 mA cm^{-2}	[28]
Ce-Ni_2P/NF	1 M KOH + 0.3 M urea	1.780 V@100 mA cm^{-2}	[16]
NiHCF/NF	1 M KOH + 0.33 M urea	1.800 V@100 mA cm^{-2}	[29]
$Ni_{0.85}Se/CoSe_2$/NF	1 M KOH + 0.33 M urea	1.758 V@100 mA cm^{-2}	[30]
CoP/MoO_2/NF	1 M KOH + 0.5 M urea	1.690 V@100 mA cm^{-2}	[31]

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