Ultrahigh-energy sodium ion capacitors enabled by enhanced intercalation pseudocapacitance of self-standing Ti$_2$Nb$_2$O$_9$/CNF anodes

Liaona She$^{1,2}$, Feng Zhang$^1$, Congying Jia$^1$, Liping Kang$^1$, Qi Li$^1$, Xuexia He$^1$, Jie Sun$^1$, Zhibin Lei$^1$, Zong-Huai Liu$^1$*

$^1$Key Laboratory of Applied Surface and Colloid Chemistry (Shaanxi Normal University), Ministry of Education, Xi’an, 710062, P. R. China; Shaanxi Key Laboratory for Advanced Energy Devices; Xi’an, 710119, P. R. China; School of Materials Science and Engineering, Shaanxi Normal University, Xi’an, 710119, P. R. China.

$^2$Institute of Science and Technology for New Energy, Xi’an Technological University, Xi’an, 710021, P. R. China.

*Correspondence should be addressed to:
Prof. Zong-Huai Liu
School of Materials Science and Engineering, Shaanxi Normal University
Xi’an, Shaanxi, 710062, P. R. China

Tel: ++86-29-81530706
Fax: ++86-29-81530702
E-mail: zhliu@snnu.edu.cn
ORCID iD: 0000-0003-4263-0628
Fig. S1. XRD patterns of bulk KTiNbO$_5$, bulk HTiNbO$_5$, delaminated HTiNbO$_5$ slurry, and HTiNbO$_5$ nanosheets.
Fig. S2. FE-SEM images of bulk KTiNbO$_5$ (a), bulk HTiNbO$_5$ (b), HTiNbO$_5$ nanosheets (c), TEM image (inserted for the delaminated HTiNbO$_5$ nanosheets suspension) (d), AFM image (e), and the thickness profile (f) of the delaminated HTiNbO$_5$ nanosheets.
Fig. S3. SEM (a), TEM (b), and HRTEM (c) images of Ti$_2$Nb$_2$O$_9$. 
Fig. S4. Cross-sectional morphology of Ti$_2$Nb$_2$O$_9$/CNF film.
Fig. S5. XPS spectra of Ti$_2$Nb$_2$O$_9$/CNF film: survey spectrum (a), high-resolution Nb 3d (b), and Ti 2p (c).
Fig. S6. SEM image of Ti$_2$Nb$_2$O$_9$/CNF electrode after 2000 cycles at 1 A g$^{-1}$. 
**Fig. S7.** CV curves at different scan rates (a) and b-value calculated through cathodic scan and peak currents (b) of Ti$_2$Nb$_2$O$_9$ electrode, the capacitive and diffusive contribution to the current density at 1 mV s$^{-1}$ of Ti$_2$Nb$_2$O$_9$/CNF electrode (c), and capacitive-controlled contribution at different scan rates (d) of Ti$_2$Nb$_2$O$_9$ electrode.
Fig. S8. CV curve at 1 mV s\(^{-1}\) (a), galvanostatic charge and discharge curves at 0.05 A g\(^{-1}\) between 3.0-4.5 V (b), rate capability at different current densities (c), and cycling stability at 0.2 A g\(^{-1}\) (d) of AC electrode.

The quasi-rectangular CV curve at 1 mV s\(^{-1}\) and linear GCD curves at 0.05 A g\(^{-1}\) indicate electric double-layer capacitive behavior of AC electrode. Its specific capacity at 0.05 A g\(^{-1}\) is estimated to be 46 mAh g\(^{-1}\), with outstanding rate capability and good cycling stability at 0.2 A g\(^{-1}\) (\(\approx 95\%\) after 200 cycles).
Fig. S9. CV curves at different scan rates from 2 to 100 mV s$^{-1}$ of Ti$_2$Nb$_2$O$_9$/CNF//AC SIC.