Supporting information

for

Self-encapsulated porous Sb-C nanocomposite anode with excellent Na-ion storage performance

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Fig. S1. TGA curves for (a) Sb-C1, (b) Sb-C2, (c) Sb-C3, and (d) Sb-C4 samples.
Fig. S2. XRD patterns of Sb-C sample after heating at (a) 400 °C and (b) 700 °C in air.

The XRD pattern of Sb-C sample after heating at 400 °C exhibited peaks corresponding to Sb₂O₃ as well as Sb (Fig. S2a). This confirms that the first-step oxidation of Sb occurred at 230 °C in air, which was indicated by the slight weight gain of the samples at this temperature (Fig. S1). Furthermore, all the diffraction peaks of the Sb-C sample after heating at 700 °C were assigned to the standard diffraction pattern of Sb₂O₄ (Fig. S2b). This indicates that the second-step oxidation of the samples was completed and the weight of the samples became stable, as shown in Fig. S1.
Fig. S3. N$_2$ adsorption-desorption isotherms and corresponding cumulative pore volume (insets) of Sb-C nanocomposites: (a) Sb-C1, (b) Sb-C2, (c) Sb-C3, and (d) Sb-C4.
Fig. S4. (a) XPS general survey spectrum of Sb-C3; high resolution XPS spectra of (b) C1s and (c) Sb3d.
Fig. S5. Discharge–charge profiles of the (a) Sb-C1, (b) Sb-C2, and (c) Sb-C4 electrodes under cycling at a rate of C/10.
Fig. S6. (a) Cyclability and coulombic efficiency of pyrolytic carbon at a rate of C/10; (b) cyclability of Sb-C composites, which was determined based on the mass of electrode, at a rate of C/10.
Fig. S7. (a) Optical images of the Sb-C3 electrodes before cycling and after 200 discharge–charge cycles; (b) electrochemical impedance spectra for the Sb-C3 electrode before and after cycling; (c, d) TEM images of Sb-C3 after 200 cycles.
Fig. S8. Cyclability of Sb-C3 electrodes with high mass-loading of 3 mg cm$^{-2}$, measured at a rate of C/10.
Fig. S9. XRD pattern of Na$_3$V$_2$(PO$_4$)$_3$, prepared via the method used by Hui et al.$^1$
The charge-discharge behaviour of Na$_3$V$_2$(PO$_4$)$_3$ (NVP) electrode was investigated in a potential range of 2.5–4.0 V vs. Na/Na$^+$ at a rate of 0.5C (1C = 117.6 mA g$^{-1}$) as shown in the Fig. S10. The NVP electrode exhibited the plateaus at 3.48 and 3.28 V vs. Na/Na$^+$ during charge and discharge, respectively, which correspond to V$^{4+}$/V$^{3+}$ reactions, and showed a reversible specific capacity of 104 mAh g$^{-1}$. Moreover, the NVP electrode delivered a specific discharge capacity of 99.7 mAh g$^{-1}$ corresponding to the capacity retention of 96% after 100 cycles. This indicates that NVP electrode has good cyclability at a rate of 0.5C and is suitable as cathode material for SIBs.
Electrochemical impedance spectroscopy (EIS) tests were conducted for the Sb-C1, Sb-C1, Sb-C2, Sb-C3, and Sb-C4 electrodes before cycling. All the Nyquist plots exhibited similar profiles, consisting of a depressed semicircle followed by an inclined line in low frequency range. The semicircle observed in the higher frequency region includes the information on the charge transfer resistance ($R_{ct}$) at the electrode–electrolyte interface, and the inclined line in the low frequency range corresponds to the Warburg diffusion. On the whole, the overall impedance of the electrode decreased with increasing the carbon content in the Sb-C nanocomposites. When comparing between the electrodes, the Sb-C3 electrode exhibited the smaller impedance than others, which is associated with the lower charge transfer as well as ohmic resistance of the electrode.

Reference