Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Supporting Information: On the stability of anion exchange membrane fuel cells incorporating polyimidazolium ionene (Aemion+®) membranes and ionomers

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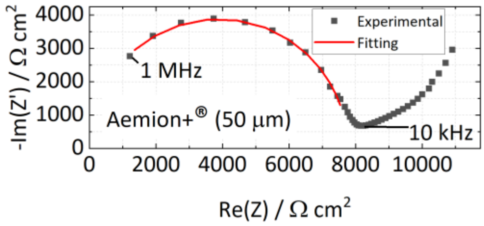
a



b

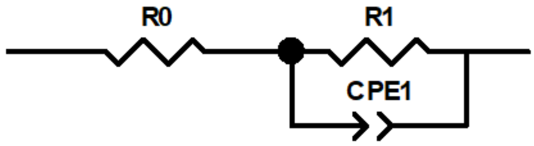


Figure S1: (a) Example of fitting the EIS spectra for ex-situ conductivity measurements. Fitting was conducted with the equivalent circuit **(b).** R1 is taken as the resistance for ionic conduction within the AEM.

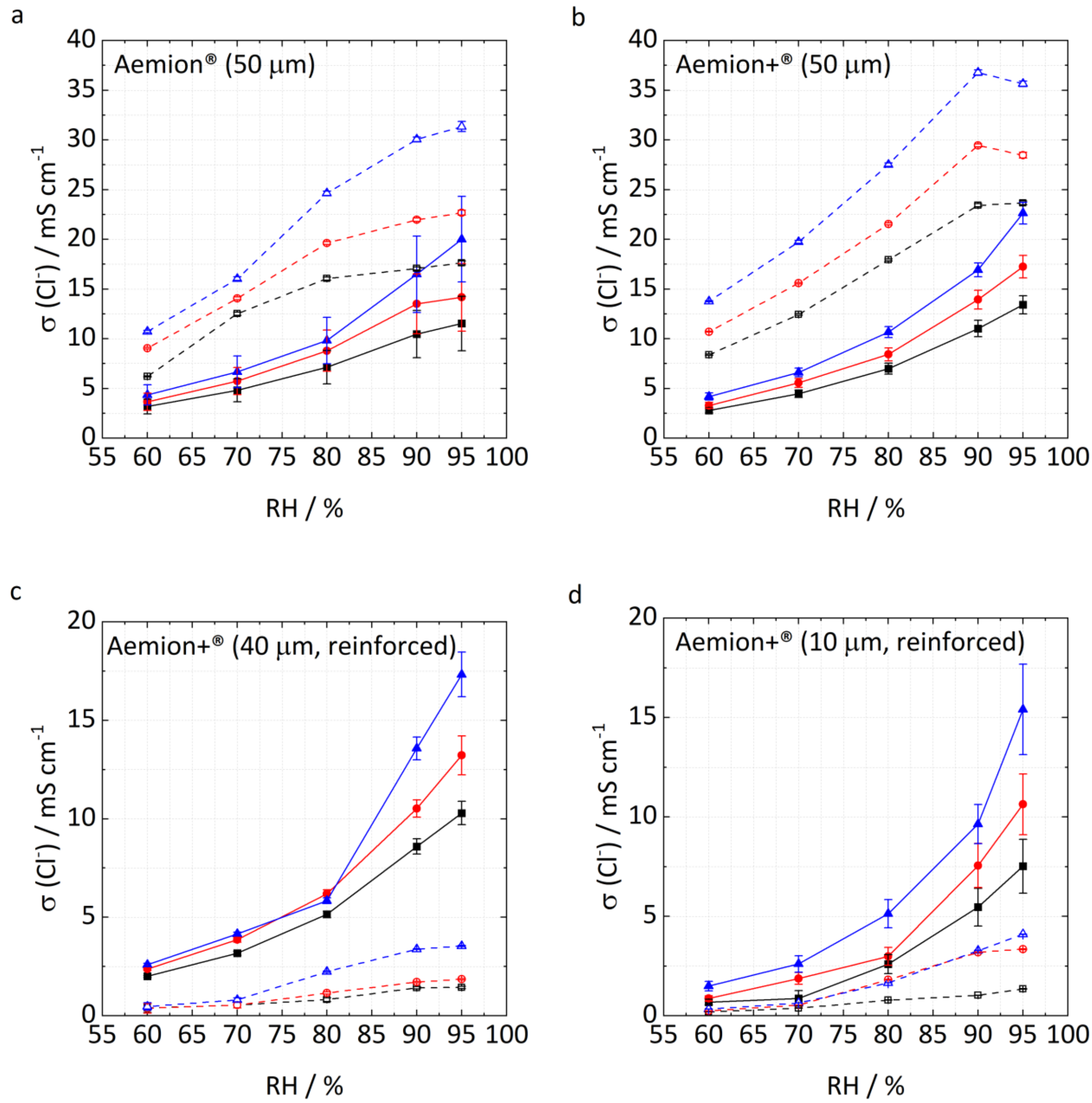


Figure S2: In-plane (solid) and through-plane (dashed) Cl^- conductivity for all AEMs tested at 60 (black), 70 (red) and 80 (blue) °C.

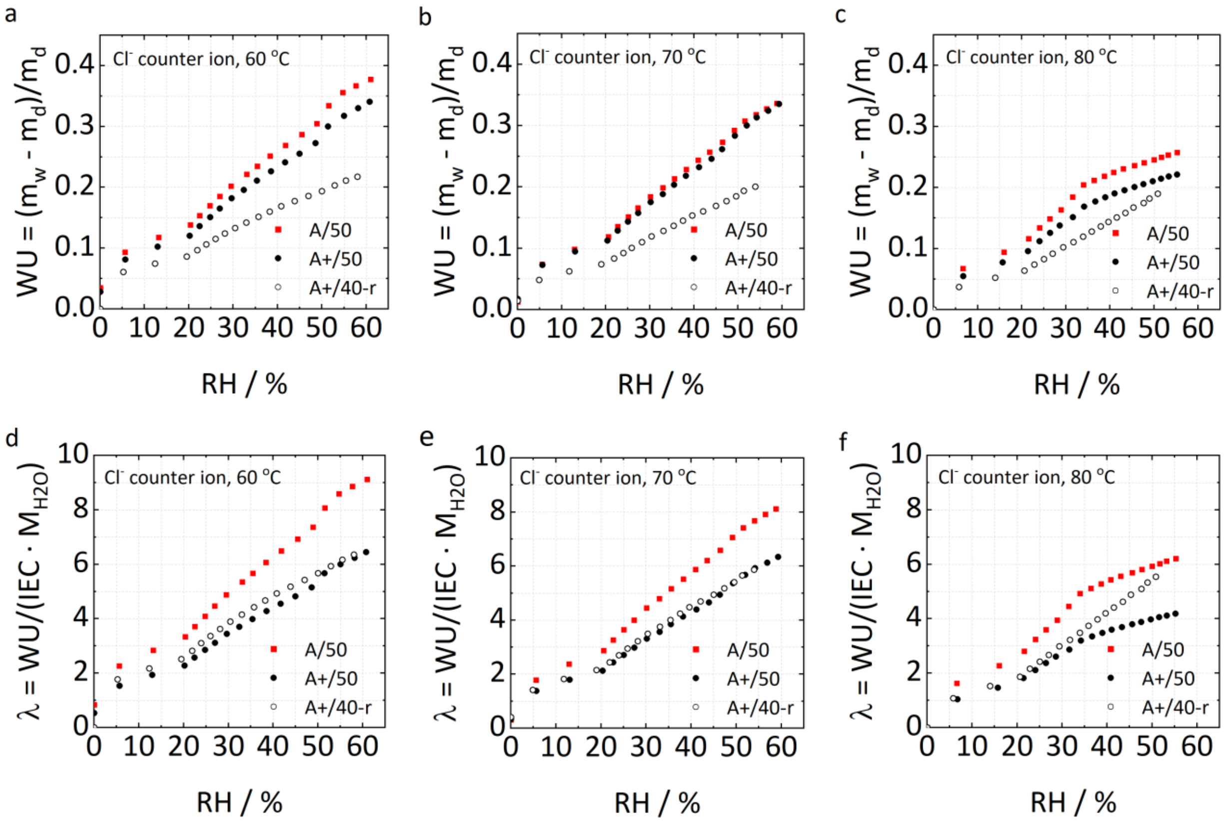


Figure S3: DVS for all three temperatures and AEMs investigated in the AEMFC study. Thicker variants were used for direct comparison with the ex-situ conductivity measurements. All isotherms were acquired in the desorption direction (high RH to low). Materials characterized are: ■ Aemion®, 50 µm (A/50) ● Aemion+®, 50 µm (A+/50) ○ Aemion®+, 40 µm, reinforced (A+/40-r).

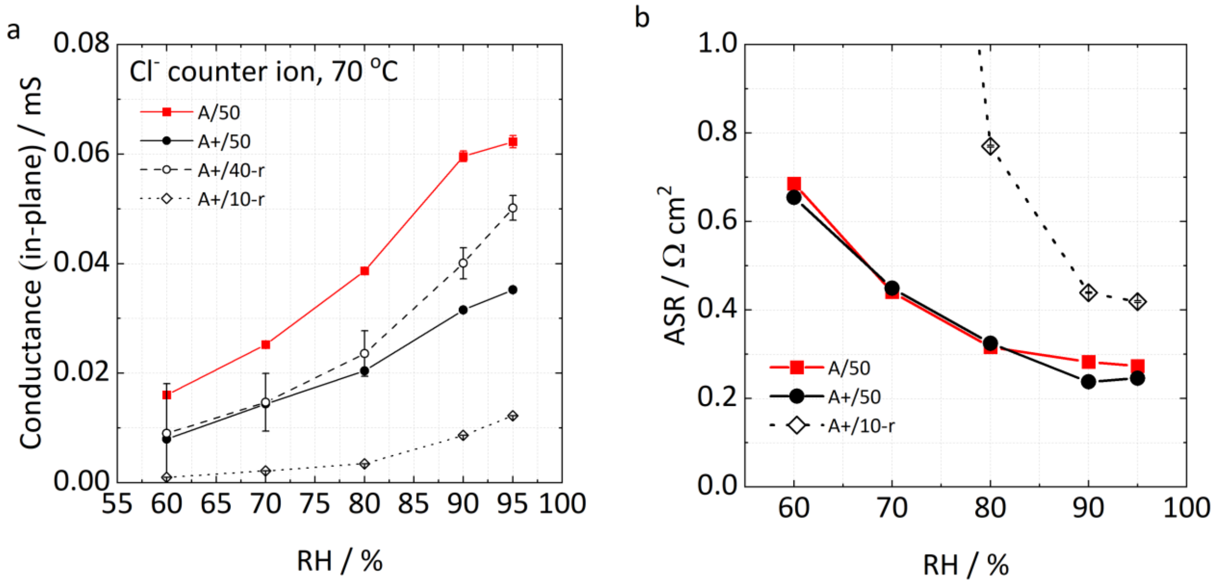


Figure S4: (a) In-plane conductance for AEMs in their Cl^- form at 70 °C and (b) through-plane area specific resistance focused on the monolithic AEMs. Materials characterized are: ■ Aemion®, 50 µm

(A/50) ● Aemion+®, 50 µm (A+/50) ○ Aemion®+, 40 µm, reinforced (A+/40-r) and ◇ Aemion+®, 10 µm, reinforced (A+/10-r).

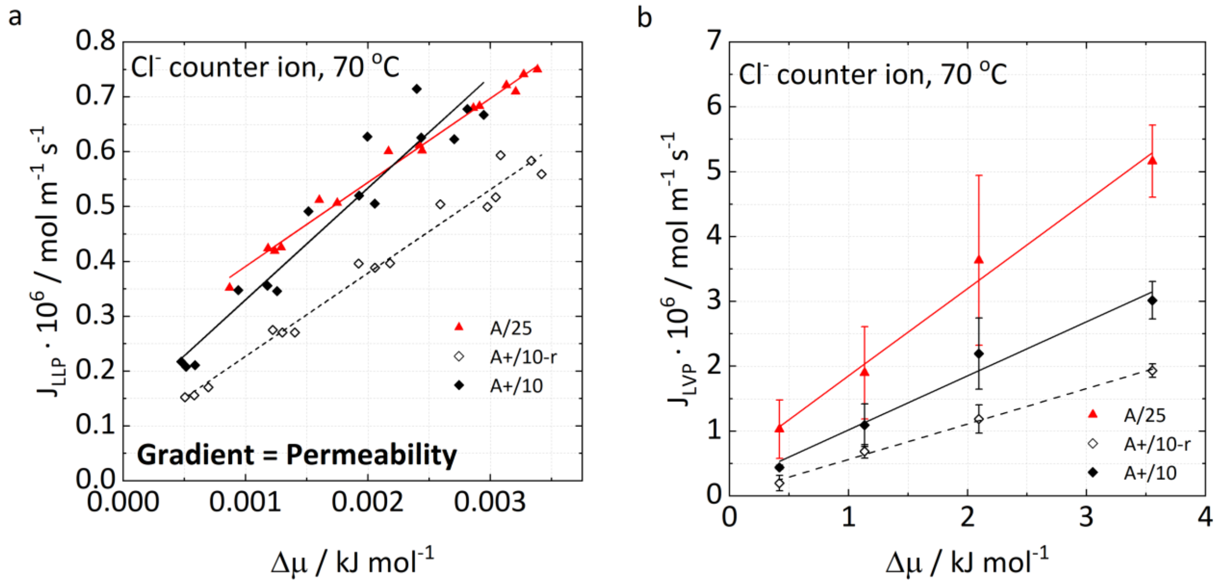
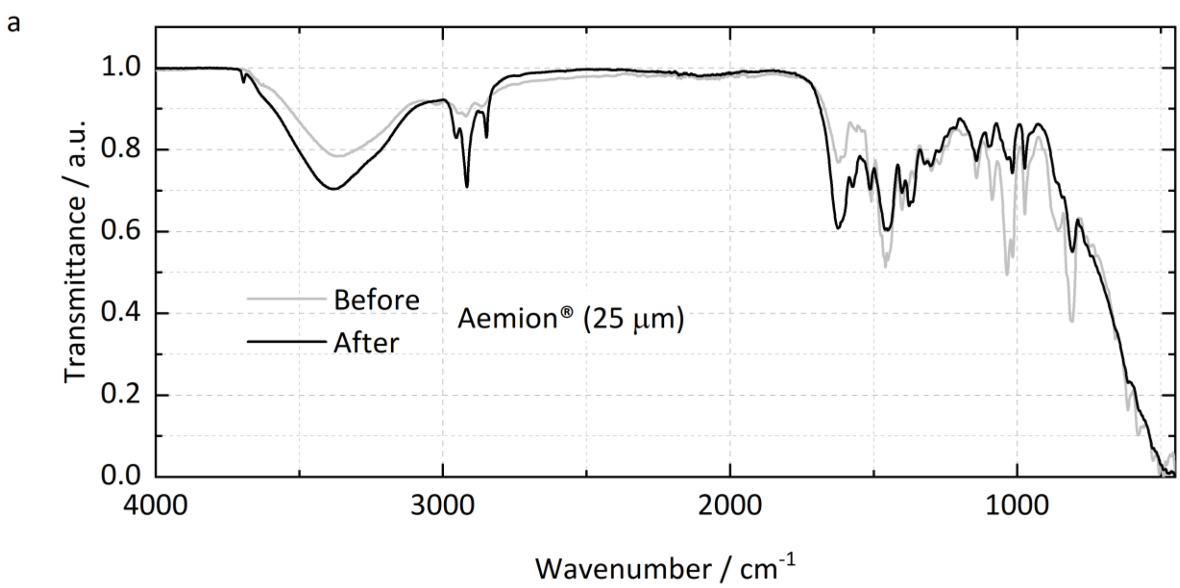
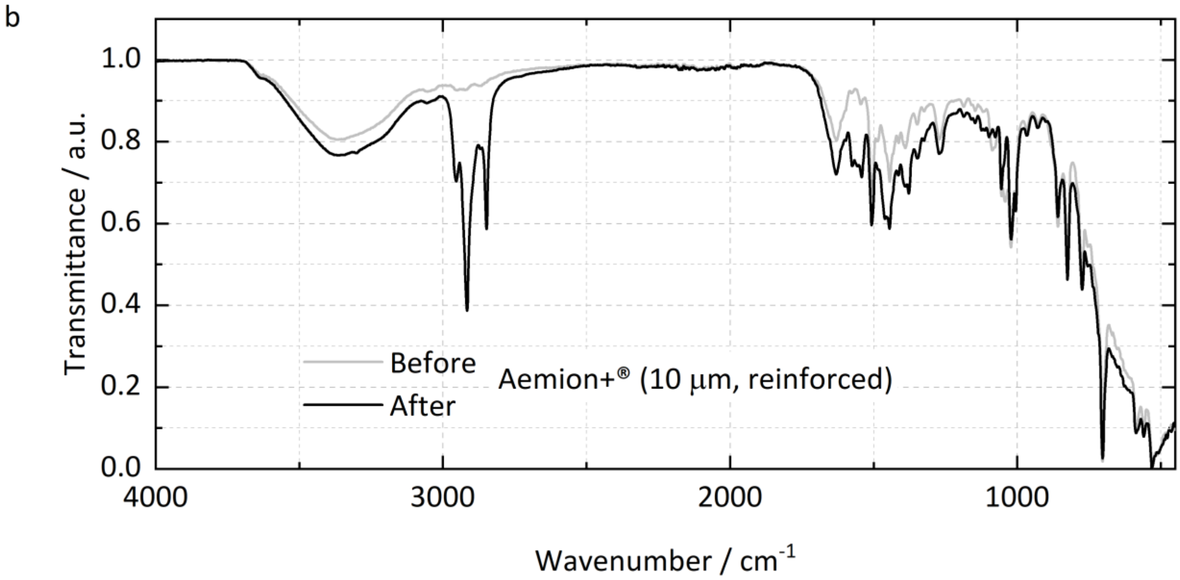


Figure S5: (a) LLP and **(b)** LVP where the water flux on the y-axis is normalized for the wet thickness of the AEM. The slope therefore corresponds to the permeability. Materials characterized are: ▲ Aemion®, 25 µm (A/25) ◆ Aemion+®, 10 µm (A+/10) and ◇ Aemion+®, 10 µm, reinforced (A+/10-r).





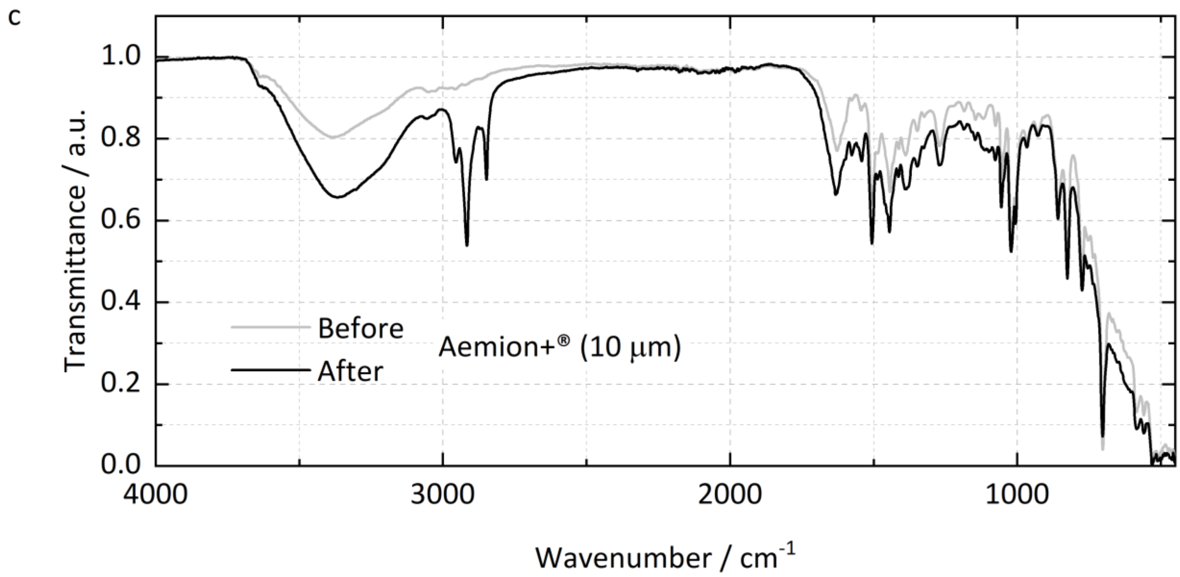


Figure S6: ATR-FTIR of AEMs in their Cl^- form. Before (pristine) and after degradation by submerging in 3 M $KOH_{(aq)}$ for 7 days at 80 °C. **(a)** Aemion®, 25 µm, **(b)** Reinforced Aemion+®, 10 µm, **(c)** Aemion+®, 10 µm. Transmittance is normalized between 1-0.

	Tensile Strength / MPa	Elongation at break / %	Young's Modulus / MPa
Aemion+® (10 µm)	28 ± 4	40 ± 14	443 ± 58
Aemion+® (10 µm, reinforced)	29 ± 10	61 ± 24	403 ± 132

Table S1: Mechanical strength tests of AEMs in their Cl^- form, atmospheric conditions after degradation in 3M $KOH_{(aq)}$ for 7 days at 80 °C. Aemion® was too brittle after the degradation test to be measured.

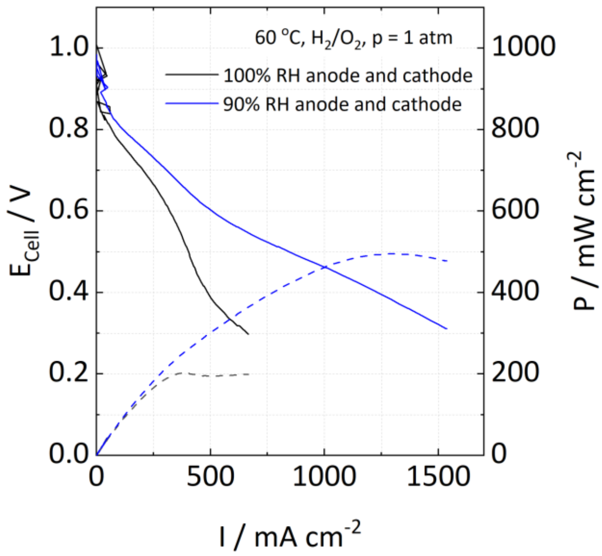


Figure S7. Polarization curves and power density curves of single cells between OCP and 0.3 V using TKK Pt/C as cathode and PtRu/C as anode with a Pt loading of 0.5 mg_{Pt} cm^{-2} on both cathode and anode. The H_2 and O_2 flows are set to 0.5 slpm. The cell temperature was 60 °C. The effect of anode and cathode RH on an MEA with Aemion+® (10 µm, reinforced) is shown.

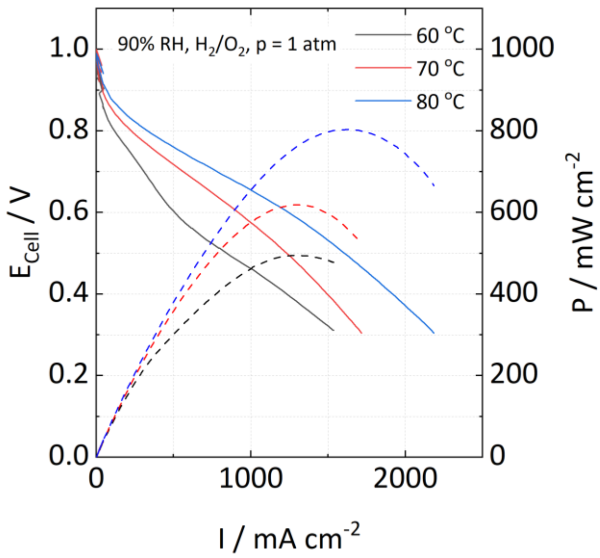


Figure S8. Polarization curves and power density curves of single cells between OCP and 0.3 V using TKK Pt/C as cathode and PtRu/C as anode with a Pt loading of 0.5 mg_{Pt} cm^{-2} on both cathode and anode. The H_2 and O_2 flows are set to 0.5 slpm. The RH at the anode and cathode was 90%. The effect of cell temperature on an MEA with Aemion+® (10 µm, reinforced) is shown.

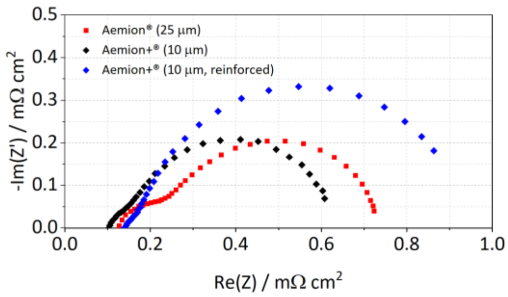


Figure S9: EIS in the frequency range 10 kHz – 0.1 Hz at 0.8 V with amplitude 10 mV. AEMFC conditions are the same as in **Figure 2a**.

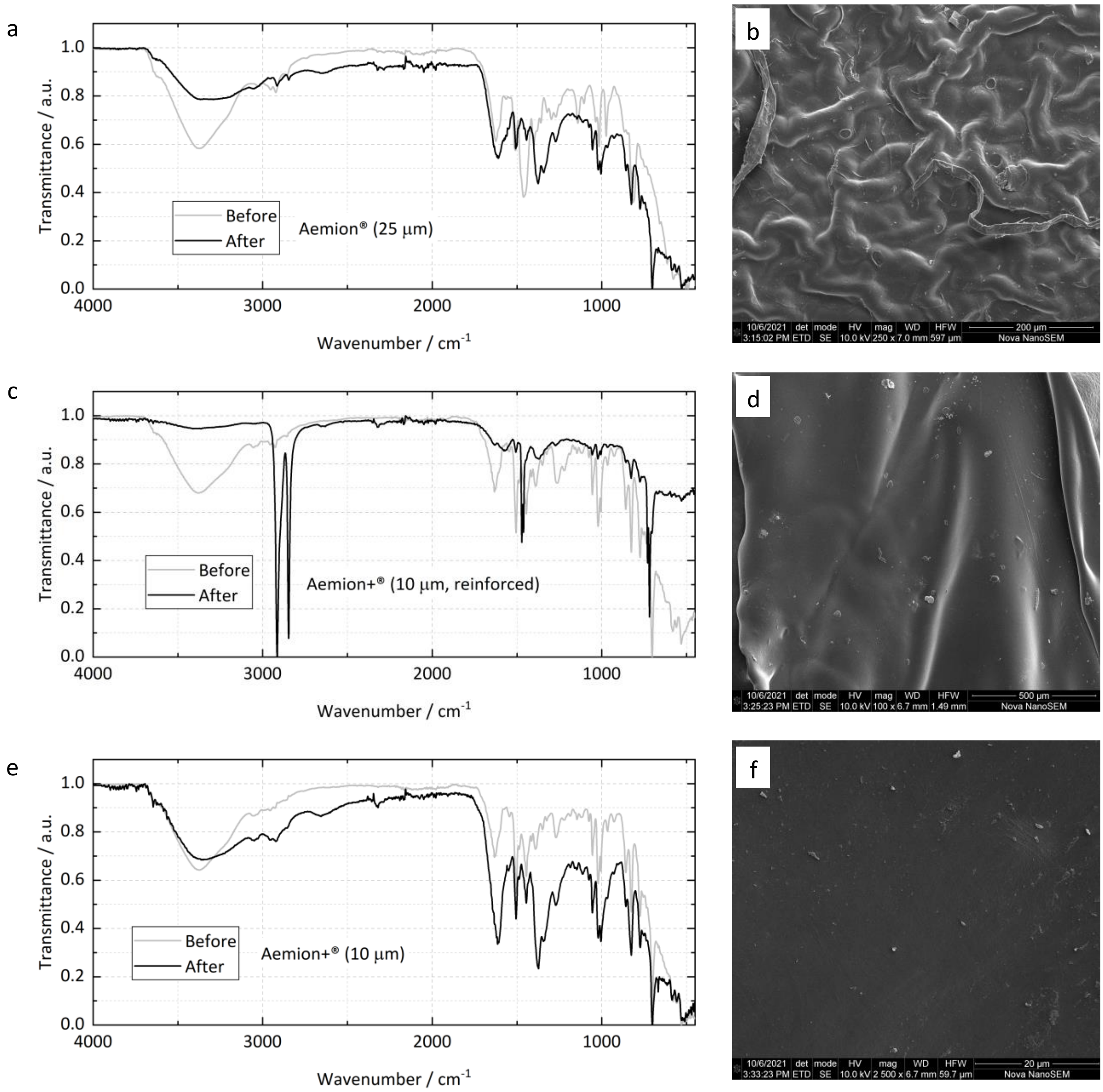


Figure S10: ATR-FTIR spectrums and matching active area surface SEM images of membranes after AEMFC test: **(a)-(b)** Aemion® (25 μm); **(c)-(d)** Aemion®+ (10 μm); **(e)-(f)** Aemion®+ (10 μm, reinforced). Transmittance is normalized between 1-0.

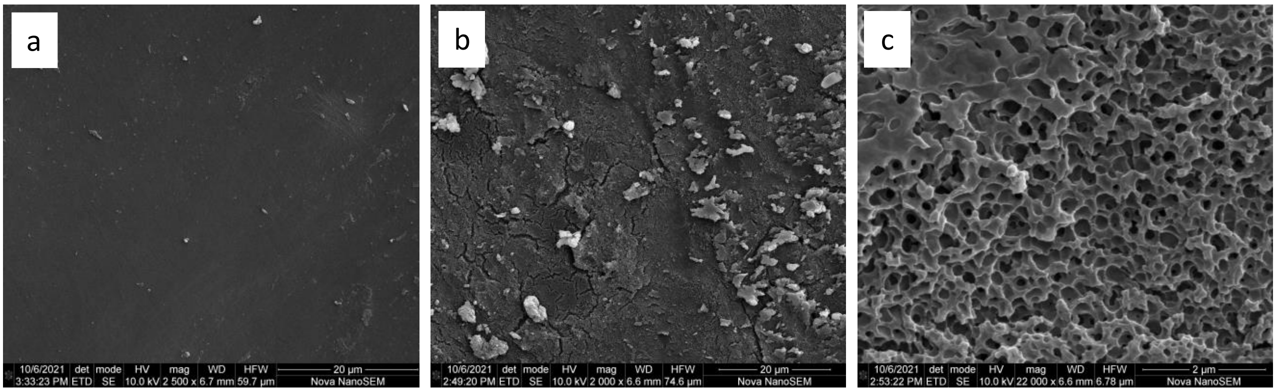


Figure S11: Active area surface SEM images of the reinforced Aemion®+ membrane: **(a)** Anode side; **(b)** Cathode side; **(c)** Side B magnification.

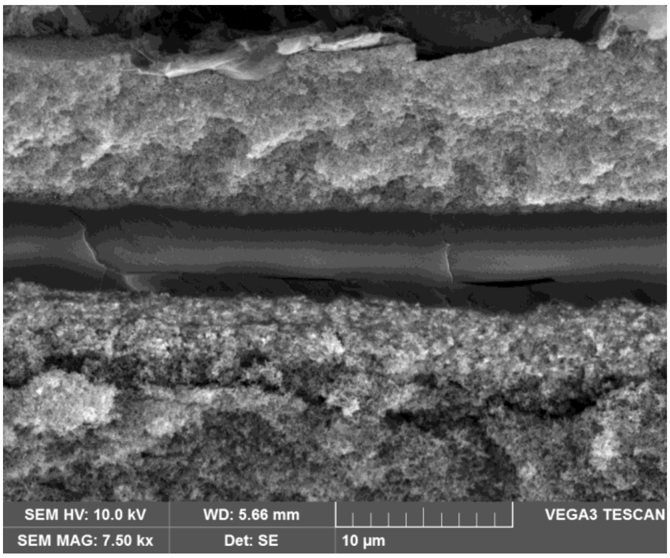


Figure S12: SEM image of the MEA cross-section of the DMD-based AEM fuel cell, showing the thin total membrane thickness of only 5 µm.

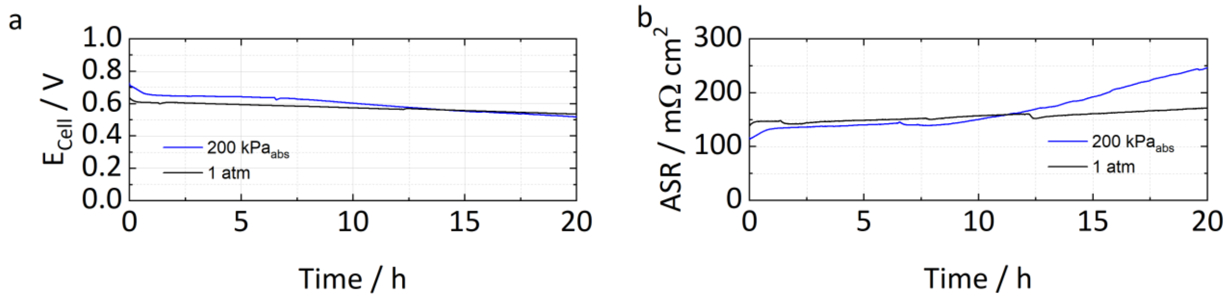


Figure S13: (a) Voltage decay and, **(b)** ASR increase of single cells with TKK Pt/C as cathode and PtRu/C as anode with a Pt loading of 0.5 mg_{Pt} cm^{-2} on both cathode and anode. The H_2 and O_2 flows are set to 0.5 slpm. The RH at the anode and cathode was 90%. The cell temperature was 70 °C and the current density was 600 mA cm^{-2}. Aemion+® (10 µm, reinforced) was used as the AEM.