

In-Situ Polymer Coating of V₂O₅ Nanowires for Improved Cathodic Stability

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When developing rechargeable lithium-ion battery electrodes out of next generation materials, addressing the challenges of irreversible capacity, cycle stability, and efficiency are paramount. Cathode materials like lithium iron phosphate and vanadium oxide have unique challenges associated with their use in Li-ion cells, including large volumetric changes and poor conductivity. Through a combination of altering the active material nanostructure and applying thin polymer coatings to the surface, the cycling performance of electrodes can be significantly improved [1].

Vanadium pentoxide, with a theoretical capacity of ~440mAh/g [2], is increasingly regarded as an alternative Li-ion cathode material to more commonly used LiCoO₂, LiFePO₄, and LiMnO₂, but poor conductivity and cycle stability remain major obstacles to its use. The synthesis of V₂O₅ nanowires and their evaluation in devices has shown that a high aspect ratio nanostructure improves the electrical conductivity and the speed of ion diffusion while allowing for fully reversible lithium intercalation [3]. Here, we demonstrate a facile one-pot hydrothermal growth of V₂O₅ nanowires (Fig. 1) and the subsequent coating of electroactive polyaniline (PANI) onto the V₂O₅ surface (Fig. 2). The application of polymers by a simple in-situ polymerization method [4-6] is shown to nearly double the capacity of V₂O₅ and improve its rate capability in half cells versus Li foil (Fig. 3). We demonstrate the controllable nature of the coating method through syntheses of V₂O₅-PANI composites with weight percentages of PANI ranging from 21-51%. We find that increased amounts of PANI in the composite correlates with increased stability, with particular improvement at higher rates.

Formation of V₂O₅ nanowire composite electrodes via the layer-by-layer (LbL) method [7] is aided by the improved dispersion quality of V₂O₅-PANI composites in cathode nanoparticle inks. Sequential application of these solutions with oppositely charged polyelectrolytes permits the facile assembly of V₂O₅-composite thin films. Coupling these two techniques of polymeric coating (LbL and in-situ polymerization) yields thin film electrodes that are easily integrated into a microbattery architecture.

References:

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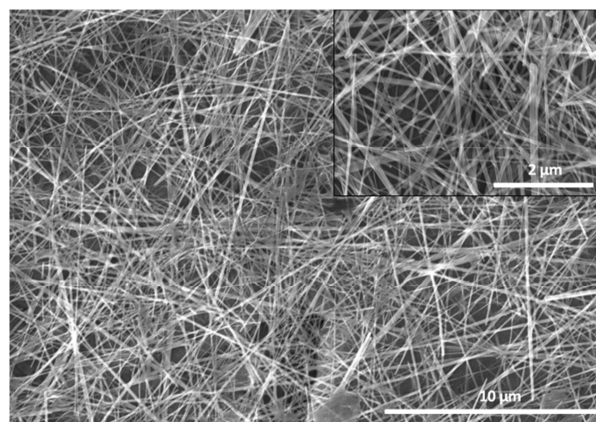


Figure 1. Hydrothermally grown V₂O₅ nanowires

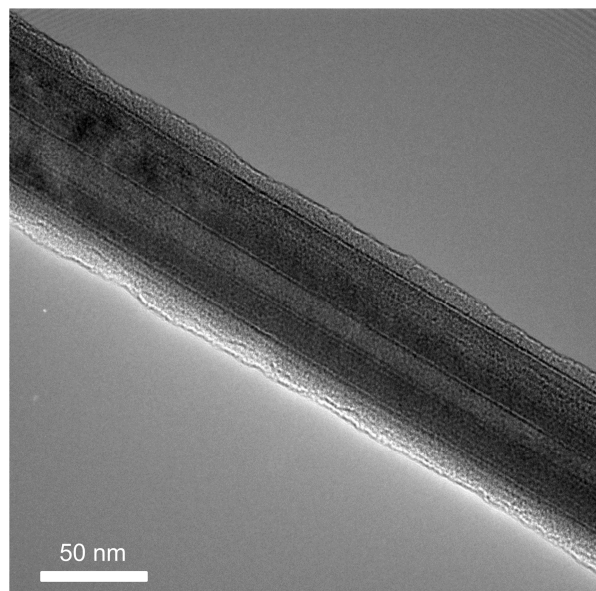


Figure 2. TEM image of V₂O₅-PANI sample

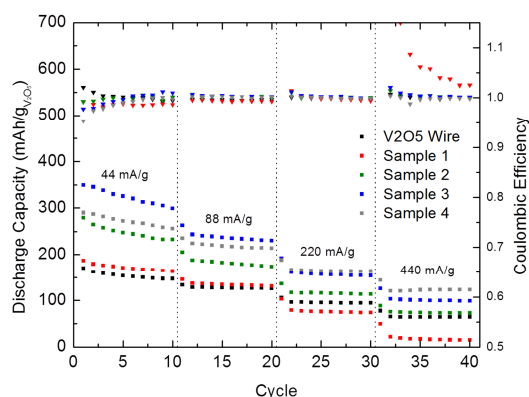


Figure 3. Half-cell capacity of V₂O₅-PANI composites under several charge rates