Mechanistic investigation on hybrid Zn/V_2O_5 rechargeable battery using a binary Li^+/Zn^{2+} aqueous electrolyte

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Low cost, easy processing and environment-friendly aqueous rechargeable zinc batteries have great potential for large-scale energy storage, which justifies they have been receiving extensive attention in recent years. An original concept based on the use of a binary Li^+/Zn^{2+} aqueous electrolyte is described here in the case of Zn/ V_2O_5 system.

The Zn // Li_2SO_4 − $ZnSO_4$ // V_2O_5 cell presents, in the narrow 1.6 - 0.8 V voltage range, interesting capacity values about 136-125 mAh g^{-1} at C/20-C/5 rates respectively. At 1C, a capacity of 80 mAh g^{-1} is outstandingly stable over more than 300 cycles with a capacity retention of 100 %. A detailed structural study by XRD and Raman spectroscopy allows unravelling the peculiar response of the V_2O_5 layered host lattice. Strong similarities with the well-known structural changes reported in nonaqueous lithiated electrolytes are highlighted, although the emergence of the usual distorted δ-Li V_2O_5 phase is not detected upon discharge to 0.8 V. The pristine host structure is restored and maintained along cycling with mitigated structural changes leading to the high capacity retention. The present electrochemical and structural findings reveal a reaction mechanism mainly based on Li^+ intercalation, but cointercalation of a few Zn^{2+} ions cannot be completely dismissed. The presence of zinc cations between the oxide layers is thought to relieve the structural stress induced in V_2O_5 under operation, resulting in a limited volume expansion of 4 %.

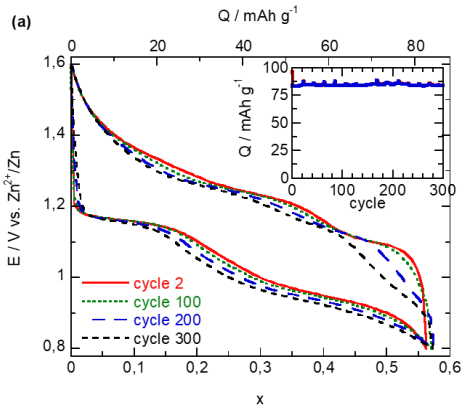

Fig. 1. Cycling performance of V_2O_5 in the Zn/Li_2SO_4-$ZnSO_4$/V_2O_5 aqueous battery at 1 C in the 1.6 V/0.8 V voltage range.

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