

High-energy cathode material for long-life and safe lithium batteries

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Layered lithium nickel-rich oxides, $\text{Li}[\text{Ni}_{1-x}\text{M}_x]\text{O}_2$ (M=metal), have attracted significant interest as the cathode material for rechargeable lithium batteries owing to their high capacity, excellent rate capability and low cost. However, their low thermal-abuse tolerance and poor cycle life, especially at elevated temperature, prohibit their use in practical batteries. Here, we report on a concentration-gradient cathode material for rechargeable lithium batteries based on a layered lithium nickel cobalt manganese oxide. In this material, each particle has a central bulk that is rich in Ni and a Mn-rich outer layer with decreasing Ni concentration and increasing Mn and Co concentrations as the surface is approached. The former provides high capacity, whereas the latter improves the thermal stability. A half cell using our concentration-gradient cathode material achieved a high capacity of 209mAh g^{-1} and retained 96% of this capacity after 50 charge-discharge cycles under an aggressive test profile (55 C between 3.0 and 4.4 V). Our concentration-gradient material also showed superior performance in thermal-abuse tests compared with the bulk composition $\text{Li}[\text{Ni}_{0.8}\text{Co}_{0.1}\text{Mn}_{0.1}]\text{O}_2$ used as reference.