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Electronic Supplementary Information

Single ion conducting lithium sulfur polymer batteries with improved safety and stability

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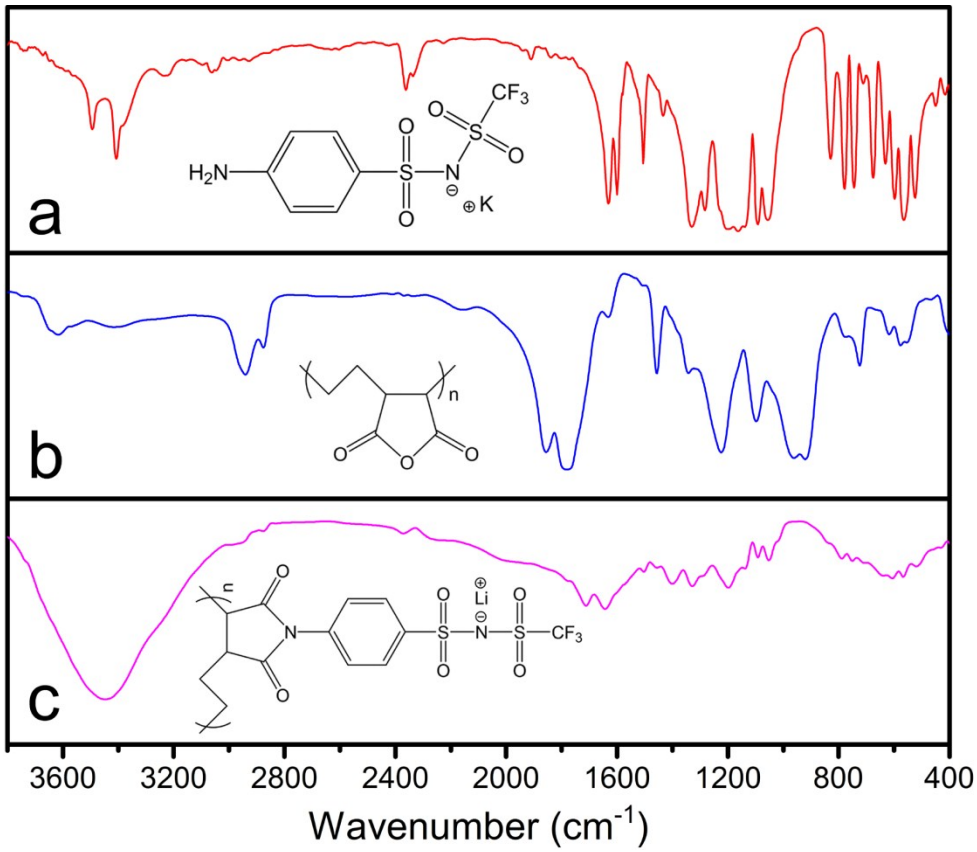

Fig. S1 FT-IR spectra of (a) KATFSI, (b) PEMA and (c) PEMA-*graft*-LiATFSI.

The FT-IR spectra of the KATFSI, PEMA and PEMA-*graft*-LiATFSI are shown in **Fig. S1**. For KATFSI (**Fig. S1a**), 3494 cm^{-1} (ν_{N-H}, *as*, $-NH_2$), 3408 cm^{-1} (ν_{N-H}, *s*, $-NH_2$), 1632&1601 cm^{-1} (δ_{N-H}, $-NH_2$), 1506 cm^{-1} (ν_{C-F}, $-CF_3$), 1328&1282 cm^{-1} ($\nu_{S=O}$, *as,* two types of $-SO_2-$), 1092&1053 cm^{-1} ($\nu_{S=O}$, *s,* two types of $-SO_2-$). For PEMA (**Fig. S1b**), 1855 cm^{-1} ($\nu_{C=O}$, *s*, anhydride), 1780 cm^{-1} ($\nu_{C=O}$, *as*, anhydride), 1224 cm^{-1} (ν_{C-O-C}, anhydride). For PEMA-*graft*-LiATFSI (**Fig. S1c**), 1712 cm^{-1} ($\nu_{C=O}$, *s*, anhydride), 1641 cm^{-1} ($\nu_{C=O}$, *as*, anhydride), 1502 cm^{-1} (ν_{C-F}, $-CF_3$), 1399&1327 cm^{-1} ($\nu_{S=O}$, *as,* two

types of -SO_2-), 1091&1051 cm^{-1} ($\nu_{S=O}$, *s,* two types of -SO_2-).

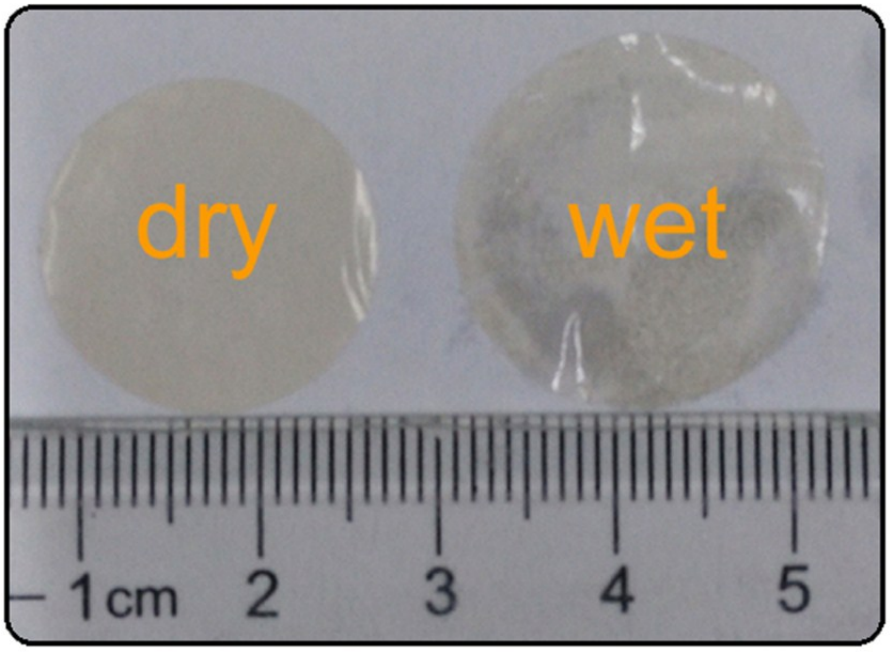

Fig. S2 The photo image of the dry and wet single ion conducting electrolyte membrane.

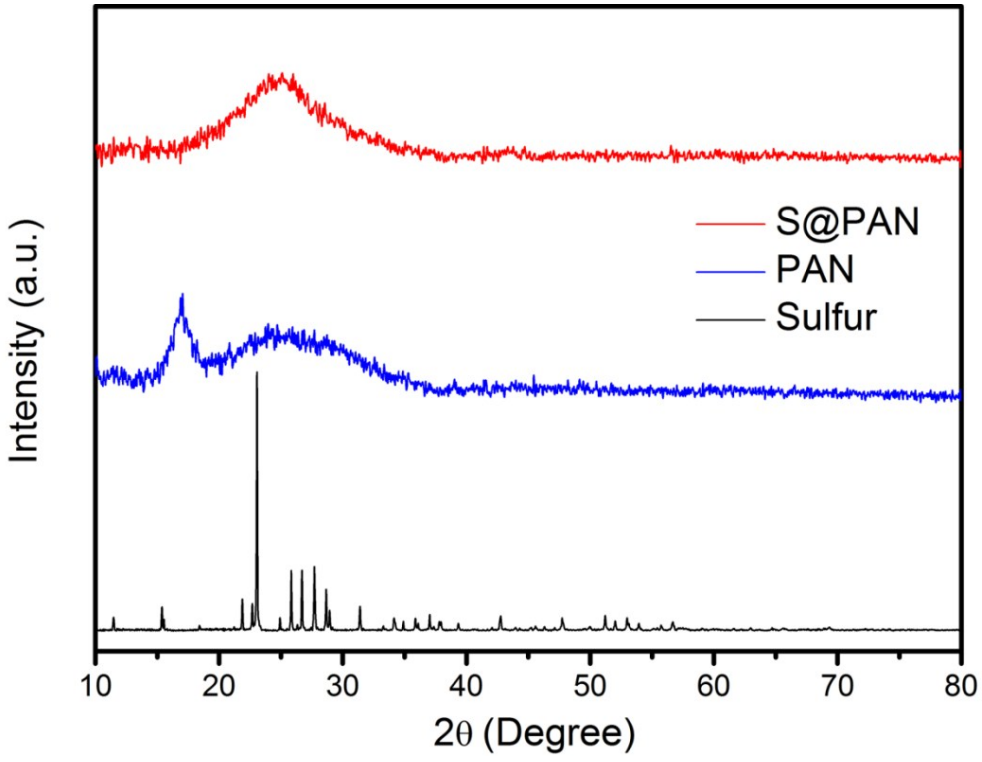

Fig.S3 XRD patterns of sulfur, PAN and S@PAN.

The XRD patterns of sulfur, PAN and S@PAN are shown in **Fig. S3**. Similar to the results reported in several previous studies,[1-5] the XRD pattern of the S@PAN obtained by the pyrolysis reaction of sulfur and polyacrylonitrile only shows a broad peak at 2θ=25° with no diffraction peak of sulfur indexed to the *Fddd* orthorhombic structure (JCPDS: 08-0247).[1-3] Moreover, the diffraction peak at 2θ=17° ascribed to the (110) plane of the crystal of polyacrylonitrile cannot be found in S@PAN.[4,5] The results indicate that sulfur is homogeneously embedded in the backbone

of the pyrolyzed polyacrylonitrile and becomes amorphous.[1-4]

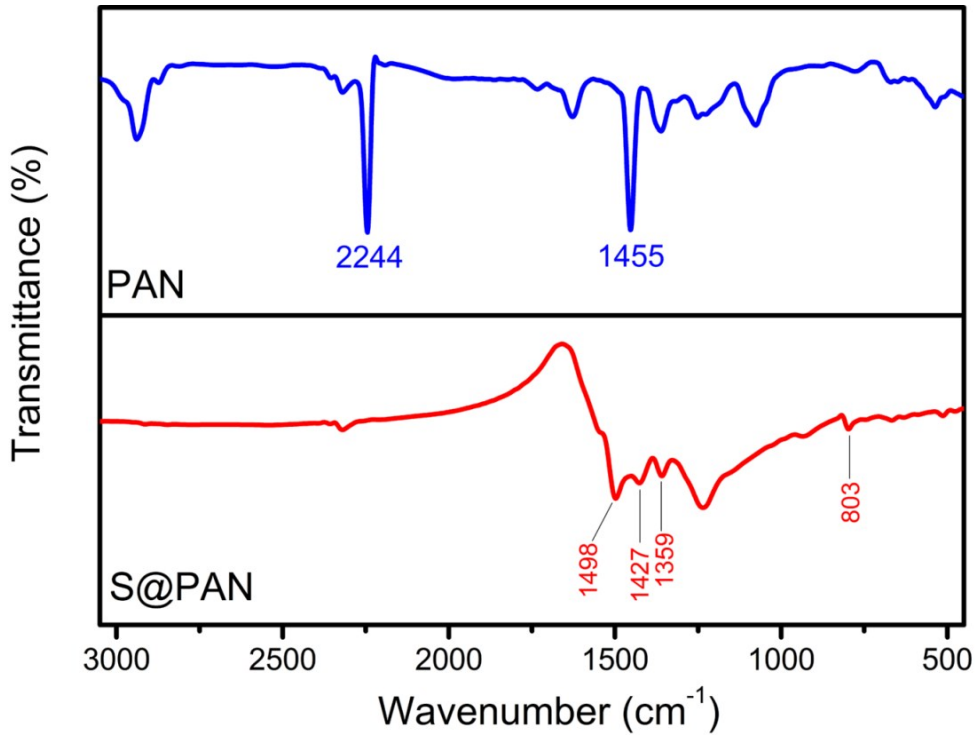

Fig. S4 FT-IR spectra of PAN and S@PAN.

Fig. S4 displays the FT-IR spectra of PAN and S@PAN. The peaks at 1455 cm^{-1} and 2244 cm^{-1} ascribed to the -CH_2 and -CN groups of PAN disappear after the pyrolysis reaction.[6] Several new peaks emerge in the FT-IR spectra of S@PAN. The peaks at 1359 cm^{-1} and 1498 cm^{-1} indicate the existence of -CH deformation and C=C double bonds, respectively. The peaks at 803 cm^{-1} and 1427 cm^{-1} correspond to the formation of a heterocyclic structure in the pyrolysis process between sulfur and polyacrylonitrile.[7]

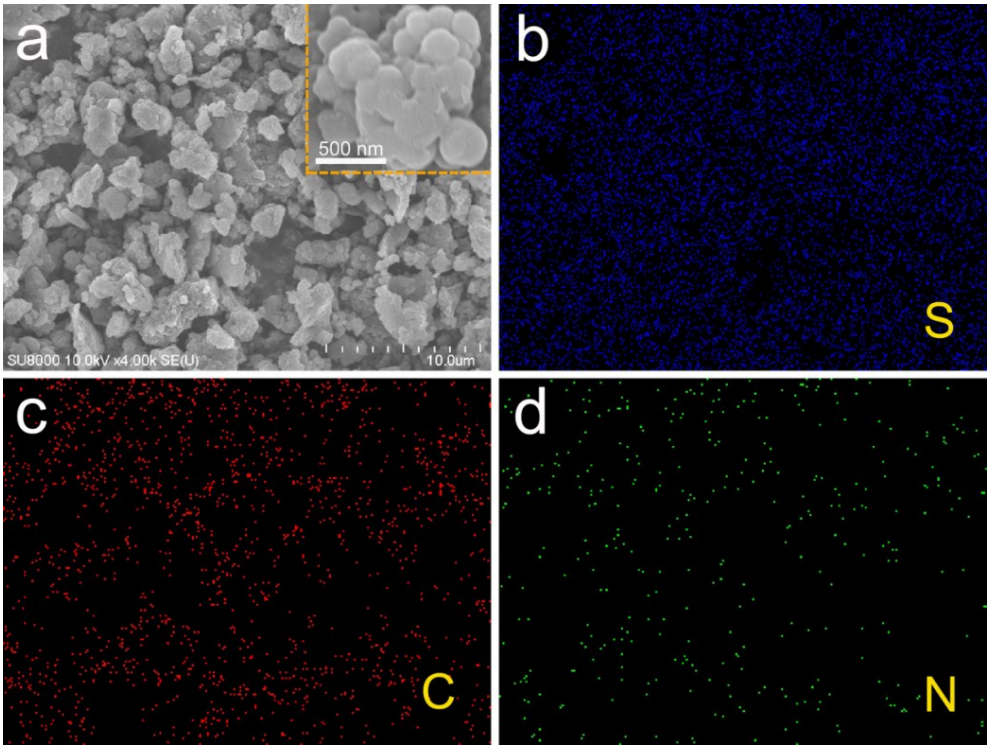

Fig. S5 Micromorphology and elemental distribution by EDS.

S@PAN represents the irregular micron-sized secondary particles made of nano-sized aggregates as shown in **Fig. S5a**. And the elemental S (**Fig. S5b**), C (**Fig. S5c**) and N (**Fig. S5d**) are distributed uniformly in the sample.

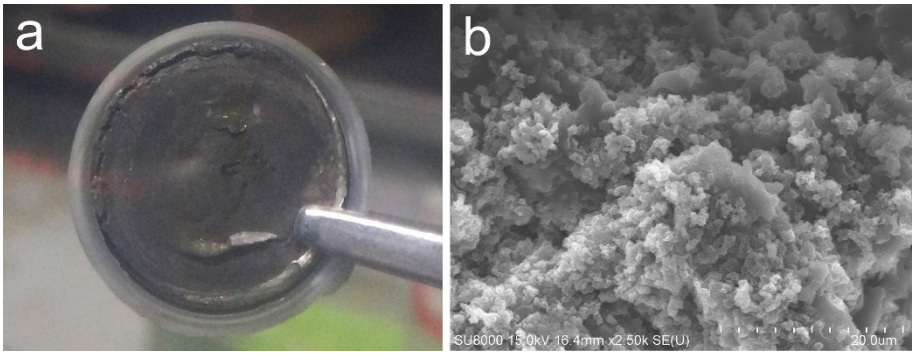

Fig. S6 The morphology of lithium metal with commercial dual ion electrolyte after 1000 cycles at 1 C. (a) Photo image; (b) FE-SEM image.

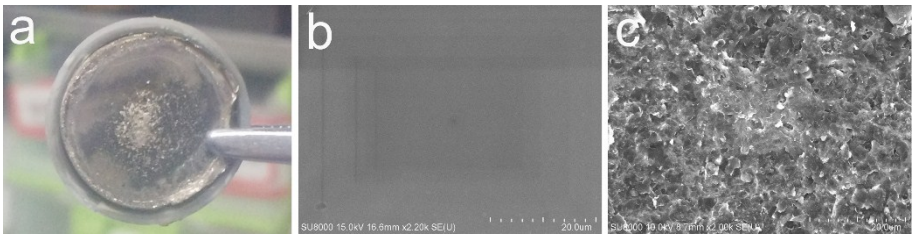

Fig. S7 The morphology of lithium metal with single ion conductor after 1000 cycles at 1 C. (a) Photo image; (b) FE-SEM image of the surface with metallic shinning; (c) FE-SEM image of the dark area.

References

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