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V₂O₅ doped with Conducting Polymer PEDOT for Cathodes of Aqueous Zinc-Ion Batteries

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Aqueous zinc-ion batteries (AZIBs) have received much attention recently as alternative power sources, owing to the advantages of high theoretical capacity, low cost, environmental friendliness, and good safety. Among the various possible cathode materials for AZIBs, V₂O₅ is considered as a promising cathode material due to its rather stable open structure facilitating zinc ion insertion. Recent studies have shown that pre-insertion of conducting polymers into the layered structure of V₂O₅ results in better electrochemical performance of the cathode materials [1,2].

In this work we have investigated the electrochemical performance of different kinds of V₂O₅-based electrodes, with pristine and electrospun V₂O₅, and V₂O₅ doped with poly(3,4-ethylenedioxythiophene) (V₂O₅/PEDOT). The structure and morphology of all materials were studied by high resolution X-ray diffraction, energy dispersive X-ray spectroscopy, scanning electron microscopy, optical microscopy, and X-ray photoelectron spectroscopy. Electrochemical performance was studied in CR2032 coin cells with aqueous 3 M ZnSO₄. Electrochemical tests were performed by galvanostatic charge/discharge (GCD) and cyclic voltammetry (CV) in the (0.3–1.4) V potential range vs. Zn/Zn²⁺ at room temperature (20±2 °C). GCD tests were performed in the (0.3–20) A g⁻¹ current range using CT-4008 battery testing system (Neware Co., China), CV measurements were carried out at a scan rate of 0.1 mV s⁻¹ using a BCS-805 potentiostat (Biologic, France).

The activation process of V₂O₅ material structure and the corresponding evolution of electrochemical performance and enhancement of capacity was observed at initial several cycles. It is related to interlayer expansion taking place due to co-insertion of counter ions and water molecules with gradual transformation of V₂O₅ layered structure. After the transformation, two pairs of stable peaks appear at 0.78 V / 0.58 V, and 1.05 V / 0.88 V, which probably correspond to the consecutive redox process of V⁵⁺ to V³⁺, forming Zn_xV₂O₅ phases with different degrees of Zn²⁺ intercalation. Alternatively, both Zn²⁺ and protons intercalation may occur. The maximal values of specific capacities for initial and nanostructured forms of V₂O₅ were found as 260 mAh g⁻¹ at 0.1 A g⁻¹ and 350 mAh g⁻¹ at 0.1 A g⁻¹, respectively.

At the in situ oxidative polymerization/intercalation of 3,4-ethylenedioxythiophene, the V₂O₅ framework was partly reduced, so that the mixed valence compounds with increased overall electrical conductivity of V₂O₅/PEDOT were formed. Accordingly, this modification improved the cycle performance of the material. V₂O₅/PEDOT electrodes reach high steady-state capacity values without long activation processes commonly proceeding with pristine V₂O₅ electrodes. V₂O₅/PEDOT electrodes provide high specific capacity 380 mAh g⁻¹ at 0.3 A g⁻¹, improved C-rate capability (274 mAh g⁻¹ and 102 mAh g⁻¹ at 5 A g⁻¹ and 20 A g⁻¹, respectively, and better stability during long-term cycling (7% capacity loss during 200 cycles at 5 A g⁻¹).

Detailed analysis of electrochemical performance of electrodes and the reasons of improved electrochemical performance will be discussed in the report.

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References

1. A.I. Volkov, A.S. Sharlaev, O.Ya. Berezina, E.G. Tolstopjatova, L. Fu, V.V. Kondratiev, *Materials Letters* **308** (2022) 131212 (doi.org/10.1016/j.matlet.2021.131212).
2. F.S. Volkov, E.G. Tolstopjatova, S.N. Eliseeva, M.A. Kamenskii, A.I. Vypritskaia, A.I. Volkov, V.V. Kondratiev, *Materials Letters* **308** (2022) 131210 (doi.org/10.1016/j.matlet.2021.131210).