Facile synthesis of vanadium oxide nano-microstructures for sodium-ion battery cathode

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Nowadays, sodium-ion battery has been brought into focus in large-scale electric energy storage applications for renewable energy and smart grid because of its huge abundant sodium resources and low cost. One of the problems confronting sodium-ion battery today is to find long cycle life, low cost, high safety electrode materials and favorable electrolyte. Now people in growing numbers are coming to report and investigate the electrochemical properties vs. Na of various materials. However, few attentions have been paid for vanadium oxides as sodium-ion battery electrode materials. Nano-microstructured materials represent versatile electrode materials for lithium-ion and sodium-ion batteries with tunable and improved electronic properties.

Here we will describe recent studies of the synthesis, characterization, and properties of ammonium vanadium oxide (\(\text{NH}_4\text{V}_4\text{O}_{10}\), \(\text{NH}_4\text{V}_2\text{O}_9\)), novel crystalline (\(\text{NH}_4\text{V}_6\text{O}_{16}\) and graphite nitrate-like ammonium vanadium oxide), vanadium oxide (\(\text{VO}_2\), \(\text{V}_2\text{O}_5\), and \(\text{V}_6\text{O}_{13}\)) and sodium vanadium oxide (Na\(_{0.33}\)\(\text{V}_2\text{O}_5\)) nano-microstructures.

First, \(\text{NH}_4\text{V}_4\text{O}_{10}\) nanorods, macroporous \(\text{NH}_4\text{V}_2\text{O}_9\) microspheres with macropores, \(\text{V}_2\text{O}_5\) microspheres, \(\text{NH}_4\text{V}_2\text{O}_9\) square platelet, vanadium oxide cluster hybrid \(\text{V}_6\text{O}_{13}\) micro-flowers, new crystalline (\(\text{NH}_4\text{V}_6\text{O}_{16}\) platelets and graphite nitrate like ammonium vanadium oxide hierarchical nano-microstructures were prepared by a simple hydrothermal method.

Second, All these vanadium oxide nano-microstructures were tested as cathode materials for sodium-ion battery. The optimized electrochemical performance was achieved by doping cation and graphene, adjustment of morphologies and selecting proper electrolyte. Notably, ammonium vanadium oxide and \(\text{V}_6\text{O}_{13}\) are promising cathode materials for sodium-ion battery.

Third, the possible reason for the effect of various cation on ammonium vanadium oxide will be mentioned.

Last, we will describe new work focused on low potential sulfide anode materials. Prospects and unique opportunities for sodium-ion battery and applications are discussed.

![Figure 1](image1.png)

**Figure 1** SEM images of \(\text{NH}_4\text{V}_2\text{O}_9\).