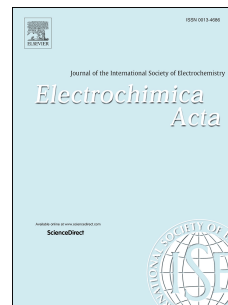


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Bo Lu, Yanfei Zhao, Yicheng Song, Junqian Zhang



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Stress-limited fast charging methods with time-varying current in lithium-ion batteries

Bo Lu^{a,b*}, Yanfei Zhao^c, Yicheng Song^{b,d}, Junqian Zhang^{b,d,e}

- a. Shanghai Institute of Applied Mathematics and Mechanics, Shanghai University, Shanghai 200072, China
- b. Shanghai Key Laboratory of Mechanics in Energy Engineering, Shanghai University, Shanghai 200072, China
- c. Department of Civil Engineering, Shanghai University, Shanghai 200444, China
- d. Department of Mechanics, Shanghai University, Shanghai 200444, China
- e. Materials Genome Institute, Shanghai University, Shanghai 200444, China

Abstract

This article sheds light on advantages of fast charging methods with time-varying current. Analytical solutions of concentration and stress for charging processes with general time-varying currents are derived. A fast charging protocol for a multistage constant current of gradually decreasing value is first evaluated. A properly designed multistage constant-current method is able to simultaneously suppress stress overflow and accelerate charging, but stress undulation induced by sharp switching between stages is inevitable. A charging scheme with a nonlinear exponential current is then investigated. The applied current varies continuously and smoothly with time so stress undulation is avoided. Suggestions for the design of an exponential current method are proposed to achieve the best charging acceleration without sacrificing charging capacity or increasing risk of mechanical failures. A well-designed exponential-current method is superior to a multistage constant-current method in accelerating charging speed.

* Corresponding author. *E-mail address*: riverbug@t.shu.edu.cn (B. Lu)

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