Synthesis of Porous and Micro-sized LiFePO$_4$/C by a Two-step Crystallization Process and Its Application to Cathode Material in Li-ion Batteries

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LiFePO$_4$ with an ordered olivine structure has been recognized as a promising cathode material for advanced Li-ion batteries due to its excellent thermal and structural stability, low cost of starting materials, high reversibility of Li ion insertion-extraction, and non-toxicity [1]. However, its practical application has suffered from the inherently poor kinetic properties caused by the low electronic and ionic transfer ($\sigma_e = 10^{-1}\text{ Scm}^{-1}$, $D_{Li^+} = 10^{-14}\text{ cm}^2\text{s}^{-1}$ at R.T.) in the LiFePO$_4$ lattice structure [2]. Recently, an improvement in the kinetic property of the LiFePO$_4$ has been accomplished by reducing its particle size to nanoscale [3]. Conversely, though a nano-structured LiFePO$_4$ shows an improved rate-capability, the gravimetric/volumetric energy density of the LiFePO$_4$ electrode is inevitably reduced; that is, the tap density of the LiFePO$_4$ decreases as the particle size decreases, and the mass fraction of bulky and inactive conducting carbon increases to secure the electrical contact between the LiFePO$_4$ nano-particles [4]. Thus, it is necessary to develop high performance LiFePO$_4$/C with high energy density.

To realize LiFePO$_4$/C composites with high energy density and high power density, porous and micro-sized (~10 μm) LiFePO$_4$/C was synthesized by a novel two-step crystallization process, which involves growth technology using LiFePO$_4$ nano-crystals prepared by a hydrothermal process as seed crystals for secondary particle growth.

The effects of synthesis routes (Solution-based and two-step crystallization process) on the crystals structure and electrochemical performance of LiFePO$_4$/C composites were examined. It is demonstrated that the cyclic retention property of the porous and micro-sized LiFePO$_4$/C prepared by the two-step crystallization process is superior to that of the LiFePO$_4$/C prepared by the other process. In addition, the improved kinetic property of the porous LiFePO$_4$/C results from the enlarged reaction sites for Li ion and the short Li ion diffusion length in the porous structure.

Reference