An Electrochemical Model Considering the Electric Double Layer of Nano-size Materials for Lithium Ion Battery

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The demand for batteries capable of providing high energy densities as well as high power densities is rapidly growing [1]. Adopting nanostructured or nanocomposite electrodes in lithium ion batteries is one of the methods to reach the goal [1]. Generally, nano-size electrodes improve energy densities and power densities of battery by shorting Li^+ ions diffusion length and achieving fast charge transfer rate [2]. Besides, in this situation, the Li^+ ions diffusion length in the electrode materials is on a scale of nm, equals to the scale of electric double layer. In addition, the surface-to-volume ratio of nano-size electrode is very large. These factors will lead effect of electric double layer on battery performance more significant. However, in most of electrochemical models for lithium ion battery, the influence of electric double layer of nano-size materials on the chemistry and transport of lithium ion battery is neglected or assumed as a constant capacitance, which leads to the deviation of simulated results and experimental results.

In literatures, the original model is developed by Newman [3] to simulate the thermodynamic and kinetic behavior of lithium ion battery and a modified Gouy-Chapman-Stern model (GCS) is established by Pilon [4,5] to simulate electric double layer capacitors with three-dimensional ordered structures. In this respect, we couples these two models and present an electrochemical model considering the electric double layer of nano-size materials to understand the electrochemical and transport mechanisms within a battery. Using this model, some electrochemical properties under galvanostatic charge/discharge behavior as well as ac-impedance behavior and rapid current pulses are in real time obtained.

References

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