Supporting Information

Rational Design of Li$_3$VO$_4$@Carbon Core-Shell Nanoparticles as Li-ion Hybrid Supercapacitor Anode Materials

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**Figure S1.** TEM images of as-prepared Li$_3$VO$_4$ NPs under different magnification.

**Figure S2.** (a) Raman spectrum and (b) SAED pattern of Li$_3$VO$_4$@C NPs.
Figure S3. (a) XRD patterns of Li$_3$VO$_4$ NPs and b-Li$_3$VO$_4$, (b and c) SEM images of Li$_3$VO$_4$ NPs, and (d and e) SEM and TEM images of b-Li$_3$VO$_4$. 
Figure S4. (a) Comparison of capacity on Li$_3$VO$_4$@C NPs and results previously reported. (b) Comparison of rate capability on Li$_3$VO$_4$@C NPs and results previously reported. (c) Cycle stability of Li$_3$VO$_4$@C NPs at 0.5 A g$^{-1}$ in the potential range from 0.2 to 3.0 V (vs. Li/Li$^+$) (Before cycling test, pre-cycling (five cycles) was carried out at 0.02 A g$^{-1}$).
Figure S5. CV curves of (a) Li$_3$VO$_4$ NPs and (b) b-Li$_3$VO$_4$ at various scan rates from 0.1 to 1.0 mV s$^{-1}$. (c) $\log(i)$ versus $\log(v)$ plots of anodic current responses on Li$_3$VO$_4$ electrodes.
Figure S6. CV curves of (a) Li$_3$VO$_4$ NPs and (b) b-Li$_3$VO$_4$ with separation between total current (solid line) and pseudocapacitive current (shaded region) at 0.1 mV s$^{-1}$.

Figure S7. GITT profiles of (a) Li$_3$VO$_4$ NPs and (b) b-Li$_3$VO$_4$. 
Figure S8. Evolution of internal resistance on Li$_3$VO$_4$ electrodes at 2$^{nd}$ cycle.
Figure S9. Characterization results of AC: (a) N$_2$ adsorption and desorption isotherm, (b) XRD pattern, (c) SEM image, and (d) TEM image. The Brunauer-Emmett-Teller (BET) surface area of the AC obtained by N$_2$ sorption isotherm is 2,274 m$^2$ g$^{-1}$. The XRD pattern of AC shows two broad XRD reflection peaks corresponding to the (002) and (101) reflections of graphite carbon, respectively, and demonstrate its amorphous nature. From SEM and TEM images, it is confirmed that the AC has irregular particle shape and disordered micropore structure.
Figure S10. (a) Galvanostatic charge-discharge profiles of AC at 0.02 A g\(^{-1}\). (b) Cycle stability of AC at 0.02 A g\(^{-1}\). (c) CV curve of AC at 0.1 mV s\(^{-1}\). (d) CV curves of AC at various scan rates from 0.1 to 1.0 mV s\(^{-1}\). (a-d) Potential range was 3.0–4.5 V (vs. Li/Li\(^+\)).
Figure S11. (a) Expected charge-discharge profiles of Li$_3$VO$_4$@C NPs (blue solid line) and AC (red solid line) in Li-HSC system. (b) Expected charge-discharge profile of Li-HSC.
Figure S12. (a) Ragone plots of Li-HSC using Li$_3$VO$_4$@C NPs anode and AC cathode with various weight ratio of the anodic and cathodic materials at various current densities from 0.01 to 5 A g$^{-1}$. (b-d) Galvanostatic charge-discharge profiles of Li-HSC at various current densities from 0.01 to 5 A g$^{-1}$. (a-d) Potential range was 0.0–4.3 V.
Figure S13. (a) Galvanostatic charge-discharge profiles of AC at 0.02 A g\(^{-1}\). (b) Cycle stability of AC at 0.02 A g\(^{-1}\). (c) CV curve of AC at 0.1 mV s\(^{-1}\). (d) CV curves of AC at various scan rates from 0.1 to 1.0 mV s\(^{-1}\). (a-d) Potential range was 2.0–4.5 V (vs. Li/Li\(^+\)).
Figure S14. (a) Galvanostatic charge-discharge profile of Li$_3$VO$_4$@C NPs at 0.02 A g$^{-1}$. (b) Expected charge-discharge profiles of pre-activated Li$_3$VO$_4$@C NPs (purple solid line) and pre-activated AC (red solid line) in A-Li-HSC system. (c) Ragone plots of A-Li-HSC using pre-activated Li$_3$VO$_4$@C NPs anode and pre-activated AC cathode with various weight ratio of the anodic and cathodic materials at various current densities from 0.01 to 8 A g$^{-1}$. Galvanostatic charge-discharge profiles of A-Li-HSC at (d) 0.01 A g$^{-1}$ and at (e) various current densities from 1 to 8 A g$^{-1}$. (f) Comparison of galvanostatic charge-discharge profiles on A-Li-HSC, Li-HSC, and symmetric AC//AC EDLC. (c-e) Potential range of A-Li-HSC was 0.0–4.3 V.
Figure S15. (a) CV curves of Li$_3$VO$_4$@C NPs and AC at 0.2 mV s$^{-1}$. (b) dQ/dV plot obtained from galvanostatic charge-discharge profile of A-Li-HSC at 0.01 A g$^{-1}$.

Figure S16. Ragone plots of A-Li-HSC and Li-HSC.
Figure S17. (a) Ragone plots of A-Li-HSC and symmetric AC//AC EDLC. (b-d) Galvanostatic charge-discharge profiles of symmetric AC//AC EDLC at various current densities from 0.01 to 5 A g\(^{-1}\). (a-d) Potential range of symmetric AC//AC EDLC was 0.0–3.0 V.