Recycling and Performance Enhancement of Spent Battery Separators via Electrospun Nanofiber Technology

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전기방사 나노섬유화 기술을 통한 폐 이차전지 분리막의 고성능화 및 재활용 연구

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Abstract

With the global lithium-ion battery (LIB) market projected to exceed USD 135 billion by 2031, driven by the rapid adoption of electric vehicles (EVs), renewable energy storage systems, and portable electronics, the generation of spent batteries has increased at an unprecedented rate. It is estimated that over 11 million tons of used LIBs will accumulate annually by 2030. Among the various components of these batteries, polyolefin-based separators, which play a critical role in ensuring ionic conductivity and electrical insulation, are particularly challenging to recycle due to their complex structure, thermal shrinkage risk, and contamination. Conventional end-of-life treatments for separators—including incineration or landfilling—not only pose serious environmental concerns but also lead to the irreversible loss of valuable polymer resources [1-3]. Thus, there is an urgent need for eco-friendly, high-value recycling strategies that transform waste battery separators into next-generation functional materials.

In this study, we propose an innovative approach to recycle waste LIB separators by leveraging electrospinning nanotechnology to fabricate high-performance nanofiber-based separator membranes. The primary objective is to develop porous, mechanically robust, and thermally stable composite nanofibers from reclaimed separator materials. Electrospinning enables the formation of interconnected nanostructures with tailored porosity and enhanced material properties, making them ideal for reuse in secondary battery systems.

The research involves material recovery and purification, formulation of functional polymer blends, and membrane fabrication via electrospinning. The resulting nanofiber membranes exhibit superior mechanical strength and thermal endurance compared to conventional separators. This work not only offers a practical solution to separator recycling but also contributes to a circular economy model by closing the loop in battery material usage.

Acknowledgments

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