

# Supplementary Materials

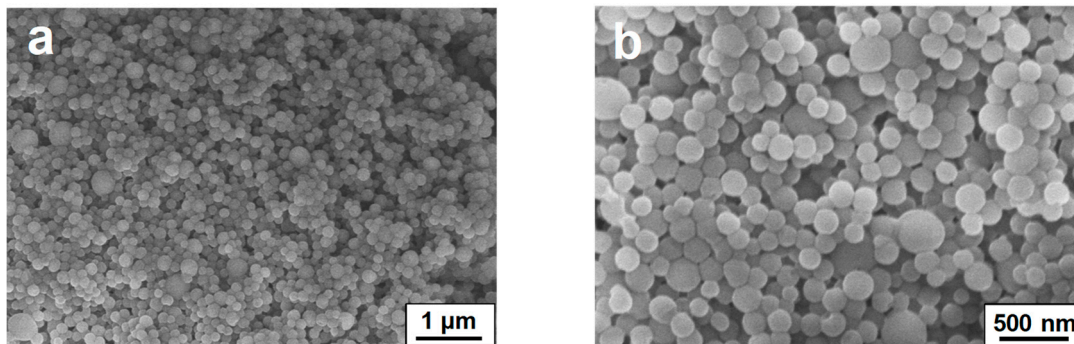


Figure S1. SEM images of the lignin-based nanospheres at different magnifications.

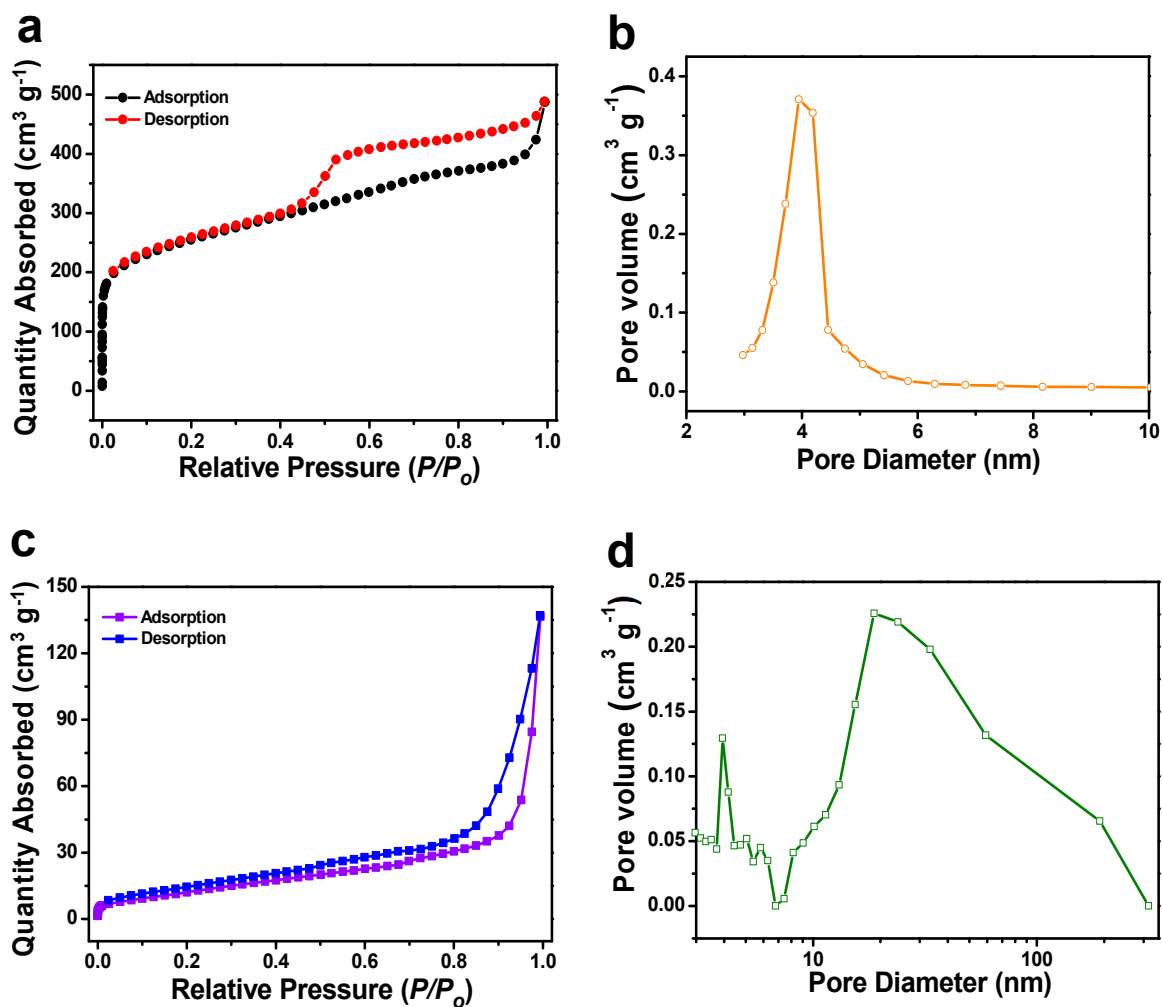
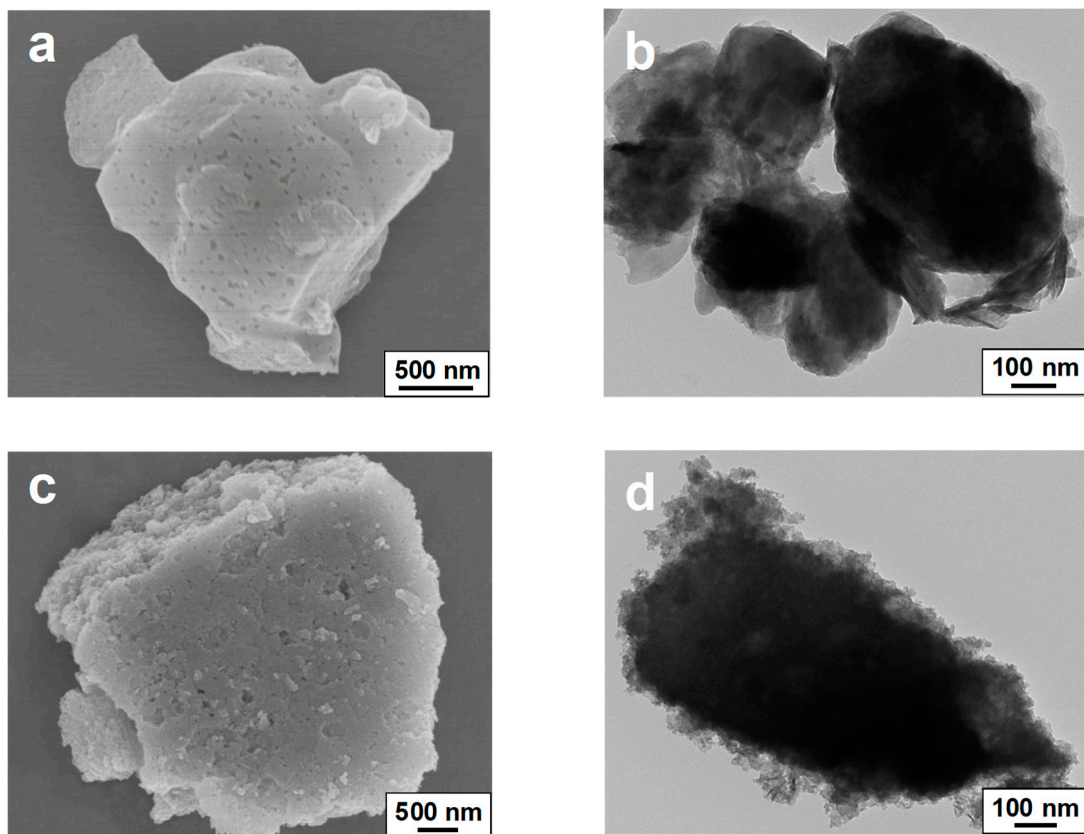
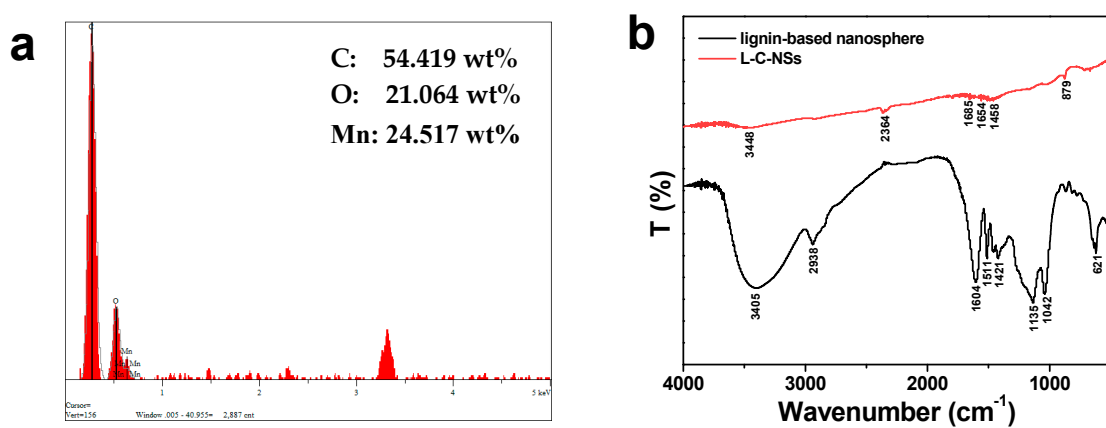


Figure S2. (a) N<sub>2</sub> adsorption-desorption isotherm and (b) pore-size distribution curve of the L-C-NSs; (c) N<sub>2</sub> adsorption-desorption isotherm and (d) pore-size distribution curve of the lignin-carbon.



**Figure S3.** (a) SEM and (b) TEM images of the lignin-carbon material; (c) SEM and (d) TEM images of the lignin-carbon@MnO<sub>2</sub> composite.



**Figure S4.** (a) Energy dispersive X-ray (EDX) microanalysis report of the L-C-NSs@MnO<sub>2</sub> composites. (b) FT-IR spectra of the lignin-based nanosphere and L-C-NSs material.

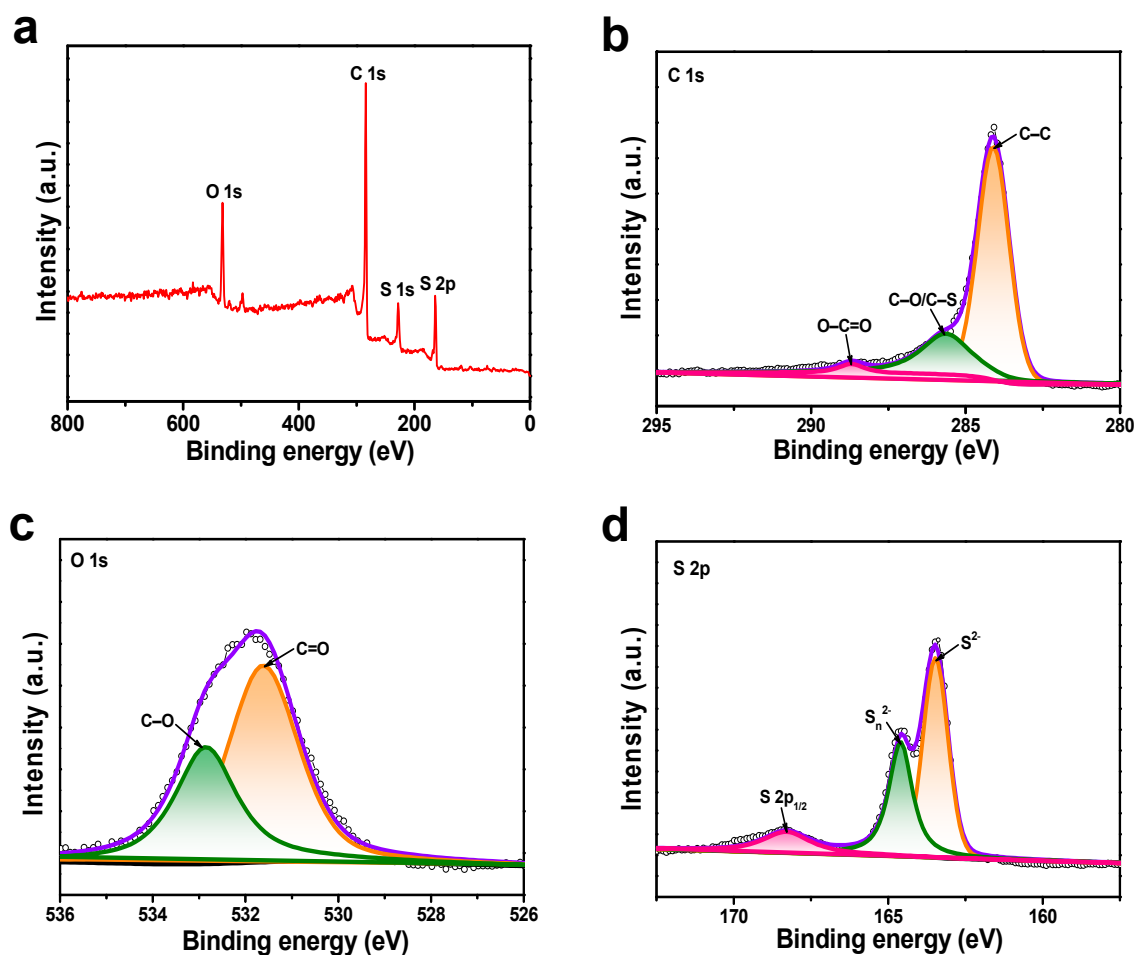


Figure S5. The XPS survey spectrum of (a) the L-C-NSs material, and high-resolution XPS spectra of (b) C 1s, (c) O 1s, and (d) S 2p.

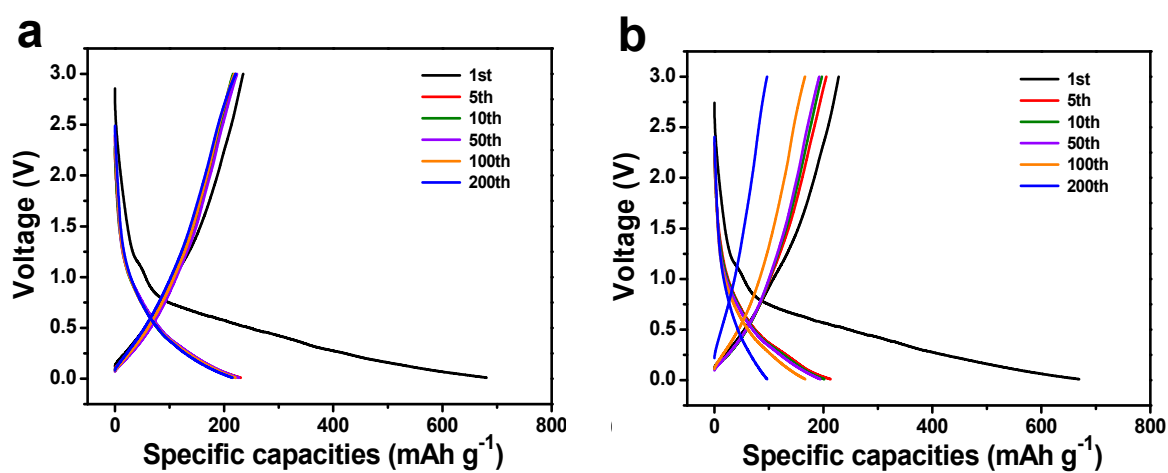
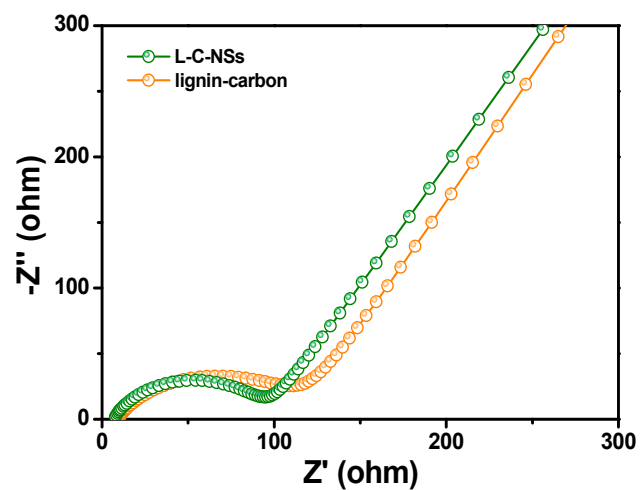


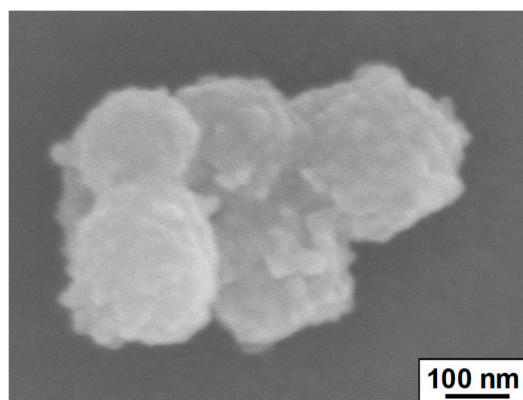
Figure S6. Galvanostatic charge/discharge profiles of the (a) L-C-NSs and (b) lignin-carbon at a current rate of 0.1 A g<sup>-1</sup> for different cycles.



**Figure S7.** The Nyquist plots of the L-C-NSs and lignin-carbon electrodes after charging to 3.0 V at the 50th cycle.

**Table S1.** Equivalent circuit parameters obtained from fitting the experimental impedance spectra of the L-C-NSs and lignin-carbon electrodes.

samples	$R_s$ ( $\Omega$ )	$R_{ct}$ ( $\Omega$ )
L-C-NSs	6.586	88.6
lignin-carbon	8.662	107.4



**Figure S8.** SEM image of the L-C-NSs@MnO<sub>2</sub> electrode after 300 repeated discharge/charge cycles.