Na$_3$V$_2$(PO$_4$)$_3$/C nanocomposite as cathode material for sodium ion batteries

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Sodium ion batteries are now actively pursued as the most attractive alternative to Li-ion batteries for large-scale energy storage, because of their potential advantages of low cost, environmental benignity and widespread availability of sodium resources. Therefore, it is a great challenge to explore new anode and cathode materials and optimize their performance to realize their high redox capacity for reversible Na-ion storage. Na$_3$V$_2$(PO$_4$)$_3$ as a cathode material showed the most promising electrochemical performance. In this study, we explored a new method to synthesize the Na$_3$V$_2$(PO$_4$)$_3$/C nanocomposite, and investigated the electrochemical performances of the Na$_3$V$_2$(PO$_4$)$_3$/C nanocomposite in Na cells.

The Na$_3$V$_2$(PO$_4$)$_3$/C cathode material was synthesized by a simple mechanochemical reaction. V$_2$O$_5$, NH$_4$H$_2$PO$_4$, Na$_2$CO$_3$, oxalic acid and appropriate sucrose were put into a ball-milling vial with some ethanol. Then the mixture was dried by high-energy ball milling for 2 h under Ar. The mixing precursor was dried and sintered for 8h at 800°C in Ar atmosphere to yield the Na$_3$V$_2$(PO$_4$)$_3$/C composites. The Na$_3$V$_2$(PO$_4$)$_3$/C material had been characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and transmission electron microscopy (TEM). The electrochemical measurements were based on cyclic voltammetry (CV) and galvanostatic techniques.

CV test was performed with a powder microelectrode at a scan rate of 0.1 mV s$^{-1}$ (Fig. 1). A pair of very symmetric redox bands with their anodic and cathodic peak currents at 3.41 V and 3.29 V can be observed, ascribable to the V$^{4+}$/V$^{3+}$ redox couple. Fig. 2 shows the charge/discharge curves of the Na$_3$V$_2$(PO$_4$)$_3$/C cathode at a current rate of 20 mA g$^{-1}$, it has a pair of flat plateaus which are similar to LiFePO$_4$. The initial discharge capacity was 106 mAh g$^{-1}$, indicated that 1.8 Na can be reversibly inserted during the first discharge. As shown in Fig. 3, the Na$_3$V$_2$(PO$_4$)$_3$/C material exhibited decent cycling performance. A reversible capacity of 95 mAh g$^{-1}$ was retained throughout 50 cycles, showing good cycling performance. Further results about the electrochemical and structural properties of the electrode materials will be exposed and discussed in the meeting.

References:

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