

## Supporting Information

### Red Phosphorus Embedded Cross Link Structural Carbon Films as Flexible Anodes for Highly Reversible Li-Ion Storage

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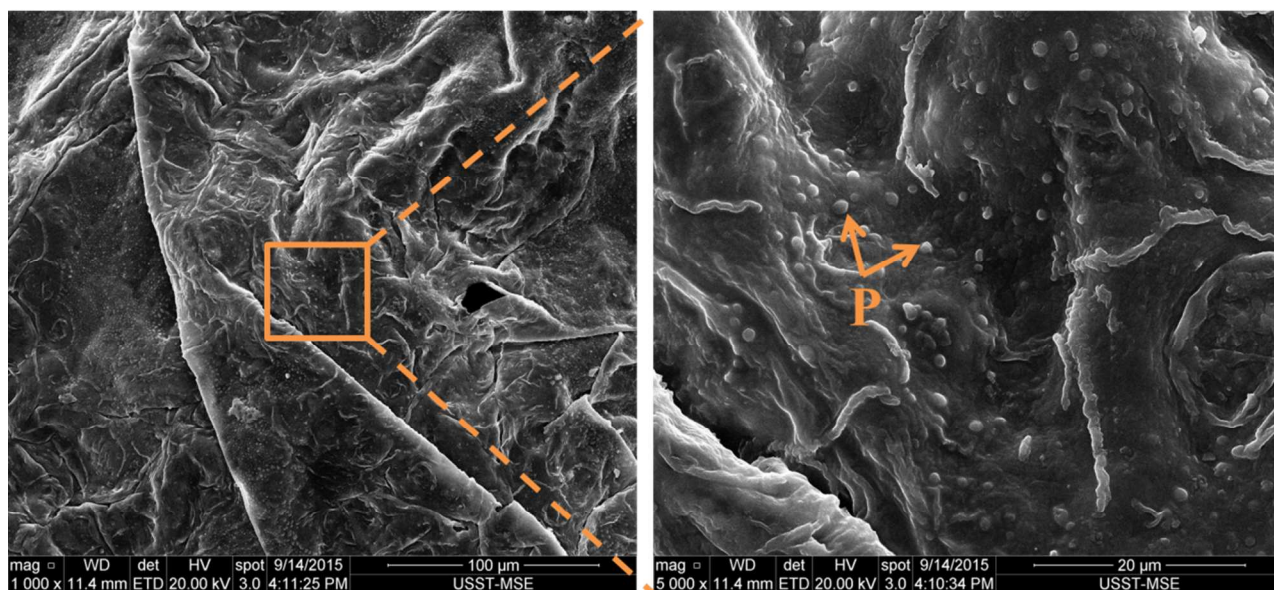
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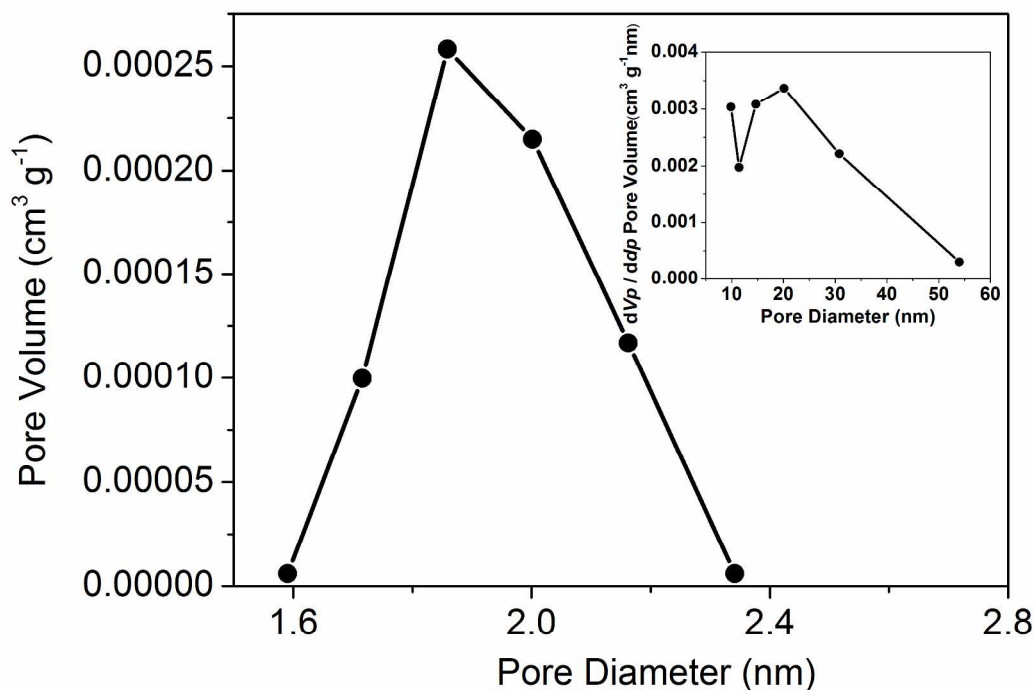
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**Figure S1**



**Figure S1.** SEM images of the P-PPy films.

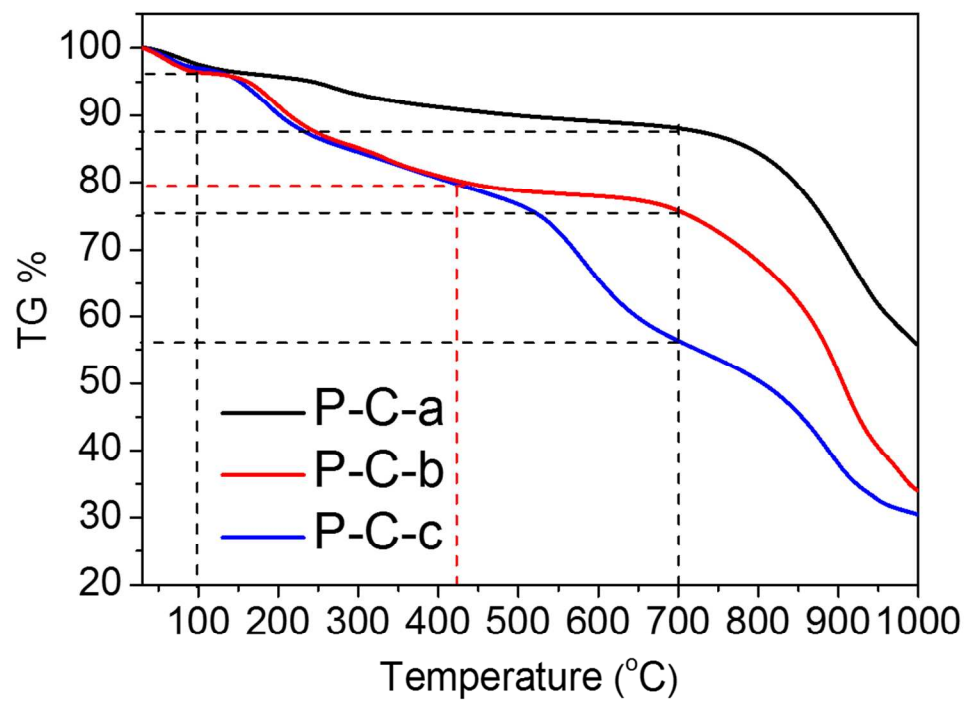
**Figure S2**



**Figure S2.** The pore size distributions of P-C and C films (insert).

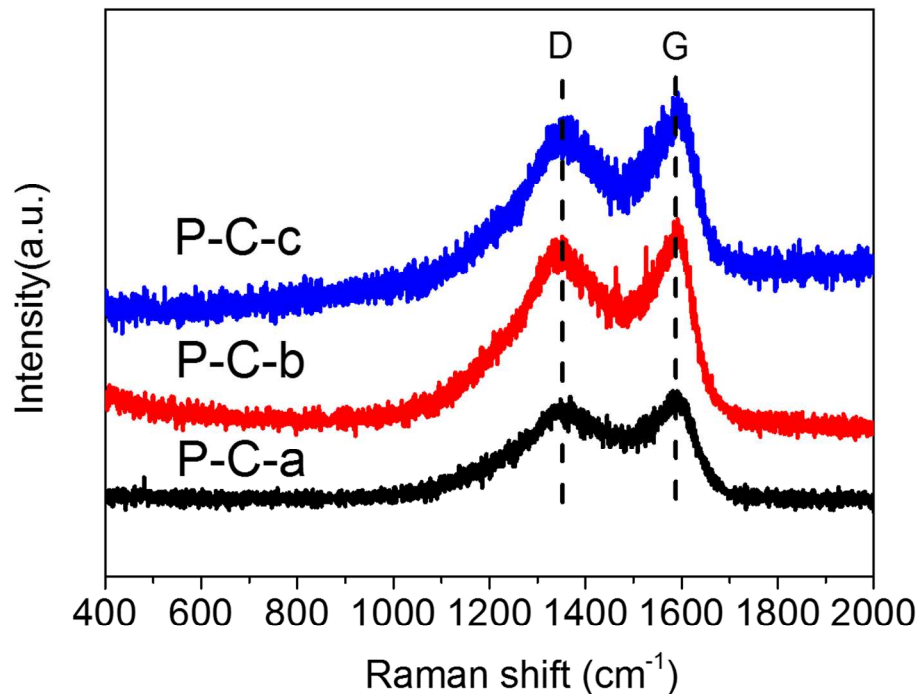
Pore size distribution of C and P-C film were measured using the N<sub>2</sub> adsorption-desorption isotherms. As shown in **Figure S2**, the Barrett-Joyner-Halenda (BJH) average pore size of the C film and the P-C film are 25.9 nm and 1.9 nm respectively, which indicates that the pore structure changes from mesoporous to microporous as loading red P. The BET specific surface area is reduced from 38.8 m<sup>2</sup> g<sup>-1</sup> for the C film to around 2.61 m<sup>2</sup> g<sup>-1</sup> for the P-C composite film, as same time, the micropore volume is reduced from 1.5×10<sup>-1</sup> cm<sup>3</sup> g<sup>-1</sup> to 2.67×10<sup>-2</sup> cm<sup>3</sup> g<sup>-1</sup>.

**Figure S3**



**Figure S3.** The TG curves of P-C films with various P contents at the temperature range from 30 to 1000 °C under Ar atmosphere with a heating rate of 10 °C min<sup>-1</sup>.

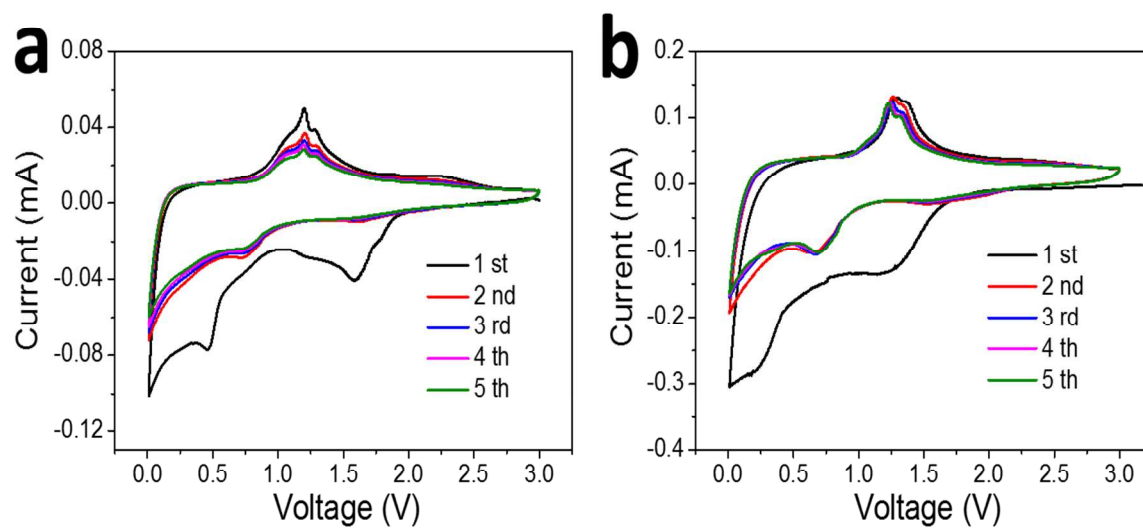
**Figure S4**



**Figure S4.** Raman patterns of the P-C-a, P-C-b and P-C-c films.

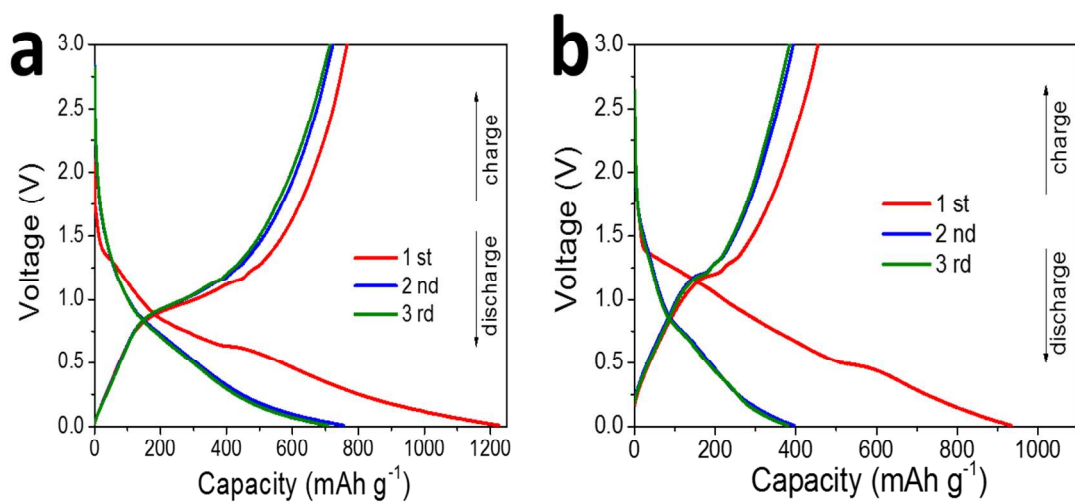
The degree of graphitization of the P-C films can be further investigated by Raman spectroscopy. As shown in **Figure S4**, all samples exhibit two pronounced Raman shifts around 1348 cm<sup>-1</sup> and 1571 cm<sup>-1</sup>, which are identified respectively as the D-band (defect-induced mode) and G-band (E<sub>2g</sub> mode of graphite). D- and G-band intensity ratio ( $I_D/I_G$ ) has often been used to quantify the degree of system disorder. The values of  $I_D/I_G$  for the P-C-a film, P-C-b film and P-C-c film are calculated to be 0.90, 0.93 and 0.91 respectively, which indicate all the carbon films have a low degree of graphitization, which were also confirmed by XRD characterization.

**Figure S5**



**Figure S5.** Cyclic voltammetry curves of a) P-C-a film, b) P-C-c film anodes at a scan rate of  $0.1 \text{ mV s}^{-1}$ .

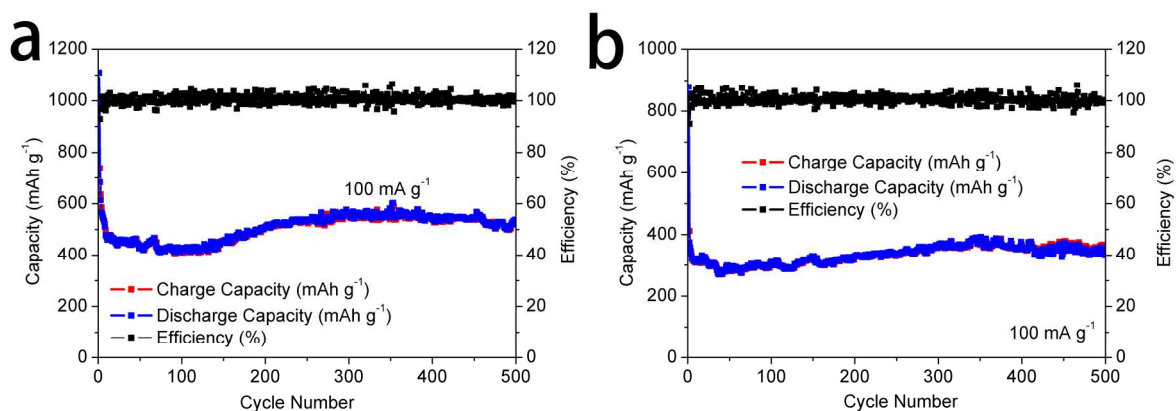
**Figure S6**



**Figure S6.** First three discharge/charge profiles of a) P-C-a film and b) P-C-c film anodes at a current density of 100 mA g<sup>-1</sup>.



**Figure S7**



**Figure S7.** Cycling and corresponding Coulombic efficiency of a) P-C-a film and b) P-C-c film anodes at a current density of 100 mA g<sup>-1</sup>.

As shown in **Figure S7**, the P-C-a film anode maintains 530.1 mAh g<sup>-1</sup> after 500 cycles at a current density of 100 mA g<sup>-1</sup>, while the P-C-c film anode maintains 331.8 mAh g<sup>-1</sup> after 500 cycles at the same current rate. The Coulombic efficiencies of both electrodes are close to 100 %.