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Supplementary Information

In-situ growth of urchin-like cobalt-chromium phosphide on 3D graphene foam for efficient overall water splitting

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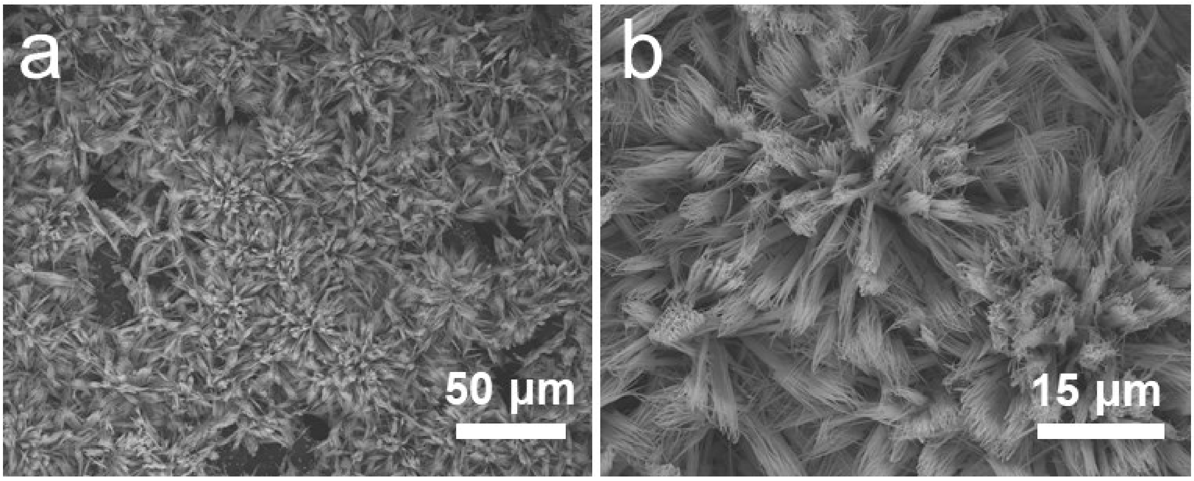

Fig. S1. SEM images of CoP@3DGF.

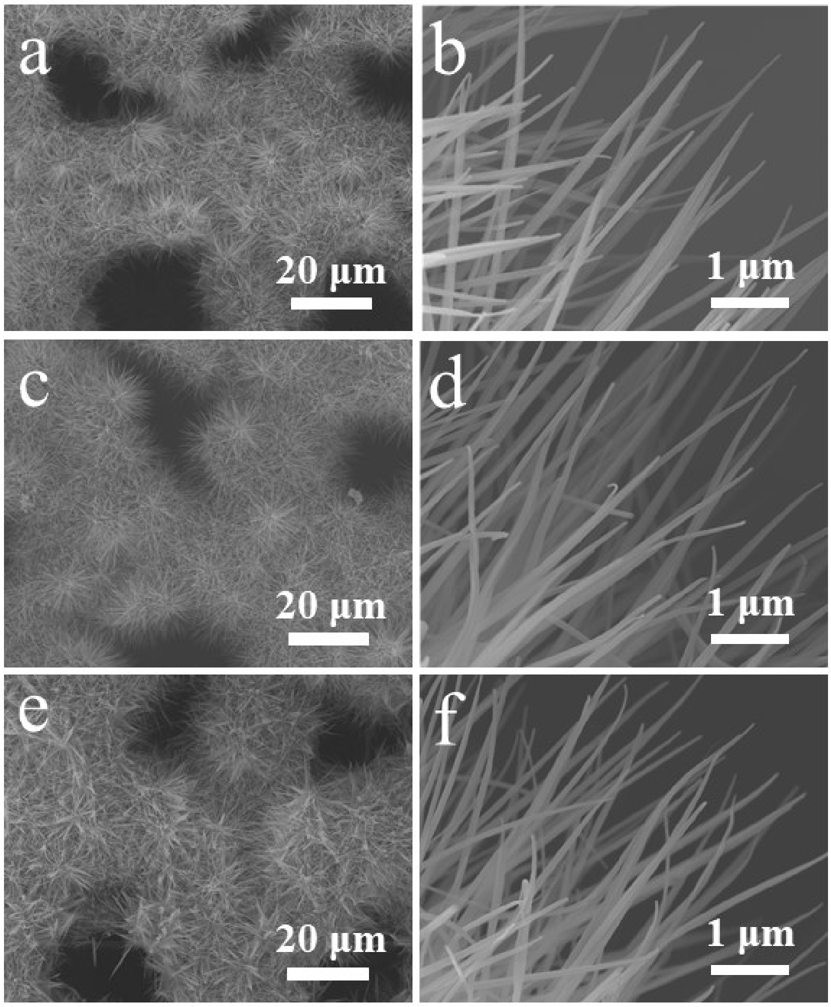

Fig. S2. SEM images of CoCr-P@3DGF with different Co/Cr ratios of (a-b) 1:1, (c-d) 3:1 and (e-f) 4:1.

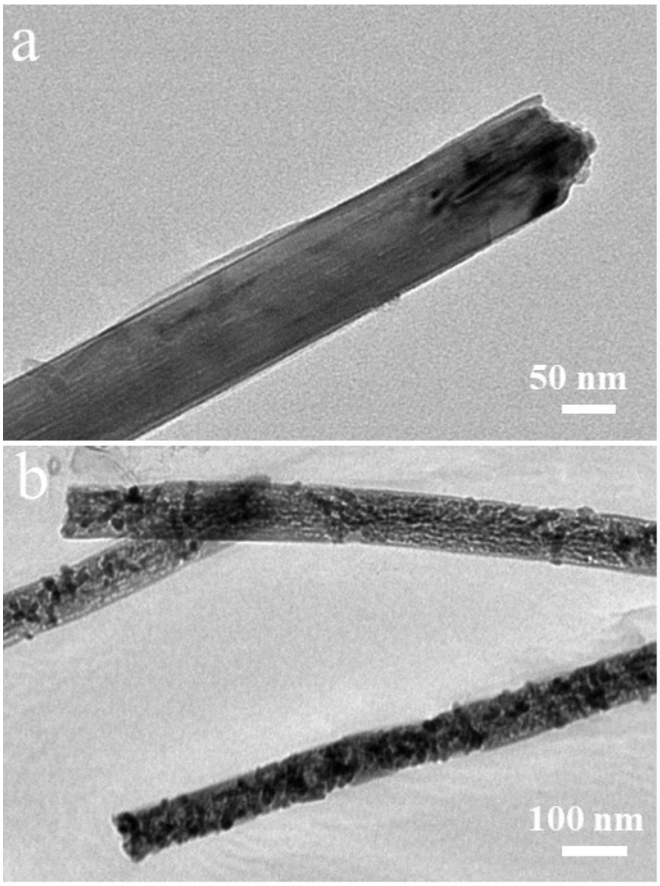

Fig. S3. TEM images of (a) Co_2Cr_1-LDH@3DGF and (b) Co_2Cr_1-P@3DGF.

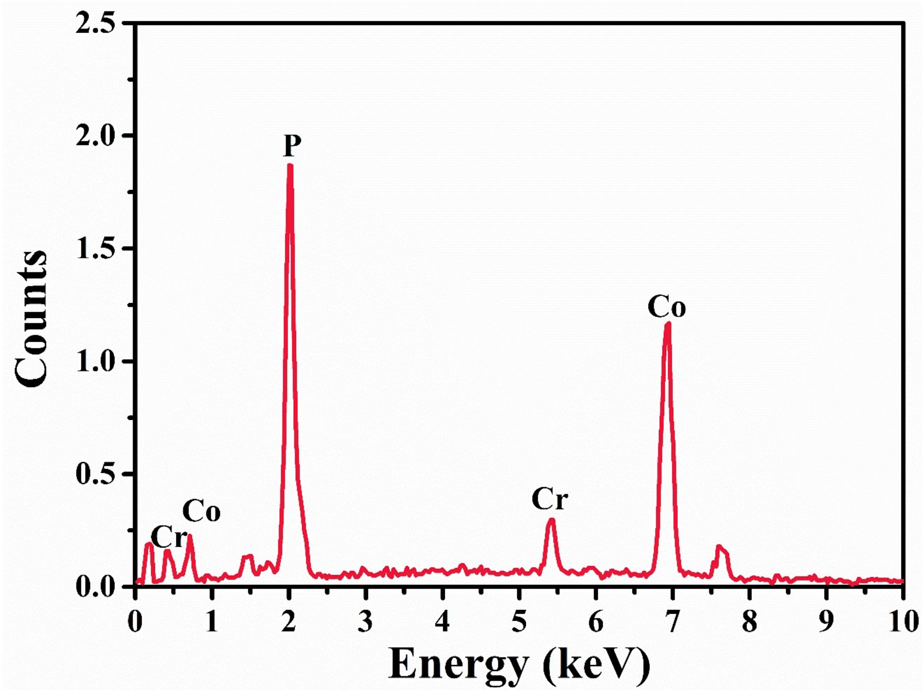

Fig. S4. EDS spectrum of Co_2Cr_1-P@3DGF composite.

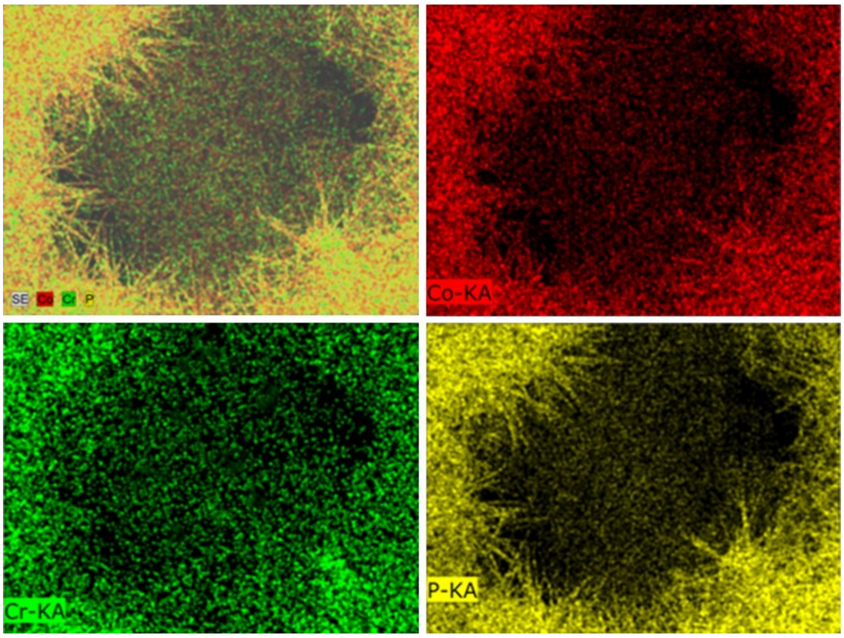

Fig. S5. Element mapping images of Co_2Cr_1-P@3DGF (red: Co; green: Cr; yellow: P).

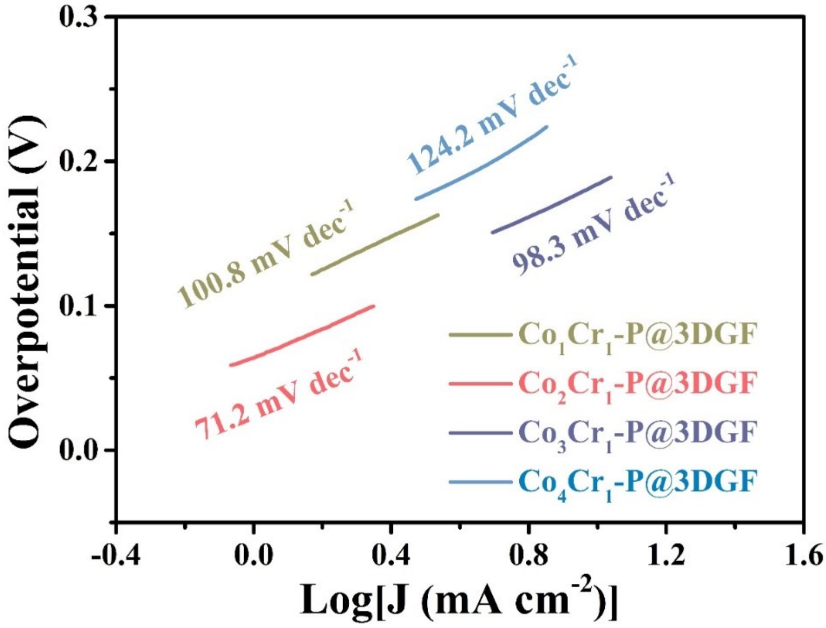

Fig. S6. Tafel curves of CoCr-P@3DGF with different Co/Cr ratios towards HER in 1.0 M KOH.

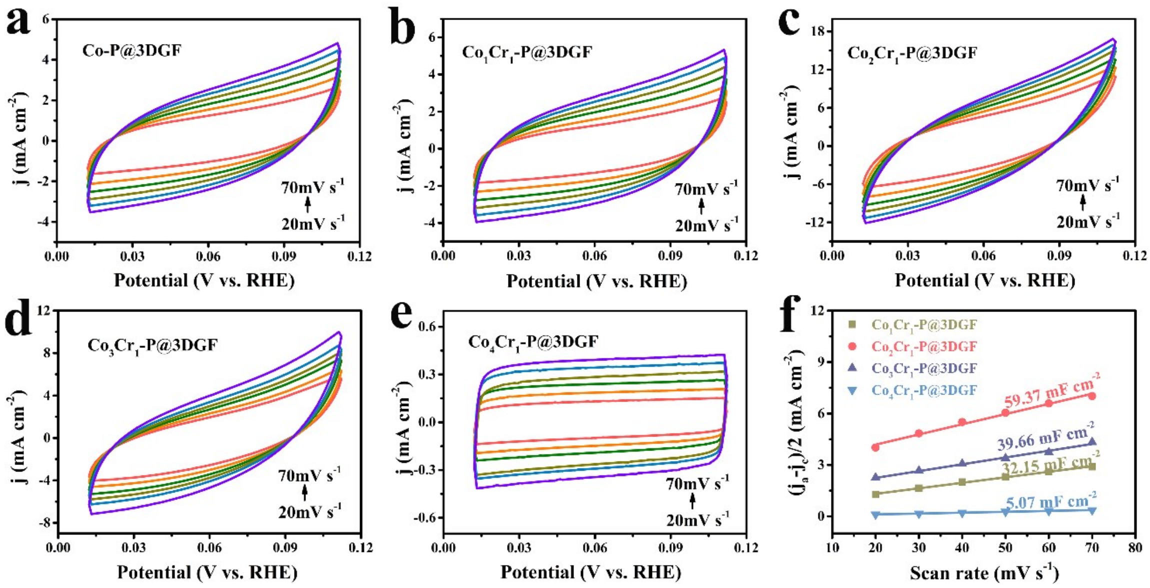

Fig. S7. CV curves of (a) Co-P@3DGF, (b) Co_1Cr_1-P@3DGF, (c) Co_2Cr_1-P@3DGF, (d) Co_3Cr_1-P@3DGF, (e) Co_4Cr_1-P@3DGF with various scan rates in 1.0 M KOH. (f) Double layer capacitances of CoCr-P@3DGF with different Co/Cr ratios.

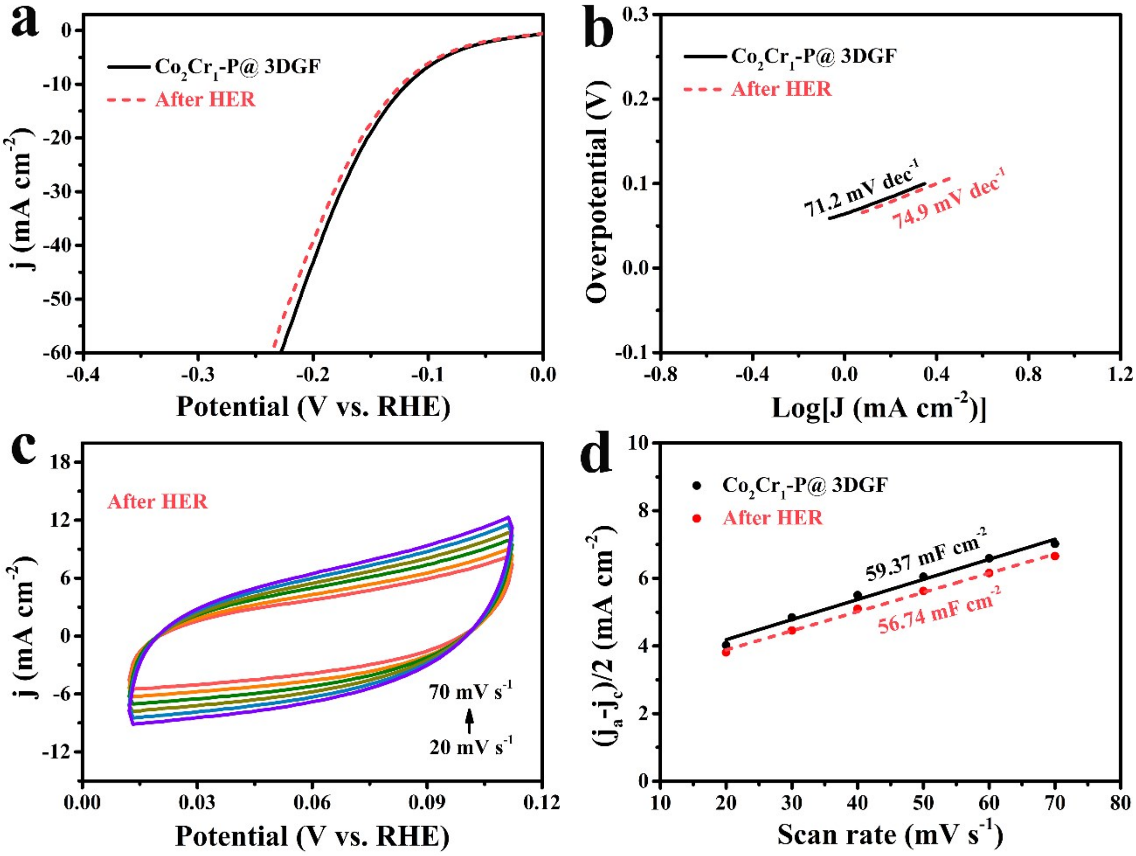

Fig. S8. (a) The polarization, (b) Tafel curves and (c) CV curves of Co_2Cr_1-P@3DGF after 50 h stability tests for HER reaction in 1.0 M KOH. (d) Double layer capacitances of Co_2Cr_1-P@3DGF before and after HER reaction.

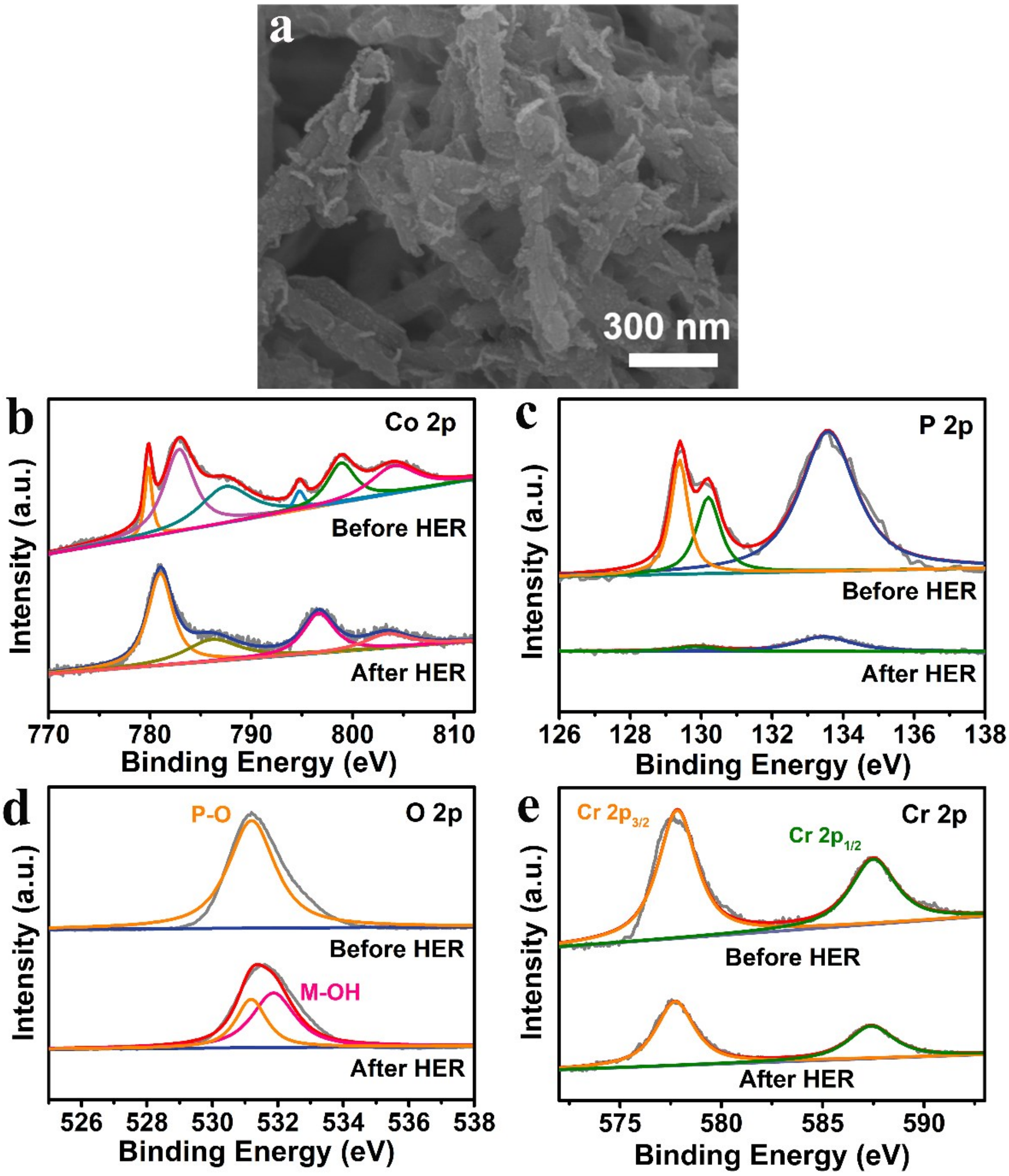

Fig. S9. (a) SEM images of Co_2Cr_1-P@3DGF after the stability test of HER. High-resolution XPS spectra of Co_2Cr_1-P@3DGF for (b) Co 2p, (c) P 2p, (d) O 1s, (e) Cr 2p before and after HER test.

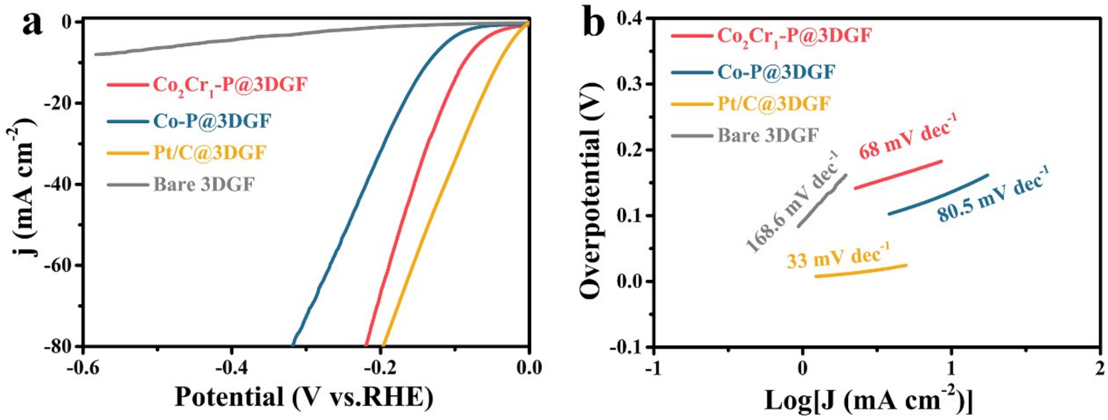

Fig. S10. (a) Polarization curves and (b) corresponding Tafel curves of Co_2Cr_1-P@3DGF, Co-P@3DGF, Pt/C@3DGF and bare 3DGF in 0.5 M H_2SO_4.

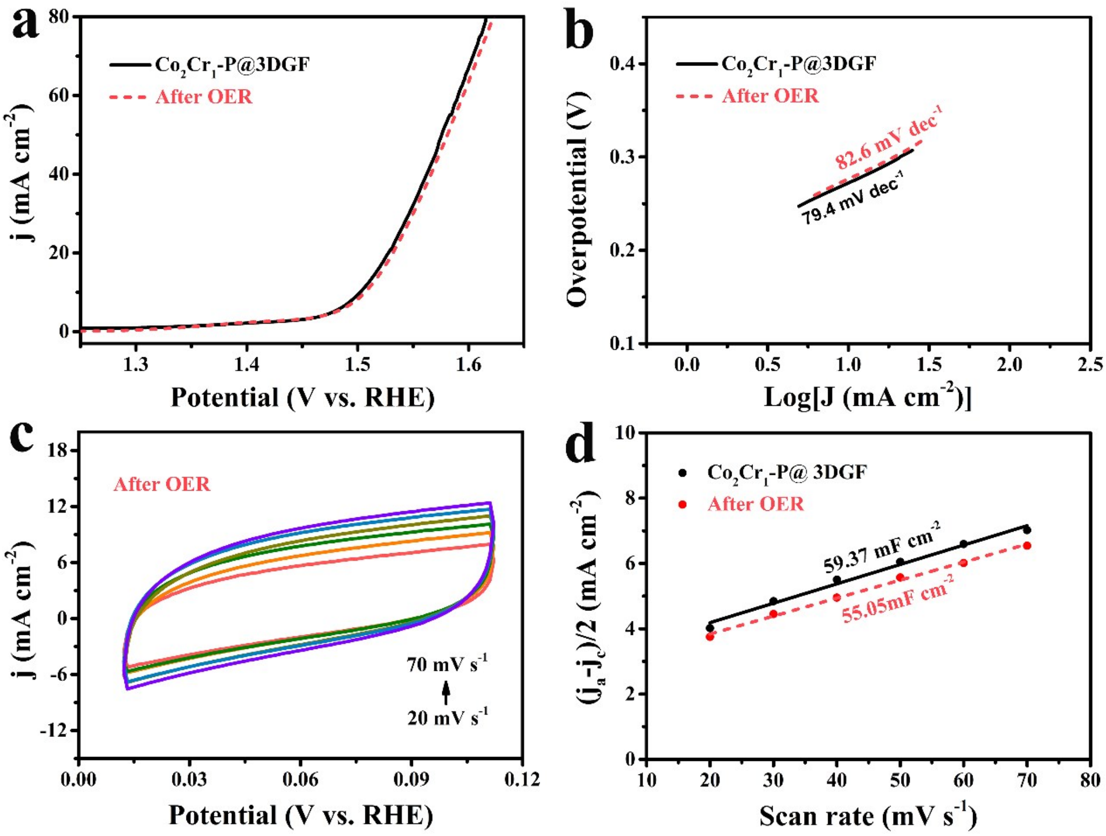

Fig. S11. (a) The polarization, (b) Tafel curves and (c) CV curves of Co_2Cr_1-P@3DGF after 50 h stability tests for OER reaction in 1.0 M KOH. (d) Double layer capacitances of Co_2Cr_1-P@3DGF before and after OER reaction.

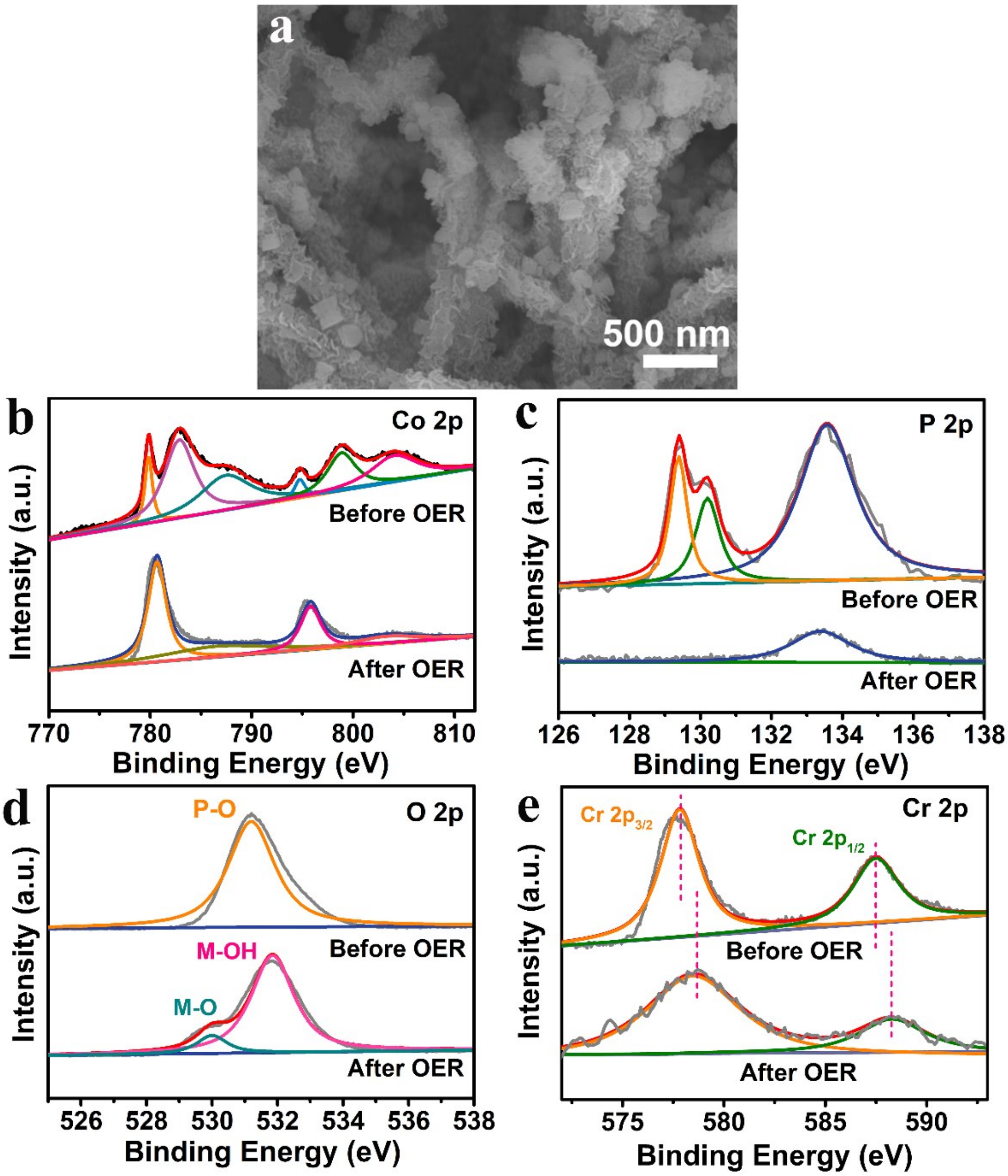

Fig. S12. (a) SEM images of Co_2Cr_1-P@3DGF after the stability test of OER. High-resolution XPS spectra of Co_2Cr_1-P@3DGF for (b) Co 2p, (c) P 2p, (d) O 1s, (e) Cr 2p before and after OER test.

Table S1. Estimated chemical formula of CoCr-P with different Co/Cr feeding ratios.

Co/Cr feeding ratio	EDS analysis [at%]			Estimated chemical formula
	Co	Cr	P	
1:1	50.75	7.53	41.71	$Co_{0.87}Cr_{0.13}$-P
2:1	50.91	5.77	43.32	$Co_{0.89}Cr_{0.11}$-P
3:1	45.21	4.62	50.17	$Co_{0.91}Cr_{0.09}$-P
4:1	46.10	2.65	51.25	$Co_{0.95}Cr_{0.05}$-P

Table S2. Comparison of HER performances of Co_2Cr_1-P@3DGF with recently reported catalysts in 1.0 M KOH.

Catalysts	**j (mA cm^{-2})**	**Overpotential (mV)**	**Tafel slope (mV dec^{-1})**	**Ref.**
Co_2Cr_1-P@3DGF	**10**	**118**	**71.2**	**This work**
Er-doped CoP NMs	10	66	61	S1
Hollow Mo-CoP arrays	10	40	65	S2
$Co_{5.47}N$ NP@N-PC	10	149	86	S3
Co_4Ni_1P NTs	10	129	52	S4
CoP/C	10	160	20	S5
$Cu_{0.075}Co_{0.0925}P$/CP	10	47	47.2	S6
$(Ni,Co)Se_2$-GA	10	127	79	S7
CoP-400	10	151	72	S8
S-CoP	10	109	79	S9
Co_3S_4@MoS_2	10	136	74	S10

Table S3. Comparison of HER performances of Co_2Cr_1-P@3DGF with recently reported catalysts in 0.5 M H_2SO_4.

Catalysts	j (mA cm^{-2})	Overpotential (mV)	Tafel slope (mV dec^{-1})	Ref.
Co_2Cr_1-P@3DGF	**10**	**88**	**68**	**This work**
Er-doped CoP NMs	10	52	32	S1
$Cu_{0.075}Co_{0.0925}P$/CP	10	70	55.1	S6
Urchin-like CoP	10	105	46	S11
CoP-400	10	113	67	S8
CoP_3/Ni_2P	10	115	49	S12
W-CoP NAs/CC	10	89	58	S13
CoMoP-5	10	95	61.1	S14
CoP@CC	10	131	64	S15
CoP/NCNHP	10	140	53	S16
HNDCM-Co/CoP	10	138	64	S17

Table S4. Comparison of OER performances of Co_2Cr_1-P@3DGF with recently reported catalysts in 1.0 M KOH.

Catalysts	j (mA cm^{-2})	Overpotential (mV)	Tafel slope (mV dec^{-1})	Ref.
Co_2Cr_1-P@3DGF	**10**	**270**	**79.4**	**This work**
Er-doped CoP NMs	10	256	70	S1
Hollow Mo-CoP nanoarrays	10	305	56	S2
$Co_{5.47}N$ NP@N-PC	10	248	72	S3
Co_4Ni_1P NTs	10	245	87	S4
CoP/C	10	430	115	S5
$Cu_{0.075}Co_{0.0925}P$/CP	10	221	70.4	S6
(Ni,Co)Se_2-GA	10	250	70	S7
CoCr-LDH	10	340	81	S18
Co@Co_9S_8 nanochains	10	285	86.5	S19
S-CoP	10	270	82	S9

Table S5. Comparison of overall water splitting performances of Co_2Cr_1-P@3DGF with recently reported catalysts in 1.0 M KOH.

Catalysts	Cell voltage (V) at j = 10 mA cm^{-2}	Ref.
Co_2Cr_1-P@3DGF	**1.56**	**This work**
Er-doped CoP NMs	1.58	S1
Hollow Mo-CoP nanoarrays	1.56	S2
$Co_{5.47}N$ NP@N-PC	1.62	S3
Co_4Ni_1P NTs	1.59	S4
$Cu_{0.075}Co_{0.0925}P$/CP	1.55	S6
(Ni,Co)Se_2-GA	1.6	S7
Co_3S_4@MoS_2	1.58	S10
CoP@CC	1.68	S15
CoP/NCNHP	1.64	S16
CoP-Co_2P@PC/PG	1.567	S20

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