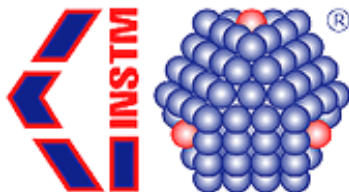


Transizione energetica: i materiali del futuro



Elza Bontempi

elza.bontempi@unibs.it

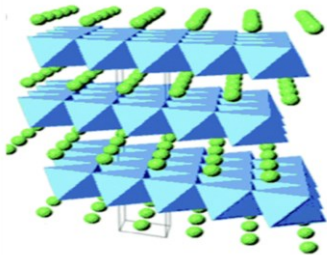
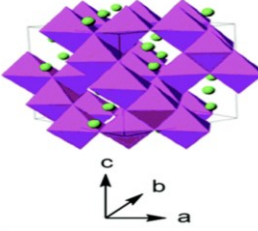
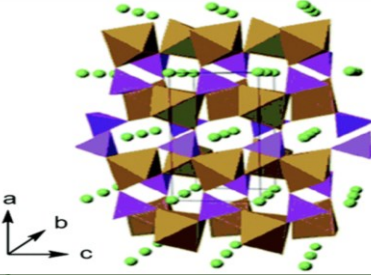
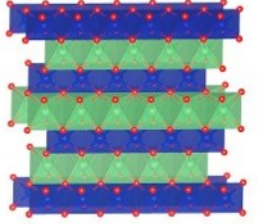
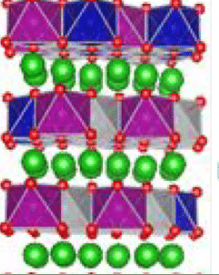


MICS
Made in Italy
Circolare e Sostenibile



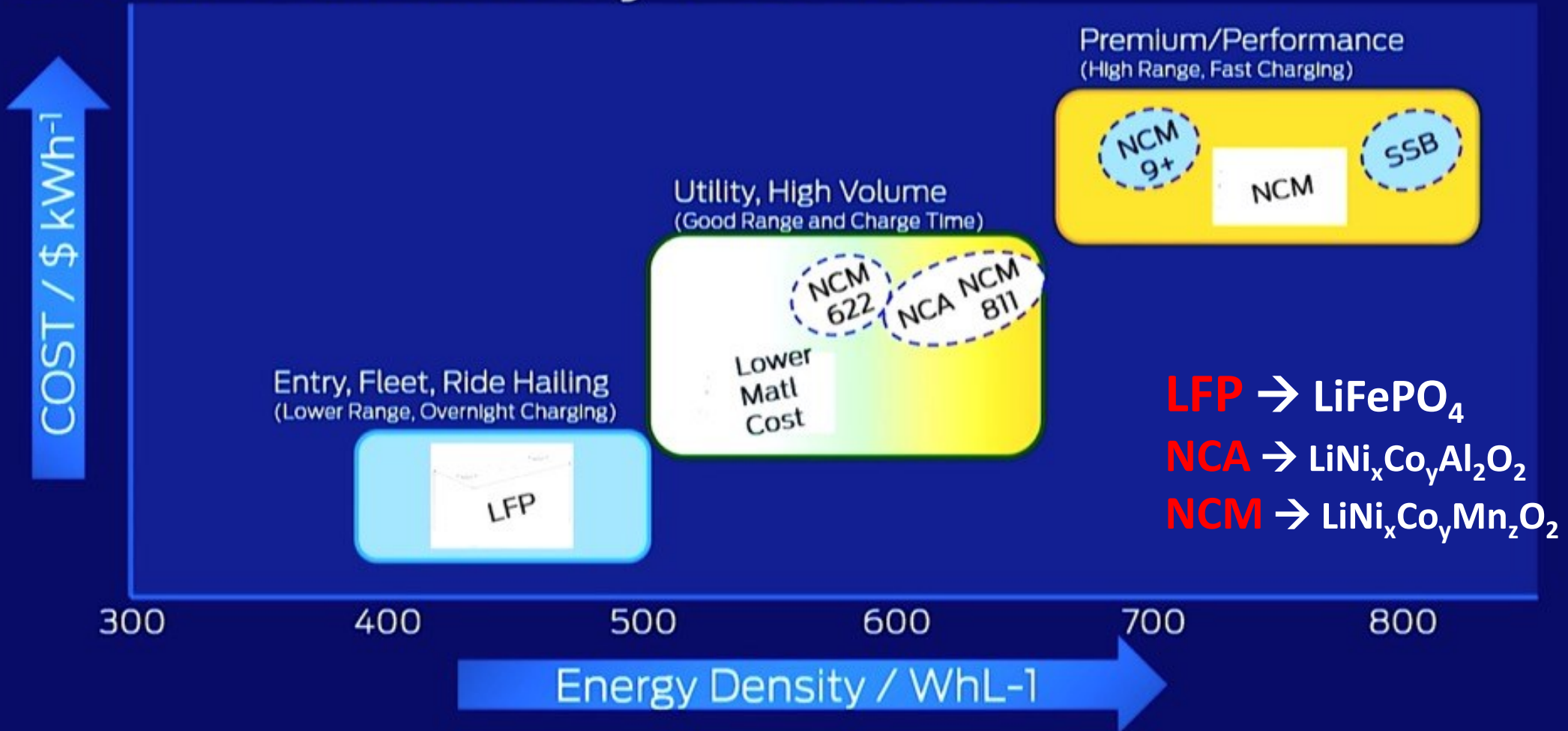
Cathode materials from the most commonly used commercial LIBs



Cathode types	LCO	LMO	LFP	NCA	NCM
Chemical formula	LiCoO_2	LiMn_2O_4	LiFePO_4	$\text{LiNi}_x\text{Co}_y\text{Al}_z\text{O}_2$	$\text{LiNi}_x\text{Co}_y\text{Mn}_z\text{O}_2$
Structure					 <ul style="list-style-type: none"> ● Li ● Co ● Mn ● Ni ● O
Market share	Dumped	Small	Growing	Steady	Main force
Typical use	Portable electronic devices	Power tools and electric bikes	Electric bikes, large EVs and power tools	Panasonic batteries for Tesla EVs	Portable electronic devices and EVs
Comments	Low safety, high cost, medium performance	Medium safety, low cost, medium energy density, low lifetime	Good safety, low cost, high thermal stability, medium energy density	Medium safety, medium cost, higher energy density	Medium safety, medium cost, higher energy density, high lifetime

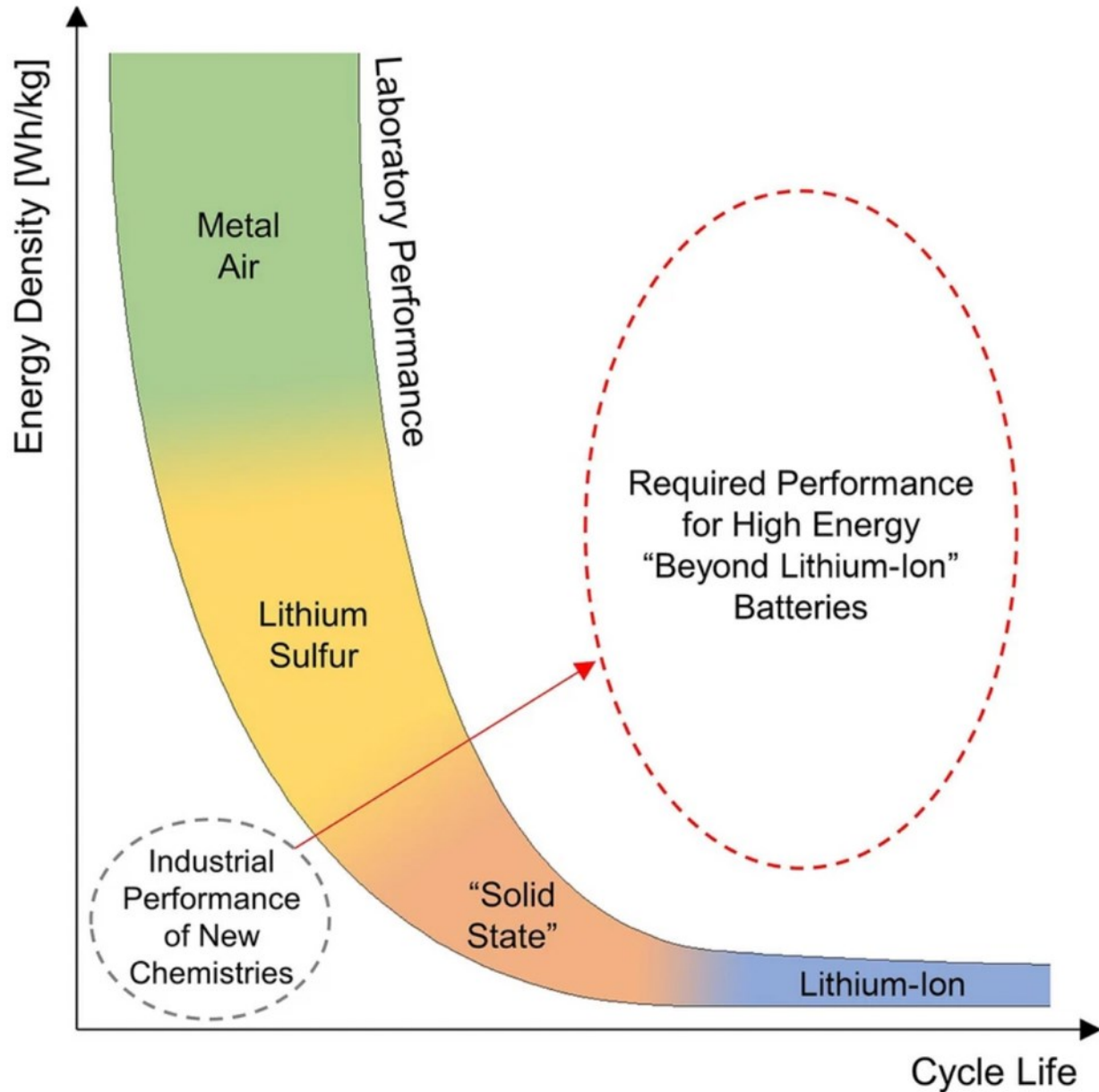
Materials for batteries

Multi-Chemistry Portfolio



Multi-Chemistry Portfolio Enables Delivery of Optimum Batteries For Customer Segments

Emerging materials for batteries



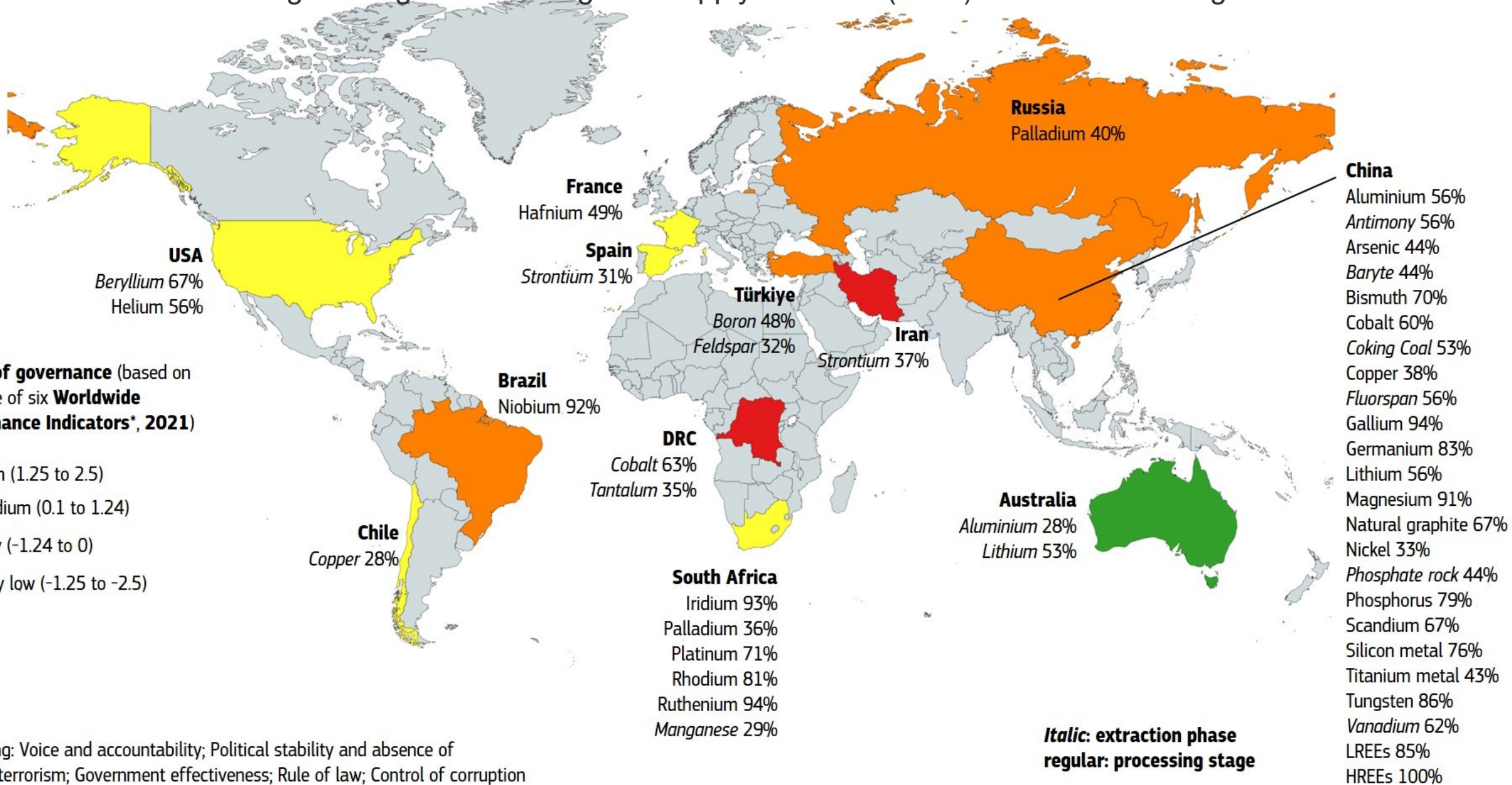
Increasing the energy density remains a central driving force in advancing battery research and innovation.

However, the new chemistries also aim to:

- New advanced materials
- Diversification
- Reduced reliance on CRM

Critical raw materials

Countries accounting the largest share of global supply of CRMs (2023) and their level of governance



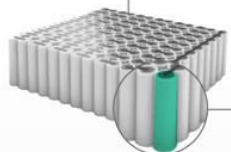
Breaking Down the Cost of an EV BATTERY CELL

The average cost of lithium-ion batteries has declined by 89% since 2010.

What makes up the cost of lithium-ion cells?



EV CHASSIS



A battery pack consists of multiple interconnected modules, and each module is made up of hundreds of individual cells.

\$101/kWh
Avg. Cell Cost In 2021



The **cathode** material determines the capacity and power of a battery, typically composed of lithium and other battery metals.



The largest EV battery **manufacturers** are all headquartered in Asia.

80% of all cell manufacturing occurs in China.



The **anode** is the negatively-charged electrode, typically made of graphite.



Separators prevent electric contact between the cathode and the anode.



The **electrolyte** is the medium that transports lithium ions from the cathode to the anode.



Battery housings are cases that contain and protect battery packs, usually made of steel or aluminum.

Percentages may not add to 100 due to rounding.
Source: BloombergNEF

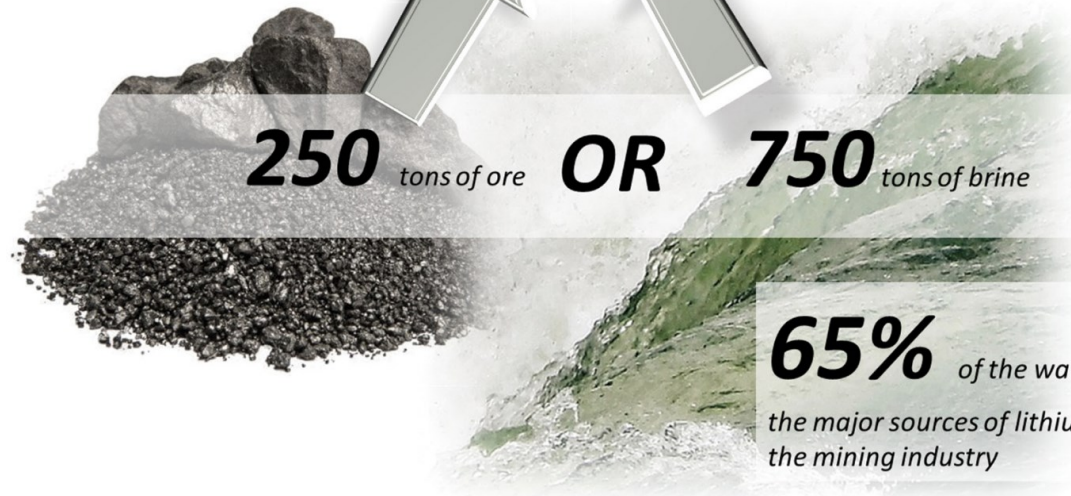
1 ton of virgin lithium



250 tons of ore

OR

750 tons of brine



65% of the water in Chile (one of the major sources of lithium) is consumed by the mining industry

CO₂ 15 tons

5 tons

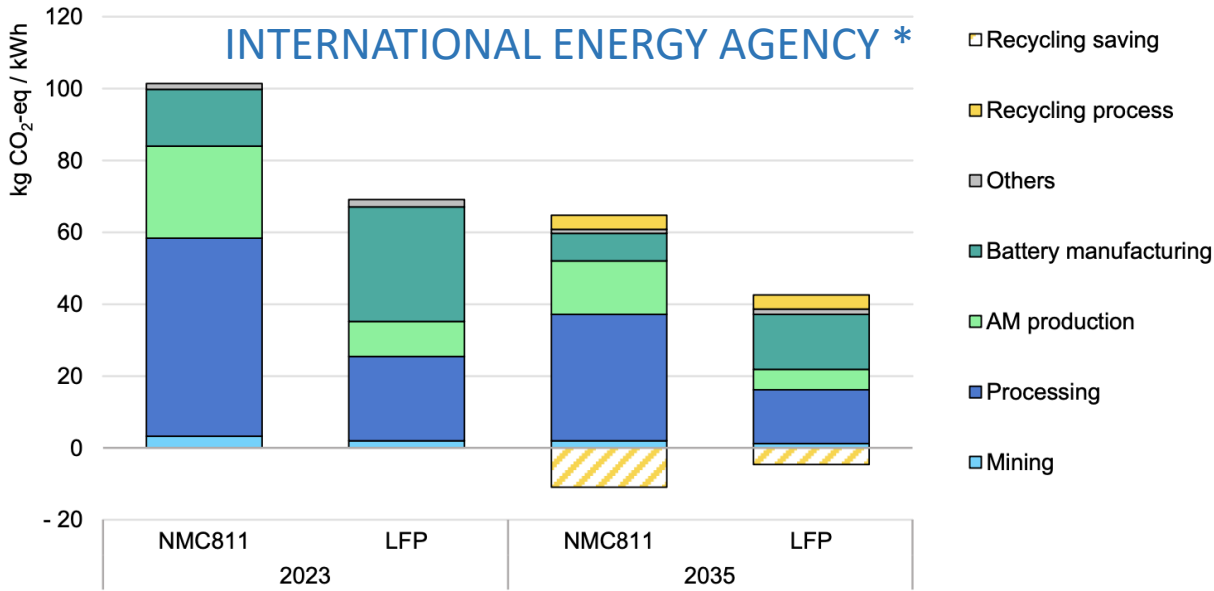
Water 170 m³

469 m³

Use of land 464 m²

3,124 m²

Mitigation and Improvement Measures



European Critical Raw Materials Act

2030 benchmarks for strategic raw materials:



EU EXTRACTION

At least **10%** of the EU's annual consumption for extraction



EU PROCESSING

At least **40%** of the EU's annual consumption for processing



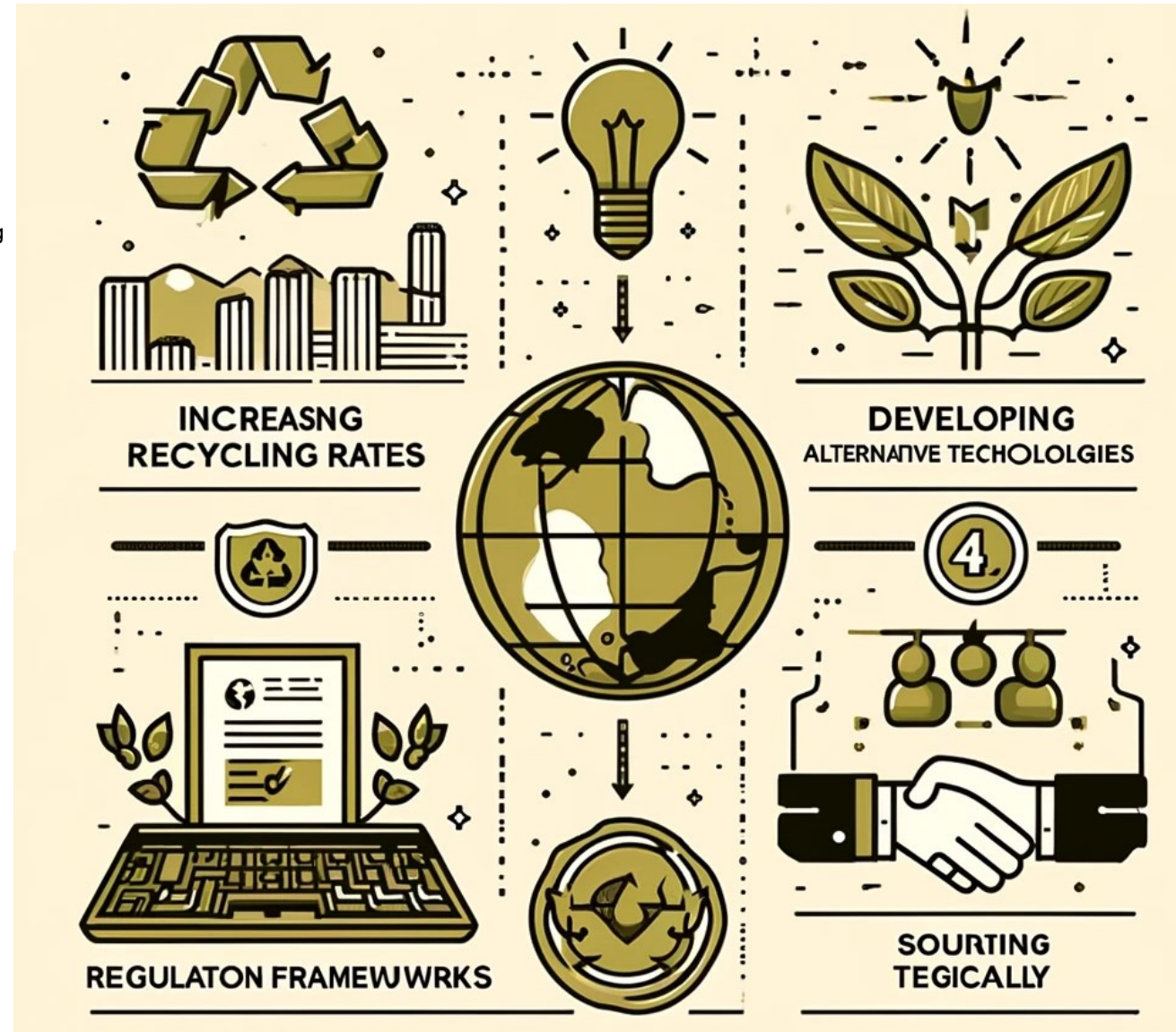
EU RECYCLING

At least **15%** of the EU's annual consumption for recycling

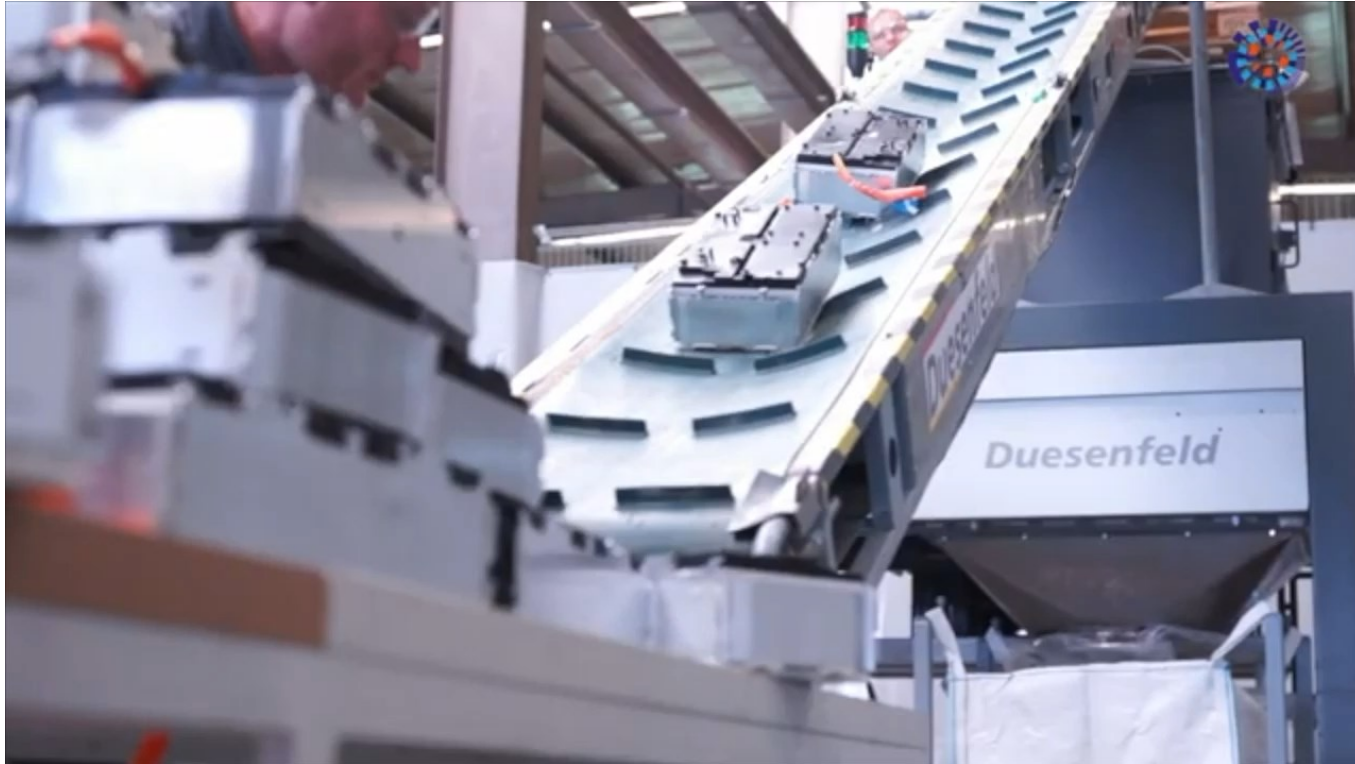


EXTERNAL SOURCES

Not more than **65%** of the EU's annual consumption of **each strategic raw material at any relevant stage of processing** from a single third country



Li-ion battery recycling value chain



<https://www.duesenfeld.com>



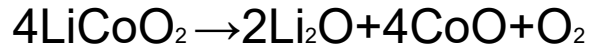
Hydrometallurgy

Pyrometallurgy

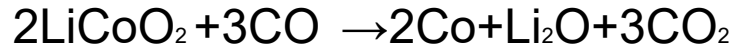


Carbothermic reduction

Electrode material LiCoO_2 decomposes at above 900°C



During the high-temperature treatment of the mixture of LiCoO_2 and **graphite** in air



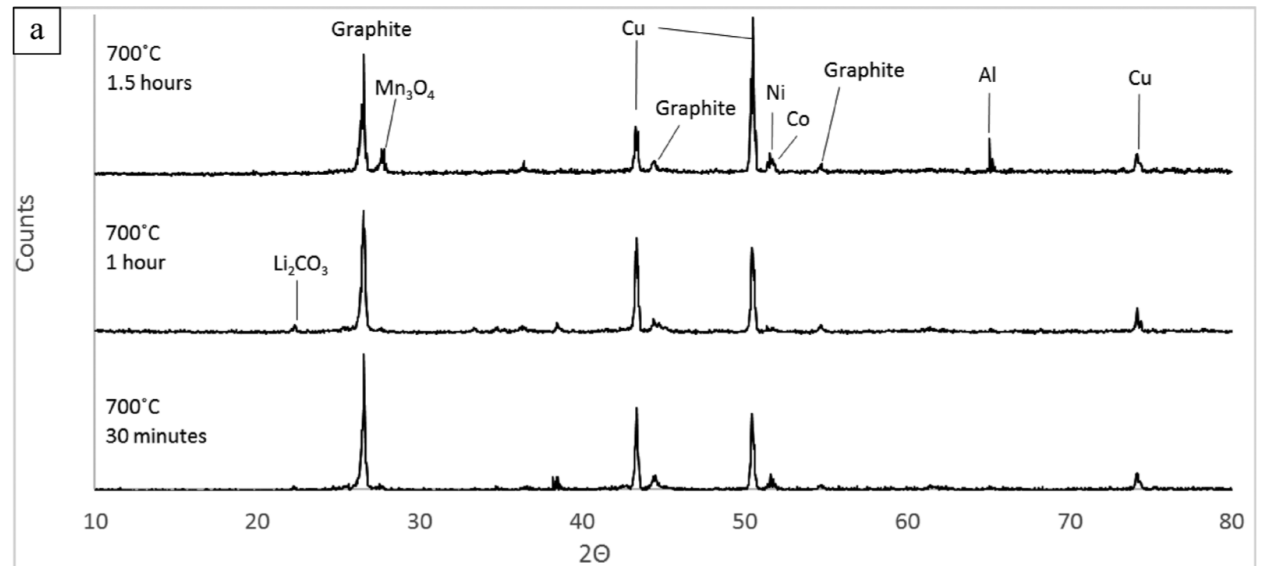
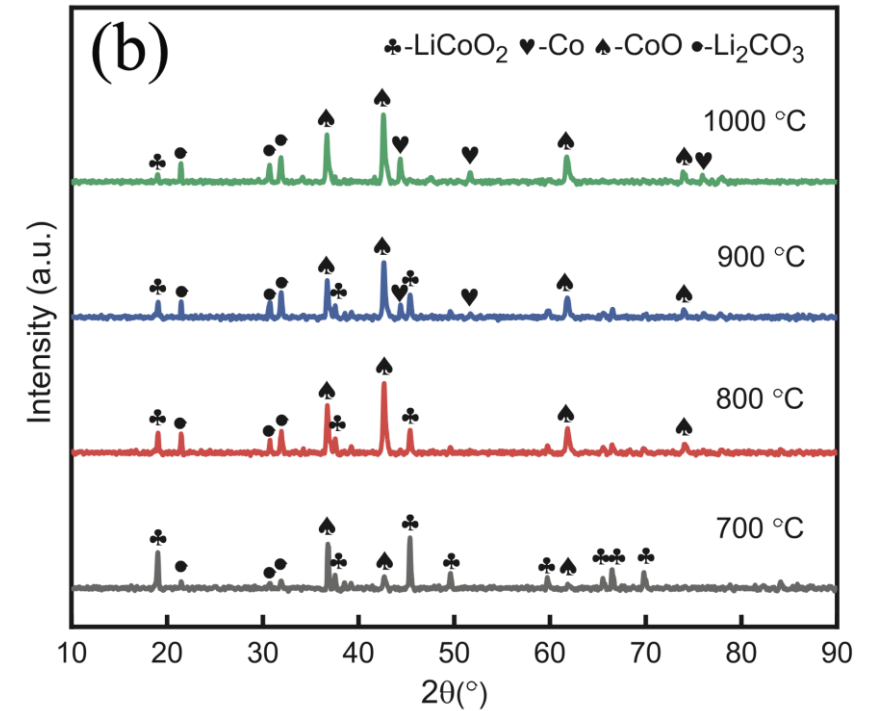
XueFeng She , Kewei Zhu, JingSong Wang and QingGuo Xue,
Journal of Chemical Research 2022

The increasing of the temperature and time of treatment promotes the carbothermic reduction and the removal of graphite and organic components. It was observed that at 700°C after 1.5 h of treatment the cathode active material is completely decomposed.

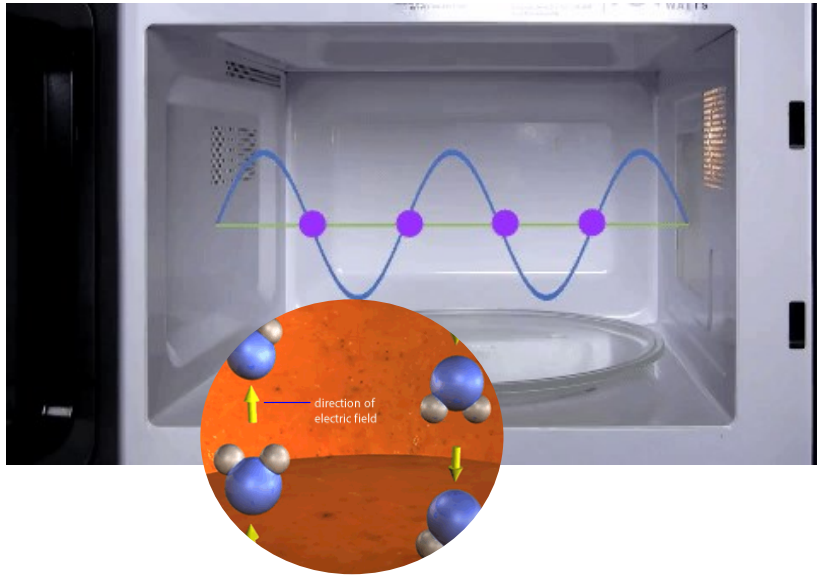
ACS Sustainable Chem. Eng. 2019, 7, 13668–13679

The chemical reactions became spontaneous at $\geq 600^\circ\text{C}$, because their Gibbs free energy became negative

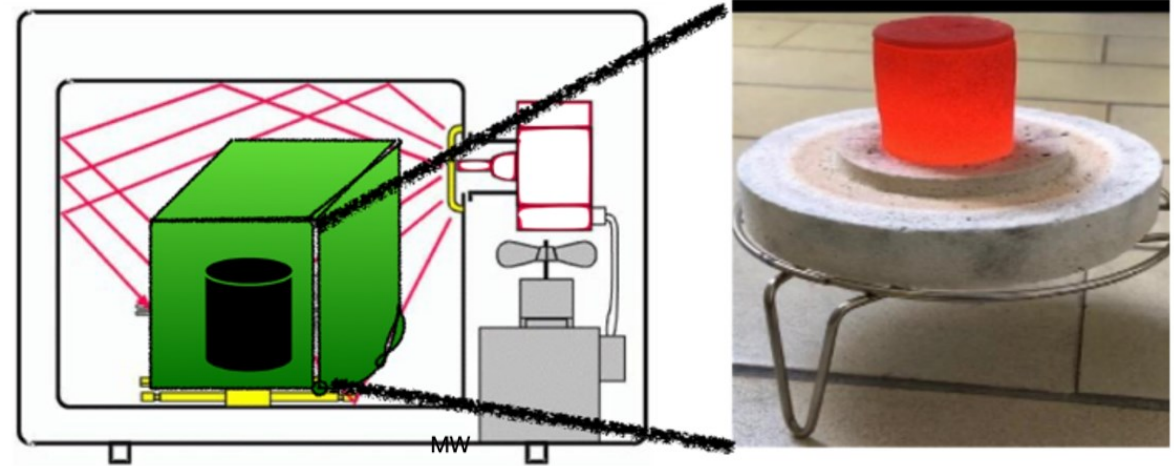
Chemical Engineering Journal 435 (2022) 135165



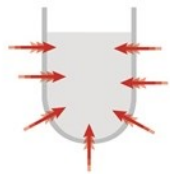
Microwave (MW)-based heating technology



hybrid heating mechanism

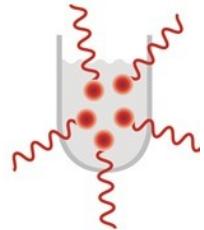


Conventional heating:

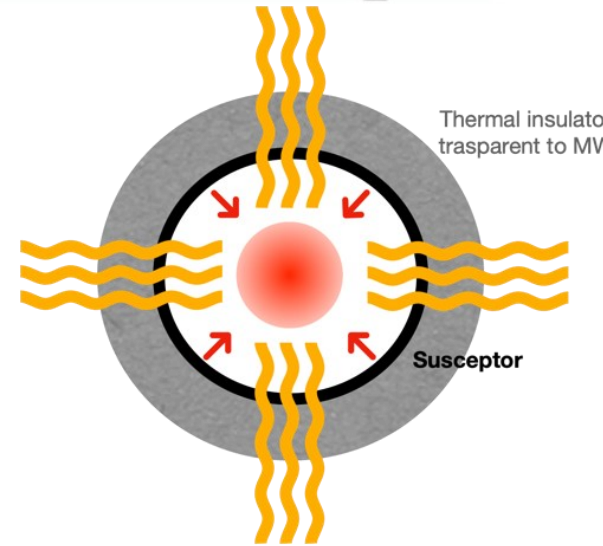


When a susceptor is excited by MW radiation it rapidly increases his temperature.

Microwave heating:



The effect of hybrid heating reduces heat loss and results in more uniform heating of the material.



Hybrid MW heating with susceptor



PCT

METHOD FOR RECOVERING MATERIALS FROM WASTE OR SCRAPS THROUGH AN IMPROVED CARBOTHERMAL PROCESS

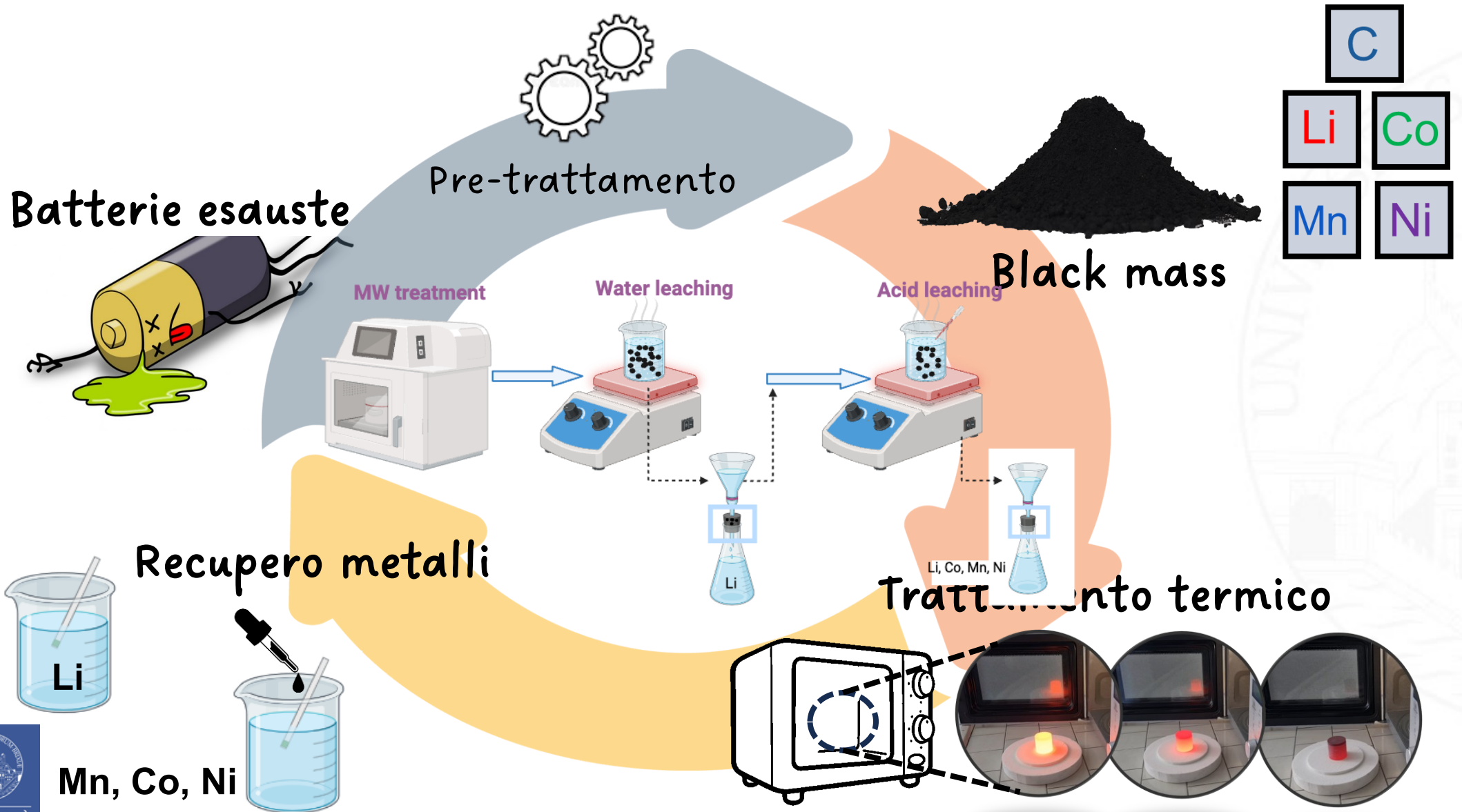


Co-funded by the Horizon 2020 programme of the European Union



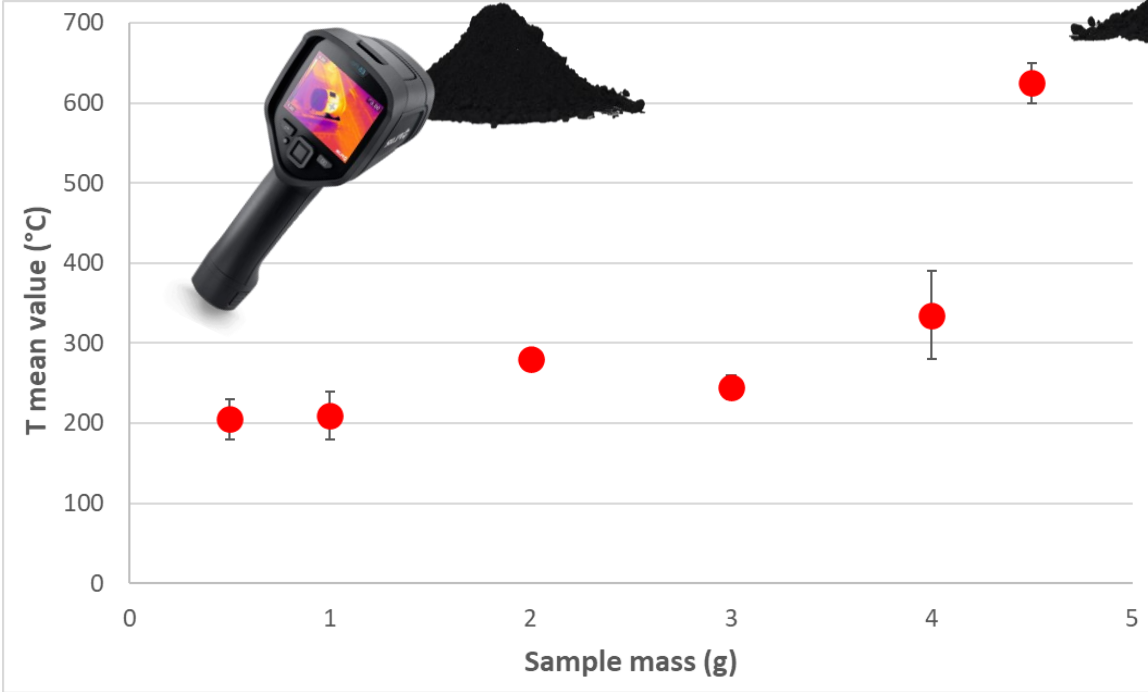
RESEARCH & INNOVATION PROGRAMME ON RAW MATERIALS TO FOSTER CIRCULAR ECONOMY

Microwave (MW)-based heating technology



Some results

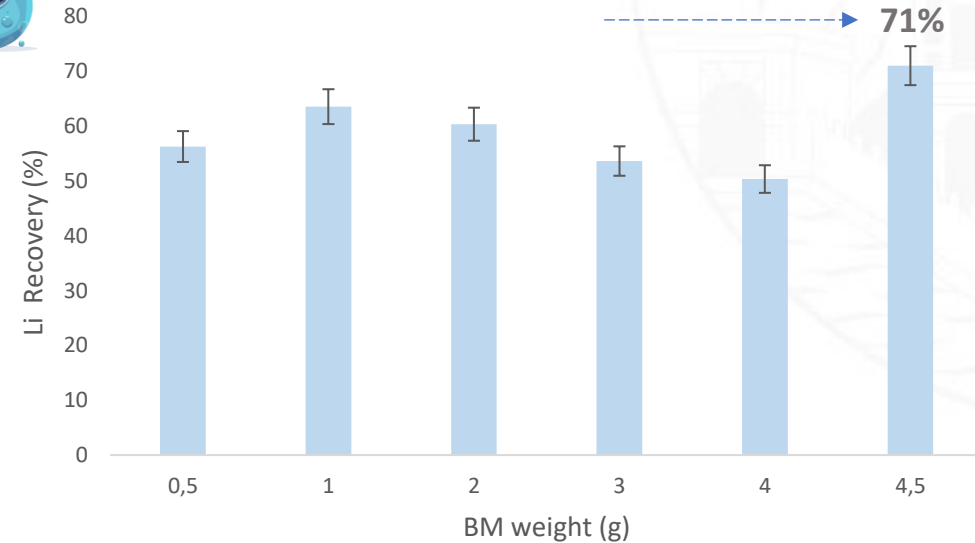
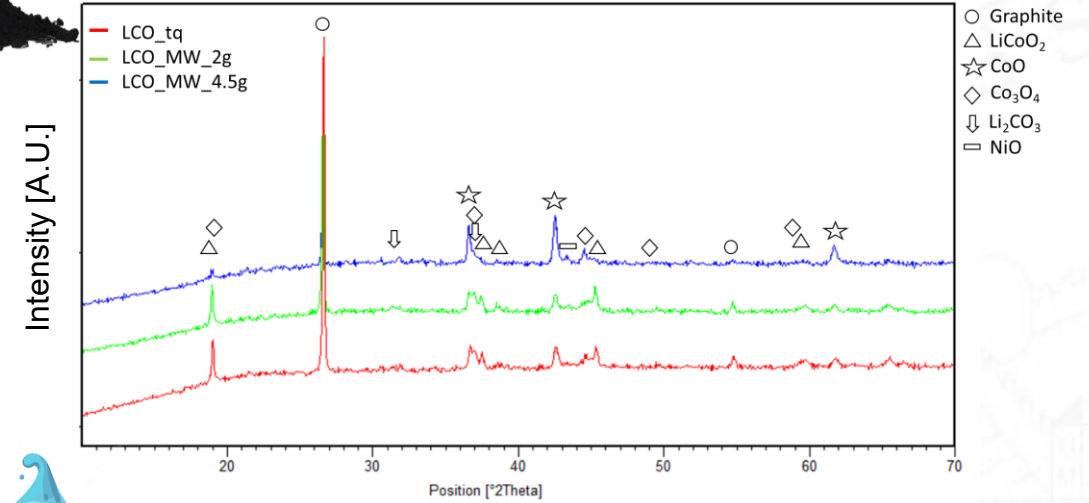
Test sperimentali



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

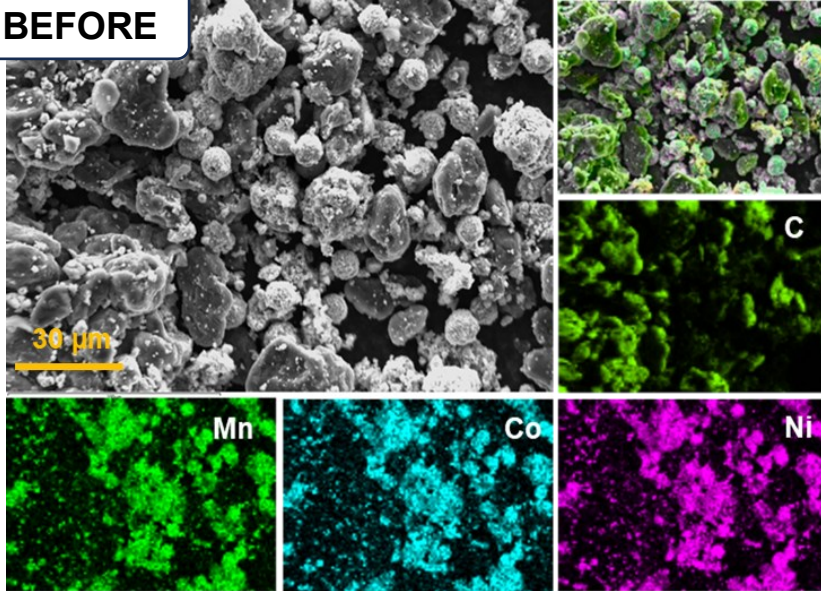
LCO (LiCoO₂)

Caratterizzazione

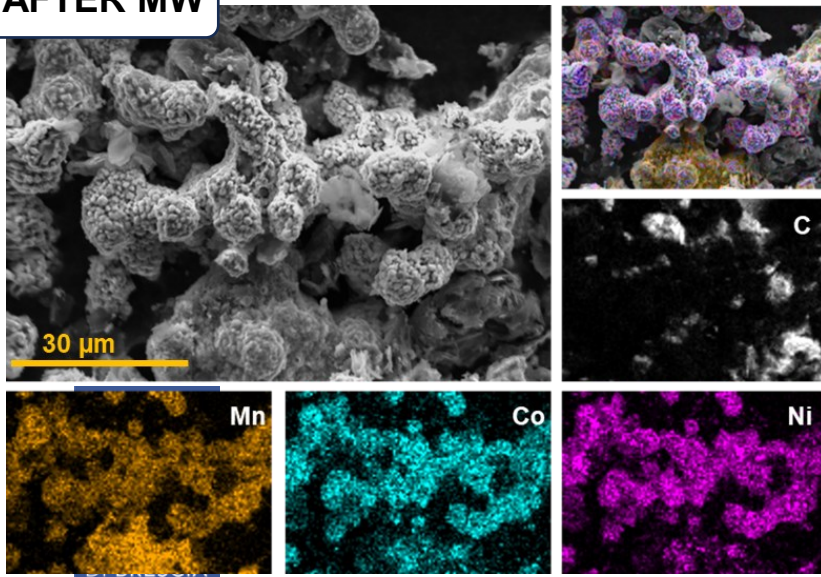


Some results

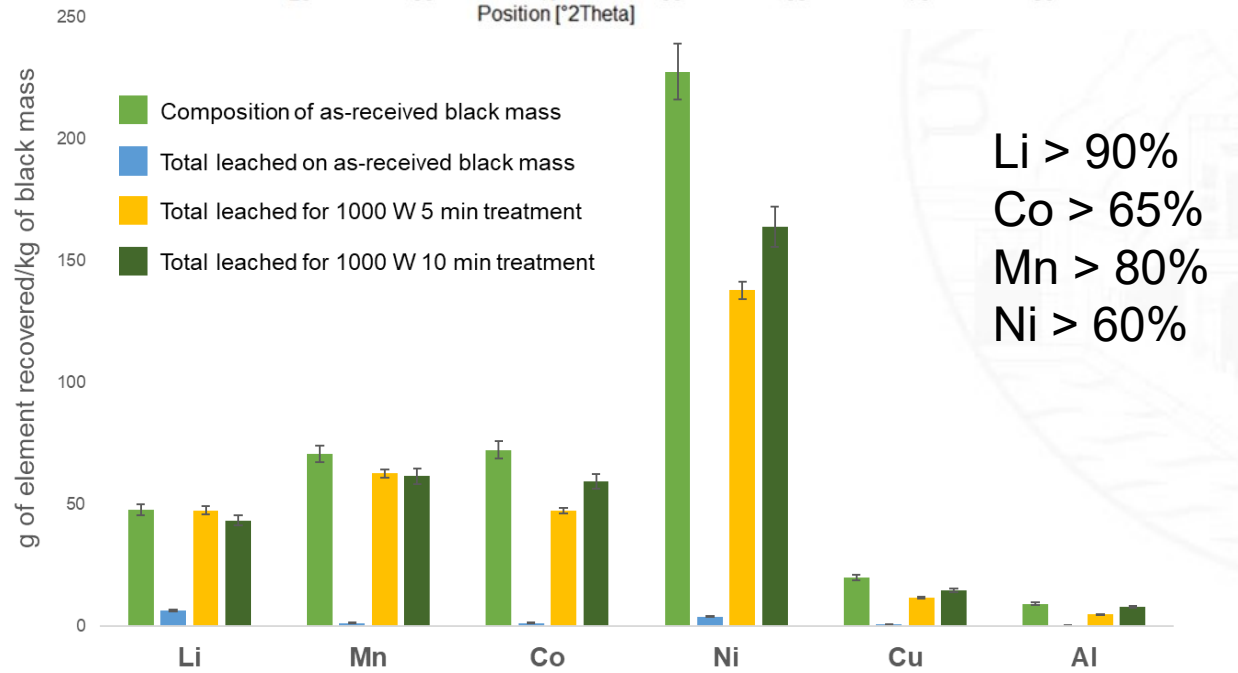
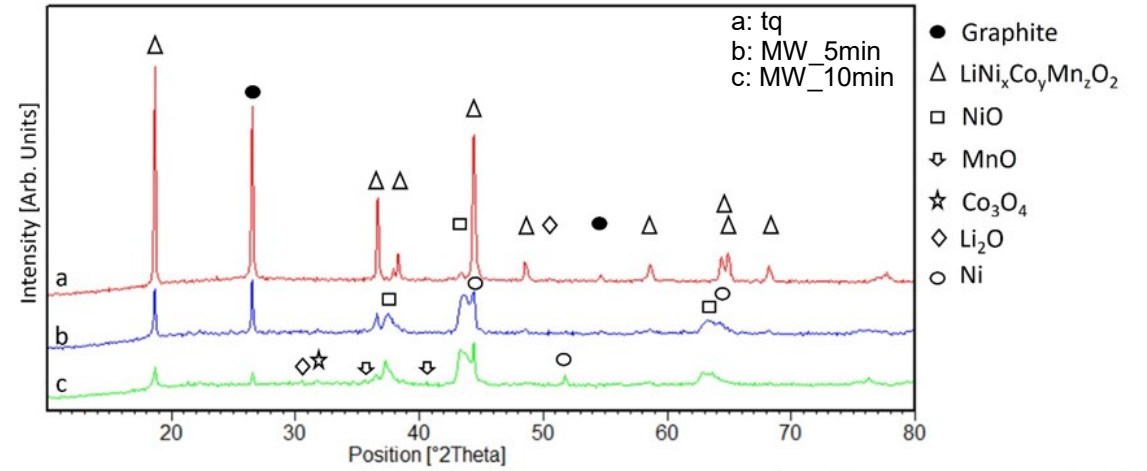
BEFORE



AFTER MW



NMC
($\text{LiNi}_x\text{Co}_y\text{Mn}_z\text{O}_2$)



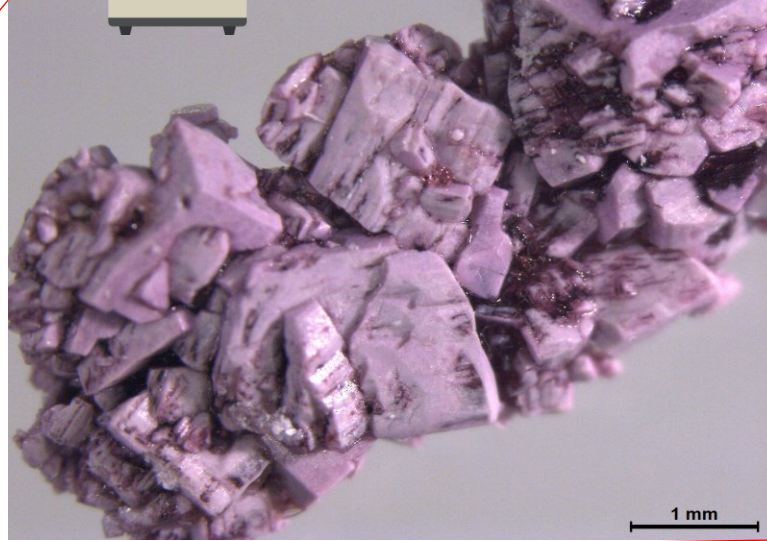
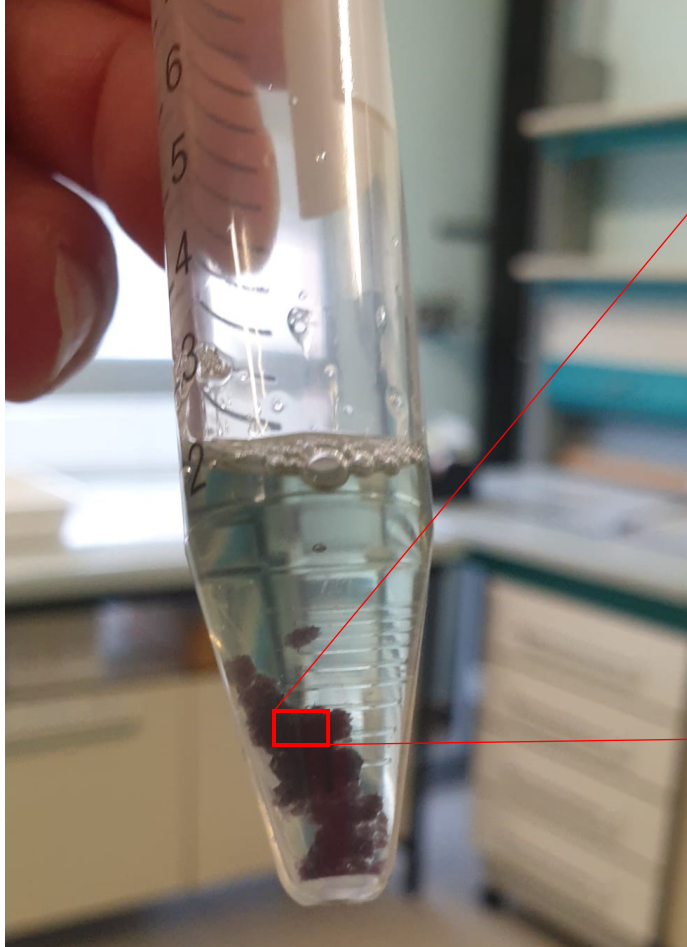
Li > 90%
 Co > 65%
 Mn > 80%
 Ni > 60%

Some results

NMC
($\text{LiNi}_x\text{Co}_y\text{Mn}_z\text{O}_2$)



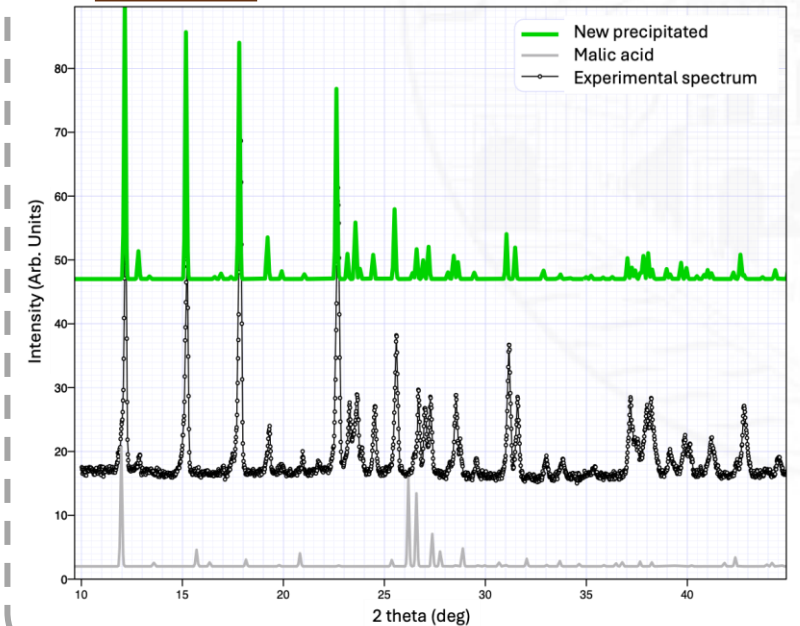
Microscopio



ICP

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

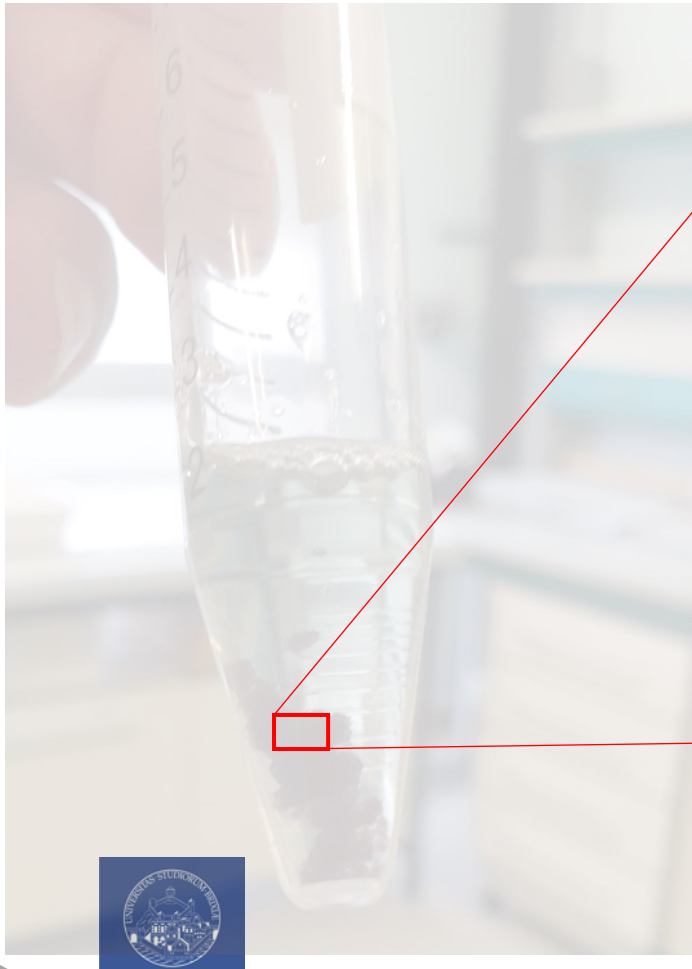
XRD



Some results



Microscopio



GIORNALE DI BRESCIA
Delitto di Capodanno
 Il giovane confessa: «Ho ucciso per paura»

Brescia e Provincia
La scoperta con l'IA: un cristallo nato dal riciclo riduce e trasforma la CO2

La scoperta con l'IA: un cristallo nato dal riciclo riduce e trasforma la CO2

Bravissima Elza, sua la ricerca che ricicla le batterie e batte la CO2

Una "cosa rosa" per l'ambiente
 La scoperta di scienziati e AI: un materiale che riduce la CO2

Aziende in liquidazione
 Dal tribunale 243 decreti

«Us da le as, il dialetto
 va in scena da protagonista

TRUST DI CERVELLI
 Capitale umano e tecnologico

@UniBS official #ElzaBontempi @UniC/Tecnica @UniMIB #serendipità #scienzaemateriali #CO2 riciclo #batteries #microronde #nickel #manganese #cobalto #chimica #ricicloidiferiti #scienza

Accedi all'articolo completo
 dal link in bio

Fonte immagine: Laboratorio di Chimica per le Tecnologie, Università di Brescia
 Elemento modificato · 2 h

ansascienza Grazie ad @unibs.official per il repost. Vi farà piacere sapere che la notizia su questa vostra interessantissima ricerca è quella con più visualizzazioni negli ultimi 30 giorni sulla pagina Instagram di @ANSAscienza. Compliment per il vostro eccellente lavoro!

1 h Piace a 2 persone Rispondi

Visualizza le risposte (1)

unicomunica 🍌
 2 h Mi piace: 1 Rispondi

Piace a chem4technologies e altri 80
 2 ore fa

Aggiungi un commento...



Scoperto con l'IA un nuovo materiale per il riutilizzo della CO2

Una "cosa rosa" per l'ambiente
 La scoperta di scienziati e AI: un materiale che riduce la CO2

TRUST DI CERVELLI
 Capitale umano e tecnologico

Sotto la lente

La scoperta

«Questo studio»

La guida del team

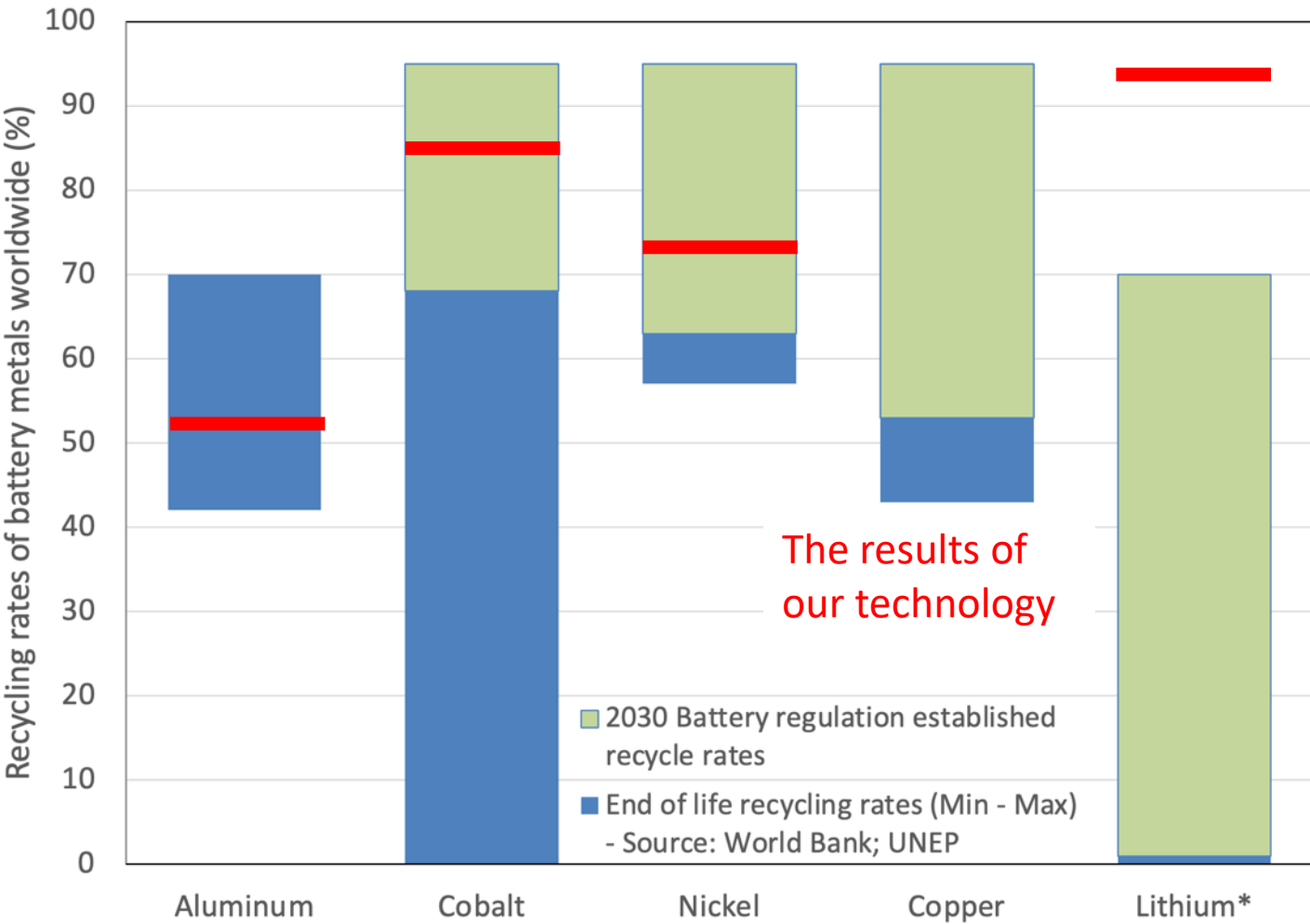
Le applicazioni



Regulation constrains

In December 2020, the European Commission published the proposed Regulation on Batteries and Waste Batteries

Recovery target on 2030
Current recovery



Project results:
 Lithium > 90%
 Cobalt > 82%
 Manganese > 85%
 Nickel > 70%
 Aluminum > 50%



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;
- Analisi sostenibilità della tecnologia proposta.

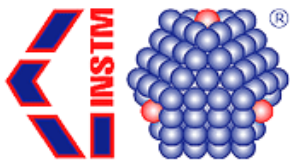


Work in Progress



Elza Bontempi
elza.bontempi@unibs.it

Laboratorio di Chimica per le Tecnologie



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Ministero
dell'Università
e della Ricerca

