

## Supporting Information

# A Water-based Binder for Improved Adhesion and Reversibility of the Graphite Cathode for Sodium Dual-Ion Batteries

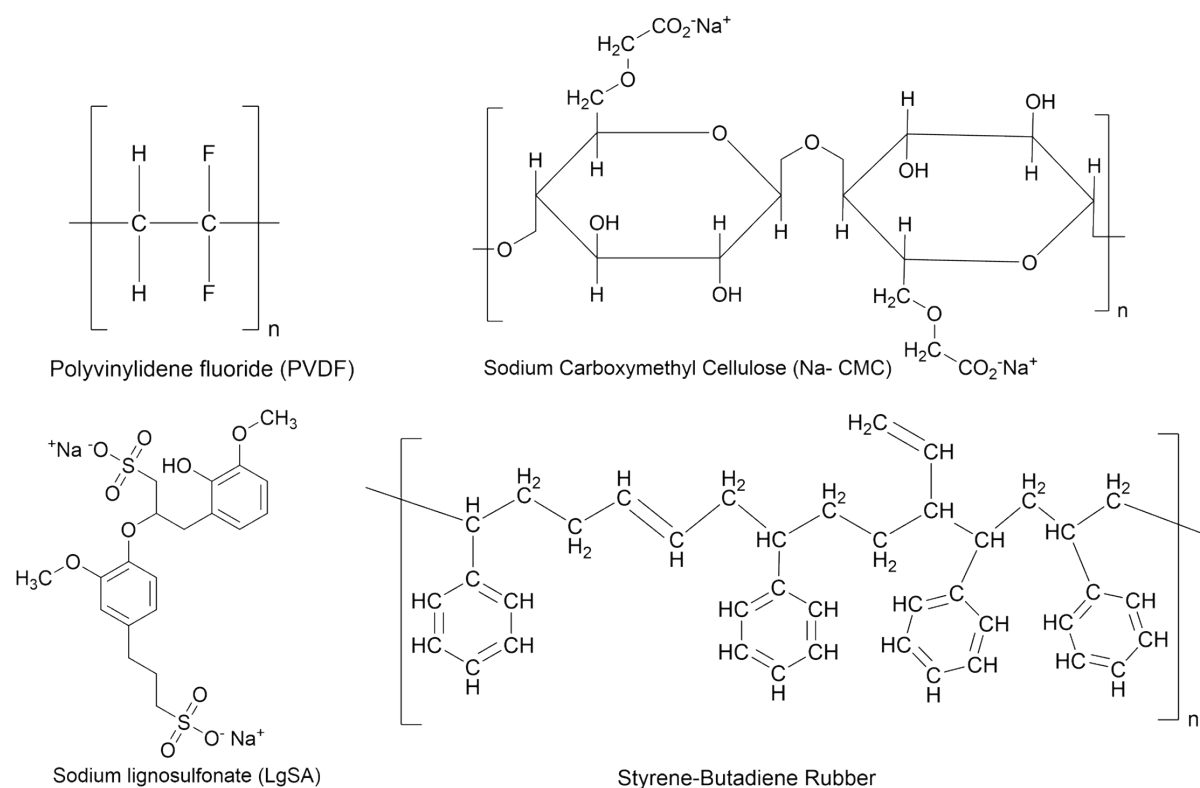
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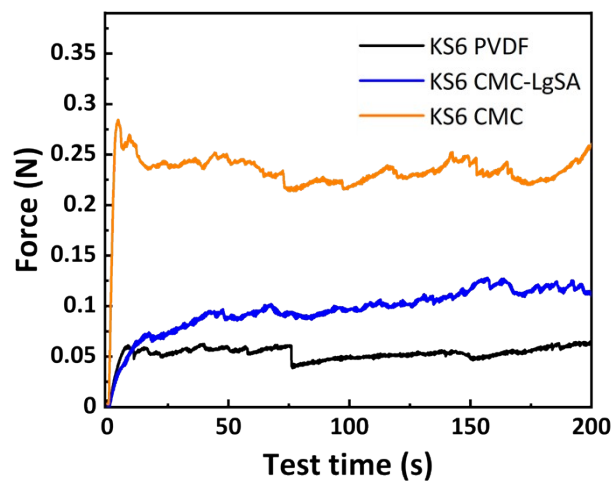
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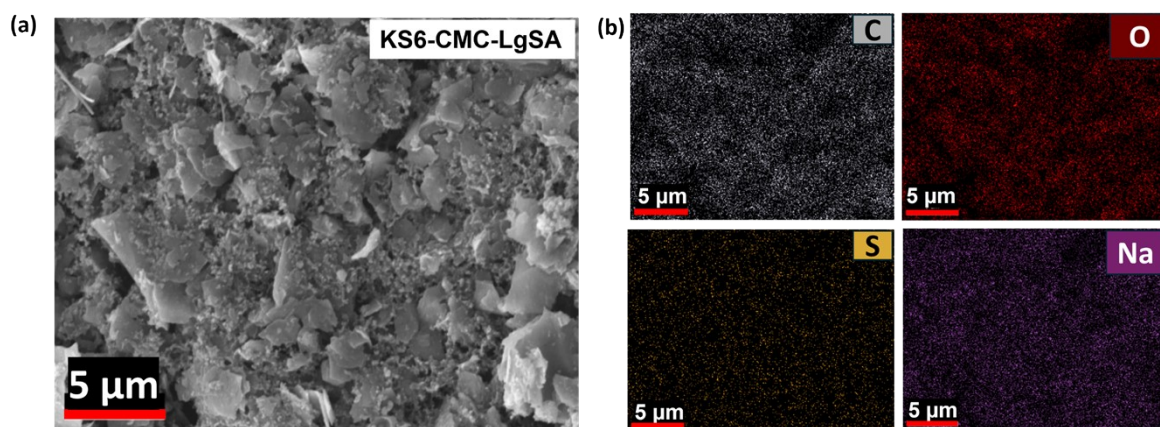


**Figure S1.** Chemical structure of polyvinylidene fluoride (PVDF), sodium carboxymethyl cellulose (Na-CMC), sodium lignosulfonate (LgSA), and styrene-butadiene rubber (SBR).

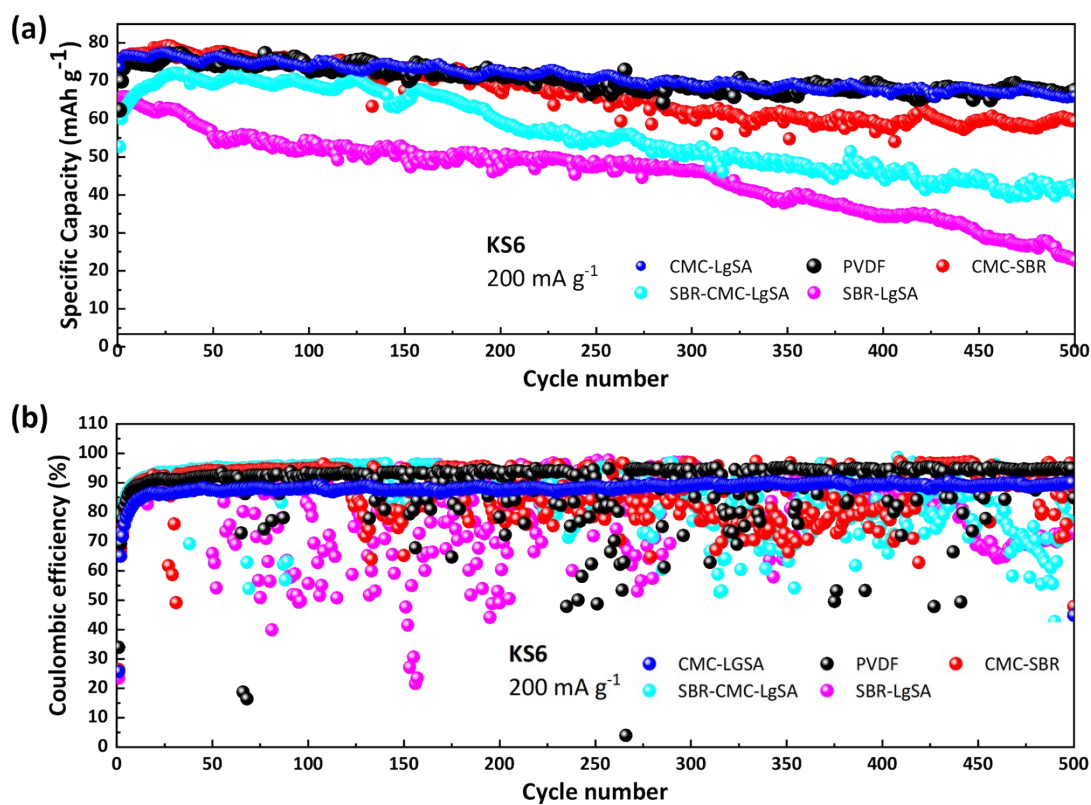
Examining the adhesion strength of the KS6 graphite cathode with CMC (10 wt%) alone reveals that its adhesion is almost 5 times higher than that of the PVDF-based graphitic cathode. In contrast, the CMC-LgSA (5:5 wt%) based cathode also exhibited higher strength than the PVDF-based cathode.



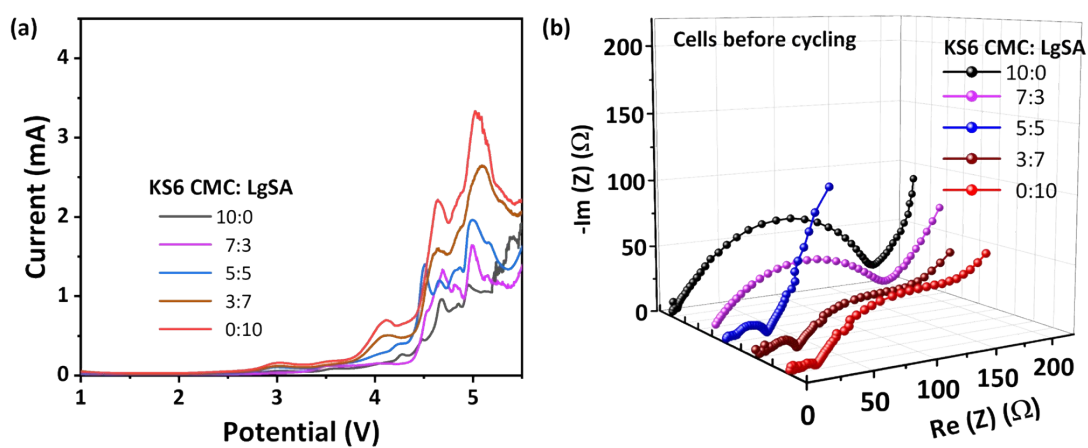
**Figure S2.** Peel test of the KS6 graphite cathode with CMC (10 wt %), CMC-LgSA (5:5 wt%) and PVDF (10 wt%).



**Figure S3.** a) FESEM and b) corresponding EDX imaging of the KS6 CMC-LgSA electrode.

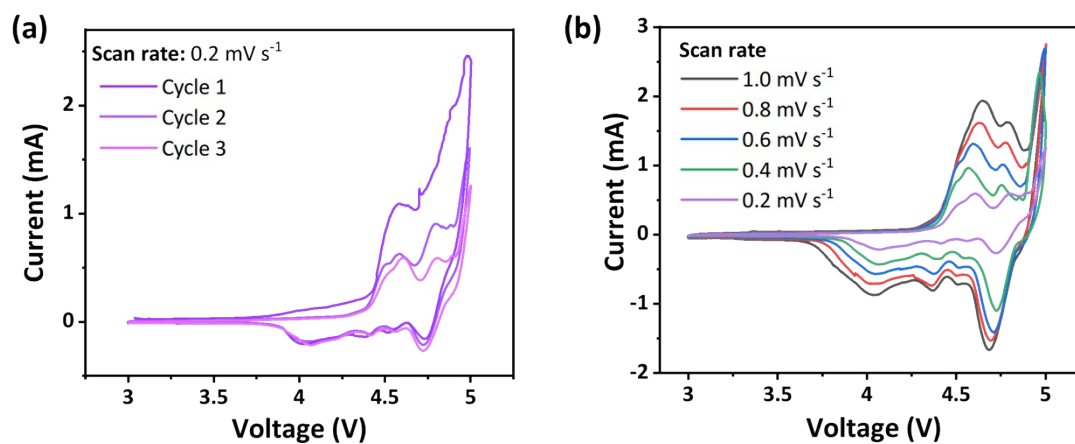


**Figure S4.** a) Cycling stability and b) Coulombic efficiency of the KS6 graphite electrodes with different binders.

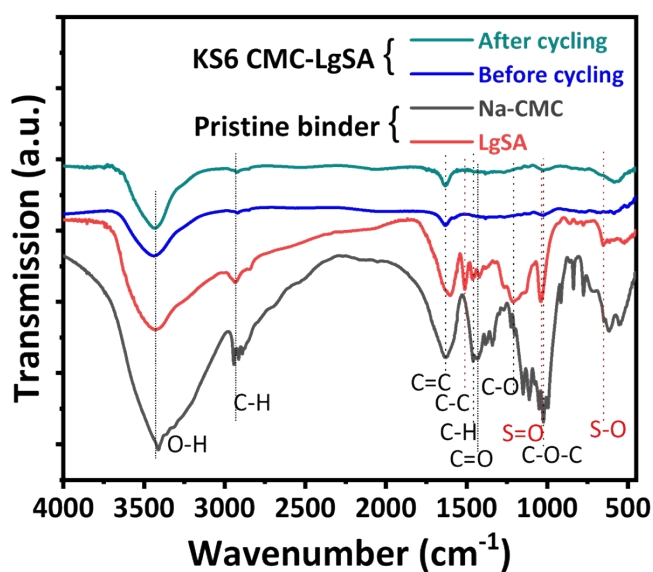


**Figure S5.** a) LSV and b) EIS of the KS6 graphite-based half-cell prepared with CMC, LgSA in different proportions of binder.

Cyclic voltammetry of the prepared electrode Na|| KS6 Graphite (CMC-LgSA) cell with 1M NaPF<sub>6</sub> in EC: DMC (1:1 v/v)



**Figure S6.** Cyclic voltammetry of the KS6 CMC-LgSA half-cell.



**Figure S7.** The FTIR spectra of the pristine Na-CMC, pristine LgSA along with KS6 CMC-LgSA electrode before and after 500 cycling.

**Table S1.** Comparison of Graphite cathode with different binders for SDIBs.

S. no	Cathode	Binder	V range	Electrolyte	Electrochemical performance
1	Graphite	PVDF <sup>1</sup>	3-5 V	1M NaPF <sub>6</sub> in EMC/PC (1:1 v/v)	~90 mAh g <sup>-1</sup> with 83% capacity retention after 1000 cycles, at 100 mA g <sup>-1</sup>
2	Graphite	PVDF <sup>2</sup>	3-5 V	1 M NaPF <sub>6</sub> -PC+5 % FEC	60 mAh g <sup>-1</sup> after 100 cycles at 200 mA g <sup>-1</sup>
3	Graphite	PVDF <sup>3</sup>	3-5 V	1 M NaPF <sub>6</sub> /EC:EMC	~90 mAh g <sup>-1</sup> at 100 mA g <sup>-1</sup> after 500 cycles
4	Graphite <b>(This work)</b>	CMC-LgSA (Water-based binder)	3-5 V	1M NaPF <sub>6</sub> in EC: DMC (1:1, v/v)	~77 mAh g <sup>-1</sup> capacity with 87% capacity retention after 500 cycles, at 200 mA g <sup>-1</sup>

#### References

- 1 Z. Guo, G. Cheng, Z. Xu, F. Xie, Y. S. Hu, C. Mattevi, M. M. Titirici and M. Crespo Ribadeneyra, *ChemSusChem*, 2023, **16**, e202201583.
- 2 Z. Yang, X. Z. Zhou, Z. Q. Hao, J. Chen, L. Li, Q. Zhao, W. H. Lai and S. L. Chou, *Angew. Chem. Int. Ed.*, 2024, **63**, e202313142.
- 3 X. Hou, W. Li, Y. Wang, S. Li, Y. Meng, H. Yu, B. Chen and X. Wu, *Chinese Chemical Letters*, 2020, **31**, 2314–2318.