Supporting Information

Hollow Carbon Spheres Embedded with VN Quantum Dots an as Efficient Cathode Host for Lithium-Sulfur Batteries

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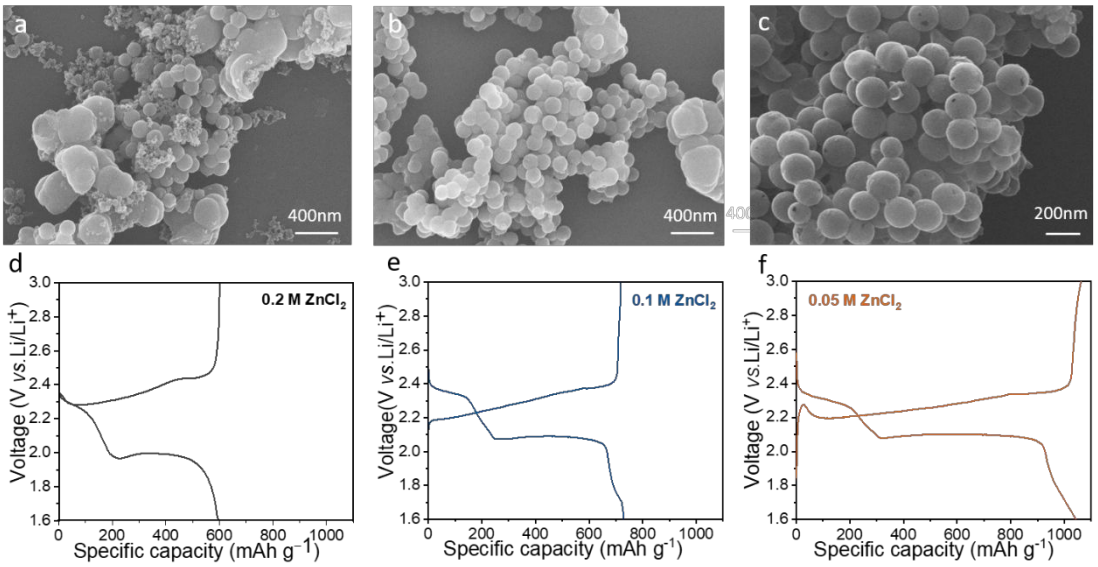

Figure S1. SEM images VN-H-C samples prepared at (a) 0.2 M (b) 0.1 M (c) 0.05 M concentration of $ZnCl_2$. (d-f) Discharge–charge profiles of the corresponding S@VN-H-C cathode at 0.5 C.

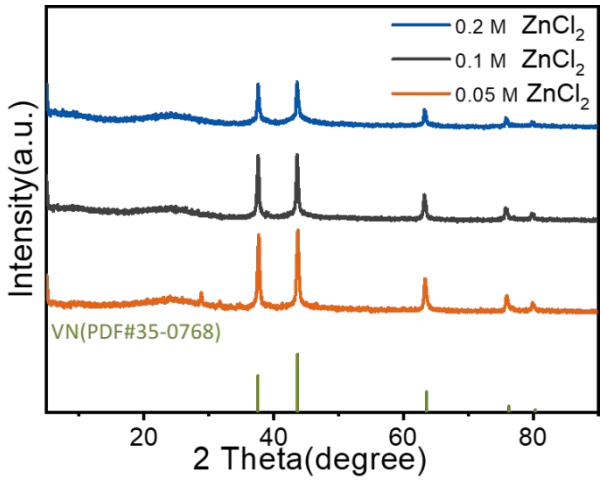

Figure S2. XRD patterns of VN-H-C samples prepared under different concentration of $ZnCl_2$.

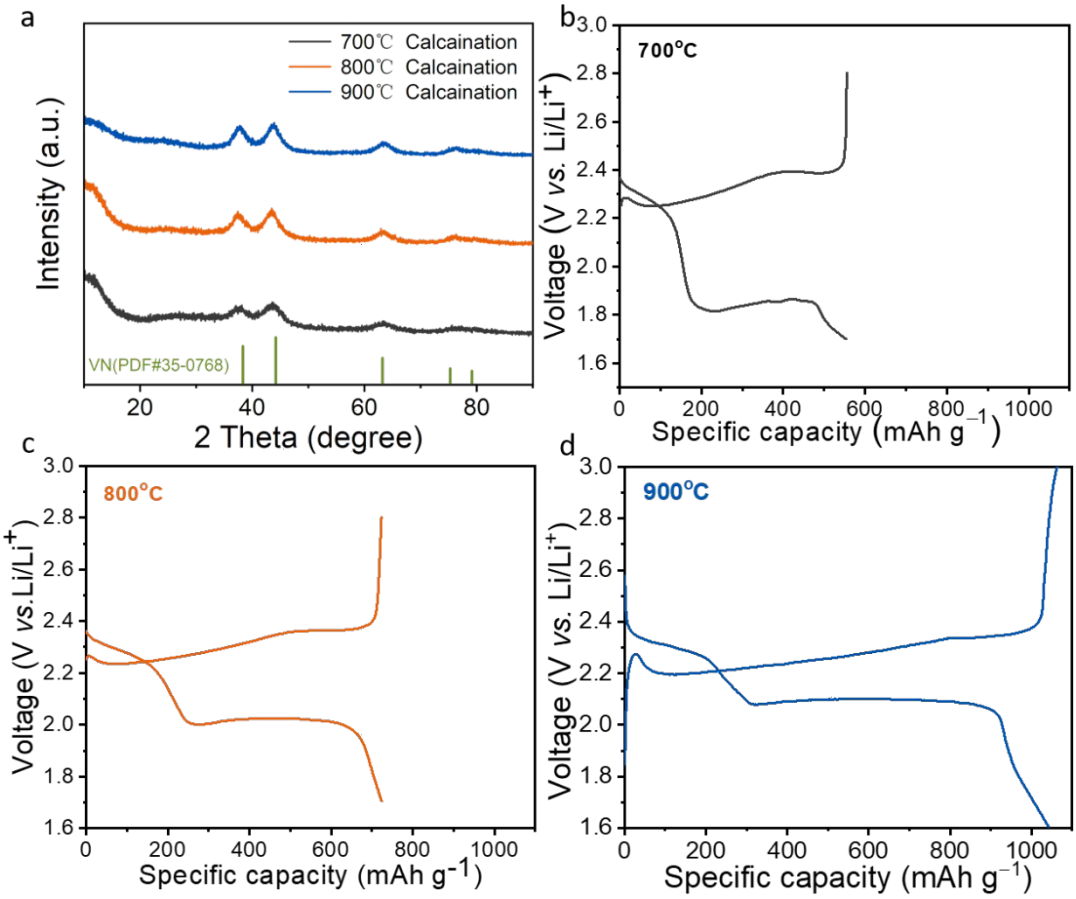

Figure S3. (a) XRD patterns of VN-H-C under different calcination temperatures. Discharge–charge profiles the S@VN-H-C cathode at (b) 700 °C, (c) 800 °C and (d) 900 °C calcination temperatures at 0.5 C.

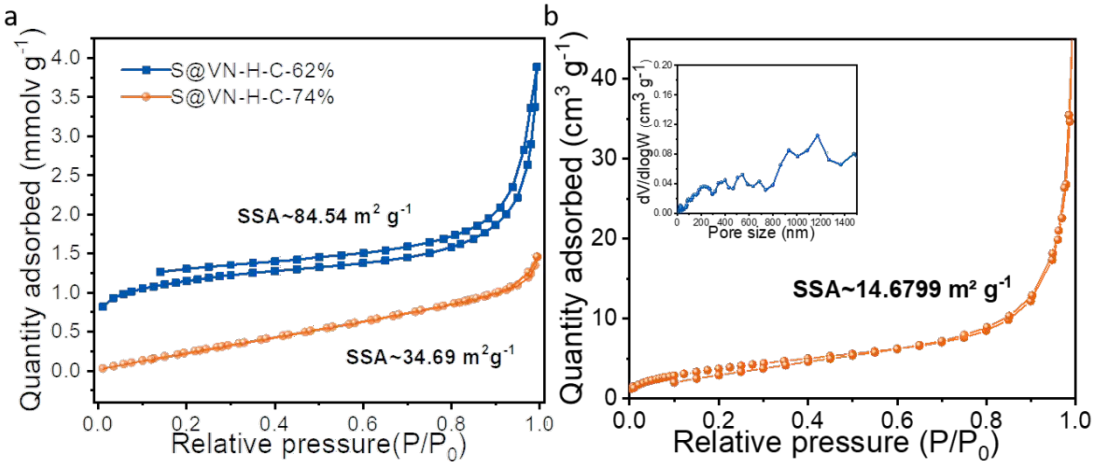

Figure S4. The nitrogen absorption and desorption curve of (a) S@VN-H-C, (b)H-C and pore size distribution of H-C samples.

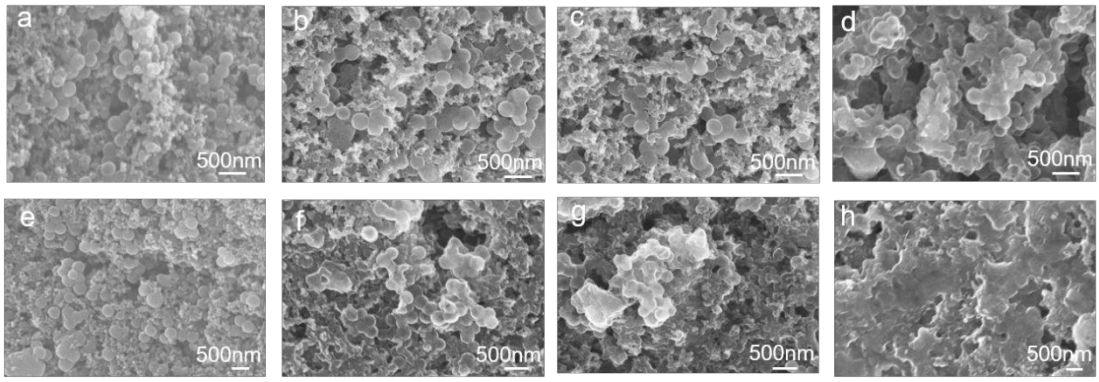

Figure S5. SEM images of the surface of S@VN-H-C cathode (a) before cycling, after (b) 50 cycles, (c) 100 cycles and 500 cycles at 1 C. SEM images of the surface of S@H-C cathode (a) before cycling, after (b) 50 cycles, (c) 100 cycles and 300 cycles at 1 C.

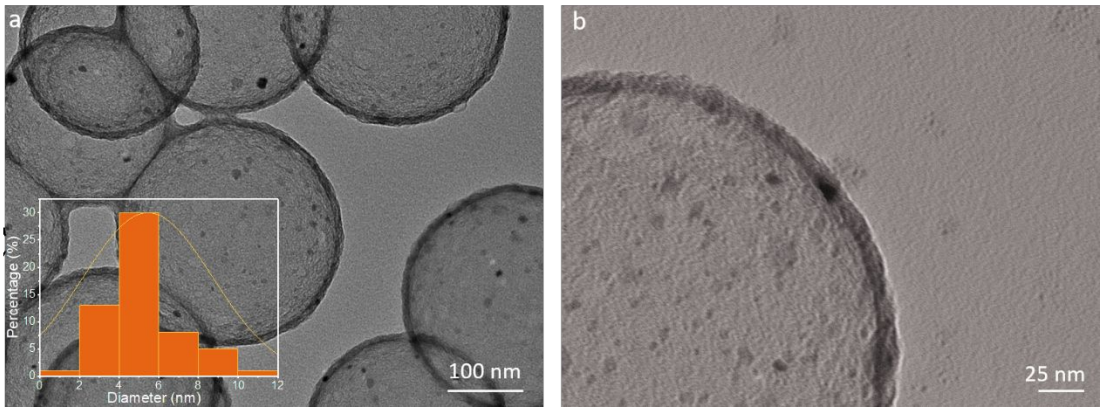

Figure S6. (a-b) TEM images of VN-H-C.

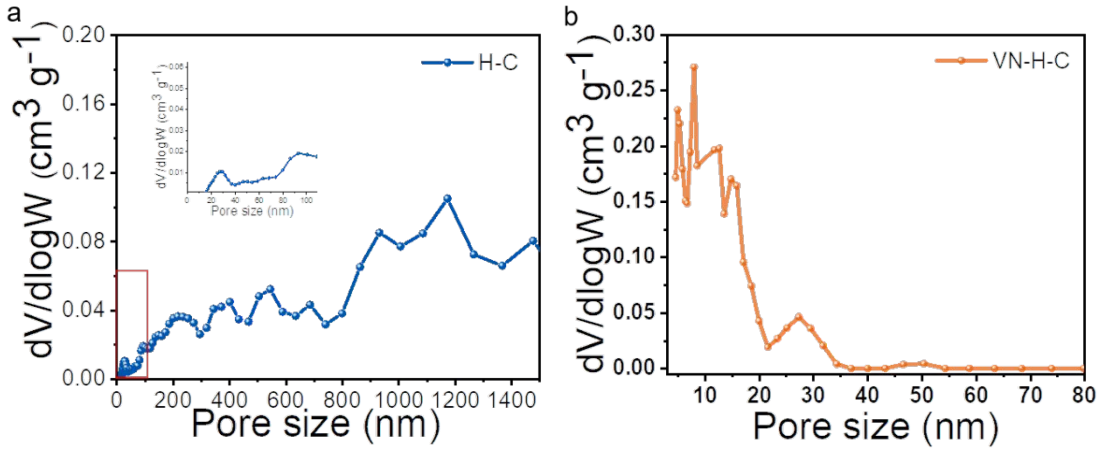

Figure S7. Pore size distributions of (a) H-C and (b) VN-H-C.

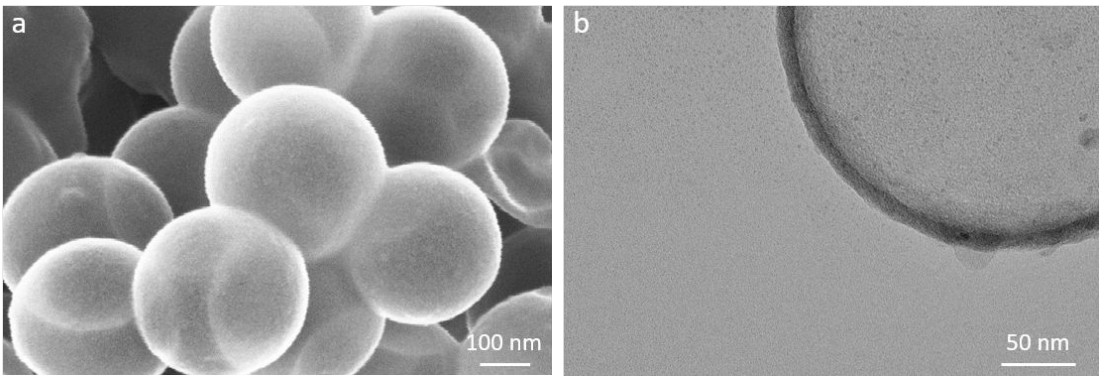

Figure S8. (a) SEM image and (b) TEM image of H-C.

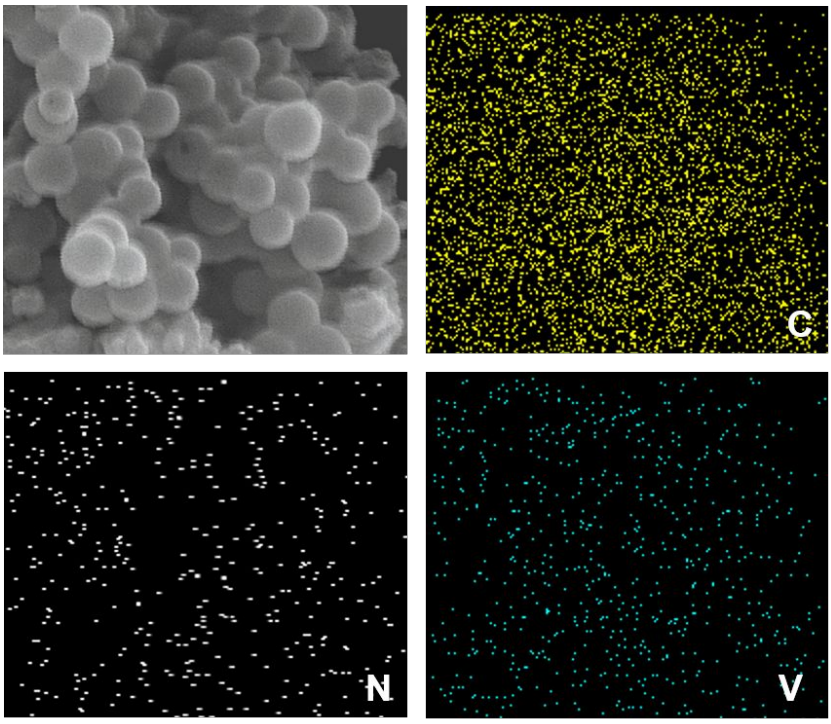

Figure S9. SEM image and mapping images of VN-H-C.

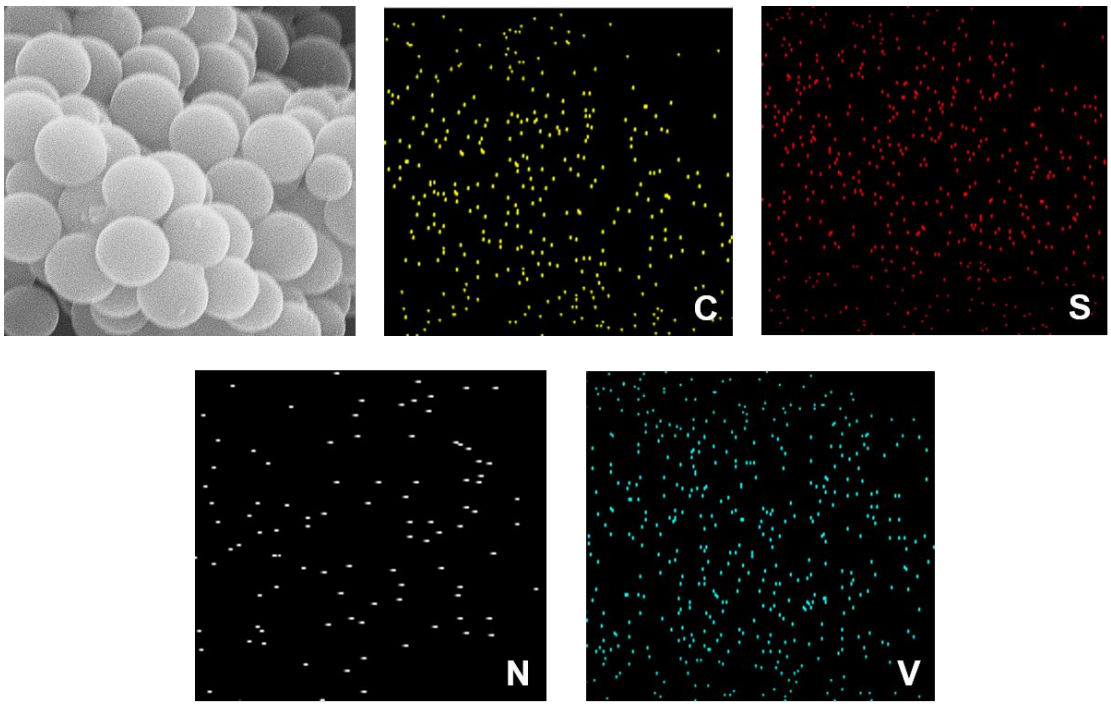

Figure S10. SEM image and mapping images of S@VN-H-C.

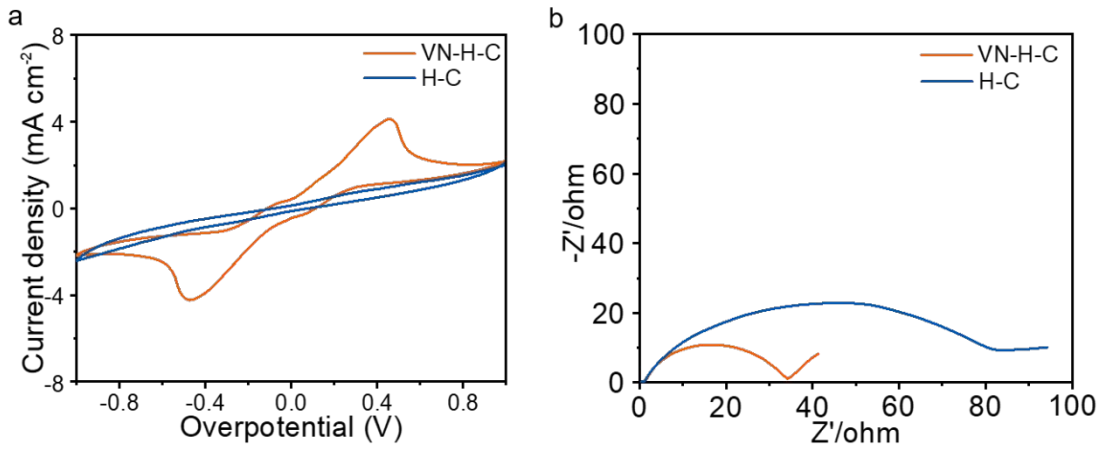

Figure S11. (a) CV curves and (b) the electrochemical impedance spectra (EIS) of the symmetric cells with the H-C and VN-H-C electrodes in electrolyte with Li_2S_6.

Table S1. The respective resistance of the S@VN-H-C and S@H-C electrodes.

Electrode	R1(Ω)	R2 (Ω)	R3 (Ω)
S@VN-H-C	4.25	41.69	35.97
S@VN-H-C (50 cycles)	4.27	11.76	10.79
S@VN-H-C (100 cycles)	4.47	10.4	6.06
S@H-C	4.96	60.87	53.59
S@H-C (50 cycles)	6.12	39.01	19.69
S@H-C (100 cycles)	4.25	46.29	27.53

Material Characterization

The microstructure of the as-obtained samples were characterized by transmission electron microscopy (TEM, HITACHI-800), scanning electron microscopy (SEM, ZEISS SUPRA 55) and high-resolution TEM (HRTEM, JEOL JEM-2100). The crystal structures were detected by powder X-ray powder diffractometer with Cu Kα radiation(λ = 1.5406 Å). X-ray photoelectron spectroscopy was selected to analyze the chemical status of elements (Thermo Electron ESCALAB 250). N_2 adsorption-desorption tests were evaluated by the Brunauer-Emmett-Teller (BET) measurement. The pore size distributions of VH-H-C and H-C were calculated based on Barrett-Joyner-Halenda (BJH) method. Thermogravimetry analysis (TGA) was performed with a NETZSCH STA 449F3 type thermal analysis system in an argon atmosphere at a rate of 10 °C min^{-1} in the range 40- 800 °C.

Electrochemical Measurements

The cathode slurry was prepared by using S@VN-H-C or S@H-C composites, Super P, and polyvinylidene fluoride powder with ratio of 7:2:1 and about 1 ml N-methyl pyrrolidone (NMP). Then the mixture was coated on Al foil and dried in 60 °C oven for 12 hours, with its loading density of 3.0 mg cm^{-2} (S loading of 1.5 mg cm^{-2}). The 2032 type coin cells were assembled in an Ar-filled glove-box with the above electrodes as the cathode and lithium foil as anode. The diameter of the cathode is 10 mm, lithium metal anode is 12 mm, and polypropylene separator (Celgard 2325) is 16 mm. The electrolyte (20 μL mg^{-1}_{sulfur}) is composed of 1 M LiTFSI in a mixture of DOL/DME (1:1 v/v) with 2.0 wt% lithium nitrate. The CV curves and EIS were measured on an CHI660E electrochemical workstation (Chenhua, Shanghai). LAND CT2001A battery test system was used to Galvanostatic charge/discharge tests at 25 °C.