A New Cathode Material for Rechargeable Batteries: Synthesis, Characterization, and Electrochemical Performance of "MV_3O_8 nH_2O"

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The aqueous synthesis and electrochemical properties of the new nanocrystalline phase MV_3O_8 nH_2O (nominal composition) are described. It is easily made by precipitation from acidified vanadate solutions, followed by drying. MV_3O_8 nH_2O has been characterized by X-ray powder diffraction (Figure 1), electron microscopy, TGA, chemical analyses, and electrochemical studies. The actual composition is $M_{1-x}V_3O_8A_y$ nH_2O, where M is a cation from the starting vanadate salt and A is the anion from the acid. This material exhibits high, reversible Li capacity and may be considered for use in a cathode in primary and secondary batteries.

Critical parameters identified in the synthesis of MV_3O_8 nH_2O, with respect to achieving high Li-ion insertion capacity and product yield, are acid/vanadium ratio (H^+/V), starting vanadate salt, and temperature. Using material synthesized under optimized conditions, the lithium capacity of electrodes composed of $NH_4V_3O_8$ nH_2O/EPDM/carbon black (88/4/8) is in the range of 380-410 mAh/g (Figure 2) and energy densities are as high as ~ 1000 Wh/kg (120 µm thick, 4-1.5 V, using a Li metal anode).

An appealing feature of the synthesis method is the ability to easily dope in other metals, or to precipitate the product in the presence of other solid materials in order to modify the final physical and electrochemical properties. For example, incorporating carbon black into the product can significantly decrease the electrochemical-cell polarization. This is done by precipitating the MV_3O_8 nH_2O in the presence of carbon. With 8 % wt. carbon in the MV_3O_8 nH_2O particles, the lower polarization (Figure 3) is believed to be due to better electronic conductivity. Lower polarization is most evident in the 1.5-2.5 V range.

Other modifications of the synthesis method, such as the chemical doping of silver or other metals, or precipitation of MV_3O_8 nH_2O in the presence of other solid materials, may further improve the final physical and electrochemical properties.

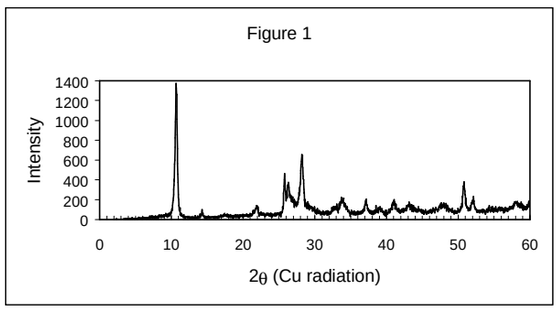

Figure 1. Typical XPD pattern of MV_3O_8 nH_2O

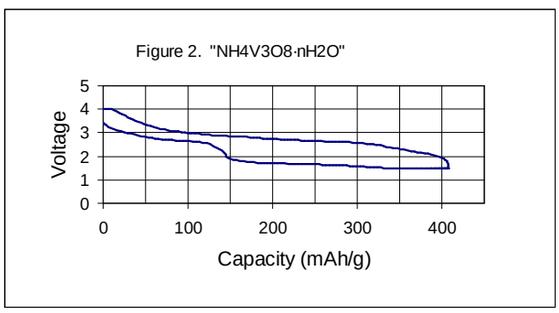

Figure 2. Charge-discharge cycle for $NH_4V_3O_8$ nH_2O (nominal composition).

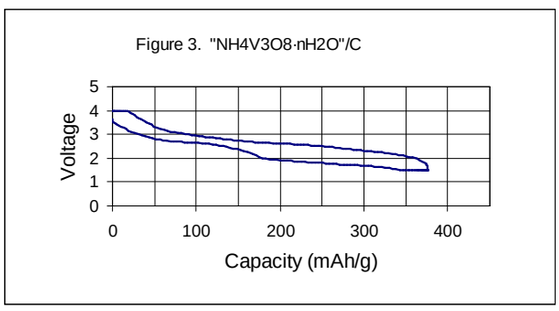

Figure 3. Charge-discharge cycle for $NH_4V_3O_8$ nH_2O (nominal composition) precipitated onto carbon.