Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

ELECTRONIC SUPPLIMENTAL INFORMATION

A high conductivity ultrathin anion-exchange membrane with 500+ h alkali stability for use in alkaline membrane fuel cells that can achieve 2 W cm^{-2} at 80 °C

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This document provides additional data in support of the main article

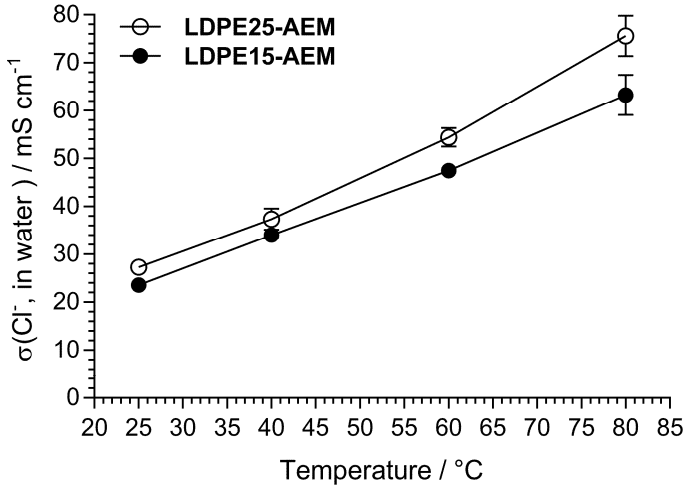

Fig. S1 The 4-probe (in-plane) conductivities of **LDPE15-AEM** and **LDPE25-AEM** on the chloride anion forms submerged in water. Error bars are from measurements on *n* = 3 samples of each anion form of the AEM (some error bars are smaller than the symbols).

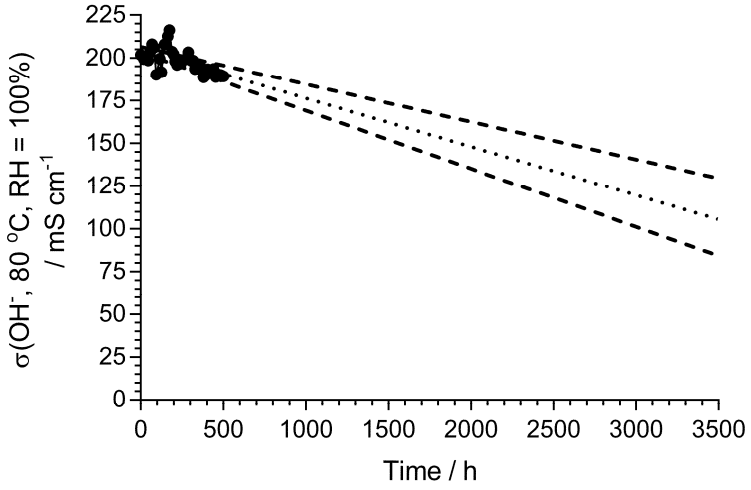

Fig. S2 A 500 h *ex situ* stability test where **LDPE15-AEM** was maintained in the OH^- form at 80 °C in a N_2 (CO_2-free, RH = 100%) gas flow. The extended linear regression to 3500h is shown (dotted line) with the best- and worst-case scenarios donated with the dashed lines (based on the standard errors of the linear regression).

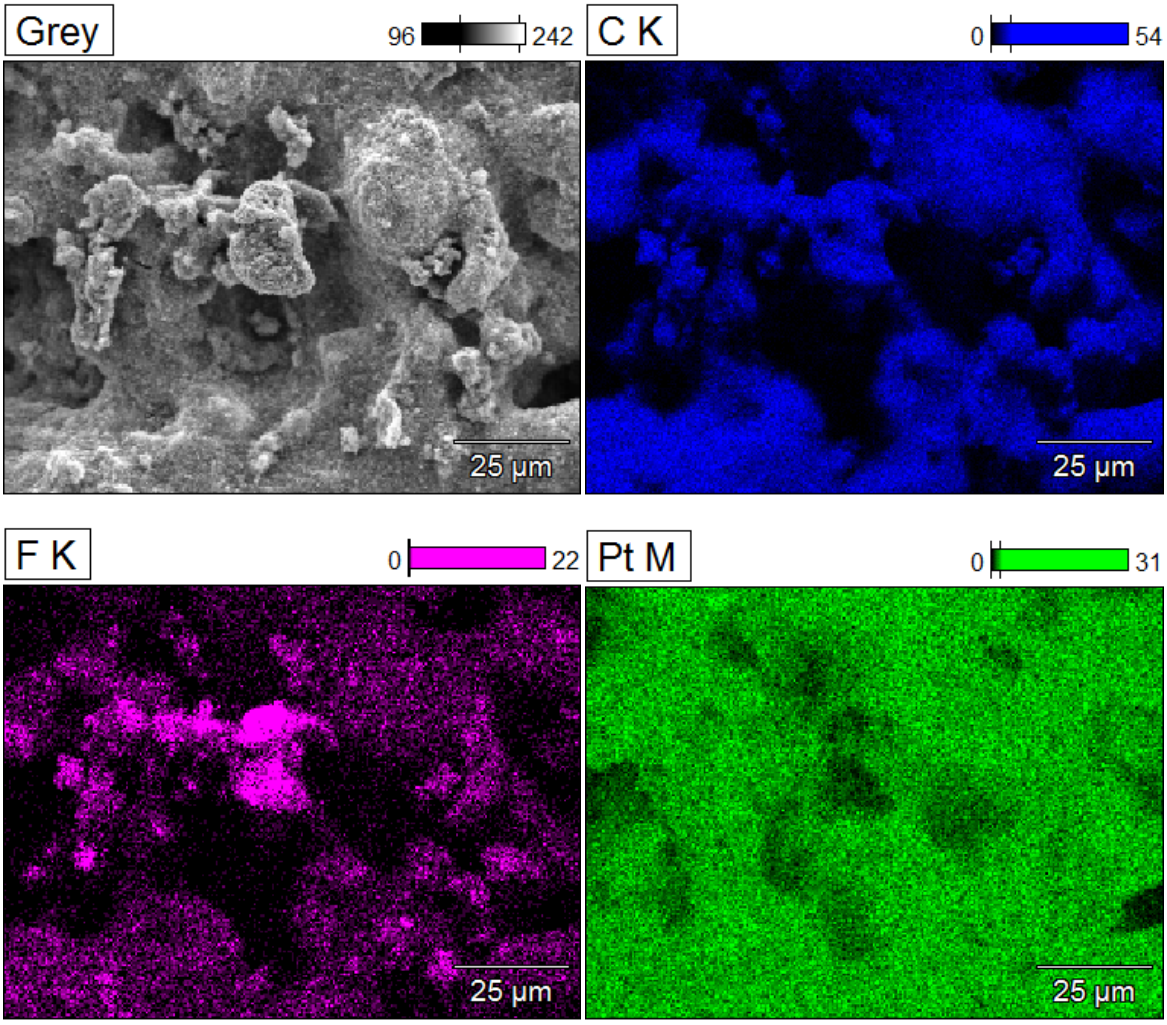

Fig. S3 The scanning electron microscope image (SEM) and energy-dispersive X-ray spectroscopy (EDX) maps of a sample of the surface of the cathode electrode containing the Pt/C electrocatalyst (40% wt. metal content, 0.40 mg cm^{-2} metal loading) and the ETFE-based radiation grafted AEI ionomer powder (20% wt. in electrode, IEC = 1.26 ± 0.06 mmol g^{-1}). These were recorded using a Noran system seven (ver. 3.1) ultradry SSD X-ray detector coupled to a JSM-7100F Field Emission SEM. Magnification = 1000×.

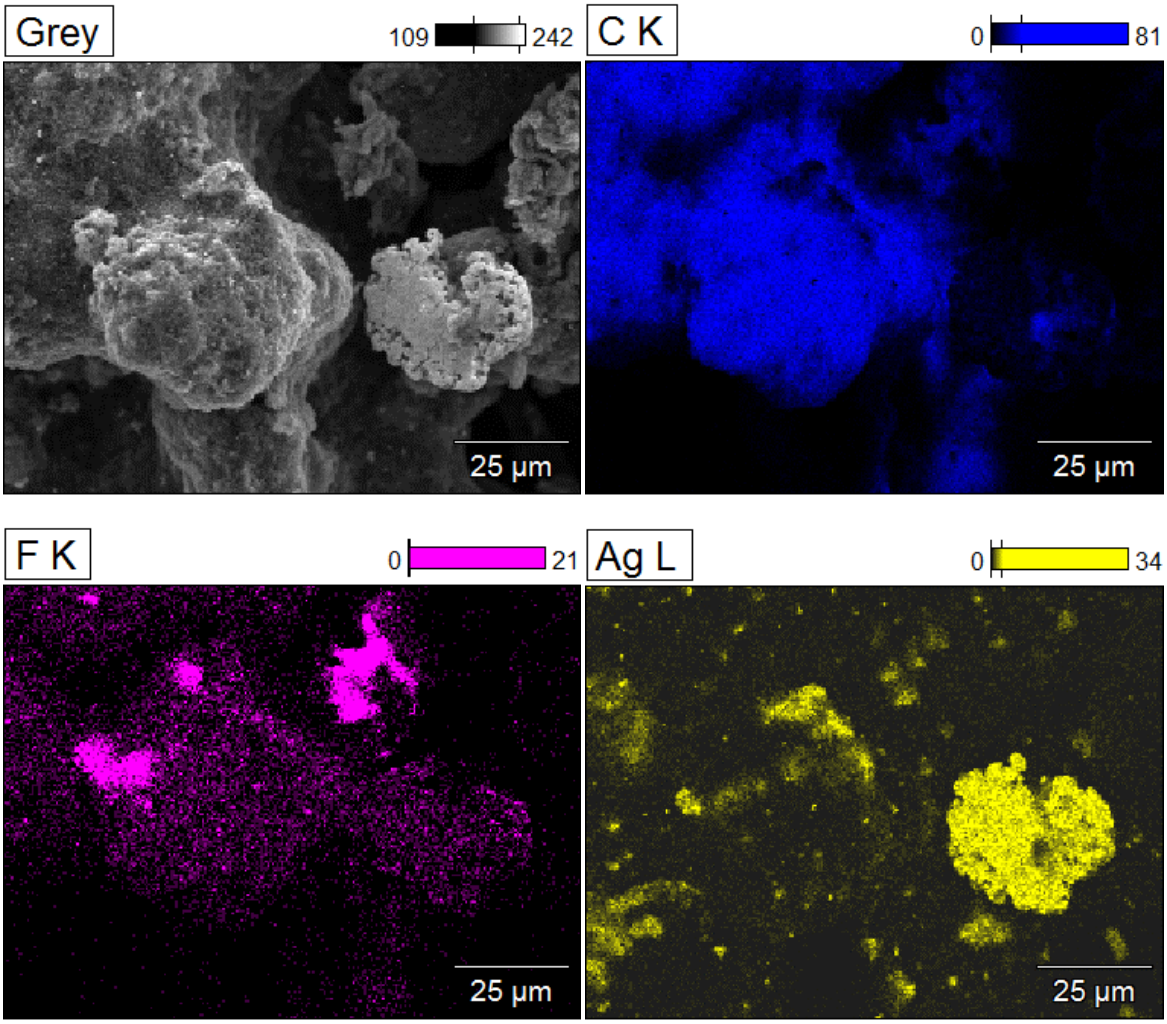

Fig. S4 The scanning electron microscope image (SEM) and energy-dispersive X-ray spectroscopy (EDX) maps of a sample of the surface of the cathode electrode containing the Ag/C electrocatalyst (40% wt. metal content, 0.86 mg cm^{-2} metal loading) and the ETFE-based radiation grafted AEI ionomer powder (20% wt. in electrode, IEC = 1.26 ± 0.06 mmol g^{-1}). These were recorded using a Noran system seven (v. 3.1) ultradry SSD X-ray detector coupled to a JSM-7100F Field Emission SEM. Magnification = 1000×.

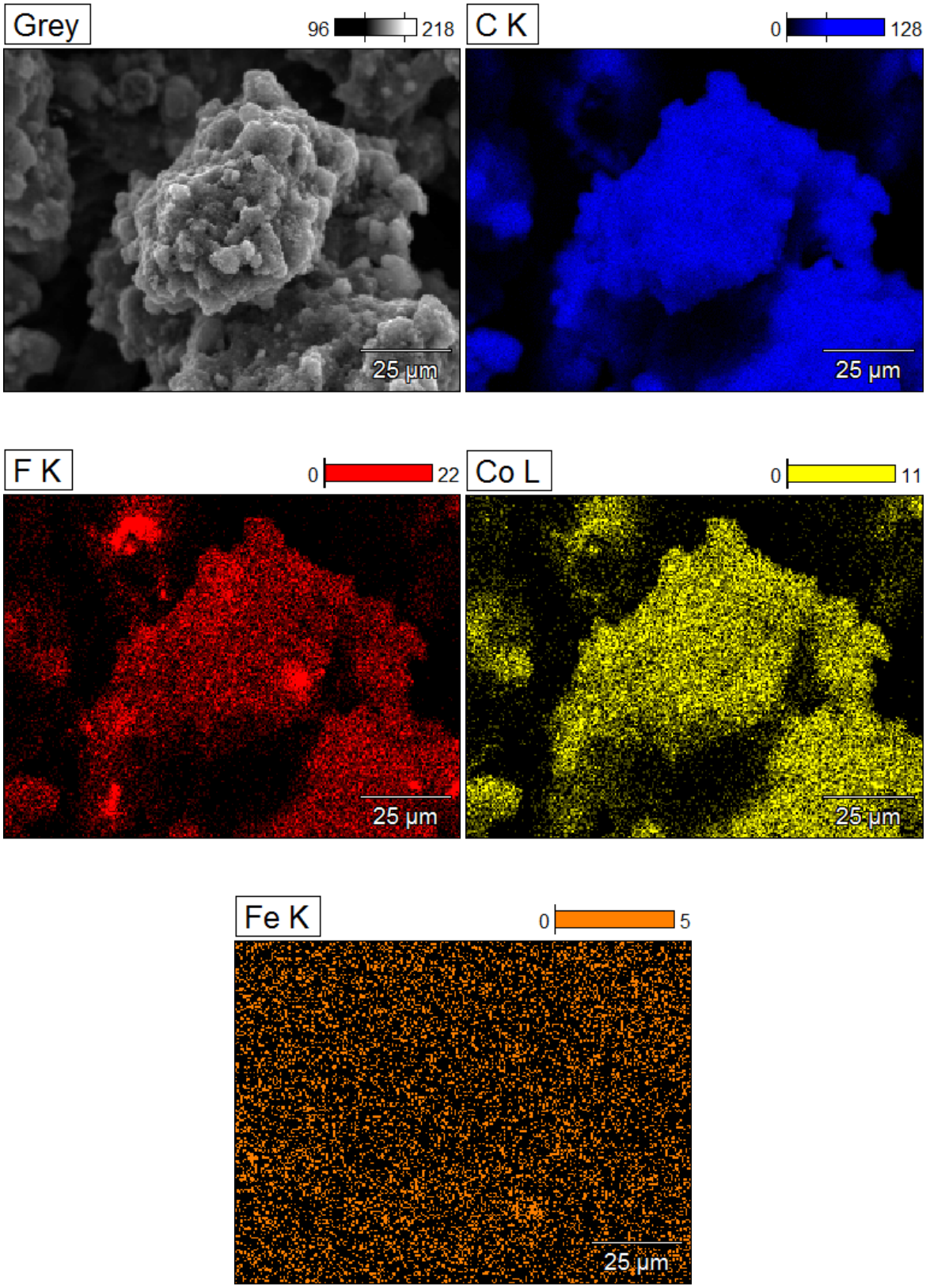

Fig. S5 The scanning electron microscope image (SEM) and energy-dispersive X-ray spectroscopy (EDX) maps of a sample of the surface of the cathode electrode containing the FeCoPc/C electrocatalyst (3% wt. metal content, <0.01 mg cm^{-2} metal loading) and the ETFE-based radiation grafted AEI ionomer powder (20% wt. in electrode, IEC = 1.26 ± 0.06 mmol g^{-1}). These were recorded using a Noran system seven (v. 3.1) ultradry SSD X-ray detector coupled to a JSM-7100F Field Emission SEM. Magnification = 1000×. Note that the Fe-based EDX map does reliably detect the presence of Fe in the electrode but the presence of Fe was previously proven by XANES and EXAFS [1].

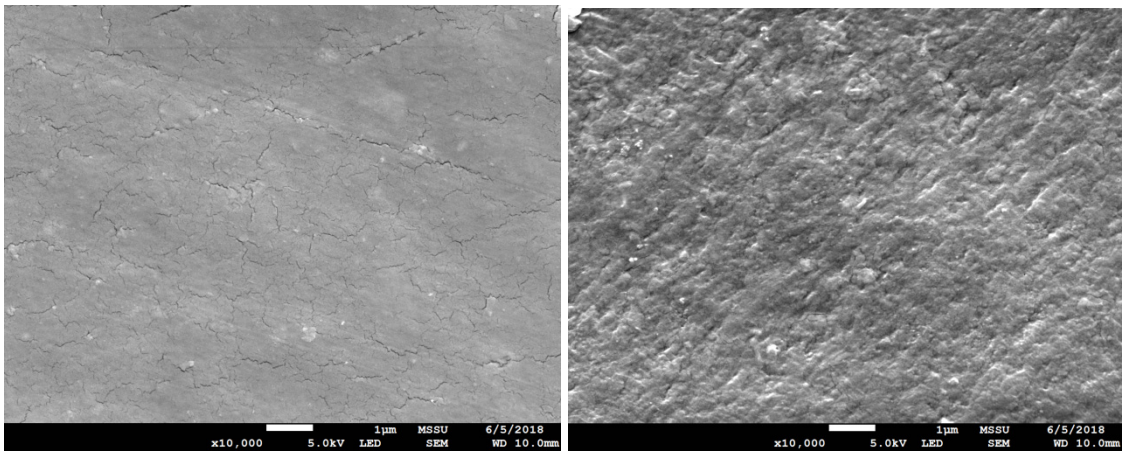

Fig. S6 Surface SEM for a sample of **LDPE15-AEM** recorded before and after the 500 h 80 °C *ex situ* stability test (presented in Fig. 3 in the main article). A 2 nm Au coating (75 mA) was applied to the surface of each sample. The scale bars represent 1 µm.

Table S1 Comparison of the key grafting conditions used to synthesise **LDPE15-AEM** and **LDPE25-AEM**.

AEM	**LDPE15-AEM**	**LDPE25-AEM**
Grafting mixture temperature / °C	40	55
Grafting time / h	6	16
IEC / mmol g^{-1}	2.54 ± 0.21	2.87 ± 0.05

Table S2 EDX data for a sample of **LDPE15-AEM** (average of *n* = 3 EDX spectra on different areas of the same sample) recorded before and after the 500 h 80 °C *ex situ* stability test (presented in Fig. 3 in the main article). The post-degradation AEM was converted back the Cl^- form before EDX analysis to allow comparison with the Cl^- form pre-degraded AEM. The data was corrected by removal of Au contents from the percentages in the table (a 2 nm Au coating was applied to the surface of each sample for SEM/EDX). These EDX experiments were not sensitive enough to detect the amine-related N content in these AEMs. Note that unlike the (bulk) conductivity, IEC and Raman data presented in the main text, EDX data is biased towards the surface of the AEMs, where a higher level of degradation is expected.

Element Line	**Weight %**		**Atom %**	
	Start (0 h)	End (500 h)	Start (0 h)	End (500 h)
C_K	72.4 ± 1.2	80.7 ± 0.8	88.6 ± 1.0	92.5 ± 0.9
Cl_K	27.6 ± 2.9	19.3 ± 3.1	11.4 ± 1.2	7.5 ± 1.2
Total	100.0	100.0	100.0	100.0

References to ESI:

[1] V. Bambagioni, C. Bianchini, J. Filippi, A. Lavacchi, W. Oberhauser, A. Marchionni, S. Moneti, F. Vizza, R. Psaro, V. Dal Santo, A. Gallo, S. Recchia and L. Sordelli, *J. Power Sources*, 2011, **196**, 2519-2529.