Electronic Supporting Information

Nitrogen-doped bamboo-like carbon nanotubes as anode material for high performance Potassium-ion batteries

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Experimental Section

Synthesis of NBCNTs

Firstly, 0.5 g of $Co(CH_3COO)_2 \cdot 4H_2O$ and 10 g of urea were mixed with 20 mL of distilled water, and then vigorously stirred until the raw materials were completely dissolved. Subsequently, the solution was heated at 80^oC to evaporate the solvent. The obtained mixture powder was then annealed at 800^oC for 1 h or 2 h under Ar atmosphere,

with a heating rate of 3°C min^{-1}. After that, the residuum was dissolved in 2 M HCl solution for 48 h. Finally, the product was obtained by washing with distilled water several times and then dried overnight in a vacuum oven at 80°C.

Characterization

The specimens of samples were examined by using X-ray diffraction (XRD) technique (Bruker D8 Advance (Germany) with Cu Kα radiation, λ = 1.5418 Å). The morphology of the samples were studied with scanning electron microscopy (SEM, FEI Quanta 200 FEG) and high-resolution transmission electron microscopy (HRTEM, Tecnai G2 F20 S-TWIN, Japan) operating at 200 KV. XPS was performed on a Thermo K-Alpha XPS spectrometer (Thermo Fisher Scientific) equipped with a monochromatic Al Kα X-ray source (hν =1468.6 eV). Raman spectroscopic measurement was performed using a Renishaw RM1000 microspectroscopic system.

Electrochemical Tests

The active material electrodes were composed of the NBCNTs, carbon black, and a binder of polyvinylidene fluoride (PVDF) with a mass ratio of 80:10:10. Cu foil was used as current collector, and the 2032-type coin cells were fabricated in glovebox filled with Ar. The mass loading of the active material was about 0.5 mg cm^{-2}. The K disks, glass-fiber, and 0.8 M KPF6 in EC: DEC (1:1) were utilized as the counter/reference electrode, separator, and electrolyte, respectively. The K disks were made by rolling potassium lumps into a thin plate, and were then cut into circulated disks in glove box with water/oxygen content lower than 1 ppm. Galvanostatic charge and discharge measurements were carried out using a LAND CT2001A battery testing system (Wuhan,

China) within the voltage range of 0.01−3.0 V. Cyclic voltammetry (CV) measurements were performed using a CHI660A electrochemical workstation at a scan rate of 0.1 mV s^{-1} from 0.01 to 3.0 V.

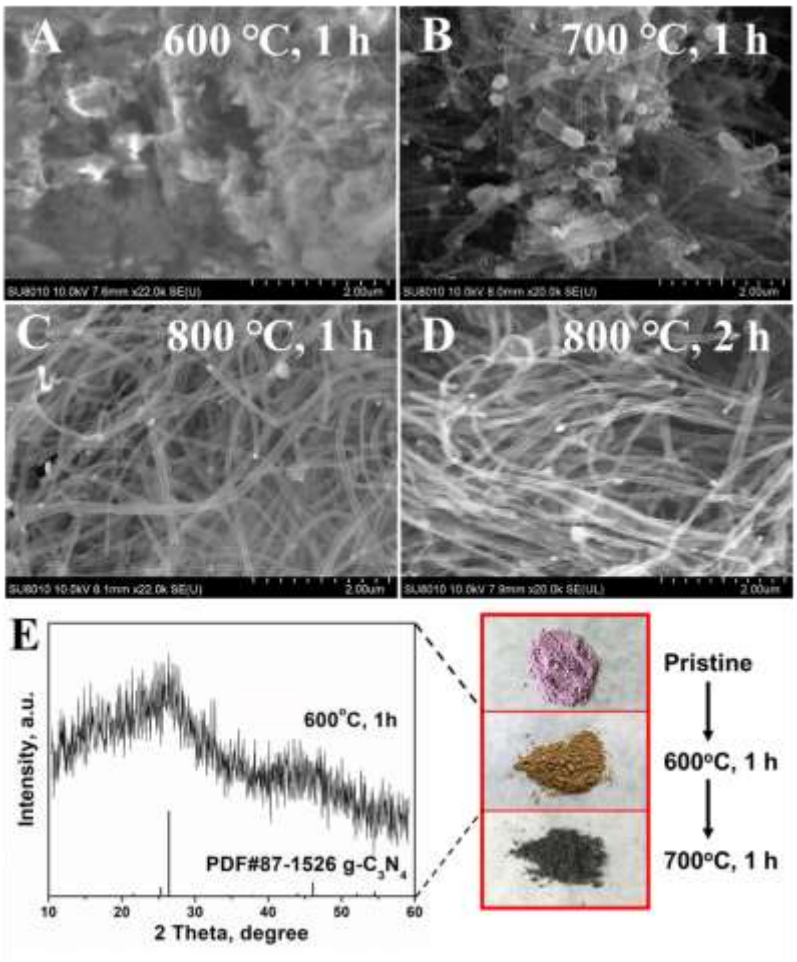

Figure. S1 SEM images of samples annealed at 600°C for 1h (A), 700°C for 1h (B), 800°C for 1h (C), 800°C for 2h (D), and the XRD pattern of sample annealed at 600°C for 1h and the digital photos of samples at different temperatures (E).

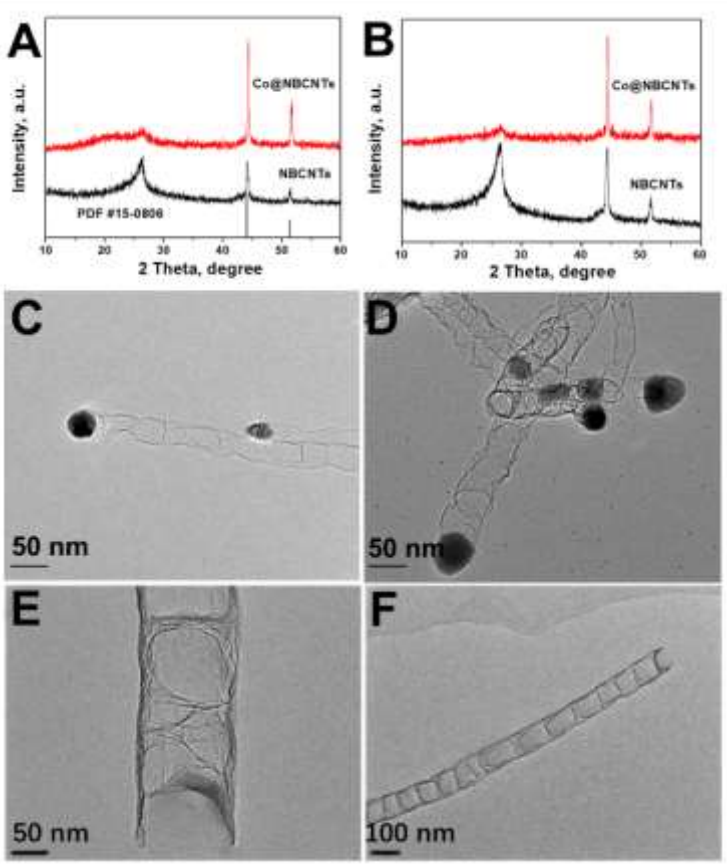

Figure. S2 XRD patterns of NBCNTs-1 (A) and NBCNTs-2 before and after removing Co, and TEM images of NBCNTs-1 (C) and NBCNTs-2 (D) after removing Co.

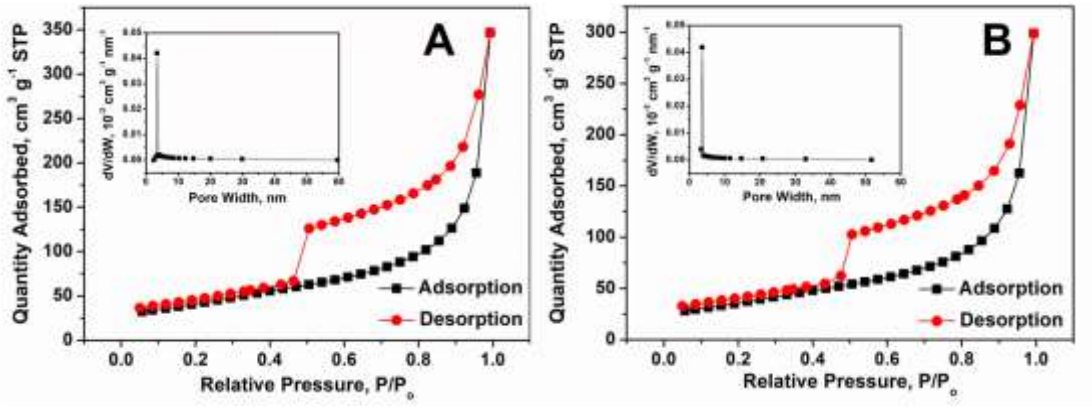

Figure. S3 Nitrogen adsorption-desorption isotherm and pore size distribution (insert) of NBCNTs-1 (A) and NBCNTs-2 (B).

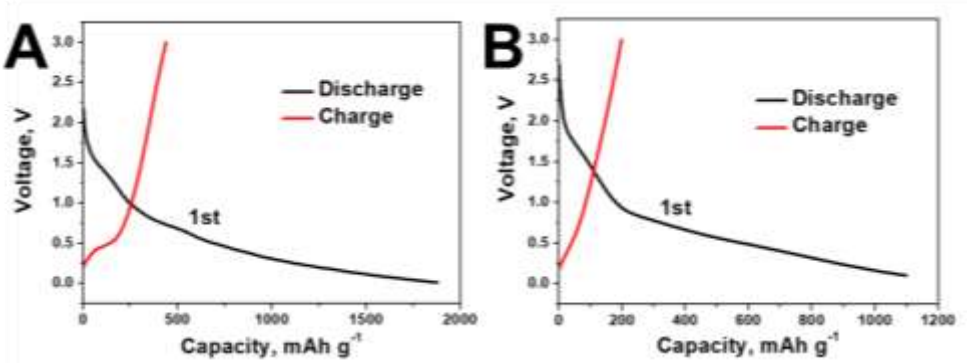

Figure S4. First cycle charge-discharge profiles at 500 mA g^{-1} of NBCNTs-1 (A) and NBCNTs-2 (B).

Table S1. Comparison of the K storage performance with reported carbonaceous materials.

Types of materials	**Current density (mA g^{-1})**	**Cycle number**	**Specific capacity (mAh g^{-1})**	**Ref.**
Carbon microspheres	28	100	216	r1
N-doped CNFs	279	1900	170	r2
Mesoporous carbon	1000	1000	146.5	r3
N-doped CNTs	2000	500	102	r4
N-rich hard carbon	504	4000	180	r5
Porous CNFs paper	200	1200	211	r6
N/O doped carbon	50	100	230.6	r7
Graphite	200	500	174	r8
N-doped CNTs	500	1000	204	This work

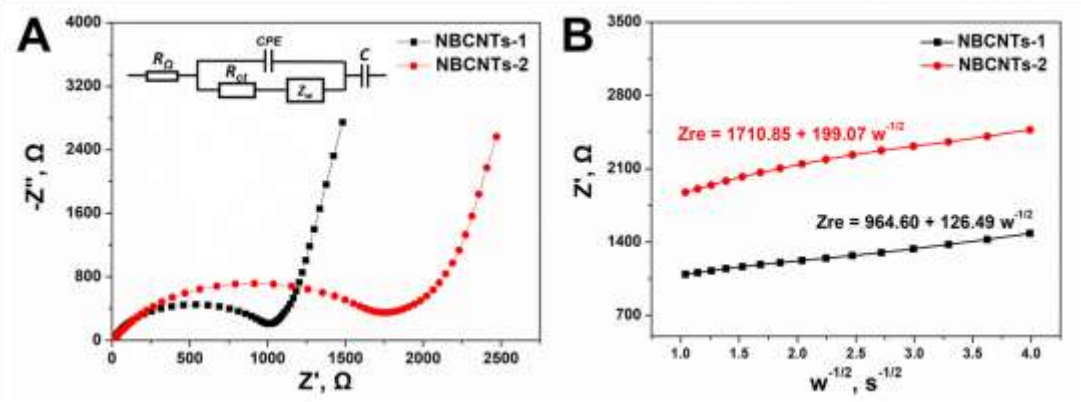

Figure S5. Electrochemical impedance spectroscopy for NBCNTs-1 and NBCNTs-2 and equivalent circuit (insert) (A), and the corresponding relationship of the plots real impedance components and the inverse square root of frequency (B).

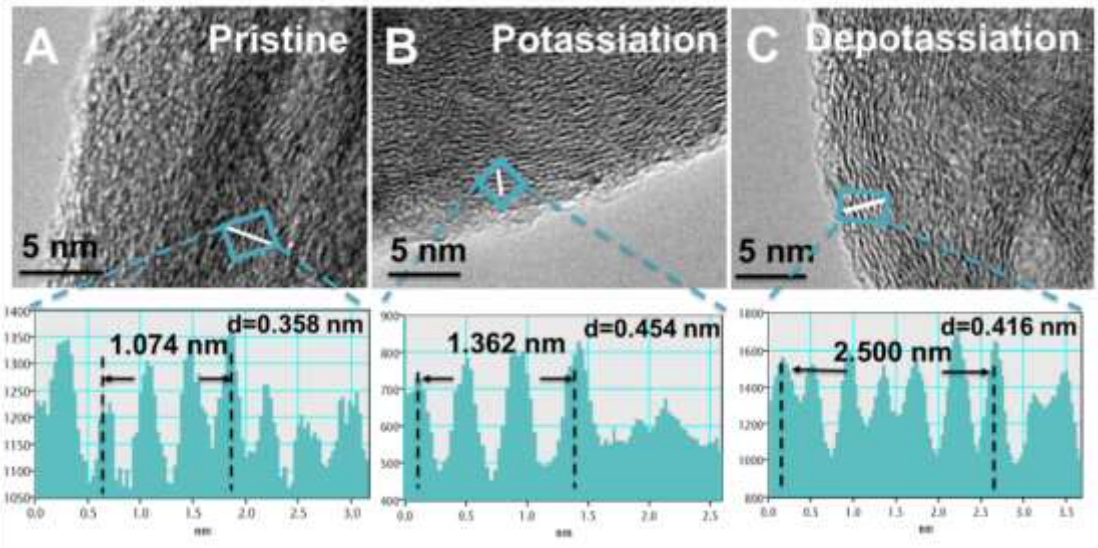

Figure S6. HRTEM images of A) pristine NBCNTs-1 and those at B) discharging to 0.01 V and C) charging to 3.0 V with the lattice distances of the corresponding samples.

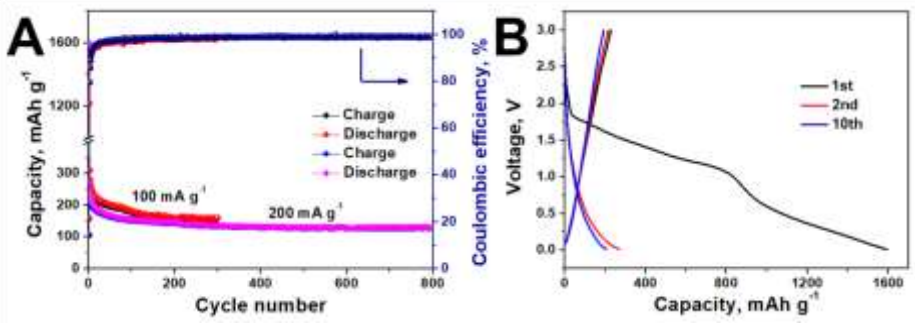

Figure S7. Cycle performance (A) and charge-discharge profiles (B) of NBCNTs-1 as anode material for SIBs.

References:

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