Tech4Lib: Economia circolare e innovazione per le Batterie agli Ioni di Litio (LIB)

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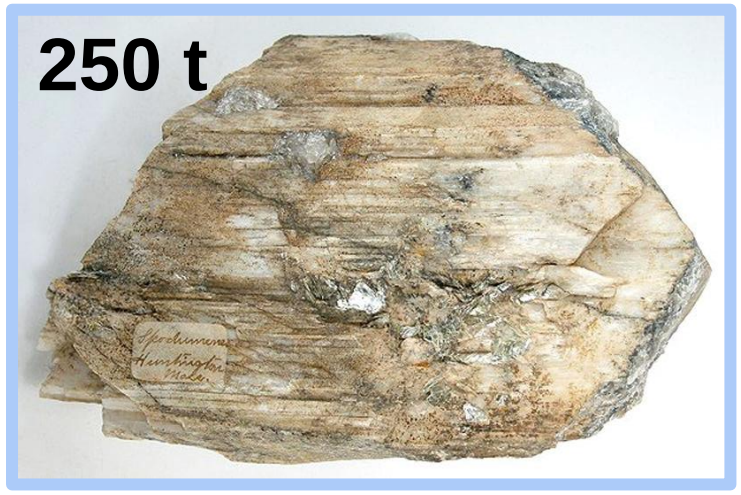
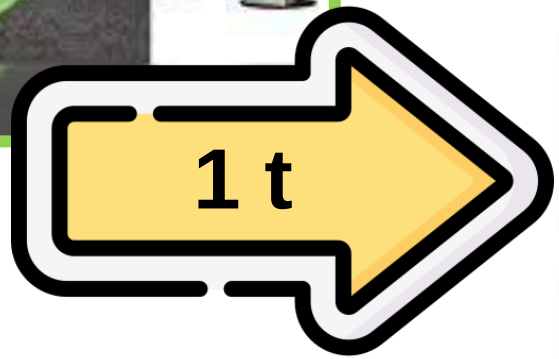
TECNOLOGIE CIRCOLARI E SOSTENIBILE: Innovazione per il futuro delle **batterie** e il **recupero delle materie prime**

25 Febbraio 2025

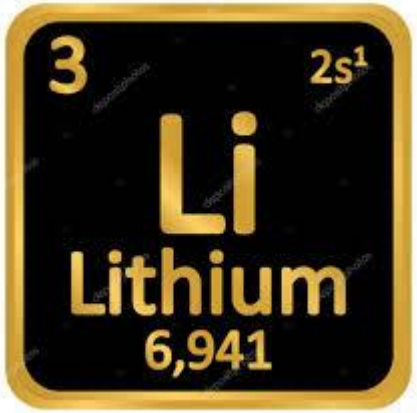
Estrazione Litio



256 batterie da EVs



Considerando la crescita di EVs, le **riserve di Li** (~81Mt) che potrebbero durare alcuni secoli, dureranno solo **pochi decenni (40-50)**



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Riciclaggio delle LIBs

Process	Advantages	Disadvantages	Challenge
Hydrometallurgical process	High recovery rate High purity product Low energy consumption Less waste gas High Selectivity	More wastewater Long process	Wastewater treatment Optimize the process
Pyrometallurgical process	Simple operation and short flow No requirement for categories and the size of inputs High efficiency	Li and Mn are not recovered High energy consumption Low recovery efficiency More waste gas and the cost of waste gas treatment	Reduce energy consumption and pollution emissions Reduce environmental hazards Combine hydrometallurgy well

Reagenti più comuni: acido nitrico, cloridrico, solforico oppure soda e ammoniaca.

T (800-1300°C) → fusione metalli permettendone recupero come leghe (Cu, Co, Ni, Fe) poi raffinazione. Nella scoria: Li, Mn, Al, Si, Ca.

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Progetto Tech4Lib

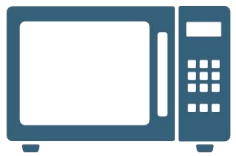
-Tecnologia brevettata
-Premio EIT Raw Material

1/03/2023 - 31/08/2026

2022

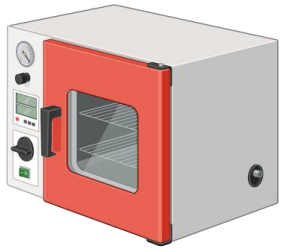
2021

Microonde commerciale



2023

Microonde da laboratorio



2026

-Fondo MITO
-Premio 2031 (percorso messo in palio da Paradigma Exponential Hub)

Partners

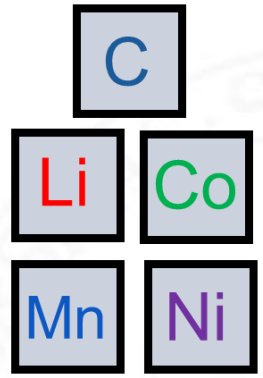
Stakeholders

Tecnologia Innovativa

Batterie esauste

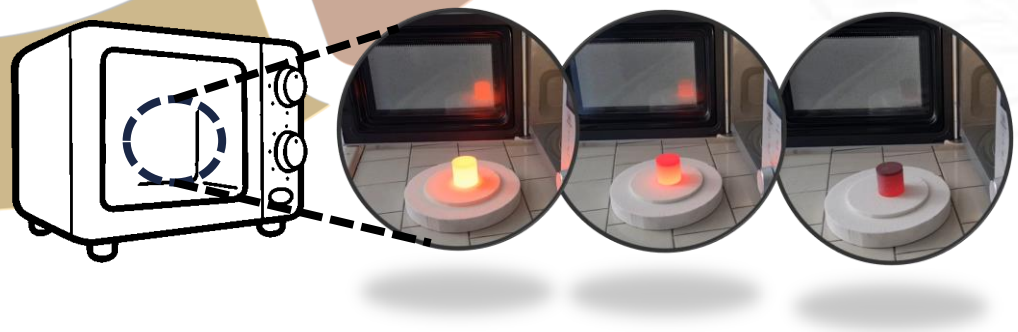
Pre-trattamento

Black mass



Tech4Lib
Spent lithium-ion battery recovery

Trattamento termico



Recupero metalli

Mn, Co, Ni

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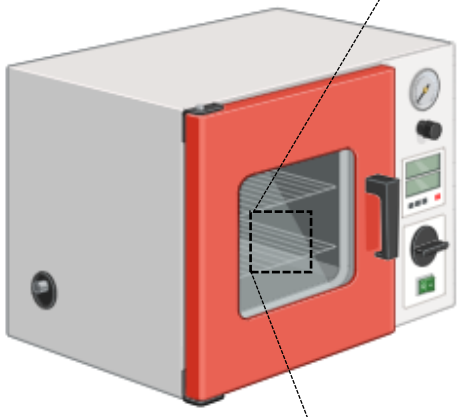
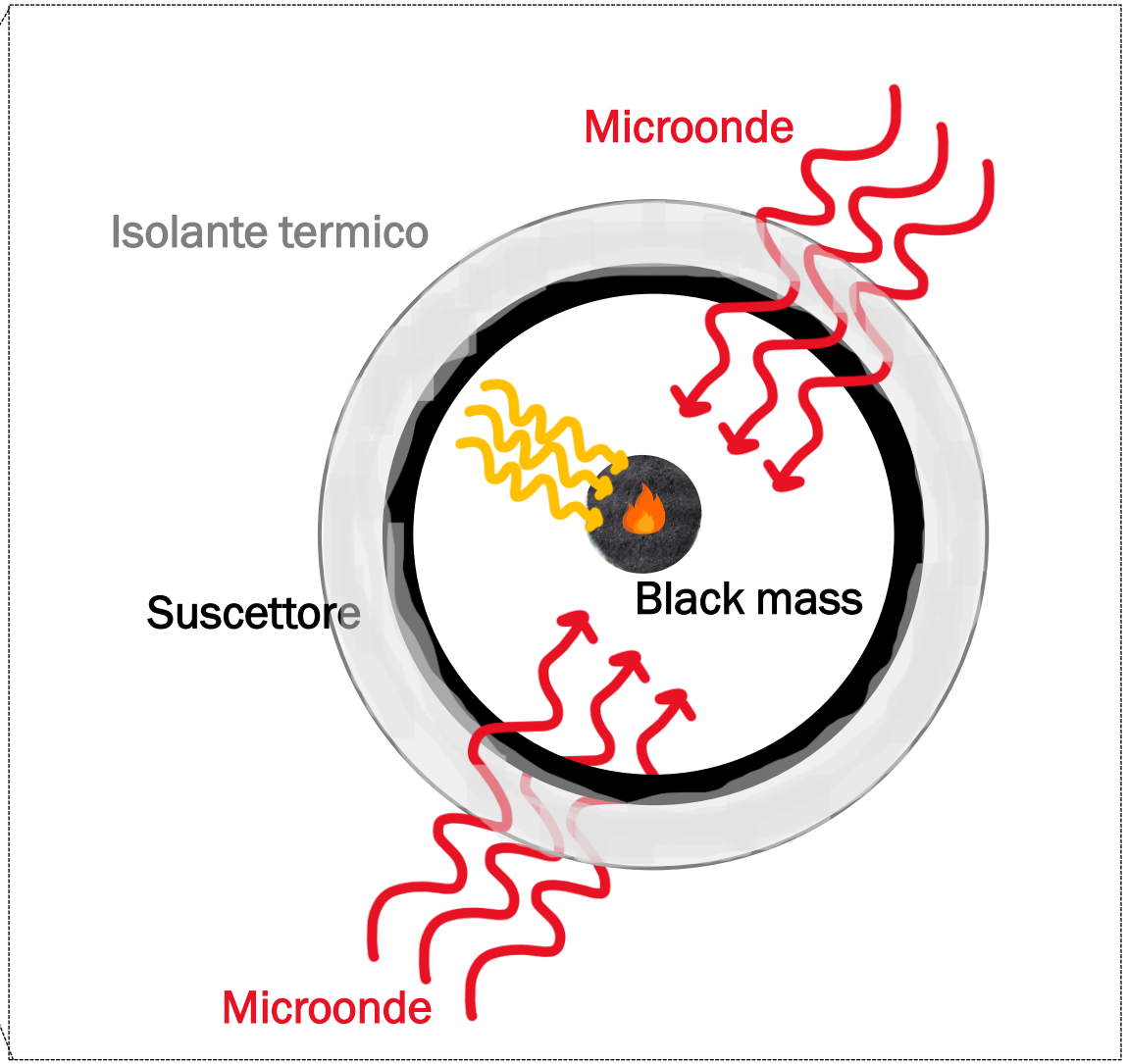
Trattamento microonde





PARAMETRI:

- Potenza: max 1800 W
- Tempo
- Temperatura: max 1200 °C

✓ Rapida;
✓ Risparmio energetico;
✓ Facile da usare su scala di laboratorio;
✓ Aumenta l'efficacia di lisciviazione.

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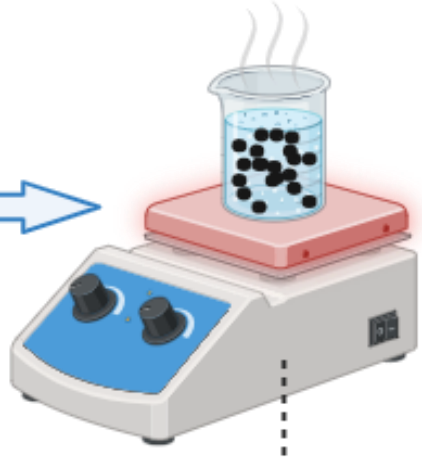
Recupero di metalli

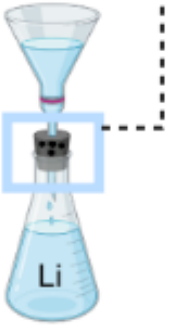
Trattamento microonde

- Potenza e tempo fissati
- Controllo temperatura

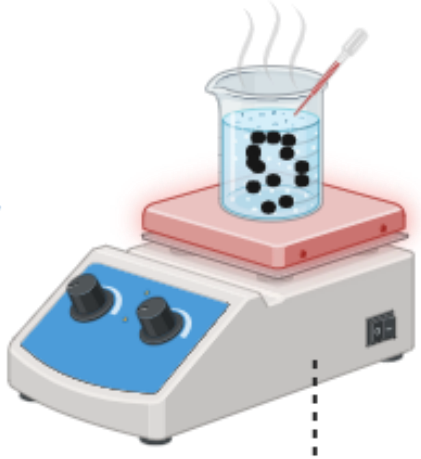
Lisciviazione acqua



- 40 g/L
- 80 °C
- 30 min
- 300 rpm



Lisciviazione acido malico



- 1.2 M acido malico
- H_2O_2 (1.5%)
- 40 g/L
- 80 °C
- 30 min
- 300 rpm

- ✓ *Environmental friendly*
- ✓ Riutilizzabile
- ✓ Economico
- ✓ Estrazione simultanea favorevole di metalli critici
- ✓ Buona alternativa agli acidi inorganici

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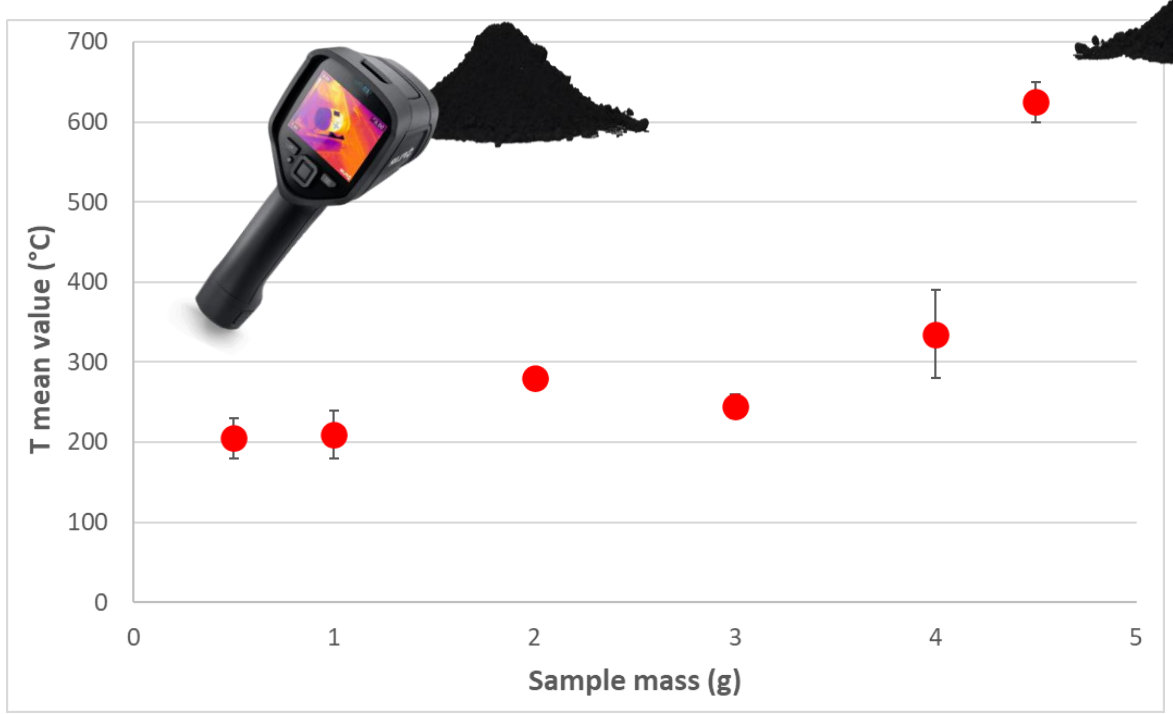
Risultati

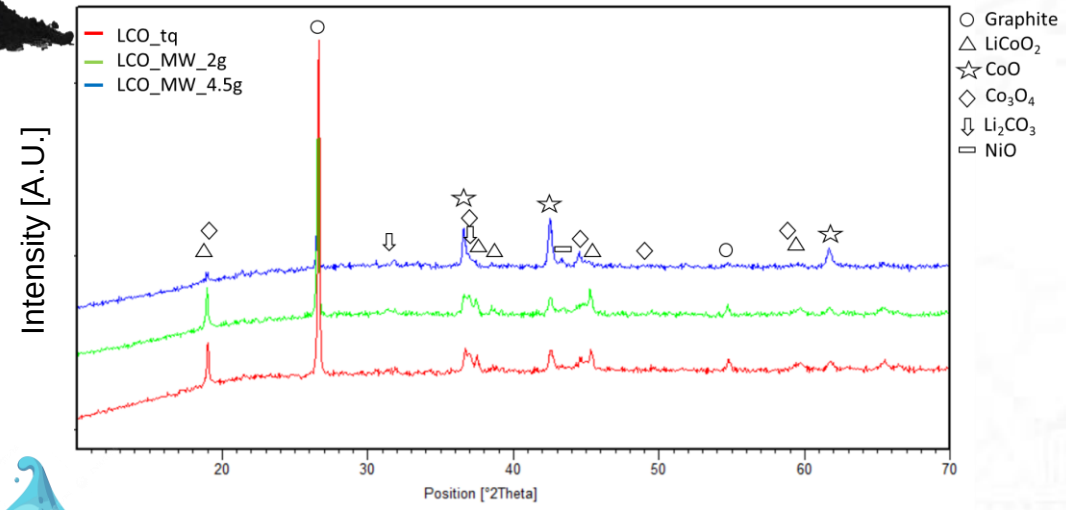
Test sperimentali

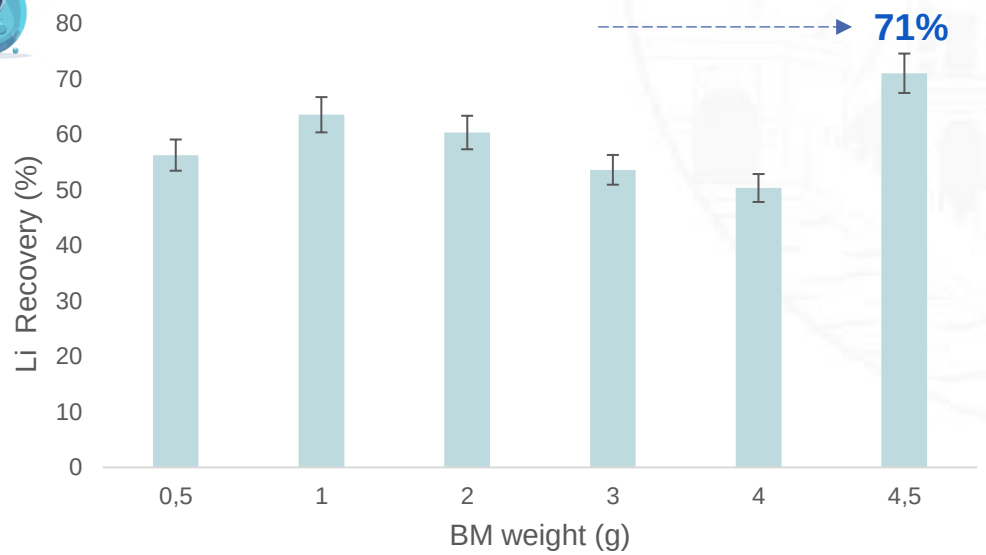


- 600 W_5 min;
- aumento massa da trattare → aumento della temperatura del campione, per la maggiore quantità di BM eccitata da MW.

LCO ($LiCoO_2$)

Caratterizzazione

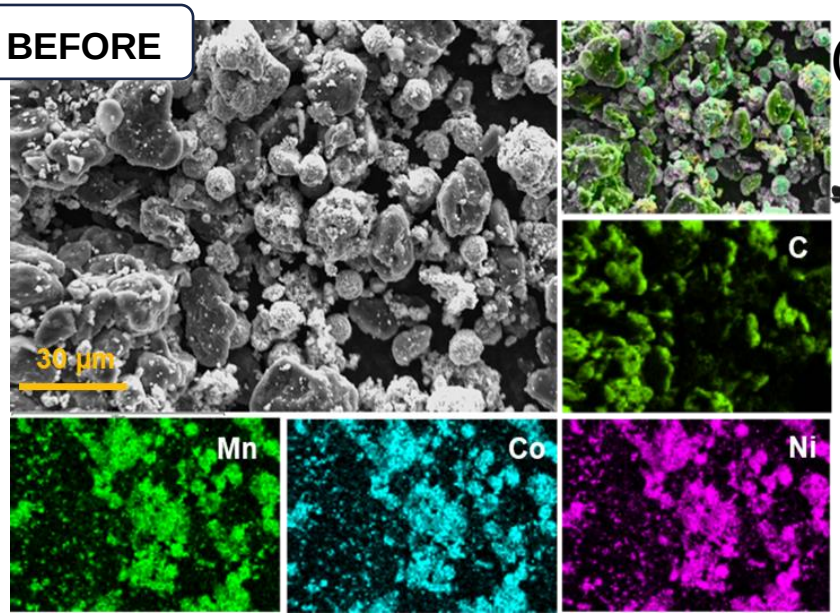




RSC Sustainability, 2024, 2505

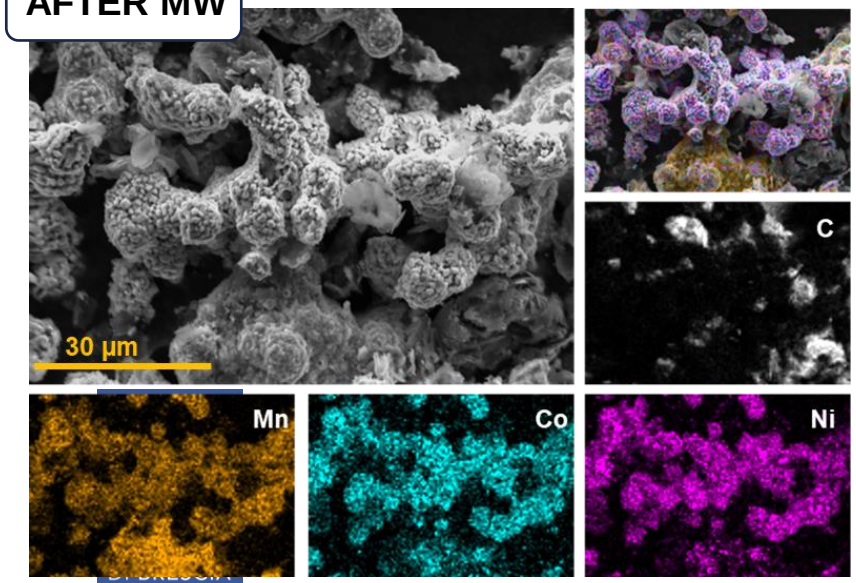
Risultati

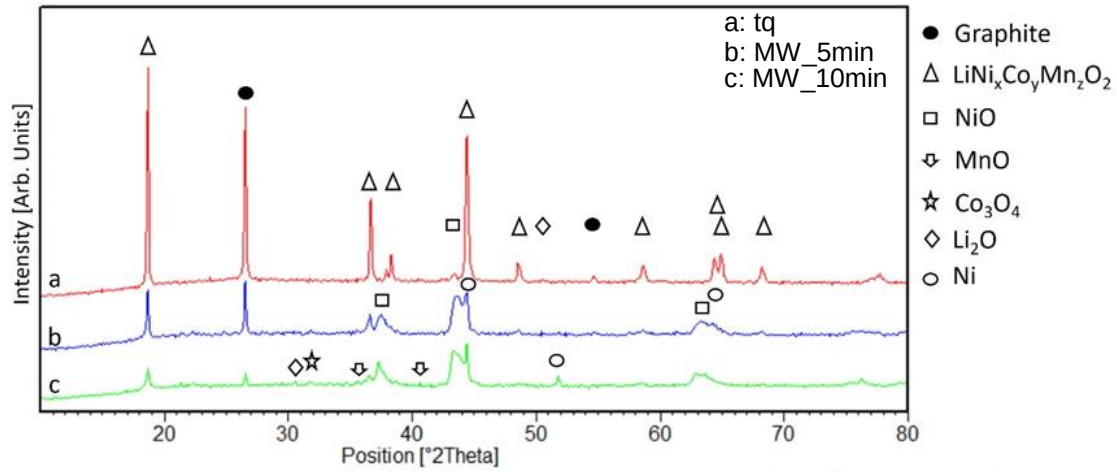
BEFORE

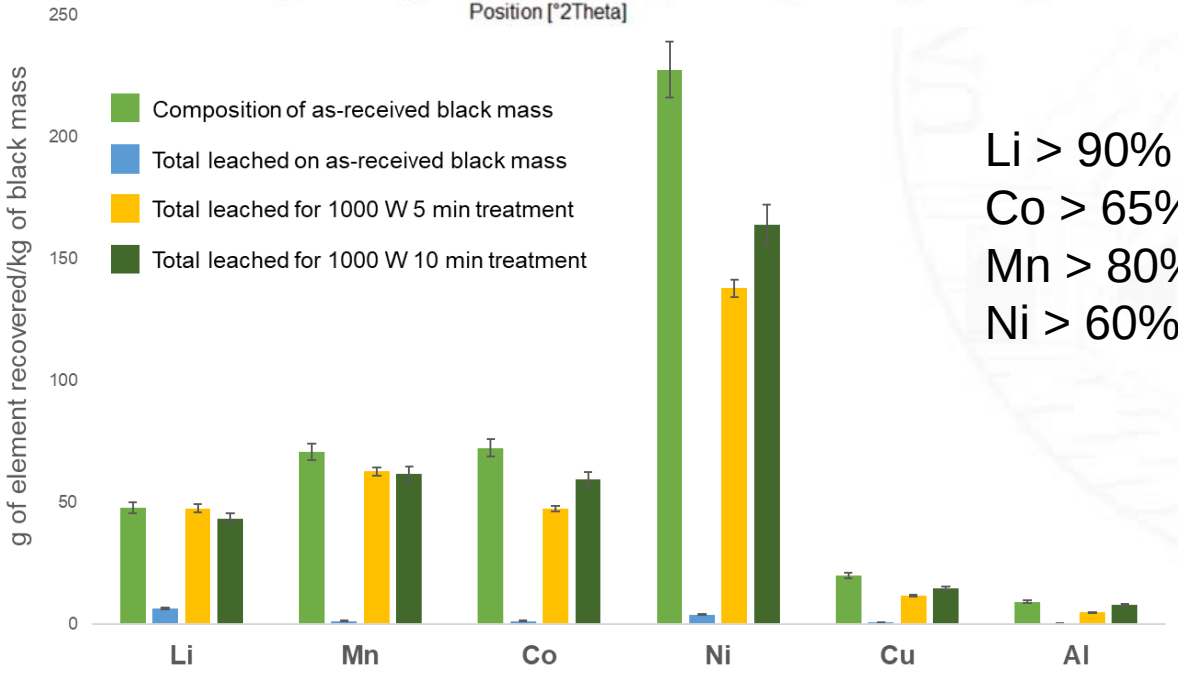


NMC
($LiNi_xCo_yMn_zO_2$)

AFTER MW







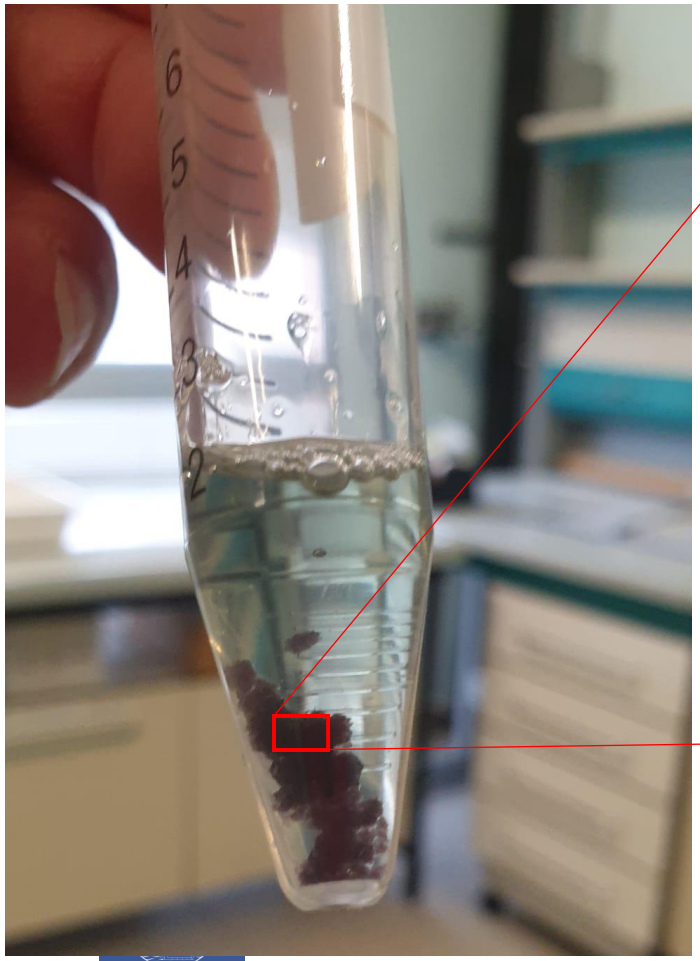
Li > 90%
Co > 65%
Mn > 80%
Ni > 60%

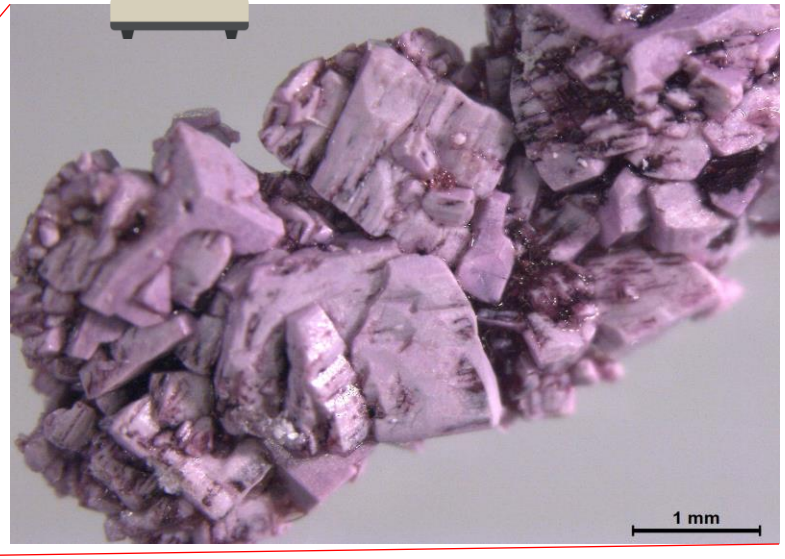
Energy Storage Materials, 2024, 103703

Risultati

NMC
($LiNi_xCo_yMn_ZO_2$)

Microscopio

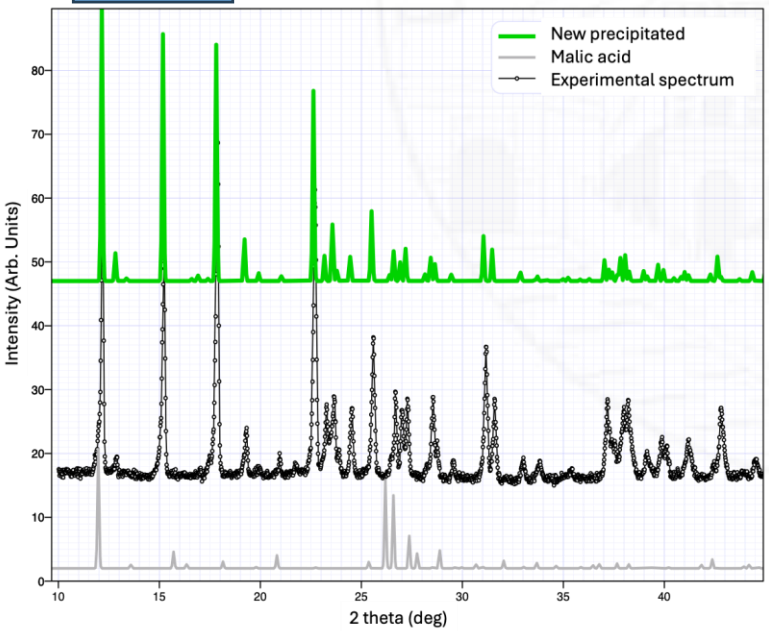




ICP

Elemento		%	
Mn	1.16	±	0.01
Co	3.21	±	0.05
Ni	9.4	±	0.1
Cu	0.96	±	0.02

XRD



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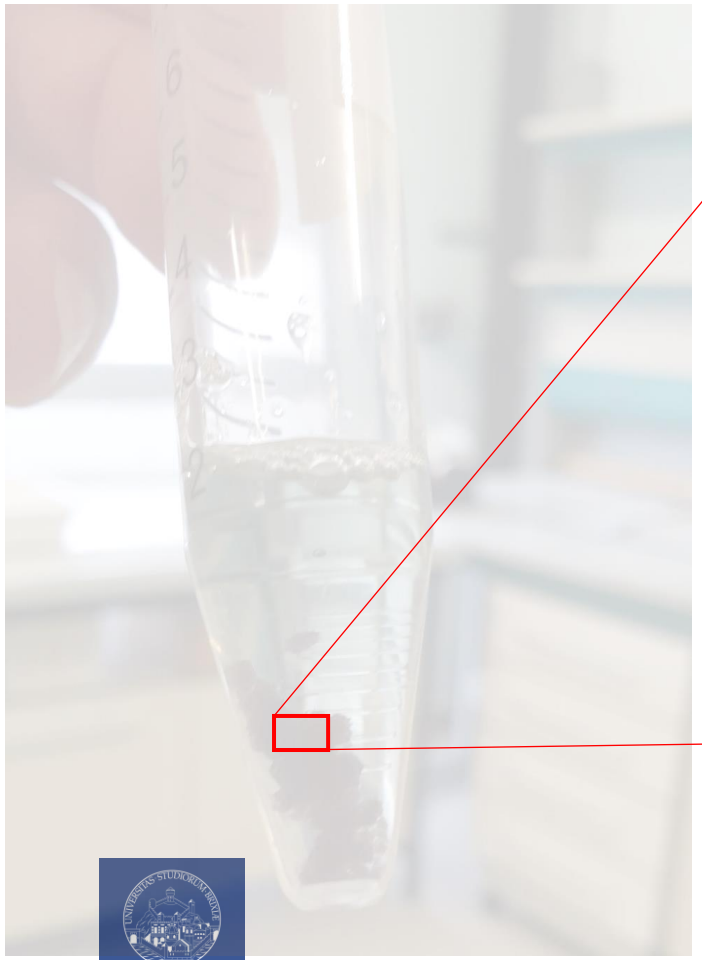
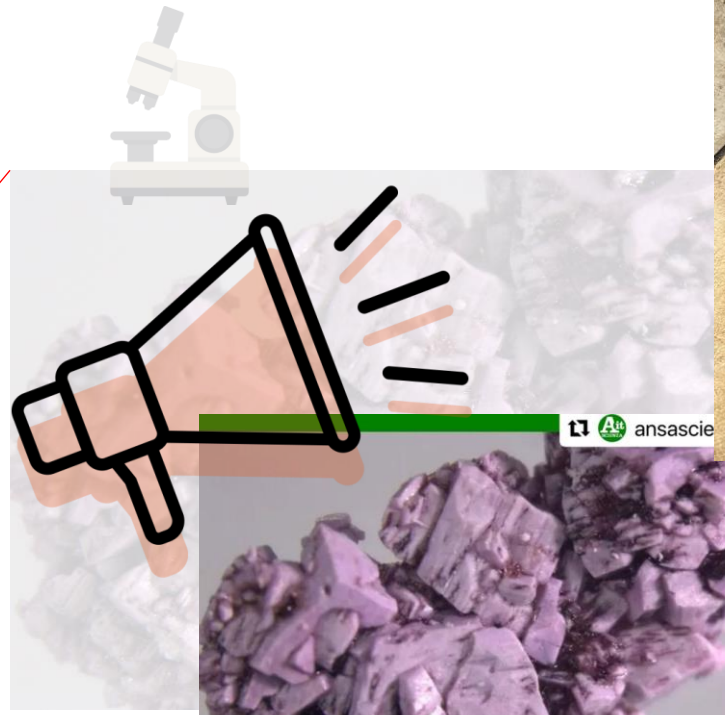
Environmental Research, 2025, 120709

Risultati

NMC
($LiNi_xCo_yMn_zO_2$)

Microscopio





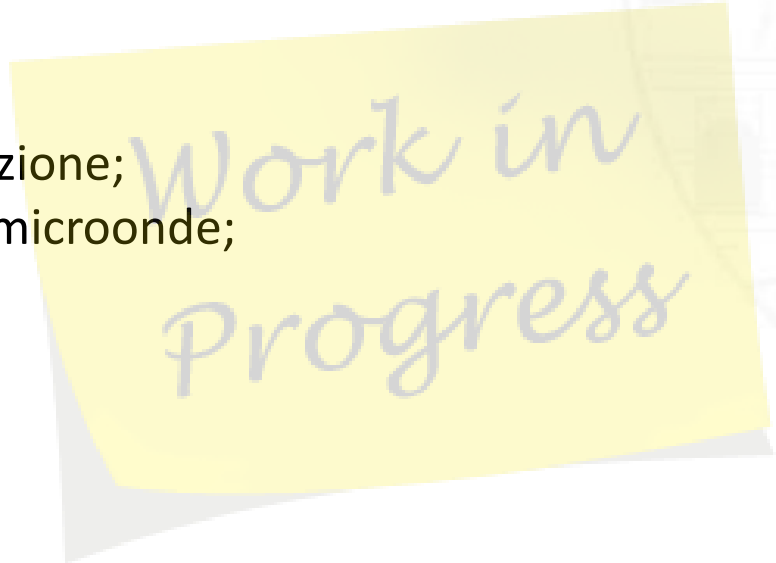
Environmental Research, 2025, 120709

Conclusioni

- La tecnologia proposta permette trattamenti minimi e quantità ridotte (vicino allo zero) di prodotti chimici commerciali;
- Il trattamento termico, basato su reazioni carbotermiche, avviene in tempi brevi rispetto ai metodi convenzionali;
- Li viene estratto in acqua;
- Il metodo è flessibile, quindi può essere adattato al trattamento di future batterie di diversa composizione chimica.

Sviluppi Futuri

- Recupero parziale della grafite, ad esempio mediante flottazione;
- Valutazione delle emissioni durante trattamento termico a microonde;
- Produzione di acidi organici da scarti alimentari (INSTM);
- Analisi sostenibilità della tecnologia proposta (SSSA).



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GRAZIE PER L'ATTENZIONE

DI BRESCIA