

Synthesis and electrochemical properties of porous materials: mesoporous tungsten oxide and vanadium oxide aerogel

E. Baudrin*, G. Sudant*, B. Dunn⁺, J-M. Tarascon*

* Laboratoire de Réactivité et Chimie des Solides, Université de Picardie Jules Verne, CNRS-UMR 6007, 33 rue Saint Leu, 80039 Amiens Cedex, France

⁺ Department of Materials Science and Engineering, University of California, Los Angeles, California 90095-1595, USA

Since the preparation of MCM-41 type materials by Mobil scientists about 10 years ago, there has been rapid progress in the design of porous, high surface area materials. In parallel, the electrochemical properties of nanomaterials have become the subject of a growing number of studies due to their specific behavior. Evolving from bulk materials to a smaller scale can affect the electrochemical mechanism or favour new reactions. The main advantage of high surface area materials is to reduce the diffusion length in the solid thus enabling faster reactions. We will illustrate these phenomena through two examples: mesoporous tungsten oxides for electrochromic applications and vanadium oxide aerogels as cathode material in lithium batteries.

A convenient approach for preparing mesoporous materials is to use a block-copolymer as a template. This approach allowed Stucky's group¹ to synthesize various oxides (TiO₂, ZrO₂, Nb₂O₅, SnO₂, WO₃...) with ordered large pores. By using this sol-gel path we prepared thin, mesoporous tungsten oxide electrodes which showed enhanced coloration/bleaching with very good reversibility in aqueous medium². As we will show, these improved properties are related to the highly porous texture of the solid.

The importance of vanadium oxide texture on electrode performance has also been well established over the past few years. In particular, it was reported that extra capacity was obtained for aerogels (~300 m²/g) compared to xerogels (~10 m²/g) or crystalline V₂O₅ (<1 m²/g)³. This reactivity was first explained by a pseudocapacitive behavior⁴ but a faradic view has been recently published⁵. In the present work we have optimized the synthesis conditions of vanadium oxide aerogels through the use of a freeze drying method. This has allowed us to obtain a range of materials with different textures and degrees of crystallization. The aerogels typically react with about 3 lithium ions per V₂O₅ (450 mAh/g) for a C/10 regime (Fig. 1). The use of a faster regime (C) induces only a small reversible capacity decrease for the high surface area material. This is only one of the positive attributes of the electrochemical properties of such oxides. The electrochemical insertion of other ions and the characterization of reduced materials will be developed in order to better describe the novel behavior of aerogels.

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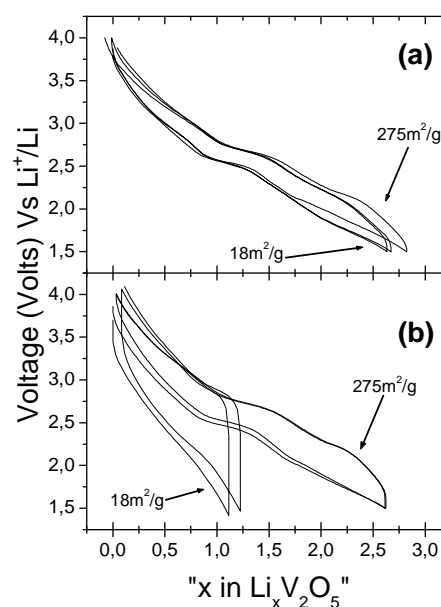


Fig. 1: Galvanostatic lithium reaction with a 275 m²/g and a 18 m²/g vanadium oxide aerogel at two regimes (a) C/10 (b) C