Supporting Information

Application of Non-precious Bifunctional Catalysts for Metal-Air Batteries

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Calculation of the H_2O_2 yield and the electron transfer number n_{app} was conducted based on the measured disc current j_{disc} and ring current j_{ring} using the following formula:[1]

$$n = 100 \frac{4\,j}{\qquad\qquad} \tag{S1}$$

and

$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \tag{S2}$$

with the collection efficiency of the ring $N_{ring} = 0.38$.

From the obtained slopes m in the KL plots, n_{KL} was calculated by the following formula:[2]

$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \tag{S3}$$

with $F = 96485$ C mol^{-1}, $D_0 = 1.9 \cdot 10^{-5}$ cm^2 s^{-1}, $v = 0.01$ cm^2 s^{-1} and $c_O^0 = 1.2 \cdot 10^{-6}$ mol cm^{-3}.

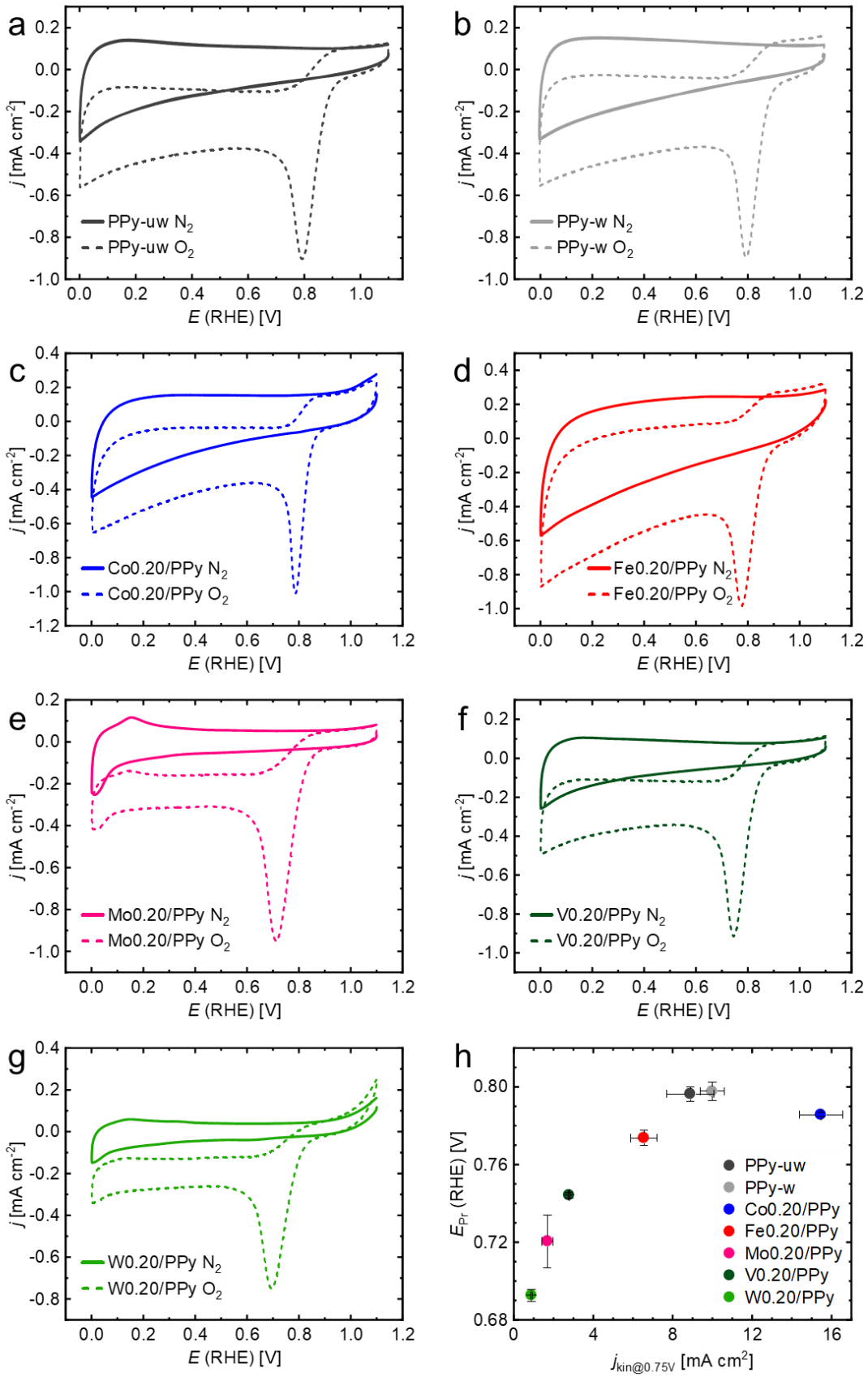

Figure S1: Cyclic voltammograms in N_2- and O_2-saturated electrolyte, recorded at scan rates of 10 mV s^{-1}: (a) PPy-uw, (b) PPy-w, (c) Co0.20/PPy, (d) Fe0.20/PPy, (e) Mo0.20/PPy, (f) V0.20/PPy, (g) W0.20/PPy, (h) peak reduction potentials E_{Pr} plotted against kinetic current densities at 0.75 V.

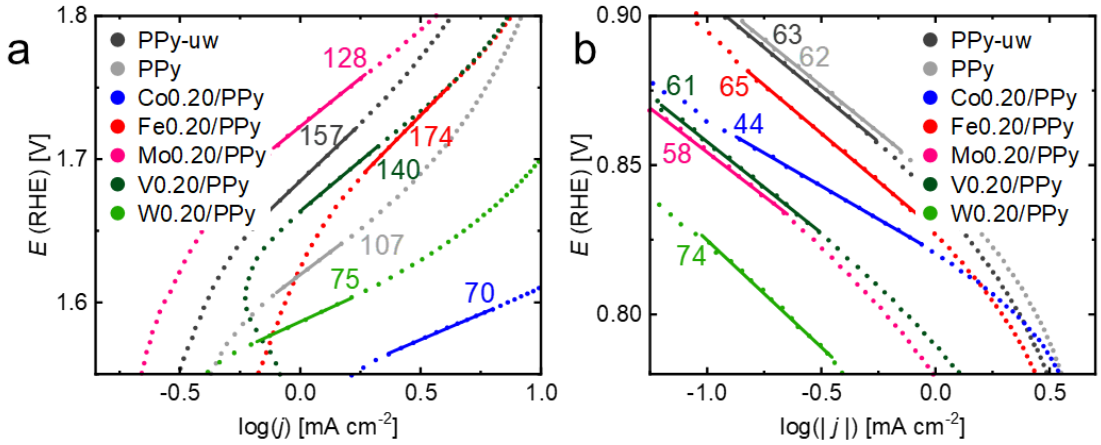

Figure S2: Transition metal variation series: (a) OER Tafel plots, (b) ORR Tafel plots, with Tafel slopes in mV dec^{-1}.

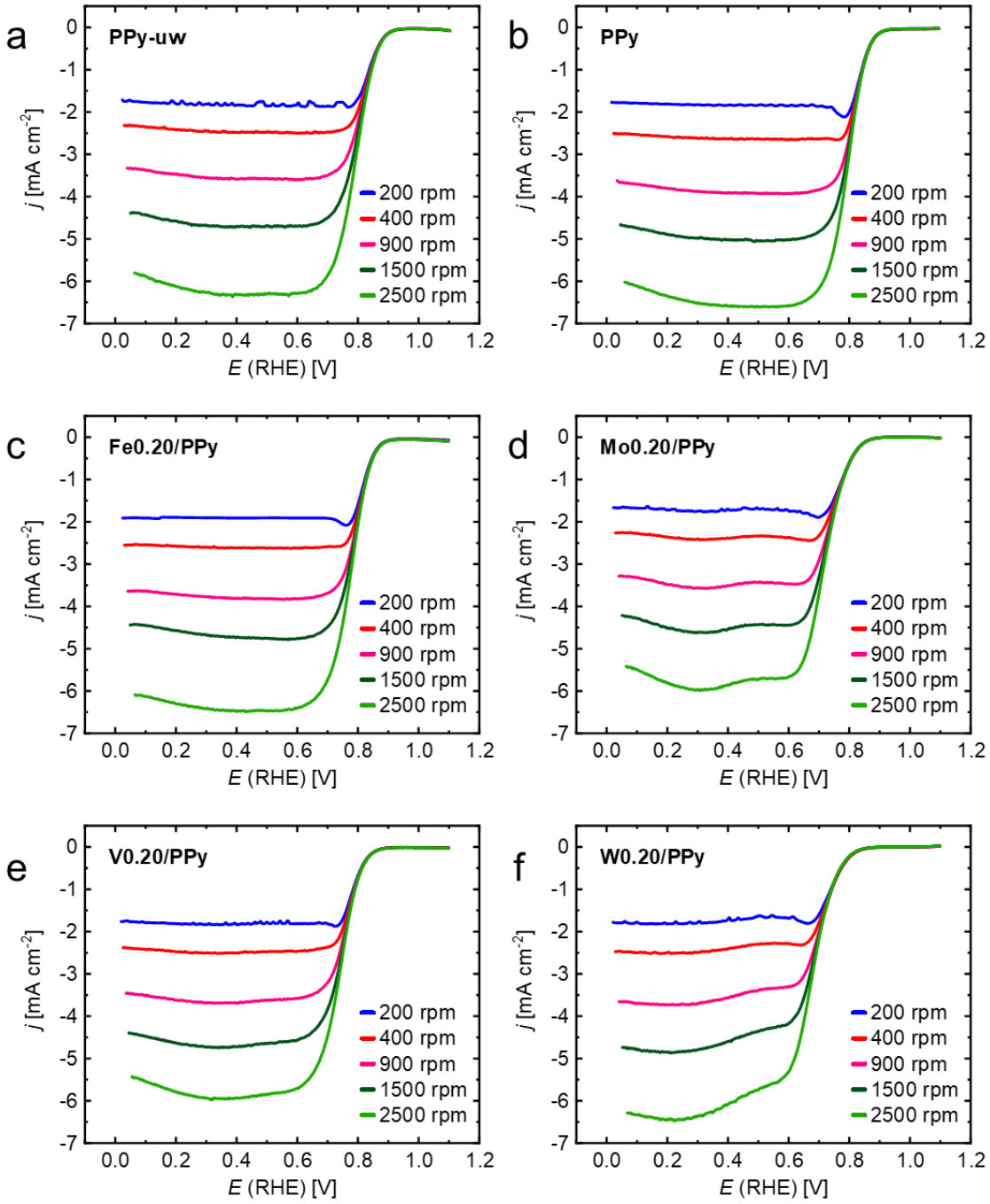

Figure S3: ORR curves recorded at 200, 400, 900, 1500 and 2500 rpm for (a) PPy-uw, (b) PPy, (c) Fe0.20/PPy, (d) Mo0.20/PPy, (e) V0.20/PPy, (f) W0.20/PPy.

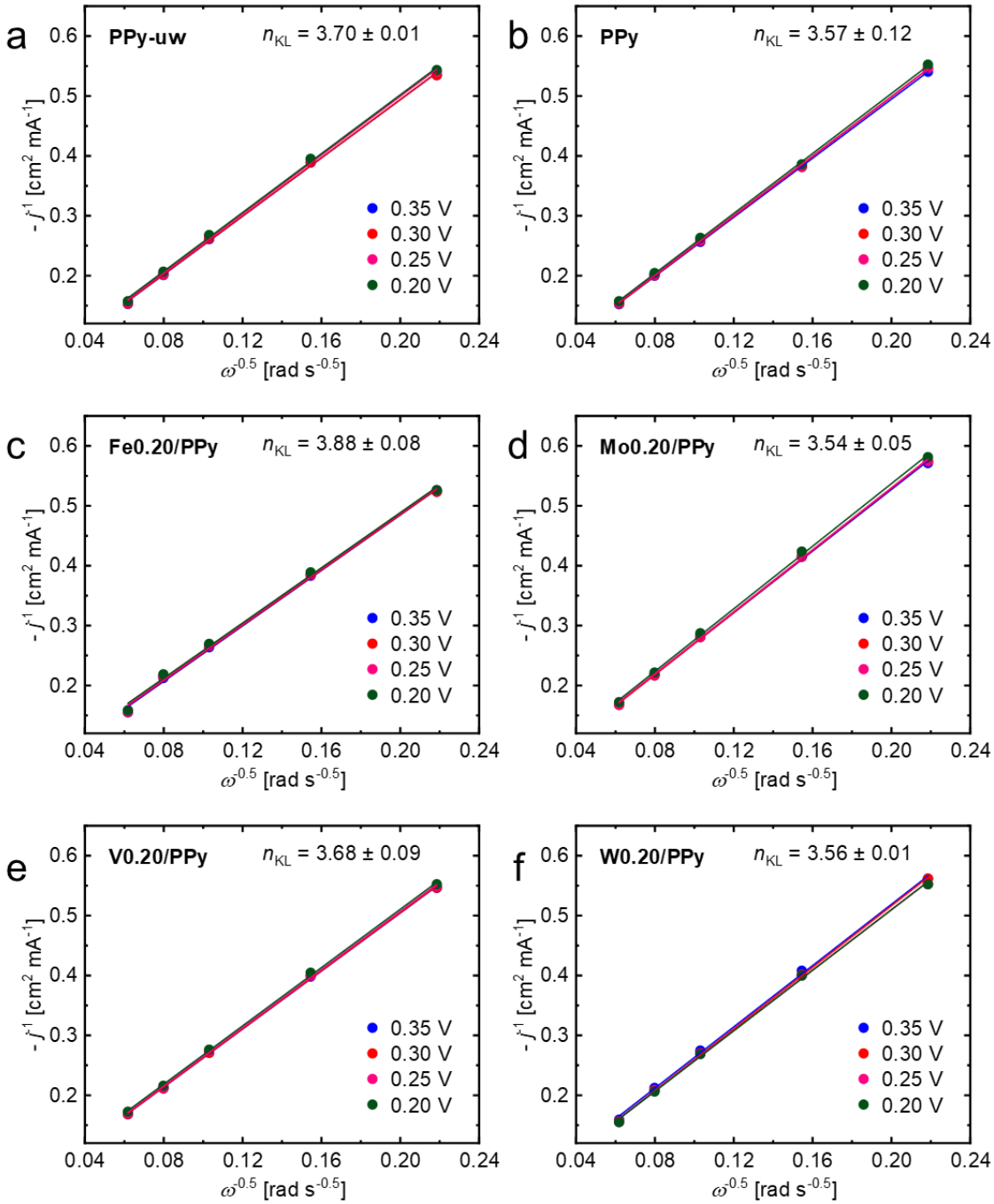

Figure S4: Koutecký-Levich plots of (a) PPy-uw, (b) PPy, (c) Fe0.20/PPy, (d) Mo0.20/PPy, (e) V0.20/PPy, (f) W0.20/PPy.

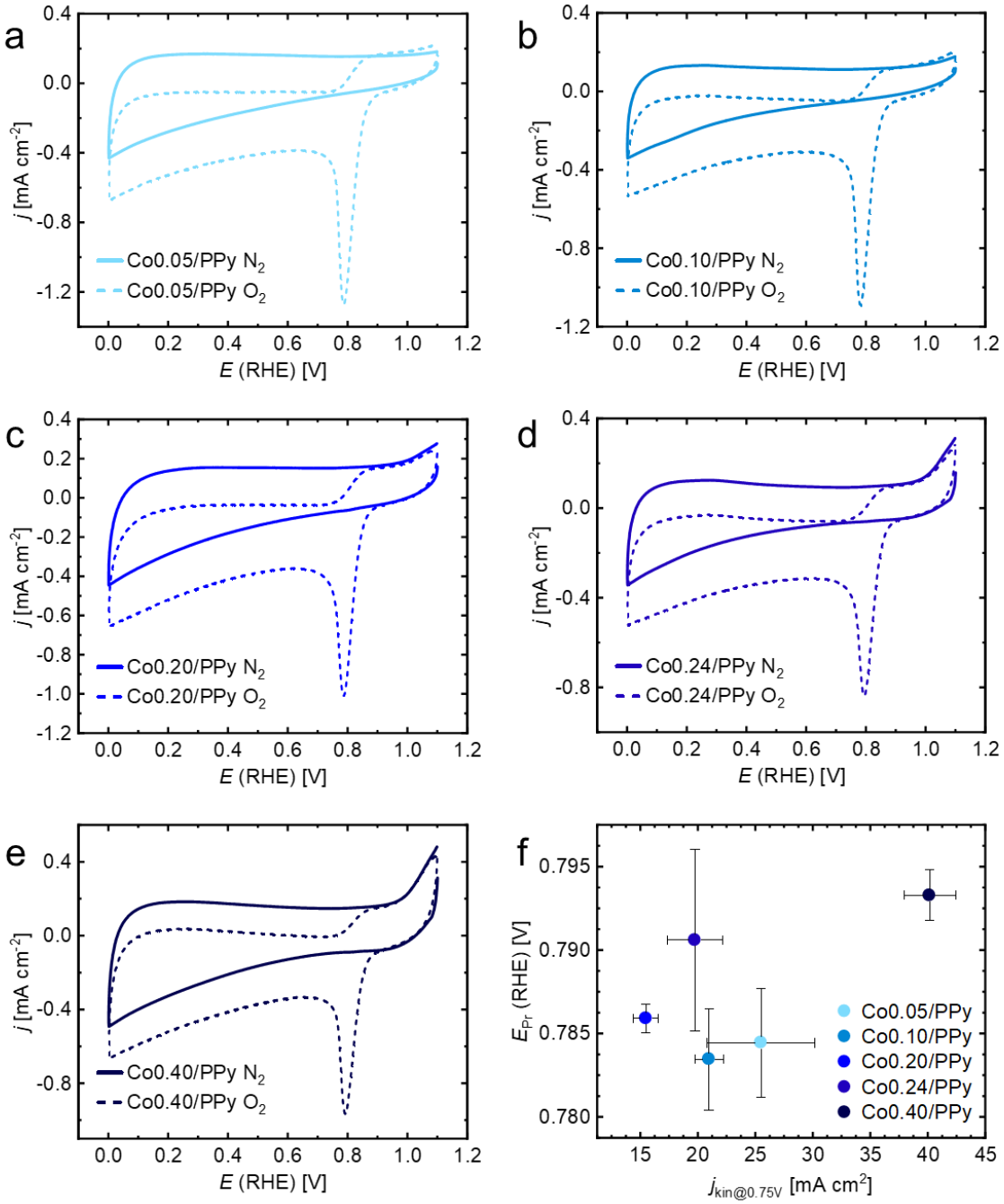

Figure S5: Cyclic voltammograms in N_2- and O_2-saturated electrolyte, recorded at scan rates of 10 mV s^{-1}: (a) Co0.05/PPy, (b) Co0.10/PPy, (c) Co0.20/PPy, (d) Co0.24/PPy, (e) Co0.40/PPy, (f) peak reduction potentials E_{Pr} plotted against kinetic current densities at 0.75 V.

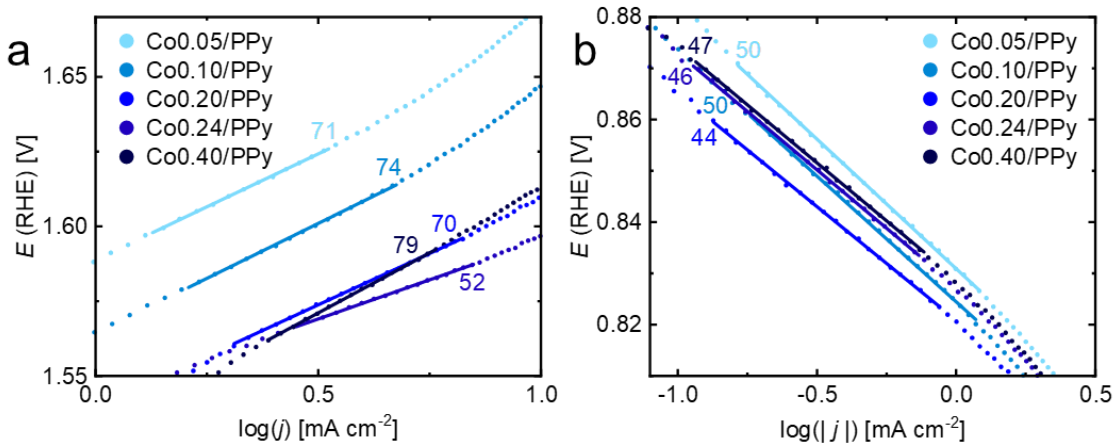

Figure S6: Cobalt loading variation series: (a) OER Tafel plots, (b) ORR Tafel plots, with Tafel slopes in mV dec^{-1}.

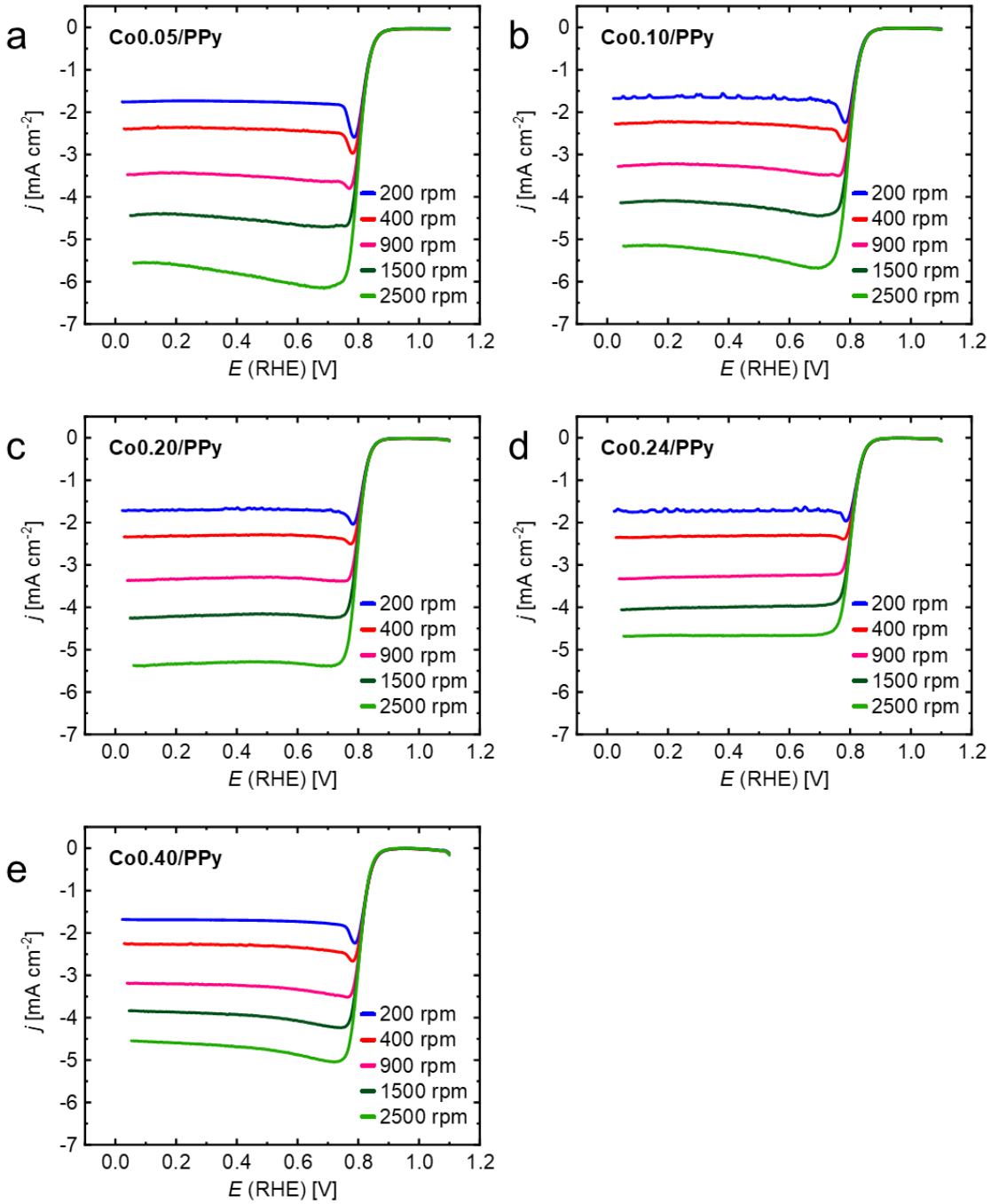

Figure S7: ORR curves recorded at 200, 400, 900, 1500 and 2500 rpm for (a) Co0.05/PPy, (b) Co0.10/PPy, (c) Co0.20/PPy, (d) Co0.24/PPy y, (e) Co0.40/PPy.

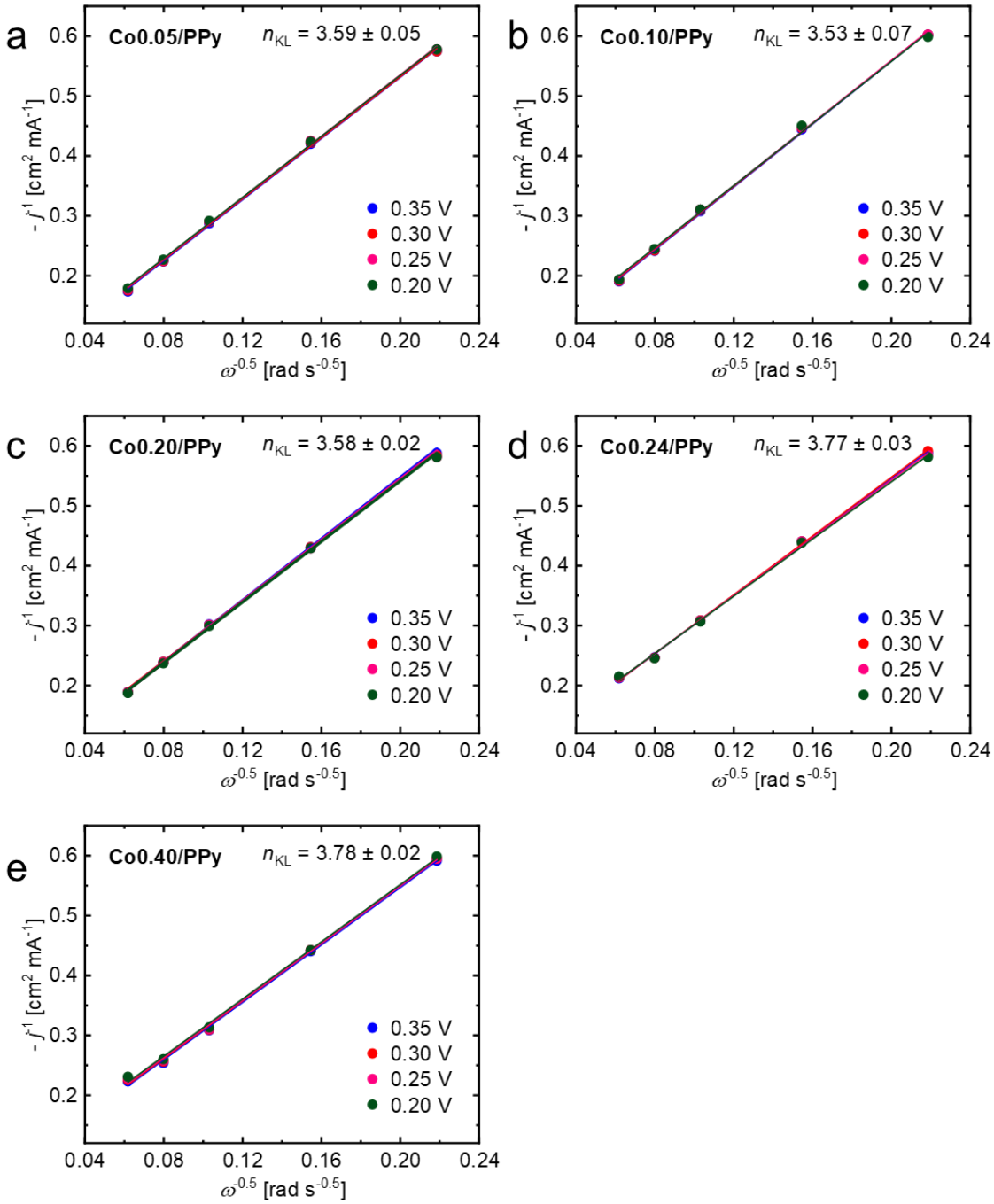

Figure S8: Koutecký-Levich plots for (a) Co0.05/PPy, (b) Co0.10/PPy, (c) Co0.20/PPy, (d) Co0.24/PPy y, (e) Co0.40/PPy.

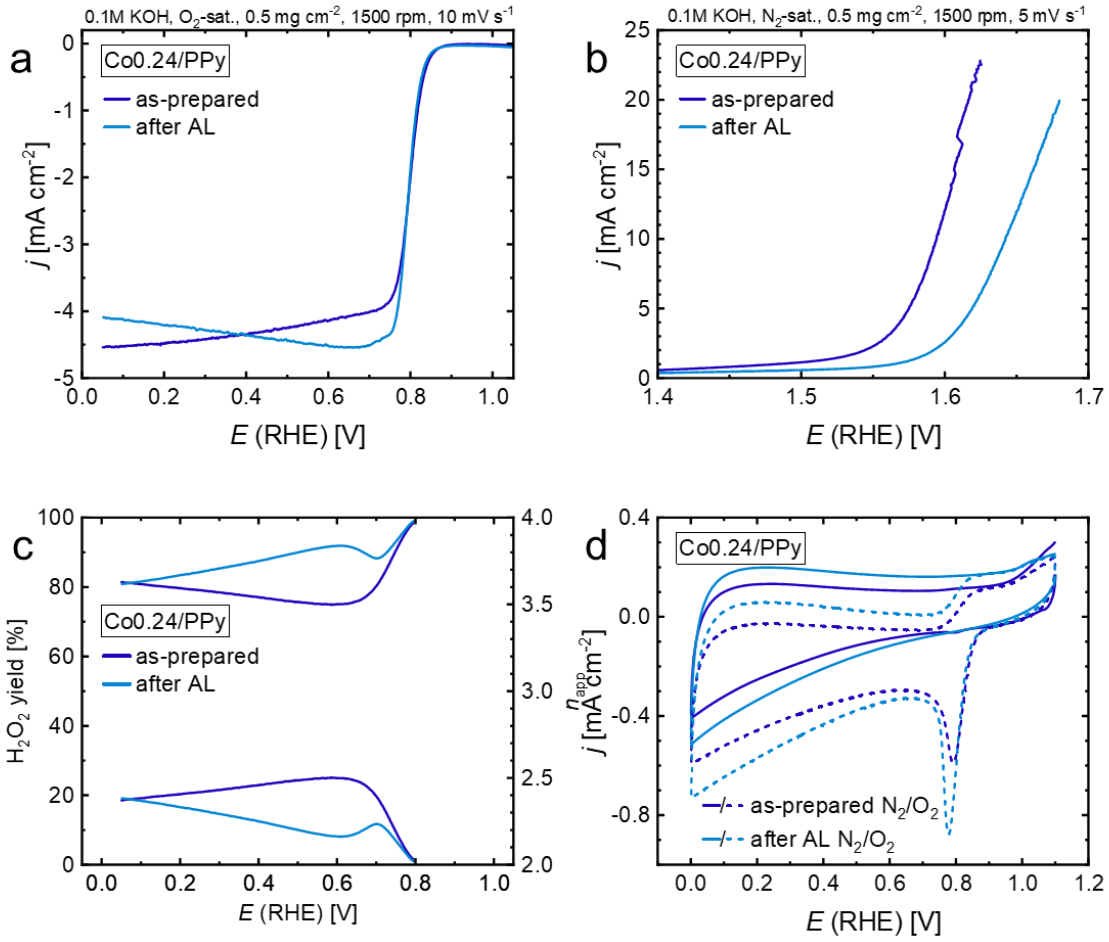

Figure S9: Acid-leaching (AL) of Co0.24/PPy: (a) ORR curves, (b) OER curves, (c) peroxide yield and apparent electron transfer number, (d) CVs recorded in N_2- and O_2-saturated electrolyte. Please note that the catalyst displayed here was prepared from a different polypyrrole batch as well as a larger microwave pyrolysis batch.

[1] Z. Jia, G. Yin, J. Zhang, *Rotating Ring-Disc Electrode Method*, in: *Rotating electrode methods and oxygen reduction electrocatalysts* (Eds: W. Xing, G. Yin, J. Zhang), Elsevier **2014**, 199 – 229.

[2] C. Dua, Q. Tana, Yina. G, J. Jiujun Zhangb, *Rotating Disk Electrode Method*, in: *Rotating electrode methods and oxygen reduction electrocatalysts* (Eds: W. Xing, G. Yin, J. Zhang), Elsevier **2014**, 171 – 198.