

Supplementary Information

**Dimensional stable multication-crosslinked poly(arylene
piperidinium) membranes for water electrolysis**

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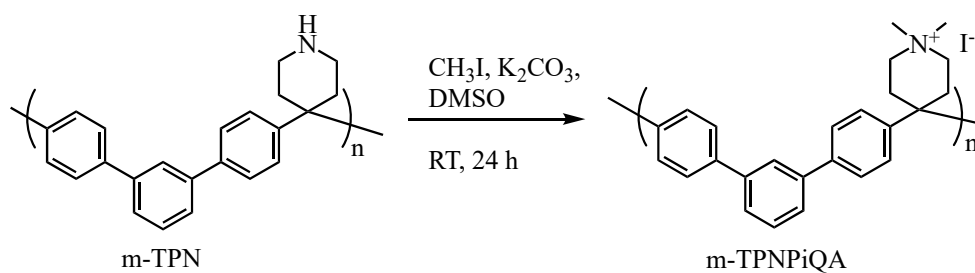
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Scheme S1 Quaternization route for m-TPNPiQA.

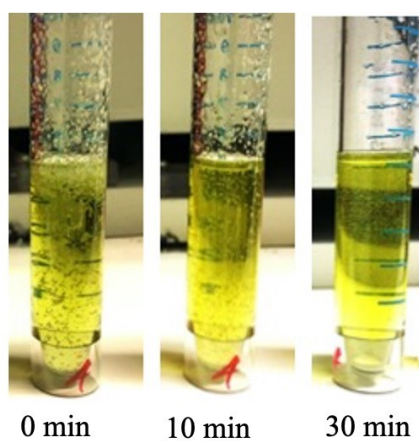


Fig. S1 Changes after adding DIPEI catalyst into the casting solution.

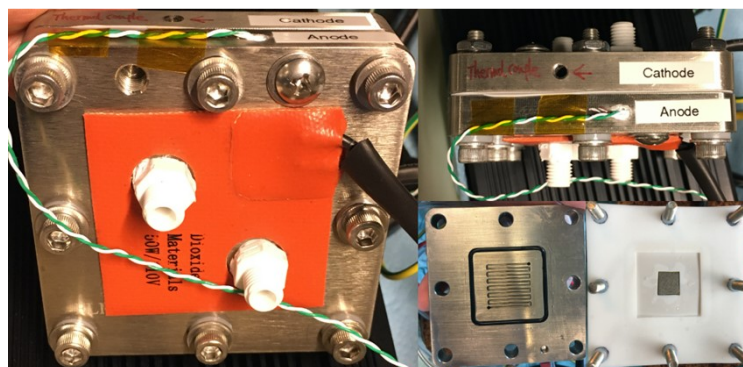


Fig. S2 The digital photos of an AEMWE cell.

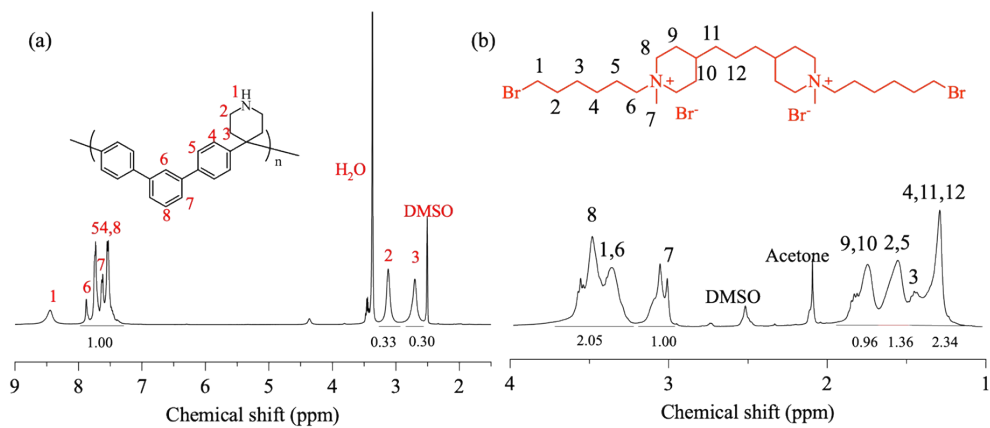


Fig. S3 $^1\text{H-NMR}$ spectra of (a) m-TPN and (b) IL.

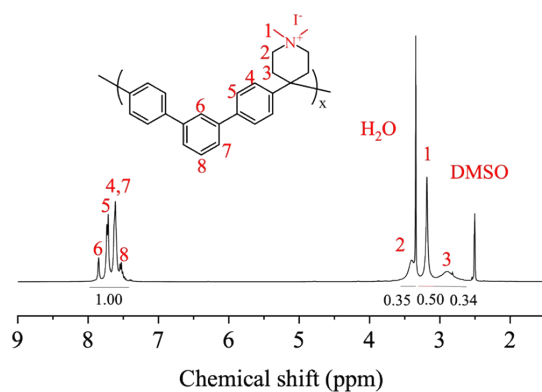


Fig. S4 $^1\text{H-NMR}$ spectrum of m-TPNPiQA.

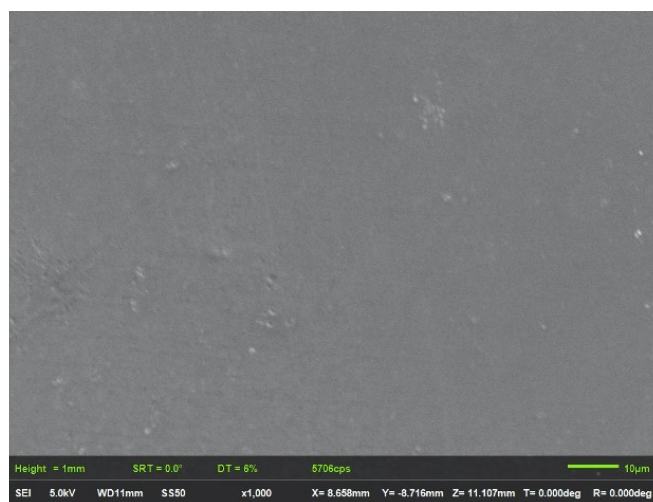


Fig. S5 SEM image of the C-IL-100 membrane.

Table S1 Mechanical properties of m-TPNPiQA and crosslinked C-IL-x membranes in the wet state.

Samples	Young's modulus (MPa)	Elongation at break (%)	Tensile strength (MPa)
m-TPNPiQA	646.67	8.94	21.05
C-IL-20	781.49	14.70	49.77
C-IL-40	729.78	16.33	39.34
C-IL-60	563.65	17.74	31.94
C-IL-80	382.57	19.13	24.30
C-IL-100	275.79	25.25	22.91

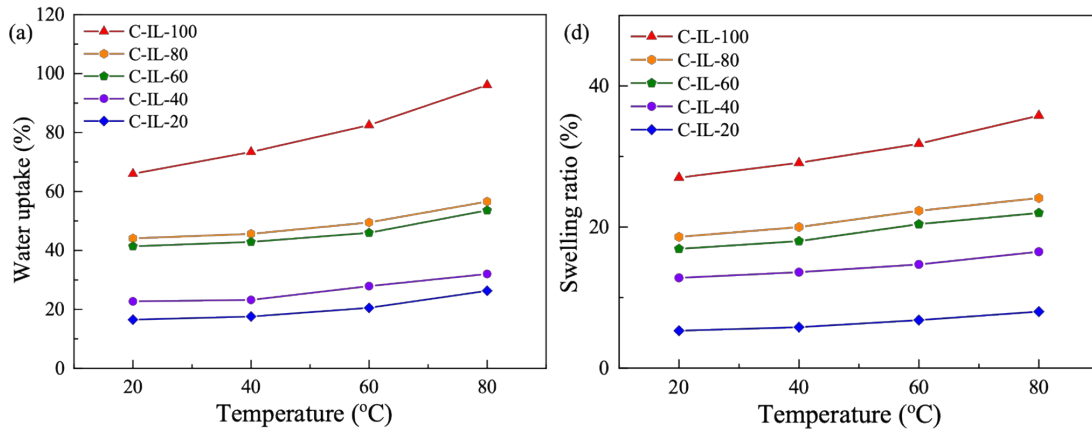


Fig. S6 (a) Water uptake and (b) swelling ratio of the crosslinked C-IL-x AEMs as a function of temperature.

Table S2 Water electrolysis performance of C-IL-100 and m-TPNPiQA membranes.

Samples	Temperature (°C)	Current density @ 2.0V(A cm ⁻²)
C-IL-100	RT	0.31
	50 °C	0.42
	80 °C	0.55
m-TPNPiQA	RT	0.11
	50 °C	0.18
	80 °C	0.25

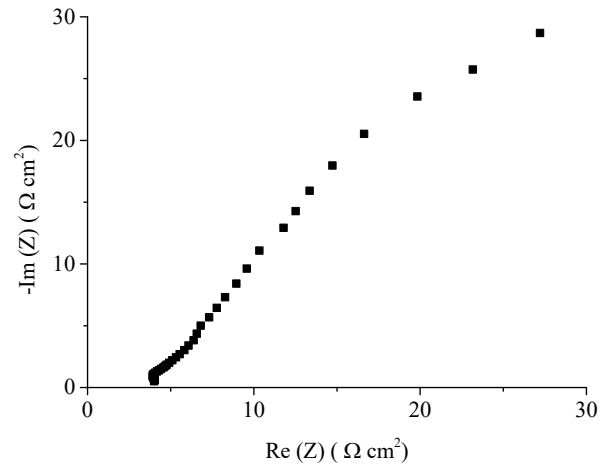


Fig. S7 Impedance data of m-TPNPIQA-based AEMWE at 50 °C and 1.5 V.

Table S3 Performance comparison of alkaline water electrolyzer using 1 M KOH electrolyte and Ni-based catalysts.

Name	Anode	Cathode	Temperature	Current density (mA cm ⁻²) /Voltage	Reference
C-IL-100	NiFe ₂ O ₄ /Stainless-Steel ^a	NiFeCO /Nickel Fiber Paper ^a	50 °C	400/2V	This work
m-TPNPiQA	NiFe ₂ O ₄ /Stainless-Steel ^a	NiFeCO /Nickel Fiber Paper ^a	50 °C	180/2V	This work
FAS-50	NiFe ₂ O ₄ /316L Sintered Stainless Steel	NiFeCO /Sigracet Carbon Paper	39BC 60 °C	240/1.8V	1
Sustainion 37-50	NiFe	NiFeCo	60 °C	1000/1.9V	2
PBI/mTPN-50.120	Ni-Fe/Ni Foam	MoNi/Ni Foam	50 °C	250/1.98V	3
PVBC-MPy/35% PEK-cardo	NiFe-LDH/Nickel Felt Paper	MoNi/Nickel Felt Paper	60 °C	500/2V	4

Reference:

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