Analysis of Diffusion Induced Deformation Considering Electro-Migration in Lithium-ion Batteries

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doi: 10.20964/2020.07.31

Received: 5 March 2020 / Accepted: 13 April 2020 / Published: 10 June 2020

Electro-migration, diffusion-induced stress and their interaction have a significant impact on the electrode materials' performance and reliability. However, electro-migration is neglected in most existed models. In this work, a coupled electro-chemo-mechanical model with electro-migration is developed by using Gauss law, mass balance and equilibrium equation. The diffusion flux is separated into two parts: one is the gradient of concentration, and the other is the coupling terms including the concentration-hydrostatic pressure gradient term and the concentration-electric potential gradient term. Then some numerical simulations in a hollow spherical electrode of LiMn_2O_4 are carried out under potentiostatic and galvanostatic operations to capture how the electro-migration impacts on the lithium-ion concentration, radial stress and hoop stress. The numerical results reveal that the electro-migration plays a significant role in the diffusion (lithium-ion concentration) and mechanical deformation in the hollow spherical electrode for larger diffusion time; when the electrical potential at the inner surface is smaller than that at the outer surface, the charging efficiency will be improved and the stresses in the electrode will be descended.

Keywords: Lithium-ion battery; Electro-chemo-mechanical coupling; Electro-migration; Diffusion-induced stress

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