Supporting Information for *Journal of Materials Chemistry A*

Konjac glucomannan biopolymer as a multifunctional binder to build solid permeable interface on $Na_3V_2(PO_4)_3/C$ cathodes for high-performance sodium ion batteries

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Supporting information consists of 15 pages, including this one.

There are 2 Tables and 10 Figures.

The calculation of the kinetic properties of the electrodes.

The interfacial resistance (R_{ct}) was utilized to calculate the activation energy (E_a) for the kinetic properties of the electrodes as followed. The i_0 and E_a for Na^+ ions intercalated into NVP can be determined from Equation 1 and 2 (Butler-Volmer equation and Arrhenius equation).[1] After logarithmic operations, Equation 2 could be transferred as Equation 3.

$$i_0 = RT/nFR_{ct} \quad (1)$$

$$i_0 = Ae^{-E_a/RT} \quad (2)$$

$$lni_0 = -E_a/RT + \ln A \quad (3)$$

Where i_0 is the exchange current, R is the gas constant, T is the temperature, n is the transferred electrons' number of the reaction per molecule, F is the Faraday constant and A is a constant coefficient. Fig. 4b shows the functions of $\ln i_0$ *versus* 1000/T. The E_a of electrodes using KGM and PVDF as binders are determined to be 64.4 and 78.5 kJ mol^{-1}, respectively.

The calculation of the Na^+ ions diffusion coefficient.

The Na^+ ions diffusion coefficient (D_{Na+}) could be calculated according to Equation 4 (Randles-Sevcik equation):

$$i_p = 2.69 \times 10^5 n^{3/2} A D_{Na+}^{1/2} C_{Na} v^{1/2} \quad (4)$$

Where i_p refers to the peak current, n refers to the number of transferred electrons of the reaction per molecule, A refers to contact area between the electrolyte and electrodes, D_{Na+} refers to the Na^+ ions diffusion coefficient, C_{Na+} refers to the concentrations of Na^+ ions in the electrode and v refers to scan rates.

Table S1. A survey of electrochemical properties of NVP in sodium ion batteries

Electrode description	Binder	Rate performance	Cycling life	Ref.
NVP-KGM	KGM	86 mA h g^{-1} at 10 C 71.6 mA h g^{-1} at 30 C 63.1 mA h g^{-1} at 50 C	93.3% retention after 200 cycles at 0.5 C 90.1% retention after 3000 cycles at 10 C 74.1% retention after 10000 cycles at 50 C	This work
$Na_3V_2(PO_4)_3$/CNT	PTFE	86.2 mA h g^{-1} at 5 C	65.3% retention after 200 cycles at 5 C	2
NVP/C	PVDF	54.3 mA h g^{-1} at 50 C	87.5% retention after 8000 cycles at 2 C	3
NVP/C porous hollow sphere	PVDF	29.5 mA h g^{-1} at ~4 C	90% retention after 300 cycles at ~0.2 C	4
NVP@C@HC	PVDF	60.4 mA h g^{-1} at 50 C	83.3% retention after 3000 cycles at 40 C	5
NVP/graphene	PVDF	83.5 mA h g^{-1} at 10 C	93% retention after 100 cycles at 1 C	6
$Na_3V_2(PO_4)_3$/N-doped C	PVDF	46.8 mA h g^{-1} at 10 C	-	7
NVP/C/rGO	PVDF	80.0 mA h g^{-1} at 30 C	94.4% retention after 200 cycles at 1 C	8
NVP/CGO	PVDF	70.4 mA h g^{-1} at 20 C	95% retention after 1000 cycles at 2 C	9
NVP-Freestanding composite	free	63 mA h g^{-1} at 30 C	88.6% retention after 150 cycles at 0.5 C	10
(C@NVP)@pC	PVDF	74 mA h g^{-1} at 100 C	68.9% retention after 1000 cycles at 100 C	11
NVP	PVDF	80 mA h g^{-1} at 10 C	91.1% retention after 100 cycles at 0.5 C	12

Table S2. Calculated Na^+ ions diffusion coefficient (D_{Na+}) of NVP-KGM and NVP-PVDF

D_{NA+}(cm^2 s^{-1})	ANODE	CATHODE
NVP-PVDF	2.17×10^{-9}	2.06×10^{-9}
NVP-KGM	3.91×10^{-9}	3.12×10^{-9}

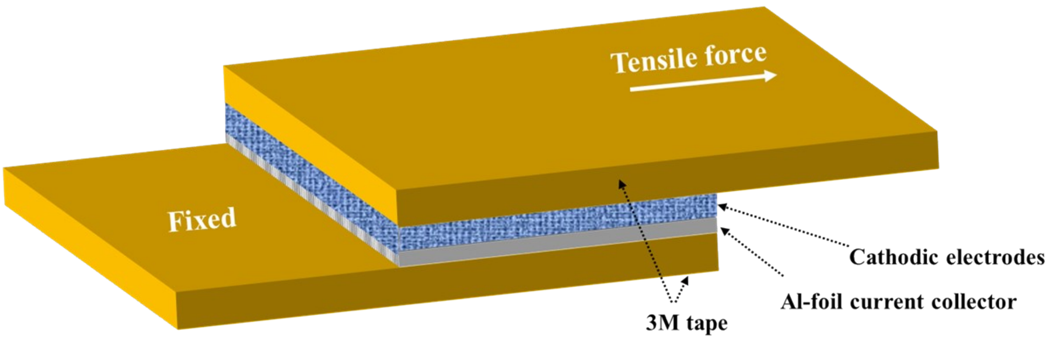

Figure S1. Schematic diagram of tensile adhesion strength tests (contact area: 18 mm × 18 mm).

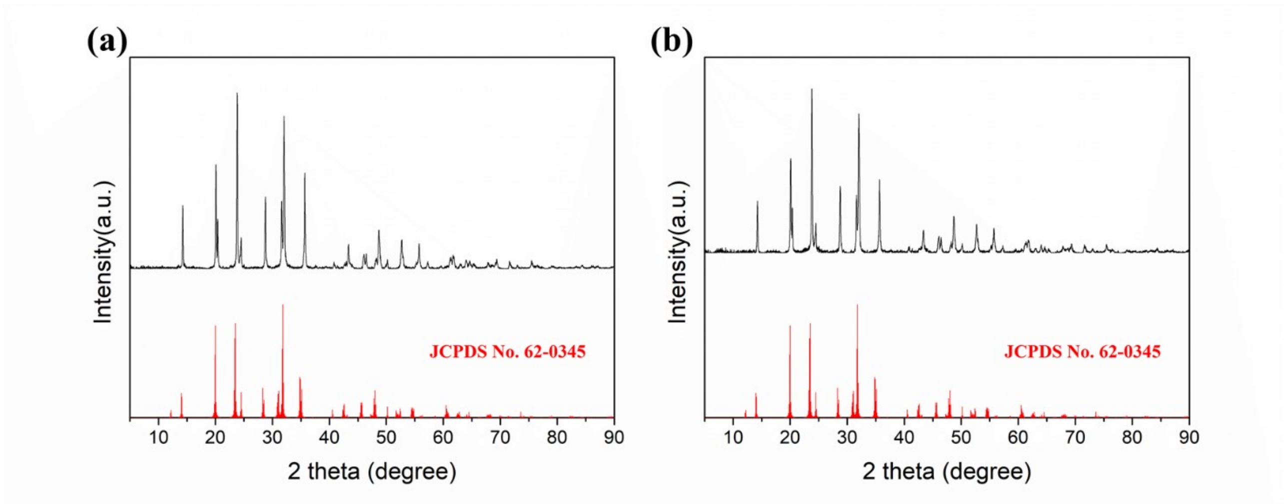

Figure S2. (a) X-ray diffraction of NVP. (b) X-ray diffraction of NVP that was soaked in KGM solution (water) for 24 h.

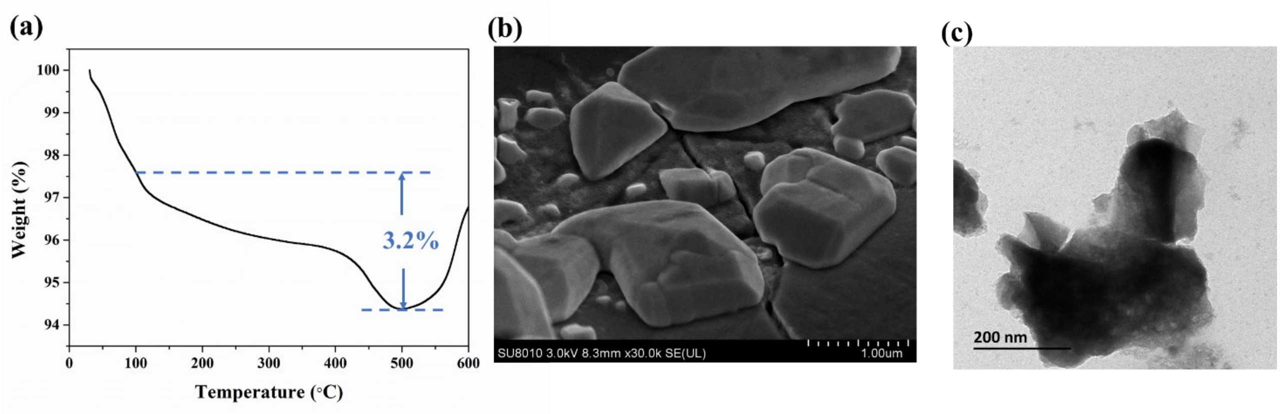

Figure S3. (a) The thermogravimetric curve of NVP from 25℃ to 600℃. (b) The SEM image and (c) TEM image of NVP.

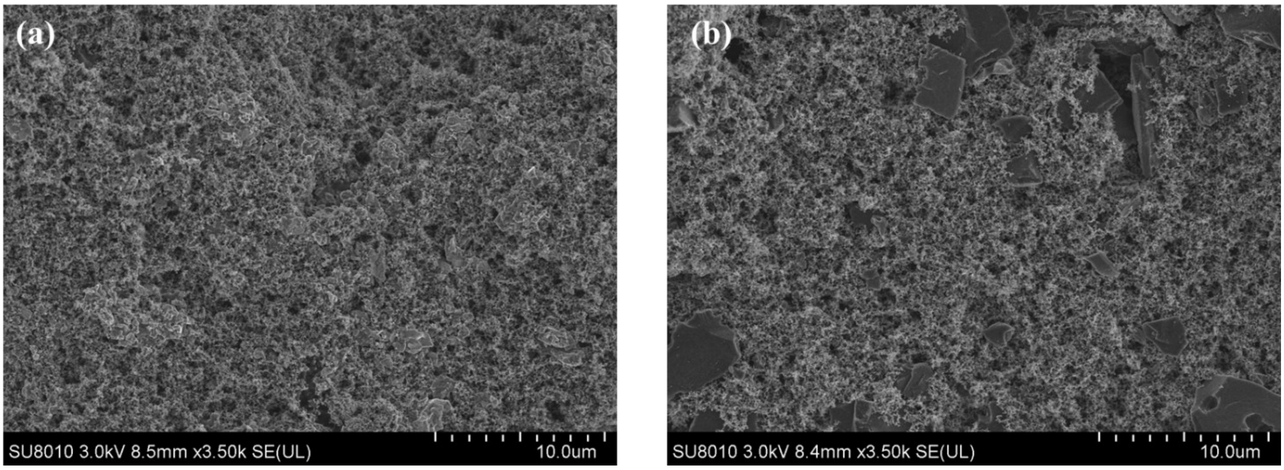

Figure S4. The SEM images of (a) NVP-KGM and (b) NVP-PVDF electrodes before electrochemical tests.

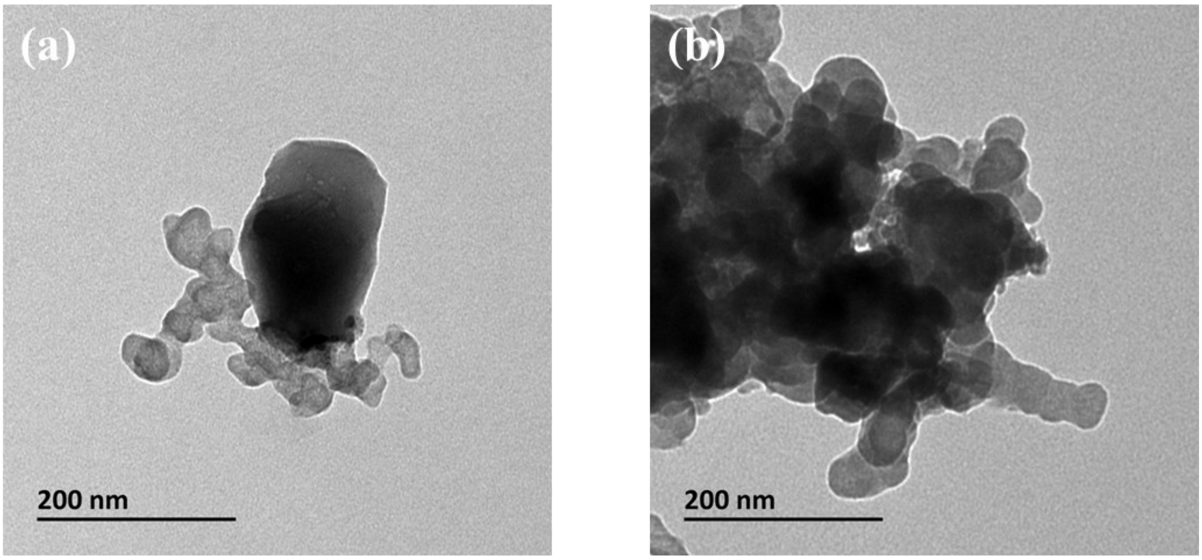

Figure S5. The TEM images of (a) NVP-KGM and (b) NVP-PVDF in the detail.

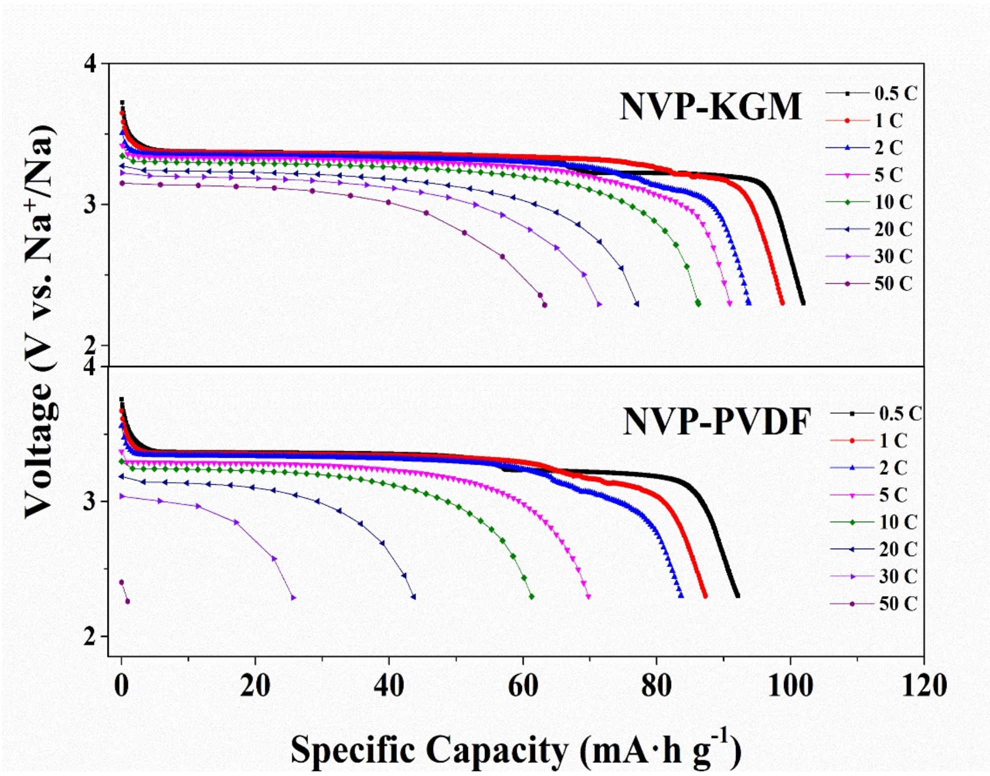

Figure S6. Discharge profiles at different current densities from 0.5-50 C.

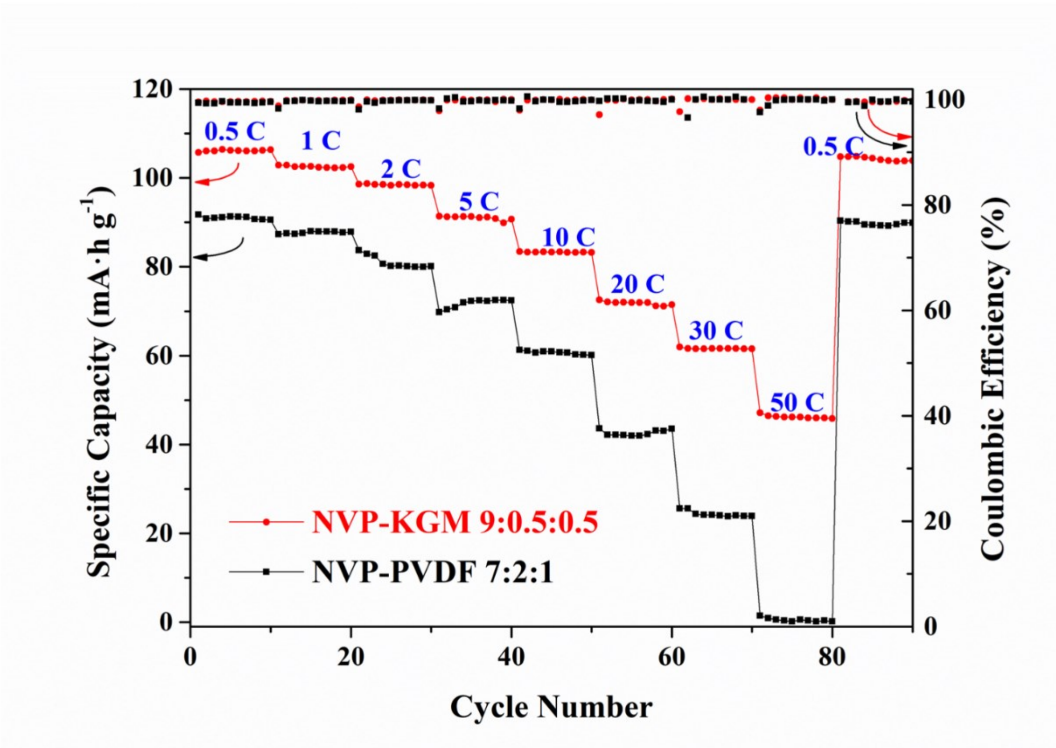

Figure S7. Rate capability test performed on NVP-KGM (NVP: super P: KGM, 9:0.5:0.5, w/w) and NVP-PVDF (NVP: super P: PVDF, 7:2:1, w/w) electrodes from 0.5-50 C.

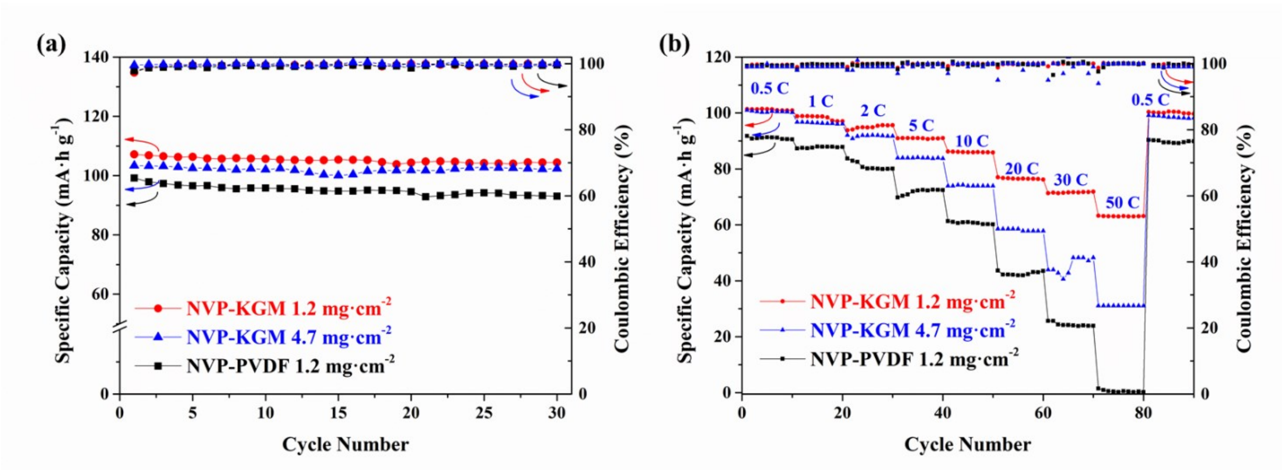

Figure S8. (a) Cycle performance at 0.5 C and (b) rate capability test from 0.5-50 C performed on low-mass-loading NVP-KGM (1.2 mg cm^{-2}), high-mass-loading NVP-KGM (4.7 mg cm^{-2}) and low-mass-loading NVP-PVDF (1.2 mg cm^{-2}) electrodes.

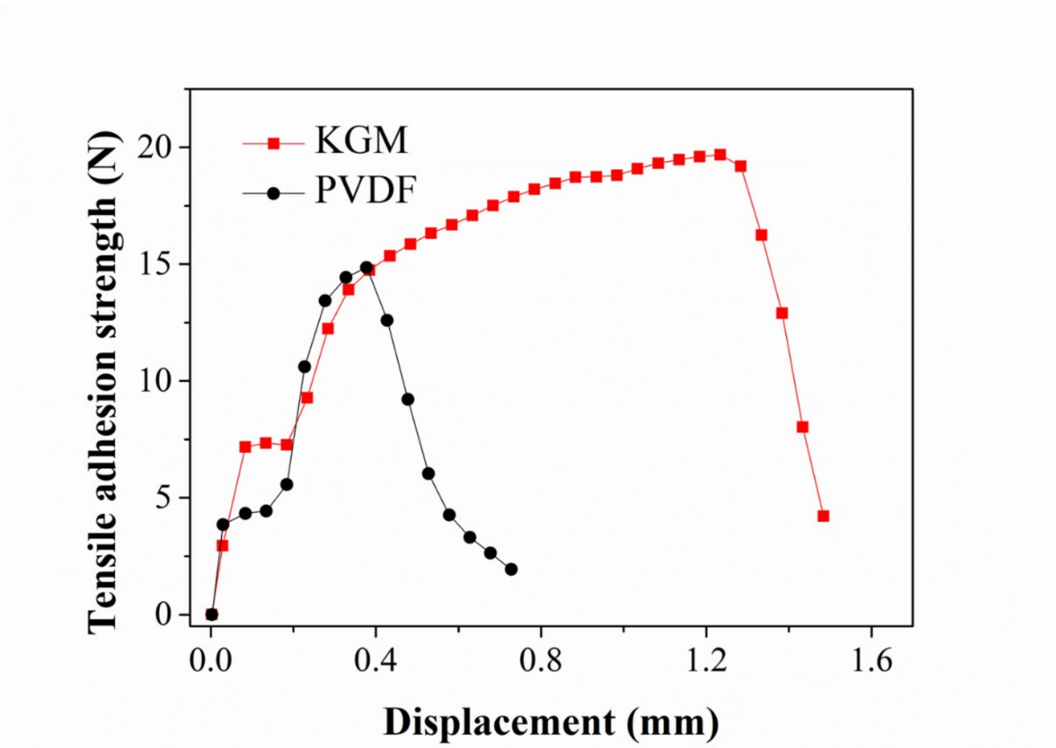

Figure S9. The tensile adhesion-displacement curves of NVP- KGM and NVP- PVDF (contact area: 18 mm × 18 mm).

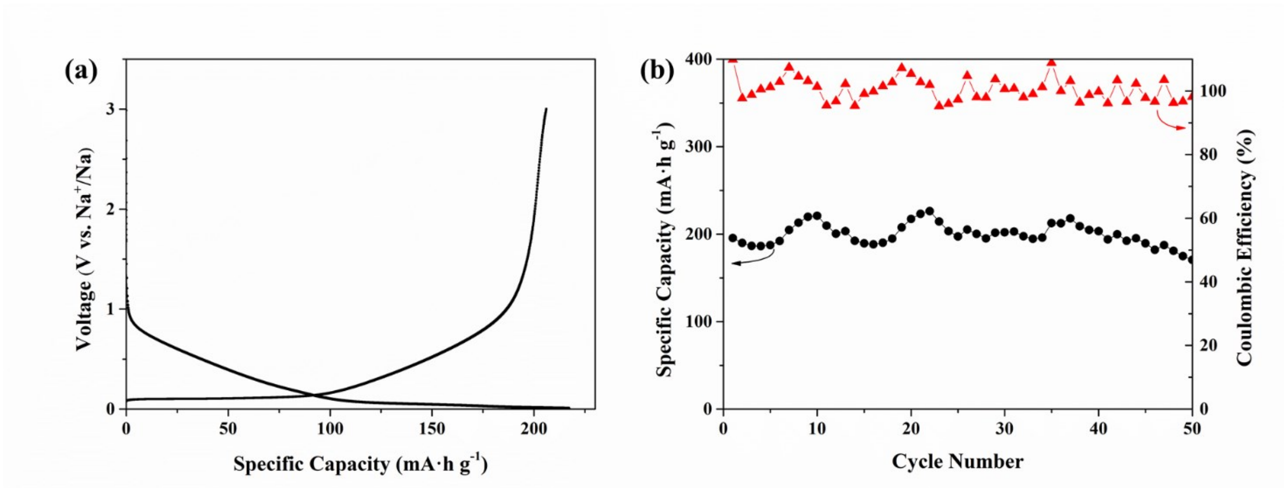

Figure S10. Charge-discharge profiles of hard carbon in sodium half batteries at the current density of 100 mA g^{-1}. (b) Galvanostatic cycling at 100 mA g^{-1} for 50 cycles of hard carbon.

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