Designing Slope-Dominated Hybrid Nanostructure Hard Carbon Anode for High-Safety and high-capacity Na-ion Batteries

Qianzheng Jin[ab], Kangli Wang*[a], Wei Li[b], Haomiao Li[a], Pingyuan Feng[b], Zhuchan Zhang[b], Wei Wang[b], Zhou Min[a], Kai Jiang*[a]

[a]State Key Laboratory of Advanced Electromagnetic Engineering and Technology
School of Electrical and Electronic Engineering
Huazhong University of Science and Technology
Wuhan 430074, P. R. China. E-mail: kjiang@hust.edu.cn; klwang@hust.edu.cn

[b]State Key Laboratory of Materials Processing and Die & Mould Technology
School of Materials Science and Engineering
Huazhong University of Science and Technology
Wuhan 430074, P. R. China

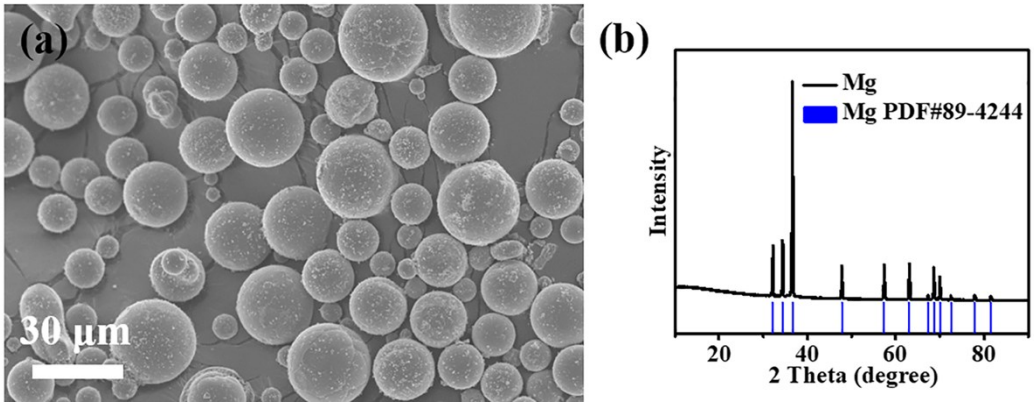

Fig. S1 (a) The SEM image of Mg spheres. (b) The XRD pattern of Mg spheres.

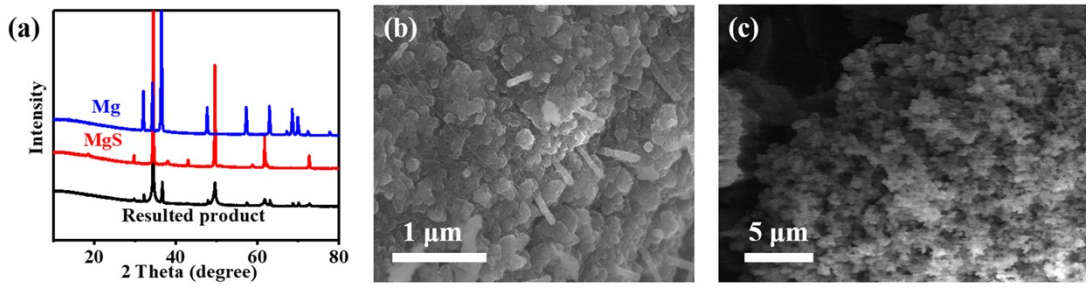

Fig. S2 a) The XRD patterns of unwashed carbonized products (resulted product), Mg and MgS. b) The SEM image of internal surface of reaction product after removing the surplus Mg. c) The SEM image after combustion of unwashed carbonized products.

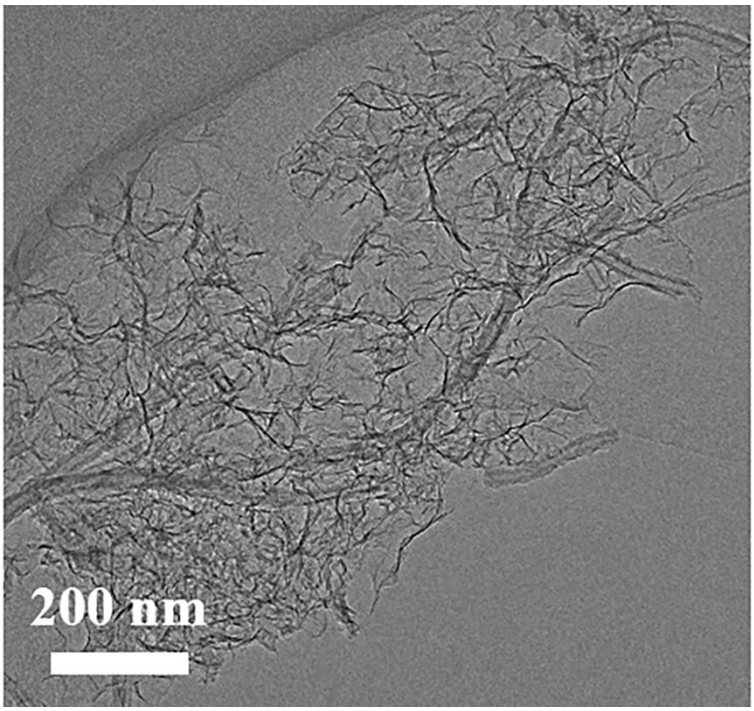

Fig. S3 The TEM image of HNCs.

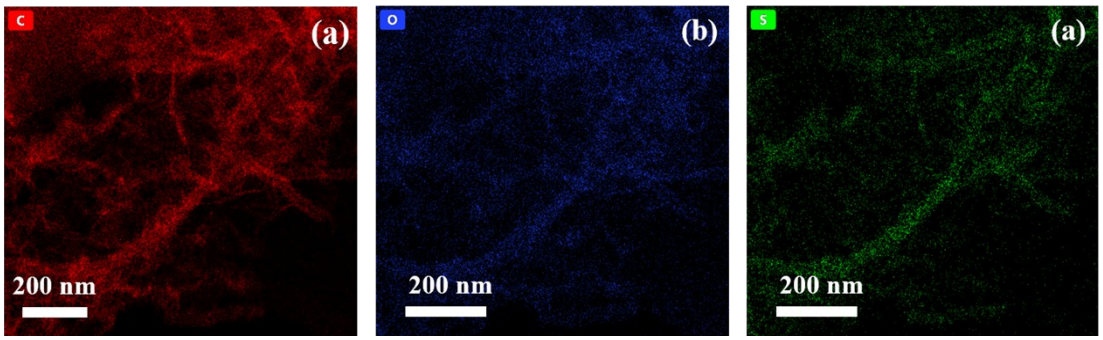

Fig. S4 The elemental mappings of C, O, S.

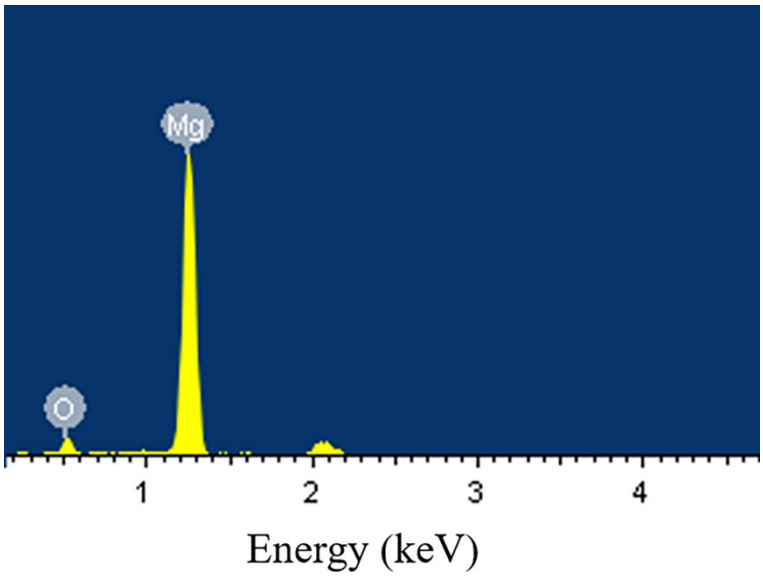

Fig. S5 The EDX image of Mg sphere.

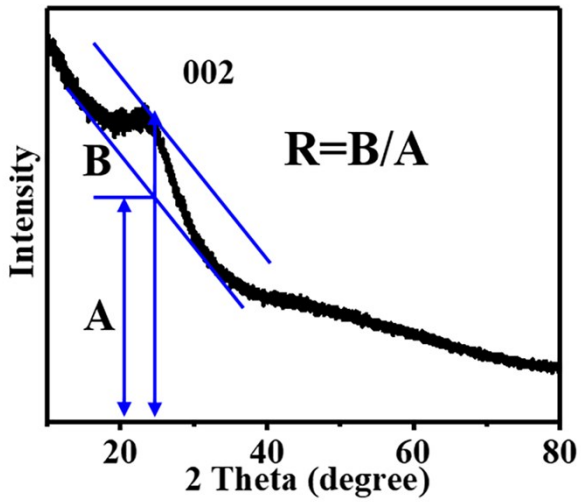

Fig. S6 The calculation of R values.

R is taken to be B/A, that is the ratio of the height to the background of (002) peak. The estimated background (A) is measured by drawing a straight line connecting the data on either side of the peak. The peak height (B), is determined by drawing a line, which is tangent to the (002) peak at a single point and parallel to the estimated linear background at the same time. As R measures the

numbers of carbon sheet which is arranged as single layer in c direction, smaller R value means the carbon is less-developed in stacking direction and in more disordered condition.

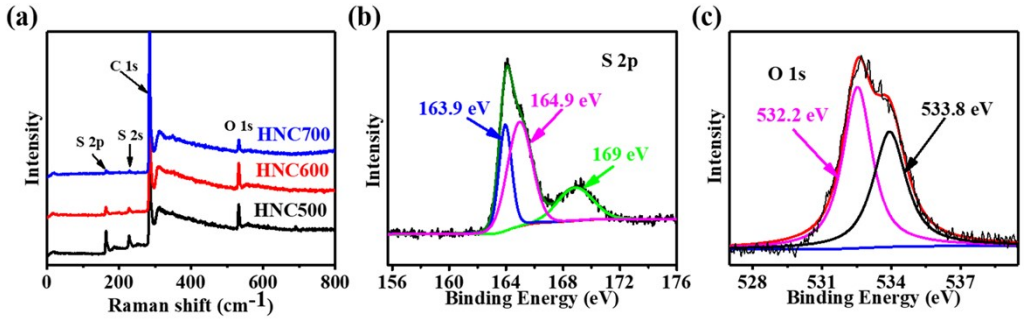

Fig. S7 a) The full XPS spectra of HNC700, HNC600, HNC500. b, c) The fitted peaks of S2p and O1s.

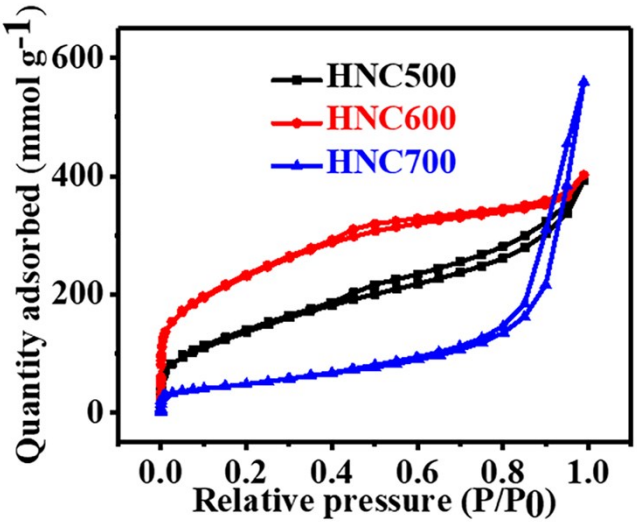

Fig. S8 The BET measurements of HNC700, HNC600 and HNC500.

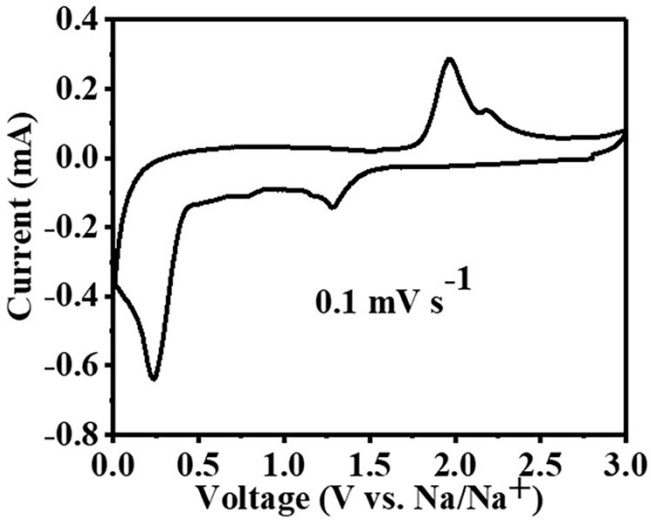

Fig. S9 The CV curve of HNC500.

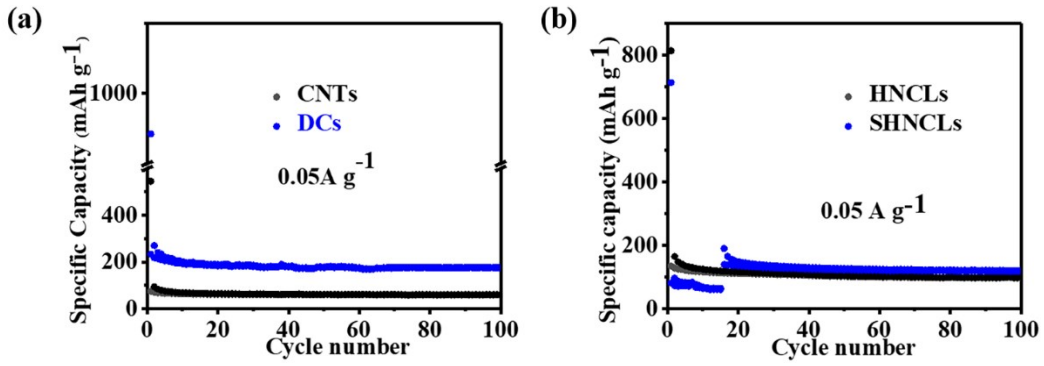

Fig. S10 The cycling performances of DCs, CNTs, HNCLs and SHNCLs at 0.05 A g^{-1} for 100 cycles.

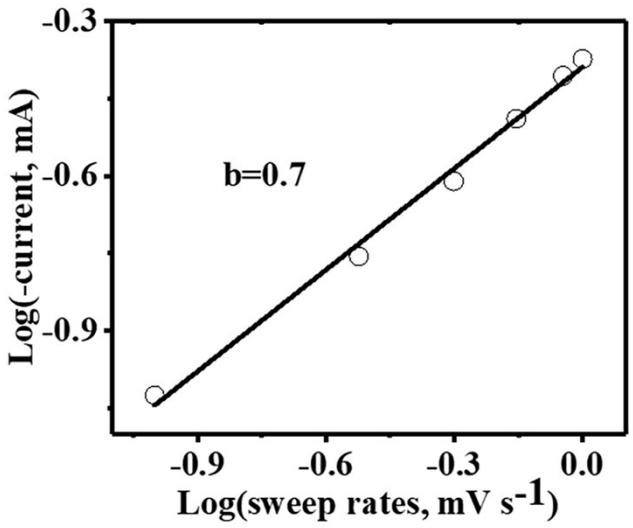

Fig. S11 The calculated b value of TNCs.

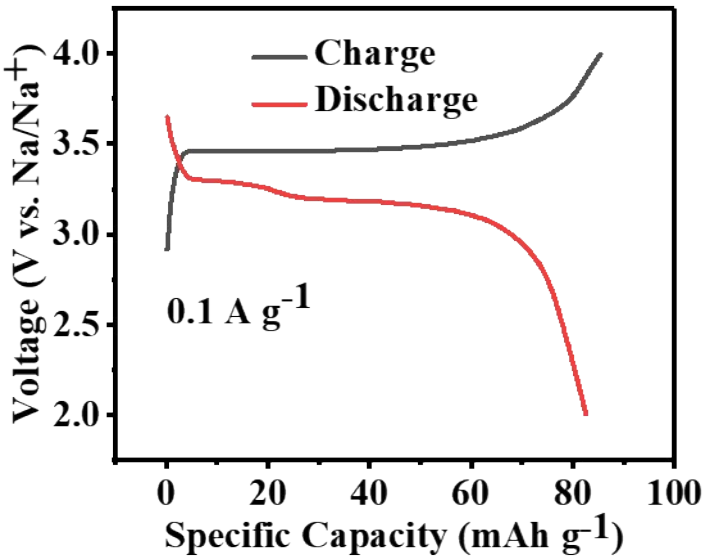

Fig. S12 The charge/discharge curve of $Na_3V_2(PO_4)_3$ electrode at half cell.

Table S1. The R values of HNCs.

	HNC500	**HNC600**	**HNC700**
R	0.308	0.310	2.531

Table S2. The elemental contents of C, O, S for HNCs.

	C wt%	**O wt%**	**S wt%**
HNC500	80.1	5.2	14.7
HNC600	89.8	5.2	5.0
HNC700	96.6	1.6	1.8

Table S3. The Nyquist plots are fitted by using equivalent circuits.

	Rs (Ω)	**R_{SEI} (Ω)**	**R_{ct} (Ω)**
HNC500	4.6	10.2	217.6
HNC600	4.3	24.1	148.5
HNC700	5.6	20.7	166.3