Supporting Information

Comparative investigations of high-rate NaCrO$_2$ cathodes towards wide-temperature-tolerant pouch-type Na-ion batteries from -15 to 55 °C: Nanowires *vs.* Bulk

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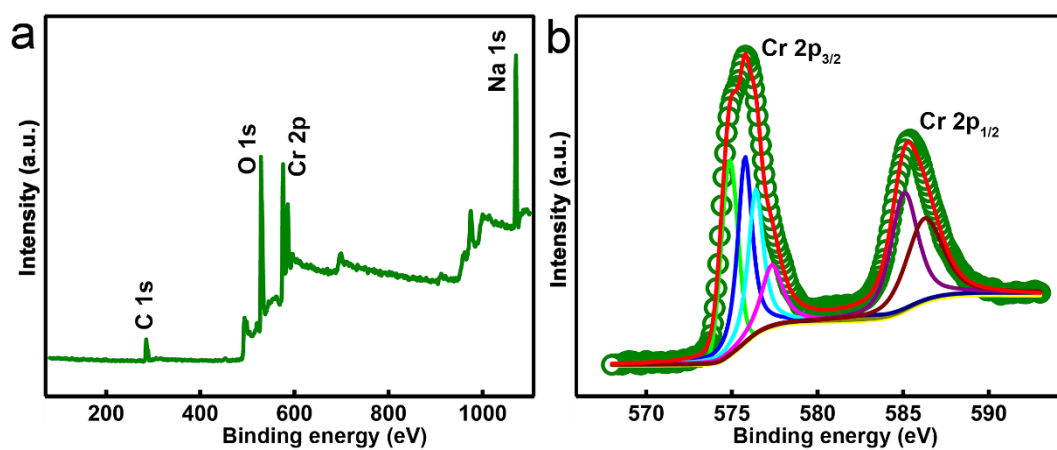*E-mail: mse_yuancz@ujn.edu.cn; ayuancz@163.com

Fig. S1 (a) XPS survey and (b) typical high-resolution elemental Cr 2p spectra and corresponding fitting profiles of the NCO NWs
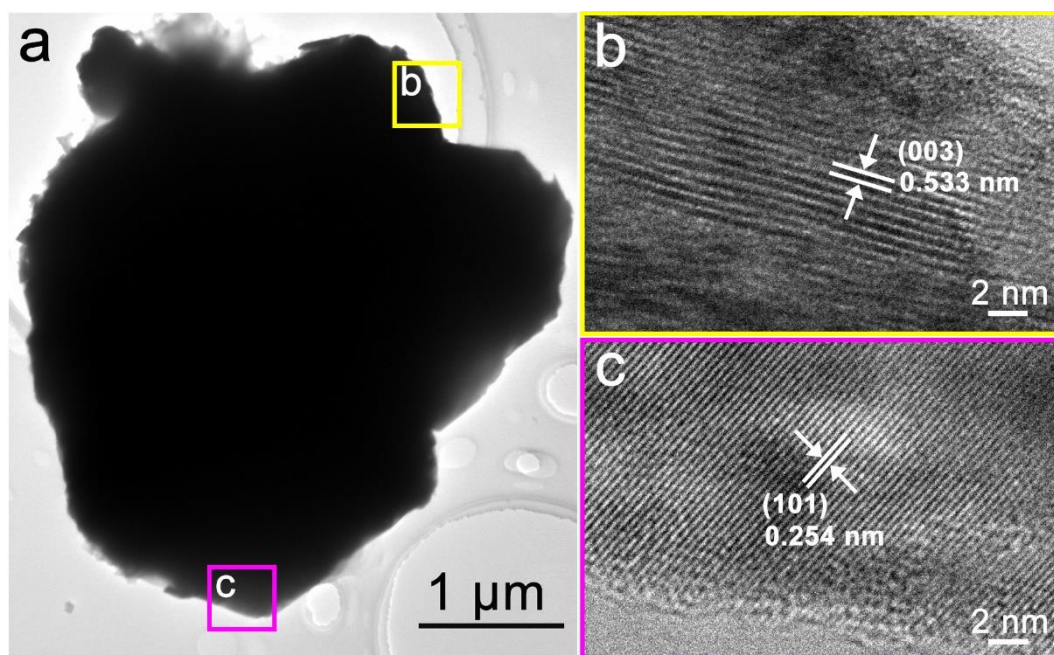
Fig. S2 (a) TEM and (b-c) HRTEM images of a single BNCO particle. The images in panels (b) and (c) are taken from the yellow and pink rectangle regions in panel (a), respectively
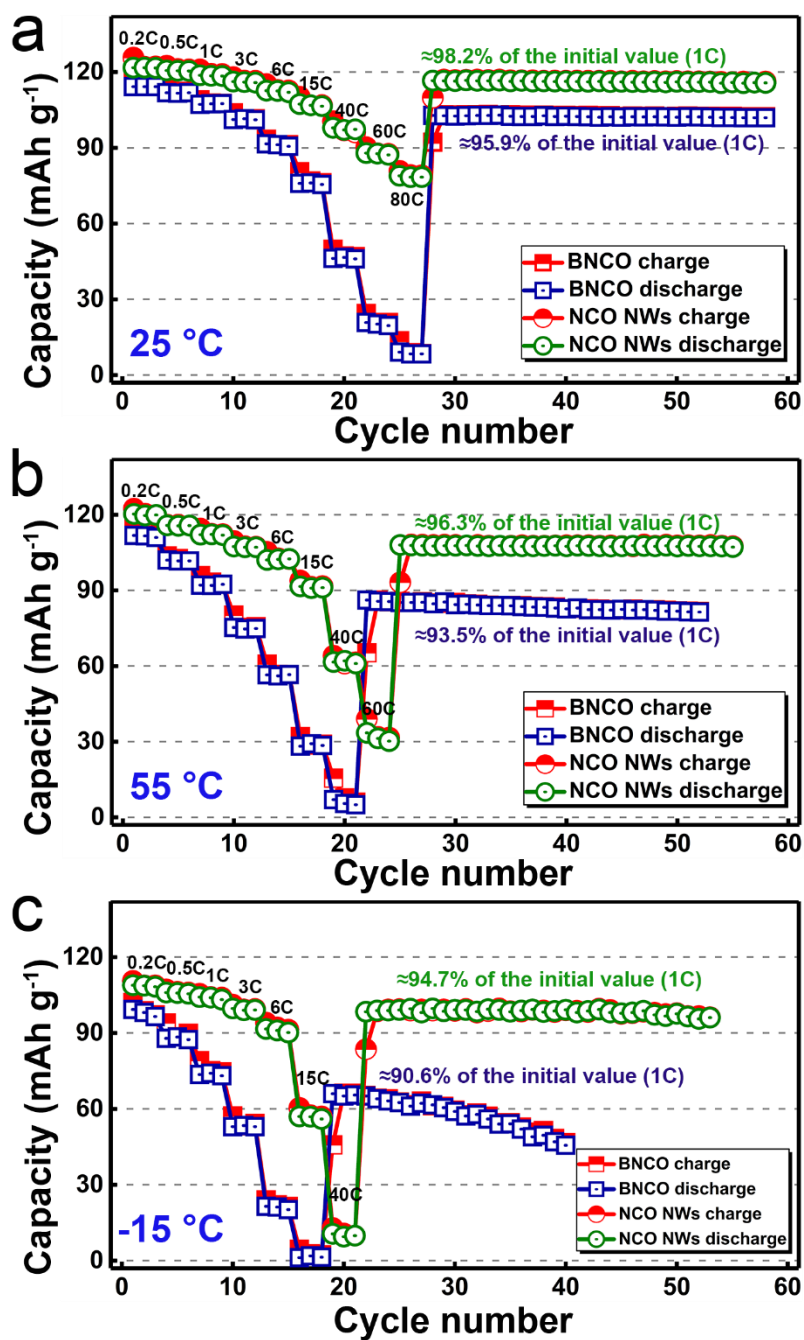
Fig. S3 Typical rate properties of both BNCO and NCO NWs at various current rates as indicated (charged/discharged at the same rate) with three cycles per step and then back to 1 C in the voltage of 2.0 − 3.6 V at (a) 25 °C, (b) 55 °C and (c) -15 °C, respectively
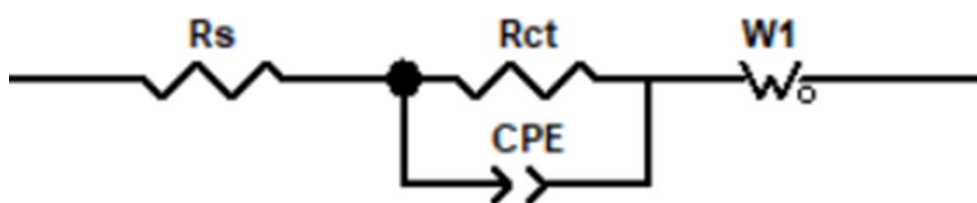
Fig. S4 Equivalent circuit model used to fit the EIS profiles
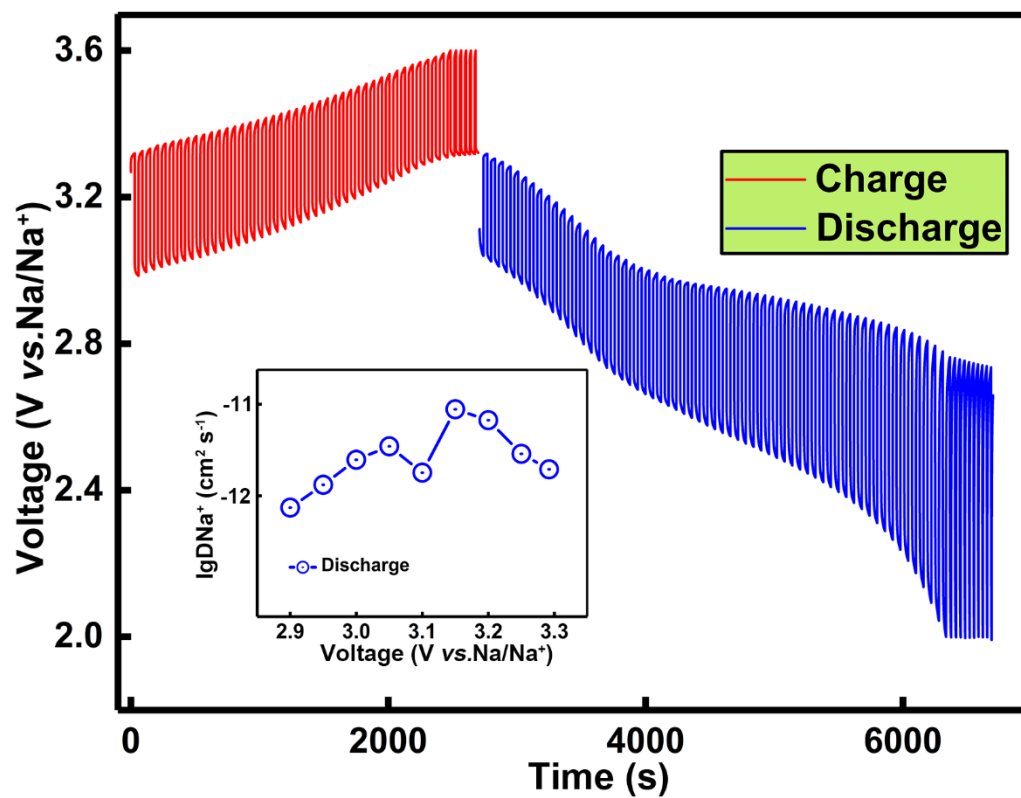
Fig. S5 GITT curves of the BNCO electrode for the charge and discharge process. The inset is the chemical diffusion coefficient of Na$^+$ ions as a function of voltage calculated from the GITT curve (after 300 cycles, current density: 2 C)
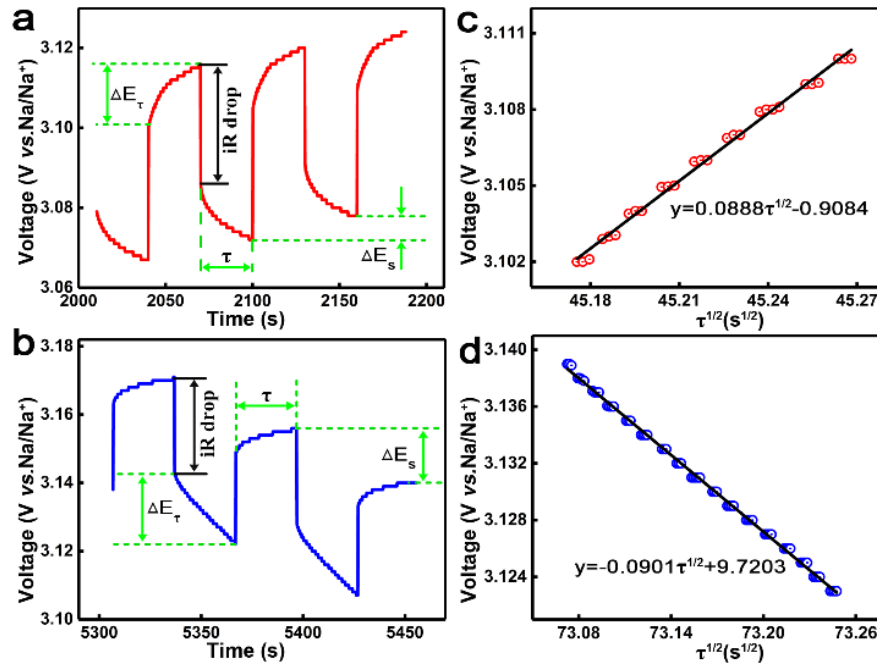
Fig. S6 (a) Detailed schematic diagram of a single GITT titration step at ~3.10 V during the charging process and (b) ~3.15 V during the discharging process and (c, d) their corresponding linear behavior of the E vs $\tau^{1/2}$ relationship of NCO NWs

The calculation of D_{Na+} is based on the equation:[1-4]

$$D_{Na+} = \frac{4}{\pi\tau}\left(\frac{m_B V_m}{M_B S}\right)^2 \left(\frac{\Delta E_s}{\Delta E_\tau}\right)^2 \quad \tau \ll \frac{l^2}{D_{Na+}}$$

where m_B, M_B, V_m, S stand for mass, molecular weight, molar volume and surface area of the cathode material respectively. ΔE_s and ΔE_τ are the difference between two consecutive stable voltages after relaxation, and the transient voltage-change during a single titration step.

Reference

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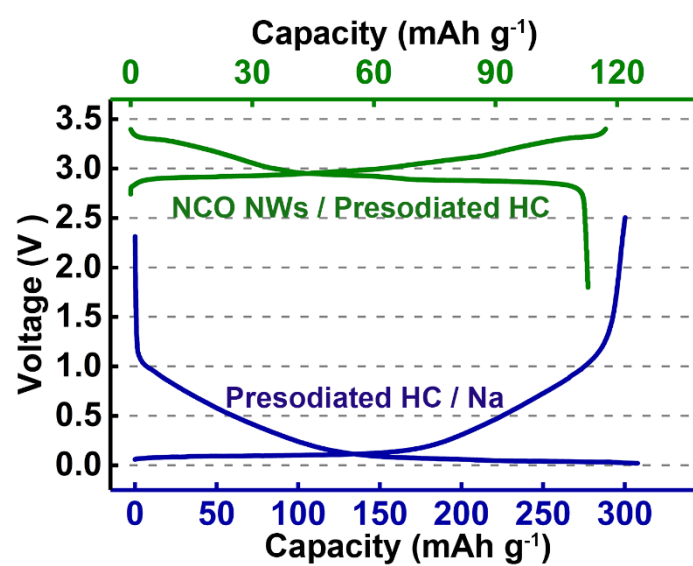
Adv. Energy Mater., 2018, **8**, 1801418.

Fig. S7 The initial charge/discharge curve at 0.1 C within a potential range of 1.8 –

3.4 V along with the typical charge/discharge profiles of presodiated HC versus Na
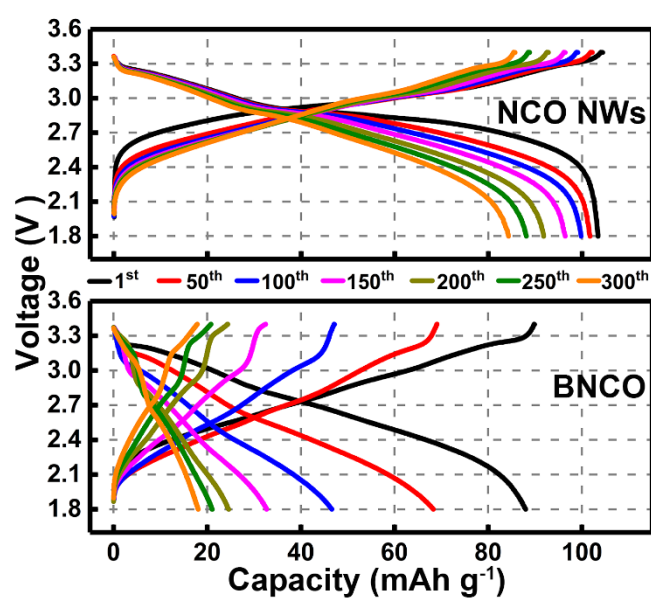
metal (0 – 2.5 V, 0.1 C)

Fig. S8 Typical charge–discharge profiles charged 1 C/discharged 2 C rate within a voltage range of 1.8 − 3.4 V at 55 °C for different cycles of the BNCO (the lower) and NCO NWs (the upper) full cells

Table S1. Lattice parameters calculated from Rietveld refinement of XRD data of the

BNCO

	BNCO
Space group	$R\bar{3}m$
Crystal system	Rhombohedral
a/Å	2.9743
b/Å	2.9743
c/Å	15.9678
V/Å^3	122.32

Table S2. EIS fitted parameters of two samples after different cycles

Samples	Cycles	R_s (Ω)	R_{ct} (Ω)	σ (Ω s$^{-1/2}$)
BNCO	50	~3.5	~130.3	–
	100	~3.7	~203.1	~38.2
	200	~4.0	~306.8	~73.9
	300	~4.8	~410.2	–
NCO NWs	50	~3.9	~223.8	–
	100	~4.1	~487.9	~22.8
	200	~4.9	~882.5	~30.2
	300	~7.3	~1543.6	–