Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Disordered Carbon Tubes Based on Cotton Cloth for Modulating the Interface Impedance in β''-Al_2O_3-based Solid-state Sodium Metal Batteries

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Keywords: carbon tubes, β''-Al_2O_3, interfaces, sodium anode, solid-state sodium batteries.

1. SEM images for cross-section (a) and top view (b) of the BASE pellet.

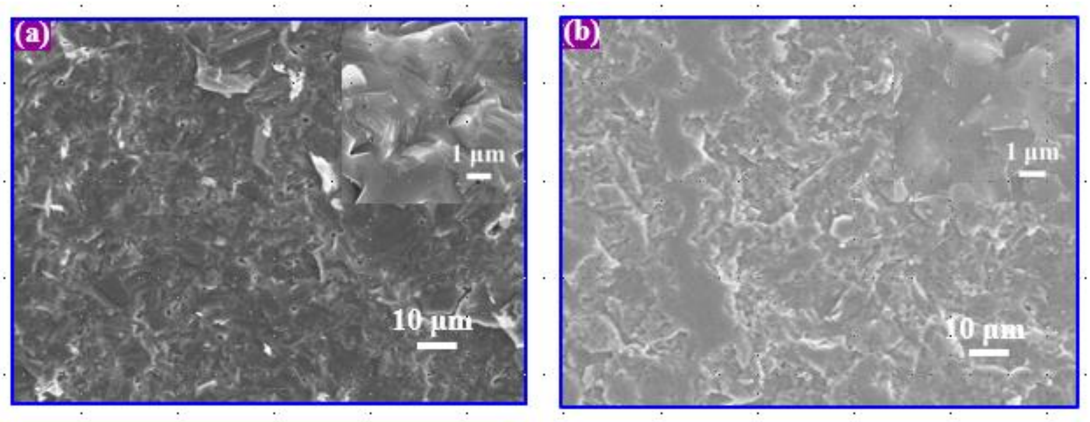

Figure S1. SEM images for cross-section (a) and top view (b) of the BASE pellet.

2. EIS of the BASE pellets at low temperature from -20–40 ºC.

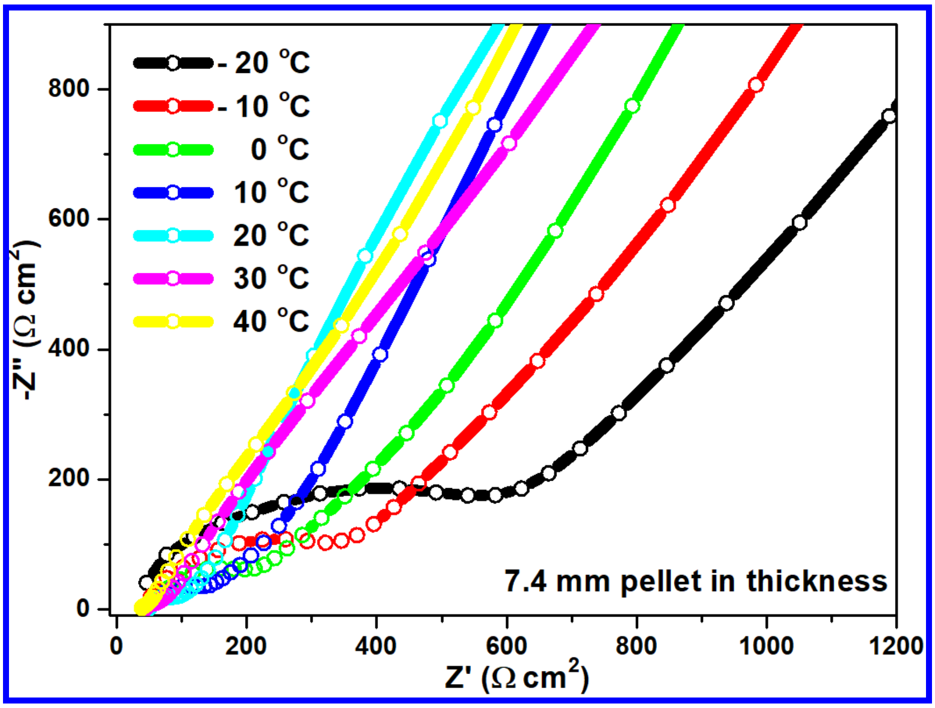

Figure S2. EIS of the BASE pellets at low temperature from -20–40 ºC.

3. **Arrhenius plot of the BASE ionic conductivity.**

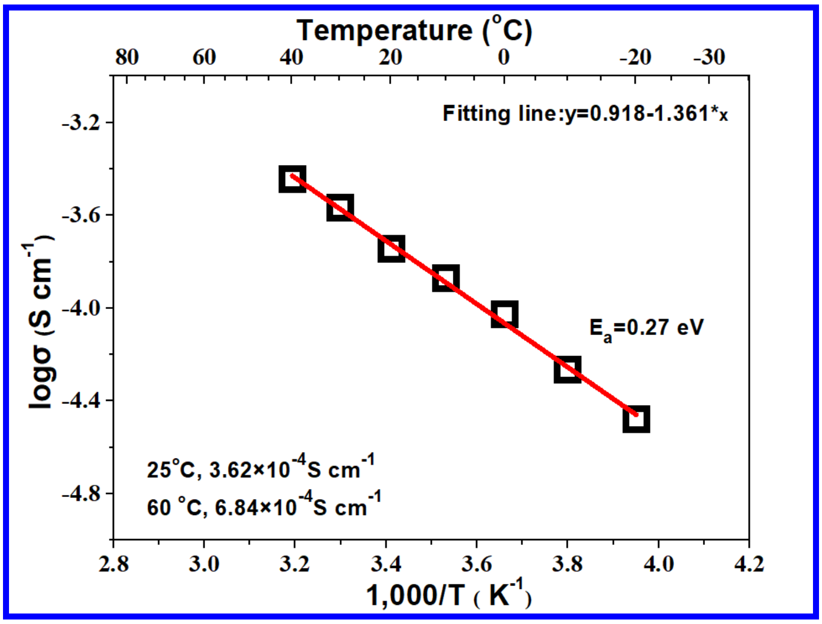

Figure S3. Arrhenius plot of the BASE ionic conductivity.

4. **A photo comparing the white cotton cloth and black DCDCT.**

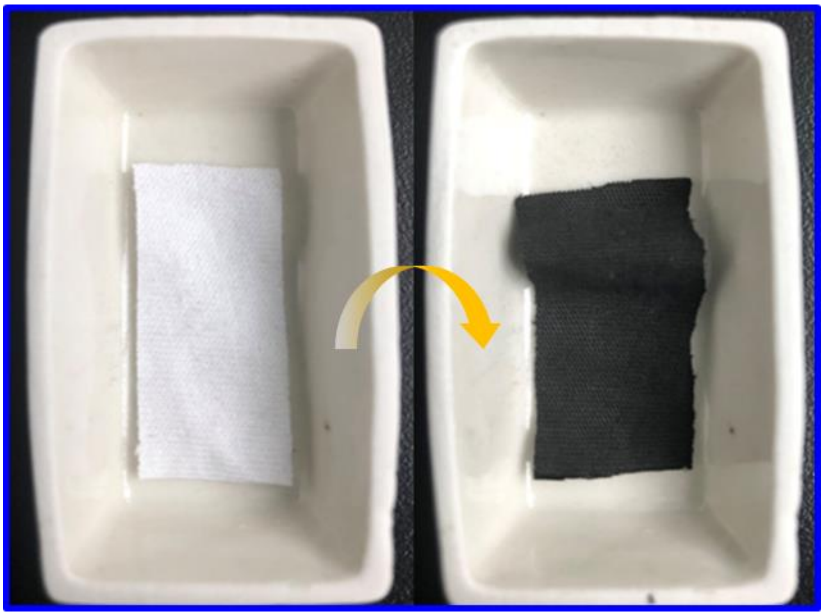

Figure S4. A photo comparing the white cotton cloth and black DCDCT.

5. The SEM image of the textile cotton cloth.

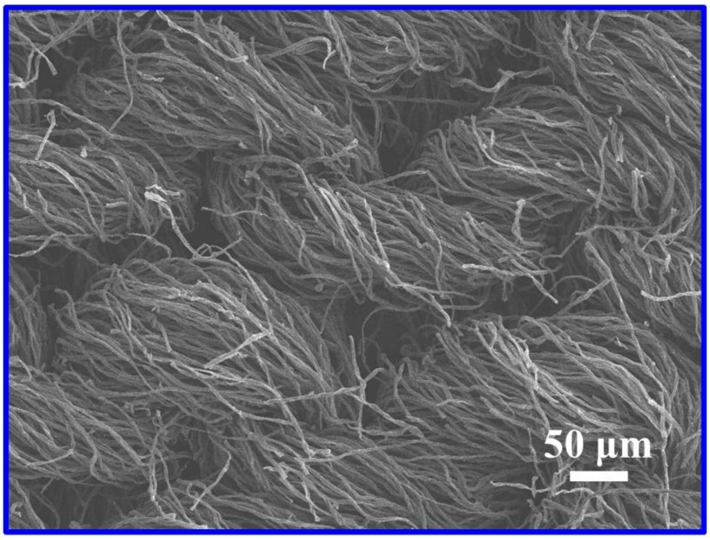

Figure S5. The SEM image of the textile cotton cloth.

6. Time evolution of Na infusion into DCT-BASE.

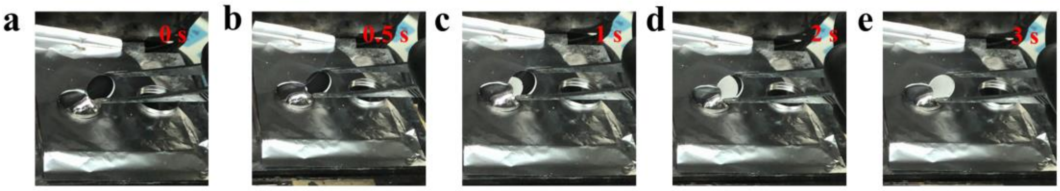

Figure S6. Time evolution of Na infusion into DCT-BASE. Time-lapse images (a, 0s; b, 0.5 s; c, 1s; d, 2s; e, 3s) of Na infusion process into the DCT layer. The edge of the DCT-BASE was put in contact with the molten Na.

7. Simple test on separating sodium metal from the BASE.

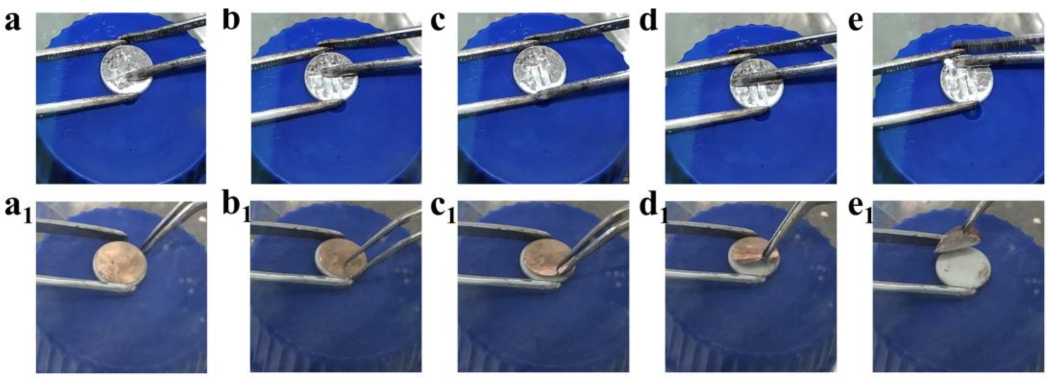

Figure S7. Test on separating sodium metal from the DCT-BASE (a-e) and untreated BASE surface with tweezers (a_1-e_1).

8. SEM images of the BASE/Na and DCT-BASE/Na interface.

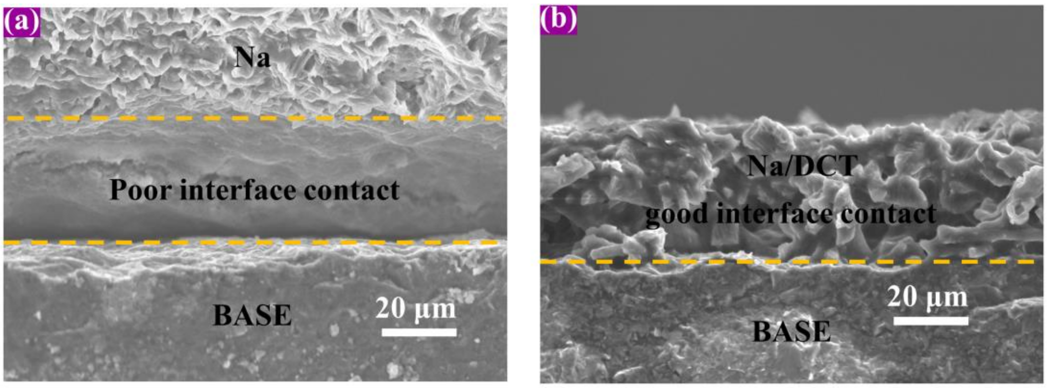

Figure S8. SEM images of the BASE/Na and DCT-BASE/Na interface.

9. Electrochemical performance of the DCT electrodes for NIBs.

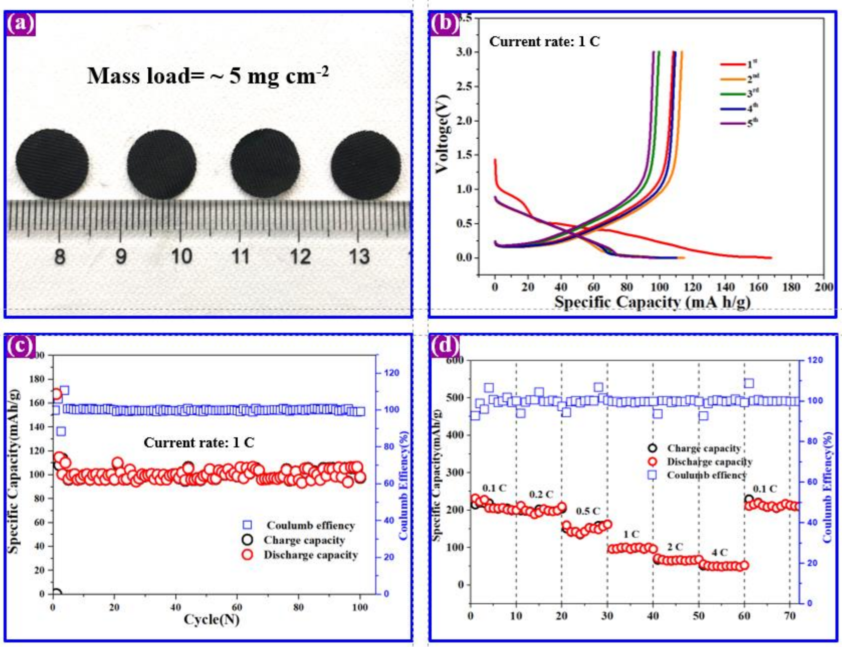

Figure S9. Electrochemical performance of the DCT electrodes for NIBs. (a) photograph of the disordered carbon tubes (DCT) electrode. (b) Charge/discharge profiles during the initial five cycles of the DCT electrode at current rate of 1C. (c) Cycle performance of the DCT electrode at a rate of 1 C (d) Rate performance of the DCT electrode.

10. Rate performances of the Na/DCT-BASE/Na symmetric cells at different current densities.

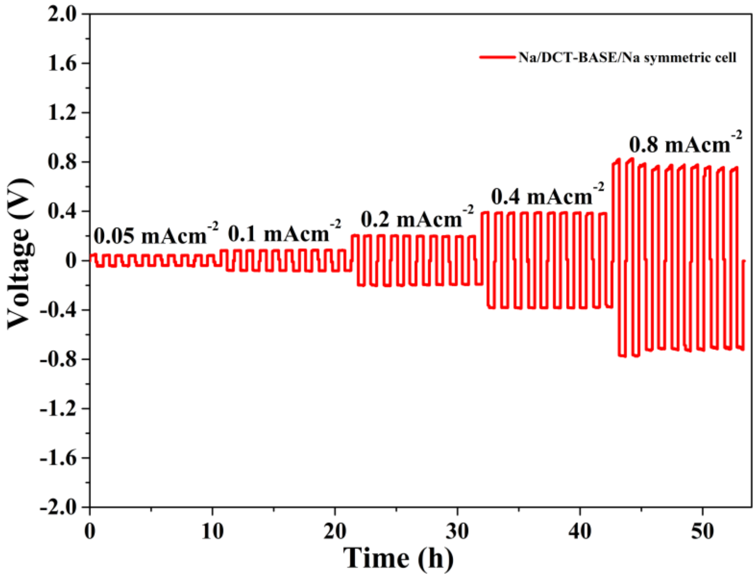

Figure S10. Rate performances of the Na/DCT-BASE/Na symmetric cells at different current densities.

11. SEM and EDX mapping images of the cross-sectional Na/DCT-BASE interface after 100 cycles.

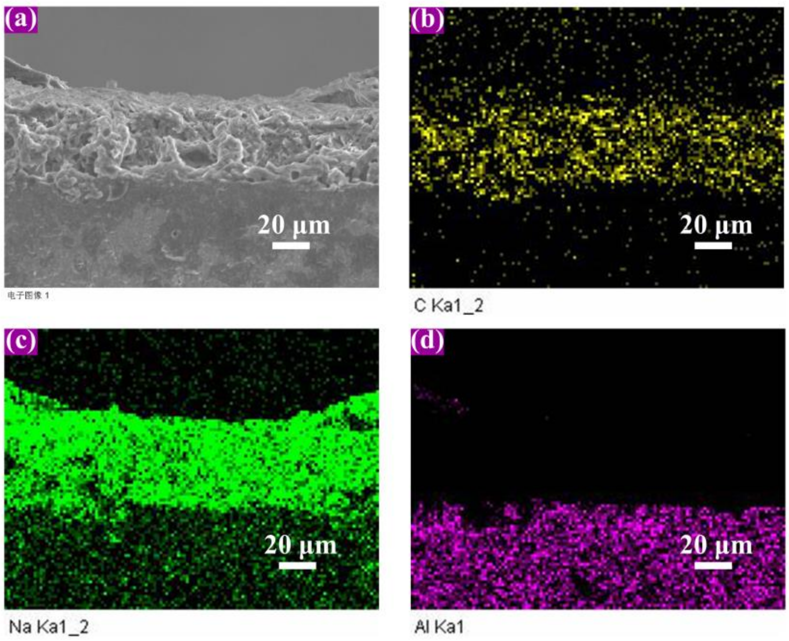

Figure S11. SEM image of the cross-sectional Na/DCT-BASE interface after 100 cycles (a), Corresponding C, Na and Al elemental maps (b-d).

12. Corresponding fitted equivalent electrical circuit of the solid-state sodium batteries with the DCT modified BASE.

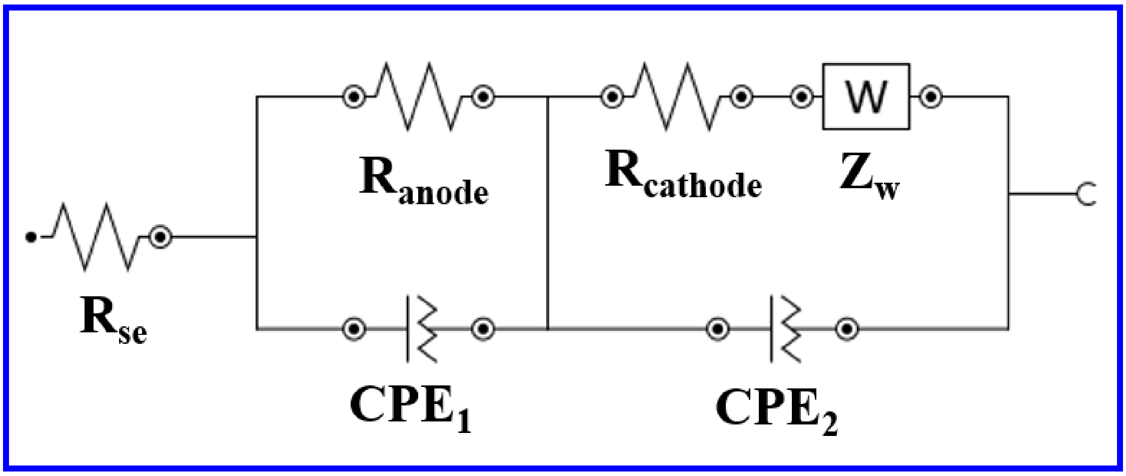

Figure S12. Corresponding fitted equivalent electrical circuit of the solid-state sodium batteries with the DCT modified BASE. R_{se} represents the impedance contributed by the solid electrolyte; R_{anode} and CPE_1 represent the resistance and capacitance of the anode interface, respectively (high-frequency). $R_{cathode}$ and CPE_2 are the resistance and capacitance of the cathode interface, respectively (medium-frequency). Z_w is the Warburg impedance related to the diffusion of Na ions into the electrodes.

Table S1. **The interfacial resistances of the solid-state sodium batteries on the anode side (R_{anode}) and on cathode side ($R_{cathode}$) with the DCT-modified BASE before cycling and after 100 cycles.**

Resistances	Before cycling	After 100 cycles
R_{se}	15.4	15.5
R_{anode}	155.1	200.2
$R_{cathode}$	213.2	510.5

13. Rate performance of the solid-state cells with the DCT-modified BASE.

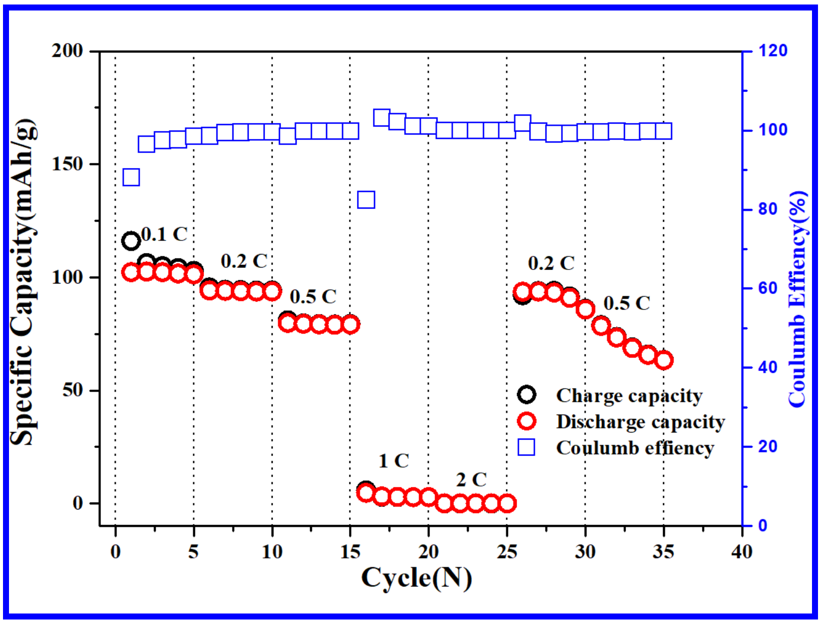

Figure S13. Rate performance of the solid-state cells with the DCT-modified BASE.