

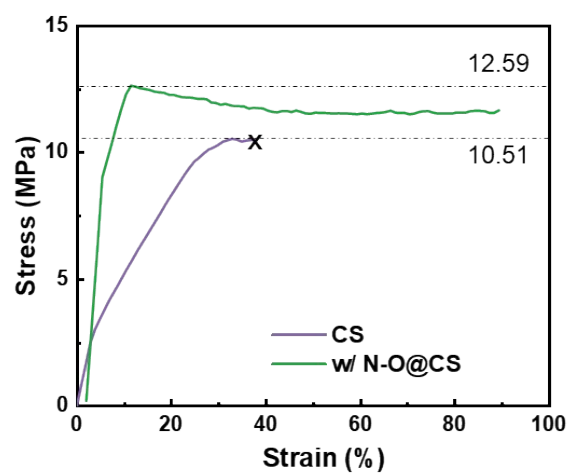
## **Functional Separator with a Nitrogen/Oxygen-Rich Interlayer for Enhancing Performance of Li-S Batteries**

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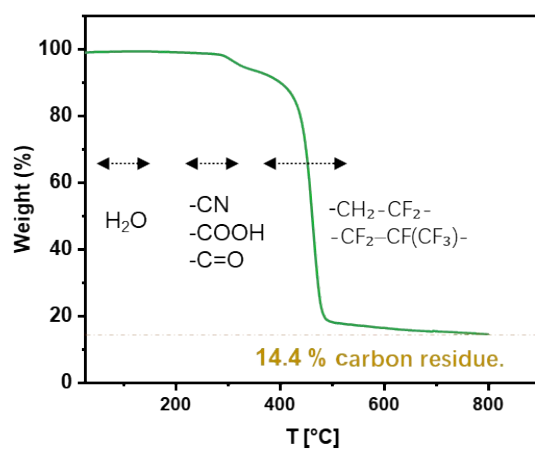
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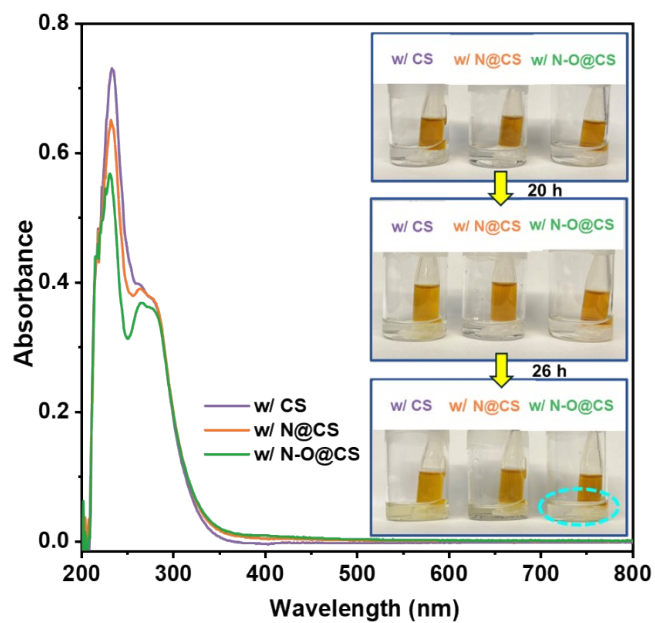
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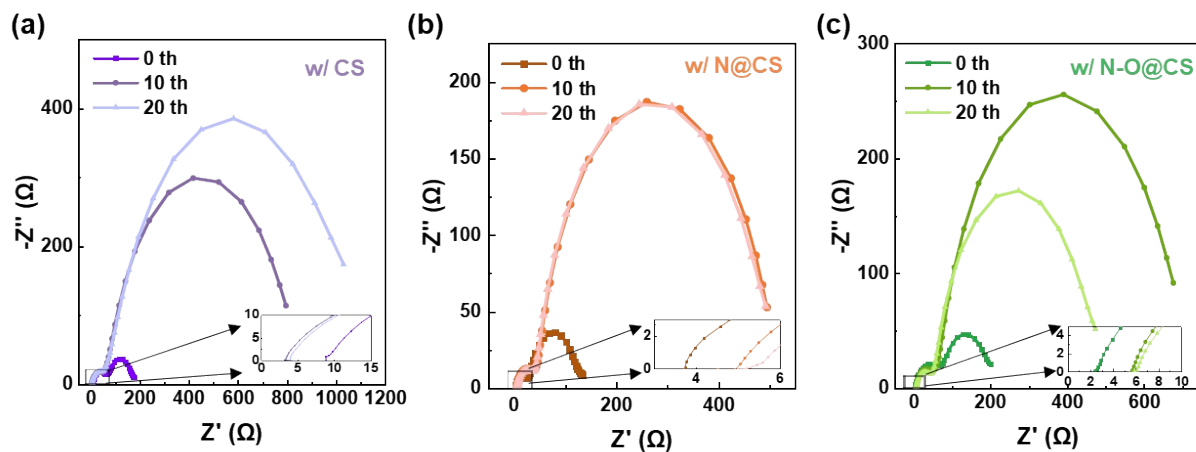
**Figure S1.** Tensile stress-strain curves of CS separator and N-O@CS-modified separator.



**Figure S2.** TGA curves showing thermal stability of N-O@CS-modified separator from 25 to 800 °C.



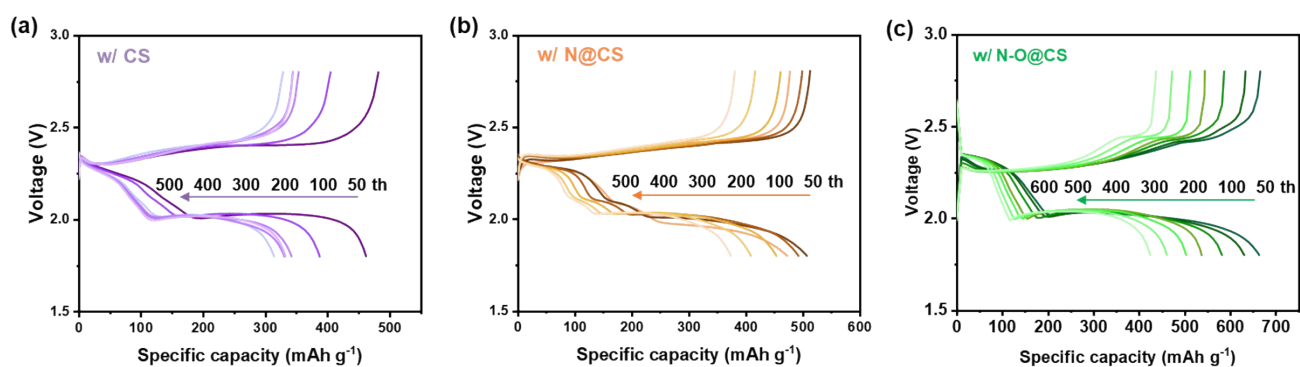
**Figure S3.** UV-vis absorbance spectra from  $\text{Li}_2\text{S}_8$  diffusion tests using CS, N@CS, and N-O@CS separators, with corresponding diffusion photographs shown as insets.



**Figure S4.** Nyquist plots from EIS measurements for Li-S cells with (a) CS separator, (b) N@CS separator and (c) N-O@CS separator at cycles of 0, 10 and 20.

**Table S1.** Fitting circuit model and parameters obtained from electrochemical impedance spectroscopy (EIS) for Li-S cells with different separators.

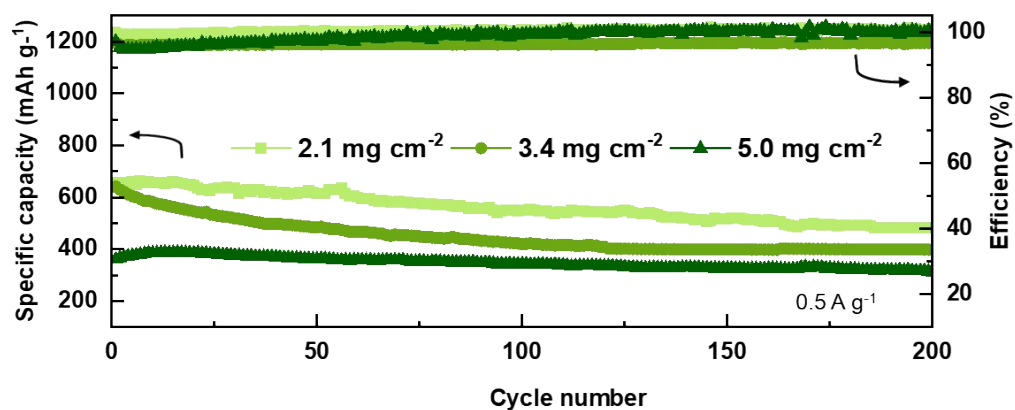
| Samples   | $R_b$ ( $\Omega$ ) |       |       | $R_{SEI}$ ( $\Omega$ ) |       |       | $R_{ct}$ ( $\Omega$ ) |        |        |
|-----------|--------------------|-------|-------|------------------------|-------|-------|-----------------------|--------|--------|
|           | 0 th               | 10 th | 20 th | 0 th                   | 10 th | 20 th | 0 th                  | 10 th  | 20 th  |
| w/ CS     | 8.81               | 3.32  | 4.12  | 51.99                  | 51.35 | 52.92 | 117.13                | 737.58 | 967.92 |
| w/ N@CS   | 3.71               | 4.91  | 5.62  | 26.07                  | 32.09 | 39.60 | 107.31                | 461.16 | 453.91 |
| w/ N-O@CS | 2.34               | 5.09  | 5.59  | 59.36                  | 47.10 | 39.37 | 140.3                 | 425.45 | 127.75 |



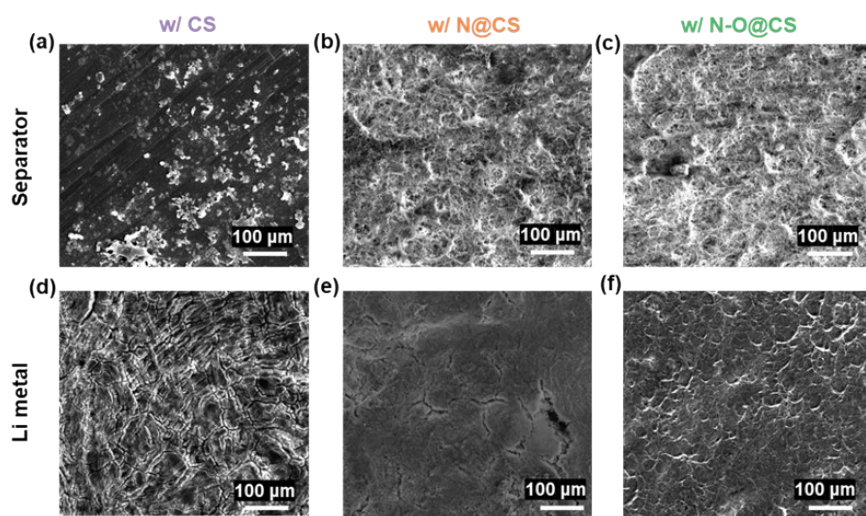
**Figure S5.** Voltage profiles of Li-S cells with (a) CS separator, (b) N@CS-modified separator and (c) N-O@CS-modified separator at selected cycles.

**Table S2.** Comparison of charge/discharge midpoint voltage differences ( $\Delta V$ ) among samples.

| Samples | $Q_{\text{start}}$<br>(mAh g <sup>-1</sup> ) | $Q_{\text{end}}$<br>(mAh g <sup>-1</sup> ) | $Q_{\text{mid}}$<br>(mAh g <sup>-1</sup> ) | $V_{\text{mid}}$<br>( $\Delta V$ ) |
|---------|--|--|--|------------------------------------|
| CS      | 160.56                                       | 328.62                                     | 244.59                                     | 0.381                              |
| N@CS    | 152.26                                       | 457.25                                     | 304.76                                     | 0.383                              |
| N-O@CS  | 195.83                                       | 604.56                                     | 400.20                                     | 0.323                              |



**Figure S6.** Electrochemical performance of the Li-S batteries with N-O@CS separator under elevated sulfur loadings.



**Figure S7.** SEM images of separators and corresponding Li metal anodes after 200 cycles at  $0.5 \text{ A g}^{-1}$ . Surface morphologies of (a, d) CS, (b, e) N@CS, and (c, f) N-O@CS separators with their paired Li metal anodes.