Hierarchical Carbon Coated $Li_4Ti_5O_{12}$-TiO_2 Octahedron-like Nanoparticles Composed Microspheres for High Performance Li-ion Batteries

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Over the past decades, there have been many projections about renewable energy technologies on the future depletion of the fossil fuel reserves on earth as well as the rapid increase in green-house gas emissions. For reduction of emissions of carbon dioxide and conquer the greater and greater scarcity of fossil fuels, one of the most effective ways is to use electrical vehicles (EVs) or hybrid electrical vehicles (HEVs).[1] Those electric vehicles will require the development of advanced rechargeable batteries. In recent commercial lithium ion batteries (LIB), graphite is a widely used anode materials, however, graphite based batteries can't satisfactorily meet the performance of some important applications, especially in the safety, high rate and cycling.[2] Being inherently safe and chemically compatible with the electrolyte, titanium based materials are considered to be alternatives to the commercial anodes in LIB. As a improved anode material, spinel titanium oxides ($Li_4Ti_5O_{12}$), with the Ti^{4+}/Ti^{3+} redox couple showing zero-strain insertion (no structural change) characteristics and extremely flat discharge and charge plateaus at about 1.55 V (versus Li/Li^+) which can avoid reduction of electrolyte on the surface of the electrode and formation of the solid-electrolyte interphase (SEI) layer,[3] resulting in being entirely eliminate potential safety issues and exhibit excellent cycling performance, has been demonstrated as a potential candidate anode materials for the high power LIB. On other hand, anatase TiO_2 also could be considered to be one of the best candidates as a lithium ion host among the Ti-based materials, because this kind material is an appropriate insertion potential (2 V), fast Li ion insertion/extraction and low volume expansion (3-4%) during charge and discharge.[4] Therefore, in this work, we introduce mesoporous carbon coated $Li_4Ti_5O_{12}$-TiO_2 microsized (3-4 μm) hierarchical spheres (C-LTO-HS) consisting of octahedron-like nanoparticles (<100 nm) via a two-step solvo/hydrothermal treatment using tetrabutyl titanate (TBT), acetate acid (HAc) and lithium hydroxide (LiOH),[5] and the microstructure and morphology of the C-LTO-HS products were characterized systematically by SEM, TEM, EDS, XPS, XRD and BET. For application in rechargeable lithium-ion batteries, C-LTO-HS composite electrode delivers a remarkable capacity of above 230 mA h/g when charged/discharged at 0.2 C (Figure 1), which is much higher than the theoretical capacity of neat $Li_4Ti_5O_{12}$ (175 mA h/g). The high capacity should be ascribed to the induction of anatase TiO_2 in C-LTO-HS electrode. Furthermore, this electrode based battery also can yielded good cycling stability and excellent rate capability of about 120 mA h/g at a current density of 10 C up to 100 cycles, which is much higher than that of carbon free LTO-HS electrode (~90 mA h/g) (Figure 1), a reflecting of significant improvements in both the conductivity and Li ion diffusion coefficient after carbon coating.

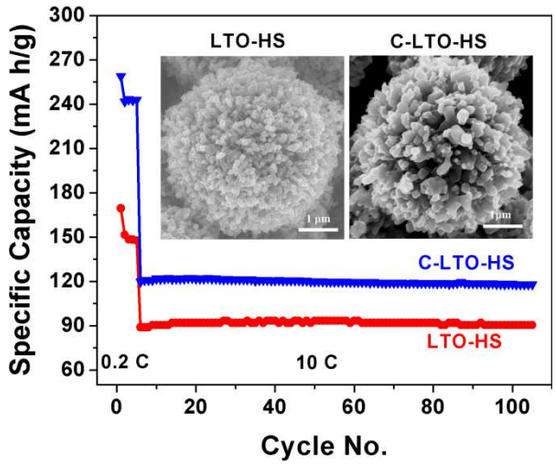

Figure 1. SEM images of LTO-HS and C-LTO-HS and rate performance at 0.2 C and 10 C.

References

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