Supporting Information

Partial Occupation of Selenium in Porous Carbon Enhanced Selenium Utilization for Potassium-ion Batteries

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Experimental section

Synthesis of Zn-HKUST-1

As a typical procedure, $Zn(Ac)_2 \cdot H_2O$ (7.497 mmoL, 1.64 g) was dissolved in 15 ml distilled water, 1,3,5-benzentricarboxylic acid (9 mmoL,1.89 g) was dissolved in 25 ml ethanol. The two solutions were mixed and keep stirring 30 min at room temperature. The mixture solution was sealed in a teflon-lined stainless steel vessel keep at 175℃ for 24 h and cooled to room temperature. The white powders was collected by washed with ethanol and distilled water, then dried at 80℃for 12 h under vacuum.

Synthesis of porous carbon (ZC)

The porous carbon was derived by Zn-HKUST-1. The white powder of $Zn_2(BTC)_3$ was placed into a tube furnace and heated for 3 h at 450℃ at ramping rate of 5℃/min, and then a carbonization process was conducted for 3 h at 600℃ to obtain black porous carbon (ZC).

Synthesis of Se/C PSC and Se/C FSC

Se/C PSC and Se/C FSC were prepared by a melt diffusion method. Firstly, nitrogen sorption isotherms and Brunauer−Emmett−Teller (BET) surface of ZC was analyzed at 77K using a Micromeritics ASAP 2020 plus. According to the data of its micropores volume, the mass of Se required to fill all the micropores can be calculated. Then, 6.83mg Se and 100mg ZC were uniformly mixed and placed in a 10ml sealable glass container. The glass container was later transferred into a tube furnace and annealed at 260℃ in Ar flow with a heating rate of 5℃/min for 10 h, then heated for 3 h at 600℃ to get black Se/C PSC sample.

Se/C FSC was prepared by the similar method to Se/C PSC, the mass of Se required to fill all

the micro/mesopores was calculated on the basis of total pores volume. 700mg Se and 100mg ZC were uniformly mixed and placed in a 10ml sealable glass container. The similar calcination process was conducted and obtained the Se/C FSC sample.

Structural Characterizations.

X-ray diffraction (XRD) and in-situ XRD patterns were examined by X-ray powder diffractometry (Smart Lab, Rigaku, Japan) at a scan rate of 10 degree per minute with Cu Kα radiation (λ=0.15406 nm). The morphologies of Se/C PSC sample and Electron diffraction pattern was investigated by Transmission Electron Microscope (JEM-2100F, JEOL, Japan) Nitrogen sorption isotherms and Brunauer−Emmett−Teller (BET) surface were conducted at 77K using a Micromeritics ASAP 2020 plus. The Se content of samples were calculated in N_2 atmosphere by thermogravimetric analysis instrument (TGA, Netzsch STA 449 F5) . The cycled cells were disassembled in an Ar-filled glove box. Raman spectra were taken by LabRAM HR Evolution. X-ray photoelectron spectroscopy (XPS) was obtained via a VG Microtech ESCA 2000 using a monochromic Al X-ray source (2kV, 1486 eV). The Se content of samples was determined by thermogravimetric analysis (TGA) instrument (Q5000IR, America) in nitrogen flow.

Electrochemical measurements

Firstly, Se/C PSC or Se/C FSC sample were directly conducted to assemble 2032-type coin cells in an argon-filled glove box, using K metal as counter and reference electrodes. The separator was glass fiber (Whatman). The area Se loading on each electrode is about 1.5 mg cm^{-2}. Consisting of 3M Bis(fluorosulfonyl)imide (KFSI) in a solvent mixture of ethylene carbonate (EC) and diethyl carbonate (DEC, 1:1 in volume) was used in this work. Galvanostatic discharge–charge experiments were conducted on a battery-testing system (Land-CT2001A) in the potential range of 0.1–3 V (versus K/K+) at room temperature. Cyclic voltammetry (CV) was performed using a CHI660D electrochemical workstation. Electrochemical impedance spectroscopy (EIS) were collected by an electrochemical workstation (Zahner Zennium Pro, Germany) with an AC amplitude of 5 mV in the frequency range of 10 kHz to 1Hz. The specific capacity was calculated on the basis of the active Se material.

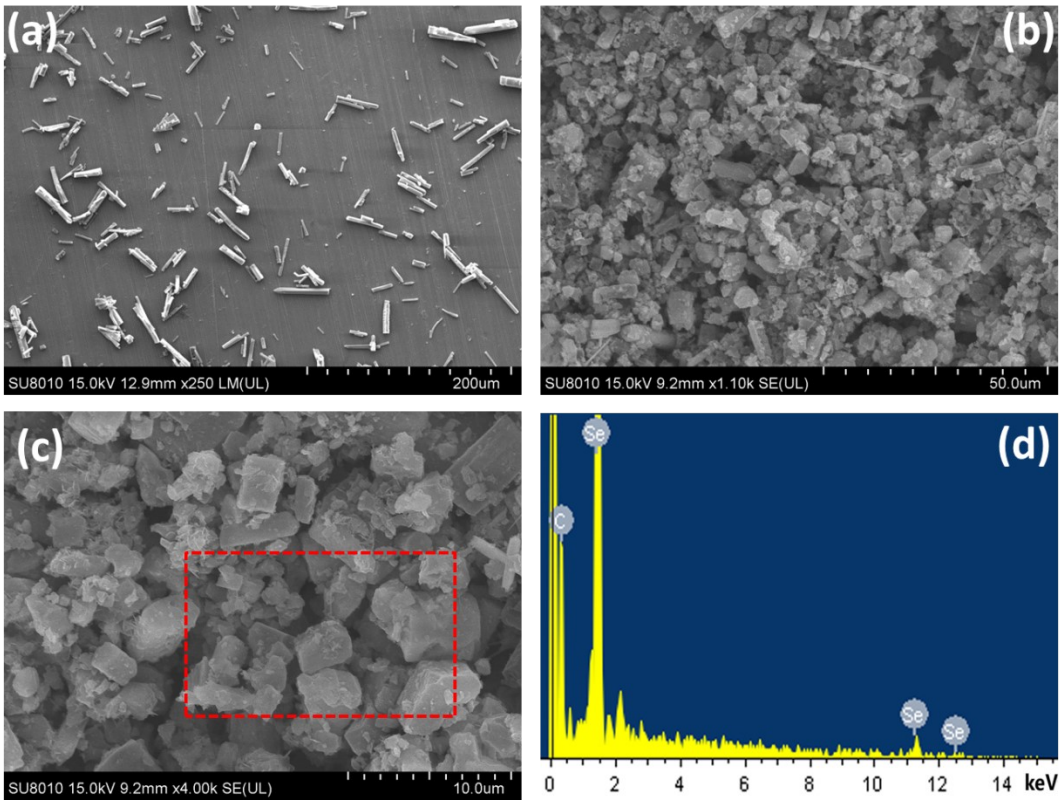

Fig. S1 SEM images of Zn-HKUST-1 (a), Se/C PSC (b,c) samples. The EDS image (d) of Se/C PSC showed the composition of Se and C.

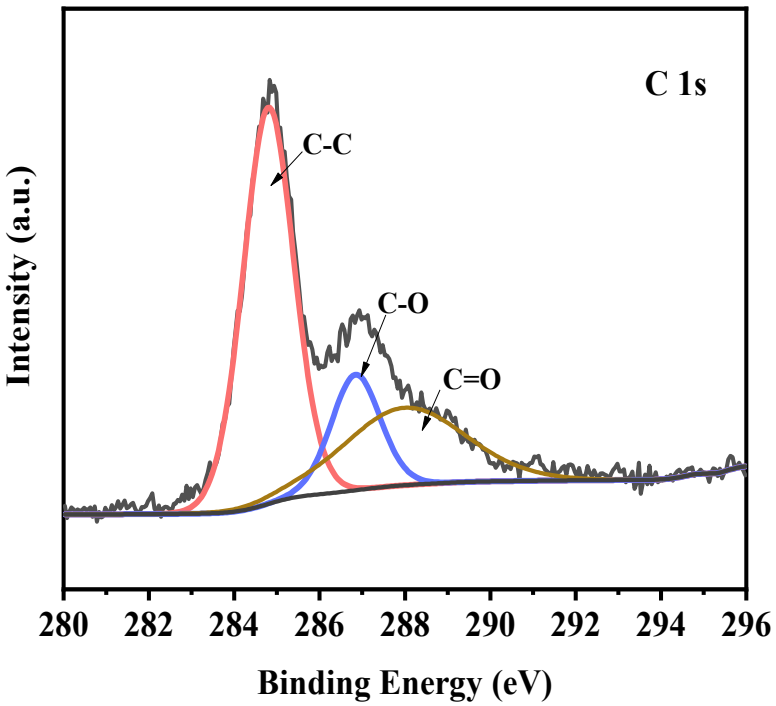

Fig. S2 The C1s spectrum of Se/C PSC.

Table S1. Porosity properties of ZC, Se/C PSC, and Se/C FSC.

Sample	S_{BET} [m^2 g^{-1}]	V_t [cm^3 g^{-1}]	V_{meso} [cm^3 g^{-1}]	V_{micro} [cm^3 g^{-1}]	Average diameter [nm]
ZC	995.07	1.47	1.39	0.038	5.85
Se/C PSC	276.02	0.54	0.48	0.0014	7.80
Se/C FSC	1.19	0.0047	0.0046	0.000021	12.51

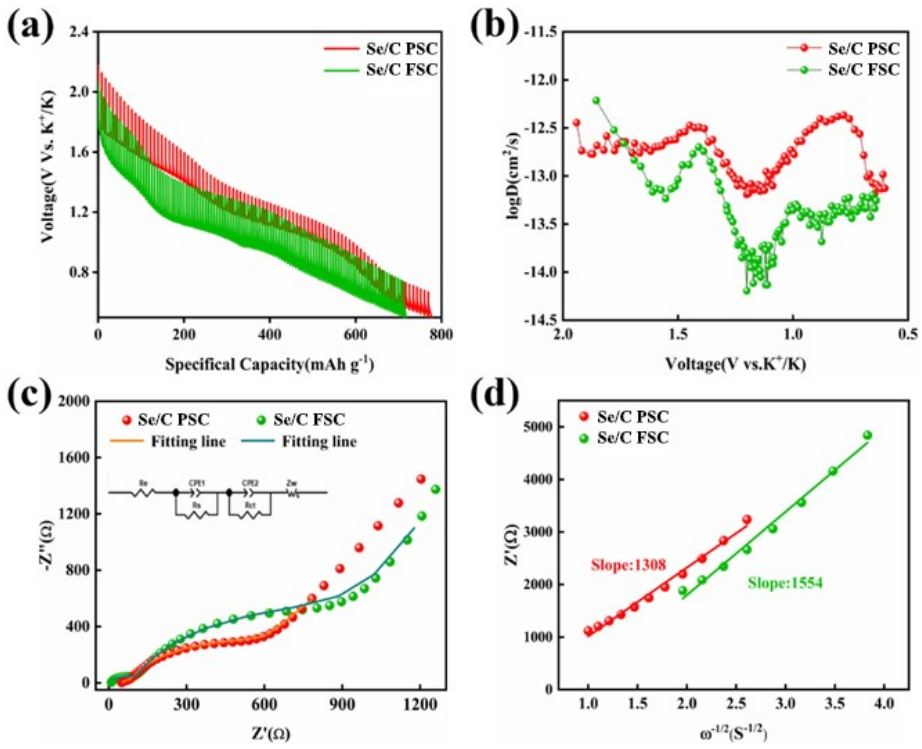

Fig. S3. (a) (b) Charge-discharge GITT profiles and the logarithm of corresponding K^+ diffusion coefficients. (c) Electrochemical impedance tests of Se/C PSC and Se/C FSC. (d) b values of Se/C PSC and Se/C FSC.

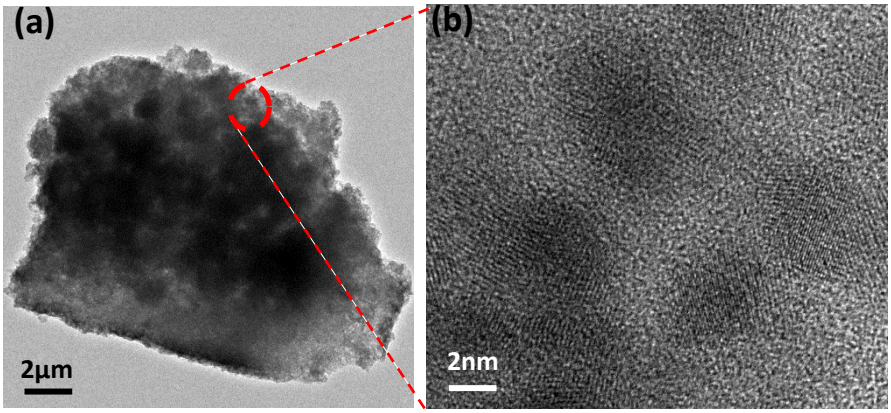

Fig. S4. (a,b)The transmission image and select electron diffraction image of Se/C PSC over 100 cycles.

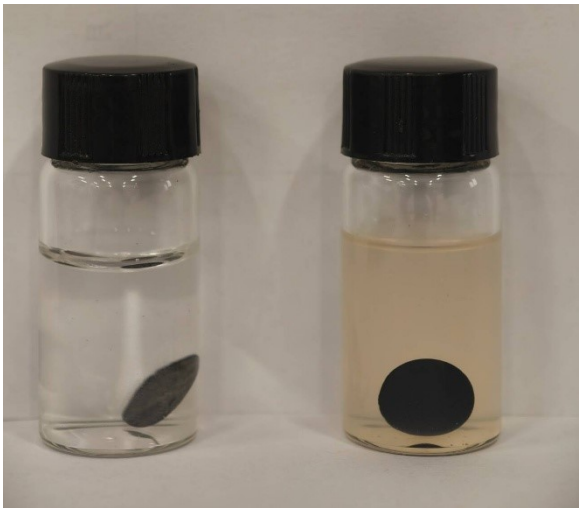

Fig. S5. The figures of cycled PSC (left) and FSC (right) electrodes soaked in electrolyte.