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Parametric Analysis of $LiCoO_2$ Composite Cathode Using Impedance Spectroscopy

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A numerical image of $LiCoO_2$ composite cathode, which is a set of state-of-charge dependent parameters relevant to thermodynamic and kinetic properties of the active material and composite electrode, can be obtained from measurements of electrochemical impedance spectra at several different state of charge in sandwich type three-electrode cell and by fitting of impedance spectra to a linear model consisting of bulk transport, interfacial charge transfer, solid-state diffusion and intercalation with inhomogeneous phase formation of lithium.

Electrochemcial kinetics of intercalation material can be formalized as a nonlinear equivalent circuit of which element values are defined in numerical image. Taking advantage of fast circuit analysis algorithm such formalization allows numerical simulation of discharge behavior at arbitrary load conditions within reasonably short calculation time. The accuracy of performance prediction for $LiCoO_2$ composite cathode was tested by comparing voltage profiles calculated on basis of numerical image at discharge rates from C/10 to 3C.

Model parameters represented as resistance or capacitance at a given state of charge can also be used to compare the relative contribution from different kinetic steps on discharge behavior in composite electrodes. We investigated the change of relative contributions of kinetic parameters upon thickness by generating impedance spectra of composite electrode at different thickness. Such predetermination of quantitative relation between model parameters and electrode performance would be useful at the stage of optimization for design and production of battery.