Enhanced Electrochemical Performances by Carbon Surface Modification on the $Li_4Ti_5O_{12}$ Anode Material for Sodium-Ion Batteries

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Sodium-ion battery (SIB) system, which is close alternative new-generation battery system to the LIBs due to abundance of the alkali ion's resource, has only few candidates for its available anode material, while the various carbon-based materials or alloy-based materials has been proposed. However, both systems of anode materials are suffered from formation of insulating solid-electrolyte interphase (SEI) layer or severe volume change problems in the long-term cycling.

Spinel-type $Li_4Ti_5O_{12}$ (LTO) has well known as one of the promising anode material in the lithium-ion battery (LIB) system because of the low cost, easy material preparation, and stable intercalation reaction type anode material without a formation of harmful SEI layer and negligible volume change in the cycling. Besides, LTO also has been applied to the SIB system after the examination of Na-storage behavior in the LTO which was introduced by Hu et. al.[1] The LTO shows relatively flat and high potential plateau for its Na^+ insertion/deinsertion reaction at around 0.9 V (vs. Na/Na^+), and displays a reversible capacity of 145 mA h g^{-1}.

Although LTO has stable electrochemical and chemical stability as the anode material for SIBs, this LTO exhibit intrinsically low electric conductivity which causes poor cyclability and rate capability. The low electric conductivity of LTO is generally derived from Ti^{4+}'s electron configuration of $[Ar]3d^0$ in the oxide structure.

In our work, we introduced the carbon coating layer which is easy and cheap technique for the enhancement of conductivity for LTO using a citric acid. The simple sol-gel coating process employed our preparation process, and the formed carbon coating layer well suppressed overvoltage during the cycling. The retention of capacity also increased about 75.9% whereas the pristine LTT retains only 51.6% over 50 cycles at 0.05 C. The enhanced electric conductivity was exhibited by low impedance characteristics of lower charge transfer resistance of 1.55 Ω compared to the pristine one (2.83 Ω), and higher rate capability than the pristine LTO.

References:

[1] Z. Liang, H.-L. Pan, Y.-S. Hu, H. Li, and L.-Q. Chen, Chin. Phys. B 21 (2012) 028201.