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Supplementary information for:

Anion exchange membrane water electrolysis using Aemion^{TM} membranes and nickel electrodes

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✓ *Performance analysis of AEMWE system using a broken membrane*

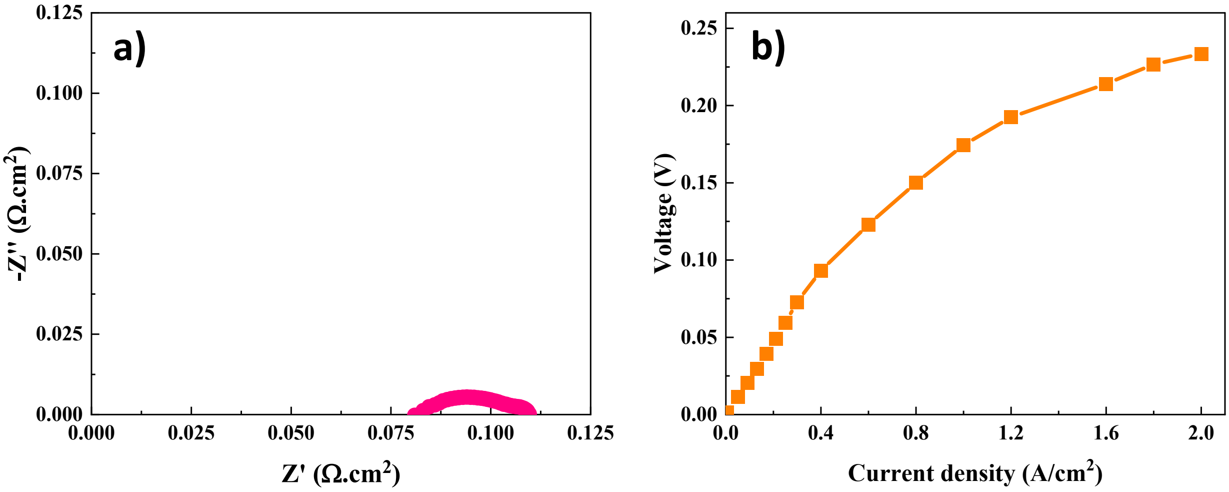

Fig. S1 Electrochemical characterization of AEMWE system using a broken membrane; a) EIS at 100 mV and b) Polarization curve at 60 °C by circulating 1 M KOH.

✓ *Effect of electrolyte purity on the AEMWE performance*

Table S1 KOH properties (data are based on Sigma-Aldrich company's website).

KOH type	KOH content	Water	Anion traces	Cation traces	N compounds	K_2CO_3
85%	>85%	10-15%	Cl^- : ≤0.01% SO_4^{2-}: ≤0.003% PO_4^{3-}: ≤5 ppm	Ca: ≤0.005% Fe: ≤0.001% Mg: ≤0.002% Na: ≤0.05% Ni: ≤0.001% Heavy metals: ≤0.001%	≤0.001%	≤2.0 %
99.99%*	>85%	15%	-	Na: ≤500 ppm	-	-

*99.99% Based on Trace Metals Analysis, Excludes Sodium Content Trace Metal Analysis

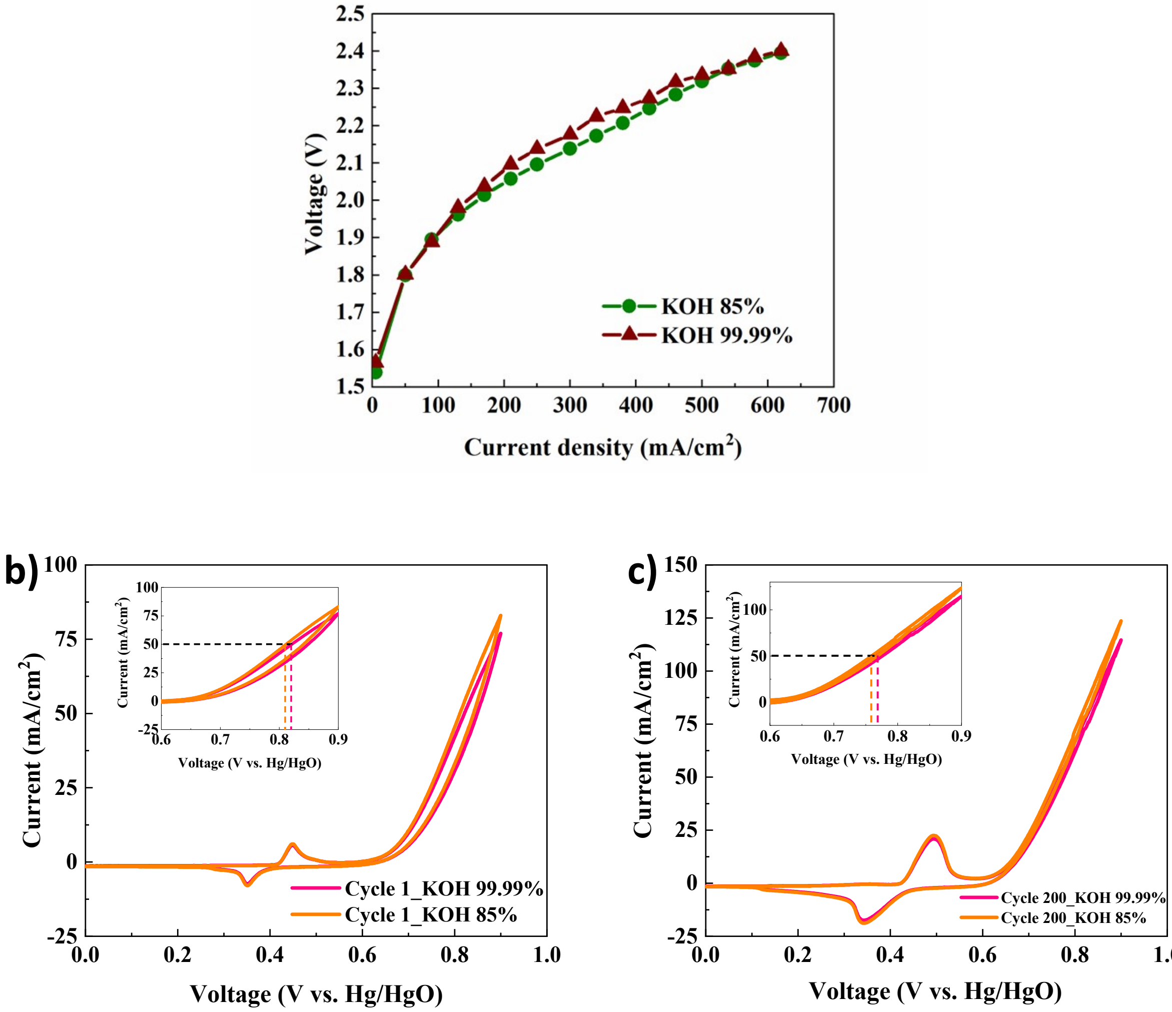

Fig. S2 a) Polarization curves of AEMWE system using AF1-HNN8-50 AEM and 1 M KOH electrolyte in two different purities at BOT. (Other experimental conditions: 10 rpm flow rate and operation at 60 ^{0}C); b,c) Three- electrode cyclic voltammetry at 10 mV/s using nickel electrode as working electrode in 1 M KOH electrolytes with two different purities (platinium and Hg/HgO were used as counter and reference electrodes).

✓ ***Steady-state AEMWE without remixing the electrolyte***

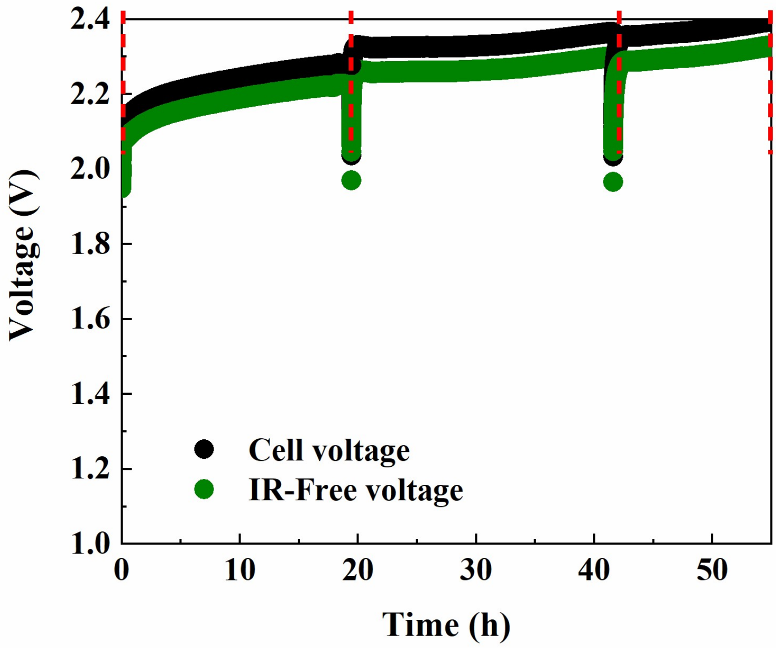

Fig. S3 Degradation tests of AEMWE system at 200 mA/cm^2 with two repetiotions and using AF1-HNN5-50 as the AEM. The electrolytes were not remixed during the electrolysis.

✓ *Electrolyte volume change during steady-state water electrolysis*

Table S2 Electrolyte volume change using AF1-HNN8-50 AEM

	Test 1 (Beginning)	Test 2 (22 h)	Test 3 (44 h)	Test 4 (66 h)	Test 5 (88 h)	Test 6 (111 h)
Anode	250 mL	285 mL	290 mL	293 mL	294 mL	295 mL
Cathode	250 mL	200 mL	195 mL	193 mL	194 mL	193 mL

Table S3 Electrolyte volume change using AF1-HNN5-50 AEM

	Test 1 (Beginning)	Test 2 (20 h)	Test 3 (43 h)	Test 4 (66 h)	Test 5 (89 h)	Test 6 (112 h)
Anode	250 mL	270 mL	283 mL	283 mL	280	277 mL
Cathode	250 mL	215 mL	205 mL	208 mL	213	210 mL

Table S4 Electrolyte volume change using AF1-HNN8-25 AEM

	Test 1 (Beginning)	Test 2 (20 h)	Test 3 (42 h)	Test 4 (64 h)	Test 5 (86 h)	Test 6 (108 h)
Anode	250 mL	286 mL	288 mL	300 mL	300	300 mL
Cathode	250 mL	195 mL	192 mL	190 mL	190	190 mL

Table S5 Electrolyte volume change using AF1-HNN5-25 AEM

	Test 1 (Beginning)	Test 2 (20 h)	Test 3 (42 h)	Test 4 (62 h)	Test 5 (85 h)	Test 6 (106 h)
Anode	250 mL	280 mL	280 mL	290 mL	290 mL	290 mL
Cathode	250 mL	190 mL	190 mL	195 mL	200 mL	200 mL

✓ *Water transport theoretical calculations based on Faraday's law*

Experimental conditions: 23 h steady state electrolysis at 1 A, 250 mL electrolyte (1 M KOH) on each side.

Cathode side (HER): $2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$	**Anode side (OER):** $4OH^- \rightleftharpoons O_2 + 2H_2O + 4e^-$
Produced H_2: $I \times t = n_{mol} \times 96500 \times n_{e^-}$ $n_{H_2} =$ 0.429 moles Consumed H_2O: $n_{H_2O} = 2n_{H_2} =$ 0.858 moles $V_{H_2O} =$ (0.858 × 18.015 × 1) = 15.457 mL Produced OH^-: $n_{OH^-} =$ 0.858 moles Lost water (Consumed+Crossedover): 15.457+54.101= 69.558 mL Compensated water from Anode: 7.728 mL **Reduced water: 61.836 mL**	Produced O_2: $I \times t = n_{mol} \times 96500 \times n_{e^-}$ $n_{O_2} =$ 0.214 moles Consumed OH^-: $n_{OH^-} = 4n_{O_2} =$ 0.858 moles Crossedover H_2O by OH^- from the cathode side: $n_{H_2O} = (3.5 \times n_{OH^-}) = 3.003$ moles $V_{H_2O} = (3.003 \times 18.015 \times 1) = 54.101$ $V_{H_2O} =$ 54.101 mL Produced and crossedover H_2O to the cathode side: $V_{H_2O} = 2n_{O_2} \times 18.015 \times 1 =$ 7.728 mL **Surplus water: 46.373 mL**

- ✓ ***Equivalent electrical circuit***

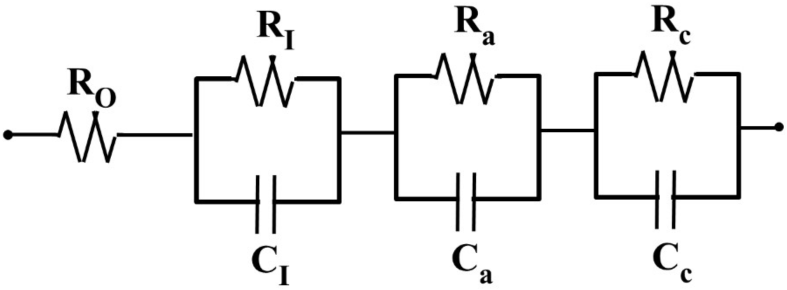

Fig. S4 Equivalent electrical circuit for analysis of the four-point electrochemical impedance spectroscopy data.

✓ ***NMR analysis of Aemion HNN5-50 membrane in two different conditions***

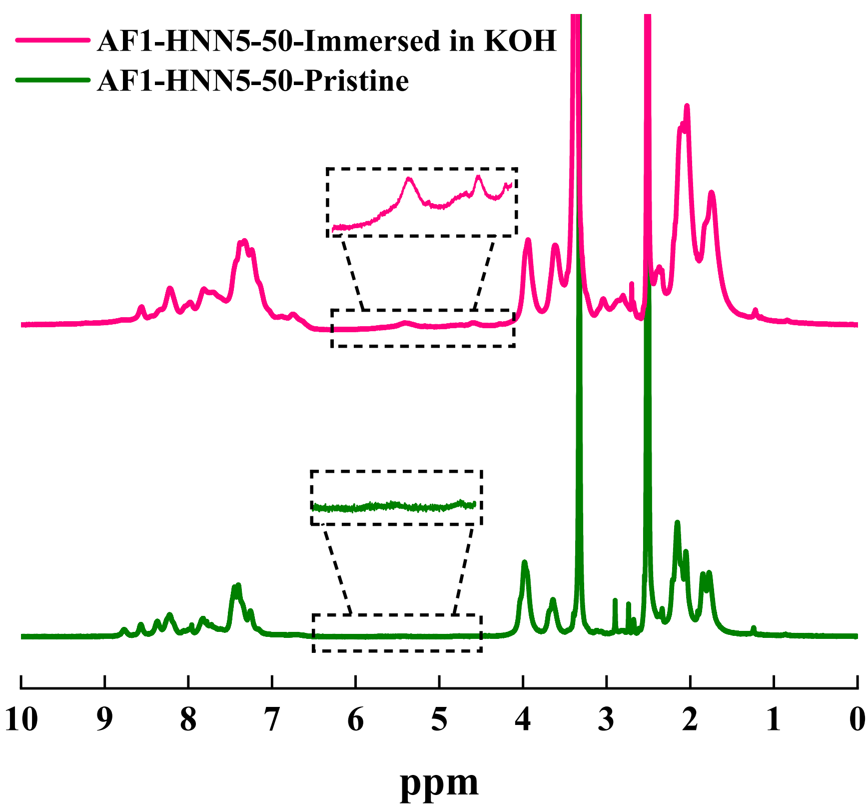

Fig. S5 ^{1}H NMR spectra of HNN5-50, in the pristine form (lower), and after exposure to 2 M KOH at 90 °C for 1 month (upper, spectra were recorded in DMSO-d_6).