Supporting Information

Vanadium-doped cobalt selenide: an efficient bifunctional electrocatalyst for overall water splitting

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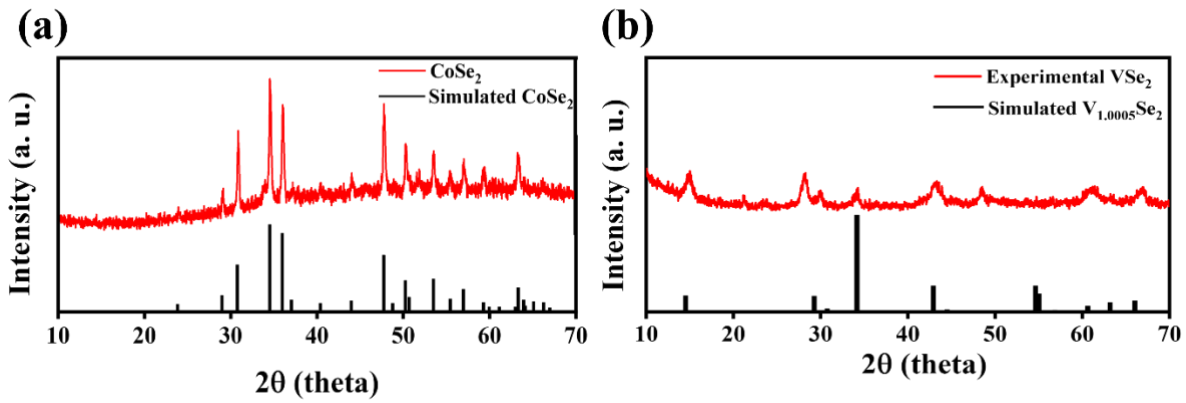

Fig. S1 (a) PXRD of $CoSe_2$, (b) PXRD of VSe_2.

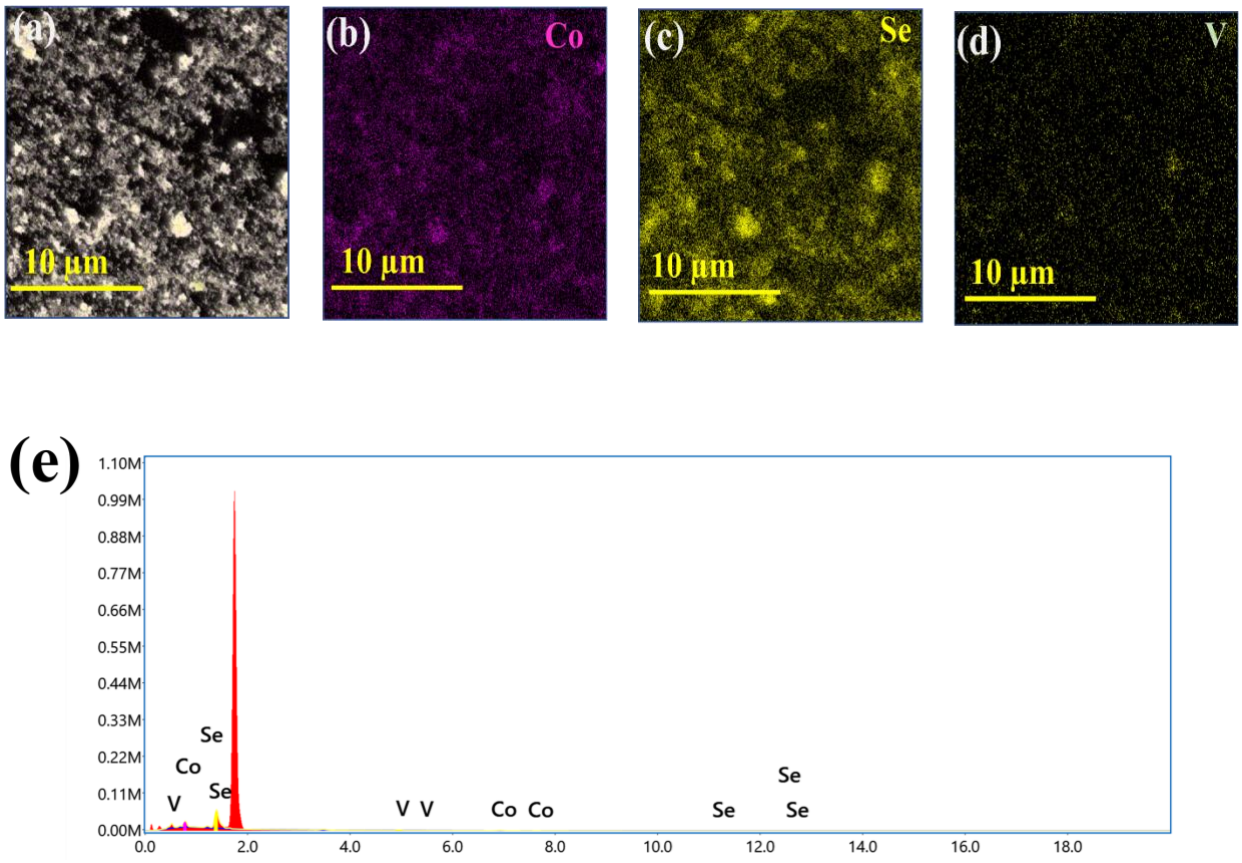

Fig. S2 (a-d) Elemental mapping, (e) EDAX spectrum of V@$CoSe_2$-1.

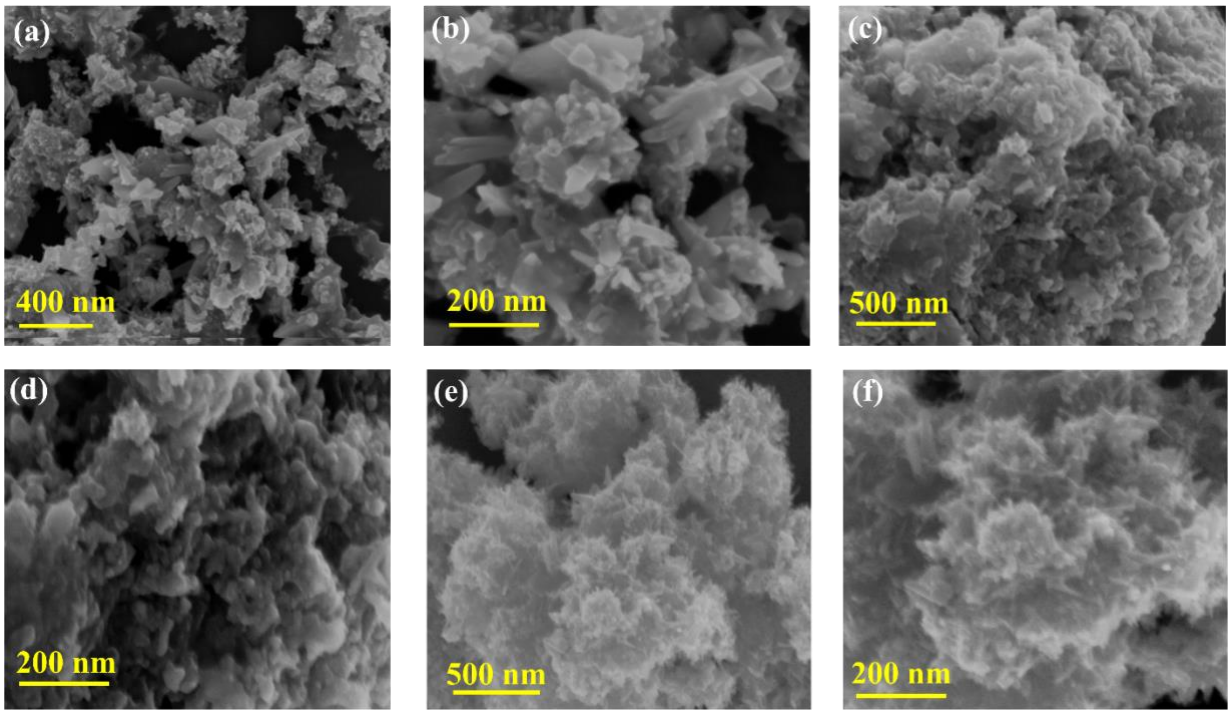

Fig. S3 (a, b) FESEM images of V@$CoSe_2$-2, (c, d) FESEM images of V@$CoSe_2$-3, (e, f) FESEM images of $CoSe_2$.

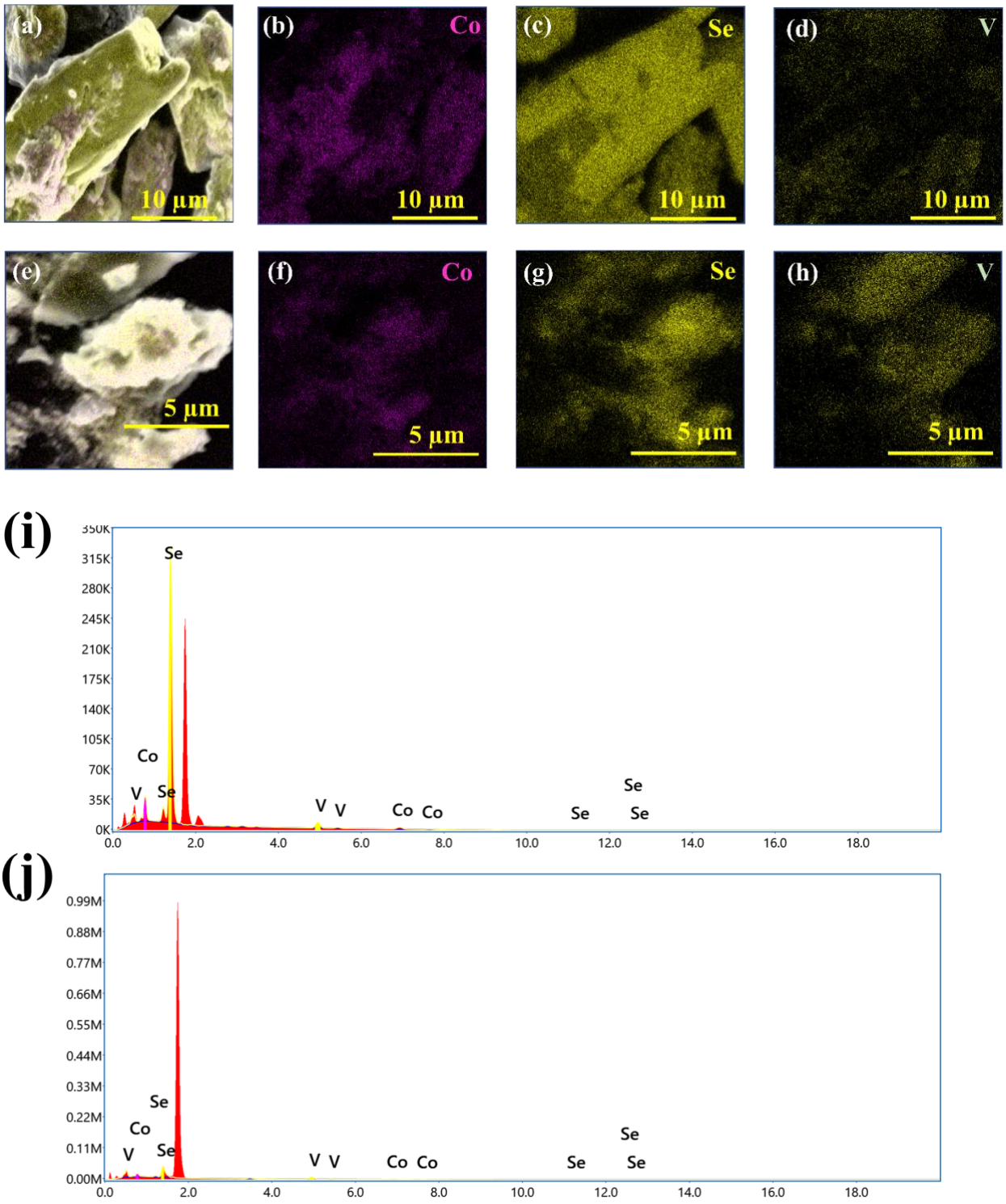

Fig. S4 (a-d) Elemental mapping of V@$CoSe_2$-2, (e-h) Elemental mapping of V@$CoSe_2$-3, (i) EDAX spectrum of V@$CoSe_2$-2, (j) EDAX spectrum of V@$CoSe_2$-3.

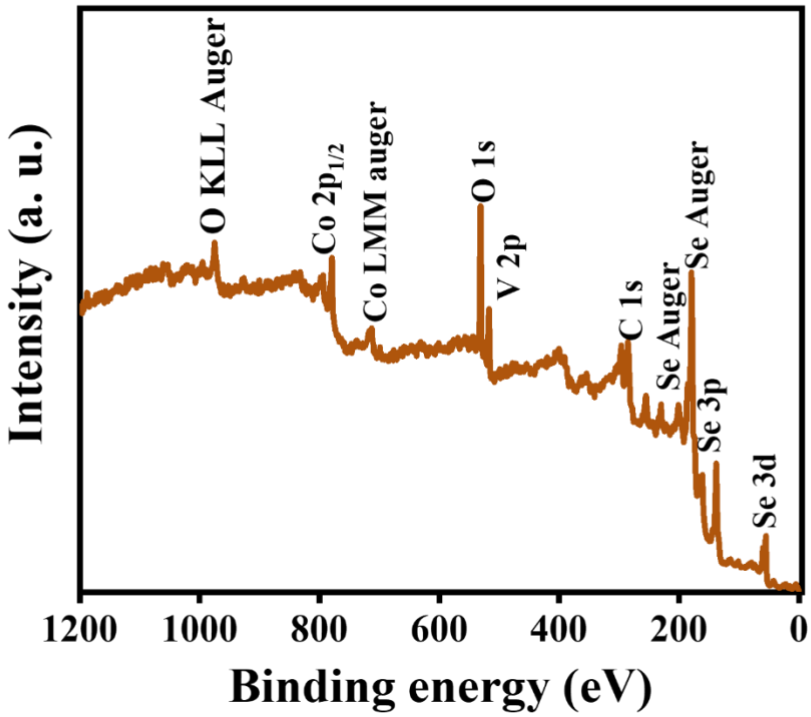

Fig. S5 Full survey spectrum of V@$CoSe_2$-1.

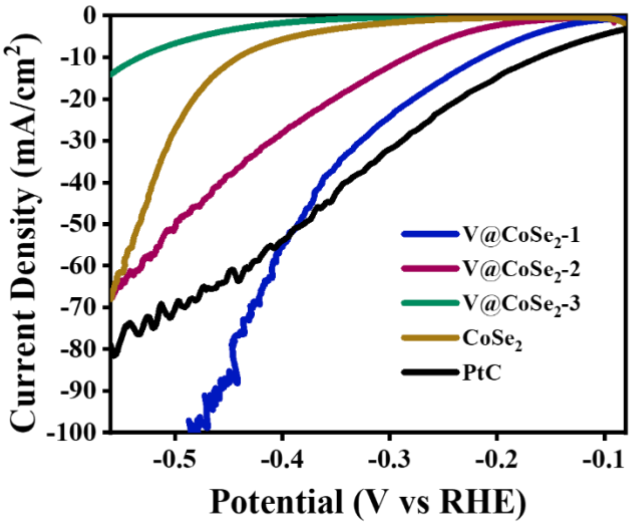

Fig. S6 Full range current density LSV of alkaline HER.

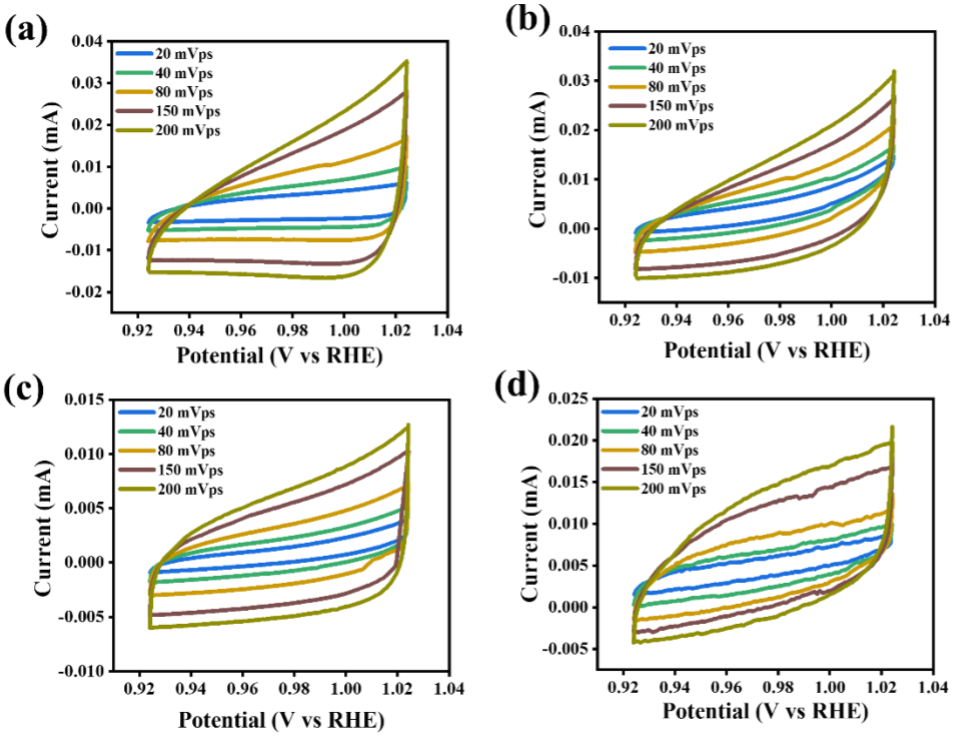

Fig. S7 CV curves of (a) V@$CoSe_2$-1, (b) V@$CoSe_2$-2, (c) V@$CoSe_2$-3, (d) $CoSe_2$ in the potential window of 0.92 V to 1.02 V for OER application.

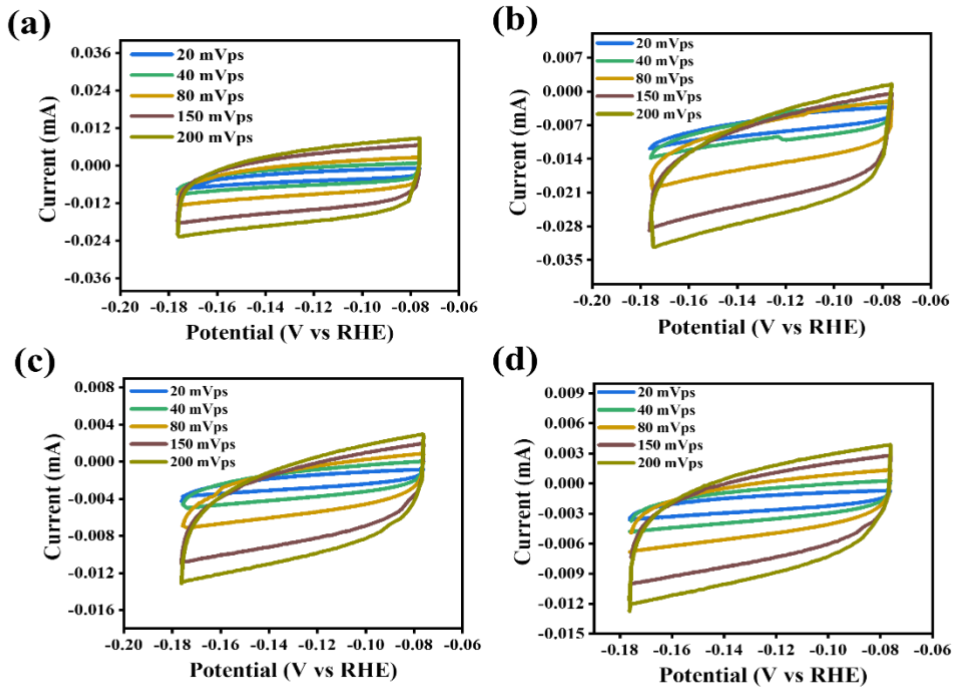

Fig. S8 CV curves of (a) V@$CoSe_2$-1, (b) V@$CoSe_2$-2, (c) V@$CoSe_2$-3, (d) $CoSe_2$ in the potential window of -0.08 V to -0.18 V for HER application.

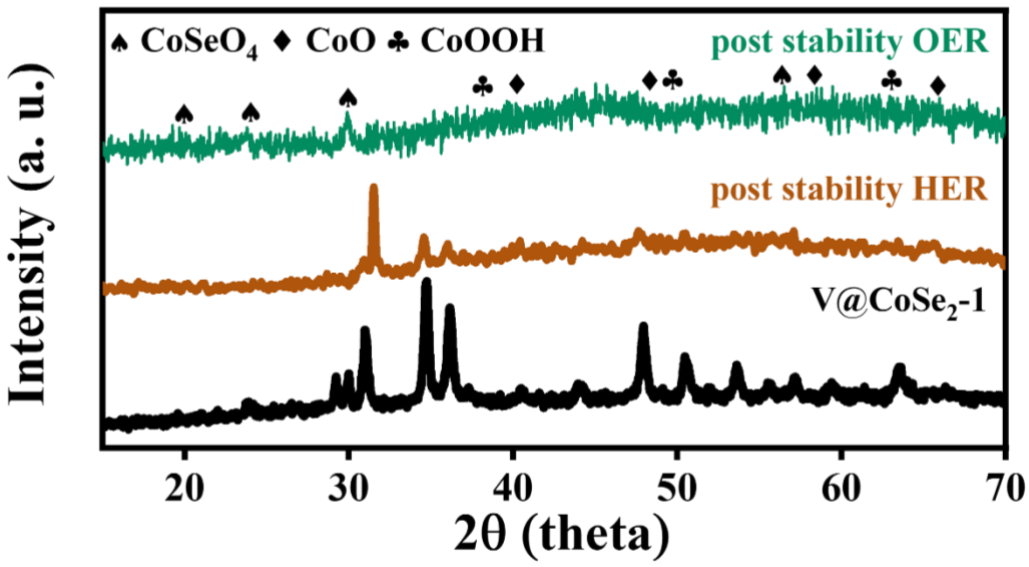

Fig. S9 PXRD of post-stability OER and HER of V@$CoSe_2$-1.

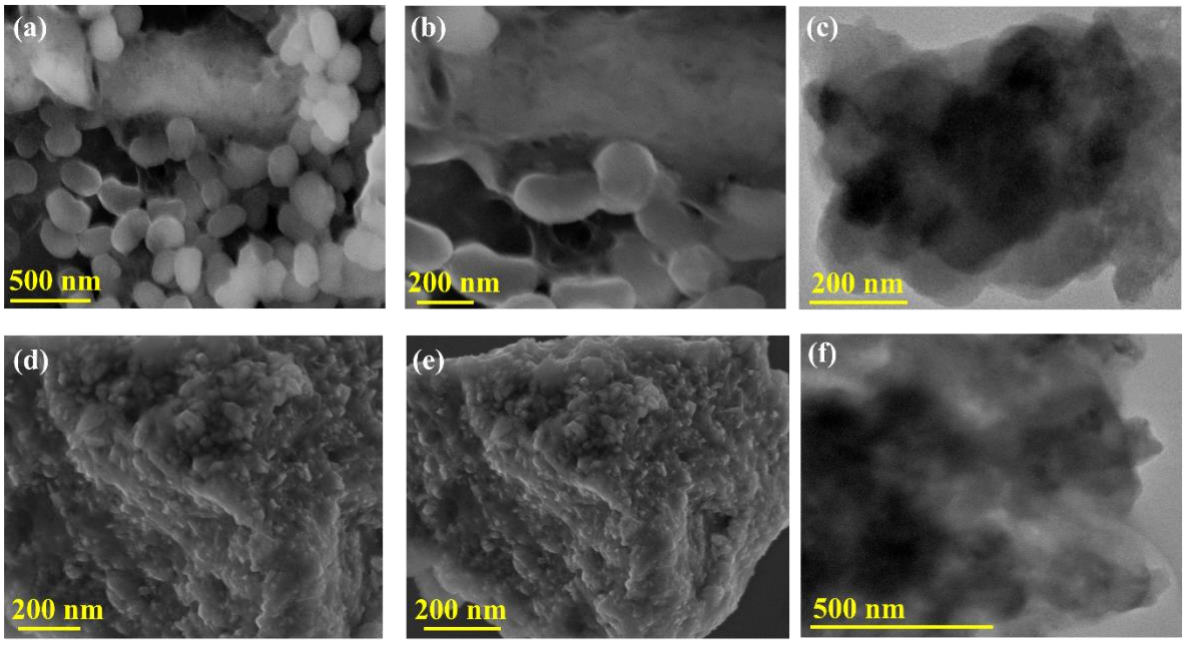

Fig. S10 (a, b) FESEM images of V@$CoSe_2$-1 post OER, (c) TEM image of V@$CoSe_2$ process -1 post OER, (d-e) FESEM images of V@$CoSe_2$-1 post HER, (f) TEM image of V@$CoSe_2$-1 post HER.

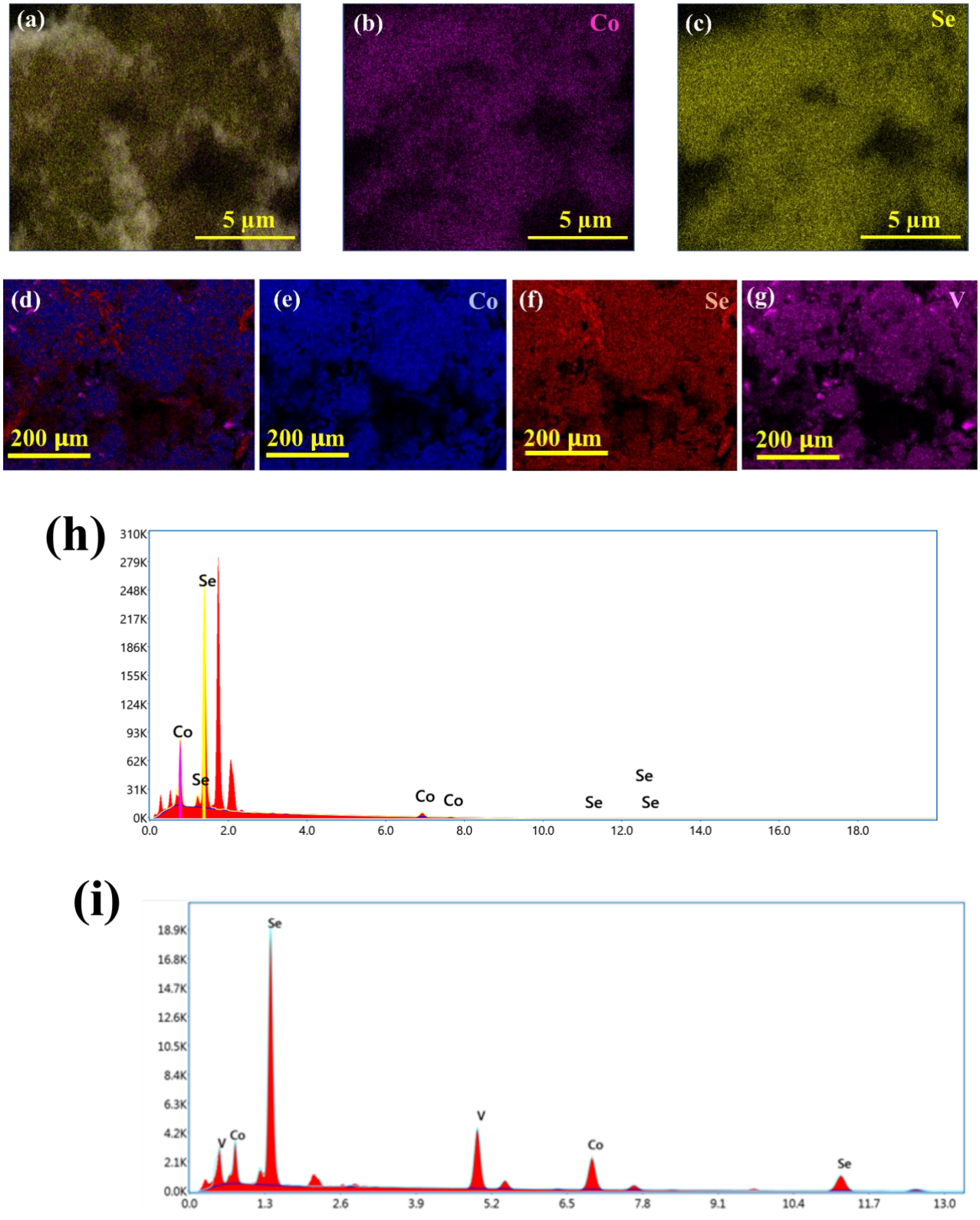

Fig.S11 (a-c) elemental mapping of post stability OER, (d-g) elemental mapping of post stability HER, (i) EDAX spectrum of post stability OER, (j) EDAX spectrum of post-stability HER of V@$CoSe_2$-1

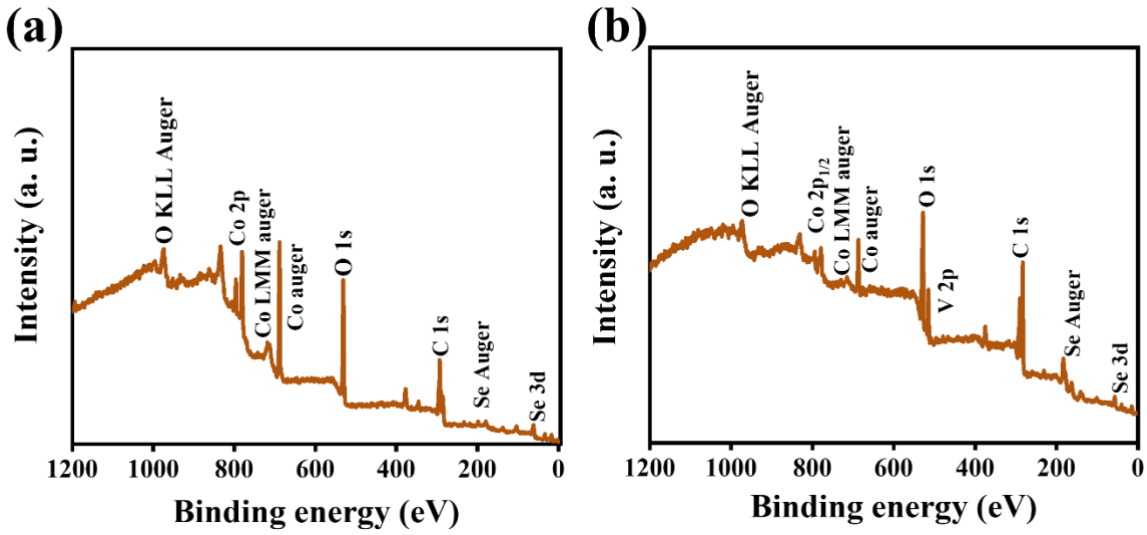

Fig. S12 (a) Full survey spectrum of post-OER, (b) full survey spectrum of post HER of V@$CoSe_2$-1.

Table S1: Comparison of weight % and atomic % of different electrocatalysts observed in EDAX spectra.

Electrocatalyst	Weight %			Atomic %		
	Co	Se	V	Co	Se	V
V@$CoSe_2$-1	20.40	67.60	12.10	24	59.50	16.50
V@$CoSe_2$-2	7.30	80.40	12.30	8.90	73.60	17.40
V@$CoSe_2$-3	11.90	40.90	47.20	12.30	31.50	56.30
V@$CoSe_2$-1 (post OER)	20.80	79.20	—	26	74	—
V@$CoSe_2$-1 (post HER)	18.90	70.71	10.40	22.58	63.05	14.37

Table S2: Molar ratios of elements of each electrocatalyst calculated from XPS spectra.

Electrocatalyst	Molar ratio
V@$CoSe_2$-1	Co:V:Se (1.5:1:3.5)
After OER V@$CoSe_2$-1	Co:Se (1:1.25)
After HER V@$CoSe_2$-1	Co:V:Se (1.7:1:1.6)

Table S3: R_s, R_{ct}, C_{dl}, ECSA of different electrocatalysts.

Electrocatalyst	R_s (Ω)		R_{ct} (Ω)		C_{dl} (μF)		ECSA (cm^2)	
	OER	HER	OER	HER	OER	HER	OER	HER
V@$CoSe_2$-1	11.89	14.9	13.16	36.9	62.7	56.1	1.56	1.40
V@$CoSe_2$-2	11.89	14.9	16.23	72.47	45.7	52	1.14	1.28
V@$CoSe_2$-3	11.89	14.9	38.91	106.7	27	22.4	0.67	0.56
$CoSe_2$	—	—	—	—	29.4	25	0.73	0.63

Table S4: Comparison of different bifunctional electrocatalysts for alkaline water splitting at 10 mA/cm^2 current density.

Electrocatalyst	**1 M KOH ŋ HER/OER (mV)**	**1 M KOH Cell voltage (V)**	**Tafel (mV/dec) HER/OER**	**Substrate taken as electrode**	***Ref.***
V@$CoSe_2$-1	**270/315**	**1.96**	**124/63**	**Glassy carbon/ graphite sheet**	**This work**
Ni-$CoSe_2$	250/325	1.69	69.3/58.6	Glassy carbon	1
Co_2B/$CoSe_2$	300/320	1.73	76/56	Carbon fibre cloth	2
$RuSe_2CoSe_2$/NC	31/248	1.57	20.8/58.1	Glassy carbon	3
$CoSe_2$@$MoSe_2$	183/309	1.524	87.69/84.04	Glassy Carbon/Ni foam	4
Co-BTC	370/437	2.03	115.1/89.1	Carbon cloth	5
H-CoS_x@NiFe LDH/NF	95/250	1.98	90/49	Nikel foam	6
Cu_2Se/$CoSe_2$	110/170	1.56	140/130	Cu foam	7
NiSe2–CoSe2	66/220	1.56	57/99.57	Carbon cloth	8

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