Electronic supplementary information (ESI)

Self-assembled hairy ball-like V_2O_5 nanostructures for lithium ion batteries

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EXPERIMENTAL SECTION

Materials Synthesis. In a typical synthesis, NH_4VO_3 (1.2 g) and $H_2C_2O_4 \cdot 2H_2O$ in a molar ratio of 1:2 were dissolved in 40 mL of deionized water under vigorous stirring for several hours until a blue clear solution is formed. The obtained blue solution was then added into a 50 mL Teflon container, followed by addition of hexamethylenetetramine under stirring. Then the container was sealed in an autoclave and transferred to an electrical oven and kept at 150 °C for different durations of 30 min, 40 min, 1 h, 2 h, 3 h and 5 h. After cooling down naturally, the precipitates were collected by centrifugation and washed with pure ethanol for three times, then dried at 60 °C overnight. Hairy ball-like V_2O_5 nanostructures were obtained by further calcining the obtained precursor in air at 360 °C for 5 h with a heating rate of 1 °C min^{-1}. In order to further study the temperature effect on the morphologies of the products, the precursors were annealed at 400 or 500°C without changing other parameters. The as-synthesized precursor with heating at 360 °C, 400 or 500 °C were designated as V_2O_5-360 °C, V_2O_5-400 °C, and V_2O_5-500 °C, respectively.

Materials Characterization. X-ray diffraction analyses of the samples were performed using an X-ray diffractometer (XRD, D/MAX2500, Rigaka) with Cu K_α radiation (λ = 1.5418 Å). The morphology of the samples was characterized by scanning electron microscopy (SEM, JEOL JSM-6300, JSM-6360LV) and transmission electron microscopy (TEM, JEOL-2010). For SEM

sample preparation, a thin Au layer (3 nm) was evaporated to form a conducting film for observation. Thermal analysis of the precursor powders were conducted using simultaneous thermal analyzer (STA, NETZSCH, Germany). A heating rate of 10°C/min was adopted. The chemical composition of the samples was analyzed by X-ray photoelectron spectroscopy (XPS, KAlpha 1063, Thermo Fisher Scientific, UK). The Brunauer-Emmett-Teller (BET) specific surface area was performed by ASAP 2020 physisorption analyzer (Micromeritics Instrument Corporation).

Electrochemical Measurements. The working electrode slurry was prepared by dispersing V_2O_5, acetylene black and poly-(vinylidene fluoride) (PVDF) binder in an N-methylpyrrolidone solution at a weight ratio of 80: 10: 10. The slurry was spread on aluminum foil disks and dried in a vacuum oven at 120 °C prior to coin-like cells assembly. Lithium foil was used as the counter and reference electrode, and 1.0 M $LiPF_6$ in ethyl carbonate/dimethyl carbonate (1:1 v/v ratio) was used as the electrolyte. Cyclic voltammetry measurements were performed on an AUTOLAB electrochemical workstation (PG302N). Galvanostatic charging/discharging was conducted on a battery tester (Land CT2001).

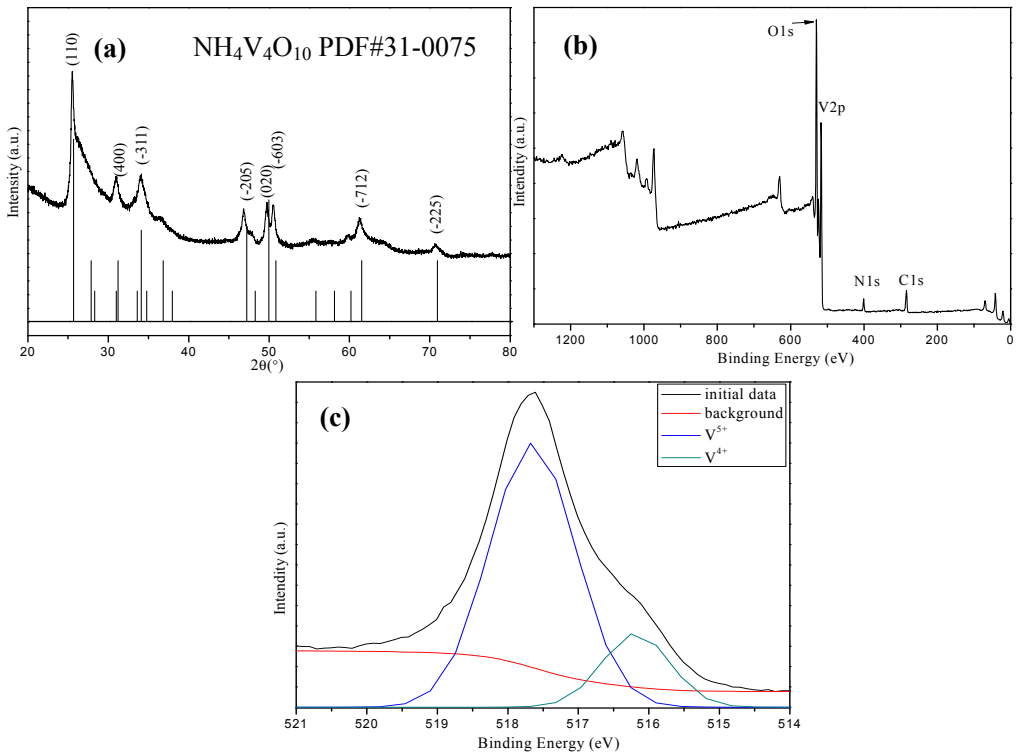

Fig. S1 XRD pattern (a), XPS survey spectrum (b) and high-resolution $V2p^{3/2}$ XPS spectra (c) of the as-prepared sample.

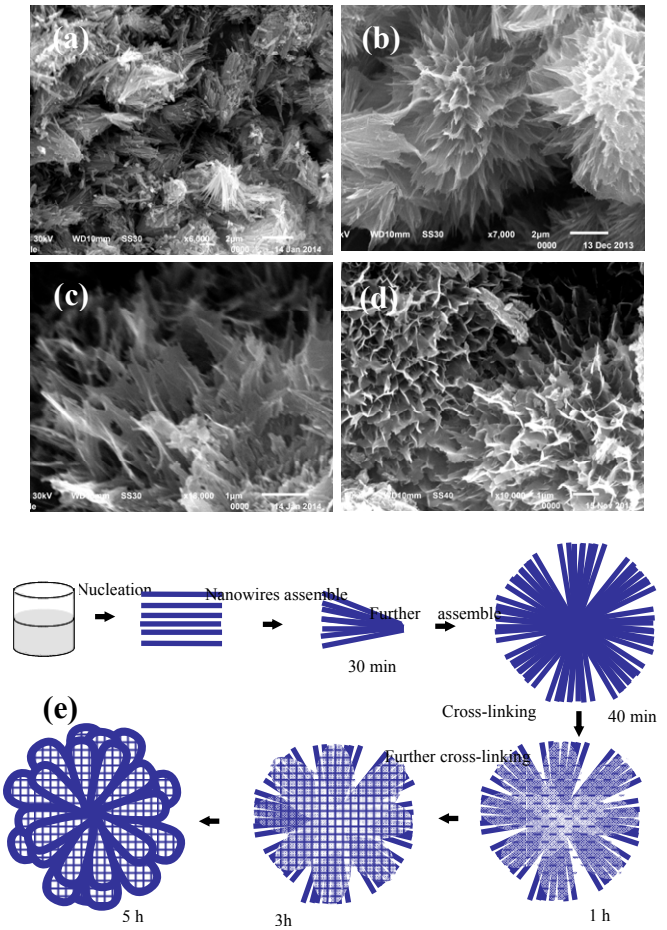

Fig. S2. SEM images of four hydrothermally prepared samples: (a) 30 min, (b) 1 h, (c) 3 h and (d) 5 h. Schematic illustration of the formation process of $NH_4V_4O_{10}$ microspheres from the side view (e).

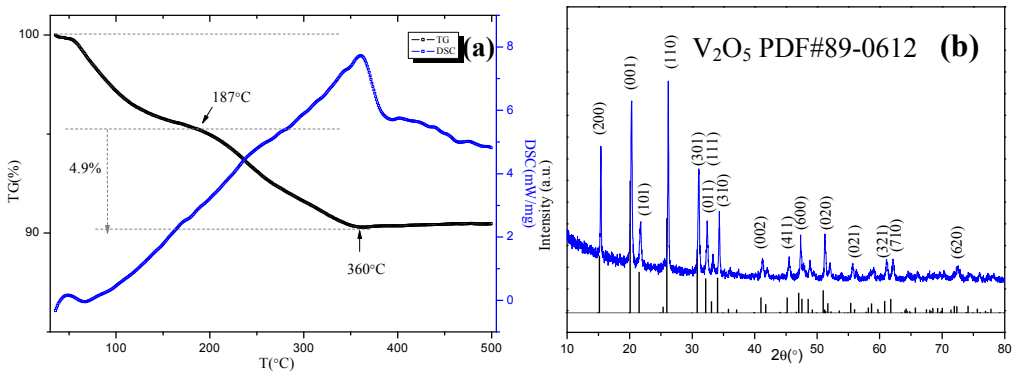

Fig. S3 (a) TG-DSC curves of the $NH_4V_4O_{10}$ powders in air atmosphere with a heating rate of 10°C/min; (b) XRD pattern of hairy ball-like V_2O_5 spheres after annealing at 360 °C.

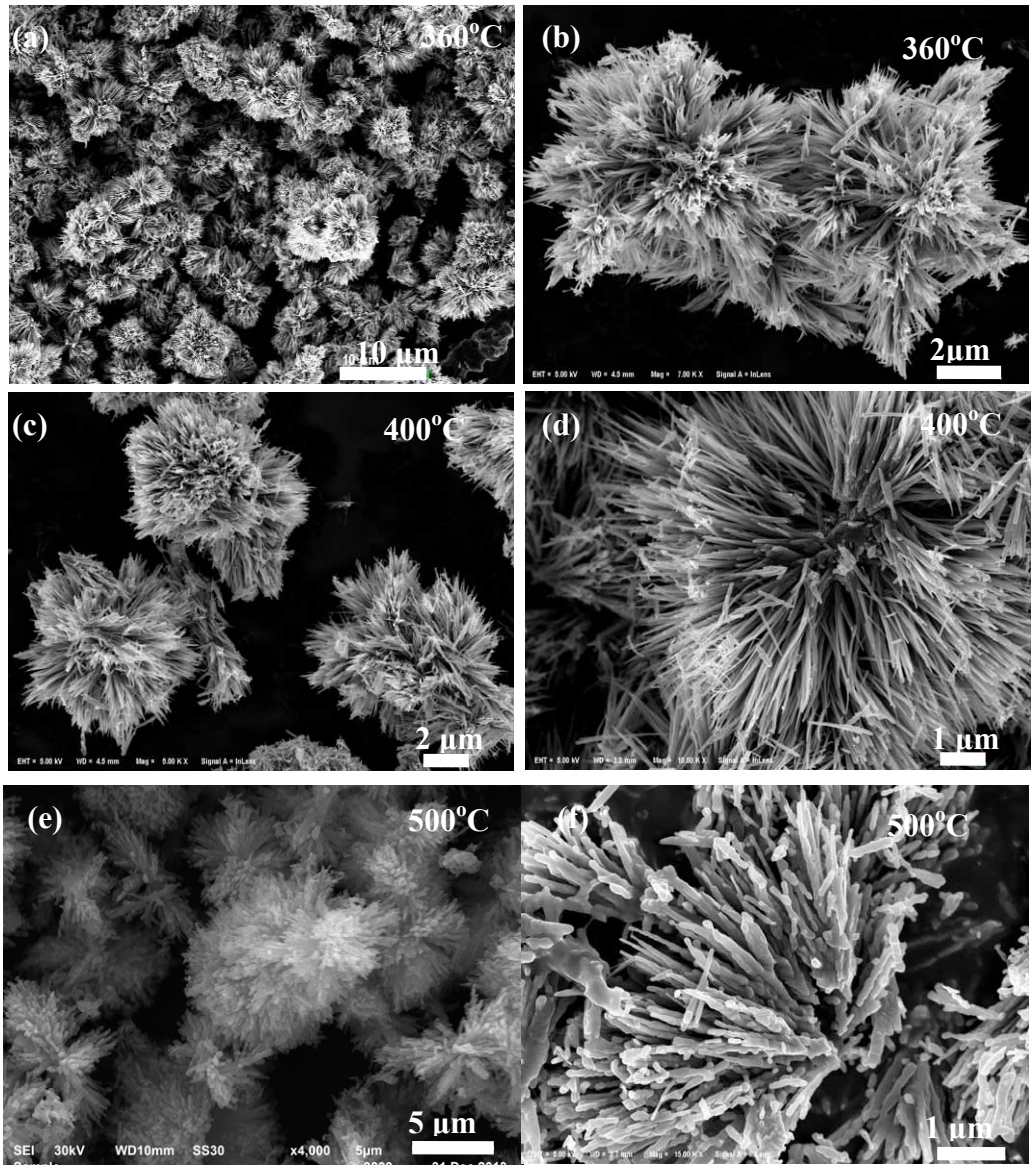

Fig. S4 low-magnification SEM images of hairy ball-like V_2O_5 spheres after annealing at different temperatures: 360 °C (a, b); 400 °C (c, d); and 500 °C (e, f).

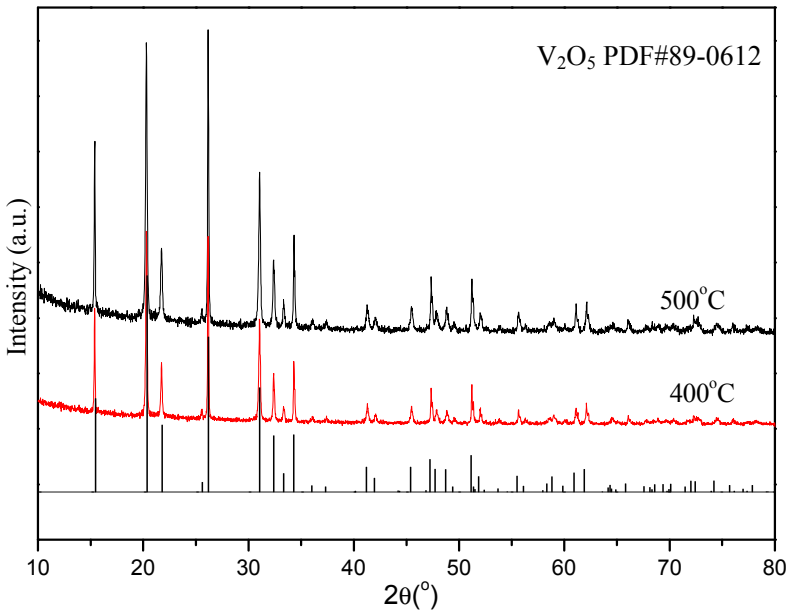

Fig. S5 XRD patterns of V_2O_5 spheres after annealing at 400 and 500 °C.

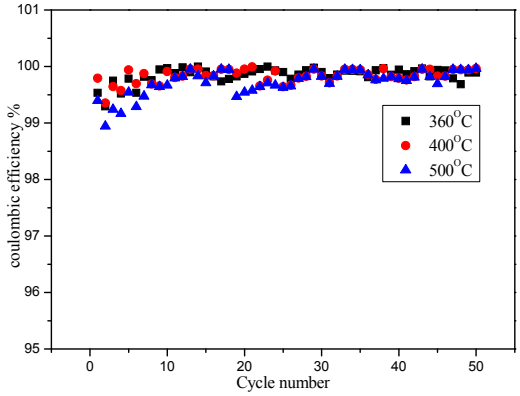

Fig. S6 During the cycles, the coulombic efficiency of V_2O_5 spheres after annealing at different temperatures.