Supporting information

Emerging Conjugated Radical Polymer Cathode with Ultra-Long Cycle Life for an Entire Polymer Rechargeable Battery

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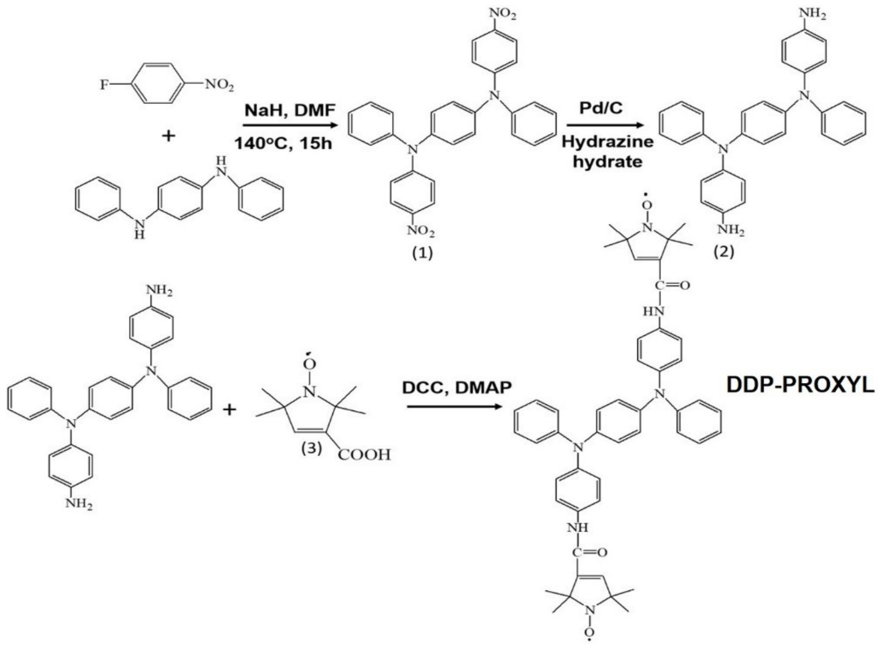

Figure S1 Synthetic route of the DDP-PROXYL

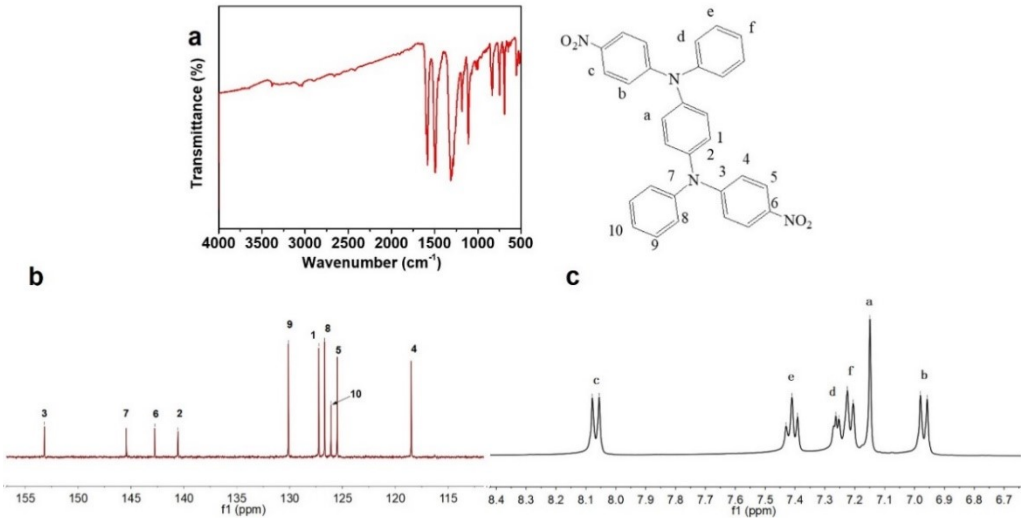

Figure S2 (a) FTIR, (b) ^{13}C NMR and (c) ^{1}H NMR spectra (400 MHz, DMSO-d_6) of *N,N'*-Bis(4-nitrophenyl)-*N,N'*-diphenyl-1,4-phenylenediamine (DDP-NO_2)

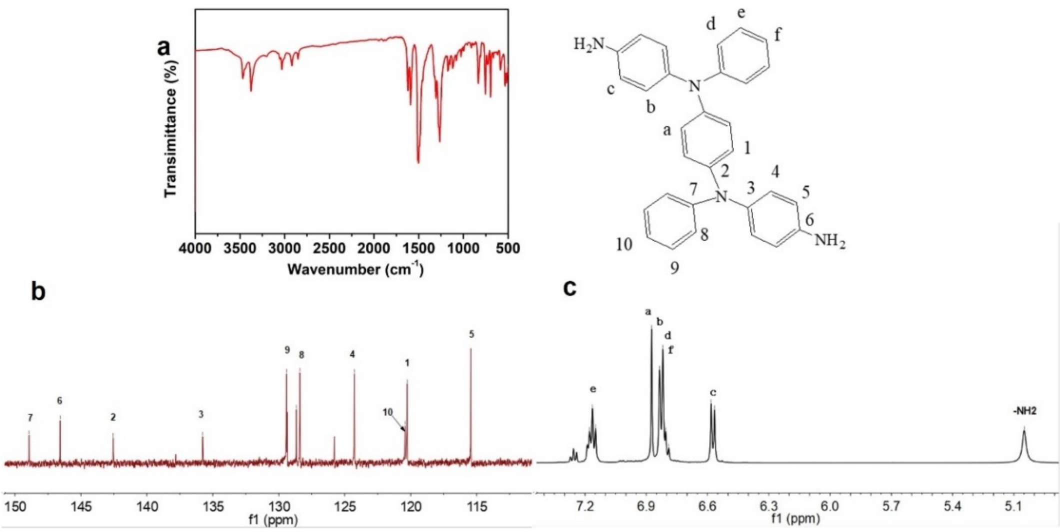

Figure S3 (a) FTIR, (b) ^{13}C NMR and (c) ^{1}H NMR spectra (400 MHz, DMSO-d_6) of *N,N'*-Bis(4-aminophenyl)-*N,N'*-diphenyl-1,4-phenylenediamin*e* (DDP-NH_2)

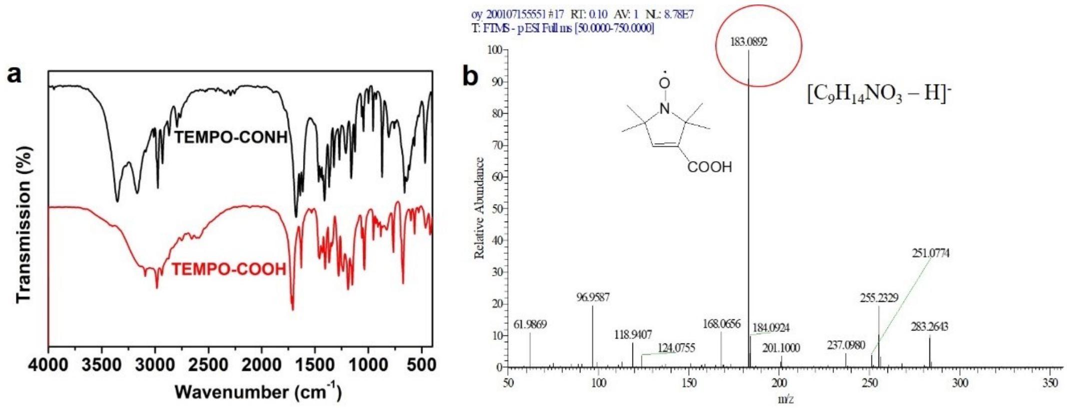

Figure S4 (a) FTIR, (b) MS (ESI) spectra of 3-carboxy-2,2,5,5-tetramethyl-3-pyrrolin-1-oxyl (PROXYL-COOH)

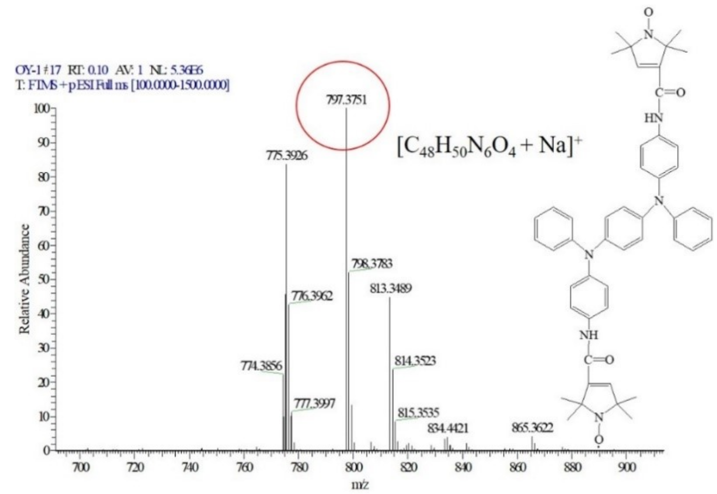

Figure S5 MS (ESI) spectra of DDP-PROXYL monomer:

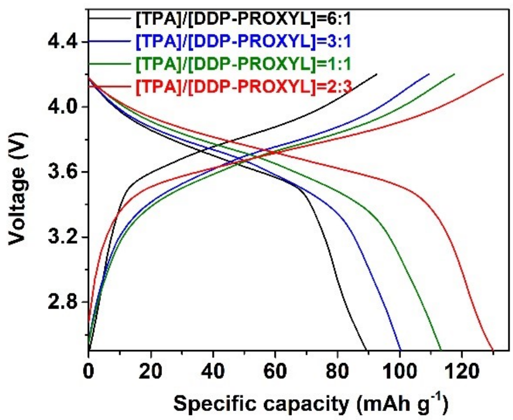

Figure S6 Galvanotatic charge/discharge curves of P(TPA-co-DDP-PROXYL) copolymer with different mole ratio of [TPA]/[DDP-PROXYL]

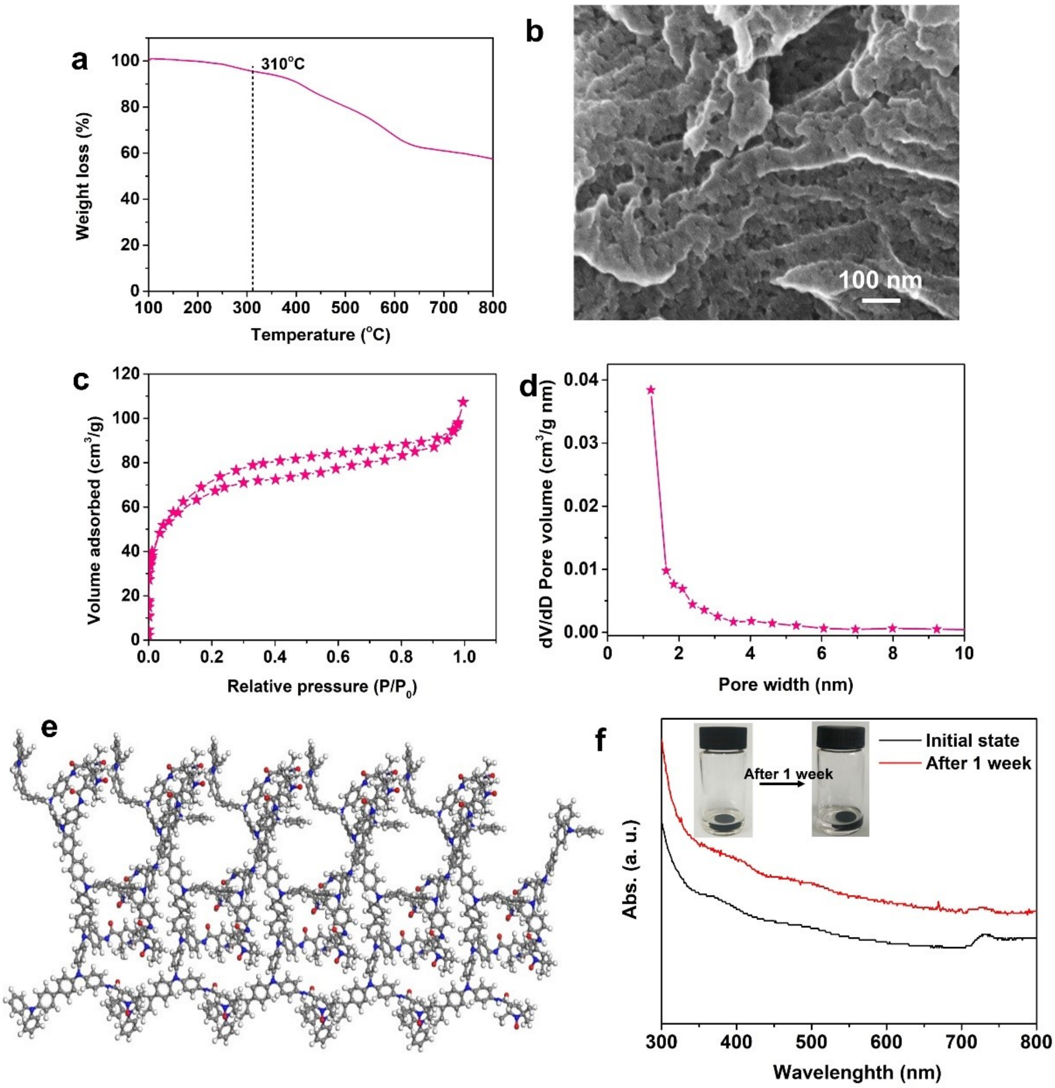

Figure S7 (a) TGA, (b) SEM image, (c) N_2 sorption isotherms at 77 K, (d) pore size distribution and (e) structure simulation of P(TPA-co-DDP-PROXYL) copolymer. (f) UV spectra of the electrolytes immersed by P(TPA-co-DDP-PROXYL) for 1 week.

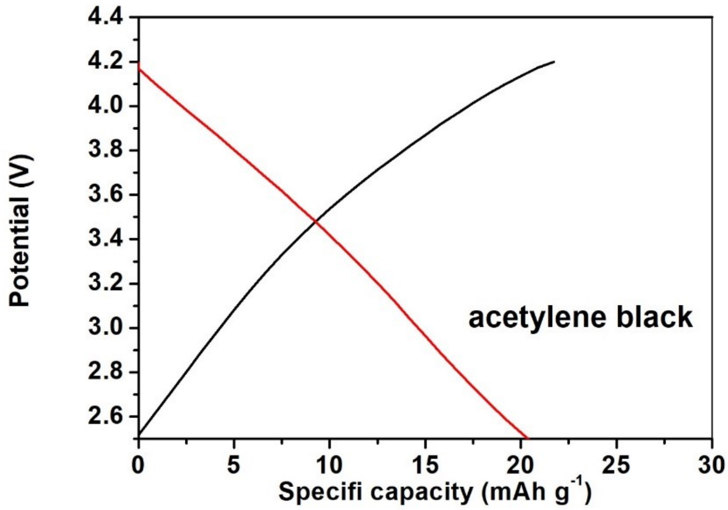

Figure S8 Specific capacity of acetylene black at 20 mA g^{-1}.

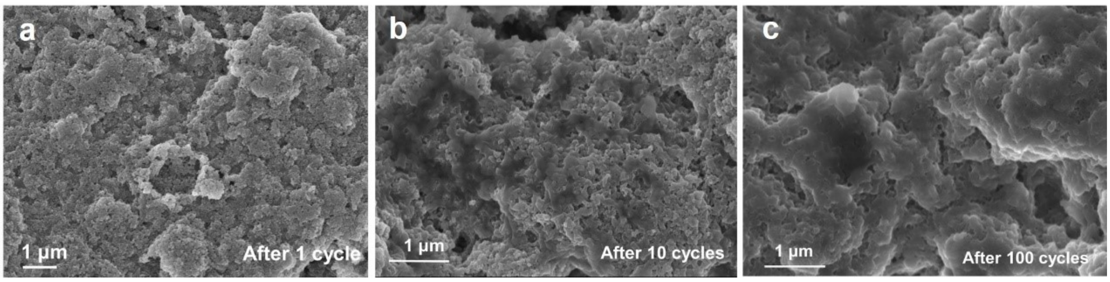

Figure S9 SEM images of P(TPA-co-DDP-PROXYL) electrode with different cycle times at 500 mA g^{-1}

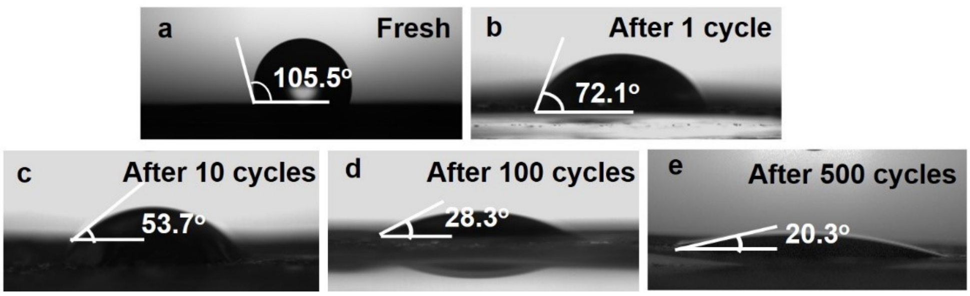

Figure S10 Water contact angle of electrode before and after cycling

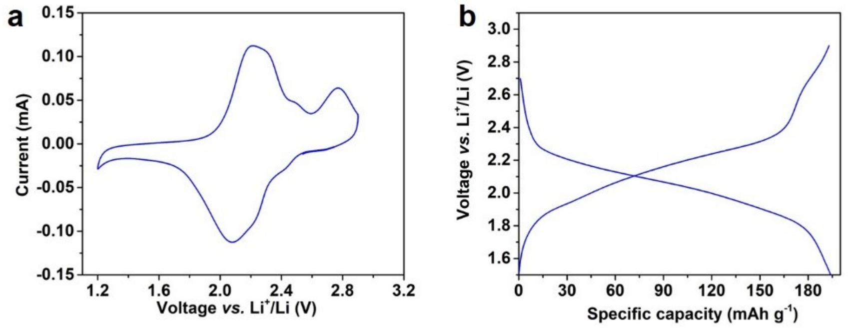

Figure S11. CV curve at the scan rate of 0.5 mV s^{-1} and (b) galvanotatic charge/discharge curves for the first three cycles at 20 mA $g^{-1}$of PAQS

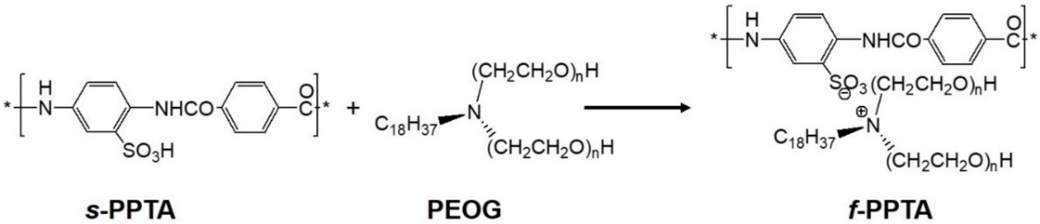

Figure S12. The synthesis route of the *f*-PPTA

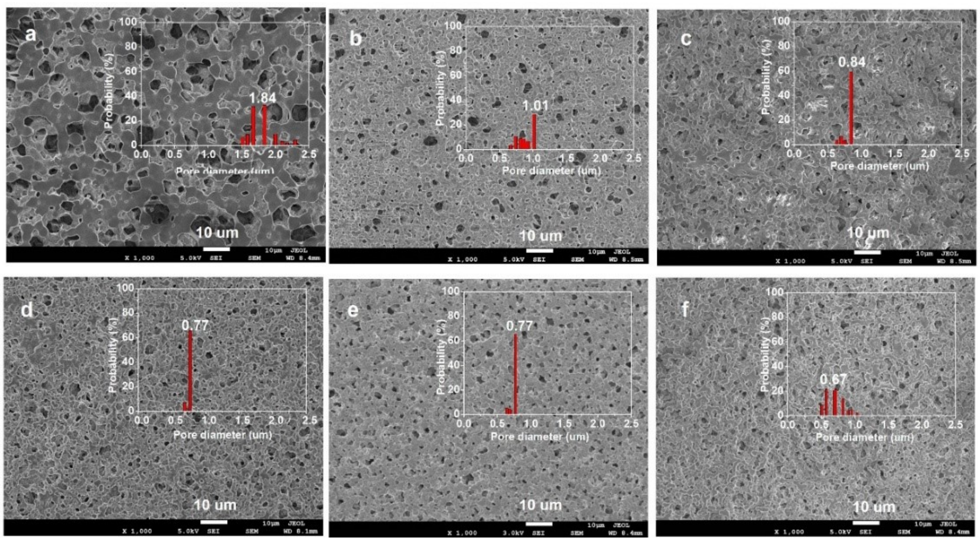

Figure S13 SEM images and pore size distributions of (a) PVDF-HFP, (b) PVDF-HFP/*f*-PPTA-1, (c) PVDF-HFP/*f*-PPTA-2, (d) PVDF-HFP/*f*-PPTA-3, (e) PVDF-HFP/*f*-PPTA-4 and (f) PVDF-HFP/*f*-PPTA-5

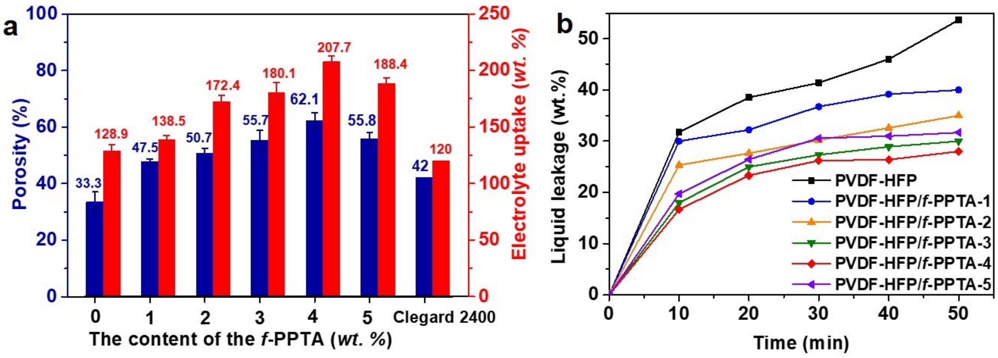

Figure S14 (a) Porosity and electrolyte uptake analysis, and (b) liquid leakage curve of PVDF-HFP/*f*-PPTA

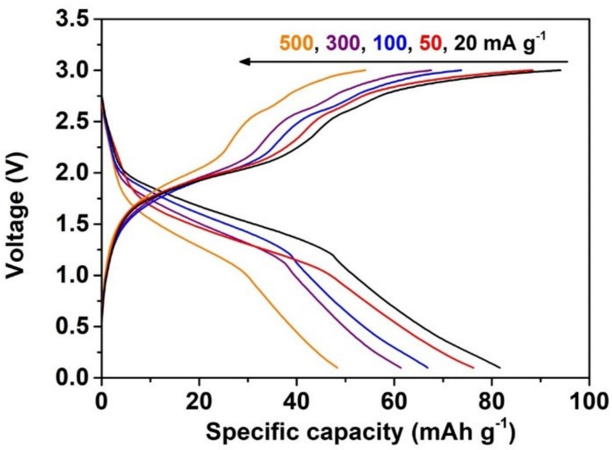

Figure S15 Charge/discharge profiles at different current density of the entire polymer rechargeable battery

Table S1. Electrochemical performance comparison of polymer cathode materials in LIBs

Samples	Reversible capacity (mAh g^{-1})	Rate capability (capacity rentantion (mAh g^{-1})@current density (mA g^{-1})	Cyclic life capacity rentantion (mAh g^{-1})@cycle number@current density (mA g^{-1})	Discharge voltage (V)	Ref
PTDATA	133.1	90.9@500	98.2@100@20	3.6	1
YPTPA	105.7	97.6@2000	92.9@1170@different current densities	3.6	2
PTTPAB	87	84@500	77@150@100	3.7	3
DANI-PYR	113	58@1500	85@180@20 60@600@500	3.2	4
PTPA-PO	134	90@500	121@100@20	3.8	5
PGVS	104	40@510	40@500@510	3.15	6
PPy-C-TEMPO	115	-	86@50@20	3.5	7
PTMA-co-GMA	104	82@550	103@50@55	3.6	8
Perylene	90	-	50@1800@-	3.8/3.3	9
PTPAFc	100.2	90@500	-	3.6	10
P1a	33	30@700	30@30000@700	3.6	11
p-DPPZ	170	125@200	125@500@200	4.1/3.3	12
PTMA	104.2	40@500	81@100@20	3.6	13
P(TPA-co-DDP-PROXYL)	127.3	100.9@2000	93.8@3000@500 71.2@3000@2000	3.7	This work

Table S2 Porosity, electrolyte uptake and ionic conductivity of P(VDF-HFP)/*f*-PPTA membrane and Clegard 2400

Sample	Ionic conductivity σ (mS cm^{-1}) 20°C
P(VDF-HFP)	0.67 （+0.024）
P(VDF-HFP)/*f*-PPTA-1	1.02（+0.057）
P(VDF-HFP)/*f*-PPTA-2	1.13（+0.006）
P(VDF-HFP)/*f*-PPTA-3	1.43（+0.132）
P(VDF-HFP)/*f*-PPTA-4	1.65（+0.050）
P(VDF-HFP)/*f*-PPTA-5	1.56（+0.076）
Clegard 2400	0.60

References

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