

Supporting Information

Boosting sodium storage in needle coke-derived hard carbon anode via mild ammonium persulfate activation

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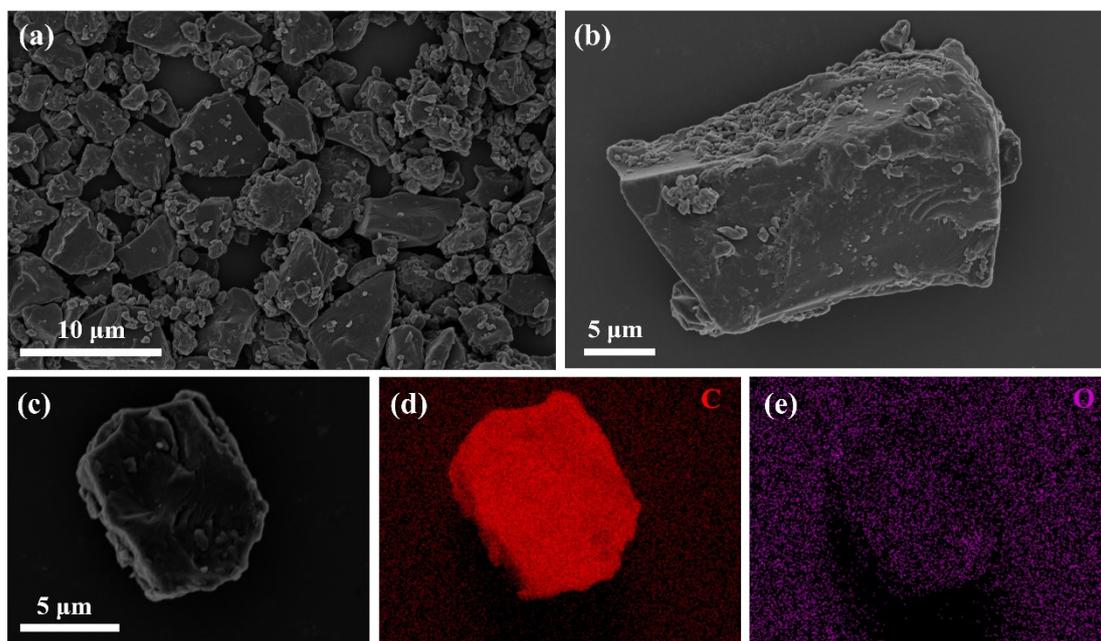


Fig. S1. (a) and (b) SEM image of NC. (c)-(e) EDS elemental mapping of NC.

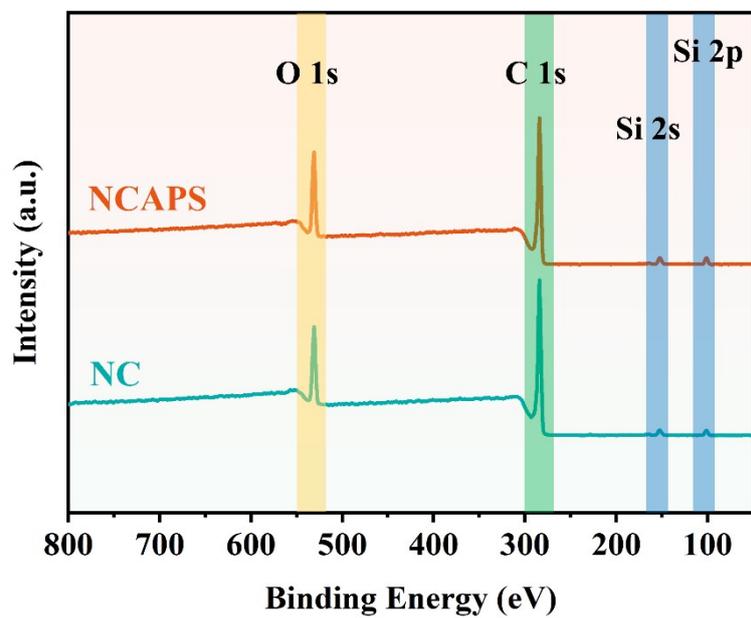


Fig. S2. XPS survey spectra of NC and NCAPS.

Table S1. Elemental analysis results of the samples from XPS measurements.

Samples	XPS spectra analysis	
	C/at.%	O/at.%
NC	79.77	17.27
NCAPS	76.93	19.09

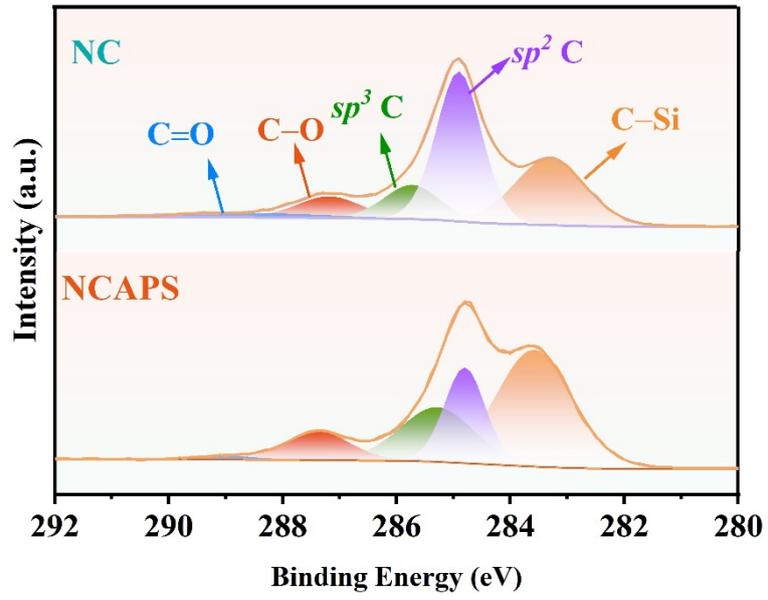


Fig. S3. The XPS spectra of C 1s of NC and NCAPS.

Table S2. Proportions of oxygen-containing functional groups in NC and NCAPS derived from XPS O 1s spectra.

	C=O (%)	C-O (%)	O=C-O (%)
NC	40.29	56.07	3.64
NCAPS	45.38	42.25	12.37

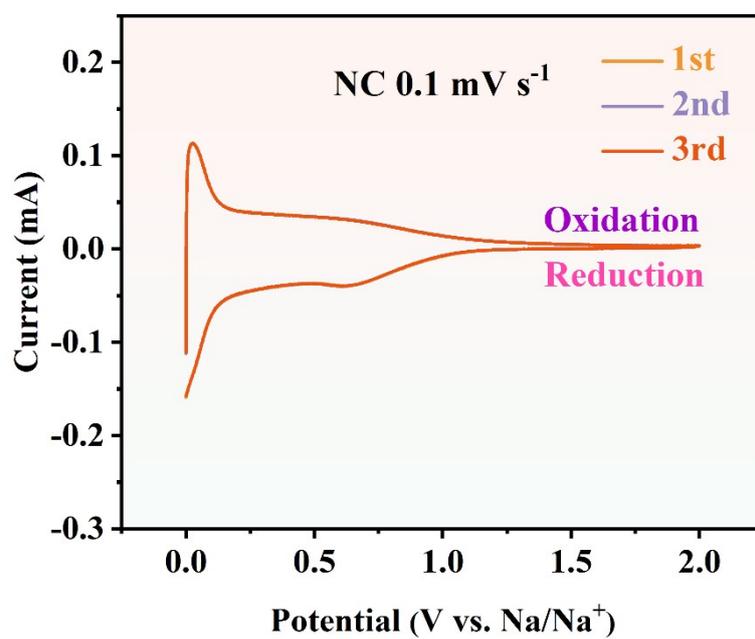


Fig. S4. CV profiles of NC at the scan rate of 0.1 mV s⁻¹.

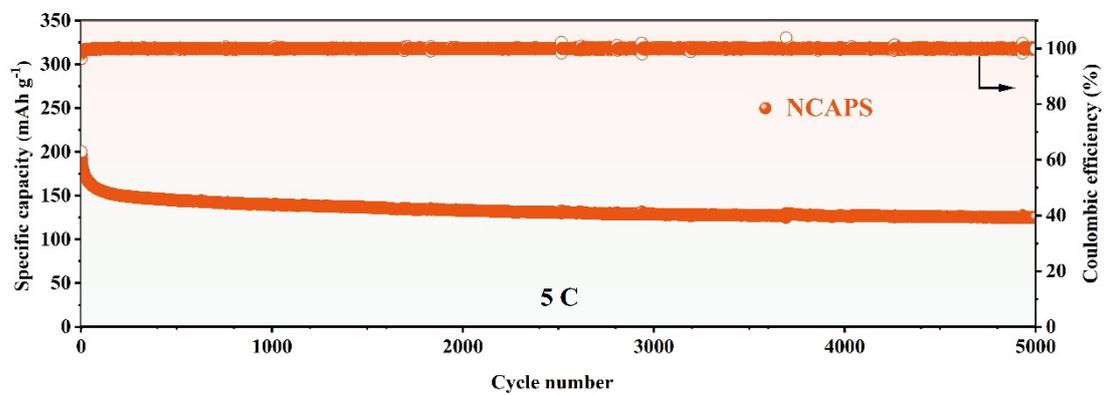


Fig. S5. Cycling performance of NCAPS at 5 C.

Table S3. Summary of modification strategy and sodium storage performance of needle coke-based hard carbons.

Ref	Modification strategy	Electrolyte	Initial reversible capacity (mAh g ⁻¹)	ICE (%)	Cycling performance (mAh g ⁻¹)	Rate performance (mAh g ⁻¹)
[1]	H ₂ SO ₄ +KMnO ₄ oxidation	Ester	0.05A/g@436	42.1	2A/g@1000cycles@153	2A/g@180
[2]	H ₂ O ₂ oxidation + hydrothermal H ₂ SO ₄ +KMnO ₄ oxidation	Ester	0.05A/g@374	48.6	2A/g@1000cycles@194	2A/g@188
[3]	+ hydrothermal	Ester	0.05A/g@398	47.5	2A/g@1000cycles@213	2A/g@222.1
[4]	Ball milling	Ester	0.05A/g@553	55.6	1A/g@1000cycles@312	2A/g@~320
This work	Ammonium persulfate solution stirring at RT	Ether	0.06 A/g@276	69.9	1.5 A/g@5000@125	1.5A/g@195

References

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- [2] H. Zhao, G. Chang, X. Gao, C. Huang and Z. Li, *Carbon*, 2023, **203**, 68-75.
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- [4] D. Sun, M. Wang, L. Zhao, Y. Yang, F. Zheng, L. Tao, C. Lu, C. Lu, C. Xu, Z. Xiao and X. Ma, *Chem. Eng. J.*, 2025, **509**, 161531.

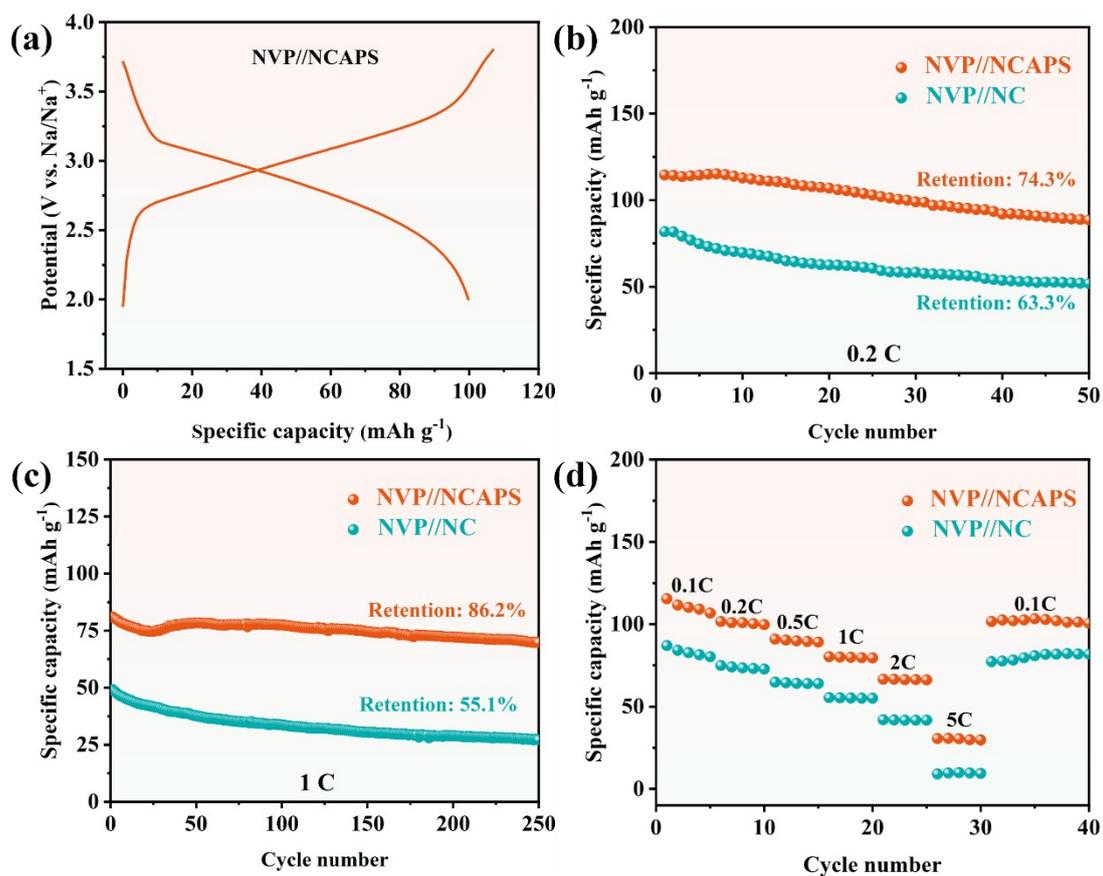


Fig. S6 (a) GCD profiles of NVP//NCAPS at 0.2 C. (b) Cycling performance of NVP//NC and NVP//NCAPS at 0.2 C. (c) Cycling performance of NVP//NC and NVP//NCAPS at 1 C. (d) Rate performance of NVP//NC and NVP//NCAPS at different current densities.

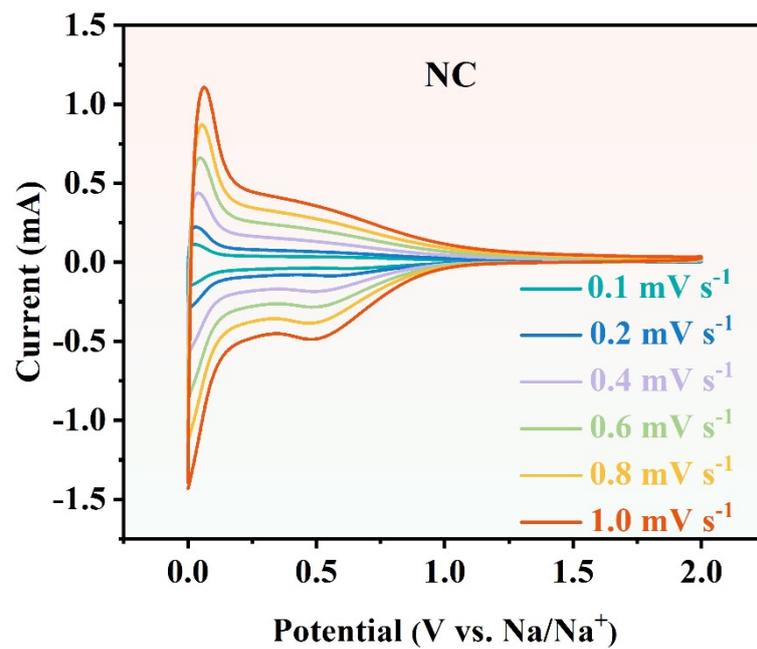


Fig. S7. CV profiles of NC electrode at scanning rates ranging from 0.1 to 1.0 mV s⁻¹.

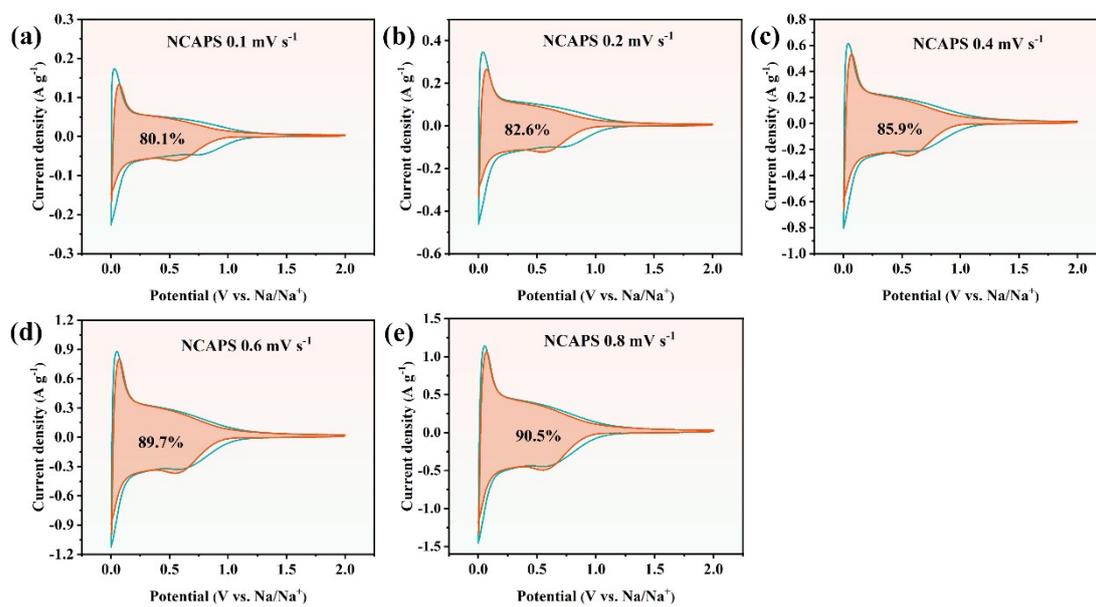


Fig. S8. Capacitive contribution of NCAPS electrode at different scanning rates.

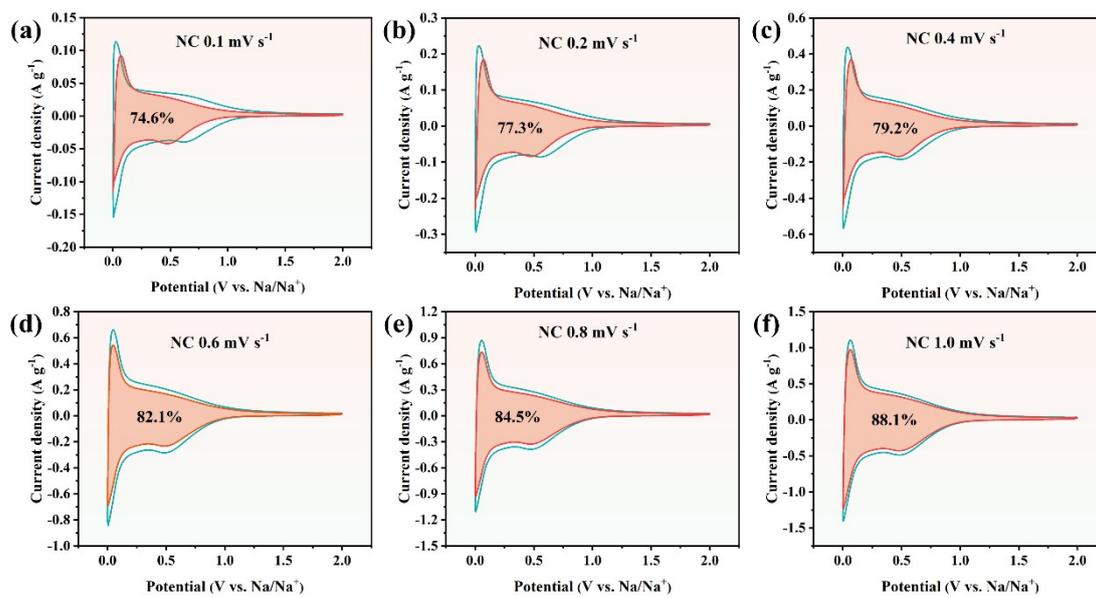


Fig. S9. Capacitive contribution of NC electrode at different scanning rates.

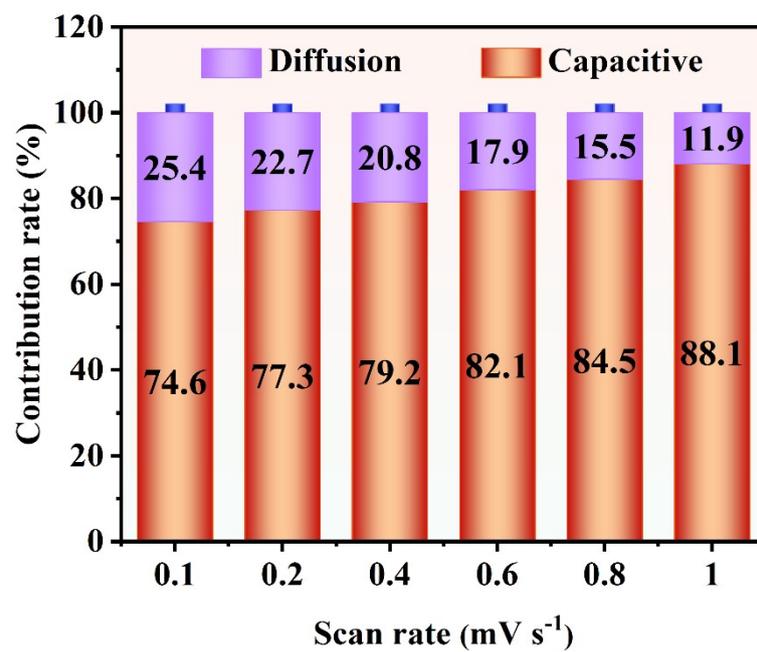


Fig. S10. Capacitive contribution percentage of the NC electrode at different scanning rates.