

BIOPOLYMER-BASED BINDER FOR ELECTRODES OF LITHIUM-ION BATTERIES

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Overview

Currently, binder materials commonly applied in lithium-ion batteries (LIBs) include polyvinylidene fluoride (PVdF), polyacrylic acid, and styrene-butadiene rubber/carboxymethyl cellulose. Among them, PVdF is the most commercialized polymer and is widely used as a binder for the anode and cathode in batteries, owing to its excellent electrical stability and chemical resistance. Cycling stability was maintained at a binder content of 1 wt%, which is lower than that (10 wt%) of typical batteries, and a high areal loading corresponding to 5.2 mA h cm⁻² was achieved. This indicates that this binder allows stable cycling, which was difficult to achieve with previously reported binders. In this study, a bio-based polyester, was applied to LIB electrodes as an eco-friendly next-generation binder. The biopolymer was confirmed to be suitable as a binder with excellent adhesion, mechanical properties, and electrochemical stability.

Method

Electrochemical tests were conducted using 2032-type coin cells and automatic battery cyclers. The working electrodes were prepared using a slurry method in which were mixed graphite with a conducting agent, a biopolymer, or PVdF binder in an *N*-methyl-2-pyrrolidone (NMP) solution and then homogeneously coated it on a Cu foil through bar coating. A liquid electrolyte of 1 M lithium hexafluorophosphate in ethylene carbonate/dimethyl carbonate(1/1 volume) was used. The mass loading was 0.9 mg cm⁻², as calculated from the mass of the active materials. Moreover, electrochemical impedance spectroscopy was performed at frequencies ranging from 1 mHz to 0.1 MHz using an impedance analyzer.

Results

The biopolymer allowed strong adhesion between the active material and the current collector and maintained the structural stability of the electrode even after long-term cycling, owing to its elastic properties. In addition, the high wettability of the binder toward the electrolyte reduced the resistance of the electrode, providing a shortened diffusion path for Li ions. As a result, the binder exhibited a superior capacity over the commercially available PVdF binder and displayed capacity retention with a high Coulombic efficiency (CE) of over 94% for 100 cycles. The binder content was reduced from 10% to 5% by weight relative to that of the electrode, while the active material content was increased. The use of the binder increased the capacity and capacity retention with a CE of 94.1% over 100 cycles, indicating its potential as a next-generation eco-friendly binder for LIBs.

Conclusions

A bio-based aliphatic polyester with electrochemical stability and excellent adhesion and elastic properties was used as an environmentally friendly binder. It is also highly soluble in polar aprotic solvents, such as NMP, and maintains a stable structure within typical battery operating temperatures. Furthermore, the initial adhesion must be maintained even after the binder is in contact with the electrolyte or after cycling. Therefore, this requires strong interfacial adhesion between the active material and the substrate. The battery system using graphite, which is currently commercialized as an anode active material, accommodates the volume change that occurs during the storage of Li ions and maintains excellent durability and high cycling stability even after extended use.

References

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