Electronic Supplementary Material (ESI) for Nanoscale Advances.

Supporting information

Fabrication of Vanadium Nitride/N-Doped Carbon Hollow Nanospheres Composite as an Efficient Electrode Material for Asymmetric Supercapacitors

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Experimental

1. Material characterization

The crystal structures of all the obtained samples were identified by X-ray power diffraction (XRD, Smart Lab). The chemical composition of VN/NCS composite was tested on X-ray photoelectron spectroscope (XPS, ESCALAB 250). The morphologies of the as-synthesized samples were obtained from transmission electron microscopy (TEM, JEM-2100 F) and scanning electron microscope (SEM, HITACHI SU8010). Nitrogen absorption-desorption measurement was performed on a MT 3000 analyzer at 77.4 K.

2. Electrochemical measurements

The electrochemical properties of the as-prepared electrode materials were estimated by cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) and the electrochemical impedance spectroscopy (EIS) on CHI660D workstation in a standard three-electrode system in a 2 M KOH electrolyte. Platinum sheet and Hg/HgO electrode were used as a counter electrode and a reference electrode, respectively. After coating the mixture paste of active material (80 wt.%), acetylene black (15 wt.%) and polyvinylidene difluoride (PVDF) (5 wt.%) on the nickel foam, the working electrode was dried for 12 h, and the loading mass of active material on the working electrode is about 2 mg.

The specific capacitance (C_s) of the electrode material was assessed by equation (a), where I (A), Δt (s), ΔV (V) and m (g) in the equation represent the discharge current, discharge time, operating potential window and mass of the active material, respectively. The coulombic efficiency is calculated by the equation (d), where t_c and t_d are the charge and discharge times, and η is the coulombic efficiency.

The capacitive contribution of the VN/NCS, NCS, and VN NWs electrodes is calculated by the equation (c), where i, v are the current and the scan rate, respectively, a and b are constants. The detailed calculation process is given as follows:

In the case of EDLC and the diffusion-controlled process, b is equal to 1 and 0.5, respectively. Following this concept, we can divide the equation as:

$$i(\mathrm{V}) = kv + k'v^{0.5}$$

where i is the current under a fixed voltage (V), k and k' are constants. By simply plotting the relationship between i and $v^{0.5}$, we can obtain the slope k. Finally, the capacitive contribution of these samples is plotted and showed in Figure. 6 by calculating the *k* value at different voltages under different scan rates.

In addition, the energy density (*E*) and the power density (*P*) are utilized to evaluate the electrochemical properties of the V_2O_3/C//VN/NC ASC device according to equation (d) and (e), respectively, where *C* (F g^{-1}) is the specific capacitance and ΔV (V) is the operating potential window, Δt (s) is the discharge time.

$C_s = I/m \times \Delta t/\Delta V$ (a)

$\eta = t_c/t_d$ (b)

$i = av^b$ (c)

$E = 0.5 \times C \times \Delta V^2$ (d)

$P = E/\Delta t$ (e)

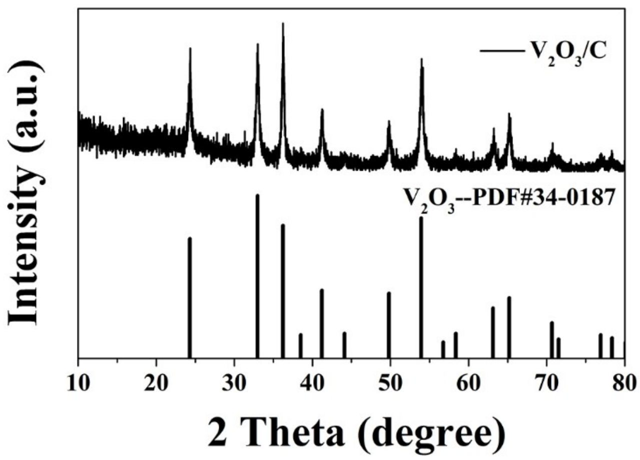

Figure S1. XRD pattern of V_2O_3/C nanocomposite.

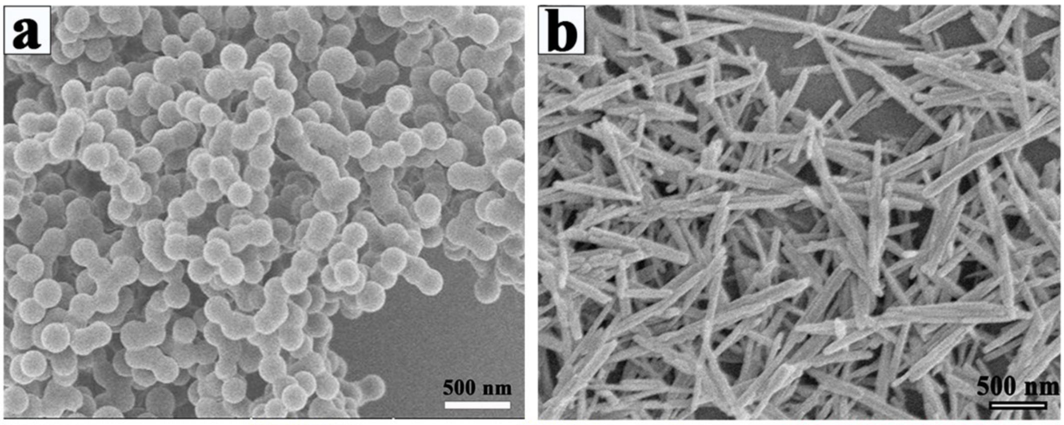

Figure S2. SEM images of (a) NCS and (b) VN NWs.

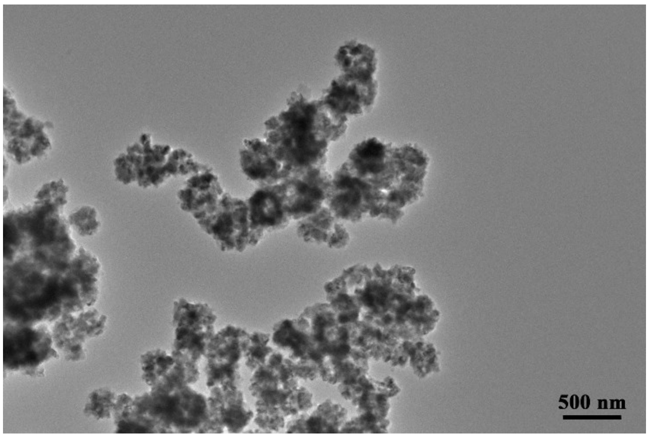

Figure S3. TEM image of V_2O_3/C composite.

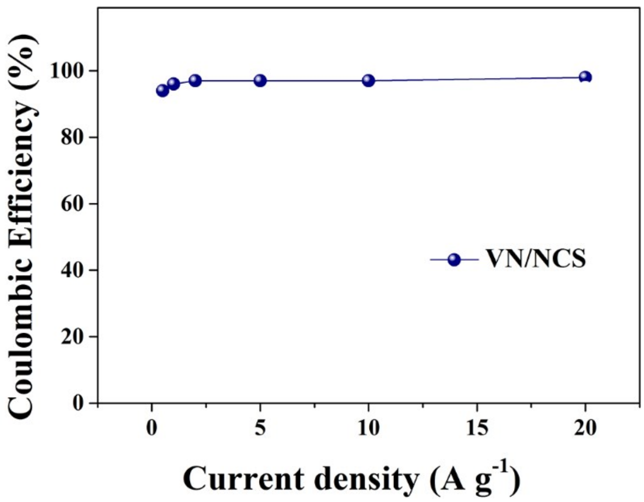

Figure S4. The coulombic efficiency of VN/NCS electrode at the various current densities (0.5-20 A g^{-1}).

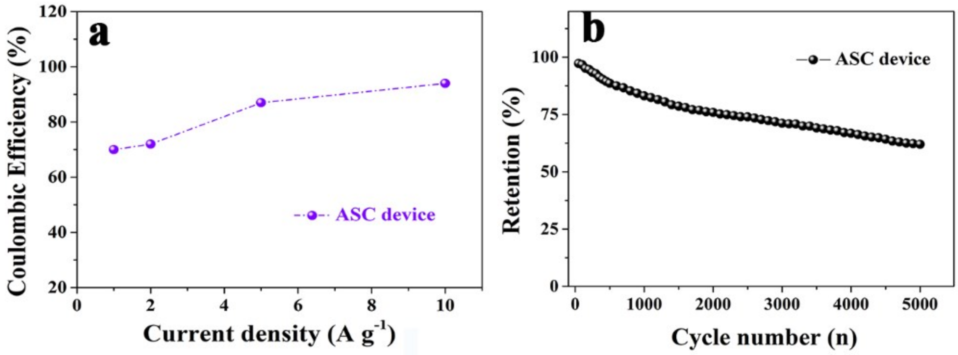

Figure S5. (a) Coulombic efficiency of the ASC device at the current density of 1-10 A g^{-1}, (b) Long-term cycling stability of the assembled ASC device at a current density of 5 A g^{-1}.

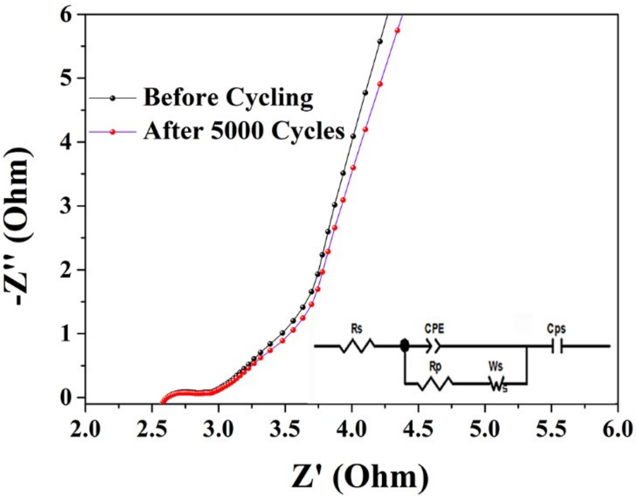

Figure S6. Nyquist plots of the ASC device before and after 5000 cycles.