

## Effect of Water in Electrolyte on Ca<sup>2+</sup> Intercalation/De-intercalation Properties of $\alpha$ -V<sub>2</sub>O<sub>5</sub>

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Calcium ion batteries have been attracting attention as next generation secondary batteries because of their higher energy density, higher safety, lower costs and more abundant elements than lithium ion batteries. On the other hand, one critical issue impeding progress in the batteries is development of a suitable organic electrolyte without a strong negative impact on electrochemical properties of the electrode material. When a completely-dehydrated organic electrolyte cannot be prepared in order to evaluate the electrochemical properties, it may give an unreliable consideration due to an influence of water in the study such as electrochemical reaction potential, structural change of electrode materials and electrolyte stability<sup>1,2</sup>. In this study, the influence of water on the Ca<sup>2+</sup> intercalation/de-intercalation properties of  $\alpha$ -V<sub>2</sub>O<sub>5</sub> was studied by changing water content in a conventional organic electrolyte.

We used  $\alpha$ -V<sub>2</sub>O<sub>5</sub> synthesized by sol-gel method<sup>3</sup> as the working electrode and 0.5 molL<sup>-1</sup> Ca(TFSI)<sub>2</sub>/ EC:PC (1:1 in vol.) +H<sub>2</sub>O as the electrolyte. The electrode was prepared by mixing the synthesized  $\alpha$ -V<sub>2</sub>O<sub>5</sub>, acetylene black (AB) and PTFE with a weight ratio of 70:10:10, then roll-pressing, followed by cutting into pellets 8mm in diameter. A constant current discharge-charge experiment was performed at 50 $\mu$ Acm<sup>-2</sup>.

The results of constant current discharge/charge test showed that overvoltage gradually decreases as the amount of water increases. From ex-situ XRD analyses of the  $\alpha$ -V<sub>2</sub>O<sub>5</sub> cathode after discharge in the electrolyte with different water content, no significant structural change was observed depending on the amount of water in the electrolyte. On the other hand, quantitative elemental analysis of ICP-AES suggested the co-insertion of H<sup>+</sup> in water containing electrolyte<sup>2</sup>. Bulk structure of the electrolyte with different water content was evaluated by Raman spectroscopy. From the result, it was revealed that co-solvation of water to Ca<sup>2+</sup> and salt dissociation were enhanced with increasing the amount of water.

From the experimental results mentioned above, it is considered that water contained in the electrolyte affects electrochemical properties of  $\alpha$ -V<sub>2</sub>O<sub>5</sub> through insertion of H<sup>+</sup>, co-solvation of water to Ca<sup>2+</sup> and enhancement of salt dissociation. Among them, it was suggested that the influence of the latter two electrolyte structure changes is rather strong and dominating the decrease in overvoltage.

### References:

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