Electronic Supplementary Material (ESI) for Energy & Environmental Science.

Supporting Information

Peanut Shell Hybrid Sodium Ion Capacitor with Extreme Energy - Power Rivals Lithium Ion Capacitors

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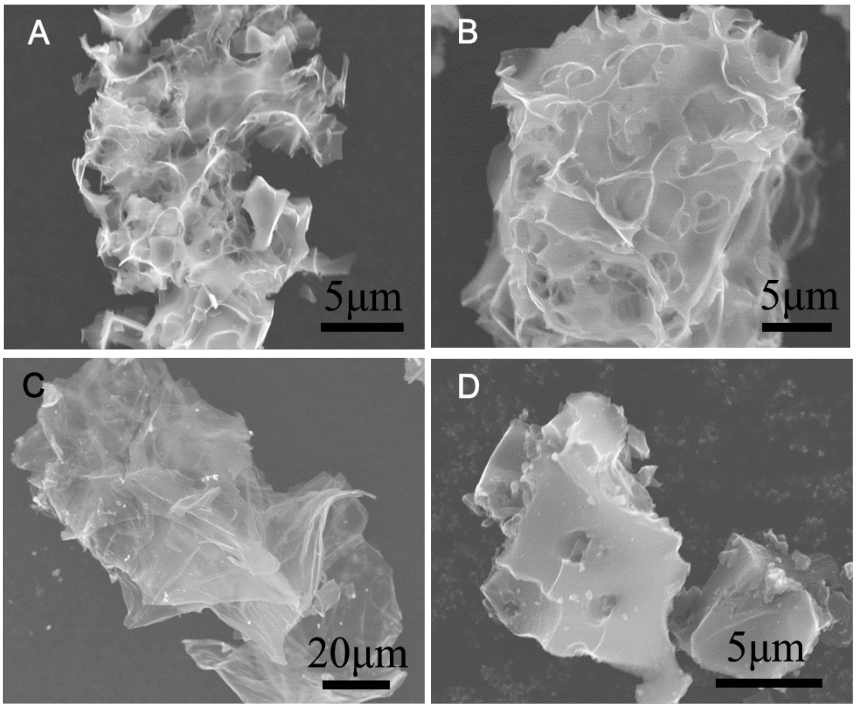

Figure S1: SEM micrographs of (A) PSNC-3-850 and (B) PSNC-2-800, (C) PSOC, (D) the baseline commercial activated carbon (CAC).

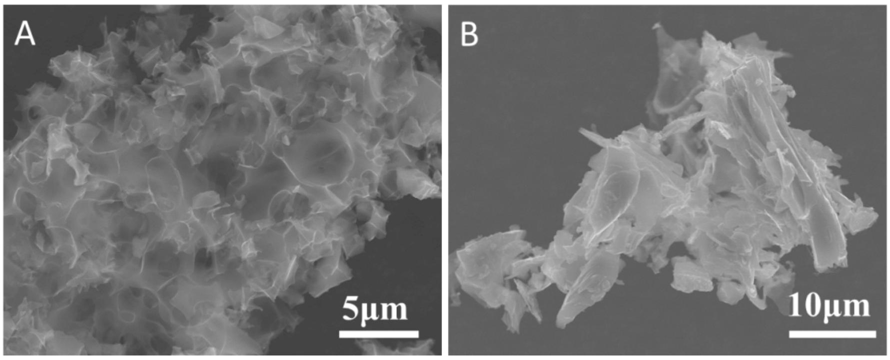

Figure S2: SEM micrographs of cathode and anode carbons achieved when employing the entire peanut shell as a single precursor for either synthesis process. (A) cathode carbon. (B) anode carbon.

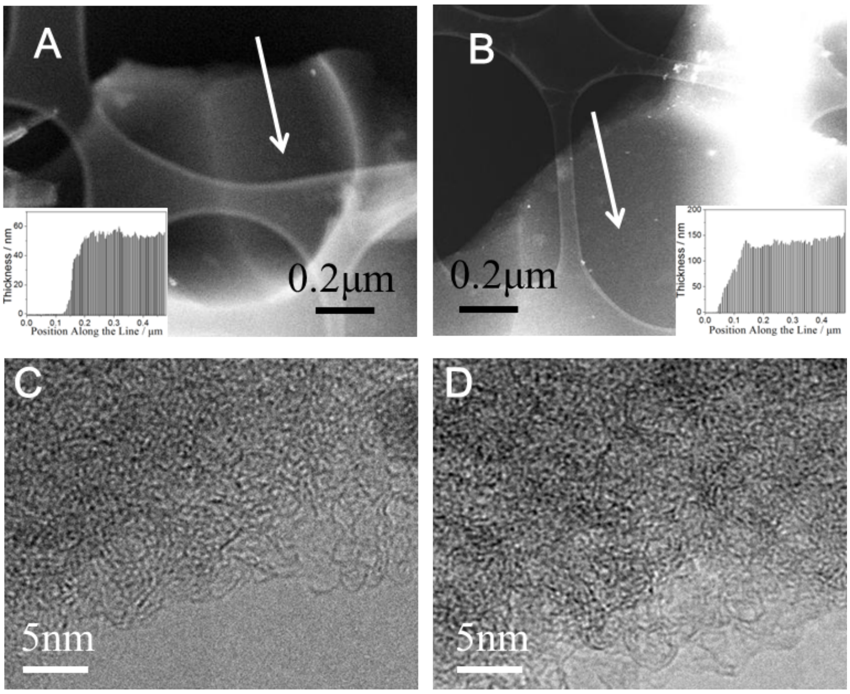

Figure S3: HAADF TEM micrographs and thickness profiles (insert) of (A) PSNC-3-850 and (B) PSNC-2-800, measured from low-loss EELS along the white arrows. HRTEM micrographs of (C) PSNC-3-850, and (D) PSNC-2-800.

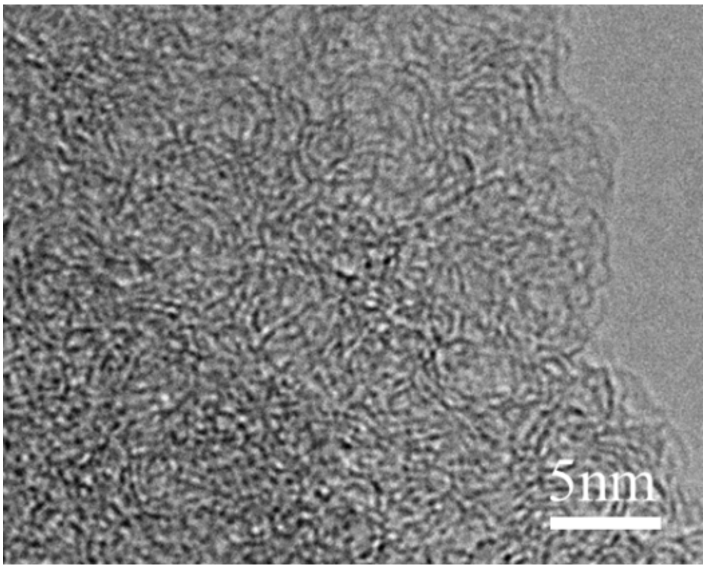

Figure S4: HRTEM micrograph of PSOC.

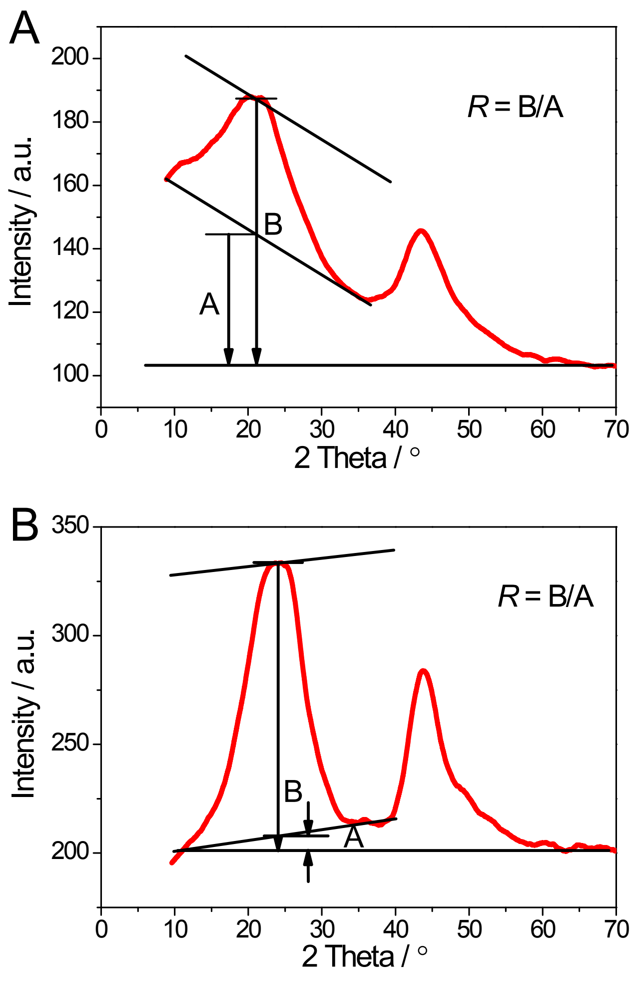

Figure S5: Scheme illustrating the *R* values calculation based on XRD patterns for PSNCs (A) and PSOCs (B).

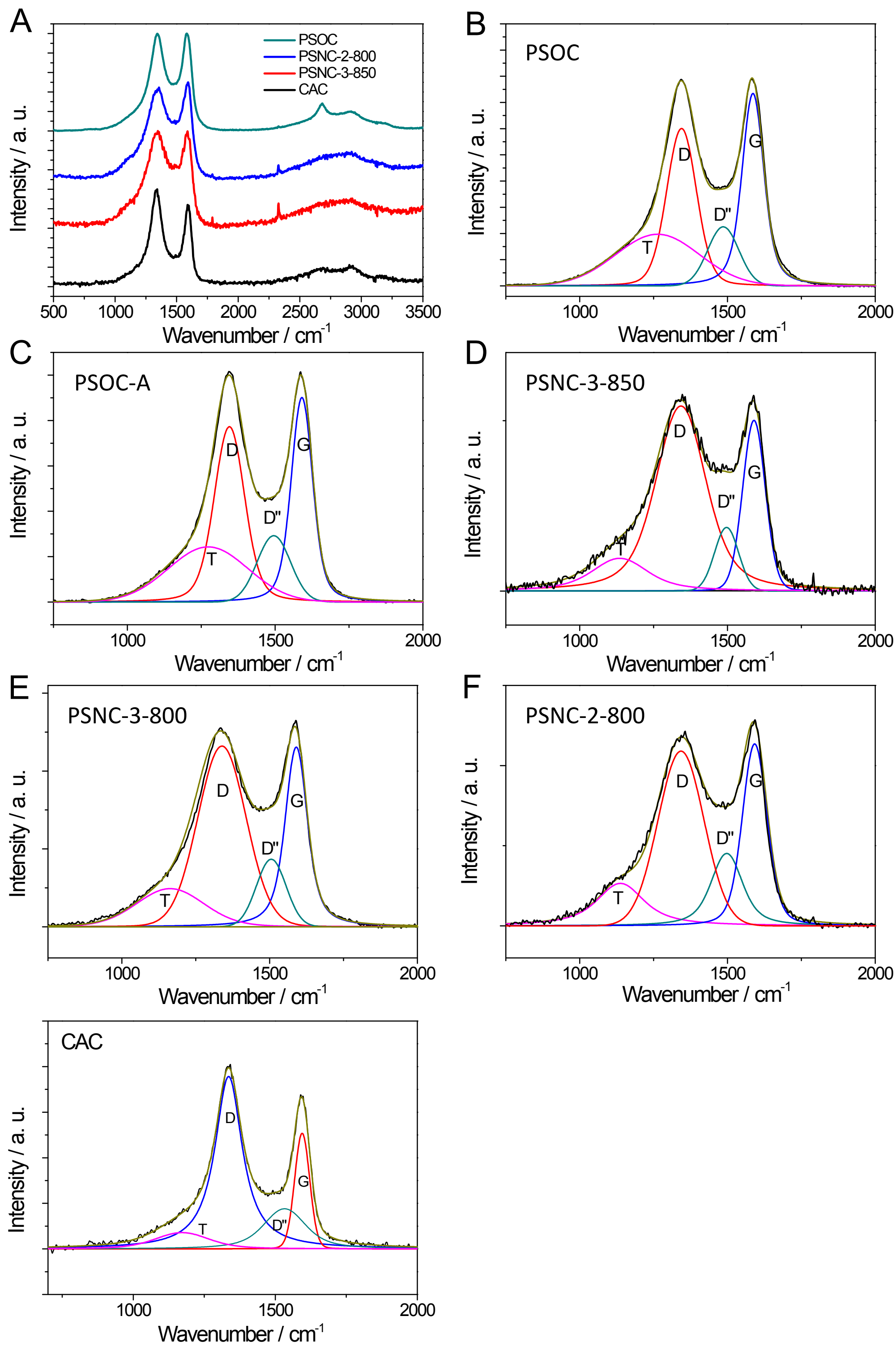

Figure S6: (A) Raman spectra of PSNC-2-800, PSNC-3-850 and PSOC specimens. (B-F) Fitted Raman spectra of PSOC, PSNC and CAC.

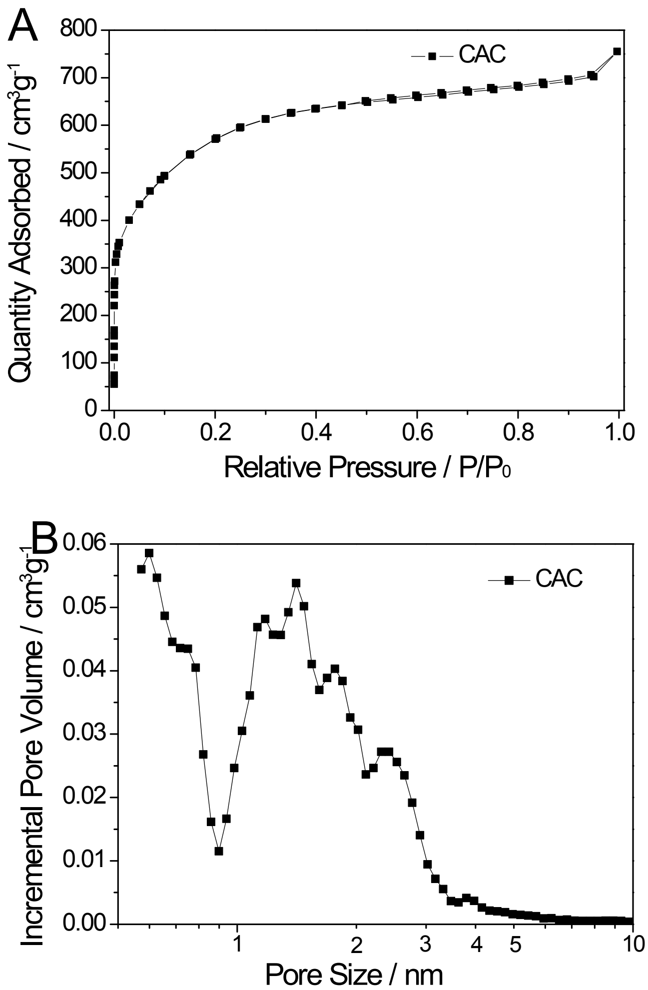

Figure S7: (A)-(B) Nitrogen adsorption-desorption isotherms and pore size distributions of CAC.

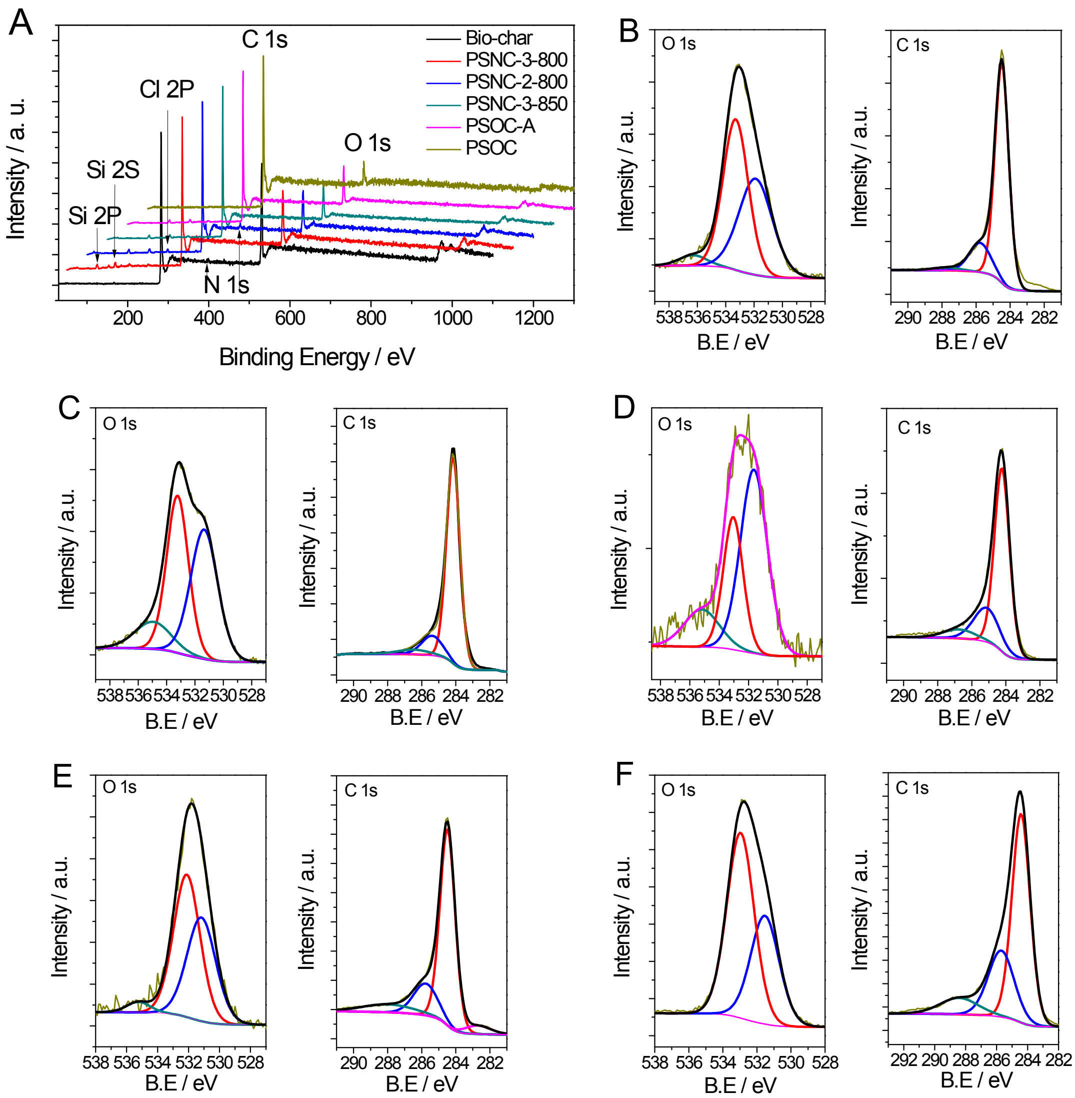

Figure S8: (A) XPS survey spectra of PSNC, PSOC and hydrothermal biochar. Magnified views of the C 1s, N 1s and O 1s core level XPS spectra with fits for (B) PSNC-3-850, (C) PSNC-2-800, (D) PSOC, (E) PSOC-A, (F) hydrothermal obtained biochar.

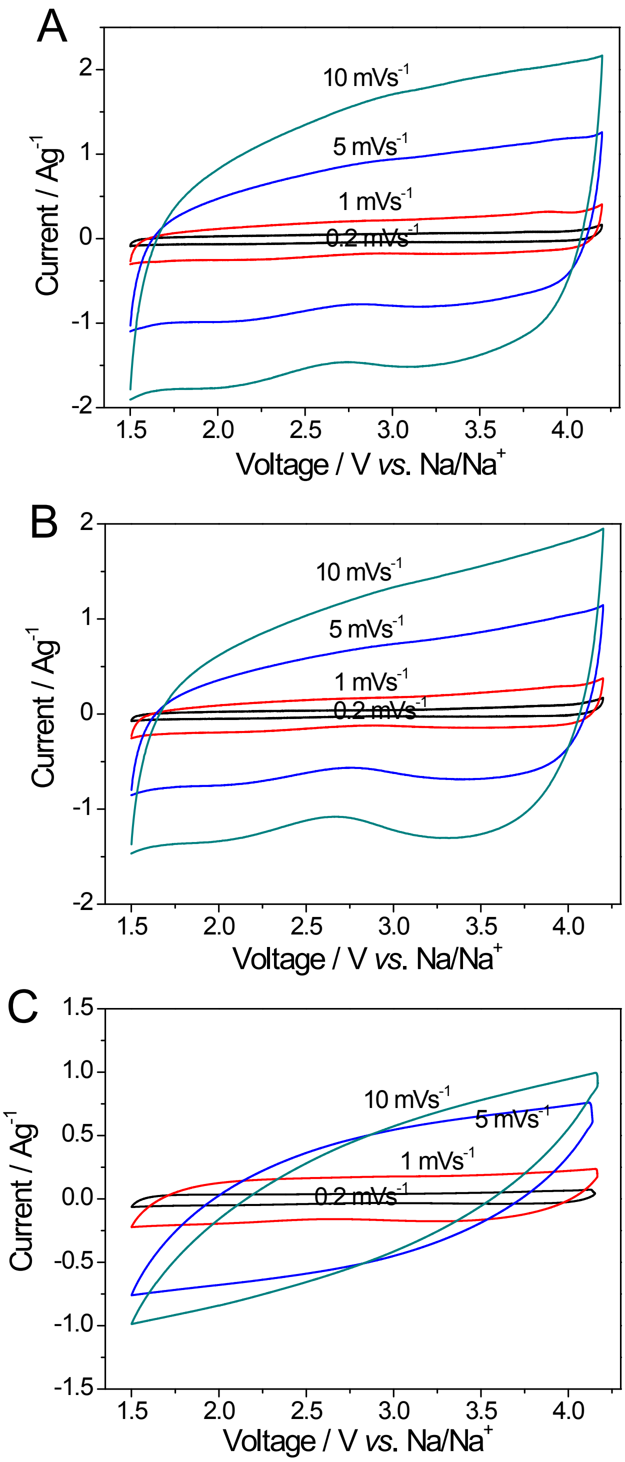

Figure S9: (A-C) Cyclic voltammograms (CVs) of PSNC-3-850, PSNC-2-800, and CAC, respectively.

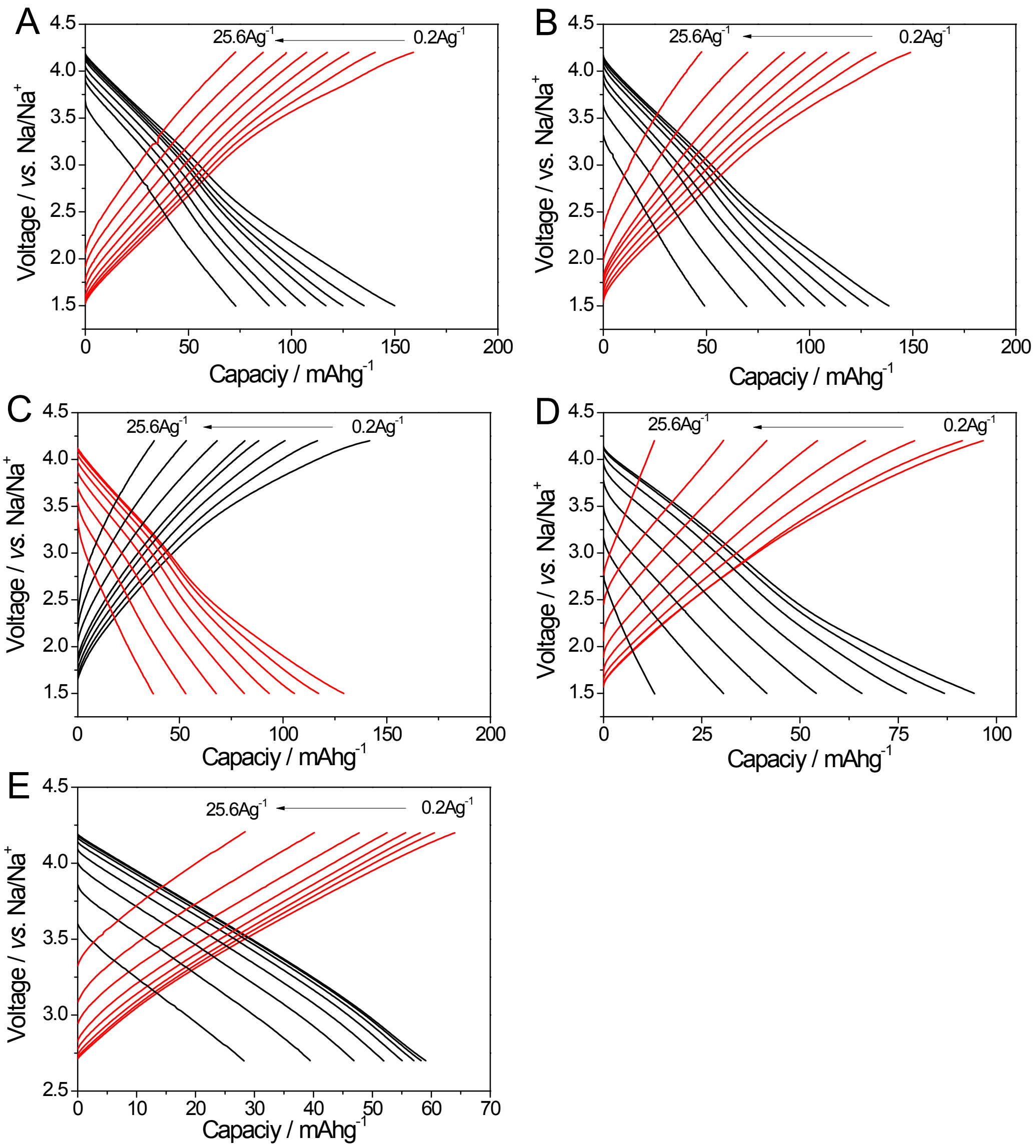

Figure S10: Galvanostatic discharge/charge profiles of (A) PSNC-3-800, (B) PSNC-3-850, (C) PSNC-2-800 and (D) CAC, (E) PSNC-3-800 within voltage region of 2.7-4.2 V *vs*. Na/Na^+.

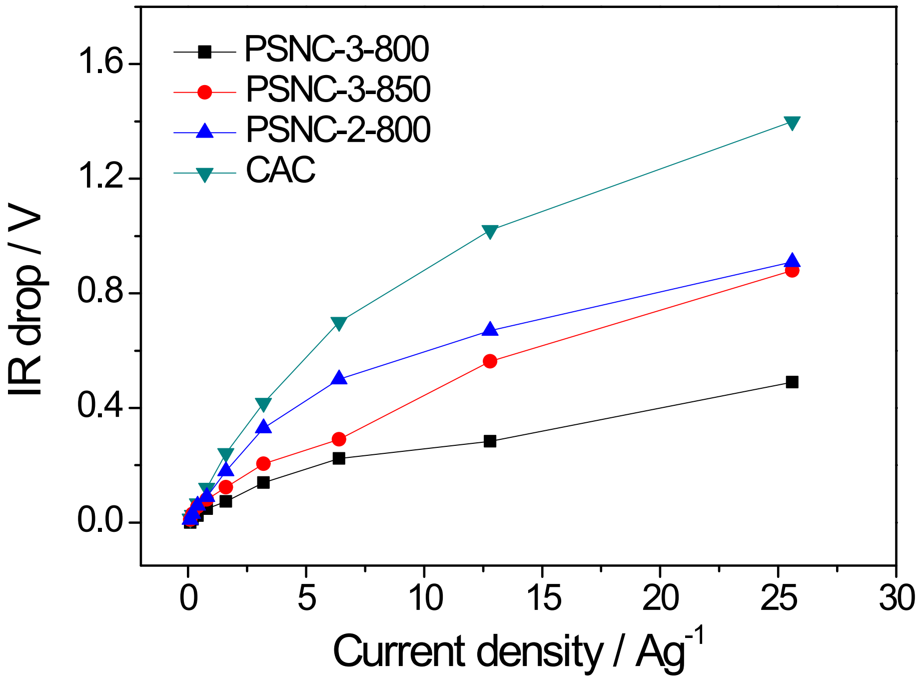

Figure S11: IR drops of PSNC specimens and CAC in half cells.

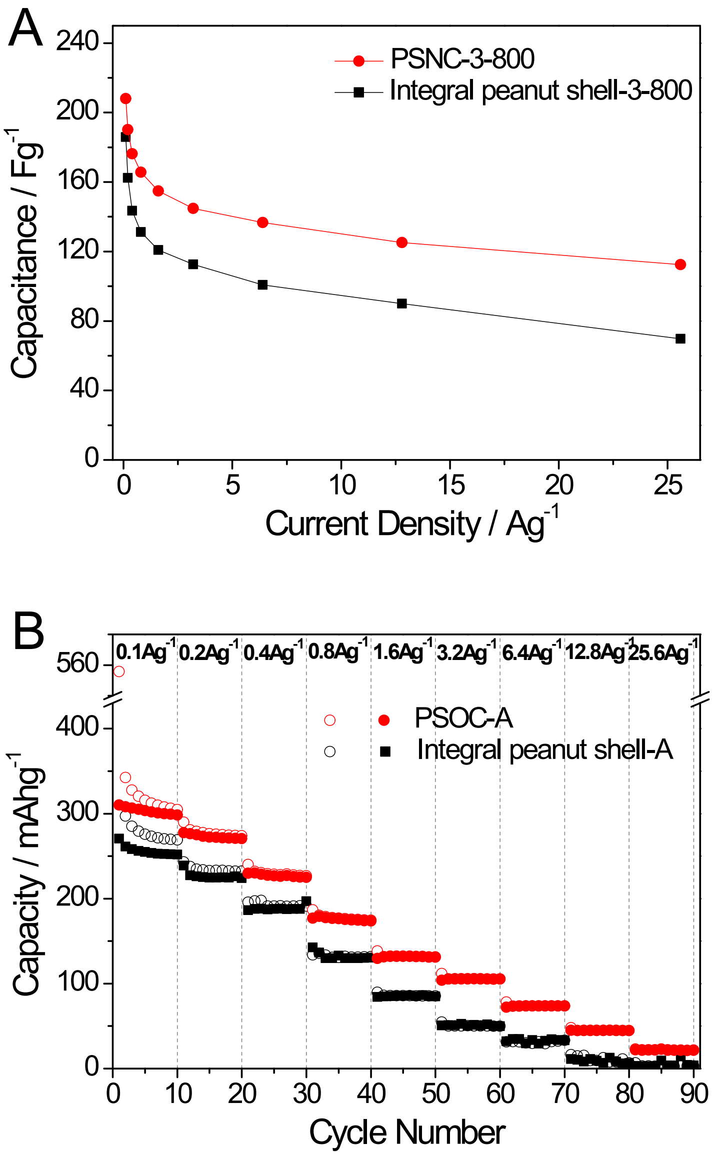

Figure S12: The electrochemical performance of cathode carbon (A) and anode carbon (B) that were derived from the entire peanut shell without separation.

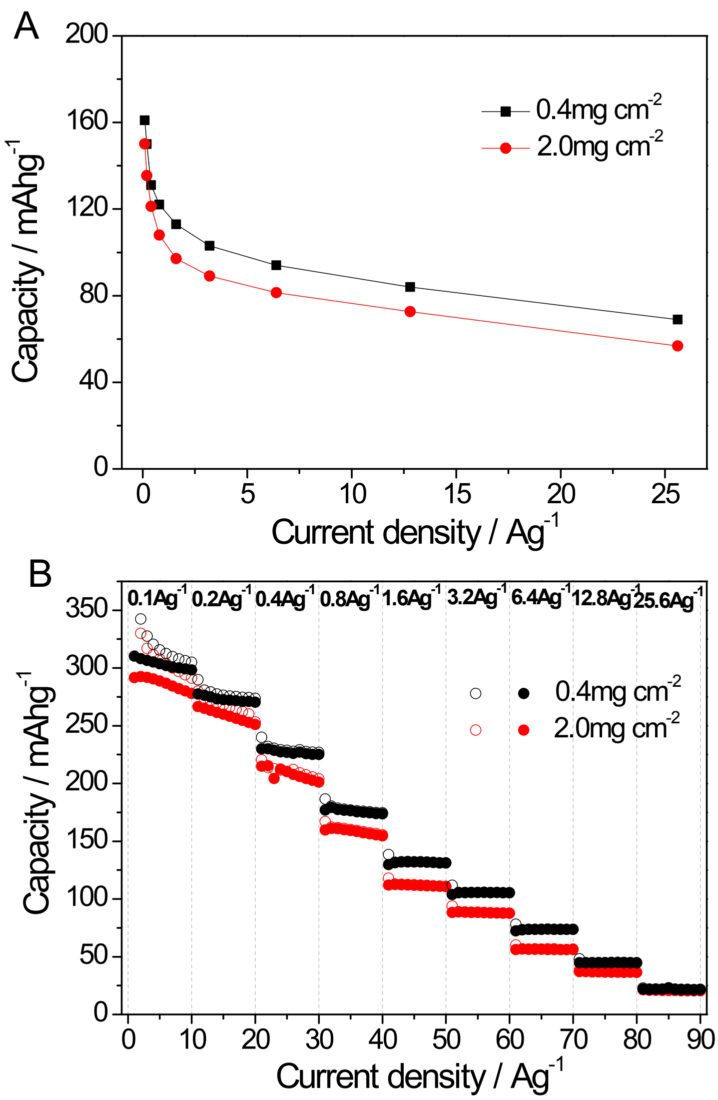

Figure S13: The electrochemical performance of PSNC-3-800 (A) and PSOC-A (B) with two different electrode mass loadings.

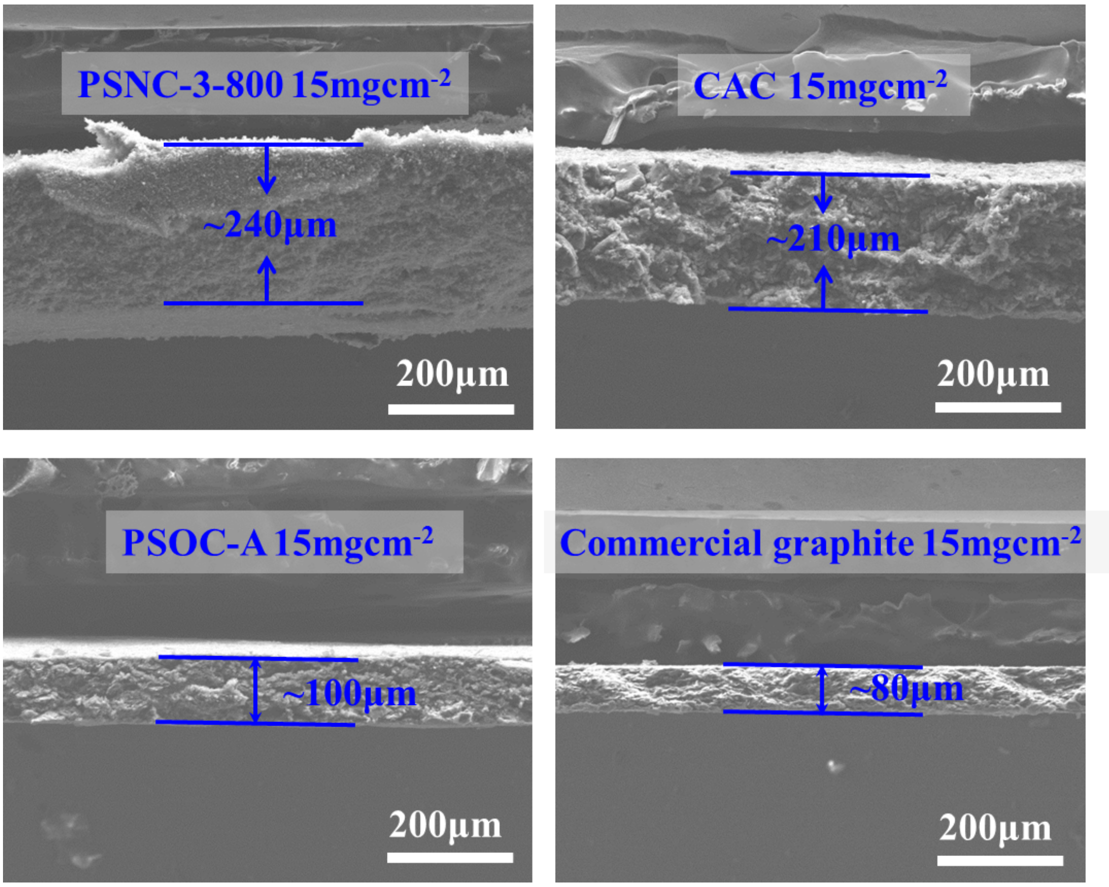

Figure S14: Cross section SEM images of (A) PSNC-3-800 (B) CAC, (C) PSOC-A and (D) commercial graphite thin film electrodes with commercial mass loadings.

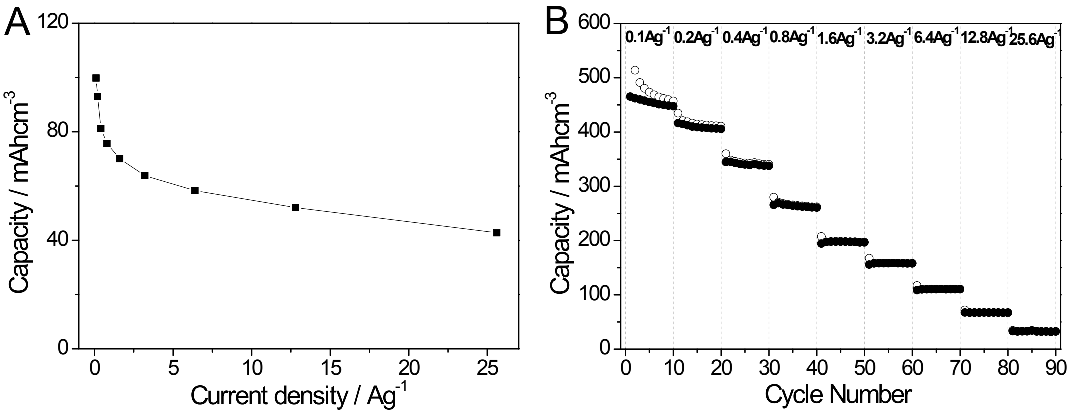

Figure S15: The volumetric capacity of PSNC-3-800 (A) and PSOC-A (B).

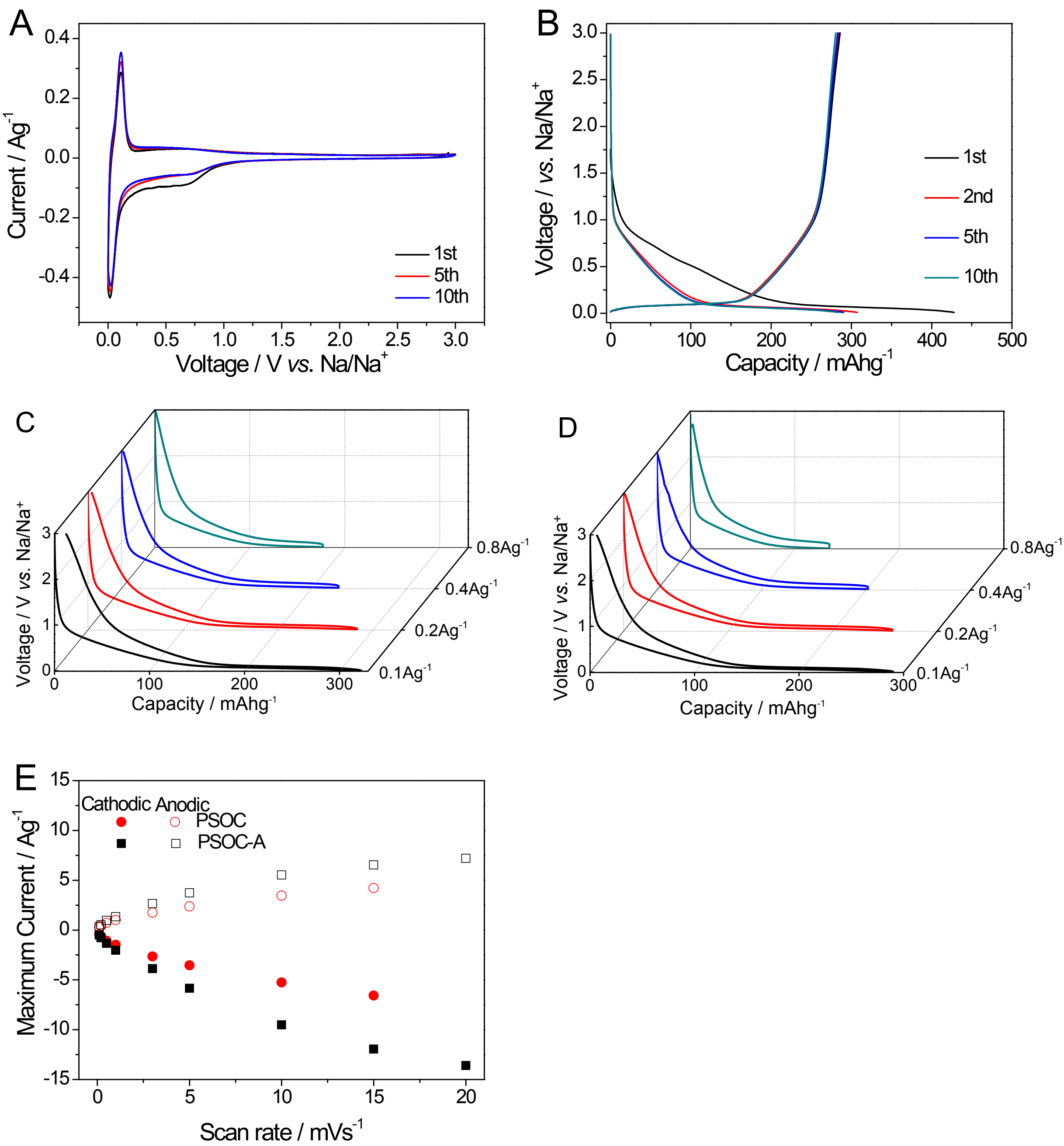

Figure S16: (A) CVs of PSOC specimen at a scan rate of 0.1mVs^{-1}. (B) Galvanostatic discharge/charge profiles of PSOC at density of 0.1Ag^{-1}. (C-D) Galvanostatic discharge/charge profiles of PSOC-A (C) and PSOC (D) at current densities of 0.1, 0.2, 0.4 and 0.8Ag^{-1}. (E) Dependence of anodic and cathodic peak currents on scan rate for PSOC and PSOC-A.

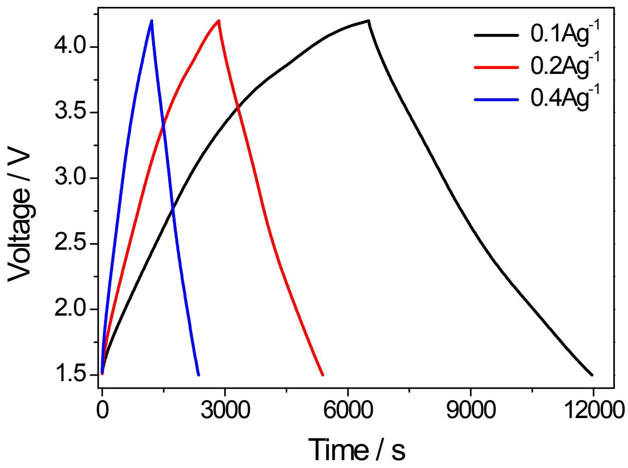

Figure S17: (A) Galvanostatic discharge/charge profiles of PSNC-3-800//PSOC-A hybrid Na-ion capacitor at low current densities.

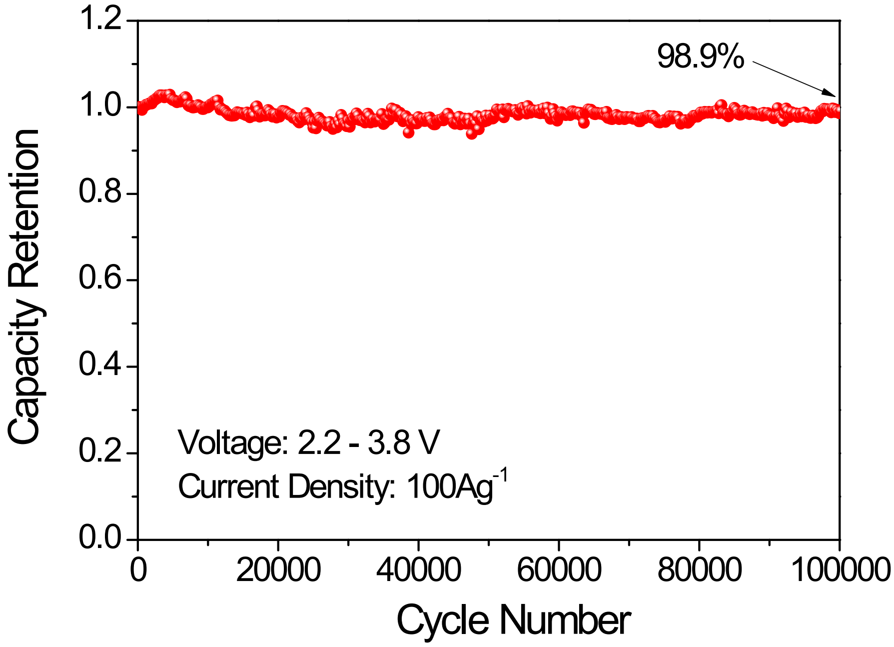

Figure S18: Cycling stability of PSNC-3-800//PSOC-A hybrid ion capacitor at a current density of $100Ag^{-1}$ and voltage window of 2.2-3.8V.

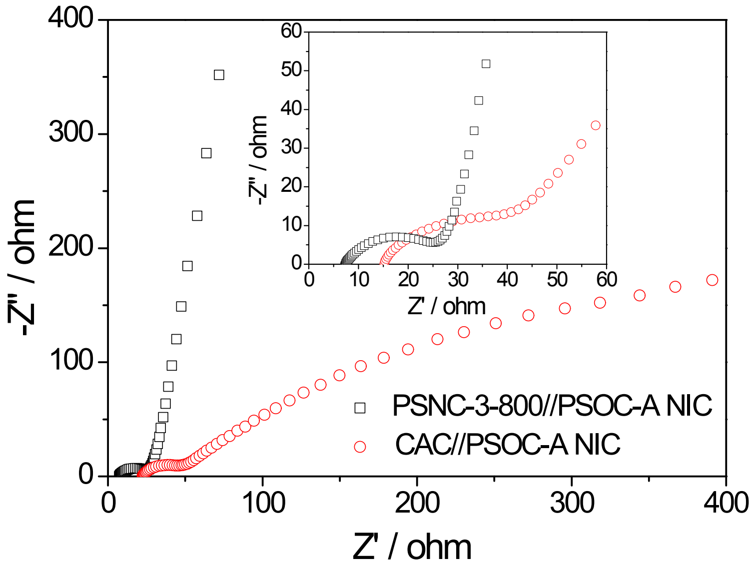

Figure S19: Nyquist plots of PSNC-3-800//PSOC-A and CAC//PSOC-A after rate tests.

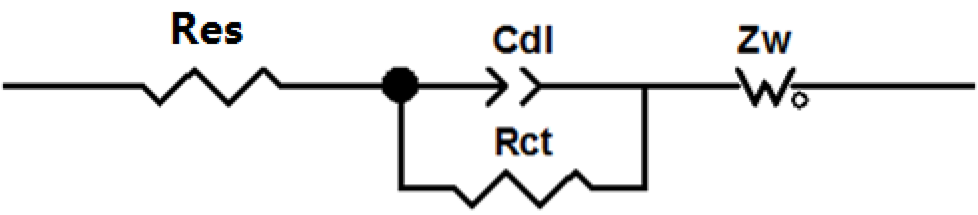

Figure S20: Equivalent electronic circuits used to simulate the EIS data. R_{es} is the sum of resistances of electrical connections in the experiment setup including ionic diffusion resistance in the electrolyte. R_{ct} reflects the charge transfer resistance and Z_w (Warburg-type element) represents Na diffusion impedance within carbon materials.

Table S1. Capacity retention comparison with literature reported hybrid devices.

Hybrid system	Voltage Window	Current density	Energy density ($Whkg^{-1}$)	Power density (Wkg^{-1})	Cycled number	Capacity retention	Ref.
PSNC-3-800//PSOC-A (Na^+)	1.5-4.2V	6.4Ag^{-1}	50-75	~8000	1000/5000/10000	79%/69%/66%	This work
PSNC-3-800//PSOC-A (Na^+)	1.5-3.5V	6.4Ag^{-1}	30-38	~7000	1000/5000/10000	92%/78%/72%	This work
PSNC-3-800//PSOC-A (Na^+)-65°C	1.5-3.5V	51.2Ag^{-1}	~20	~55000	100000	78%	This work
PSNC-3-800//PSOC-A (Na^+)	1.5-3.5V	51.2Ag^{-1}	~8	~50000	100000	88%	This work
AC//$Na_xH_{2-x}Ti_3O_7$ (Na^+)	0-3V	0.25Ag^{-1}	20-30	~200	1000	73%	43
AC//V_2O_5/CNT (Na^+)	0-2.8V	60C	16-20	~1700	900	78%	38
AC//$NiCo_2O_4$(Na^+)	0-3V	0.15Ag^{-1}	11-18	~200	2000	62.5%	45
AC//V_2O_5/CNT (Li^+)	0.1-2.7V	30C	24-30	~850	10000	80%	106
CNS//MnO/CNS (Li^+)	0-4V	5Ag^{-1}	50-70	~6000	5000	82%	44
3DGraphene//Fe_3O_4/Graphene (Li^+)	1-4V	2Ag^{-1}	60-90	2500	1000	68%	39
AC//$Li_4Ti_5O_{12}$ (Li^+)	1-3V	1.5Ag^{-1}	22-28	~3000	2000	80%	47
AC//Soft carbon (Li^+)	0-4.4V	0.74Ag^{-1}	50-80	~2000	10000	65%	40
AC//graphite (Li^+)	1.5-5.0V	0.65Ag^{-1}	60-90	~1056	10000	63%	51
AC//hard carbon (Li^+)	1.5-3.9V	10C	60-75	~750	10000	82%	52

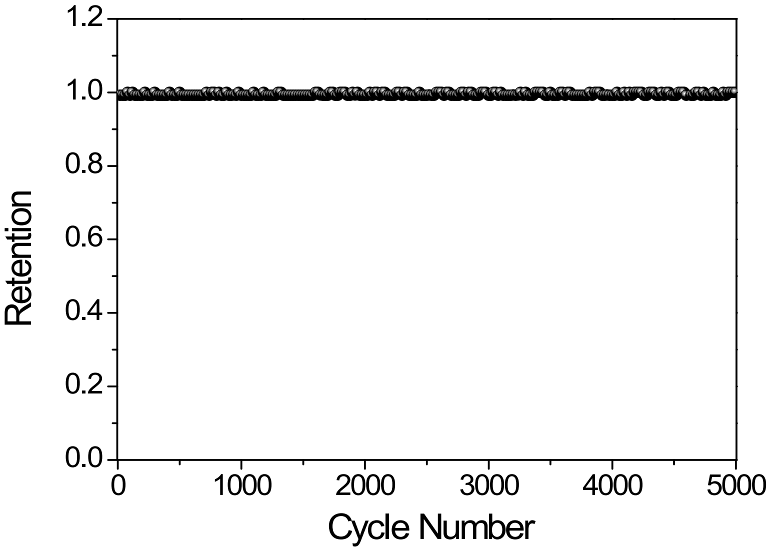

Figure S21: The cyclability of Na-Na cell.