Electrochemical Safety

Beyond Recycling

Emerging Pathways: From Battery Material Recovery to Circularity

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Discoveries in Safety™

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Why Beyond Lithium-Ion Battery Recycling?

Circularity, Safe Battery Recycling, and Critical Materials Regeneration



Recovery and regeneration of critical materials



Preserve the highest possible material and product value



Process control with safety, environmental, and quality risks



Where Battery Recycling Stands Today

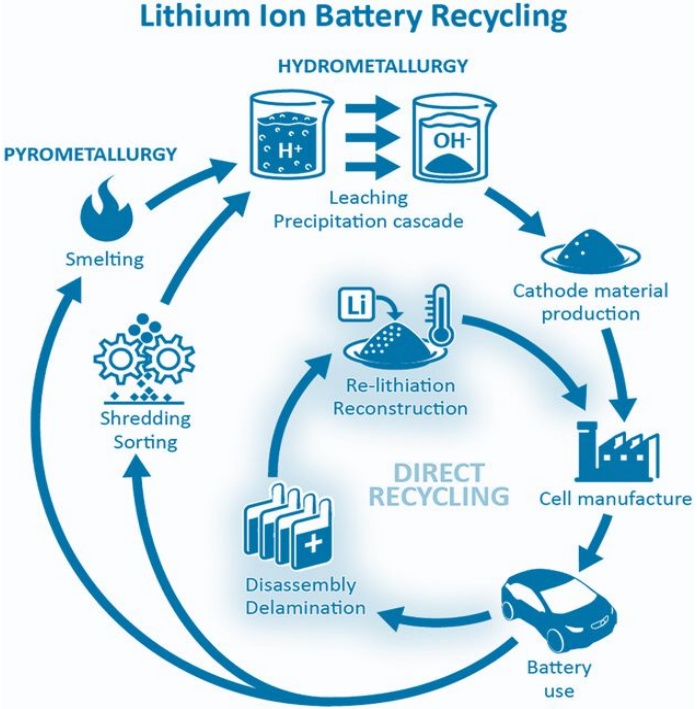
Pyrometallurgy: Robust, mixed-feed capable, but energy-intensive.

Hydrometallurgy: High recovery efficiency, but chemically and process-intensive.

Direct Recycling: Preserves and regenerates functional cathode materials.

Our Research

Advance eco-friendly, energy-efficient approaches for cathode material recovery and regeneration, from hydrometallurgy to direct recycling.



T. Wu et al. Metals 2025, 15, 552

Hydrometallurgy

Recycling and Recovery of Active Materials in Lithium-Ion Cells

Cathode Recovery and Regeneration using eco-friendly solvents



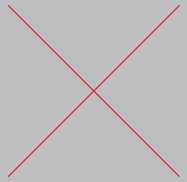
Direct Recycling

Microwave-Assisted Direct Methods towards Recycling LIB Cathodes

Structure preservation with fewer processing steps



The field is moving from extracting individual elements toward recovering, regenerating, and qualifying functional battery materials.





Technology alone does not enable circularity

What it Takes to Scale Battery Circularity



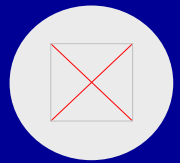
Challenges in battery collection: Li-ion cells discarded in municipal street waste streams.

What it Takes to Scale Battery Circularity

1

Infrastructure & Operational Readiness

-SOH assessment
-Feedstock variability
-Black-mass processing
-Recovered-material quality
-Scalability



2

Reporting & Traceability

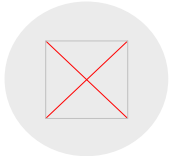
-Battery/material measurement
-Data management
-Regenerated-material characterization and processing

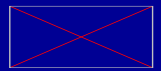


3

Regulatory Awareness

-Codes and standards
-Regulatory clarity and verification
-Safety qualification

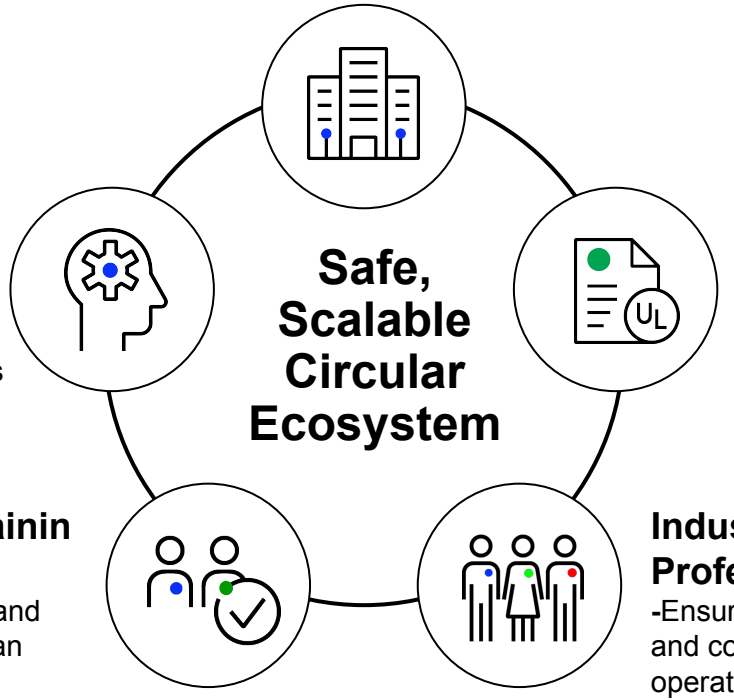




Battery Recycling Ecosystem

Emerging Technology to Safe Deployment

Government Initiatives
-Develop technology, policies, and incentives



Research & Development
-Advance technical skills and promote sustainability practices

Codes & Standards
-Develop standards to facilitate the implementation of recycling processes

Education/Training
-Build awareness and stewardship from an early age

Industry Professionals
-Ensures safe, efficient, and compliant recycling operations

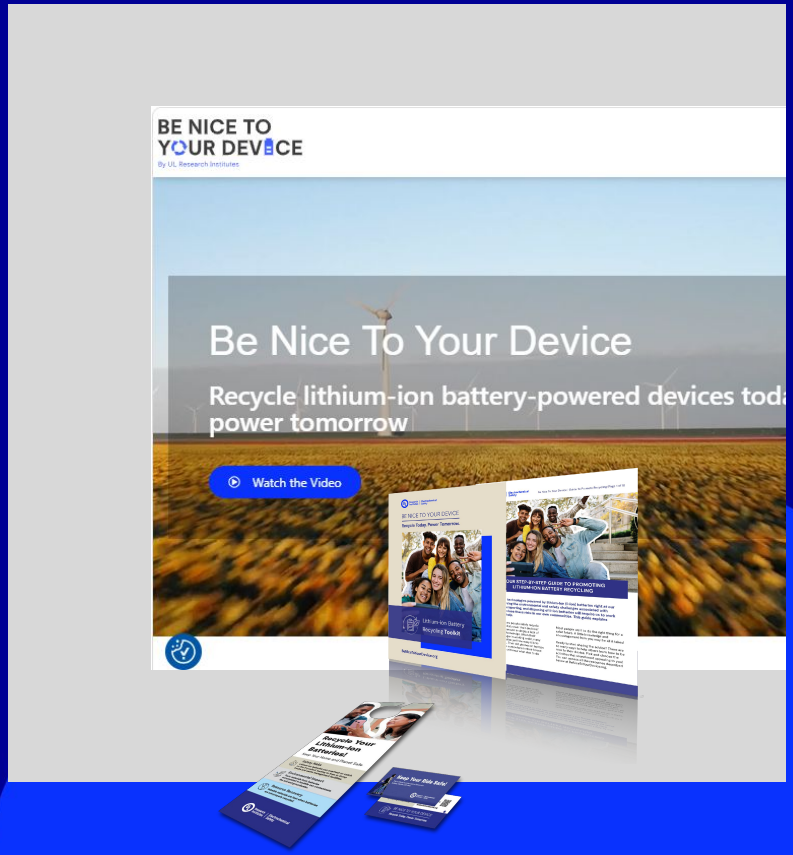
Planning to create an impact in your community?

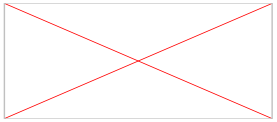
The UL Research Institutes' Electrochemical Safety Research Institute can help.

We have free resources available online at BeNiceToYourDevice.org.

We can also host webinars for your specific audiences.

Reach out to us!
BeNiceToYourDevice@ul.org





Thank you.

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