Electronic Supplementary Material (ESI) for Energy & Environmental Science


**Electronic supplementary information for**

# Ionic Shield of Polysulfides for High-Stable Lithium Sulfur Battery

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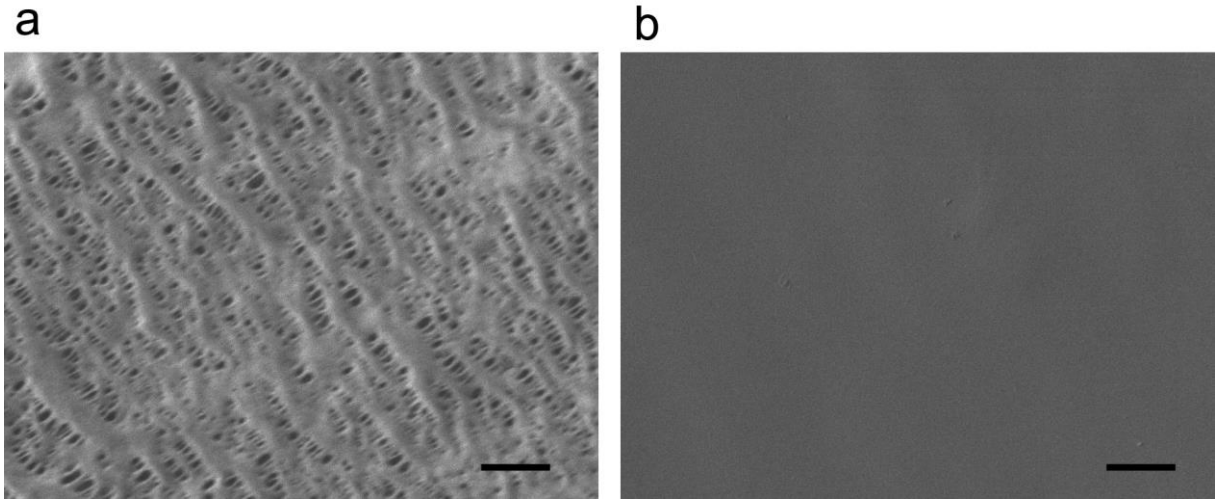


**Figure S1.** The mophologies of membranes. (a) The SEM image for Celgard membrane with the Nafion loading amount of 0.15 mg $cm^{-2}$. (b) The SEM image for Celgard membrane with the Nafion loading amount of 3.5 mg $cm^{-2}$ (b). Scale bar: 1 μm.

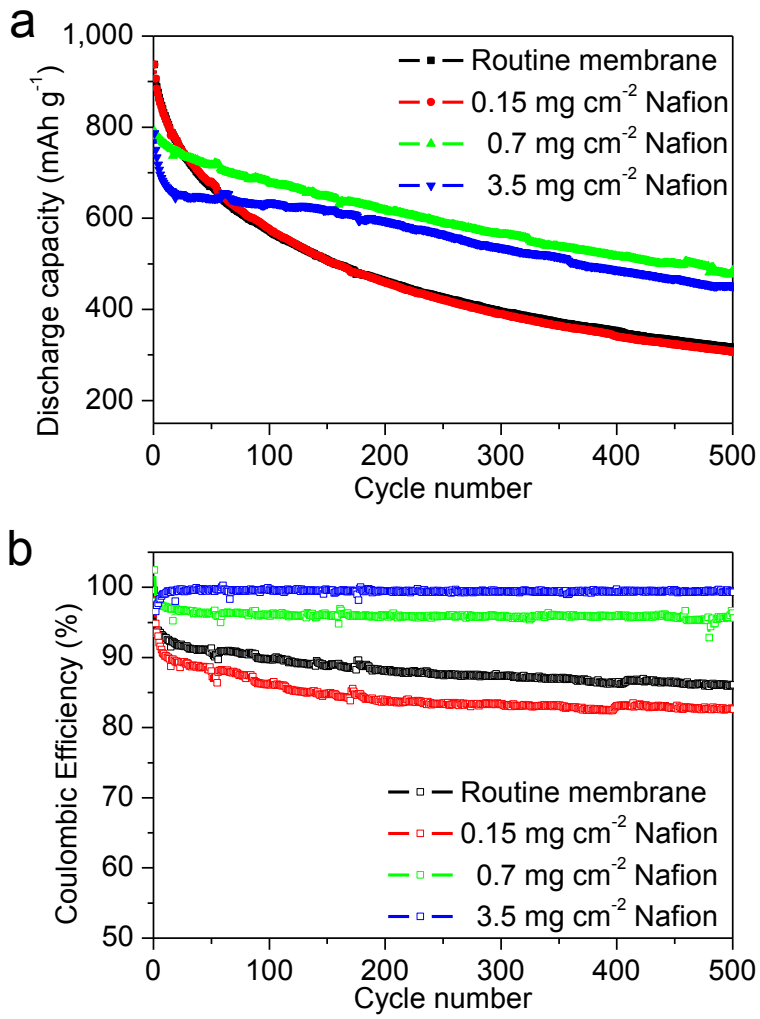


**Figure S2.** The electrochemical performances. (a) The change of discharge capacities *vs.* the cycle number and (b) The coulombic efficiencies *vs.* the cycle number. Charge and discharge current density of 1 C, corresponding to a current density of 0.89 mA $cm^{-2}$.

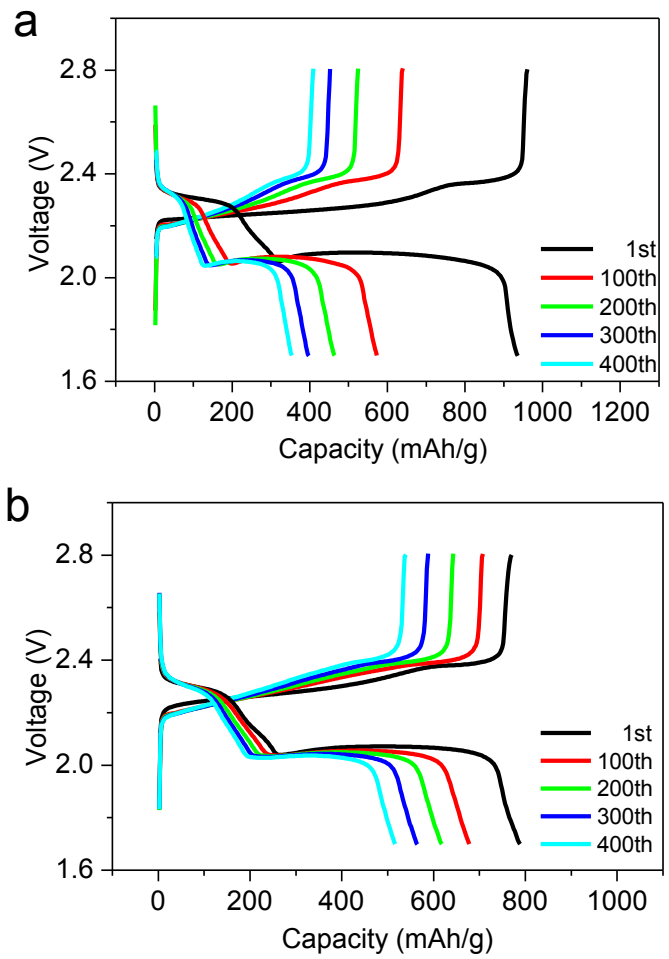


**Figure S3.** The voltage profiles of cells with routine and ion selective membranes. (a) The voltage profile of cell with routine membrane. (b) The voltage profile of cell with ion selective membranes. Charge and discharge current density of 1 C, corresponding to a current density of 0.89 mA $cm^{-2}$.

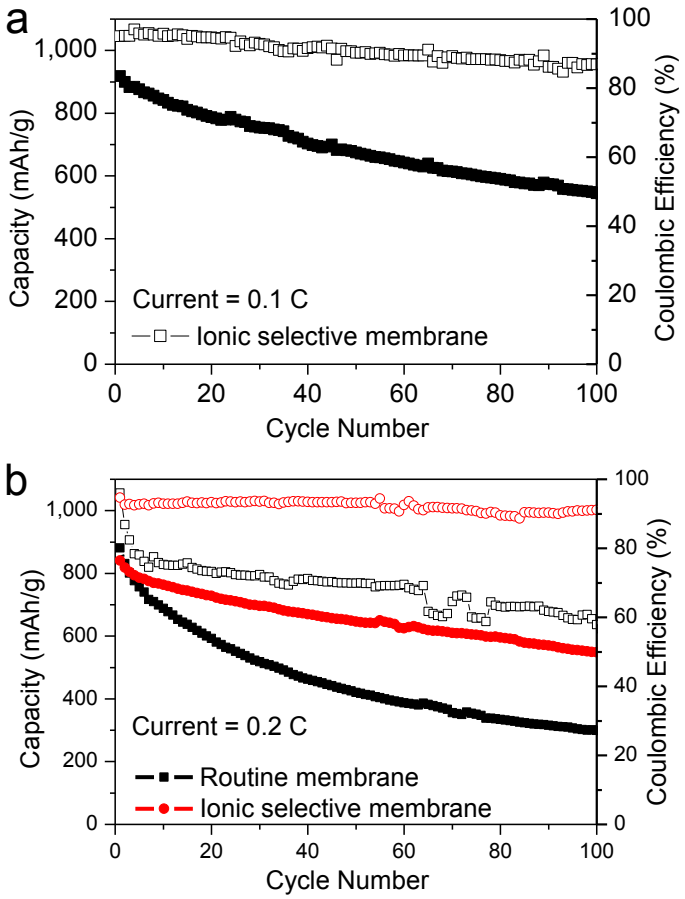


**Figure S4.** Electrochemical performances at low current densities. (a) The performance of ion selective membrane at 0.1 C, corresponding to a current density of 0.09 mA $cm^{-2}$. (b) The performance of routine and ion selective membrane at 0.2 C, corresponding to a current density of 0.18 mA $cm^{-2}$.

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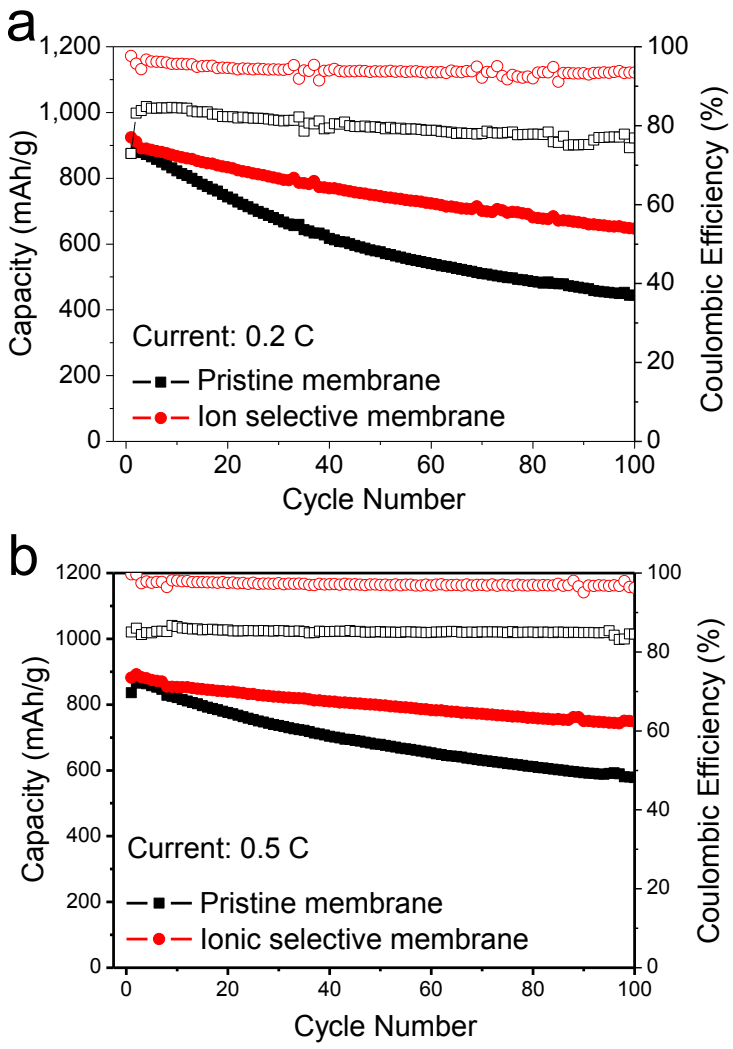


**Figure S5.** Electrochemical performances with different electrodes. The performance of ion selective membrane on SWCNT/S electrodes: (a) cyclic performance at 0.2 C (0.18 mA $cm^{-2}$). (b) cyclic performance at 0.5 C (0.46 mA $cm^{-2}$).

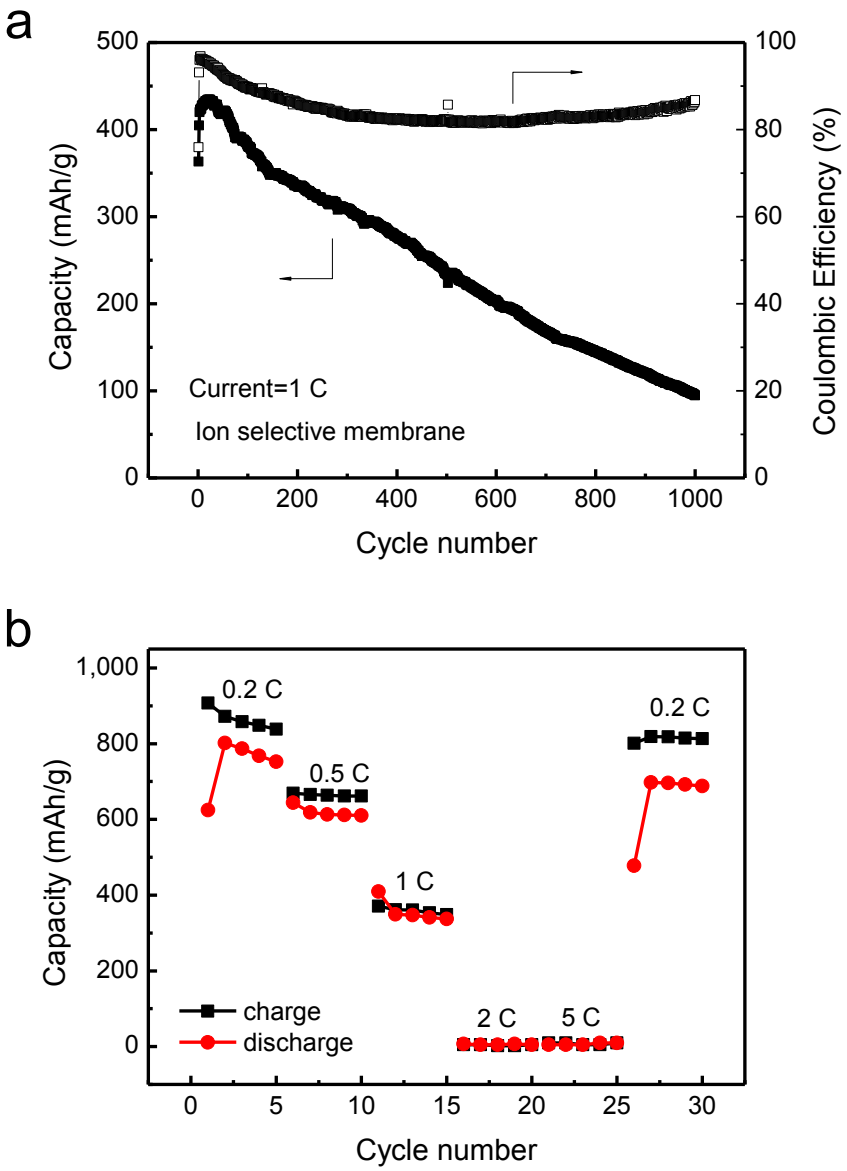


**Figure S6.** Electrochemical performances with different loading methods. (a) The cyclic performance of cell with direct Nafion loading on carbon/sulfur electrode, current density of 1C, corresponding to 0.89 mA $cm^{-2}$. (b) The rate performance of cell. Nafion loading amount of 0.7 mg $cm^{-2}$.

**Liquid leakage test for membranes**

The Nafion-based ion selective membrane is one dense membrane, which greatly reduced the leakage of the electrolyte through it. In the *in-situ* experiment, the diffusion of polysulfide were mostly blocked and the gray level indicates that there is almost no change even after 40 hr discharge. To demonstrate the different leakage property of routine membrane and Nafion-treated ion selective membrane, the liquid leak property was determined. The time that a fixed amount of electrolyte go through the membranes in under same vacuum filtration condition was measured. For routine membrane, it takes 17 min for 10 mL electrolyte to go across the membrane with a velocity of 0.046 mL $min^{-1}$ $cm^{-2}$. While for Nafion-treated ion selective membrane, no obvious liquid electrolyte leakage was observed even for a 60-min vacuum filtration, which indicates that the thorough channel through the membranes is completely covered by the dense Nafion-based ion selective membrane.