

Supporting information

ZnSe@NPSC core-shell nanorods for super sodium ion storage induced from organic polymer derived N, P, S tri-doped carbon framework

Haibin Wang^a, Lantao Chen^{a, b}, Feng Xu^b, Yufei Zhang^{b*} and Haosen Fan^{b*}

Experimental section

Synthesis of ZnO microrods

All reagents were without purification. Firstly, 0.66 g zinc acetate dihydrate and 2.4 g NaOH were dissolved in 5 mL deionized water, respectively, and then the above solutions were mixed together. Then, added 20 mL glycerin into the mixed solution and stirred for 10 min. The mixed solution was transferred into a Teflon-lined stainless-steel autoclave and was placed in a 150 °C oven for 24 h. After the reaction was completed, the obtained products were collected by centrifugation at 8000 rpm and washed several times with distilled water and ethanol. Finally, dried in a vacuum oven under 70 °C to obtain ZnO microrods.

Synthesis of ZnO@PZS

Briefly, 400 mg of ZnO was dispersed into 50 mL methanol using ultrasound for 15 minutes. Then added dropwise with another solution containing 70 mg hexachlorocyclophosphazene and 158 mg 4,4'-sulfonyldiphenol in 10 mL methanol. After stirring for 5 minutes, 185 μL of trimethylamine was added and the mixed solution was continued to stir for 6 h. At last, the product was collected by filtration and washed three times with ethanol, and dried the obtained powder at 60°C for 12 h.

Synthesis of ZnSe and ZnSe@NPS

The as-prepared ZnO and selenium powder were placed in the upper and middle parts of the porcelain boat with a mass ratio of 1:2. Then annealed at 500°C under the protection of Ar/H₂ with a heating rate of 3°C min⁻¹. After selenization for 2 h, the final ZnSe was obtained. The same procedures are to synthesize ZnO@NPS.

Material characterization

The structure of the final material was determined by X-ray diffraction (XRD, PANalytical PW3040/60 X-ray powder diffractometer) with Cu-K α radiation and 2 θ degree ranging from 10° to 80°. The field-emission scanning electron microscopy (FESEM, JSM-7001F) and transmission electron microscope (TEM, JEOL JEM2100F) were performed to perceive the morphology of the synthesized products, respectively. X-ray energy dispersive spectrometry (EDS) was carried out to observe the distribution of each element in the material. The elemental composition and molecular structure were determined by X-ray photoelectron spectroscopy (XPS, Al-K α). Thermal gravimetric analyzer (TGA) test was analyzed by TG209F3. The temperature was increased from room temperature to 750 °C at the rate of 10 °C min⁻¹ in the air atmosphere. The specific surface area and pore size distribution of ZnSe@NPSC were determined by Micromeritics ASAP 2460 tester.

Electrochemical measurements

All the electrochemical performances were evaluated in 2032-type coin cells assembled from the

materials as the anode. The working electrodes were made of 70 wt% active material, 20 wt% acetylene black, and 10 wt% polyvinylidene fluoride, respectively. Thereafter, added N-Methyl-2-pyrrolidinone (NMP) to the above mixture and ground thoroughly to the slurry. Then the slurries were coating on copper foil and dry overnight in vacuum oven at 80°C. Then the coin cells were assembled under the argon-filled ultra-pure glove box with using sodium coil, Whatman glass fiber GF/D, and 1.0M NaClO₄ as anode, separator, and electrolyte, respectively. Galvanostatic charge-discharge tests were measured on the NEWARE battery tester at 0.01-3.0V. Cyclic voltammetry (CV) test window voltage ranged from 0.01-3.0V at the scan rate of 0.1mV s⁻¹. The electrochemical impedance spectroscopy (EIS) was tested with frequency range from 0.01Hz to 100KHz.

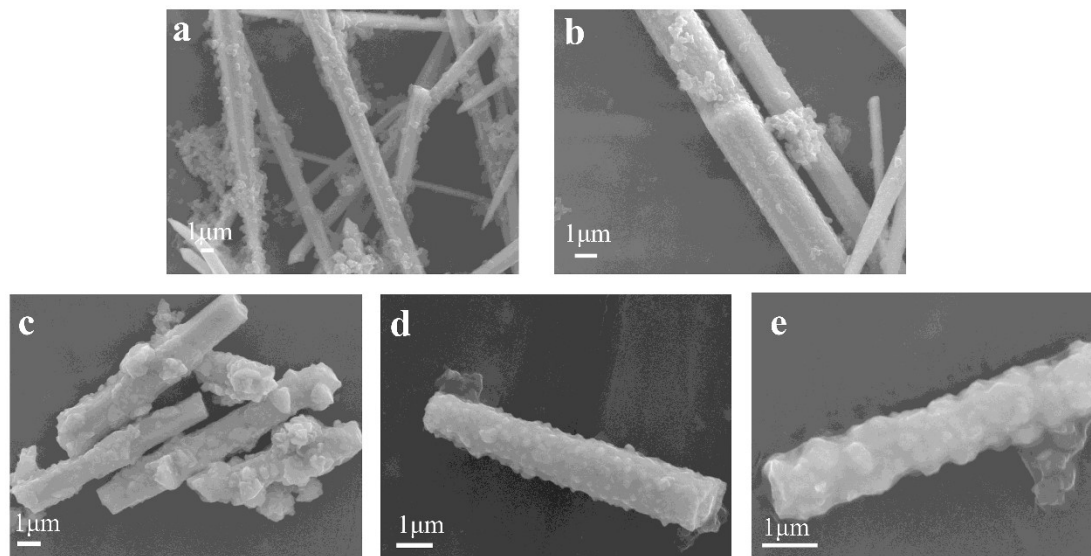


Fig. S1 SEM images of ZnSe@PZS(a and b); and ZnSe (c-e).

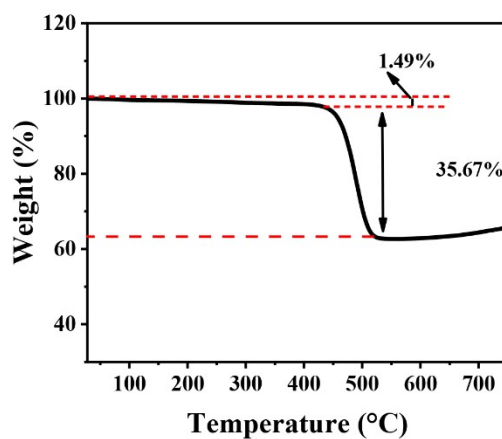


Fig. S2 TGA curves of ZnSe@NPSC.

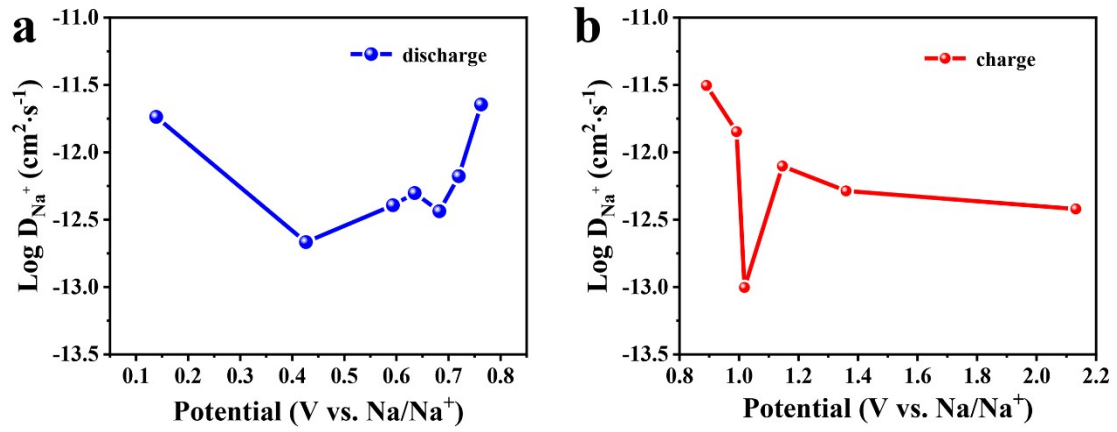


Fig. S3 The diffusion coefficient of Na⁺ during the discharge (a) and charge (b) process.

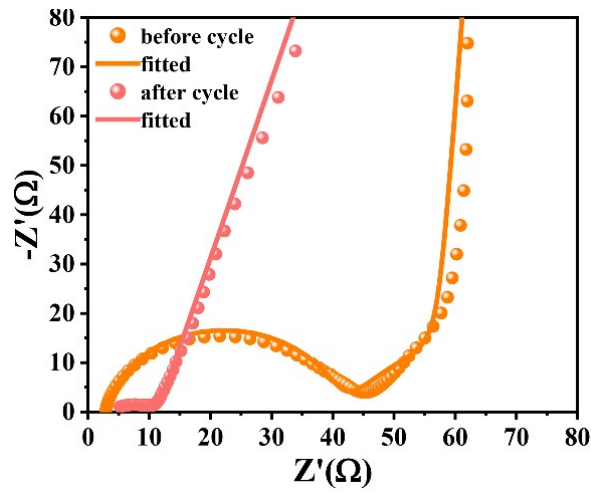


Fig. S4 The Nyquist plots of ZnSe@NPSC in SIBs.