Electrochemical Performance of Li$_{0.995}$Al$_{0.005}$Mn$_{0.85}$Fe$_{0.15}$PO$_4$/C as a Cathode Material for Lithium-Ion Batteries

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A solid-state reaction route was used to prepare Li$_{0.995}$Al$_{0.005}$Mn$_{0.85}$Fe$_{0.15}$PO$_4$/C, and the prepared sample were characterized by X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM) and electrochemical tests. The results of XRD and XPS show that Al$^{3+}$ and Fe$^{2+}$ are soluble in the Li site and the Mn site to generate a solid-solution, resulting in a shrinkage of crystal lattice and creations of Al$^{3+}$-vacancy pairs and Fe$^{2+}$-vacancy pairs. Compared with Li$_{0.995}$Al$_{0.005}$MnPO$_4$/C, LiMn$_{0.85}$Fe$_{0.15}$PO$_4$/C and LiMnPO$_4$/C, Li$_{0.995}$Al$_{0.005}$Mn$_{0.85}$Fe$_{0.15}$PO$_4$/C exhibits much better rate capability and cycling stability. When charged and discharged at 1 C, Li$_{0.995}$Al$_{0.005}$Mn$_{0.85}$Fe$_{0.15}$PO$_4$/C delivers a discharge capacity of 139 and 160 mAh·g$^{-1}$ at 25 and 60 °C, and its capacity retention ratio is 100 % after 50 cycles, respectively. The enhanced property of LiMnPO$_4$/C can be attributed to the synergistic effect of Al$^{3+}$ doping at the Li site and Fe$^{2+}$ doping at the Mn site, leading to a great improvement in the dynamic stability of the olivine structure, Li$^+$ diffusion and electrode kinetics. Thus, the electrochemical properties of lithium manganese phosphate can be effectively improved by Fe$^{2+}$ doping at the Mn site and aliovalent ion doping at the Li site.

Keywords: Lithium ion batteries; Cathode; Lithium manganese phosphate; Cation substitution

FULL TEXT

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