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Publication date: 2016

Citation for published version (APA):

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Vanadium Oxide Nanotubes as Cathode Material for Mg-ion Batteries

Christian Kolle Christensen,a, Daniel Risskov Sørensen,a Espen Drath Bojesen,b Jette Mathiesen,b, Jonas Hyldahl Kristensen,a Bo Brummerstedt Iversen,b and Dorthe Bonholdt Ravnsbæk a

1Department of Physics, Chemistry, and Pharmacy, University of Southern Denmark, 2Department of Chemistry, Aarhus University, 3DTU Energy, Danish Technical University

Introduction
Vanadium oxide compounds as cathode material for secondary Li-ion batteries gained interest in the 1970’s due to high specific capacity (>250mAh/g), but showed substantial capacity fading.1 Developments in the control of nanostructured morphologies have led to more advanced materials, and recently vanadium oxide nanotubes (VOx-NT) were shown to perform well as a cathode material for Mg-ion batteries.2 In this study we have synthesized a series of VOx-NTs with varying spacer molecules. The mechanism for Mg-intercalation and deintercalation was studied by TEM-EDX and operando synchrotron powder X-ray diffraction measured during battery operation.

Materials and Methods

• Mg2+ was successfully intercalated into C12-VOx-NTs
• Expansion and subsequent distortion of V7O16-layers
  - Increase in interlayer spacing
  - Second and smaller interlayer spacing forms
• Results indicate 150 mAh/g reversible capacity at C/10-rate

Results

• In house PXD diffraction (Fig 2) of the VOx-NTs as prepared was obtained on a Rigaku Miniflex diffractometer.
  - 00l reflections are found at low angles. These are associated with the interlayer spacing, c = 27.7Å, when dodecyl amine C12H25NH3 is used as spacer molecule.
  - 4x0 reflections are found at higher angles. These can be fitted to the 2D tetragonal basal layer (Fig. 1) with a = b = 6.12Å.

Discussion

The VOx-NTs are able to accommodate large change in layer spacing (~50%) upon exchange of the intercalated ions and retain their structural integrity. This ability makes it a interesting cathode material for Mg-ion batteries.

In the operated battery the (001) diffraction signal moved to lower angles during discharge, corresponding to a larger interlayer spacing. Simultaneously a new peak formed at a higher angles corresponding to shorter interlayer spacing. Mg-intercalation in the multilawed VOx-NTs occurs within the space between the individual vanadium oxide layers of the nanotubes while the underlying VO2 frameworks constructing the walls are affected only to a minor degree by the intercalation.

Contact information
E-mail: christiankc@sdu.dk
Phone: +45 61 71 21 84

References