Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.


# A Novel Mixed Ether-based Electrolyte for Lithium-sulfur Batteries with Li Anode Protection by Dual Salt

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**Table S1. Element composition of the SeSPAN powder**

| Element | H | C | N | S | Se |
|---|---|---|---|---|---|
| Weight ratio (%) | 1.4 | 38.3 | 14.0 | 41.8 | 4.5 |

**Table S2. Compositions (Molar Ratio) of the THF-DPE Electrolytes**

| Name of Electrolyte | LiTFSI | LiFSI | THF | DPE |
|---|---|---|---|---|
| L1L2TE-4082 | 4 | 0 | 8 | 2 |
| L1L2TE-3182 | 3 | 1 | 8 | 2 |
| L1L2TE-2282 | 2 | 2 | 8 | 2 |
| L1L2TE-1382 | 1 | 3 | 8 | 2 |
| L1L2TE-0482 | 0 | 4 | 8 | 2 |

**Table S3. Specific capacity of SeSPAN with different electrolytes in rate test (mAh $g^{-1}$)**

| Electrolyte | LDD | L1L2TE-1382 | L1L2TE-2282 | L1L2TE-1382 |
|---|---|---|---|---|
| 0.15 C | 678 | 700 | 702 | 705 |
| 0.23C | 557 | 650 | 661 | 667 |
| 0.75 C | 352 | 607 | 648 | 646 |
| 1.5 C | 206 | 580 | 582 | 616 |
| 3 C | 110 | 393 | 467 | 575 |
| 7.5 C | 76 | 62 | 92 | 300 |

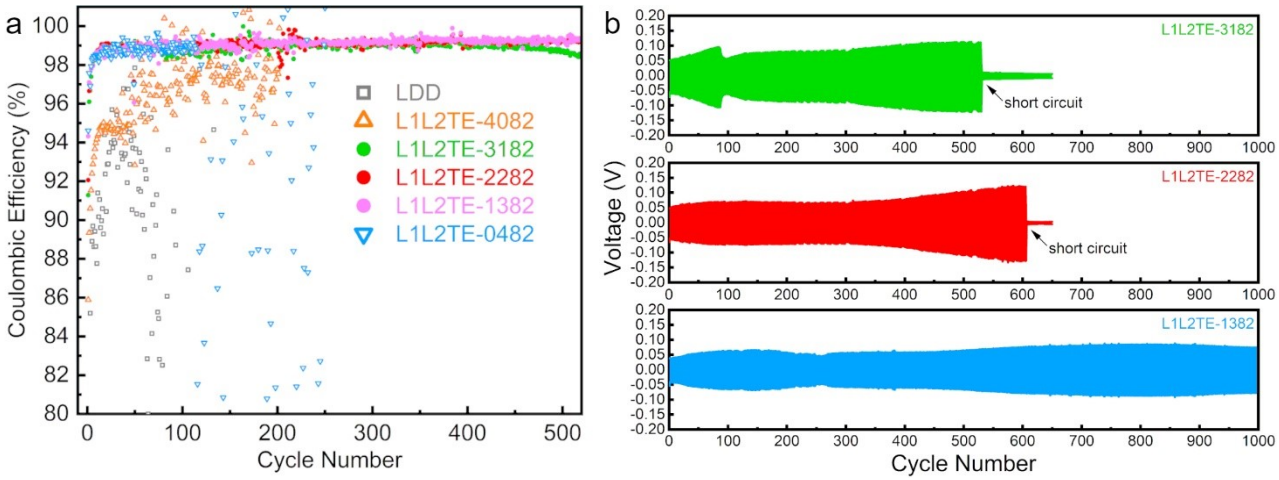


**Figure S1.** a) Coulombic efficiency of Li || Cu half-cells with the LDD, L1L2TE-4082, L1L2TE-3182, L1L2TE-2282, L1L2TE-1382 and L1L2TE-0482 electrolytes. b) Long-time cycling test of Li || Li symmetry-cells with the L1L2TE-3182, L1L2TE-2282 and L1L2TE-1382 electrolytes. See Table S1 for the details of the compositions of the electrolytes.

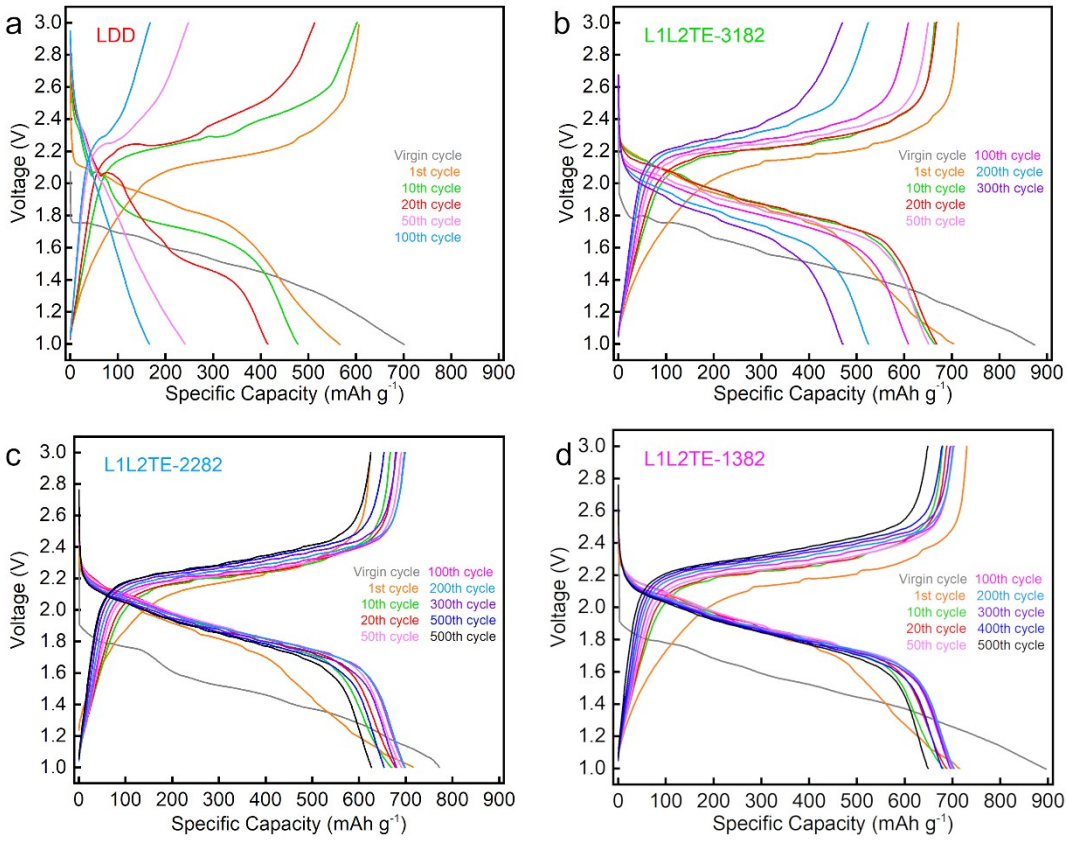


**Figure S2.** Corresponding voltage-capacity profiles of Li-SeSPAN cells on different cycle a) LDD, b) L1L2TE-3182, c) L1L2TE-2282, d) L1L2TE-1382.

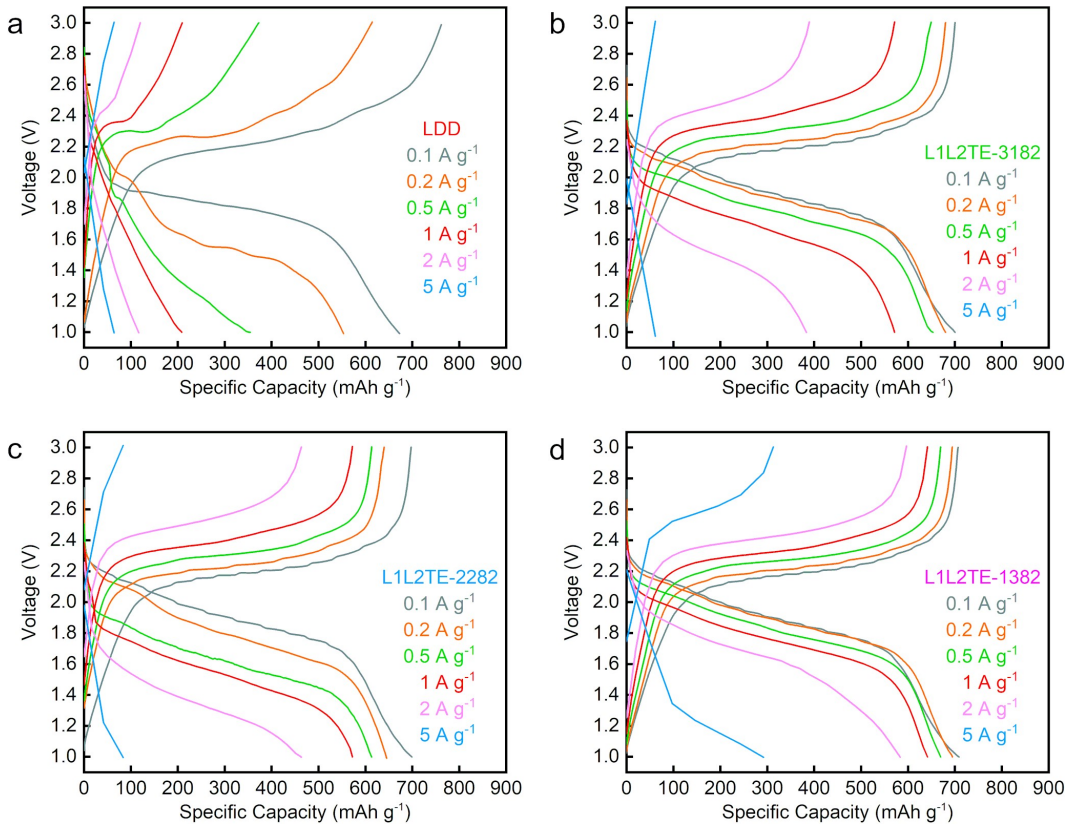


**Figure S3.** Capacity-voltage curves of the corresponding cells at various charge/discharge rate, a) LDD, b) L1L2TE-3182, c) L1L2TE-2282, d) L1L2TE-1382.

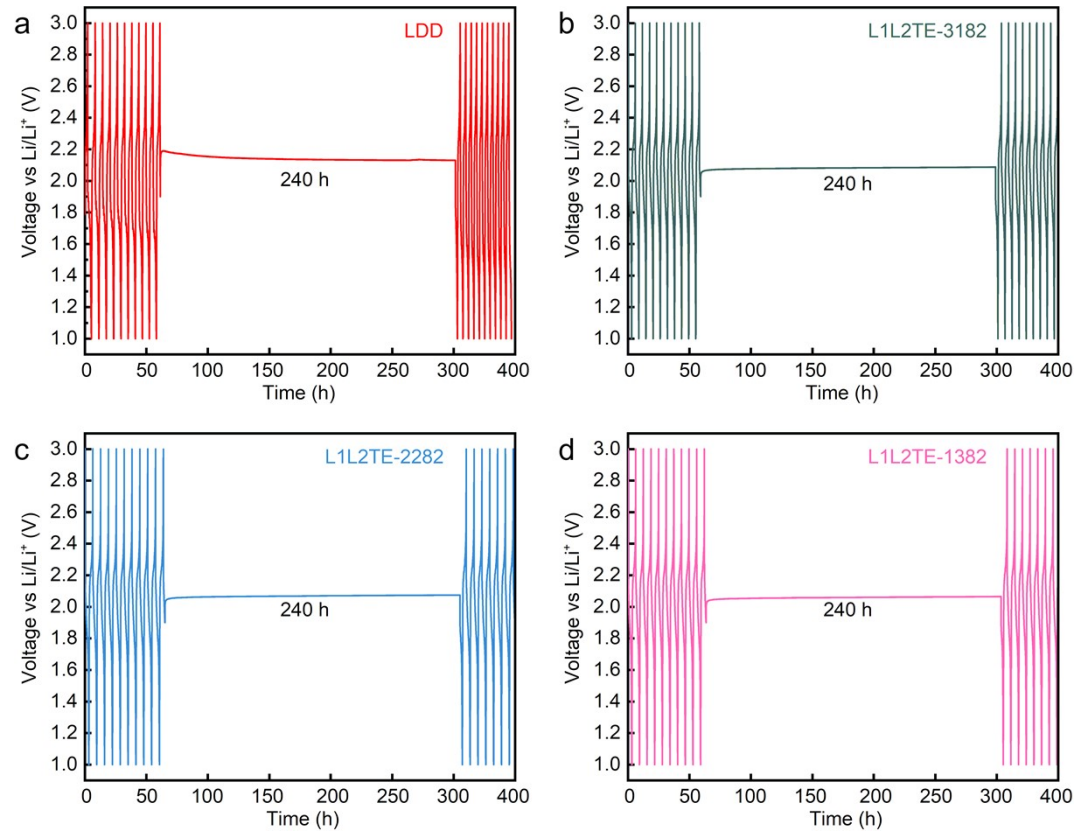

**Figure S4.** a-d) Voltage-time profiles for the storage test of cells with different electrolytes. All these cells were discharged to 1.9 V and kept for 10 d before resuming cycling.

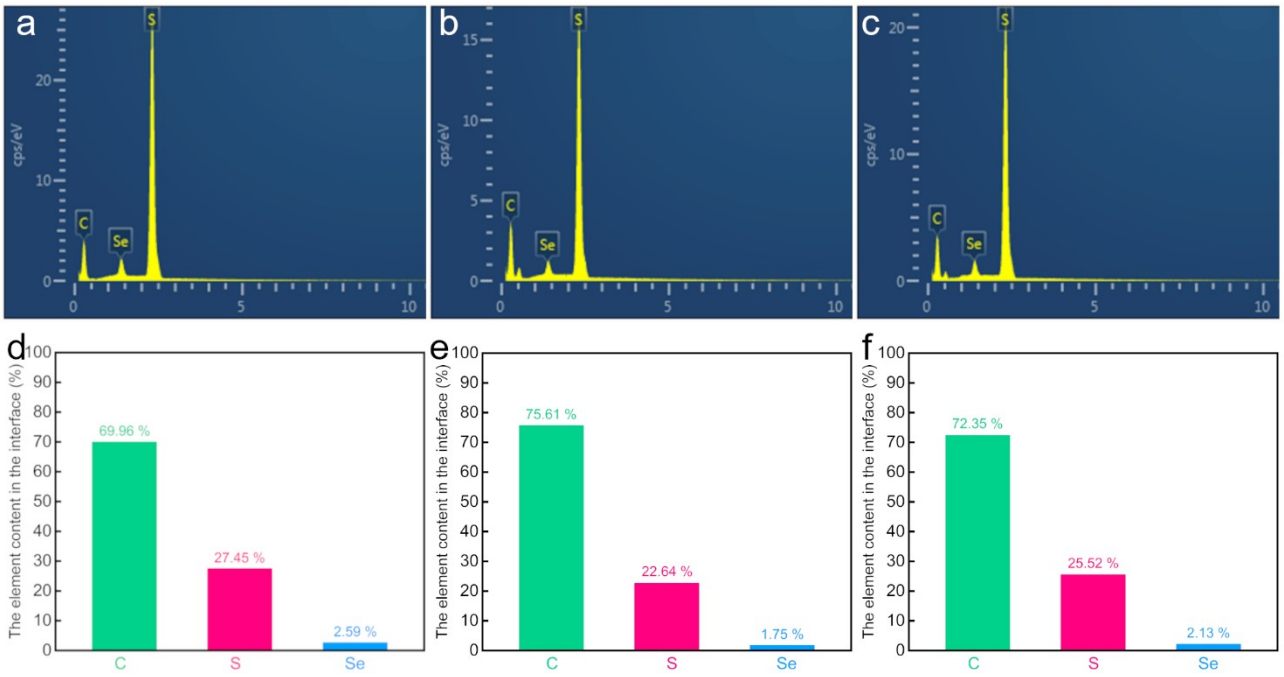


**Figure S5.** The EDS images of electrode surface, for, a) the original cathode, b) the cathode cycled in LDD, c) the cathode cycled in L1L2TE-1382. The content of elements on the electrode surface, for d) the original cathode, e) the cathode cycled in LDD, f) the cathode cycled in L1L2TE-1382.

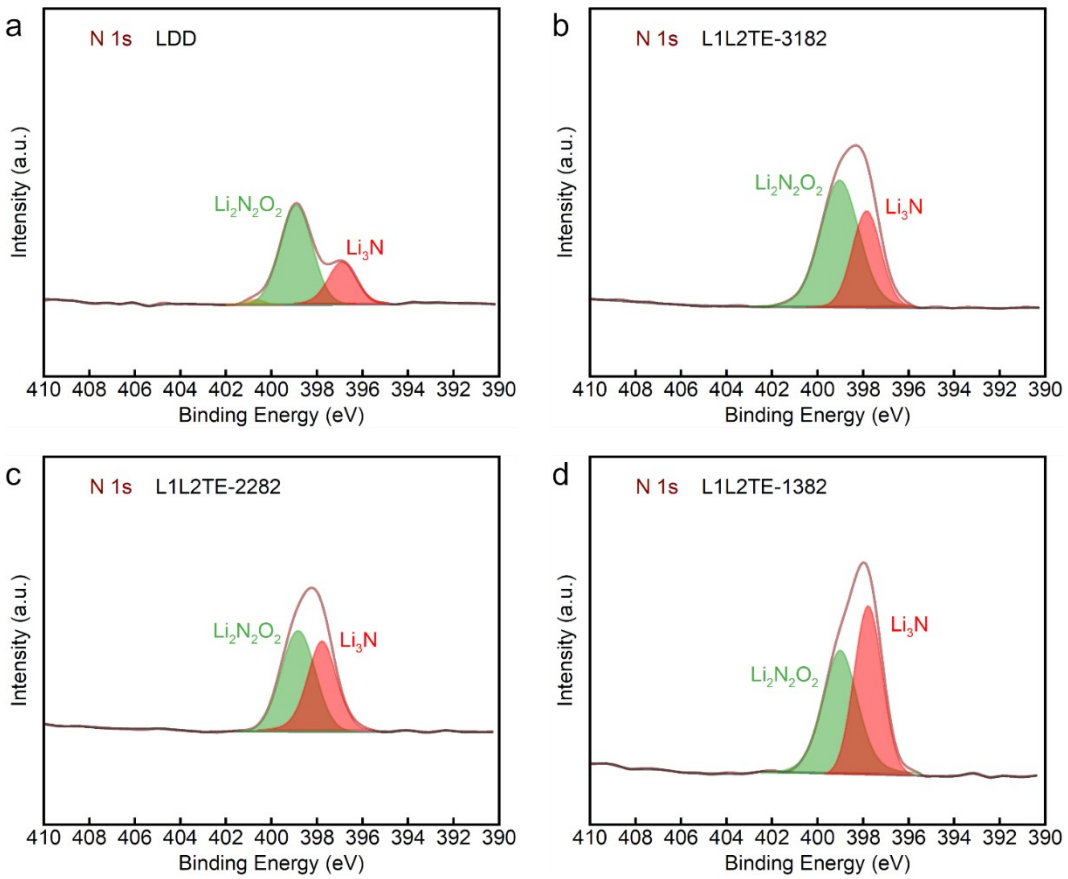


**Figure S6.** XPS spectra of N 1s of the SEI layers formed in Li-SeSPAN cells with different electrolytes after 50 cycles, for a) LDD, b) L1L2TE-3182, c) L1L2TE-2282, d) L1L2TE-1382.

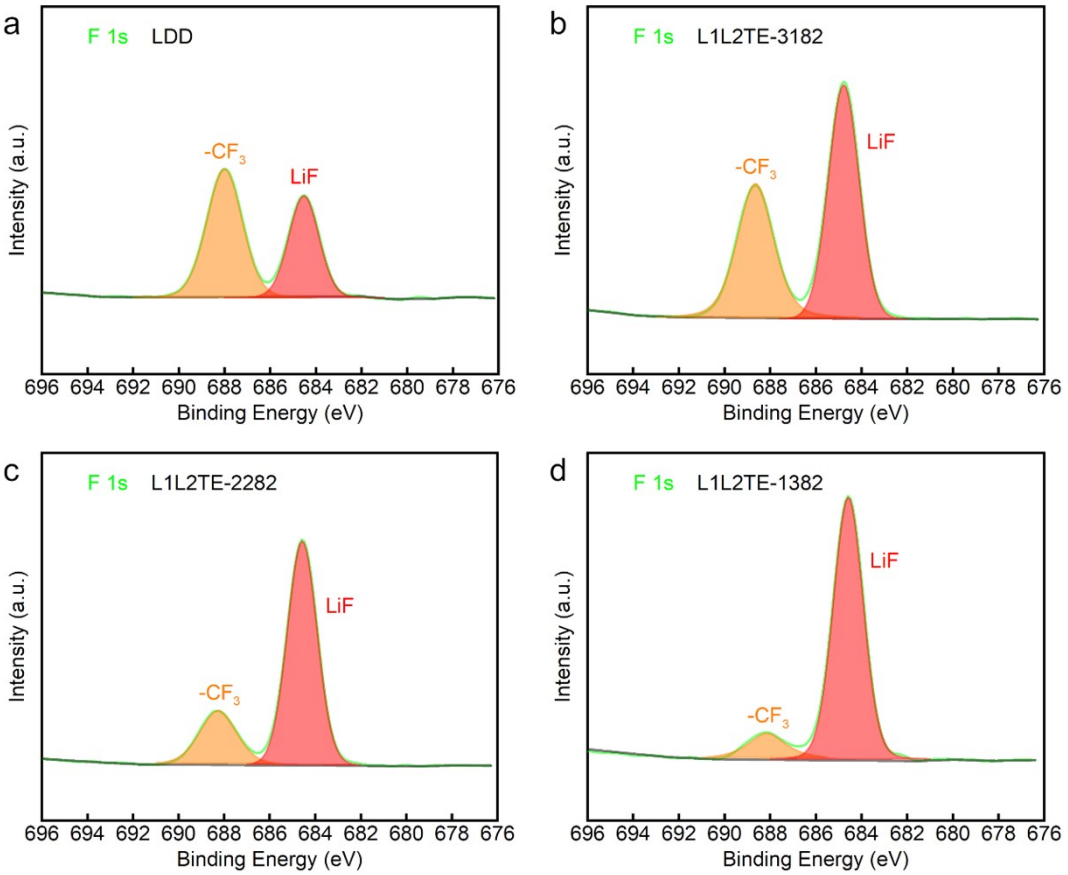

**Figure S7.** XPS spectra of F 1s of the SEI layers formed in Li-SeSPAN cells with different electrolytes after 50 cycles, for a) LDD, b) L1L2TE-3182, c) L1L2TE-2282, d) L1L2TE-1382.

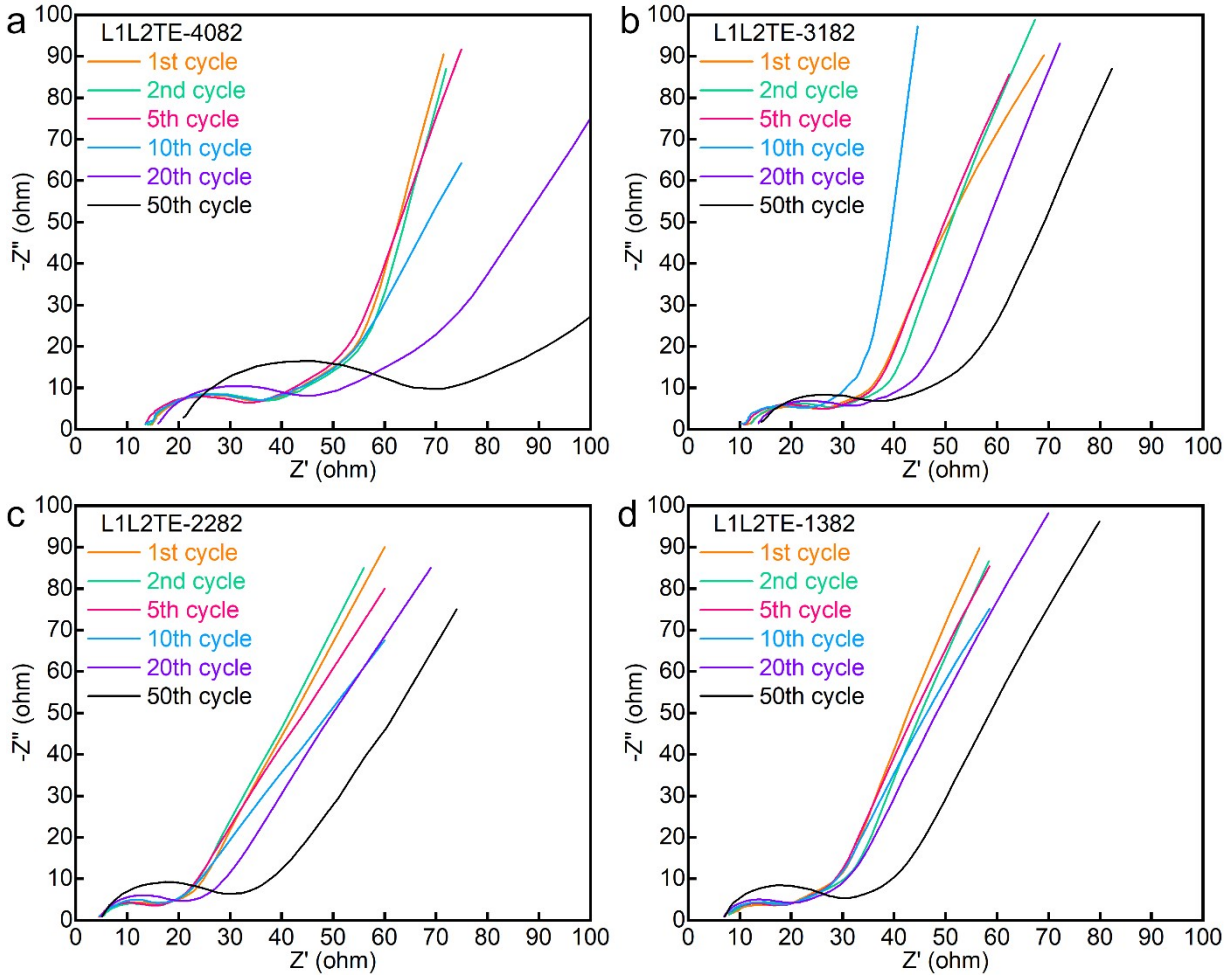


**Figure S8.** EIS spectra of the Li-SeSPAN cells with L1L2TE electrolytes cycled after 50 cycles, for a) L1L2TE-4082, b) L1L2TE-3182, c) L1L2TE-2282, d) L1L2TE-1382.