Porous Carbon Nanotubes Etched by Water Steam for High Rate, Large Capacity Lithium-Sulfur Batteries

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Supporting Information

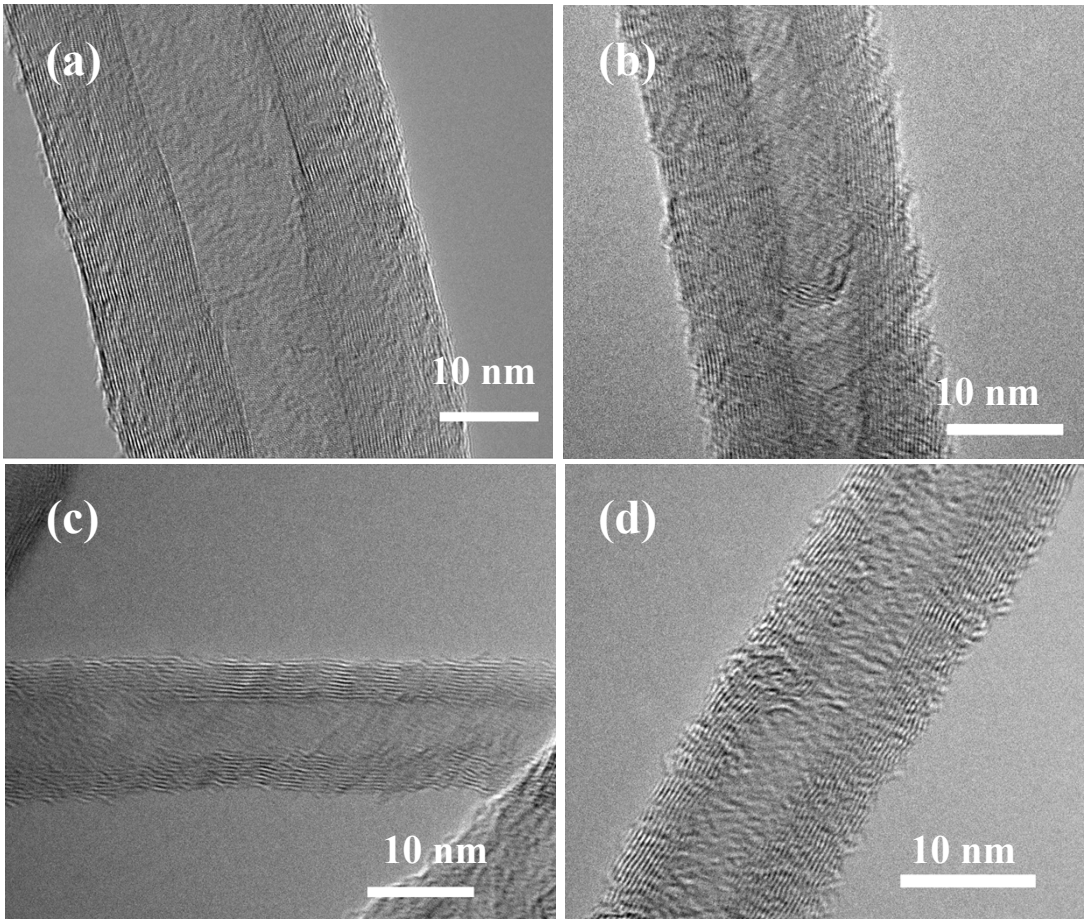

Figure S1 Typical TEM images of the raw CNTs (a) and 850PCNTs (b, c, d).

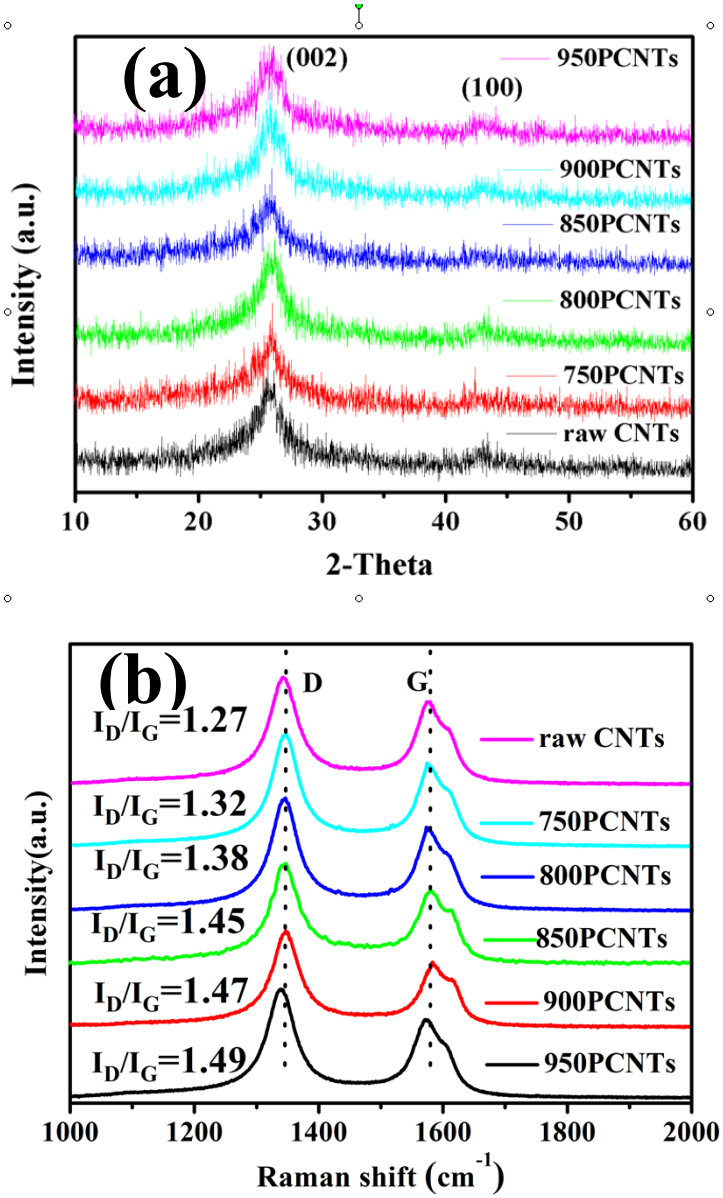

Figure S2 (a) XRD curves and (b) Raman spectras of the raw CNTs and various PCNTs

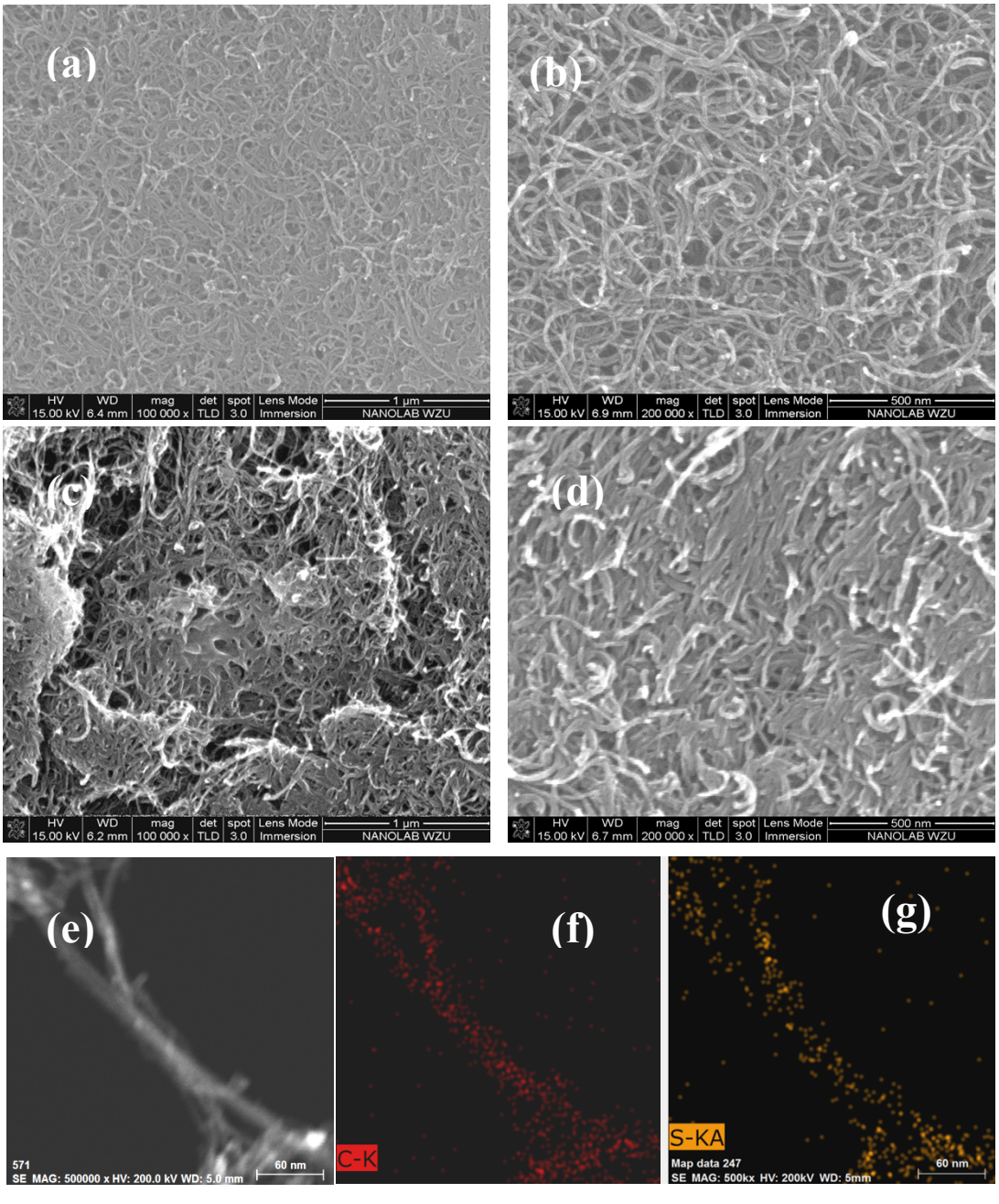
(a)
HV 15.00 kV | WD 6.4 mm | mag 100 000 x | det TLD | spot 3.0 | Lens Mode Immersion | 1 µm | NANOLAB WZU
(b)
HV 15.00 kV | WD 6.9 mm | mag 200 000 x | det TLD | spot 3.0 | Lens Mode Immersion | 500 nm | NANOLAB WZU
(c)
HV 15.00 kV | WD 6.2 mm | mag 100 000 x | det TLD | spot 3.0 | Lens Mode Immersion | 1 µm | NANOLAB WZU
(d)
HV 15.00 kV | WD 6.7 mm | mag 200 000 x | det TLD | spot 3.0 | Lens Mode Immersion | 500 nm | NANOLAB WZU
(e)
571
SE MAG: 500000 x HV: 200.0 kV WD: 5.0 mm
60 nm
(f)
C-K
(g)
S-KA
Map data 247
SE MAG: 500kx HV: 200kV WD: 5mm
60 nm

Figure S3 Typical SEM pictures of 850PCNTs (a, b) and 850PCNTs-S composites (c, d); elemental maps of 850PCNTs-S composites (e, f, g)

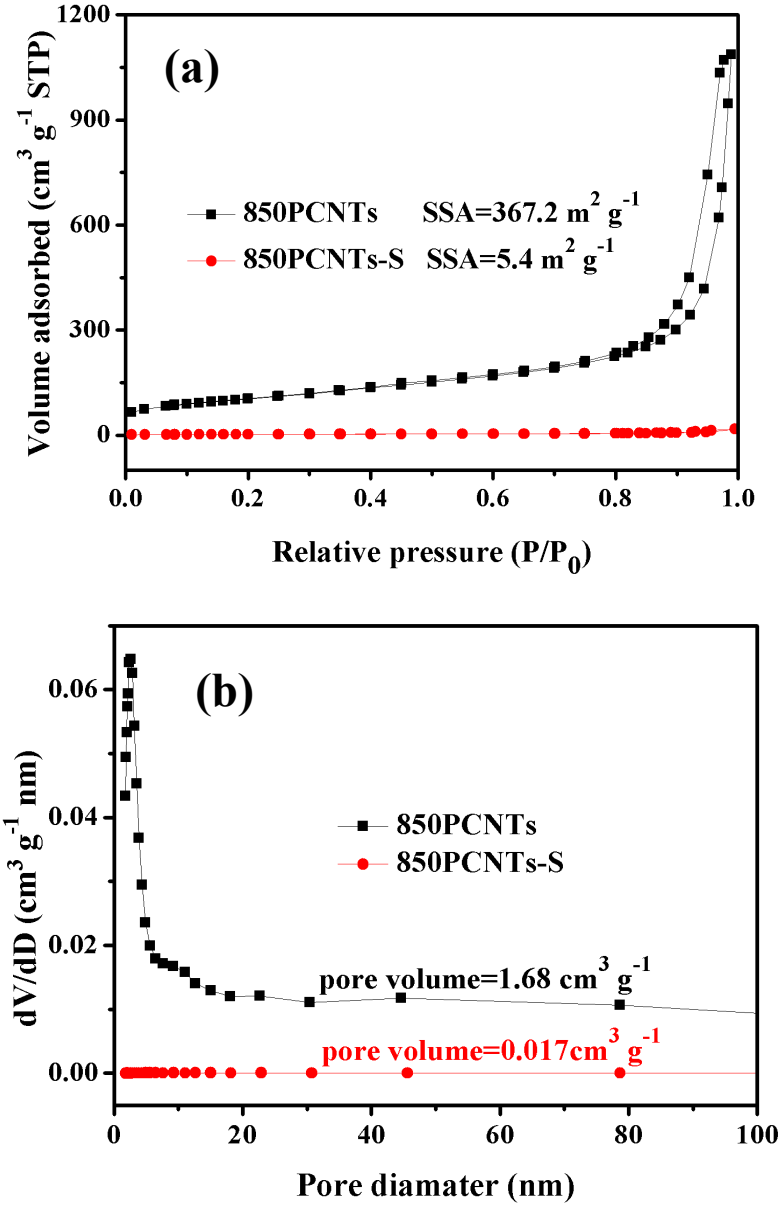

Figure S4 (a) Nitrogen sorption isotherms and (b) pore size distribution of 850PCNTs and 850PCNTs-S hybrids.

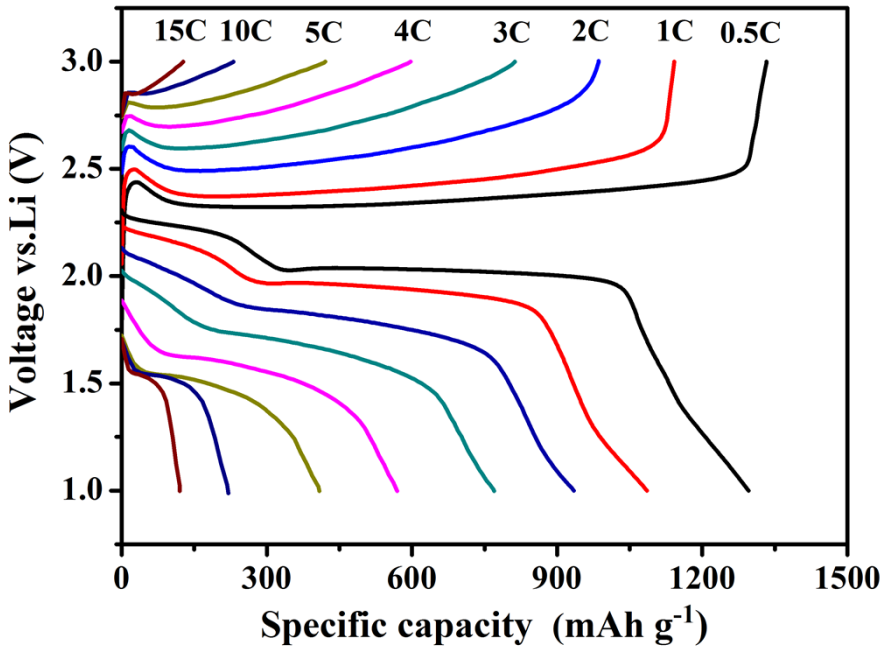

Figure S5 Galvanostatic charge-discharge curves of the 850PCNTs-S cathode at different current rates.

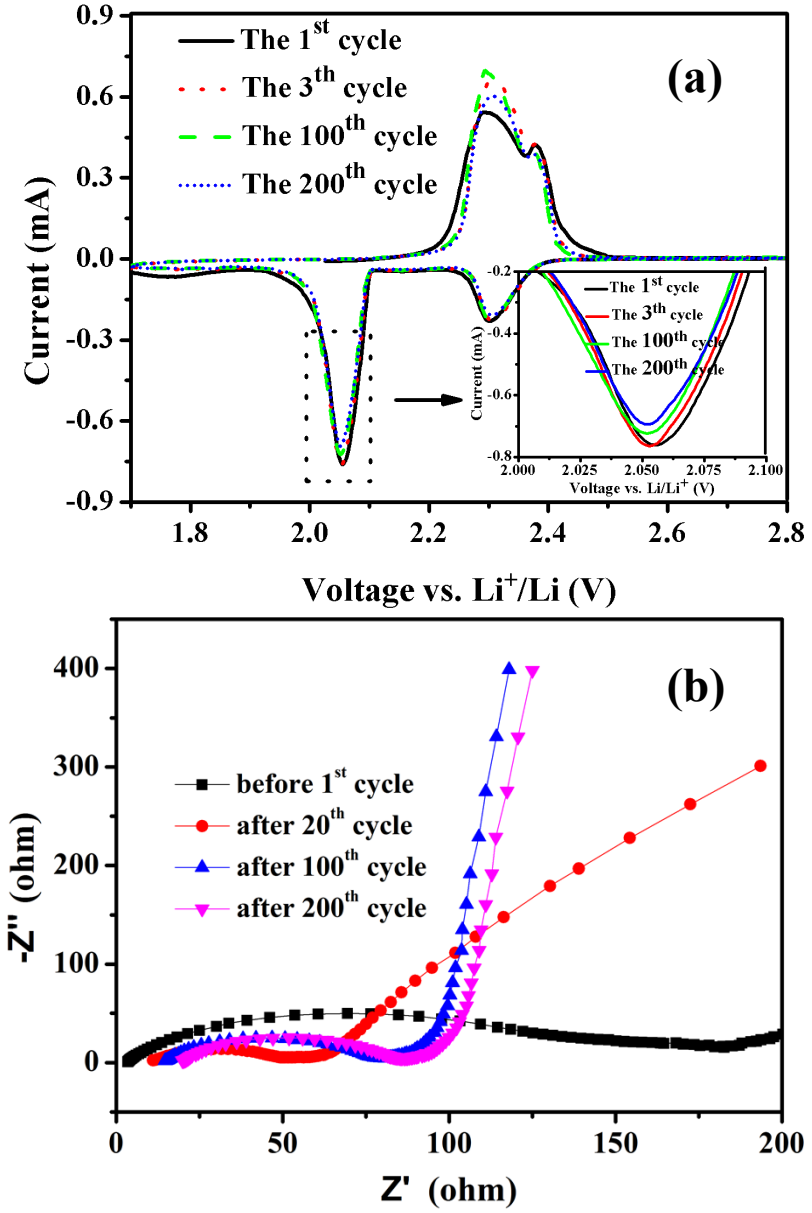

Figure S6 (a) CV profiles and (b) electrochemical impedance spectroscopy of the 850PCNTs-S cathodes.

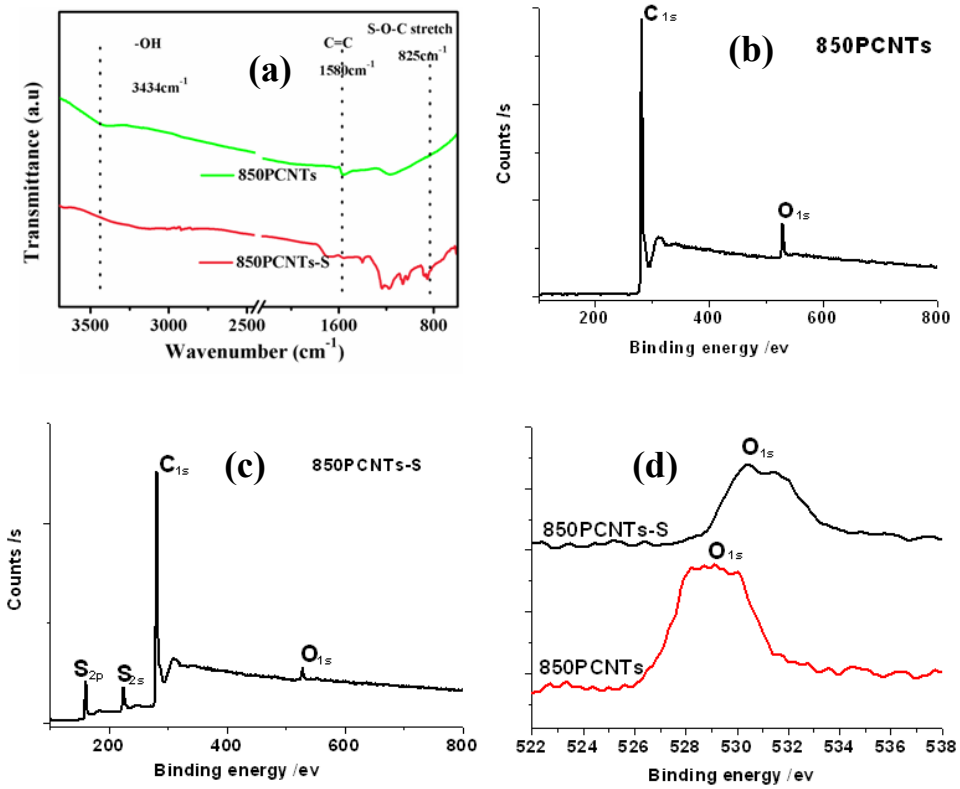

Figure S7 IR (a) and XPS curves (b, c, d) of 850PCNTs and 850PCNTs-S composites.

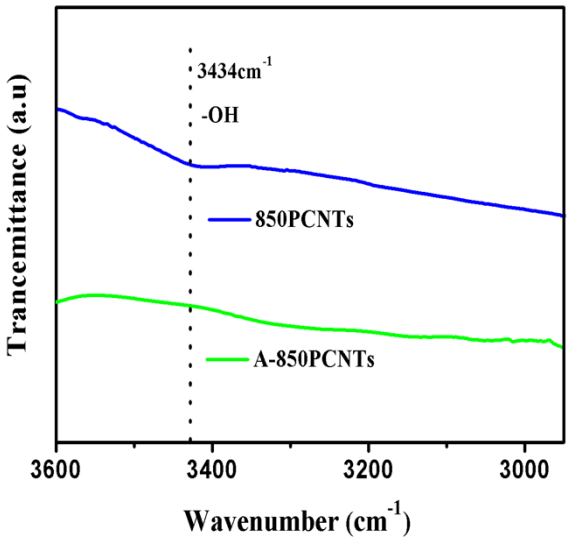

Figure S8 IR profiles of 850PCNTs and annealed 850PCNTs (A-850PCNTs).

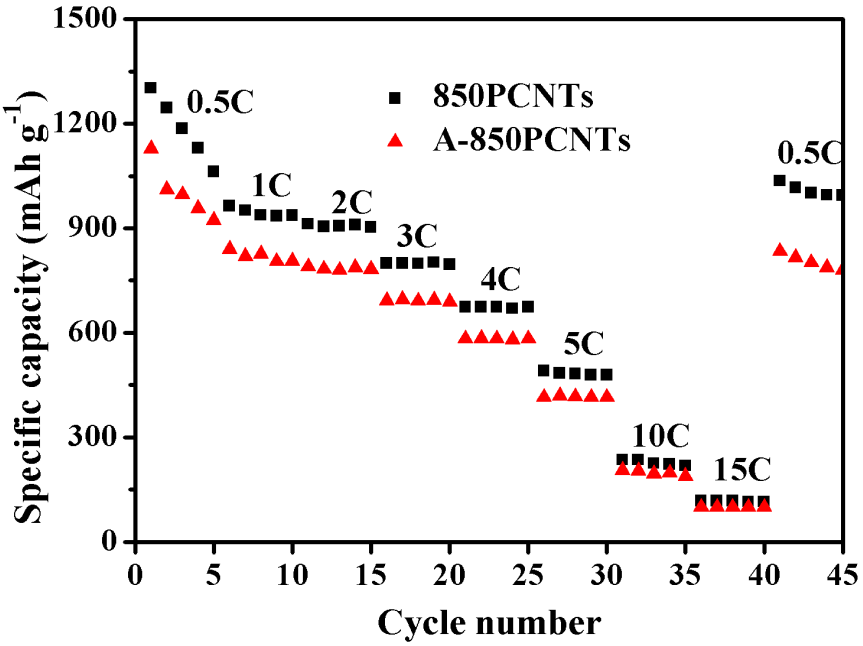

Figure S9 Rate-capacities of 850PCNTs-S and A-850PCNTs-S cathodes at various current rates.

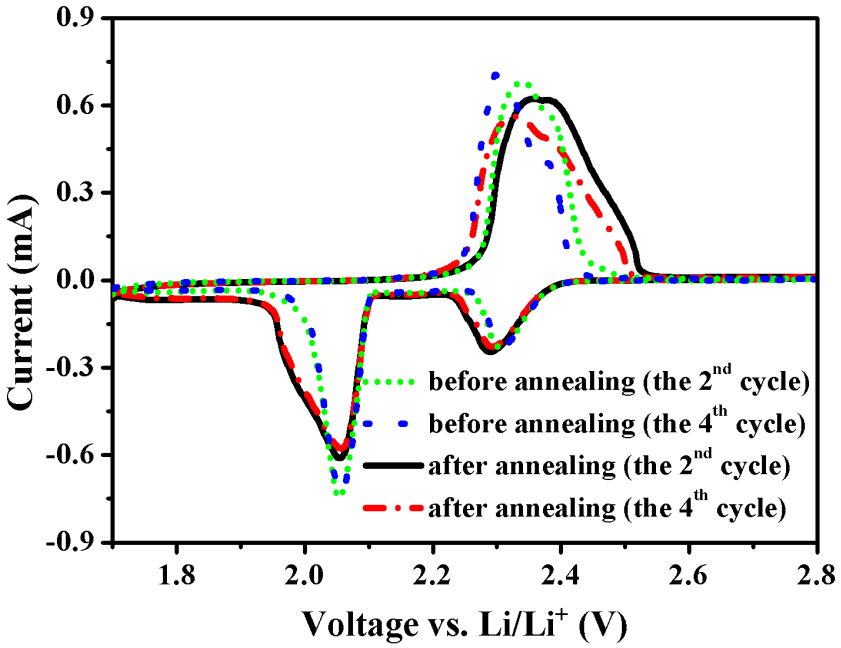

Figure S10 CV profiles of the 850PCNTs–S electrode before and after annealing.

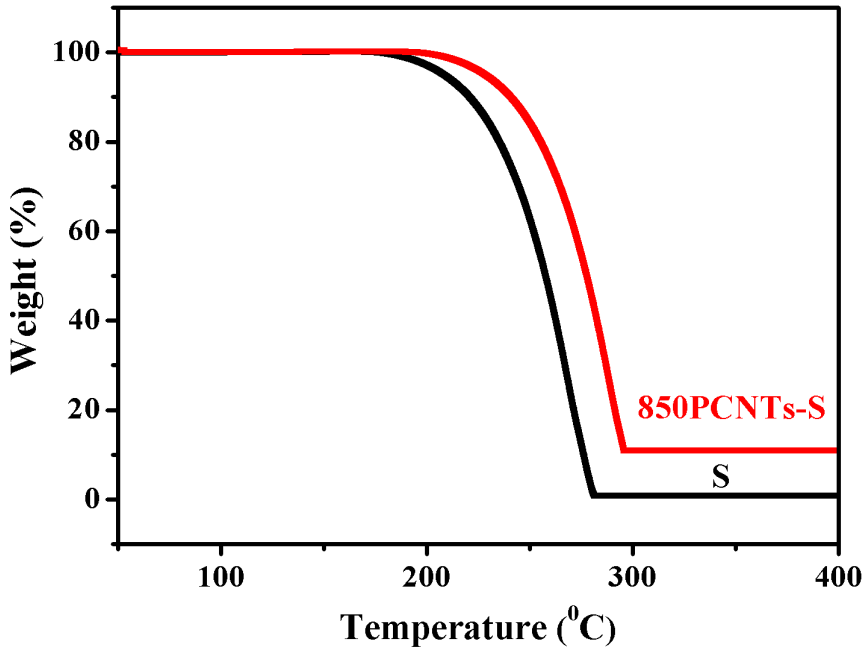

Figure S11 TGA profiles of pure S and 850PCNTs-S hybrids under N_2 atmosphere.

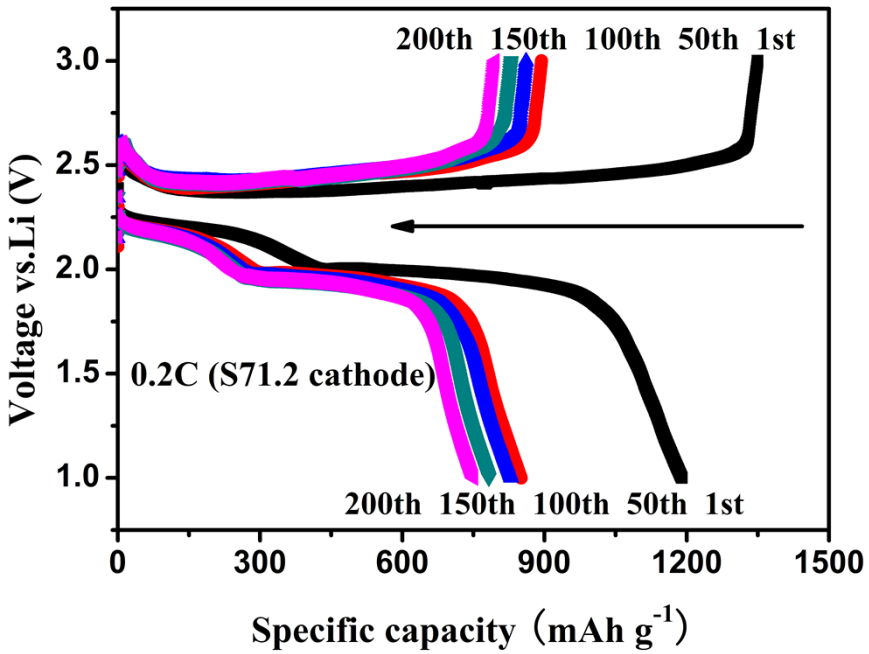

Figure S12 Galvanostatic charge/discharge voltage profiles of the S71.2 cathode at 0.2C for the 1st, 50th, 100th, 150th, 200th cycles.

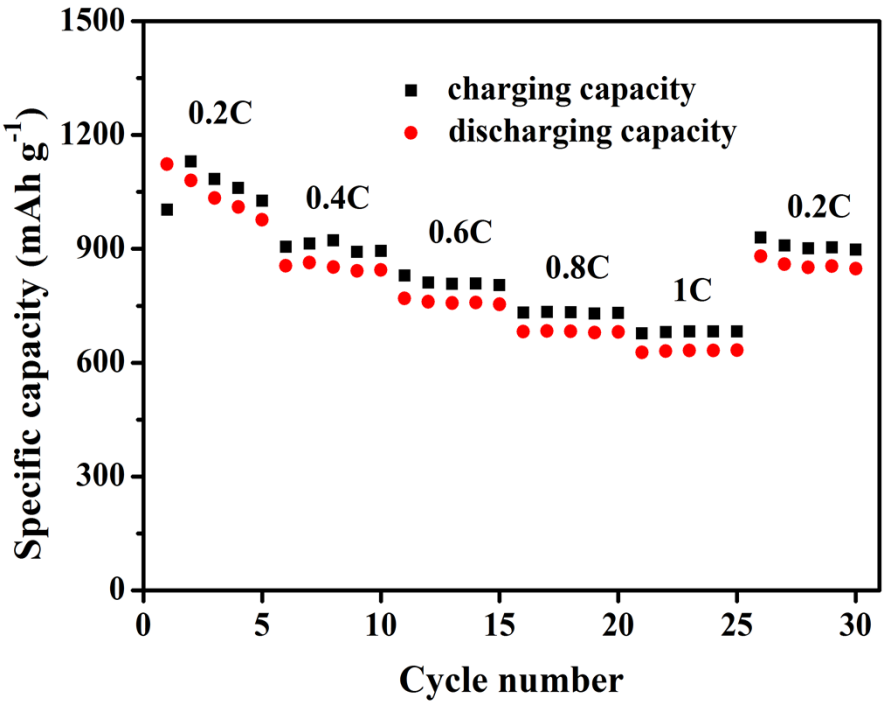

Figure S13 Rate-capacities performance of the S71.2 cathode.

S14 Control experiments:

As a control experiment, we investigated the effect of etching temperature on the electrochemical performance. Figure S14 show the rate performance curves and electrochemical impedance spectroscopy for these PCNTs samples obtained from various temperature. From Figure S14a, it can be found that all the PCNTs exhibit superior performance to raw CNTs. Moreover, the PCNTs obtained from the temperature 850℃ exhibit the highest rate values and the highest discharge capacity values of all the PCNTs samples. The observations strongly indicate that 850PCNTs holds the most outstanding electrochemical performance amongst the PCNTs and raw CNTs samples. The possible explanation for the phenomenon may be as follows: When the etching temperature increase from 750 to 950℃, this improved electrochemical performance may be due to that more pores in the samples would afford more space to accommodate sulfur and restrain the loss of sulfur and poly-sulfides. With the temperature higher than 850℃, the tardily descend electrochemical performance may be because of the increased resistance, which is confirmed the electrochemical impedance spectroscopy in Figure S14b.

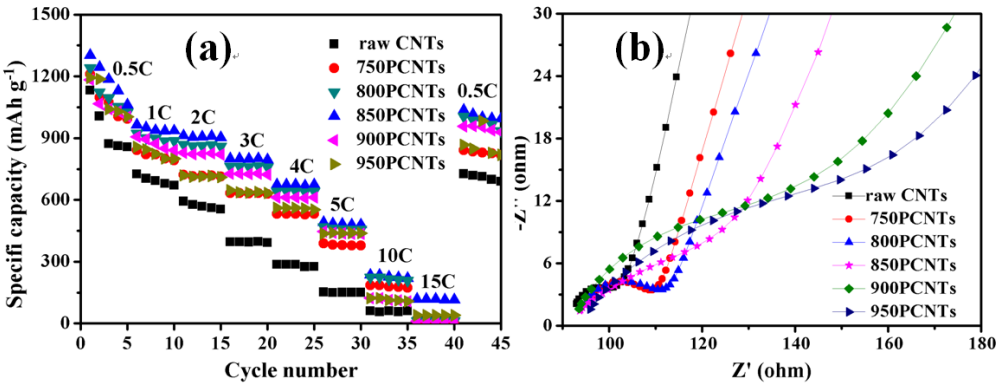

Figure S14 rate performance (a) and electrochemical impedance spectroscopy (b) of the raw CNTs and various PCNTs