Energy-efficient bifunctional CoB$_x$/GDY catalyst for urea-assisted hydrogen production via electrochemical urea oxidation and hydrogen evolution

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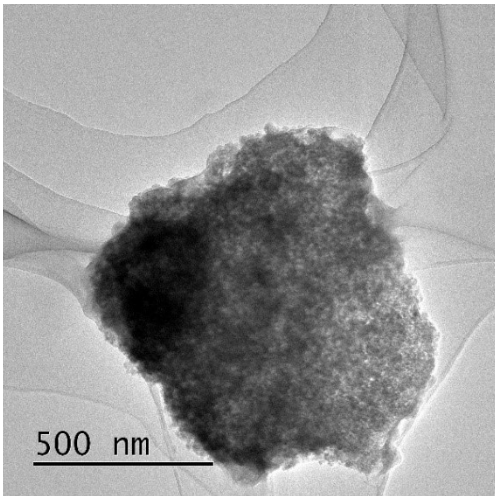

Figure S1. TEM image of CoB$_x$/GDY.

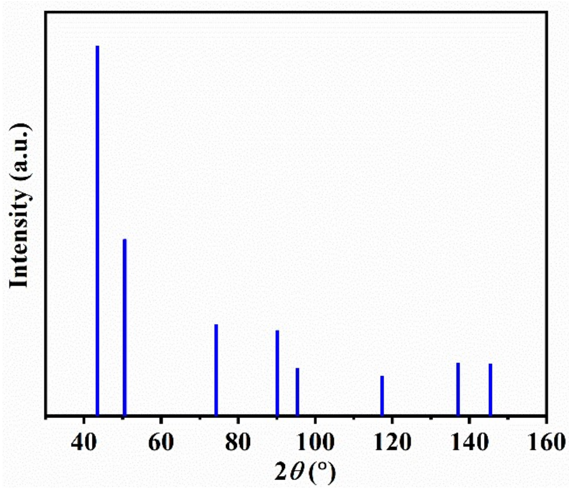

Figure S2. The standard diffraction pattern of metallic Cu (JCPDS card No. 65-9743).

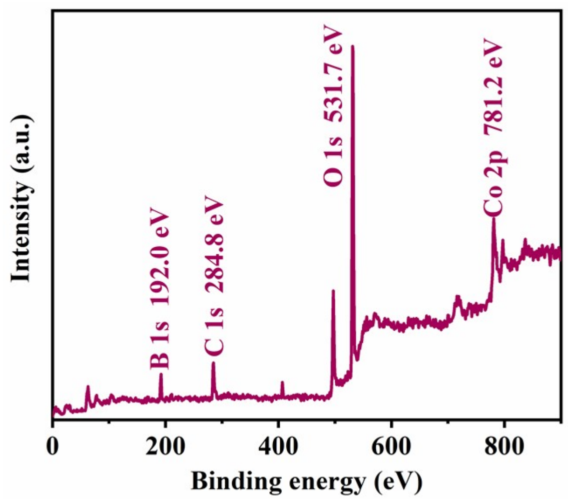

Figure S3. XPS wide survey spectrum for CoB_x/GDY.

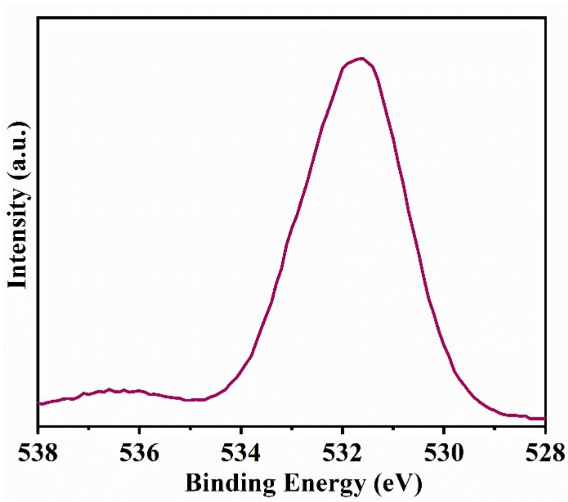

Figure S4. XPS spectrum of CoB_x/GDY in the O 1s region.

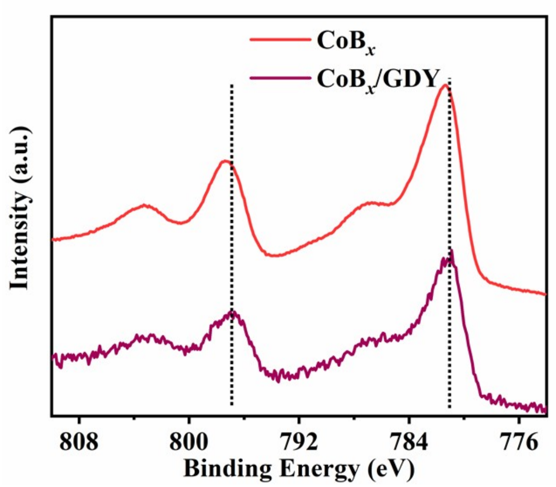

Figure S5. High-resolution Co 2p XPS spectra of CoB$_x$ and CoB$_x$/GDY.

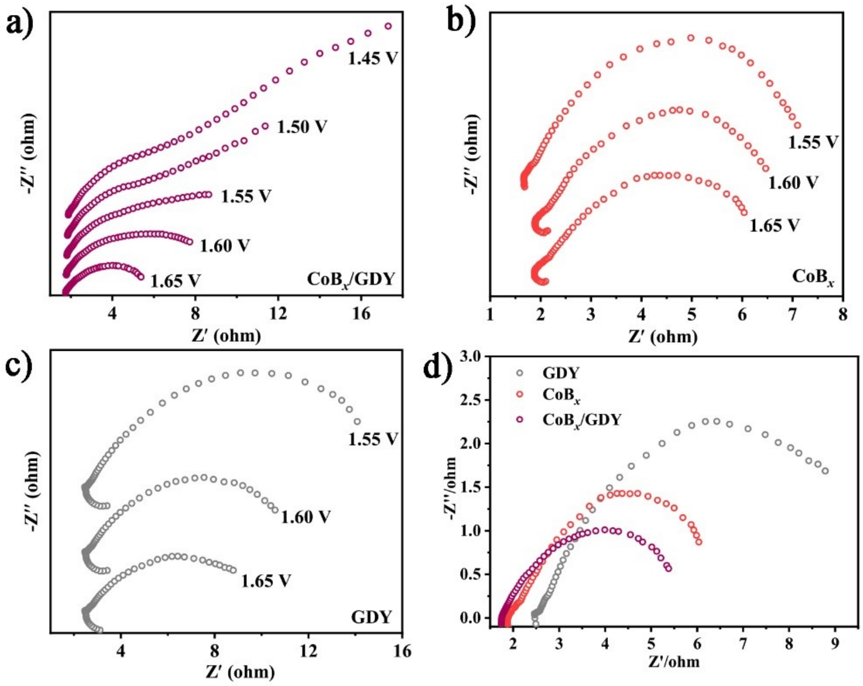

Figure S6. (a-c) Nyquist plots of CoB$_x$/GDY, CoB$_x$, and GDY at different operating potentials; (d) Nyquist plots of CoB$_x$/GDY, CoB$_x$, and GDY at 1.65 V.

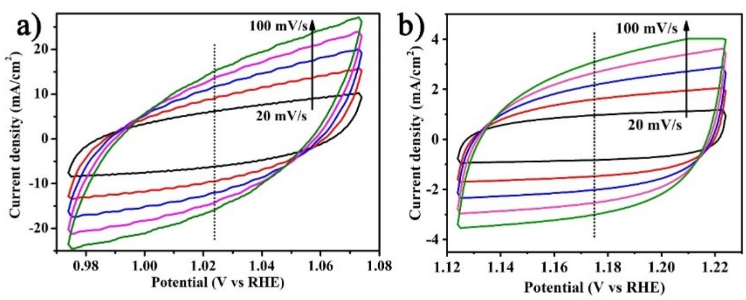

Figure S7. Typical CV curves for CoB$_x$/GDY (a) and CoB$_x$ (b).

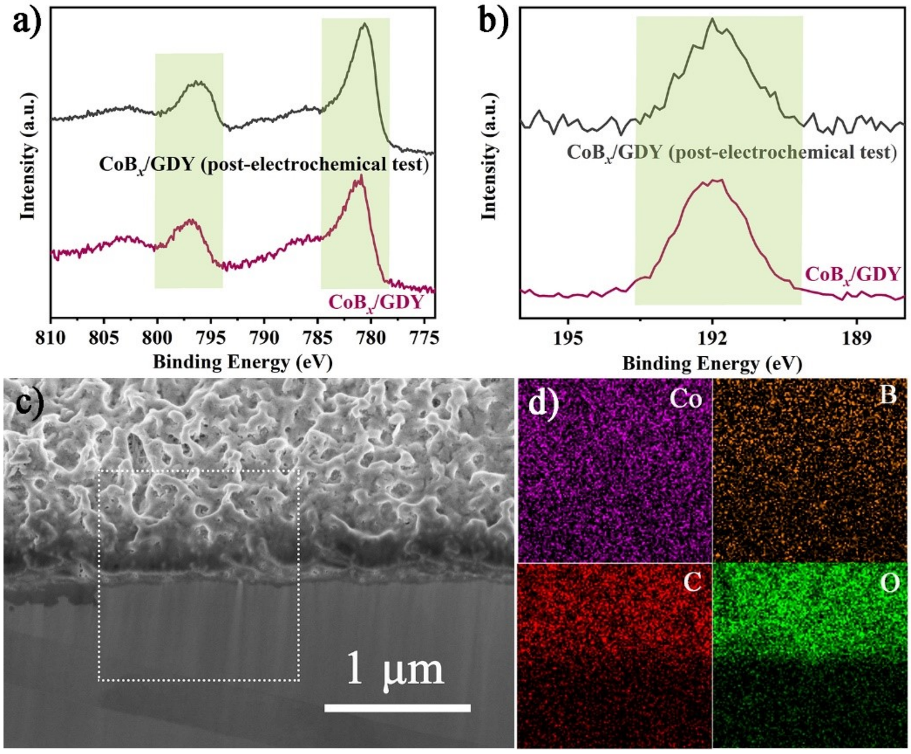

Figure S8. (a, b) Co 2p and B 1s XPS patterns of as-prepared CoB_x/GDY and the CoB_x/GDY after long-term electrolysis. (c, d) FIB-SEM image of CoB_x/GDY and the corresponding EDS elemental mapping (within the white-boxed region), showing the distribution of Co (purple), B (orange), O (green), and C (red).

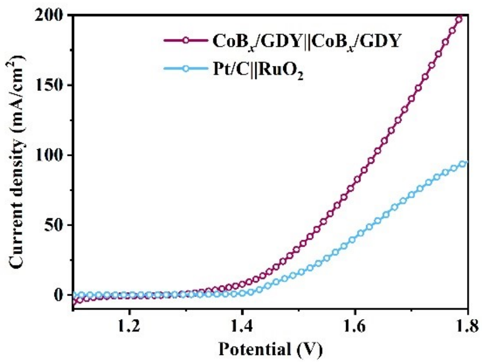

Figure S9. LSV curves of CoB_x/GDY||CoB_x/GDY and Pt/C||RuO_2 electrolyzers recorded in 1 M KOH containing 0.33 M urea.

Table S1. UOR performance of representative electrocatalysts (η_{10}, η_{50}, and η_{100}: potential at 10, 50, and 100 mA·cm^{-2}, respectively) and their corresponding Tafel slopes.

Catalysts	Electrolyte	η (V)	Tafel Slope (mV·dec^{-1})	References
CoB_x/GDY	1.0 M KOH + 0.33 M urea	η_{10}=1.26 V η_{50}=1.41 V η_{100}=1.49 V	58	This work
NiOOH/(LDH/α-FeOOH)	1.0 M KOH + 0.33 M urea	η_{10}=1.35 V η_{50}=1.37 V η_{100}=1.4 V	30.1	1
V2-$Ni(OH)_2$	1 M KOH+0.33 M urea	η_{100}=1.47 V	29.12	2
Ni-WO_x	1 M KOH + 0.33 M urea	η_{100}=1.40 V	39	3
Co–Ni–S@NF	1 M KOH + 0.33 M urea	η_{100}=1.35 V	29.6	4
Ru-Co DAS/NiO	1 M KOH + 0.33 M urea	η_{10}=1.29 V	23.3	5
CC/Ni-BDC@Co-PA	1 M KOH + 0.33 M urea	η_{100}=1.36 V	45	6
$Ni_{1.6}Co_{0.4}P$/C@HCNs	1 M KOH + 0.33 M urea	η_{10}=1.33 V	74.6	7
NF/P-$NiMoO_{4-x}$	1 M KOH + 0.33 M urea	η_{10}=1.36 V η_{100}=1.38 V	19.3	8
O-NiMoP/NF	1 M KOH + 0.5 M urea	η_{100}=1.41 V	34	9
Co_xMo_yS-CC	1 M KOH + 0.5 M urea	η_{10}=1.31 V	—	10
Co(OH)F/NF	1 M KOH + 0.7 M urea	η_{10}=1.25 V	—	11
FeCo/$CoFe_2O_4$@NGC	1 M KOH + 0.33 M urea	η_{10}=1.32 V	42.31	12
Cu_3P-P/CF	1 M KOH + 0.33 M urea	η_{10}=1.43 V	33.1	13
HC-$Co(H_2PO_2)_2$	1 M KOH + 0.33 M urea	η_{10}=1.30 V η_{10}=1.34 V	35	14
FeOOH@Co_3O_4	1 M KOH + 0.33 M urea	η_{10}=1.33 V	29	15
Fe_3O_4@FeOOH	1 M KOH + 0.33 M urea	η_{10}=1.38 V η_{50}=1.42 V η_{100}=1.46 V	28	16

$Co_2P/NiMoO_4/NF$	1 M KOH + 0.5 M urea	η_{10}=1.34 V	75	17
Ru/FeOOH@NFF	1 M KOH + 0.33 M urea	η_{10}=1.41 V	33	18
$Cu_3P@CuO_x$	1 M KOH + 0.33 M urea	η_{10}=1.37 V	29	19
$Ru_{0.4}CoP$-NC	1 M KOH + 0.33 M urea	η_{10}=1.30 V η_{50}≈1.41 V η_{100}≈1.47 V	97	20
$CoMoO_4/Co_9S_8$	1 M KOH + 0.5 M urea	η_{100}≈1.50 V	22	21

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