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Supporting Information

Highly dispersed Zn nanoparticles confined in nanoporous carbon network: promising anode materials for sodium and potassium ion batteries

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Experimental section

Synthesis of zeolitic imidazolate framework-8 (ZIF-8)

Firstly, Zn $(NO_3)_2 \cdot 6H_2O$ (5.95 g) and 2-methylimidazole (6.57 g) were each dissolved in anhydrous methanol (200 ml). Secondly, the two solutions were mixed, stirred for 0.5 h, and aged at 25 ^oC for 24 h. Finally, ZIF-8 precursor was collected by centrifuging, washing with anhydrous methanol, and drying under vacuum at 80 ^oC for 12 h.

Synthesis of highly dispersed Zn nanoparticles confined in nanoporous carbon network (ZNP/C)

ZNP/C was achieved by calcining ZIF-8 precursor at a specific temperature for 3 h in N_2 flow at a heating rate of 1 ^oC min^{-1}. The ZNP/C composites obtained at 550 ^oC, 600 ^oC, 650 ^oC and 700 ^oC were denoted as ZNP/C-550, ZNP/C-600, ZNP/C-650 and ZNP/C-700, respectively. For comparasion, nanoporous carbon material was also synthesized by treating ZNP/C-600 with hydrochloric acid for several hours at 60 ^oC and denoted as NPC-600.

Material characterization

X-ray diffraction (XRD) was conducted on an X-ray diffractometer (Bruker D8 Adv., Germany). Raman spectrum was measured by a Raman spectrometer (NEXUS 670, USA). SEM images were collected by a scanning electron microscope (JSM 6700F, Japan). TEM images and energy-dispersive X-ray spectroscopy (EDX) were performed on a transmission electron microscope (JEM 2100, Japan). X-ray photoelectron spectroscopy (XPS) was performed on an X-ray photoelectron spectrometer (ESCALAB 250, USA). N_2 sorption measurements were measured at 77 K by Quadrasorb SI. Nonlocal Density Functional Theory (NLDFT) and Brunauer-Emmett-Teller (BET) methods were utilized to study the pore structure and surface area of ZNP/C composites and NPC-600.

Electrochemical measurements

Working electrodes were made by active materials, super P and sodium carboxy methyl cellulose (mass ratio, 8:1:1). The average loading density of active materials was ~1.0 mg cm^{-2}. Na half cells were assembled by using sodium foil as counter electrode, 1 M $NaClO_4$ in EC/DMC (volume ratio, 1:1) with 2 wt% FEC as electrolyte, and glass fiber (Whatman GF/D) as separator. For the assembling of K half cells, potassium foil was employed as counter electrode, and 0.8 M KPF_6 in EC/DEC (volume ratio, 1:1) was utilized as electrolyte. Cyclic voltammetry was carried out on an electrochemical workstation (CHI760E, China) in the potential range of 0.01-3.0 V (vs. Na/Na^+ or K/K^+). Galvanostatic cyclings were relized at curent densities of 0.1-2 A g^{-1} in the potential range of 0.01-3.0 V (vs. Na/Na^+ or K/K^+) on a battery cycler (LAND CT-2001A).

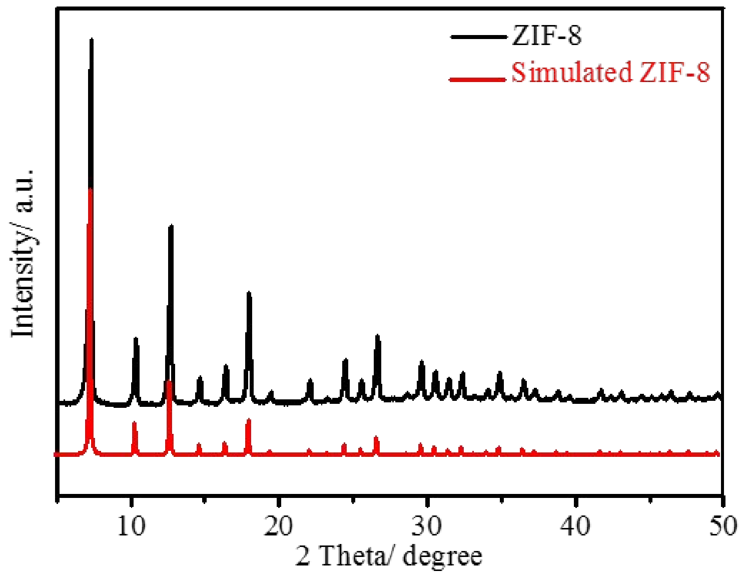

Figure S1 XRD patterns of as-prepared ZIF-8 and simulated ZIF-8.

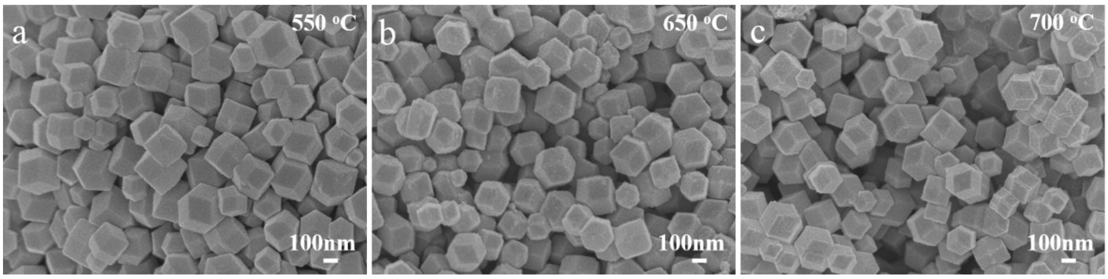

Figure S2 SEM images of (a) ZNP/C-550, (b) ZNP/C-650 and (c) ZNP/C-700.

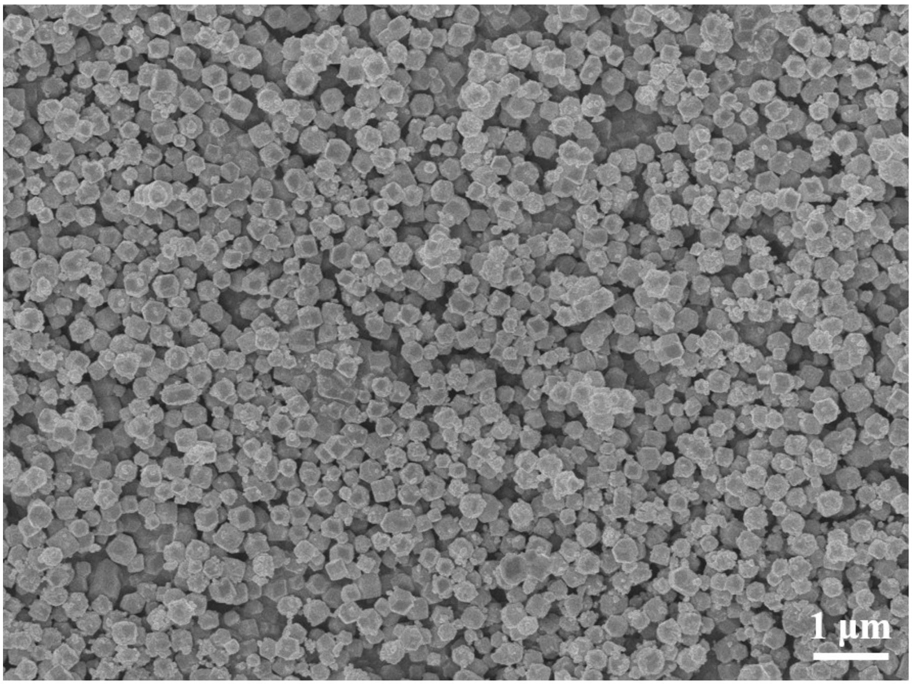

Figure S3 SEM image of ZIF-8 precursor.

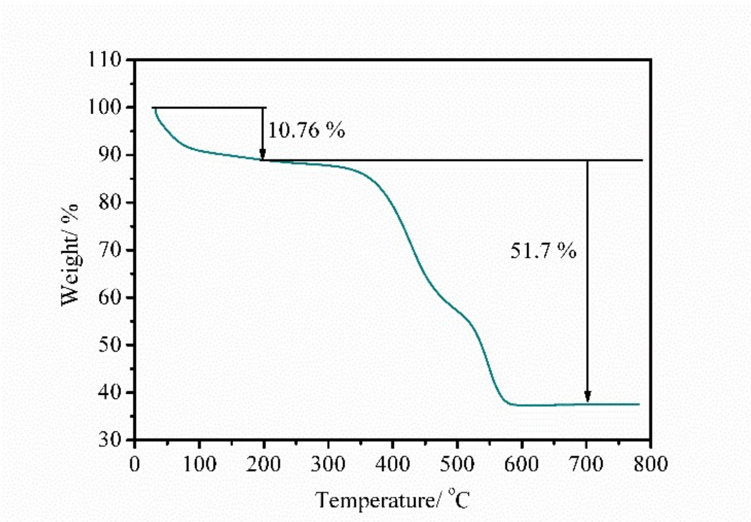

Figure S4 TG curve of ZNP/C-600 at a heating rate of 10 $^{o}C\ min^{-1}$ in air.

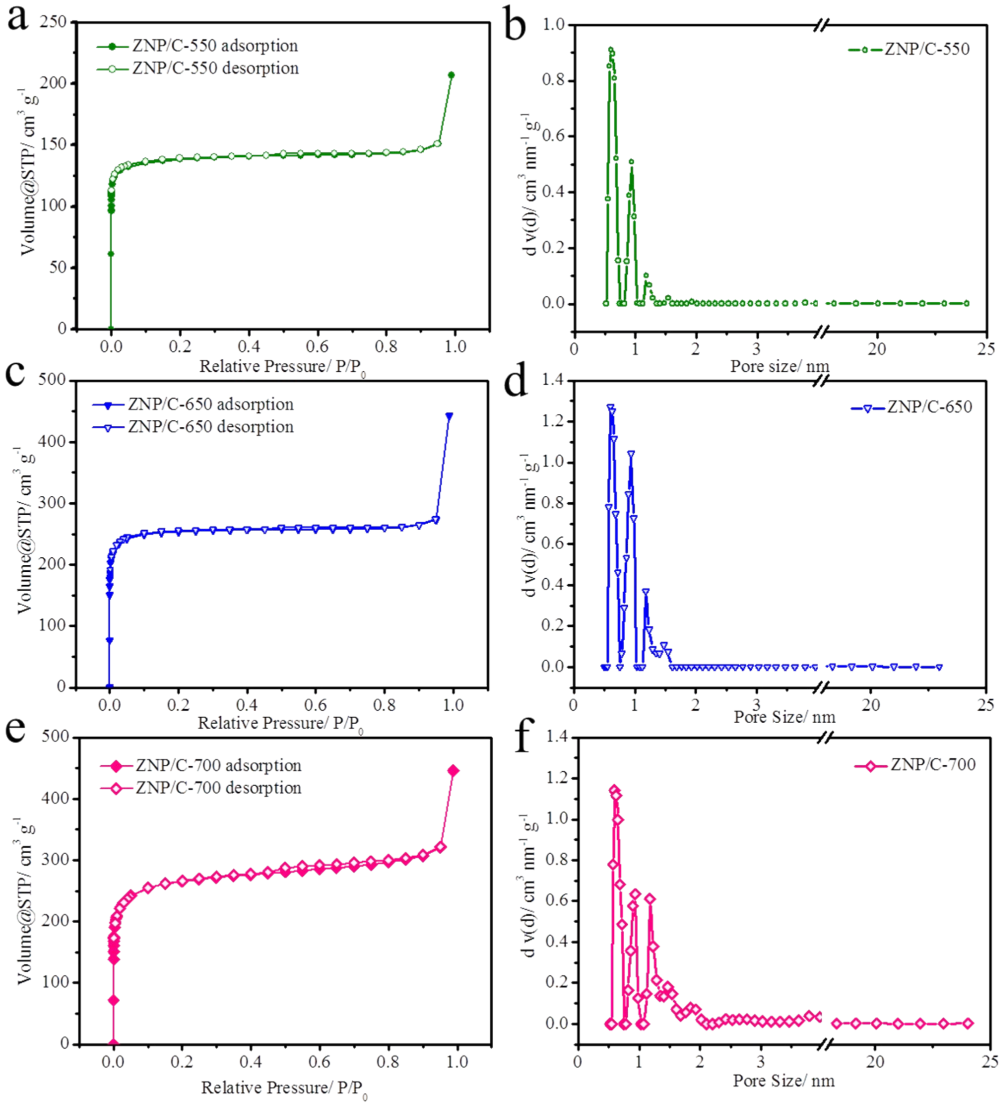

Figure S5 (a, c, e) N_2 sorption isotherms and (b, d, f) NLDFT pore-size distribution curves of ZNP/C-550, ZNP/C-650 and ZNP/C-700.

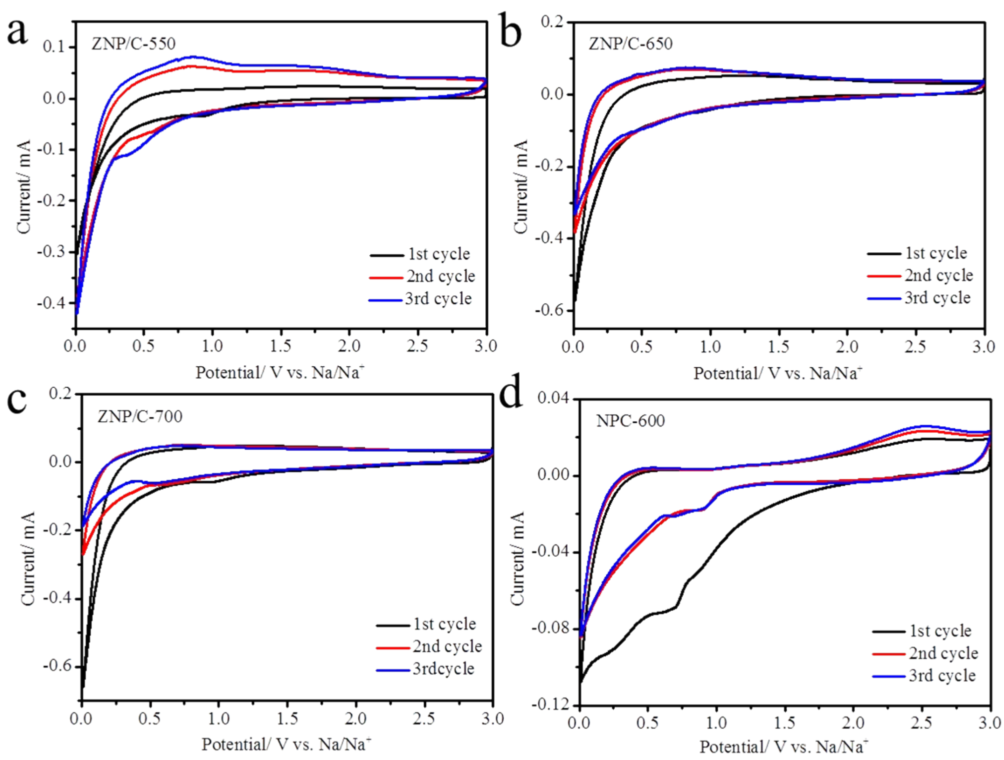

Figure S6 Cyclic voltammograms of ZNP/C-550, ZNP/C-650, ZNP/C-700 and NPC-600 between 0.01 and 3.0 V (vs. Na/Na^+) at a scanning rate of 0.2 mV s^{-1}.

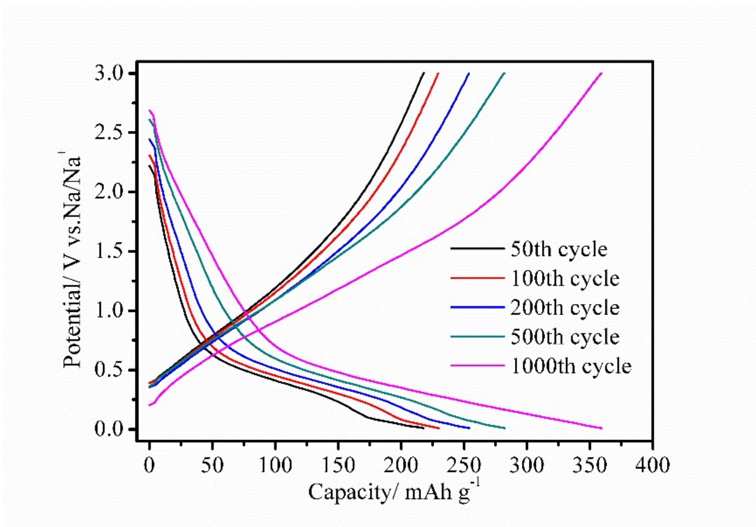

Figure S7 Discharge/charge profiles of ZNP/C-600 at 1 A g^{-1}.

Table S1 Carbonaceous and alloying materials for SIBs.

Anode material	**Reversible capacity(mAh g^{-1})@cycle number**	**Current density(mA g^{-1})**	**Reference**
carbon nanofibers	245@280	50	[1]
hollow carbon nanowires	206@400	50	[2]
hard carbon nanoparticles	260@200	50	[3]
Sulfur covalently bonded graphene	150@200	1000	[4]
N-doped graphene sheets	187.3@50	100	[5]
3D hollow porous carbon microspheres	313.8@100	100	[6]
Nitrogen-rich hard carbon	~204@1000	1000	[7]
Sb/rGO	173@150	500	[8]
Bi@C microsphere	123.5@100	100	[9]
ZNP/C-600	361@100 227@1000	100 2000	This work

Table S2 Carbonaceous and alloying materials for PIBs.

Anode material	Reversible capacity(mAh g-1)@cycle number	Current density(mA g-1)	Reference
Graphite	100@50	140	[10]
Soft carbon	118@200	279	[11]
Hard carbon	144@200	279	[11]
Reduced graphene oxide	130@175	20	[12]
Few-layered graphene	150@100	100	[13]
Activated carbon	100@100	200	[14]
Few-layered N-doped graphene	165.9@200	500	[15]
Sn/C composite	110@30	25	[16]
P/C composite	195.5@20	50	[17]
ZNP/C-600	200@100 145@300	100 500	This work

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