Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information for

Superior rate-capability and long-lifespan carbon nanotube-in-nanotube@Sb_2S_3 anode for lithium-ion storage

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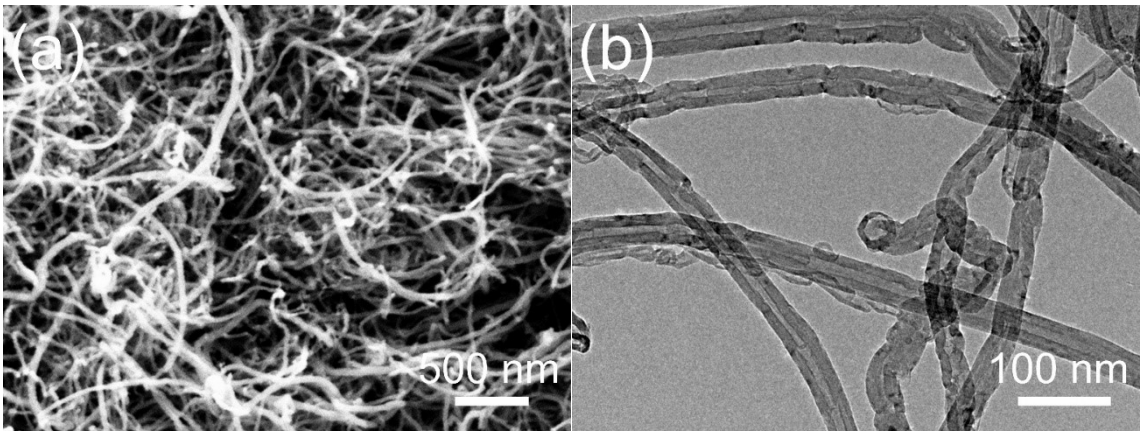

Figure S1 (a) SEM and (b) TEM images of CNTs.

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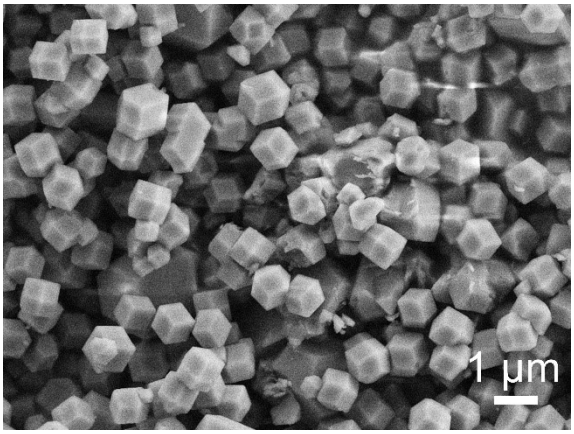

Figure S2 ZIF-8 polyhedra particles synthesized without the addition of CNTs.

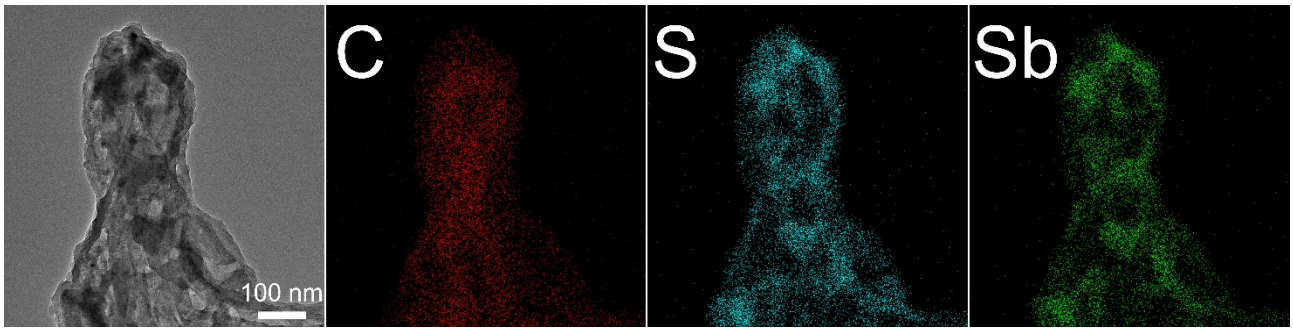

Figure S3 TEM image of the CNN@Sb_2S_3 composite and the corresponding EDS mapping of the C, S and Sb elements.

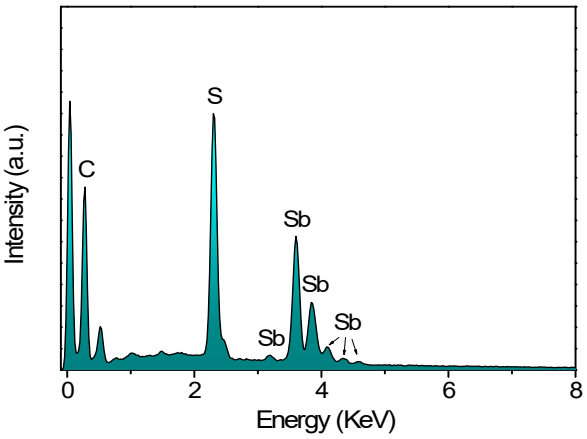

Figure S4 EDS spectrum of CNN@Sb_2S_3.

Calculation of weight percentages of Sb_2S_3, Sb and carbon in the composite

- EDS spectrum indicates that the atomic contents of Sb and S are 5.56% and 7.31%. Therefore, the atomic ratio of Sb and S is 1:1.3.

- S is 7.31%. This means that Sb in Sb_2S_3 is 4.87% (7.31%/3 × 2). Thus, the metallic Sb is 0.69% (5.56%-4.87%).

  The molar ratio of Sb_2S_3 : Sb = 2.44 : 0.69

  The weight ratio of Sb_2S_3 : Sb = 9.85 : 1

- TGA indicates that at 720 °C, the residual matter is Sb_2O_3 and its weight stabilizes at 54.96%. Sb_2O_3 comes from oxidation of Sb_2S_3 and Sb.

  In the composite, the weight of Sb is set as x%. Then, the weight of Sb_2S_3 is 9.85x%.

  $9.85x \times 291.5/339.7+x \times 291.5/243.4 = 54.96$

  $x = 5.7$

  Sb(wt%) = 5.7%, Sb_2S_3(wt%) = 56.1%

  C(wt%) = 100%-56.1%-5.7%-1.6%(water)=36.6%

  After water is deducted, Sb(wt%) = 5.8%, Sb_2S_3(wt%) = 57%, C(wt%) = 37.2%

- The theoretical capacities of Sb_2S_3, Sb and carbon are 947, 660 and 372 mAh g^{-1}.

  The theoretical capacity of the composite = $947 \times 0.57+660 \times 0.058+372 \times 0.372$

  = 716.5 mAh g^{-1}

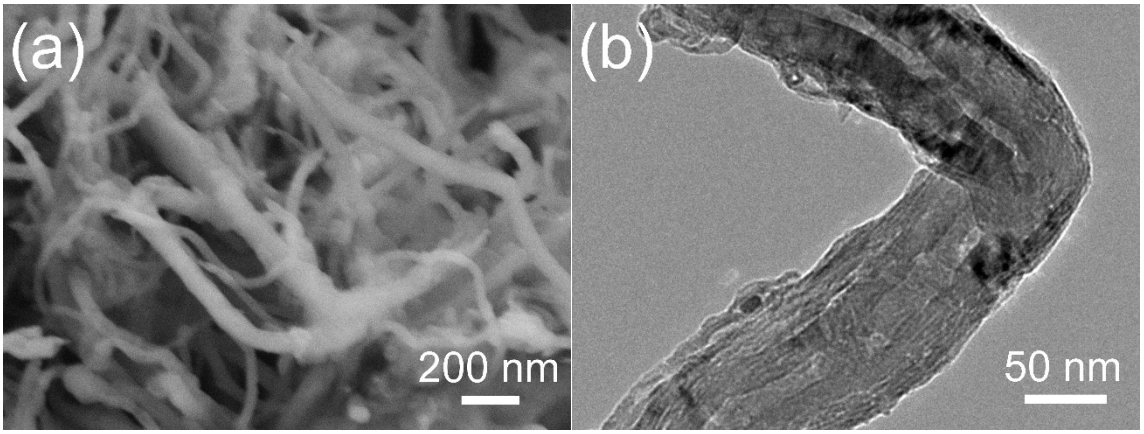

Figure S5 (a) SEM and (b) TEM images of CNTs@C as the control material.

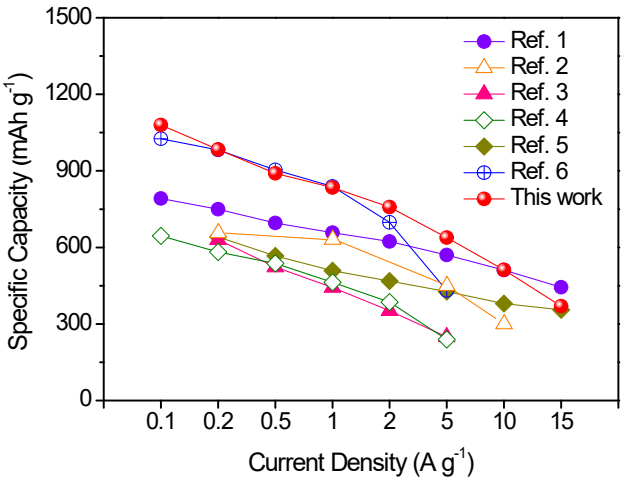

Figure S6 Comparison of rate capability between CNN@Sb_2S_3 and previously reported Sb_2S_3-based composites.

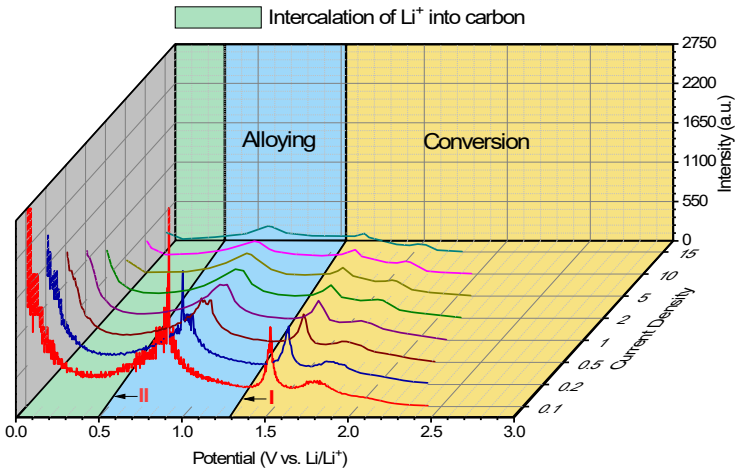

Figure S7 dQ/dV curves of rate discharge profiles of CNN@Sb_2S_3.

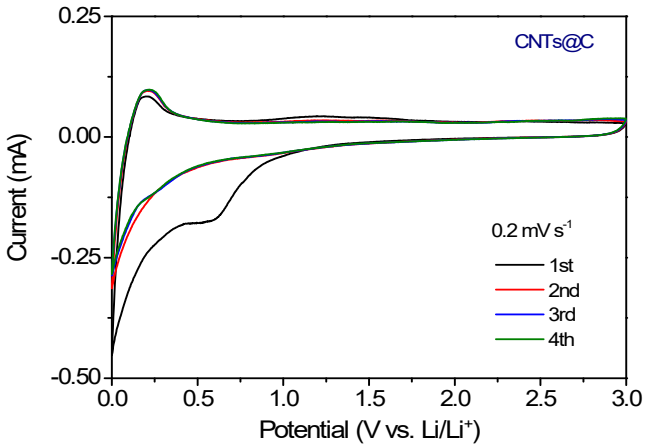

Figure S8 CV curves of CNTs@C in the first four cycles at a scan rate of 0.2 mV s^{-1}.

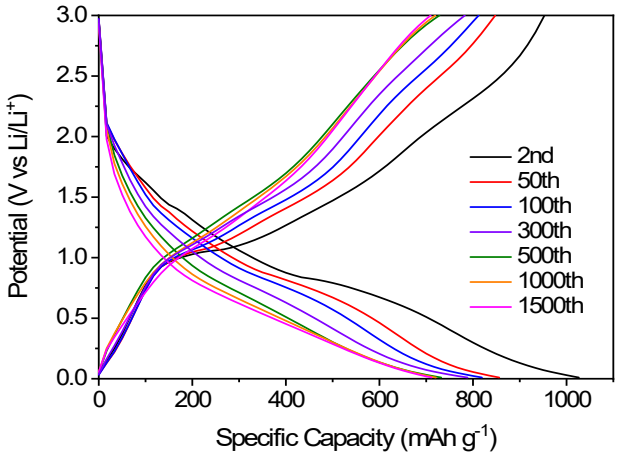

Figure S9 Galvanostatic discharge and charge curves of CNN@Sb_2S_3 at the different cycles at the current density of 1 A g^{-1}.

Table S1 Cycling performance comparison between CNN@Sb_2S_3 and previously reported Sb_2S_3-based composites.

Materials	Current Density ($A\ g^{-1}$)	Specific Capacity ($mAh\ g^{-1}$)	Cycling Performance	Ref
Sb_2S_3@EG'-S	1	646	120	1
Sb_2S_3-carbon fibers	0.2	606	150	2
S-rGO/Sb_2S_3 composite	0.5	431	600	3
Sb_2S_3 hollow microspheres	1	656	100	4
Sb@N-C nanocomposite	0.2	603	300	5
CPC/Sb_2S_3	0.1	1100	200	6
	1	500	300	
Sb_2S_3-graphite	0.2	638	250	7
	1	496	500	
Sb_2S_3/graphene	0.2	670	200	8
Sb_2S_3@C	0.1	745	160	9
Sb_2S_3/MMCN@ppy	1	556	300	10
Sb_2S_3/CNT	0.2	443	100	11
CNN@Sb_2S_3	0.2	1056.6	100	This Work
	1	710.5	1500	
	5	316	1700	
	10	201.5	1000	

Table S2 Lattice constants of Sb_2S_3 before cycling and after 500 cycles at 1 A g^{-1}.

Lattice constants	Before cycling (Å)	After 500 cycles (Å)
a	11.1465	10.1212
b	11.2618	11.1037
c	3.7628	4.0201

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