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

Supporting Information

Poly(vinyl benzyl methylpyrrolidinium) hydroxide derived anion exchange membranes for water electrolysis

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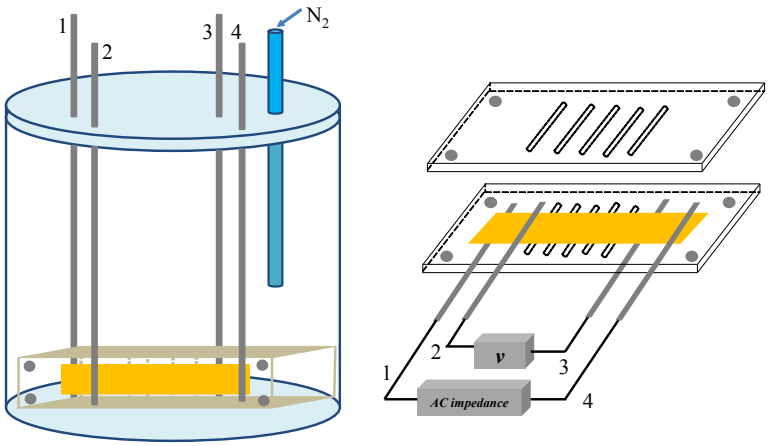


(a)

(b)

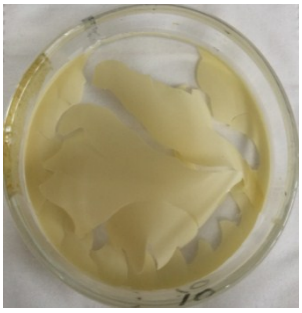
(c)

Figure S1 Schematic drawings (a) and photos (b, c) of the conductivity measurement cell.

PVBC-MPy/15%PES

PVBC-MPy/15%PSF

PVBC-MPy/15%PVC



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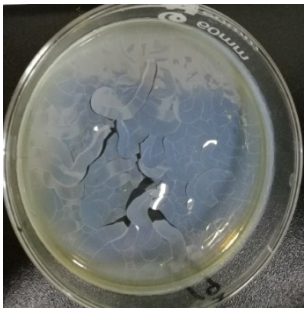
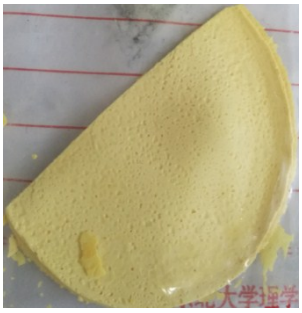
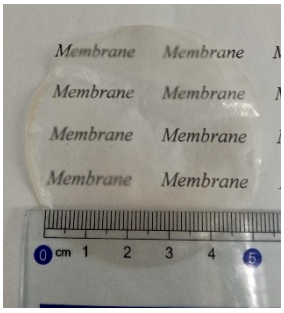


PVBC-MPy/15%PAEK



PVBC-MPy/15%PBI



PVBC-MPy/15%PEK-cardo

Figure S2 Photographs of various blend PVBC-MPy membranes with different enhanced polymers, including polyethersulfone (PES), polysulfone (PSF), polyvinyl chloride (PVC), polyvinylidene fluoride (PVDF), polyaryletherketone (PAEK), polybenzimidazole (PBI) and poly(ether ketone-cardo) (PEK-cardo)

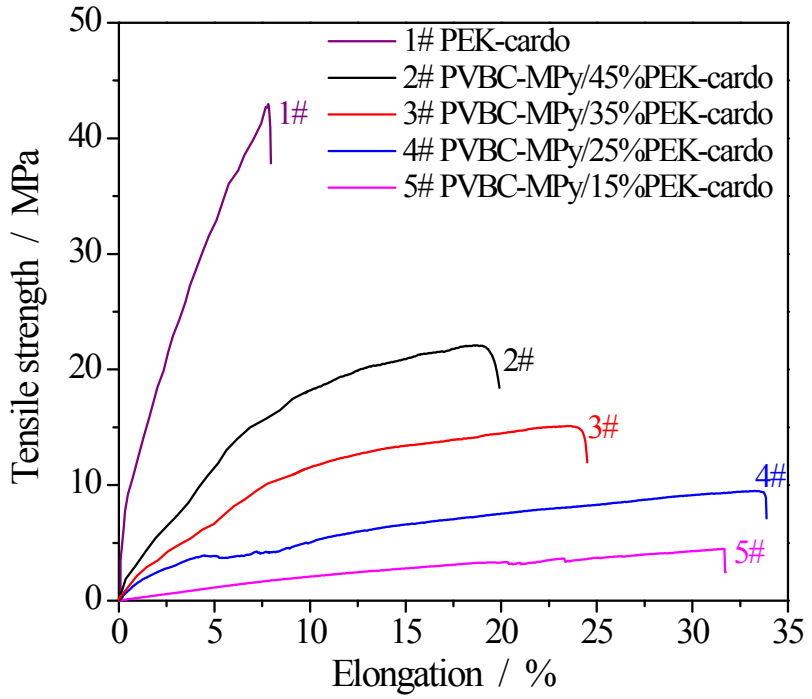


Figure S3 Representative stress-strain curves of hydrated PVBC-MPy/*x*%PEK-cardo membranes (in OH^- form) at RT.

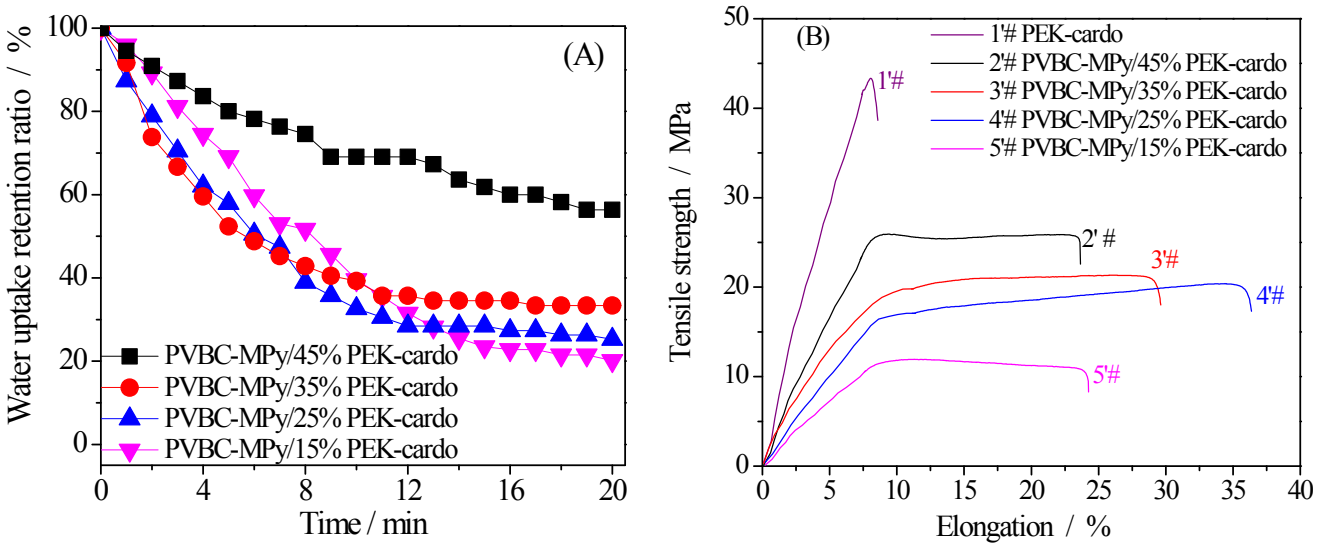


Figure S4 Water uptake retention ratio of PVBC-MPy/*x*%PEK-cardo membranes as a function of time under ambient atmosphere (A); Stress-strain curves recorded after 20 min under air atmosphere (B). The water uptake retention ratio of the membrane refers to the water uptake at each test point relative to the initial water uptake.

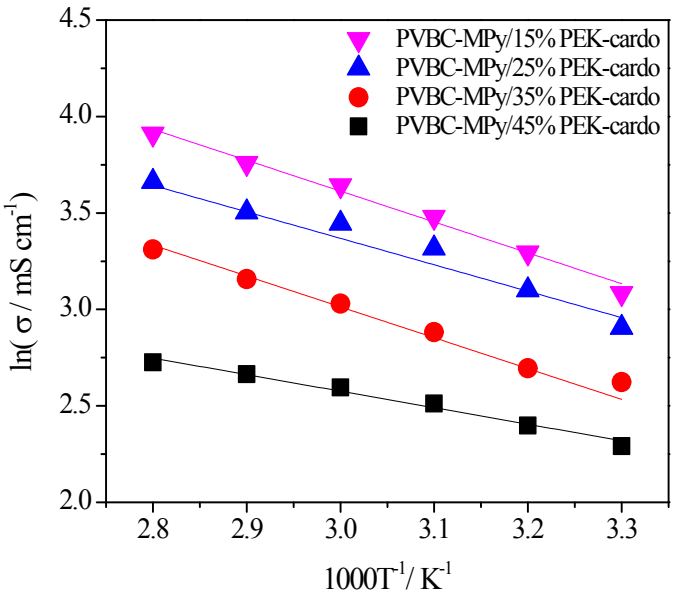


Figure S5 Arrhenius plots of PVBC-MPy/*x*%PEK-cardo membranes.

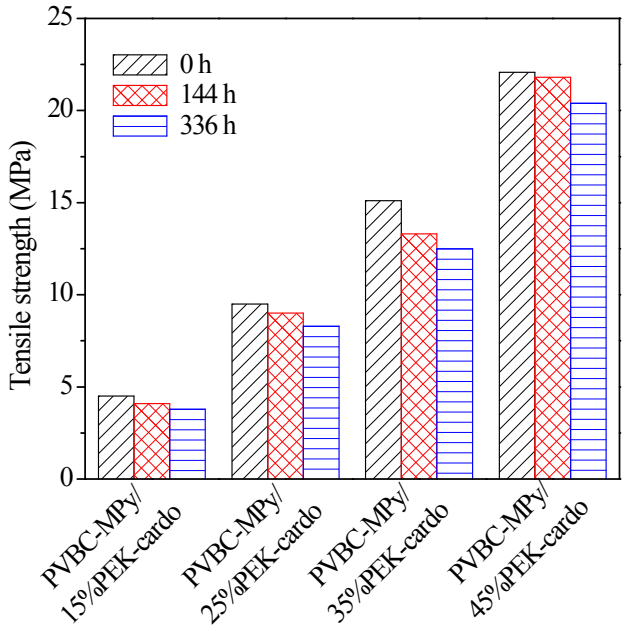


Figure S6 Mechanical strength of the PVBC-MPy/*x*%PEK-cardo membranes after aging 1 mol L^{-1} aqueous KOH at 60 °C at different time

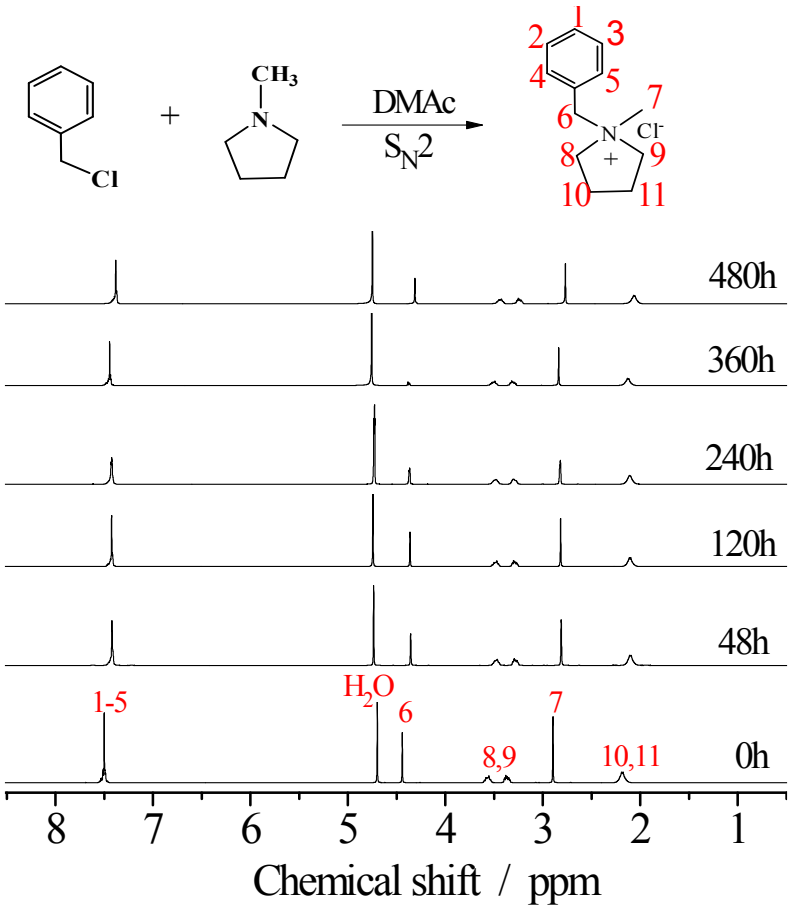


Figure S7 The ^{1}H NMR spectra of the model compound (1-benzyl-1-methylpyrrolidinium chloride) after alkaline treatment in 1 M NaOD/D_2O solution at 60 °C.

Table S1 Comparison of properties of membranes in the present work and literature

Membranes	IEC[a] (mmol g^{-1})	IEC[b] (mmol g^{-1})	Volume swelling %	Conductivity retention rate % @60°C 1M KOH	Tensile strength MPa	Ref.
PVBC-MPy/15%PEK-cardo	3.60	3.47±0.2	110±3.2	84.8 @432h	4.5	This work
PVBC-MPy/25%PEK-cardo	3.18	3.10±0.2	61±5.1	94.9 @432h	9.5	This work
PVBC-MPy/35%PEK-cardo	2.75	2.65±0.2	38±2.6	91.3 @432h	15.1	This work
PVBC-MPy/45%PEK-cardo	2.33	2.34±0.3	26±1.6	93.3 @432h	22.1	This work
PPO-MPy	2.3	1.8 ± 0.2	89.1±8.6	98.4 @216h	8.3	1
PPO-MPrD	2.2	1.7 ± 0.2	87.4±5.1	93.4 @216h	9.5	1
ImPPO-1#	1.38	0.95±0.05	41.3±7.0	12.5 @40h	21.1±2.3	2
ImPPO-4#	1.21	1.03±0.06	45.5±5.4	~92 @180h	14.6±1.0	2
PVAc(1)-c-PVBC(1)/OH	-	1.26	26.3	~66.7%@210h@40 °C	14.2	3
BPPO-MMPH	2.16	1.68±0.01	-	~42 @360h	26.21	4
BPPO-MPY	2.24	1.74±0.02	-	~85 @360h	26	4
[PEMPy][OH]	1.49	1.41±0.08	24.23±3.67	~97%@432h @80°C	7.52 ± 1.14	5
[PBenMPy][OH]	-	1.47±0.051	-	~80 @240h @80°C	7.83±1.23	5
65PAEK-BIm/SPEEK15	2.58	2.28 ± 0.15	89±5	~75 @200h	15.1 ± 1.5	6

PPO-MPy: 1-Methylpyrrolidine functionalized poly(phenylene oxide) (PPO);
PPO-MPrD: 1-Methylpiperidinium grafted PPO;
ImPPO-1#: 1-Methylimidazole functionalized PPO;
ImPPO-4#: 1-butyl-2-methylimidazolium functionalized PPO;
PVAc(1)-c-PVBC(1)/OH: Poly(vinyl acetal) containing dimethylamino crosslinked poly(vinyl benzyl chloride);
BPPO-MMPH: 4-Methylmorpholine based PPO;
[PEMPy][OH]: N,N-Ethylmethyl-substituted pyrrolidinium cation containing copolymers ;
[PBenMPy][OH]: 1-benzyl-1-methylpyrrolidinium containing copolymers;
65PAEK-BIm/SPEEK$_{15}$: Ionically crosslinked imidazolium functionalized poly(ether ether ketone).

References:

1. Y. Yang, Y. Xu, N. Ye, D. Zhang, J. Yang and R. He, *J. Electrochem. Soc.*, 2018, **165**, F350-F356.

2. J. Yang, C. Liu, Y. Hao, X. He and R. He, *Electrochim. Acta*, 2016, **207**, 112-119.

3. W. Lu, Z. G. Shao, G. Zhang, Y. Zhao and B. Yi, *J. Power Sources*, 2014, **248**, 905-914.

4. Y. Jiang, J. Liao, S. Yang, J. Li, Y. Xu, H. Ruan, A. Sotto, B. Van der Bruggen and J. Shen, *Reac. Funct. Polym.*, 2018, **130**, 61-69.

5. F. Gu, H. Dong, Y. Li, Z. Sun and F. Yan, *Macromolecules*, 2014, **47**, 6740-6747.

6. Y. Xu, N. Ye, D. Zhang, J. Yang and R. He, *J. Colloid Interface Sci.*, 2017, **497**, 333-342.