Novel poly(arylene ether ketone) /poly(ethylene glycol)-grafted poly(arylene ether ketone) composite microporous polymer electrolyte for electrical double-layer capacitors with efficient ionic transport

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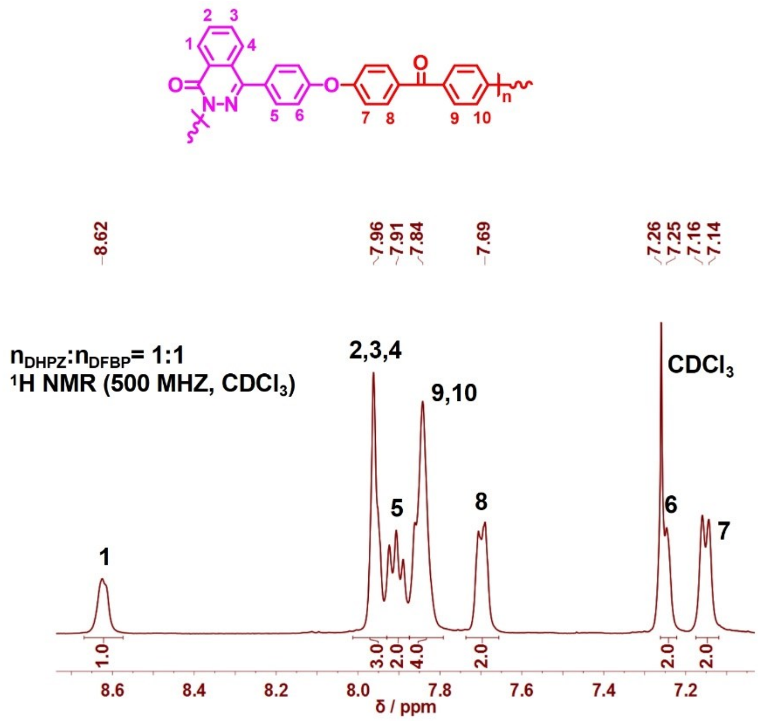
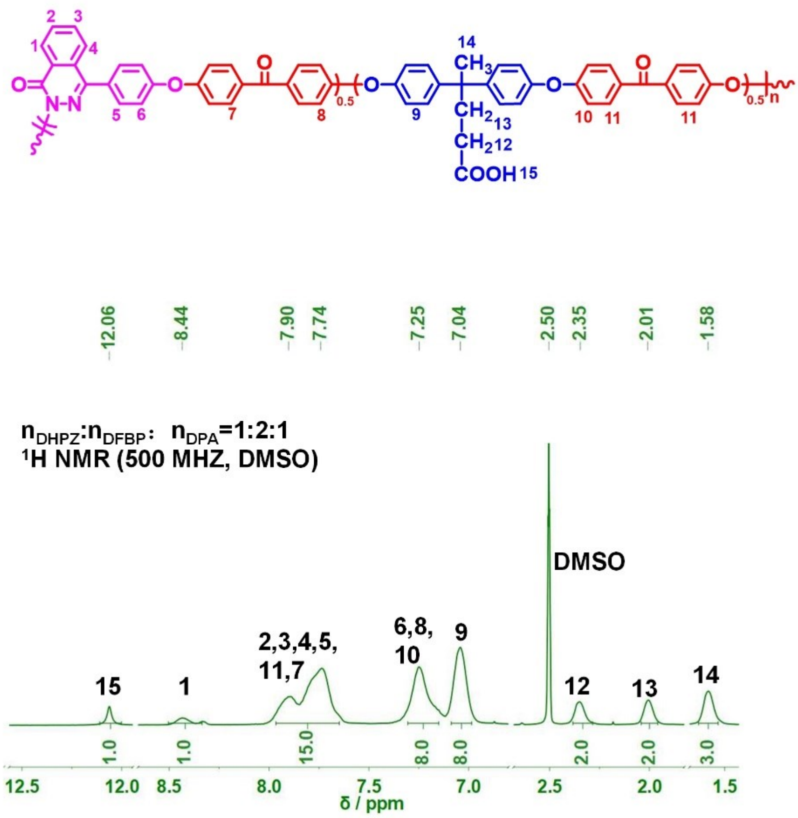
Materials

4-(4-hydroxyl-phenyl)(2H)-phthalazine-1-one (DHPZ, 99%) was kindly offered by Dalian Polymer New Materials Co., Ltd. (Dalian, China). 4,4'-difluorobenzophenone (DFBP, 99%), diphenolic acid (DPA, 98%), carboxylated chitosan (BR, water soluble, degree of substitution ⩾ 60%), methoxypolyethylene glycol (Mn=1000g mol^{-1}, 99%), N,N'-dicyclohexylcarbodiimide (DCC, 99%), 4-dimethylaminopyridine (DMAP, 99%) were all purchased from Aladdin Industrial Co., Ltd. Activated carbon powder (surface area of 1600 m^2 g^{-1}, porous volume of 0.7 mL g^{-1}) was provided by SCM Industrial Chemical Co. Ltd. Shanghai, China. Polytetrafluoroethylene (PTFE) (60 wt% dispersion), acetylene black (Specific surface area: 58 m^2/g), titanium mesh (100 mesh), lithium perchlorate (99.9%) were obtained from Guangdong Canrd New Energy Technology Co.,Ltd. Anhydrous tetrahydrofuran (THF, 99%), sulfolane (99%), toluene (99%), 1-methyl-2-pyrrolidinone (NMP, 99%), isopropanol (99%), concentrated HCl (99%) and anhydrous potassium carbonate (K_2CO_3, 99%) were all obtained from Beijing Chemical Reagent Company. Commercial separator (model: NKK-MPF30AC-100, thickness of 90–100 mm) were obtained from Saibo Electrochemical reagent company.

(a)


n_{DHPZ}:n_{DFBP}= 1:1
^{1}H NMR (500 MHZ, $CDCl_3$)
2,3,4
9,10
5
8
6
7
1
$CDCl_3$
δ / ppm

(b)


n_{DHPZ}:n_{DFBP}: n_{DPA}=1:2:1
^{1}H NMR (500 MHZ, DMSO)
DMSO
2,3,4,5,
11,7
6,8,
10
9
15
1
12
13
14
COOH
δ / ppm

(c)

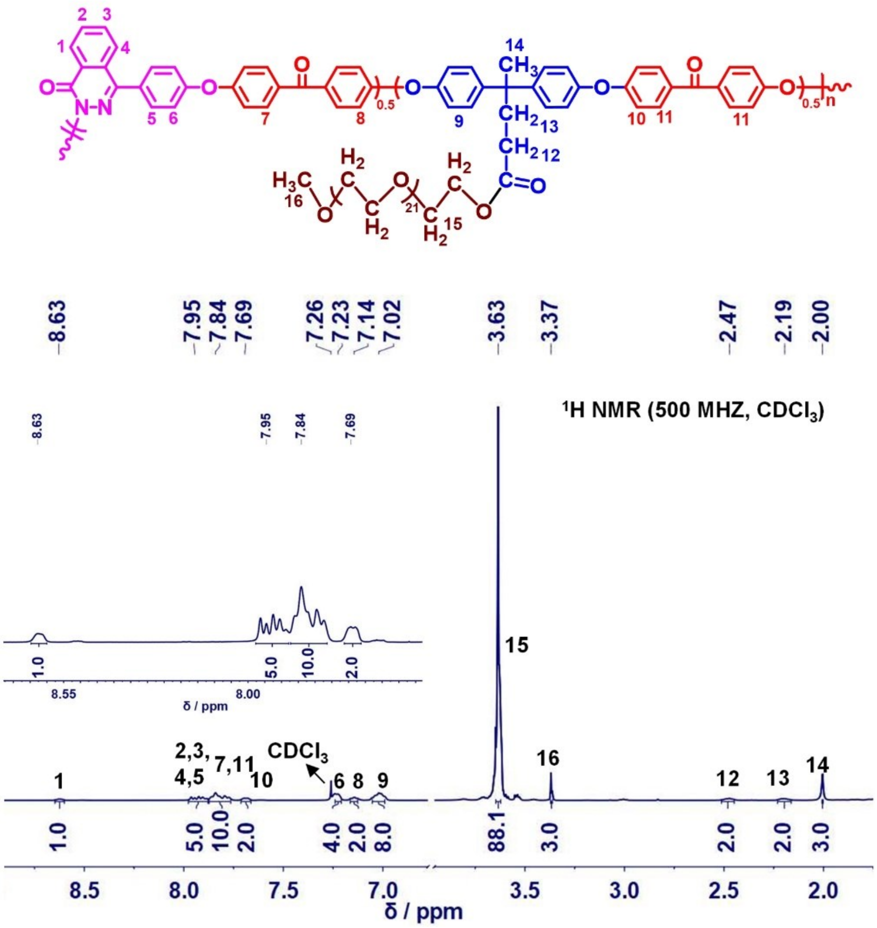


Fig. S1. ^{1}H NMR spectra of (a) PAEK, (b) PAEK-COOH, and (c) PAEK-g-PEG copolymers.

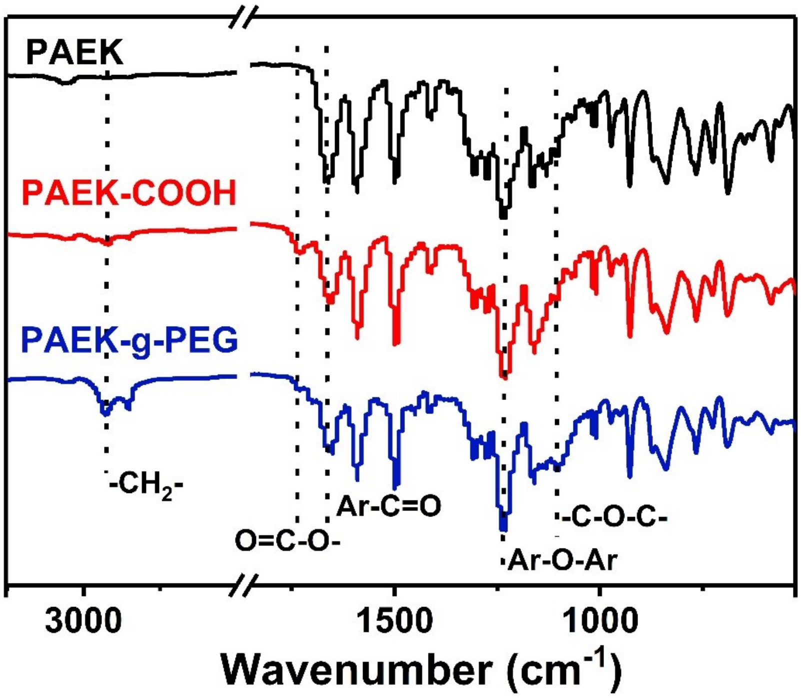


Fig. S2. FTIR spectra of (a) PAEK, (b) PAEK-COOH, and (c) PAEK-g-PEG copolymers.

Tab. S1. Thermal weight loss temperature of PAEK and PAEK-g-PEG

Thermal weight loss temperature	PAEK	PAEK-g-PEG
The first step (^{o}C)	475	175
The second step (^{o}C)	/	375

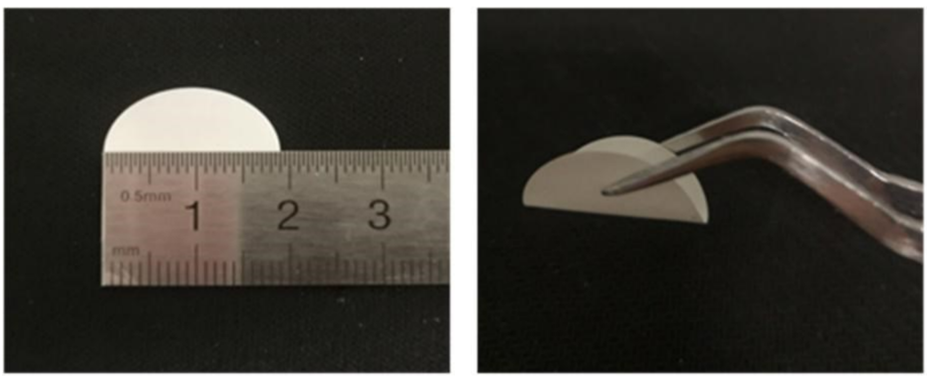


Fig. S3. The digital photos of composite microporous polymer electrolyte S3.

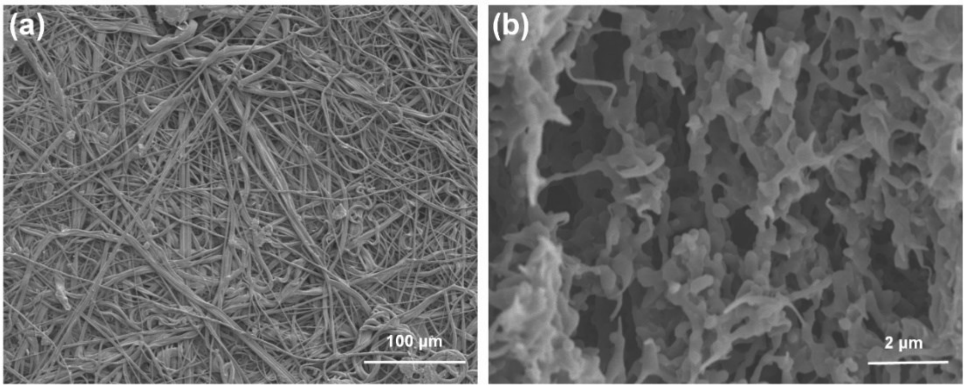


Fig. S4. (a) Surface morphology of the commercial separator CS. (b) Cross-section image of fabricated micro-porous membranes S3.

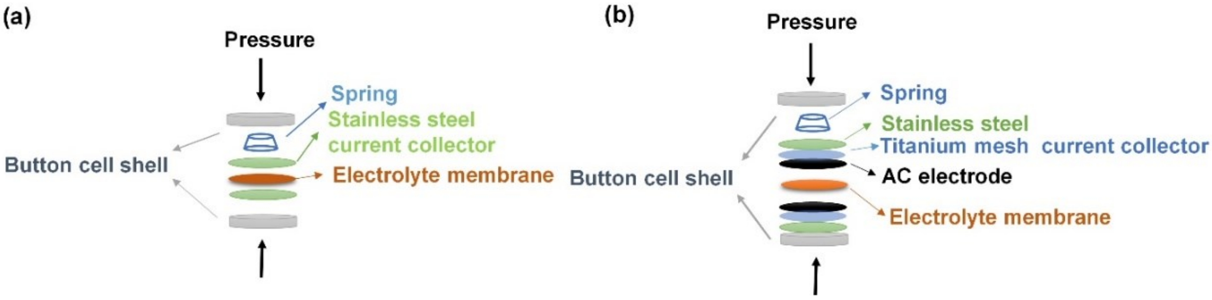


Fig. S5. (a) the assembly schematic for the bulk impedance and (b) interface impedance of solid electrolyte membrane.

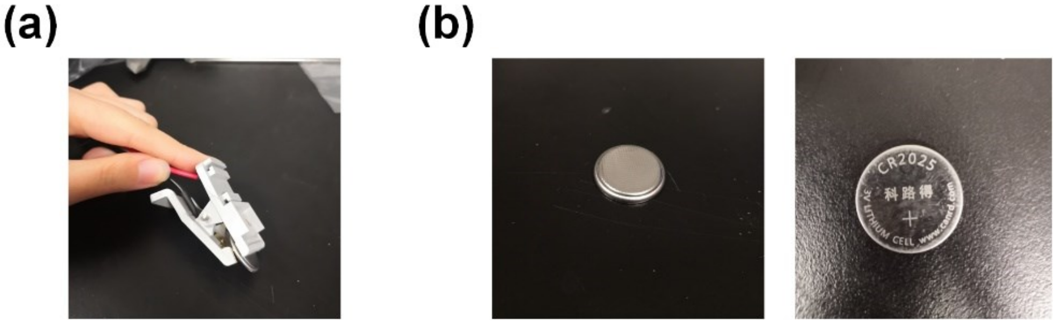


Fig. S6. (a) The digital photos of two-point test and (b) assembly device using 2025-type button cell.

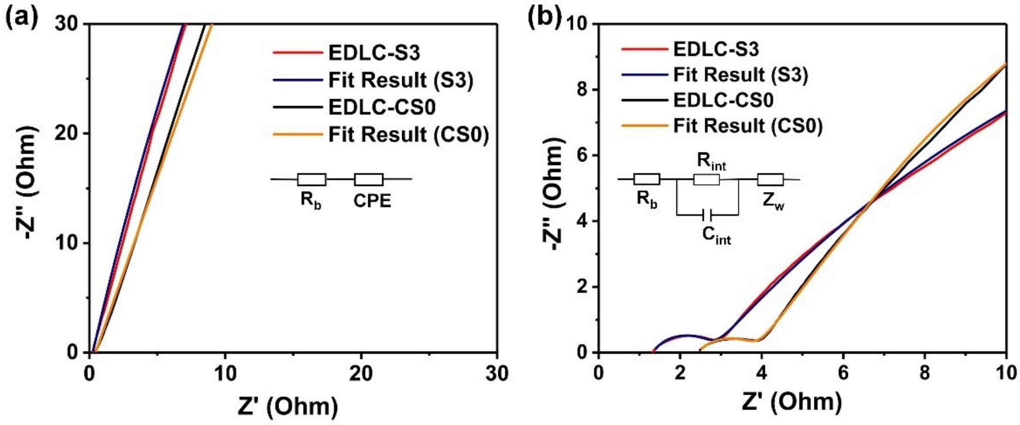


Fig. S7. (a) EIS Nyquist plot and fit figure for the frequency range of 100 kHz to 1 Hz at 293 K. (a, inset) Equivalent circuit model to extrapolate R_b (R_b - the bulk electrolyte membrane, CPE - the constant phase element, the fitting error on R_b is less than 5%) and (b) EIS Nyquist plot and fit figure for the frequency range of 0.01 Hz–100 kHz. (b, inset) Equivalent circuit model to extrapolate R_{int} (R_{int}- the interface impedance, C_{int} – the interface capacitance, Z_w – the Warburg impedance element, the fitting error on R_{int} are less than 5%).

Tab. S2. Specific capacitance C_s, energy density E_{cell}, and power density P_{cell} of EDLC-S3 and EDLC-CS0 at different current densities (0.2–5 A g^{-1})

Current density (A g^{-1})	**C_s-S3 (F g^{-1})**	**C_s-CS0 (F g^{-1})**	**E_{cell}-S3 (Wh kg^{-1})**	**E_{cell}-CS0 (Wh kg^{-1})**	**P_{cell}-S3 (W kg^{-1})**	**P_{cell}-CS0 (W kg^{-1})**
0.2	**134.38**	**126.92**	**10.47**	**9.90**	**20.92**	**20.82**
0.5	**133.70**	**125.38**	**10.38**	**9.74**	**51.91**	**51.94**
1	**122.61**	**112.11**	**9.43**	**8.64**	**103.34**	**103.47**
2	**108.96**	**101.73**	**8.22**	**7.72**	**204.73**	**205.27**
5	**90.92**	**78.27**	**6.37**	**5.50**	**493.08**	**493.75**