Supporting Information

Ultrafine \text{Co}_2\text{P} Nanorods Wrapped by Graphene Enables Long Cycle Life Performance for Hybrid Potassium-Ion Capacitor

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Fig. S1 The diameter distribution of synthesized ultrafine Co$_2$P NRs.
Fig. S2 XPS analysis of pure Co$_2$P
Fig. S3 N$_2$ adsorption-desorption isotherms and pore-size distribution (inset) of U-Co$_2$P@rGO-14 nanocomposite.
Fig. S4 XRD pattern of the C-Co$_2$P@rGO powder. All diffraction peaks agree well with an orthorhombic Co$_2$P phase (JCPDS No. 32-0306) and can be indexed using a unit cell with $a = 5.646$ Å, $b = 6.609$ Å, and $c = 3.513$ Å (space group of $Pnma$).
Fig. S5 TEM image of C-Co$_2$P@rGO. The Co$_2$P mainly consists of irregular agglomerated micrometer sized particles. The agglomerated microparticles consist of many crystalline nanoparticles around 50 nm, distributed in the amorphous carbon matrix.
Fig. S6 SEM image of agglomerated C-Co$_2$P@rGO composite.
Fig. S7 Cyclic voltammograms for the first five cycles of rGO.
Fig. S8 Rate performance of rGO at different current densities.
Fig. S9 Long-term cycling of U-Co$_2$P at a current density of 200 mA g$^{-1}$. 
Fig. S10 Cycling performance of U-Co$_2$P@rGO-5, U-Co$_2$P@rGO-14 and U-Co$_2$P@rGO-25 electrodes.
Fig. S11 *Ex-situ* FESEM images for (a) pristine, after (b) the 50th cycle of U-Co$_2$P@rGO-14 electrodes. Insets show corresponding digital photographs of the electrodes.
Fig. S12 Long-term cycle performance of U-Co$_2$P@rGO-14 and structure feature of U-Co$_2$P@rGO-14 electrodes after the 200th cycle. a) High-magnification TEM, and (b) STEM elemental mapping of U-Co$_2$P@rGO-14 after the 200th cycle at current density of 200 mA g$^{-1}$. 
**Fig. S13** Electrochemical Impedance Spectroscopy (EIS) of U-Co$_2$P@rGO-14 after 1st cycle and after 10th cycle.
Fig. S14 Galvanostatic charge-discharge curves at a current density of 200 mA g$^{-1}$ in the voltage range of 0.01-3.0 V from 10$^{th}$ cycle to 5000$^{th}$ cycle.
Fig. S15 $N_2$ adsorption-desorption isotherm of AC.
Fig. S16 (a) Galvanostatic discharge-charge curves at different current densities. (b) Rate performance of AC at different current densities and (c) Long-term cycle performance of AC at current density of 0.2 A g\(^{-1}\) for 100 cycles in half cell.
Fig. S17 The photograph of the electrochemical setup and the measurement system, (a) the composition of the coin cell, (b) the assembled coin cell, (c) the Land-2001A (Wuhan, China) automatic battery tester. (d) the VSP multichannel potentiostatic-galvanostatic system.

The electrochemical setup we used is the common coin cell. As shown in Fig. S17a, the composition of the coin cell we used, which includes electrode shell of working electrode, working electrode, separator, potassium, current collector, leaf spring and electrode shell of counter electrode are exhibited in order, based on the assembled step. After a step-by-step assembled process, the coin cell is presented in Fig. S17b. Then, the coin cell is clamped by a staple of the Land-2001A (Wuhan, China) automatic battery tester (Fig. S17c) and the VSP multichannel potentiostatic-galvanostatic system (Fig. S17d). We add the photograph of the electrochemical setup and the measurement system in the supporting information. (Fig. S17)
Table S1. Performance comparison of the alloying and conversion mechanism potassium-ion battery anodes reported in literature and this work.

<table>
<thead>
<tr>
<th>Material</th>
<th>Reversible discharge capacity</th>
<th>Rate</th>
<th>Cycle life</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Sn}_4\text{P}_3@\text{C}^1$</td>
<td>399 mA h g$^{-1}$ at 50 mA g$^{-1}$</td>
<td>221.9 mA h g$^{-1}$ at 1000 mA g$^{-1}$</td>
<td>80 % after 50 cycles</td>
</tr>
<tr>
<td>$\text{CoS}@\text{G}^2$</td>
<td>434.5 mA h g$^{-1}$ at 500 mA g$^{-1}$</td>
<td>232.3 mA h g$^{-1}$ at 4000 mA g$^{-1}$</td>
<td>56.2 % after 100 cycles</td>
</tr>
<tr>
<td>$\text{VS}_2^3$</td>
<td>400 mA h g$^{-1}$ at 100 mA g$^{-1}$</td>
<td>100 mA h g$^{-1}$ at 2000 mA g$^{-1}$</td>
<td>105 % after 100 cycles</td>
</tr>
<tr>
<td>$\text{BP-C}^4$</td>
<td>400 mA h g$^{-1}$ at 25 mA g$^{-1}$</td>
<td>300 mA h g$^{-1}$ at 2000 mA g$^{-1}$</td>
<td>61 % after 50 cycles</td>
</tr>
<tr>
<td>$\text{MoS}_2^5$</td>
<td>65 mA h g$^{-1}$ at 20 mA g$^{-1}$</td>
<td>53.8 mA h g$^{-1}$ at 160 mA g$^{-1}$</td>
<td>97.5 % after 200 cycles</td>
</tr>
<tr>
<td>$\text{MoS}_2@\text{rGO}^6$</td>
<td>679 mA h g$^{-1}$ at 20 mA g$^{-1}$</td>
<td>178 mA h g$^{-1}$ at 500 mA g$^{-1}$</td>
<td>108 % after 100 cycles</td>
</tr>
<tr>
<td>$\text{SnS}_2@\text{rGO}^7$</td>
<td>350 mA h g$^{-1}$ at 25 mA g$^{-1}$</td>
<td>120 mA h g$^{-1}$ at 2000 mA g$^{-1}$</td>
<td>78.9 % after 30 cycles</td>
</tr>
<tr>
<td>$\text{Sn-C}^8$</td>
<td>150 mA h g$^{-1}$ at 25 mA g$^{-1}$</td>
<td>Not Provided</td>
<td>75 % after 30 cycles</td>
</tr>
<tr>
<td>$\text{3D-HPCS}^9$</td>
<td>310 mA h g$^{-1}$ at 50 mA g$^{-1}$</td>
<td>150 mA h g$^{-1}$ at 500 mA g$^{-1}$</td>
<td>70 % after 100 cycles</td>
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<tr>
<td>$\text{Bi/rGO}^{10}$</td>
<td>290 mA h g$^{-1}$ at 50 mA g$^{-1}$</td>
<td>235 mA h g$^{-1}$ at 500 mA g$^{-1}$</td>
<td>41.1 % after 50 cycles</td>
</tr>
<tr>
<td>Material</td>
<td>Reversible discharge capacity</td>
<td>Rate</td>
<td>Cycle life</td>
</tr>
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<tr>
<td>SnO$_2$-G-C$^{11}$</td>
<td>270.1 mA h g$^{-1}$ at 100 mA g$^{-1}$</td>
<td>114.81 mA h g$^{-1}$ at 1000 mA g$^{-1}$</td>
<td>61 % after 100 cycles</td>
</tr>
<tr>
<td>ReS$_2$/N-CNTs$^{12}$</td>
<td>253 mA h g$^{-1}$ at 50 mA g$^{-1}$</td>
<td>Not Provided</td>
<td>72.3 % after 100 cycles</td>
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<td>Sb$_2$S$_3$-SNG$^{13}$</td>
<td>537 mA h g$^{-1}$ at 20 mA g$^{-1}$</td>
<td>340 mA h g$^{-1}$ at 1000 mA g$^{-1}$</td>
<td>89.4 % after 100 cycles</td>
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<tr>
<td>MoS$_2$@SnO$_2$@C$^{14}$</td>
<td>597 mA h g$^{-1}$ at 50 mA g$^{-1}$</td>
<td>86 mA h g$^{-1}$ at 800 mA g$^{-1}$</td>
<td>52.3 % after 25 cycles</td>
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<td>Sb-C$^{15}$</td>
<td>650 mA h g$^{-1}$ at 35 mA g$^{-1}$</td>
<td>420 mA h g$^{-1}$ at 175 mA g$^{-1}$</td>
<td>98 % after 50 cycles</td>
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<tr>
<td>Sn$_4$P$_3$@C$^{16}$</td>
<td>403.1 mA h g$^{-1}$ at 50 mA g$^{-1}$</td>
<td>169 mA h g$^{-1}$ at 2000 mA g$^{-1}$</td>
<td>80 % after 1000 cycles</td>
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<td>CoP@NPPCS$^{17}$</td>
<td>174 mA h g$^{-1}$ at 50 mA g$^{-1}$</td>
<td>54 mA h g$^{-1}$ at 2000 mA g$^{-1}$</td>
<td>without detectable capacity fading after 1000 cycles</td>
</tr>
<tr>
<td>U-Co$_2$P@rGO-14 (this work)</td>
<td>374 mA h g$^{-1}$ at 20 mA g$^{-1}$</td>
<td>141 mA h g$^{-1}$ at 2000 mA g$^{-1}$</td>
<td>64.7 % in the first 200 cycles; 83.6 % during 200 to 5,000 cycles</td>
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References