Promoting Electrochemical Rates by Concurrent Ionic-Electronic Conductivity Enhancement in Thick Cathode Electrodes Using Nanocellulose Additives

Hongli Zhu, Northeastern University

This study explores the use of sustainable and biodegradable nanocellulose materials, specifically cellulose nanocrystals (CNCs), as a multifunctional additive to enhance the performance of thick cathode electrodes in lithium-ion batteries. The research focuses on addressing the challenges of insufficient charge transfer kinetics in thick electrodes, which limit their capacity during fast charging. CNCs were utilized to simultaneously improve both the electronic and ionic conductivity of LiNi0.6Mn0.2Co0.2O2 (NMC 622) cathode electrodes. The addition of 1% CNCs optimized carbon dispersion, establishing interconnected electron transfer networks and enhancing electronic conductivity from 0.11 to 0.16 S/m. Concurrently, the CNCs created unique ion transfer bridges, shortening lithium-ion transfer pathways and increasing ionic conductivity from 0.36 to 0.62 S/m. In another work, the optimized electrode with 1% CNCs demonstrated superior electrochemical performance, particularly at high current rates and increased mass loadings. For a thick electrode with a mass loading of 17.0 mg/cm2, the CNC-enhanced cathode exhibited an eightfold increase in capacity (125 vs. 15 mAh/g) at a 3C charge rate compared to the control electrode without CNCs. This research demonstrates that the incorporation of nanocellulose additives is a promising strategy for improving the fast-charging capability of thick cathode electrodes. The approach offers a sustainable, cost-effective, and readily implementable solution for enhancing the performance of high-energy-density lithium-ion batteries, with potential applications in electric vehicles and other advanced energy storage systems.