Supporting Information

Amorphous Cobalt Vanadium Oxide as a Highly Active Electrocatalyst for Oxygen Evolution

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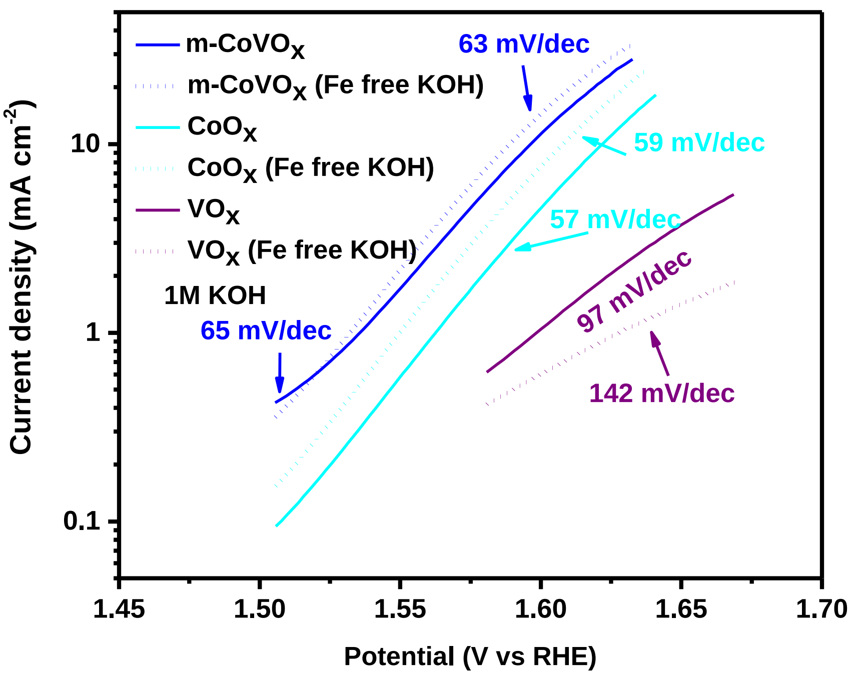

Figure S1. Tafel slopes of *m-Co*VO_x, CoO_x and VO_x in 1 M KOH and 1 M Fe-free KOH.

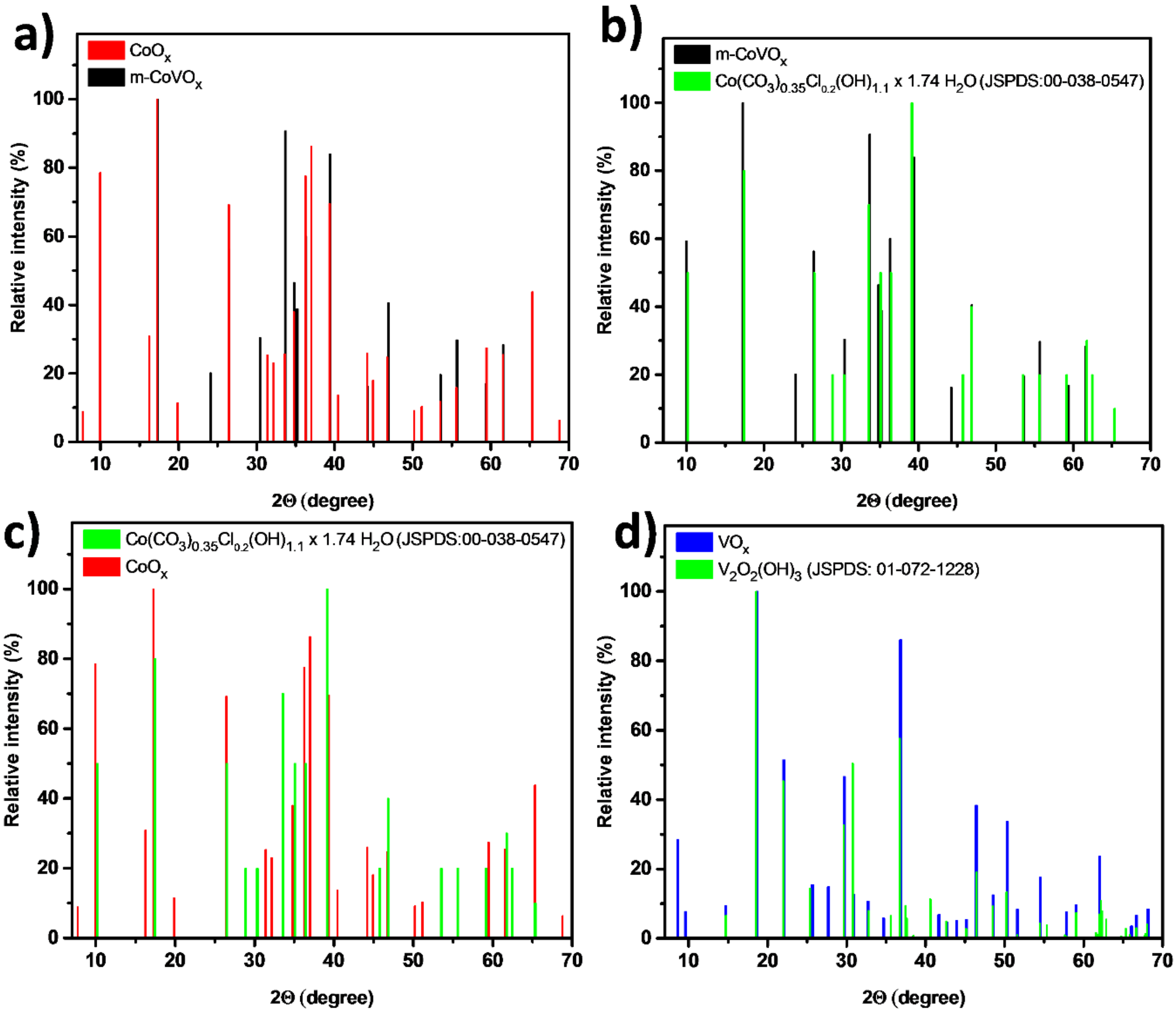

Figure S2. a) Comparison of extracted XRD peaks for *m-Co*VO$_x$ and CoO$_x$. b) Comparison of extracted XRD peaks for *m-Co*VO$_x$ and $Co(CO_3)_{0.35}Cl_{0.2}(OH)_{1.1} \cdot 1.74\ H_2O$. c) Comparison of extracted XRD peaks for CoO$_x$ and $Co(CO_3)_{0.35}Cl_{0.2}(OH)_{1.1} \cdot 1.74\ H_2O$. d) Comparison of extracted XRD peaks for VO$_x$ and $V_2O_2(OH)_3$.

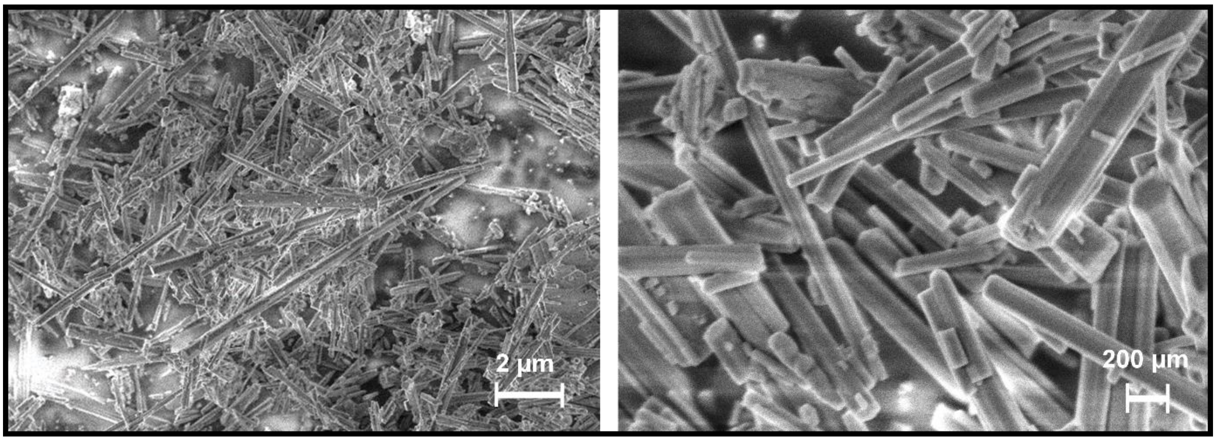

Figure S3. SEM images of CoO_x.

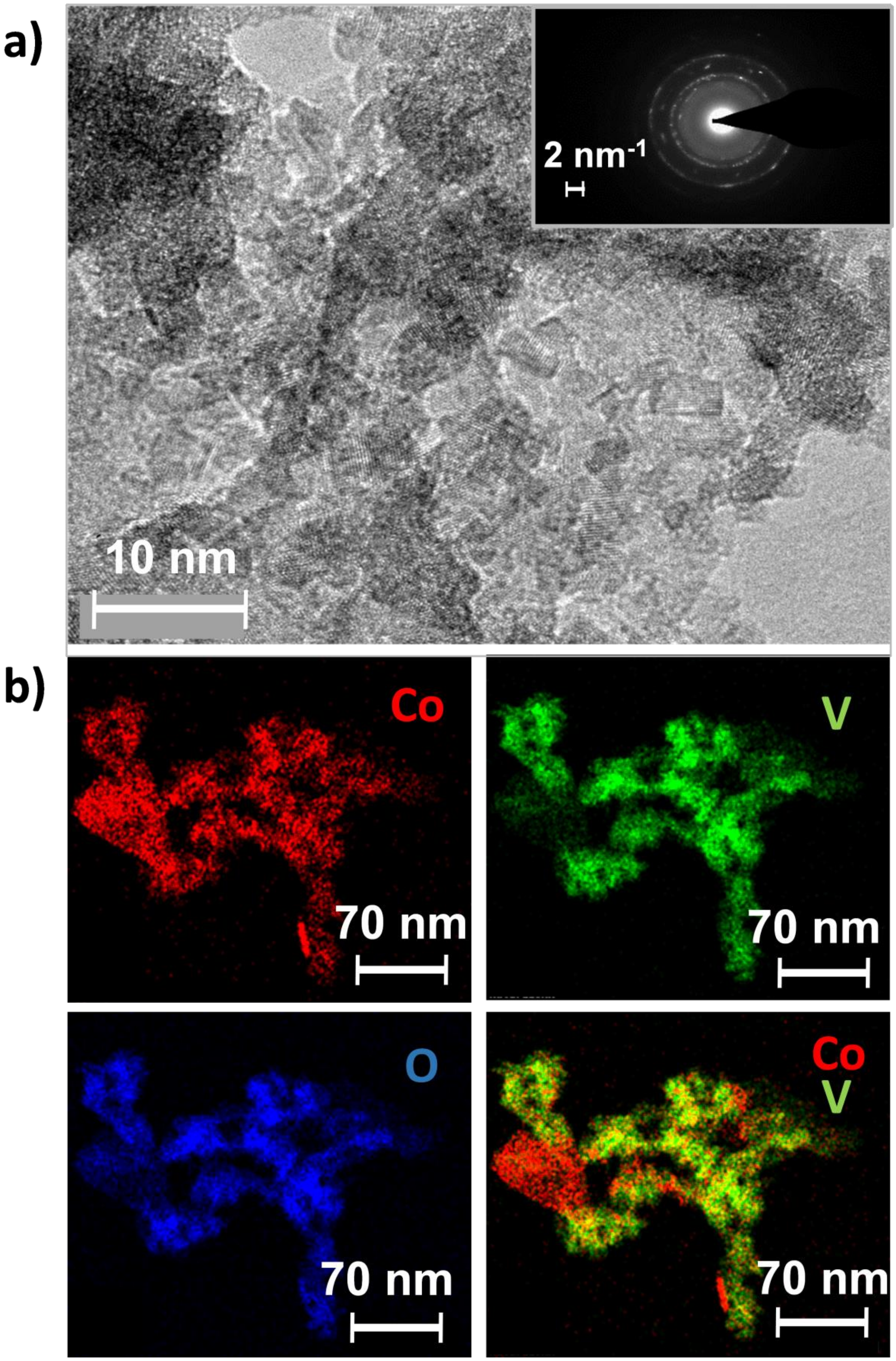

Figure S4. a) TEM image of *m*-*Co*VO_x. b) STEM-EDX mapping of *m*-*Co*VO_x.

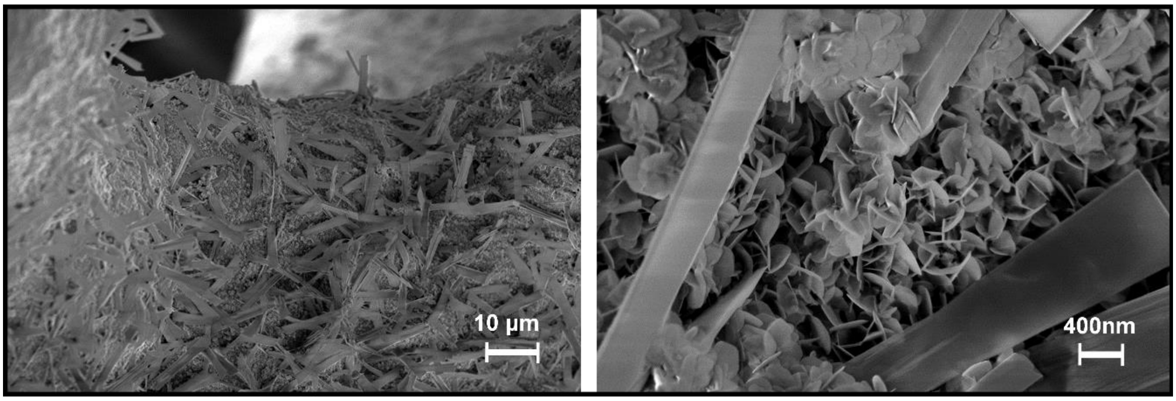

Figure S5. SEM images of *m*-*Co*VO_x on nickel foam.

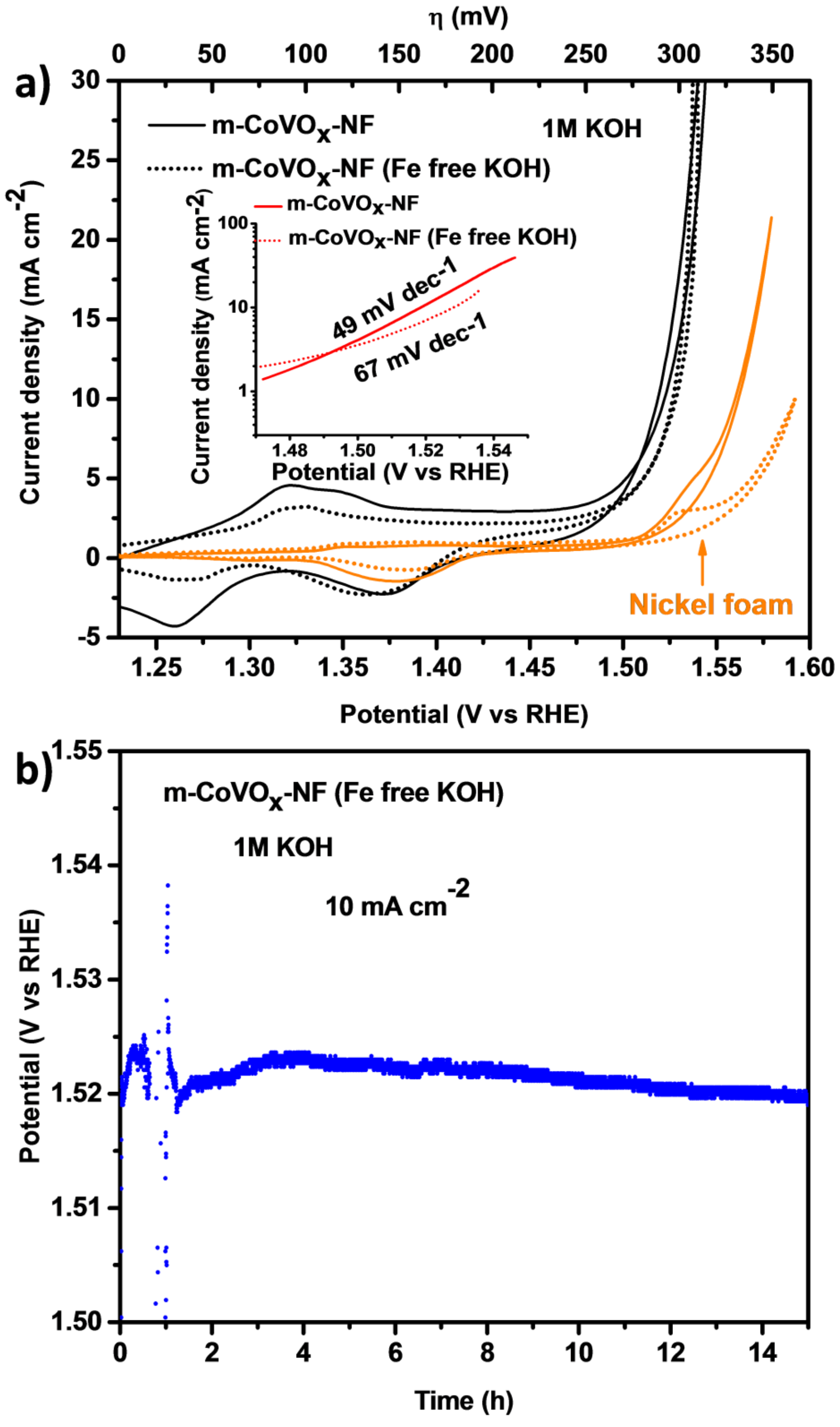

Figure S6. a) Polarization curves for *m-Co*VO_x on nickel foam and extracted tafel slopes in 1 M KOH. Scan rate 1 mV s^{-1}; iR drop corrected. b) Stability of *m-Co*VO_x on nickel foam at 10 mA cm^{-2} in 1 M Fe-free KOH.

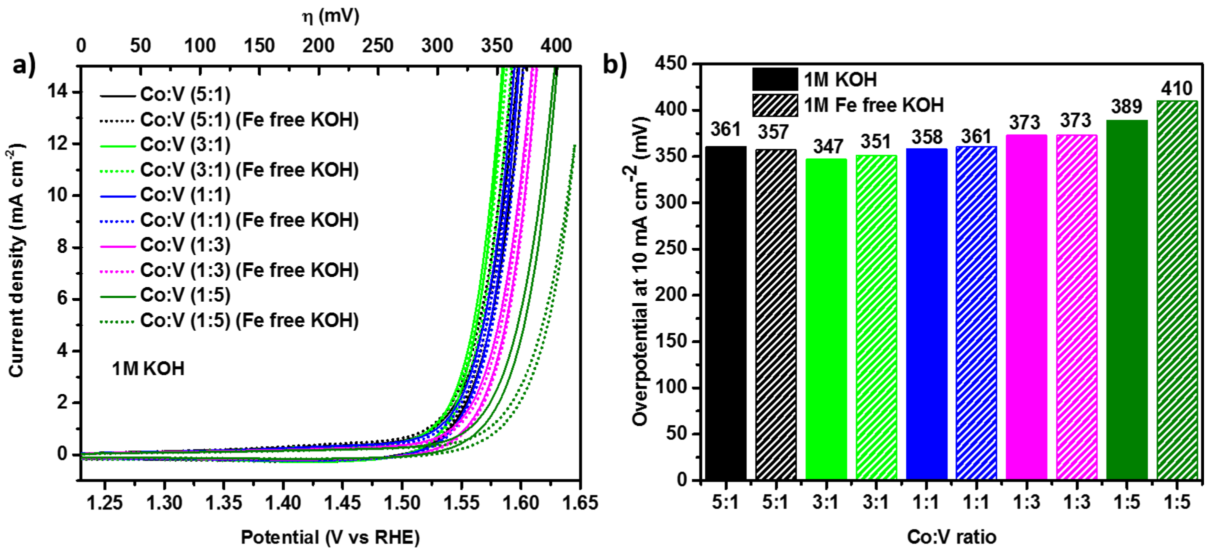

Figure S7. a) Polarization curves on glassy carbon of cobalt vanadium oxides synthesized with different Co:V ratio in the hydrothermal solution in 1 M KOH and 1 M Fe-free KOH. Scan rate 10 mV s^{-1}; iR drop corrected. b) Overpotentials for the different cobalt vanadium oxides with different Co:V ratios in 1 M KOH and 1 M Fe-free KOH at 10 mA cm^{-2}.

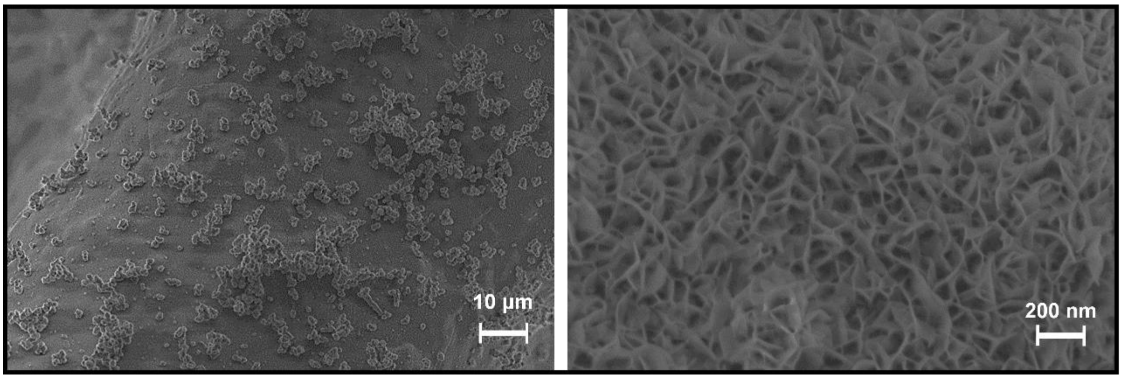

Figure S8. SEM images of *a-Co*VO_x on nickel foam.

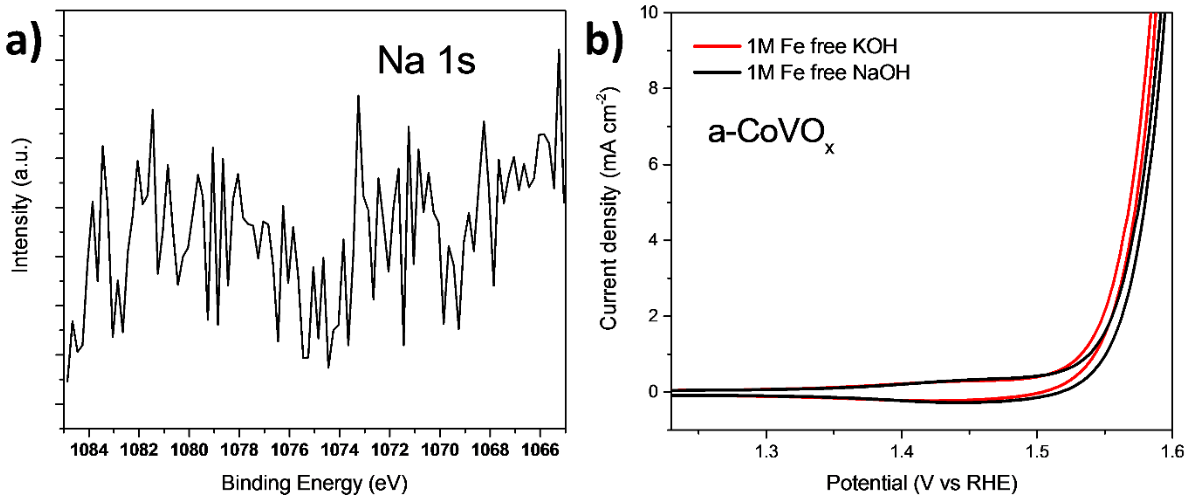

Figure S9. a) High resolution region spectra of Na 1s of XPS spectra of *a-Co*VO$_x$. b) Polarization curves on glassy carbon (loading 140 μg cm^{-2}) of *a-Co*VO$_x$ in 1 M Fe-free KOH and 1 M Fe-free NaOH. Scan rate 10 mV s^{-1}; iR drop corrected.

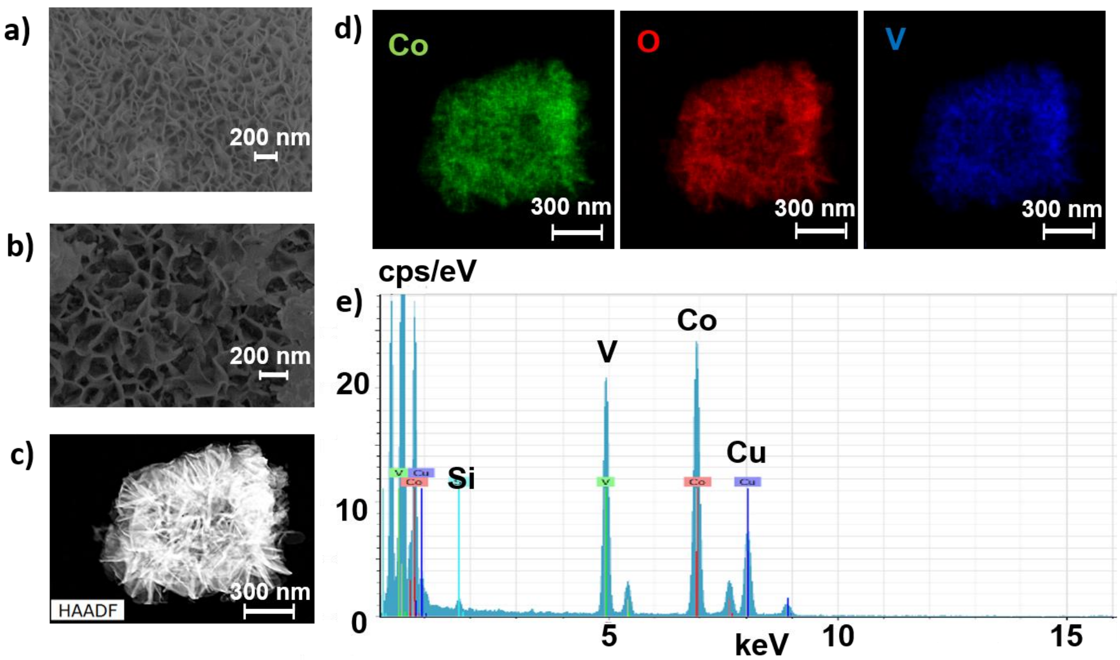

Figure S10. a) SEM image of *a-Co*VO$_x$ on nickel foam before electrolysis. b) SEM image of *a-Co*VO$_x$ on nickel foam after 15 h of electrolysis at 10 mA cm^{-2} in 1 M Fe-free KOH. c) STEM image of *a-Co*VO$_x$ initially deposited on nickel foam. d) STEM-EDX mapping of *a-Co*VO$_x$ initially deposited on nickel foam after 15 h of electrolysis at 10 mA cm^{-2} in 1 M Fe-free KOH. e) EDX spectrum of of *a-Co*VO$_x$ initially deposited on nickel foam after 15 h of electrolysis at 10 mA cm^{-2} in 1 M Fe-free KOH.

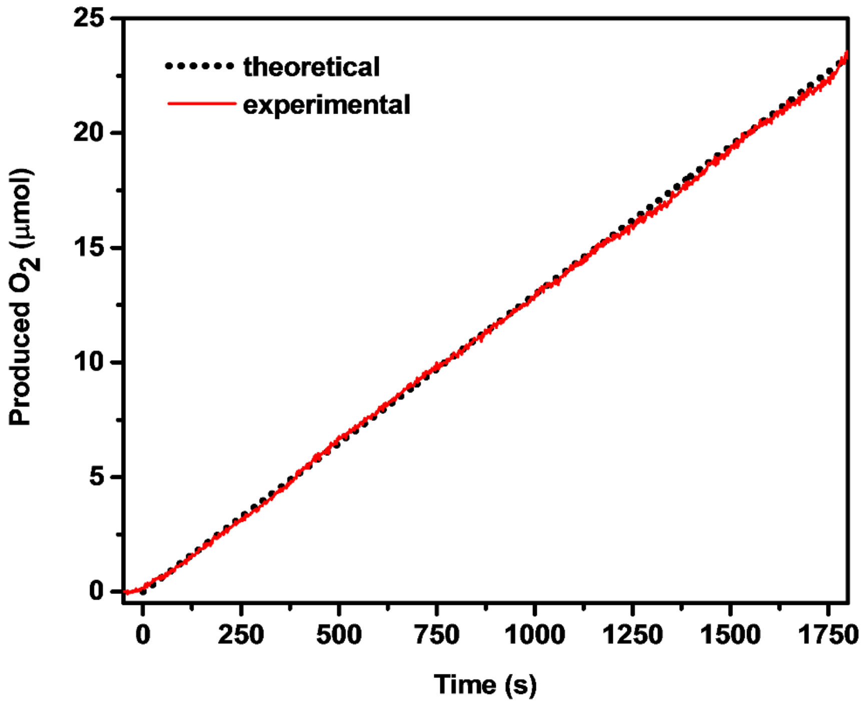

Figure S11. Agreement between measured and predicted moles of O_2 produced by *a-Co*VO_x on nickel foam indicates nearly 100% faradaic efficiency. *a-Co*

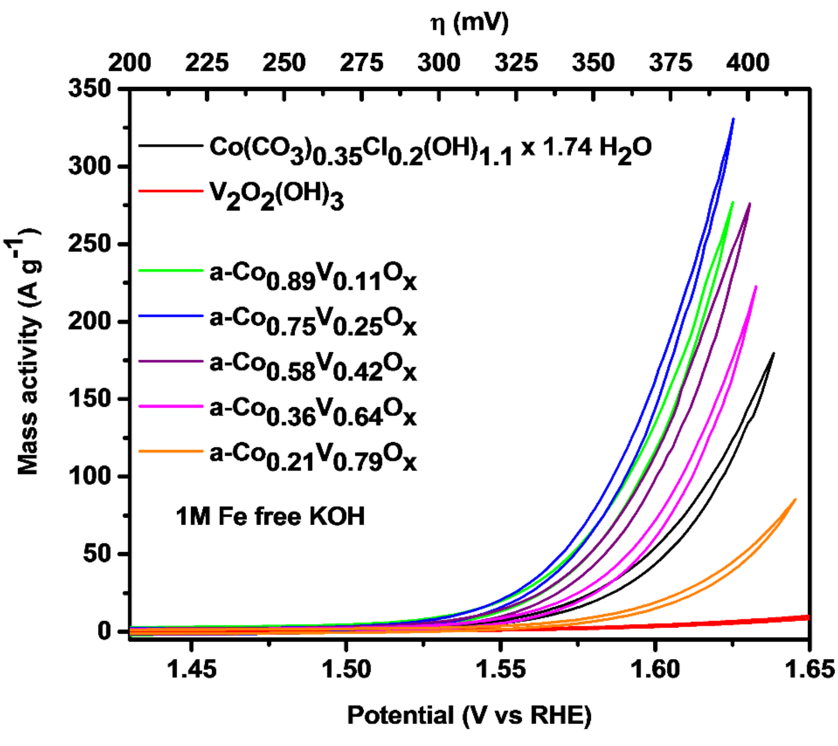

Figure S12. Mass activity of different *a-Co*$_y$$V_{1-y}O_x$ on glassy carbon (loading 140 μg cm^{-2}). Scan rate 10 mV s^{-1}; iR drop corrected.

Table S1. Comparison between the Co:V concentration ratios in the deposition solution and the Co:V ratios in the final catalysts determined by XPS.

Catalyst	Deposition bath $CoCl_2$:VCl_3 ratio	XPS Co:V ratio (atomic %)
$Co_{0.89}V_{0.11}O_x$	5:1	Co: 89%, V: 11% (9:1)
$Co_{0.75}V_{0.25}O_x$	3:1	Co: 75%, V: 25% (3:1)
$Co_{0.58}V_{0.42}O_x$	1:1	Co: 58%, V: 42% (3:2)
$Co_{0.36}V_{0.64}O_x$	1:3	Co: 36%, V: 64% (2:3)
$Co_{0.21}V_{0.79}O_x$	1:5	Co: 21%, V: 79% (1:4)

Table S2. Bond strength of the different $Co_yV_{1-y}O_x$ for physical mixtures calculated using the method proposed by Bockris and Otagawa.[1]

Mixture of metal hydroxides	M-OH bond strength (kcal mol^{-1})
Co-OH	130.4
0.89 Co-OH + 0.11 V-OH	136.8
0.75 Co-OH + 0.25 V-OH	144.9
0.58 Co-OH + 0.42 V-OH	154.8
0.36Co-OH + 0.64 V-OH	167.6
0.21 Co-OH + 0.79 V-OH	176.3
V-OH	188.5

Table S3. Summary of the mass activities of the different oxides in 1 M KOH at η = 350 mV.

Metal oxide	Mass activity (A g^{-1} at η = 350 mV)
CoO_x ($Co(CO_3)_{0.35}Cl_{0.2}(OH)_{1.1} \cdot 1.74\ H_2O$)	19.2
$Co_{0.89}V_{0.11}O_x$	56.3
$Co_{0.75}V_{0.25}O_x$	69.5
$Co_{0.58}V_{0.42}O_x$	45.6
$Co_{0.36}V_{0.64}O_x$	25.4
$Co_{0.21}V_{0.79}O_x$	6.8
VO_x ($V_2O_2(OH)_3$)	2.1

Reference

(1) Bockris, J. O. M.; Otagawa, T. *J. Electrochem. Soc.* **1984**, 131, 290-302.