Amplification of the discharge current density of lithium-ion batteries with spinel phase Li(PtAu)₀.02Mn₁.₉₈O₄nano-materials

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Abstract

In this study the synergistic and catalytic properties of a novel nano-composite cathode material of nominal composition Li(M)xMn₂-xO₄ (M = Pt-Au; x ≠ 0.2) has been explored. Li(PtAu)xMn₂-xO₄nano-material for use in lithium-ion batteries (LIB) was synthesized by incorporation of the Pt-Au (1:1) nanoparticles onto the spinel phase LiMn₂O₄.Ultra-low scan rate (0.01 mV s⁻¹) cyclic voltammetry of the cathode material in 1 M LiPF₆(in 1:1 EC:DMC), showed four sets of redox peaks, which reflect the typical redox process of the active material in the spinel structure due to lithium intercalation and deintercalation. The Li/Li(PtAu)₀.02Mn₁.₉₈O₄cell had less polarization as it effectively accommodates the structural transformation during Li⁺ion charge and discharge. The Li(PtAu)₀.02Mn₁.₉₈O₄cathode showed an increase in discharge currents densities with an exchange current density, i₀, value of 2.8 × 10⁻⁴Acm⁻², which suggests increase in the rate of electron transfer compared to LiMn₂O₄(1.8 × 10⁻⁴A cm²).Li(PtAu)₀.02Mn₁.₉₈O₄exhibited excellent capacity retention upon extended cycling and can release 90mAh g⁻¹at 10C with a capacity retention of 99% after 50 cycles. Faster charge transportation at high current rates proved to prevent the pronounced pile-up of Li⁺ions and undesired Mn³⁺ions on the surfaces. The electrochemical impedance spectroscopy (EIS) results showed a decrease in charge transfer resistance for LiMn₂O₄after surface coverage with conductive PtAu NP’s. For the lithium diffusion coefficient in Li(PtAu)₀.02Mn₁.₉₈O₄thin film, its magnitude order is 10⁻¹¹cm²·s⁻¹.