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Polypyrrole modified porous poly (ether sulfone) membranes with high performance for vanadium flow batteries

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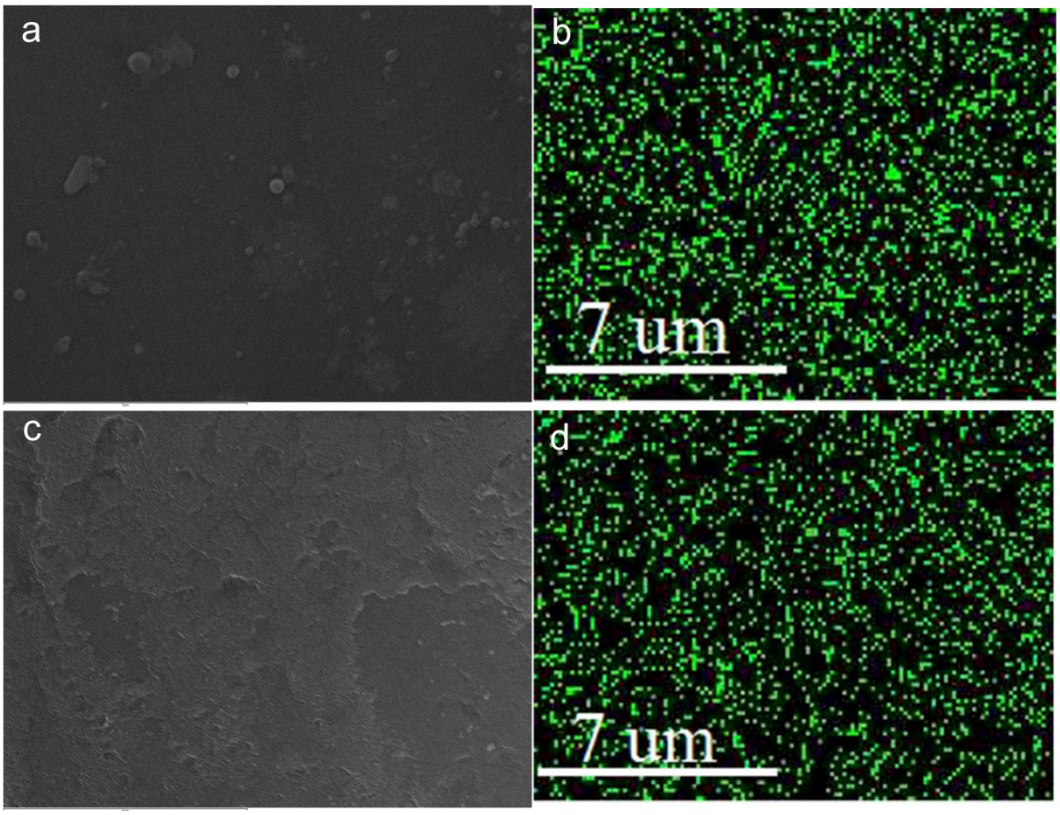

Fig. S1 Surface morphology of PPY/PES porous membranes (a) before and (c) after the cycling test; the corresponding EDS mapping of N distribution (b) before and (d) after the cycling test, confirming the uniform distribution and stability of the PPY in the membrane.

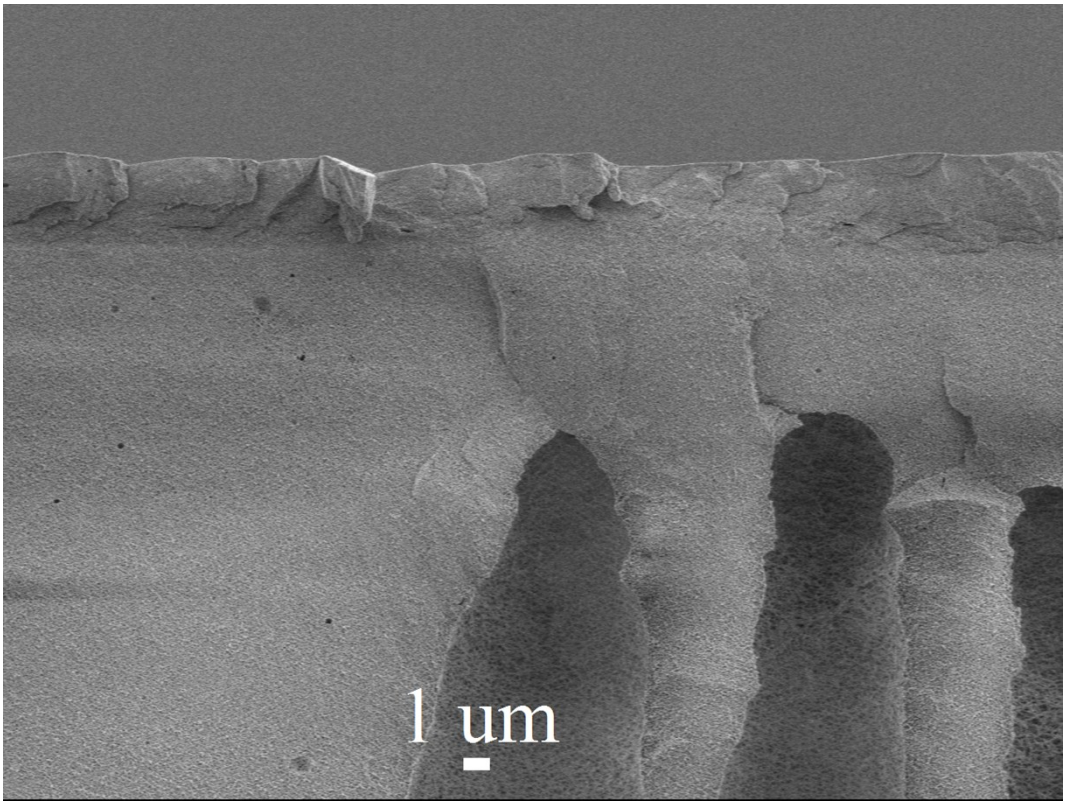

Fig. S2 Magnified cross section morphology of the substrate.

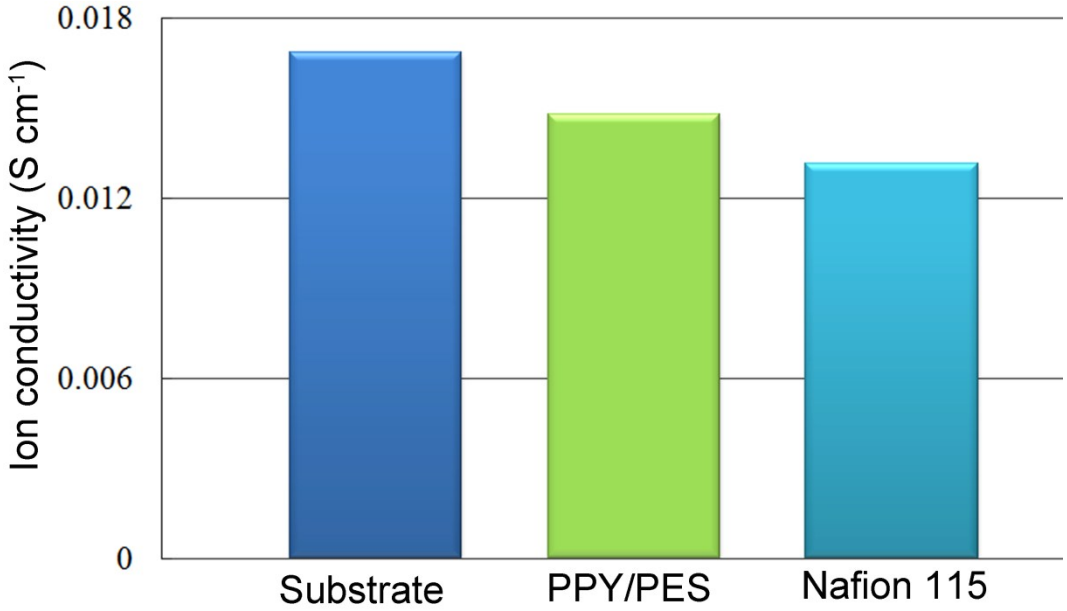

Fig. S3 Ion conductivity of the substrate, PPY/PES and Nafion 115 membranes.

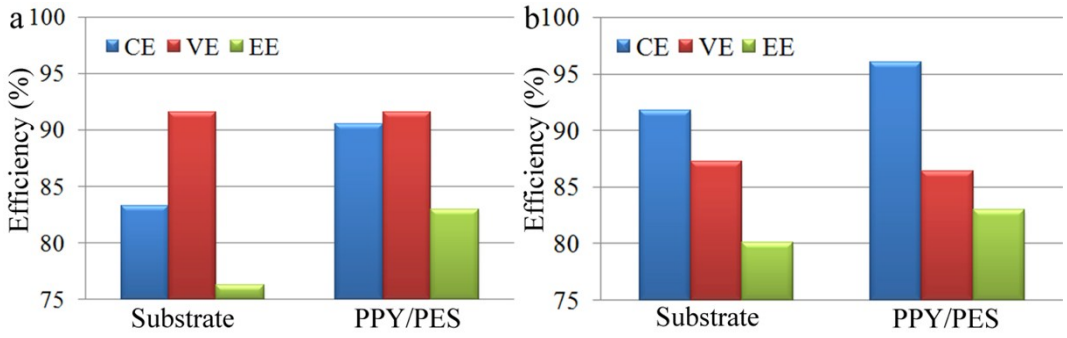

Fig. S4 The efficiency of a vanadium flow battery installed with substrate and PPY/PES with different membrane thickness (a: 85 ± 5 μm, b: 140 ± 5 μm) at 80 mA cm^{-2}.