Numerical Analysis of a LiFePO4/Graphite Lithium-ion Coin-cell Battery

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Abstract

Electric vehicles (EVs) powered by rechargeable lithium-ion batteries (LIBs) have been developed as a replacement for the conventional internal-combustion-engine automobiles. Research has been yielding a stream of improvements to the traditional LIB technology, focusing on energy and power density, durability, cost and safety. LiCoO2, which is widely used as a cathode material for lithium-ion batteries, is now being faced to a difficulty in the application for electric vehicles due to its thermal runaway problem as well as high raw material price and resource restrictions. LiFePO4 (LFP) is a favorable choice as a cathode material in EV applications due to its stable and safe olivine structure as well as low cost, environmentally benign chemistry, and abundant iron materials as resources. To improve its material performance, researchers have been working to overcome two major limitations of LiFePO4: low electrical conductivity and small Li-ion diffusivity. The surface coating and the effect of various dopants such as metal ions on the electronic conductivity have been studied. However, it is still unclear whether the conductivity enhancement is truly intrinsic or if it is the result of conductive secondary phases that surround the LFP particles. A thorough understanding of the properties of LiFePO4 cathode used in lithium-ion batteries is necessary.

In this work, the axisymmetric two-dimensional calculation of a LiFePO4/Graphite lithium-ion battery (LIB) sealed in a CR2032-type coin cell is performed by using finite element analysis software COMSOL Multiphysics. The spatial distributions of lithium ion concentration, potential and current density are obtained. The electrode reaction, discharge characteristics, and the influence of separator are analyzed and compared with those from the LiCoO2/Graphite lithium-ion batteries (LIBs).

Key words: Lithium-ion batteries; LiFePO4 cathode; Battery discharge characteristics; Numerical Simulation

References

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