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The electrochemical effect of Al-doping on $Li_4Ti_5O_{12}$as anode material for lithium-ion batteries

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Abstract

This work investigates the electrochemical performance of Al-doped $Li_4Ti_5O_{12}$(LTO) on the Li site ($Li_{4-x}Al_xTi_5O_{12}$) and Ti site ($Li_4Ti_{5-x}Al_xO_{12}$) (x = 0.15), evaluated by galvanostatic charge-discharge tests and the electrochemical impedance spectroscopy. The physical properties of the synthesized materials were determined by XRD, SEM, Raman and XPS analyses. The Al dopant observed on different sites of $Li_4Ti_5O_{12}$ showed resultant effects on the morphology, particle size, structural arrangement and crystallinity of the materials. XRD and XPS results showed peak shifts to higher angles and lower binding energies, respectively. Moreover, XPS revealed the majority of Al doped into the Ti site for $Li_4Ti_{4.85}Al_{0.15}O_{12}$ and into the Li site for $Li_{3.85}Al_{0.15}Ti_5O_{12}$. $Li_4Ti_{4.85}Al_{0.15}O_{12}$ has shown much improvement of the reversible capacity and rate capability of LTO without Li deficiency compared with $Li_{3.85}Al_{0.15}Ti_5O_{12}$. $Li_4Ti_{4.85}Al_{0.15}O_{12}$ also demonstrated superior reversible capacity at 0.2 C (172.7 mAh/g), 0.5 C (143.7 mAh/g) and 1 C (132.1 mAh/g). These were comparatively higher than $Li_4Ti_5O_{12}$ (154.8, 124.1 and 100.7 mAh/g, respectively) and $Li_{3.85}Al_{0.15}Ti_5O_{12}$ (154.4, 133.6 and 120.3 mAh/g, respectively).