Transizione energetica: i materiali del futuro

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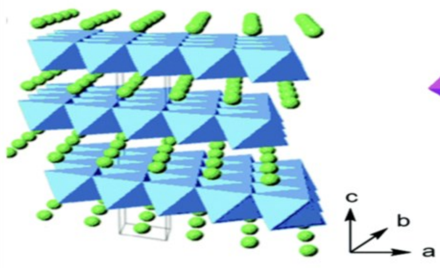
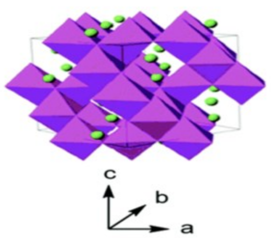
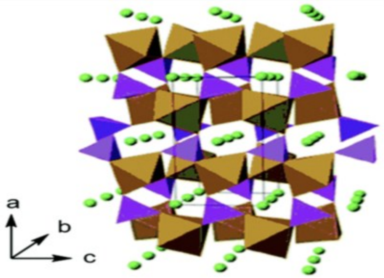
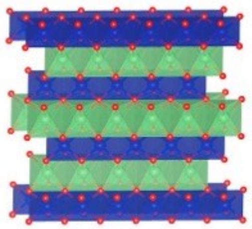
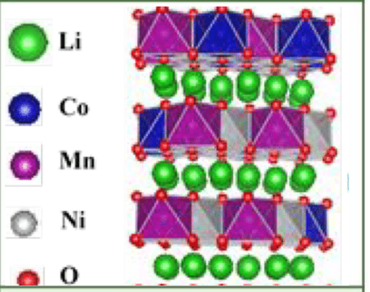
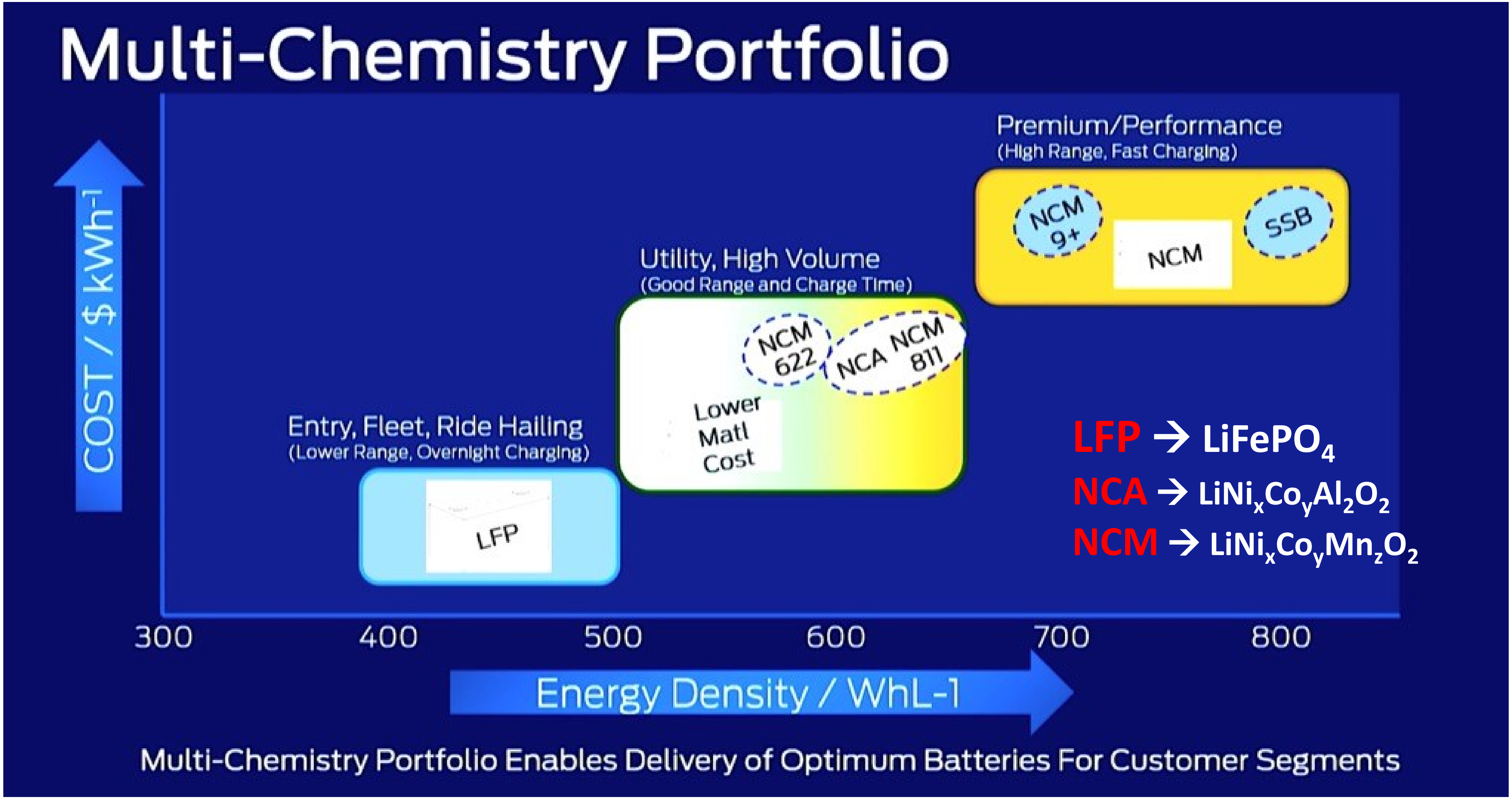
Cathode materials from the most commonly used commercial LIBs

Cathode types	LCO	LMO	LFP	NCA	NCM
Chemical formula	$LiCoO_2$	$LiMn_2O_4$	$LiFePO_4$	$LiNi_xCo_yAl_zO_2$	$LiNi_xCo_yMn_zO_2$
Structure					
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

Journal of Cleaner Production 340 (2022) 130535

Materials for batteries



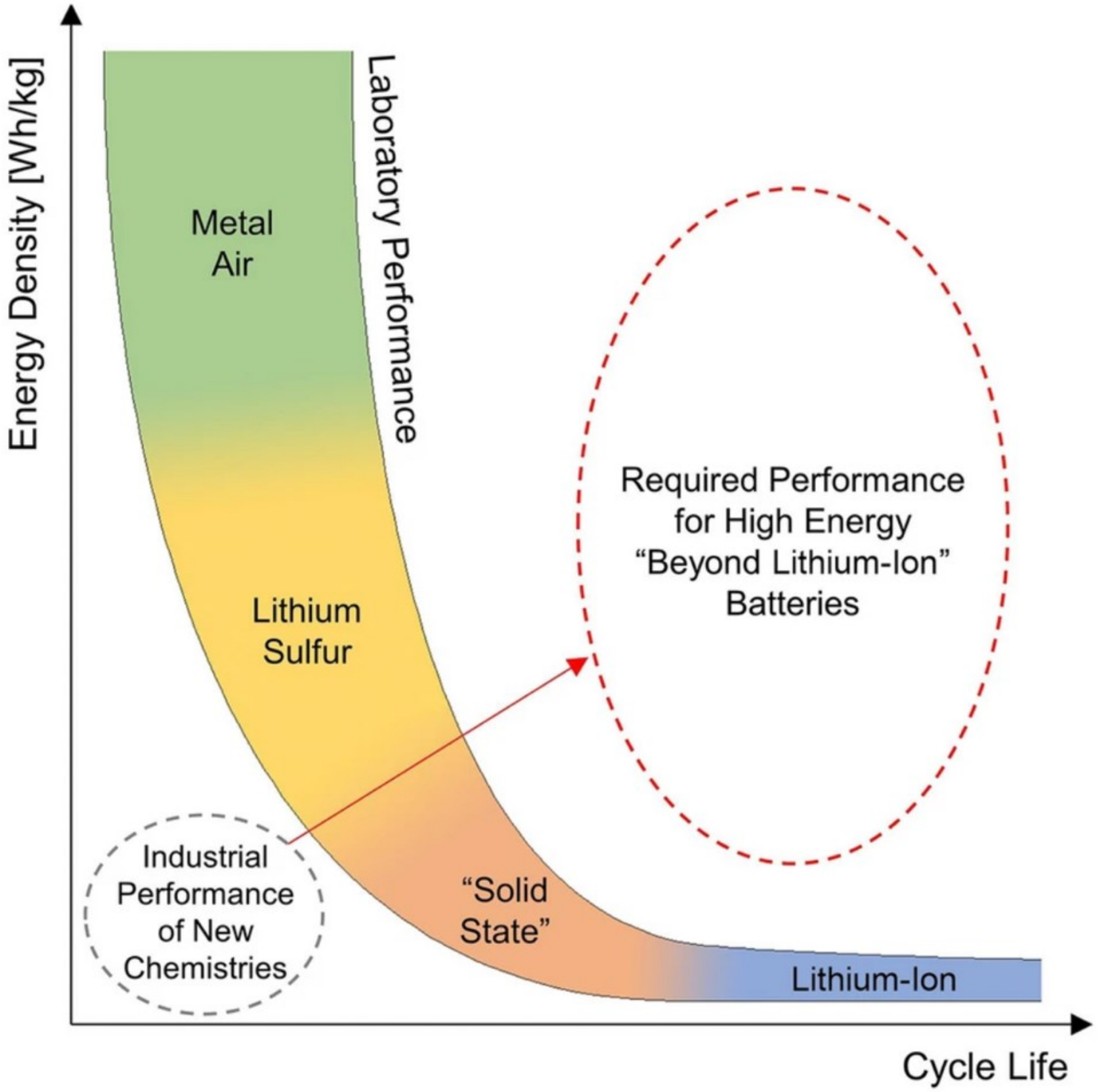
LFP → $LiFePO_4$

NCA → $LiNi_xCo_yAl_zO_2$

NCM → $LiNi_xCo_yMn_zO_2$

https://www.mdpi.com/2075-4701/13/3/543

Emerging materials for batteries



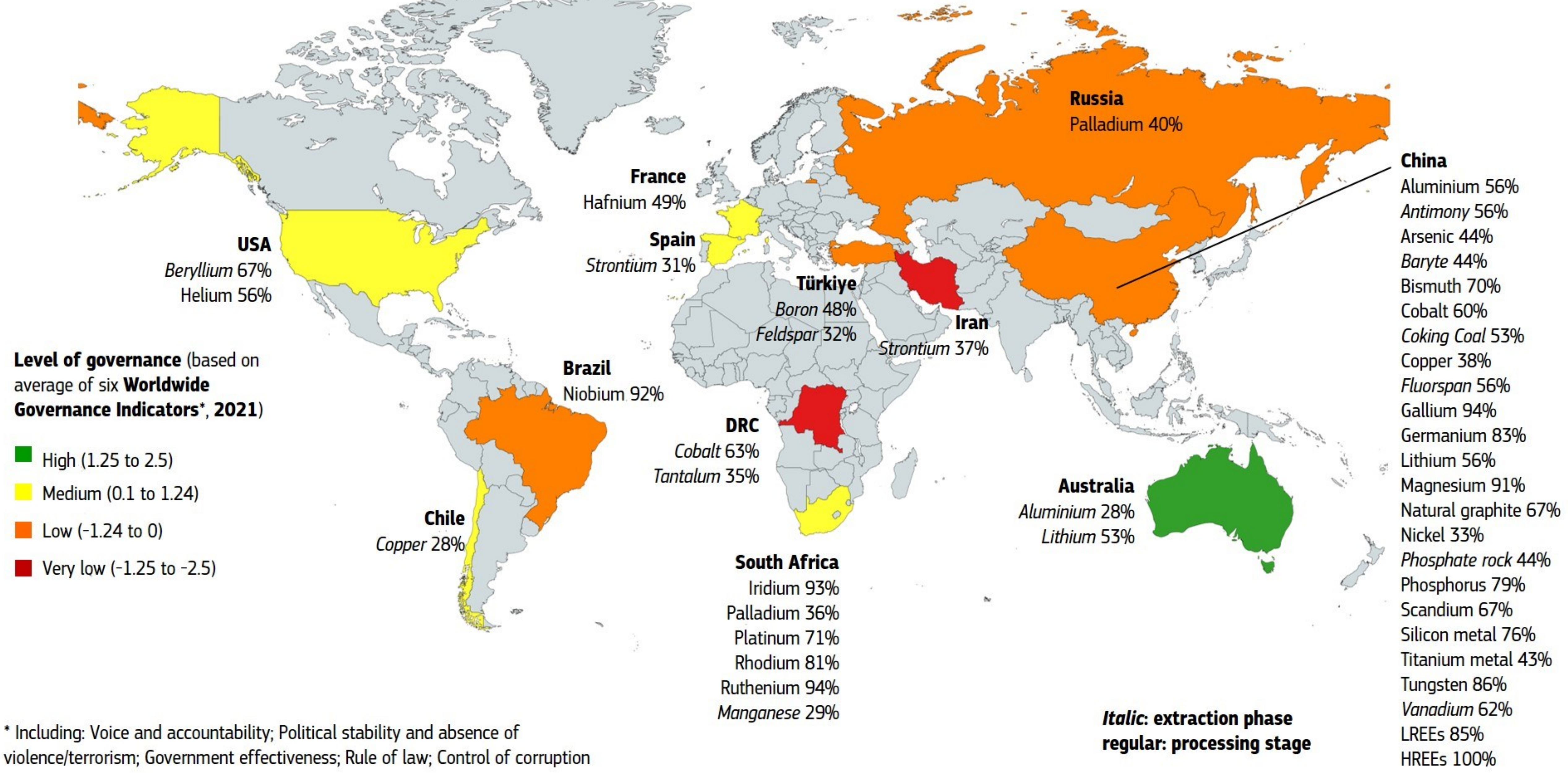
Increasing the energy density remains a central driving force in advancing battery research and innovation.

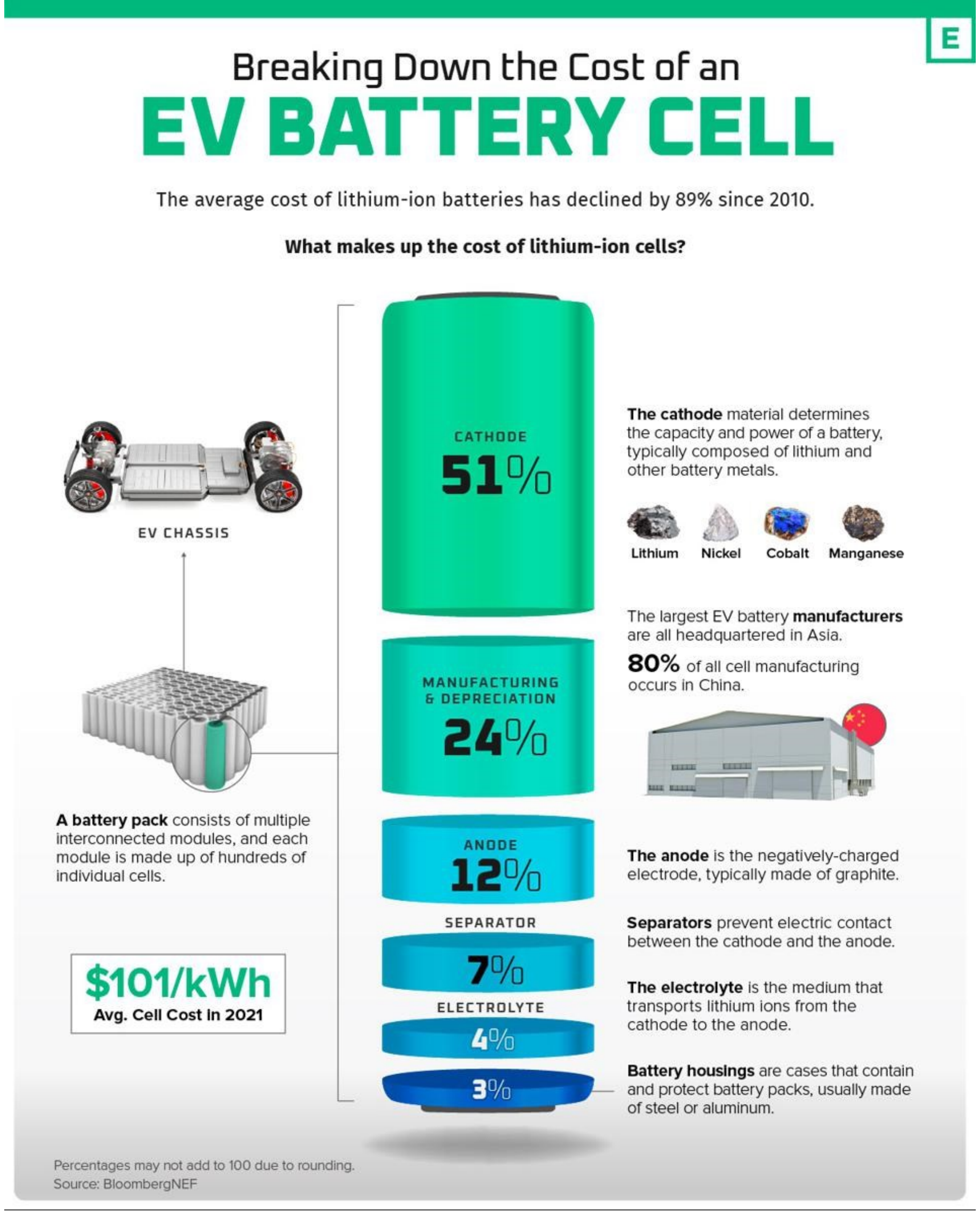
However, the new chemistries also aim to:

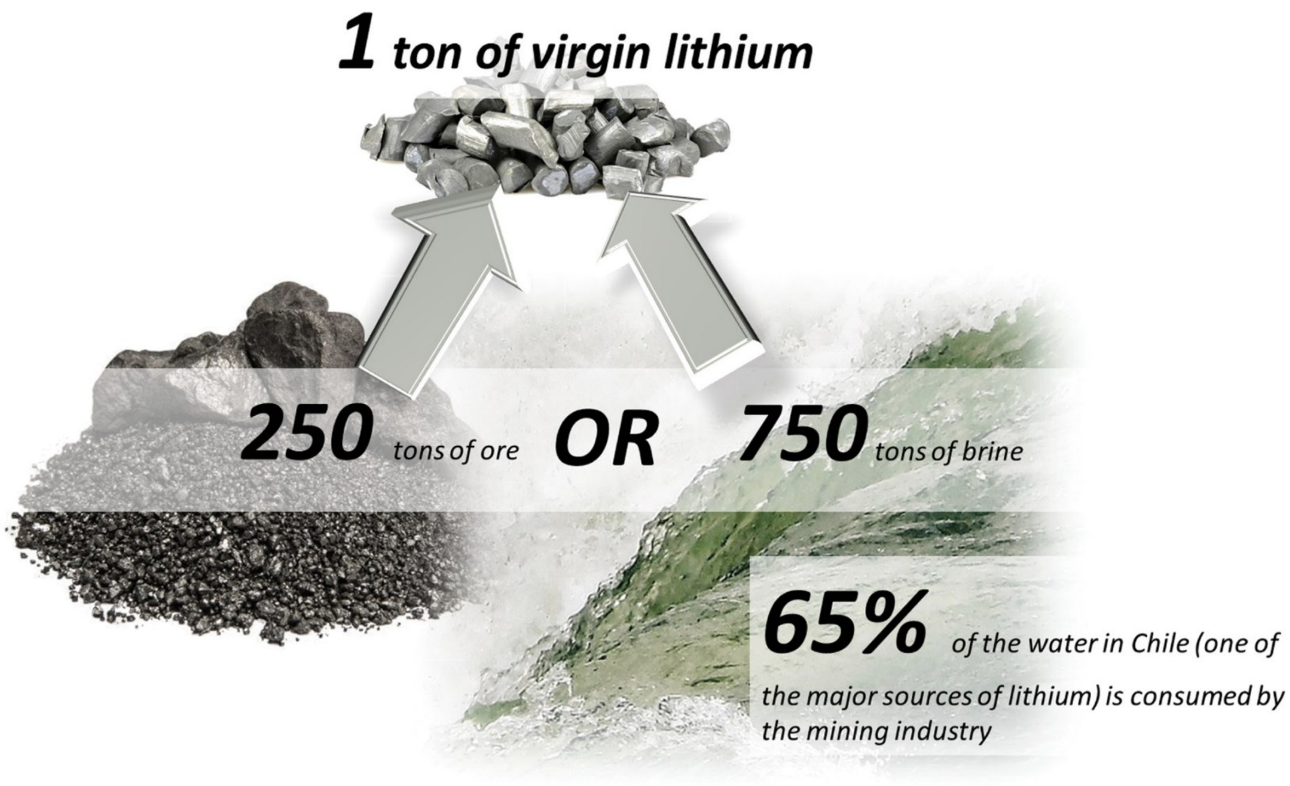
- New advanced materials
- Diversification
- Reduced reliance on CRM

Critical raw materials

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



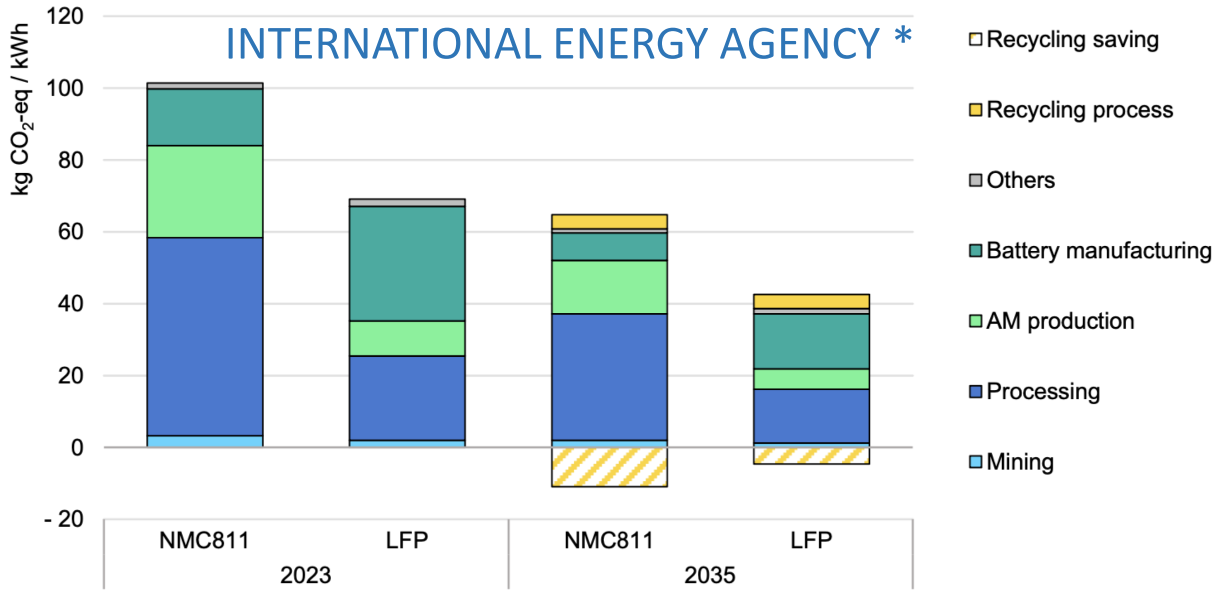


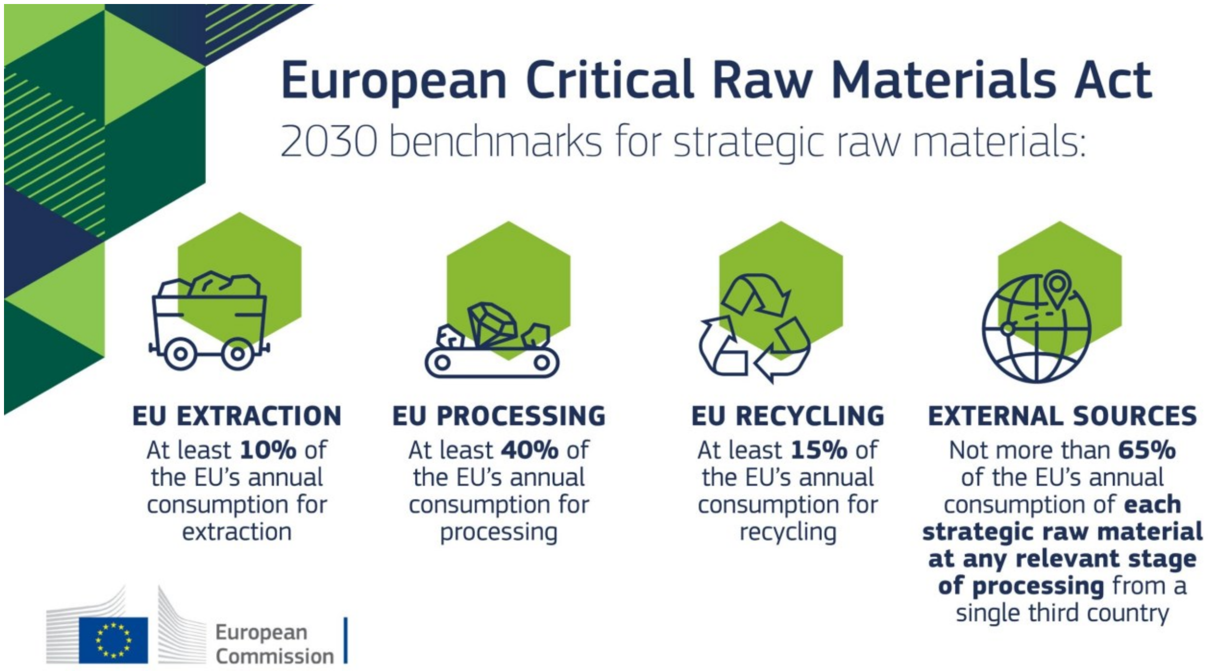


CO_2	15 tons	5 tons
Water	170 m^3	469 m^3
Use of land	464 m^2	3,124 m^2

Source Minviro

Mitigation and Improvement Measures





IEA (2024), *Global EV Outlook 2024*, IEA, Paris https://www.iea.org/reports/global-ev-outlook-2024, Licence: CC BY 4.0

Li-ion battery recycling value chain

https://www.duesenfeld.com

Hydrometallurgy

Pyrometallurgy

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Recycling and reuse are needed for supply chain sustainability and security (IEA report April 2024)

Carbothermic reduction

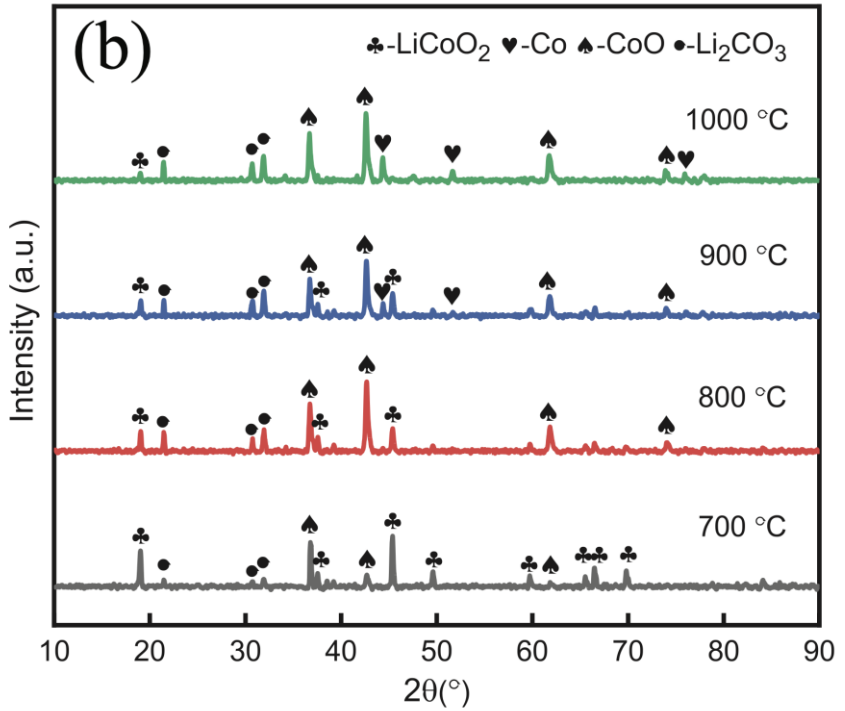
Electrode material $LiCoO_2$ decomposes at above 900°C

$4LiCoO_2 \rightarrow 2Li_2O+4CoO+O_2$

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

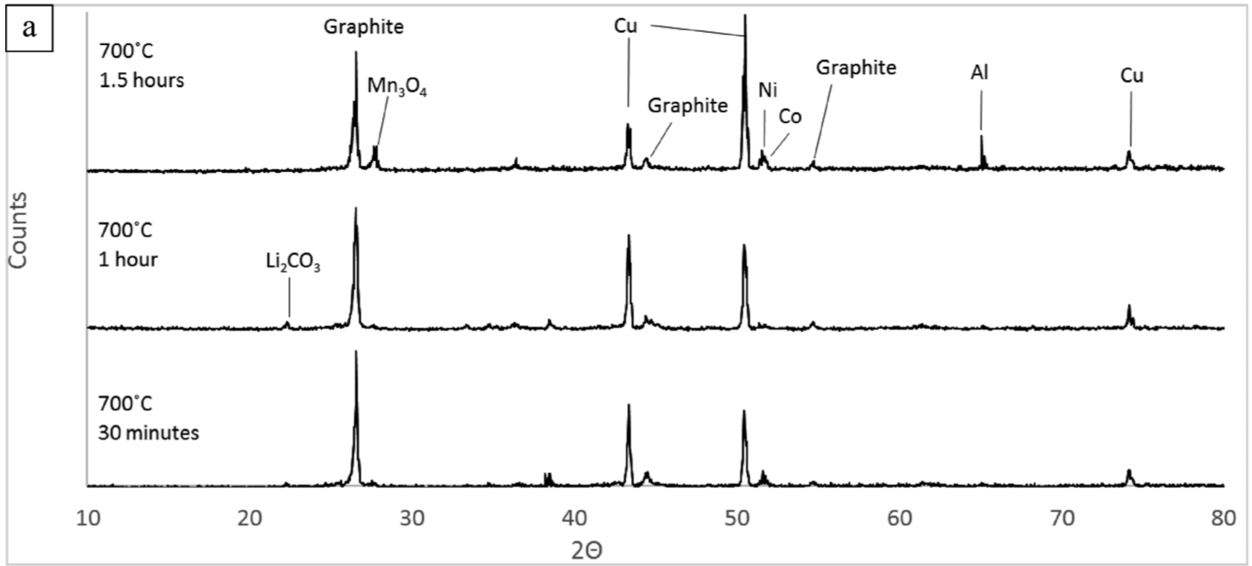
$2LiCoO_2+3CO \rightarrow 2Co+Li_2O+3CO_2$

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.

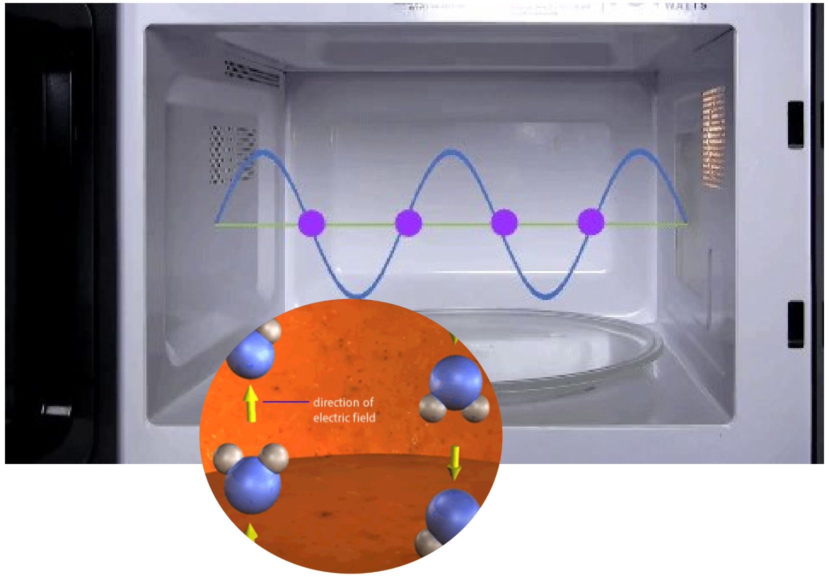
ACS Sustainable Chem. Eng. 2019, 7, 13668−13679



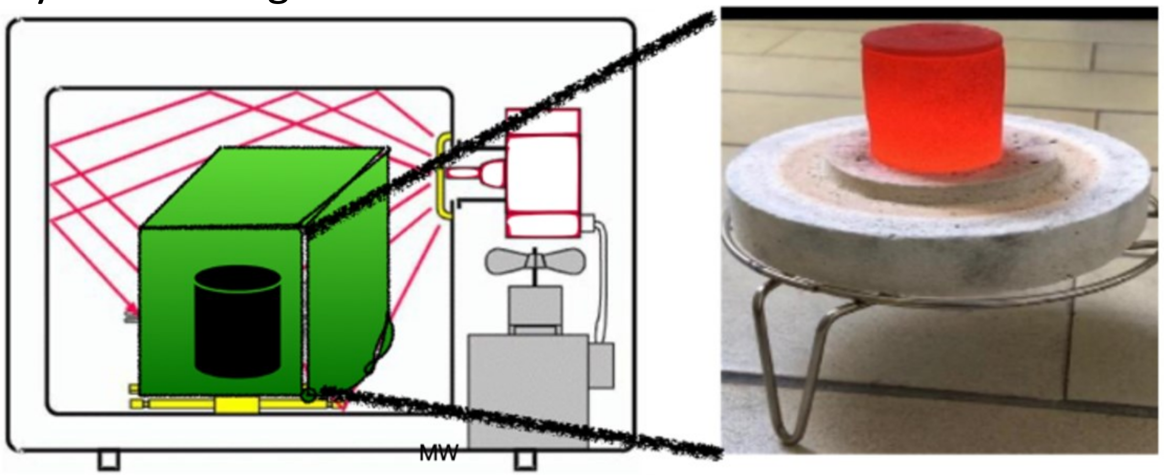
The chemical reactions became spontaneous at ≥ 600˚C, because their Gibbs free energy became negative

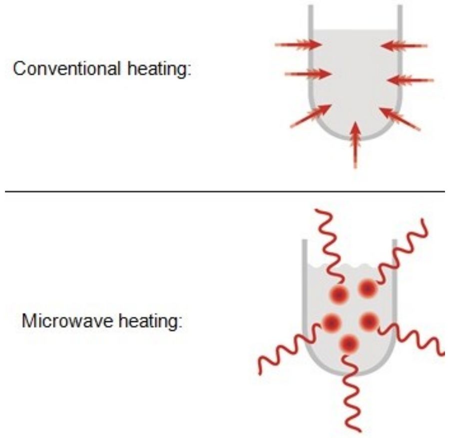
Chemical Engineering Journal 435 (2022) 135165

Microwave (MW)-based heating technology

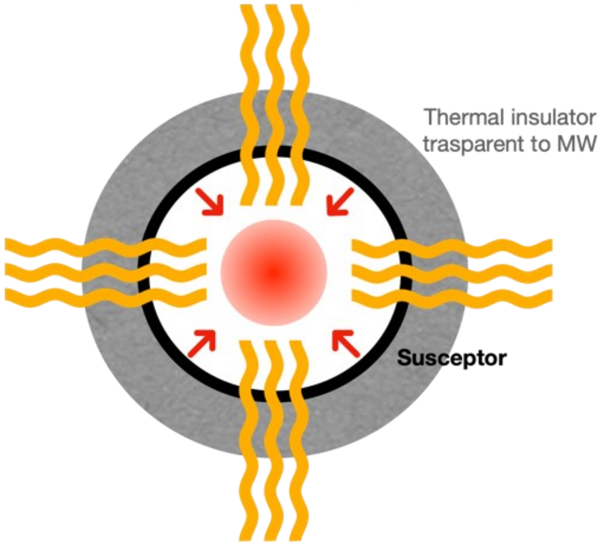


hybrid heating mechanism





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

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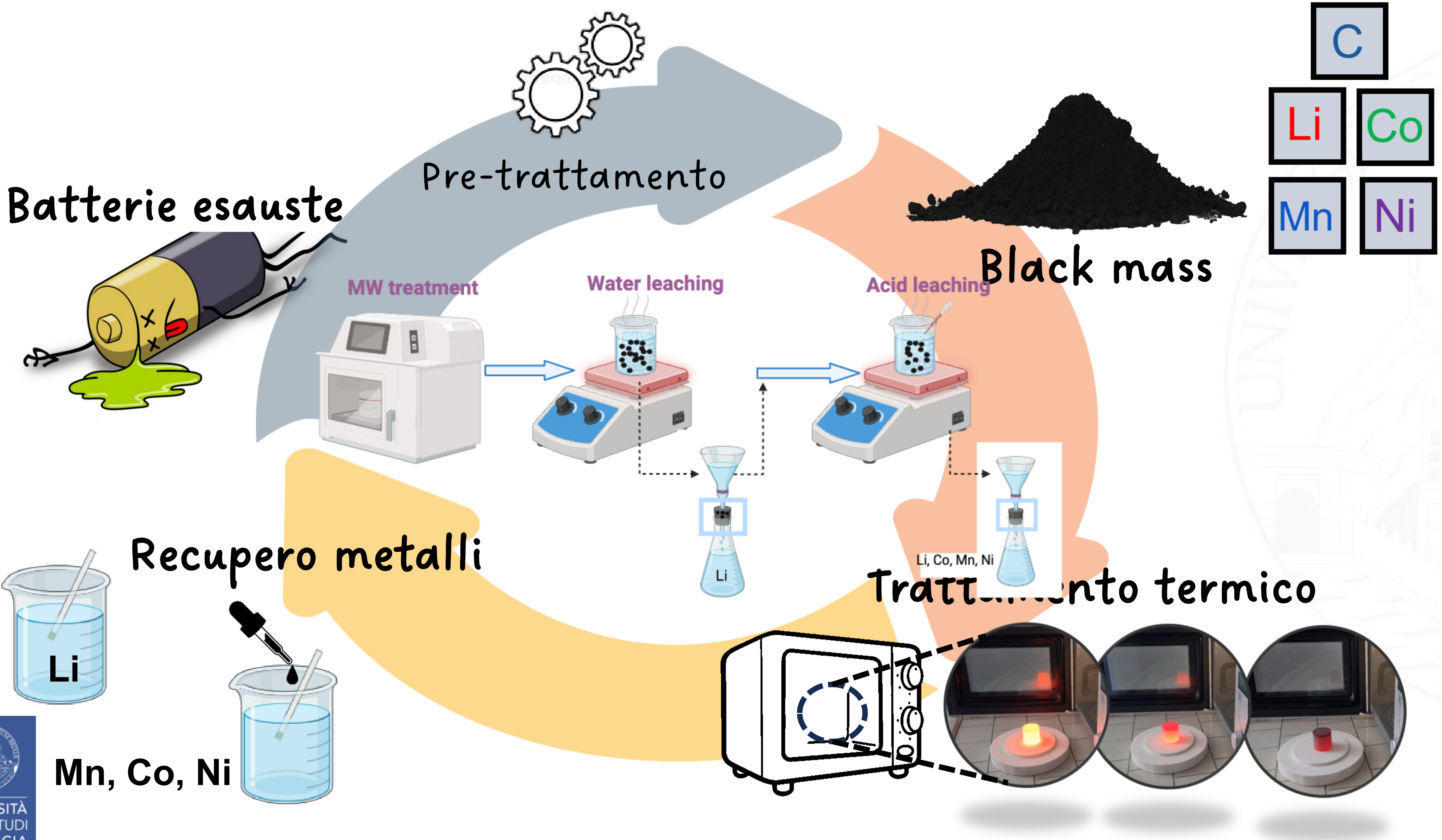
Co-funded by the Horizon 2020 programme of the European Union

ERA-MIN 2

RESEARCH & INNOVATION PROGRAMME ON RAW MATERIALS TO FOSTER CIRCULAR ECONOMY

Microwave (MW)-based heating technology



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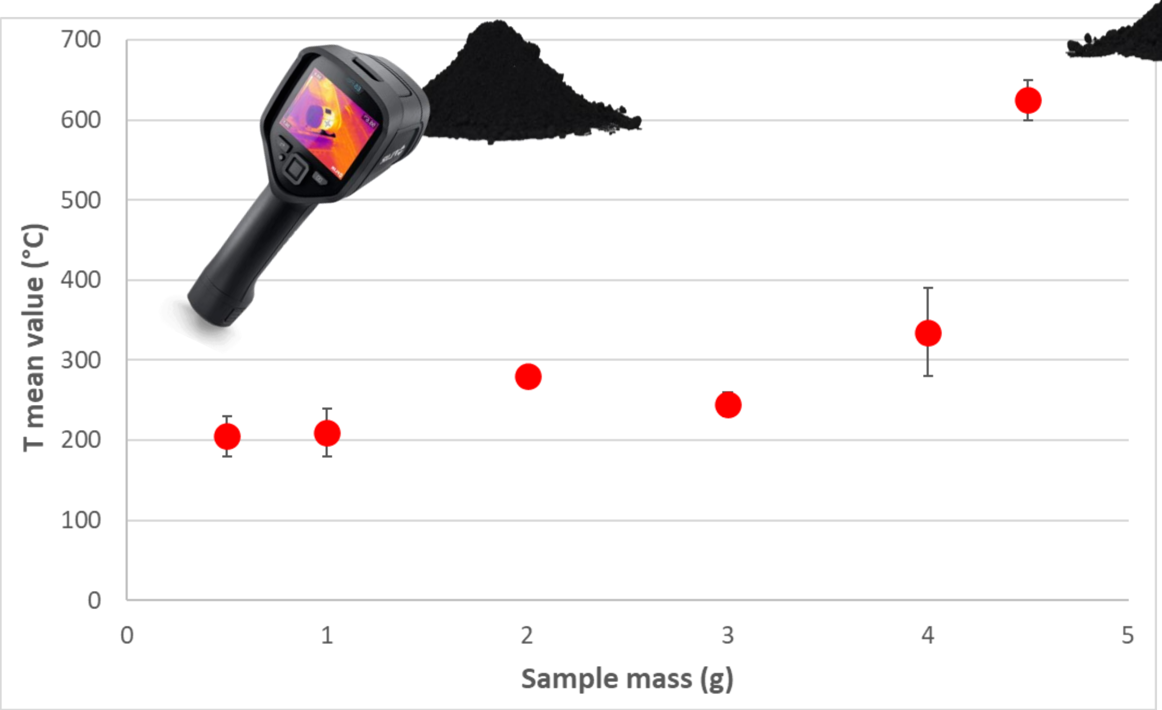
Some results

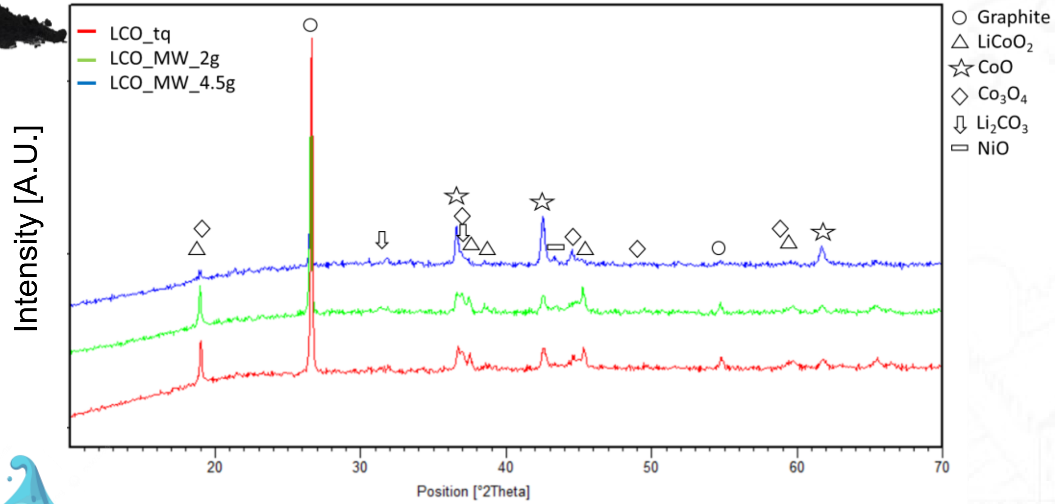
Test sperimentali

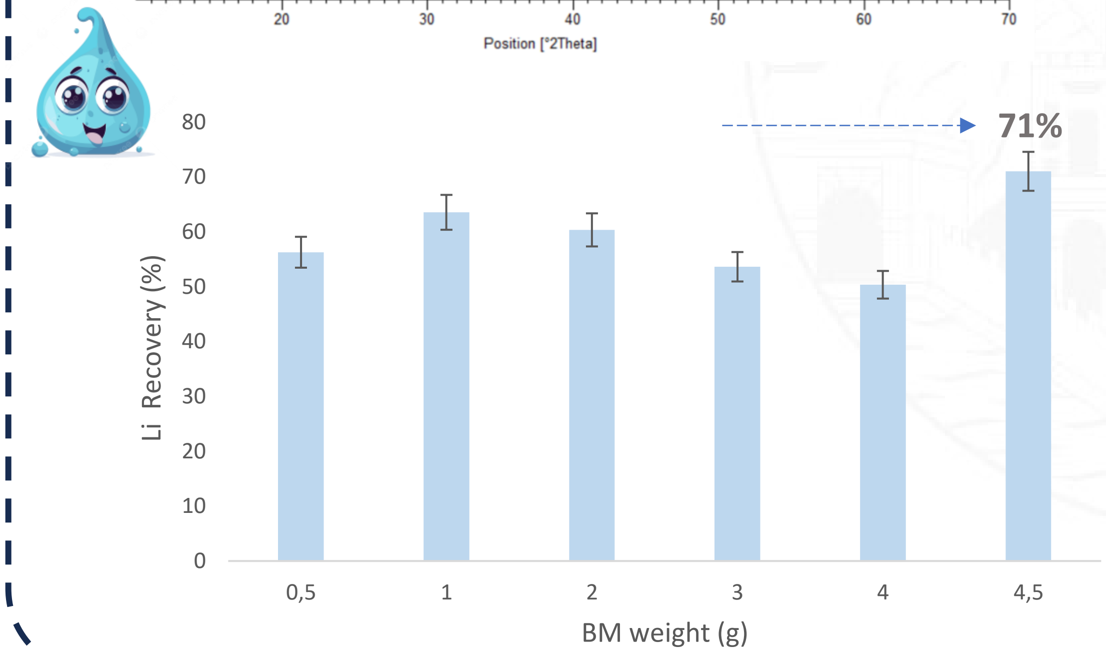


- 600 W_5 min;
- aumento massa da trattare → aumento della temperatura del campione, per la maggiore quantità di BM eccitata da MW.

LCO ($LiCoO_2$)

Caratterizzazione

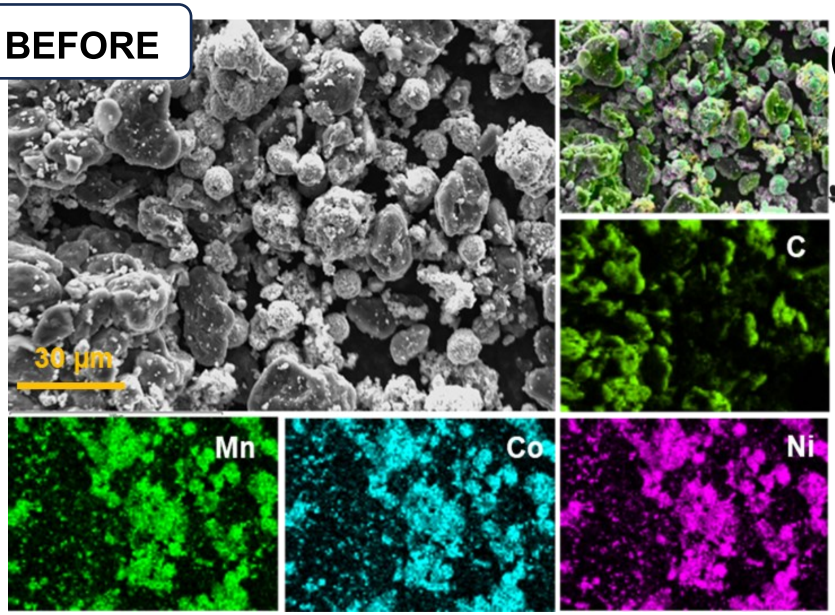




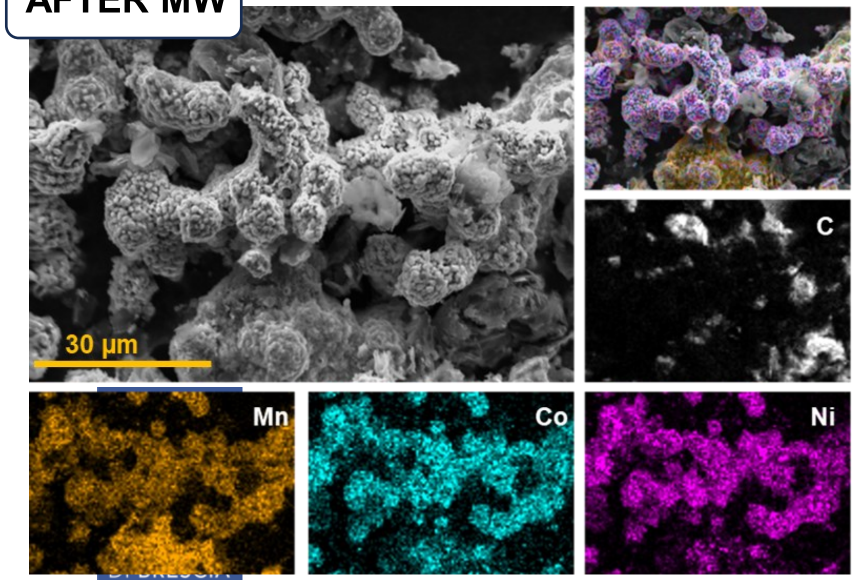
RSC Sustainability, 2024, 2505

Some results

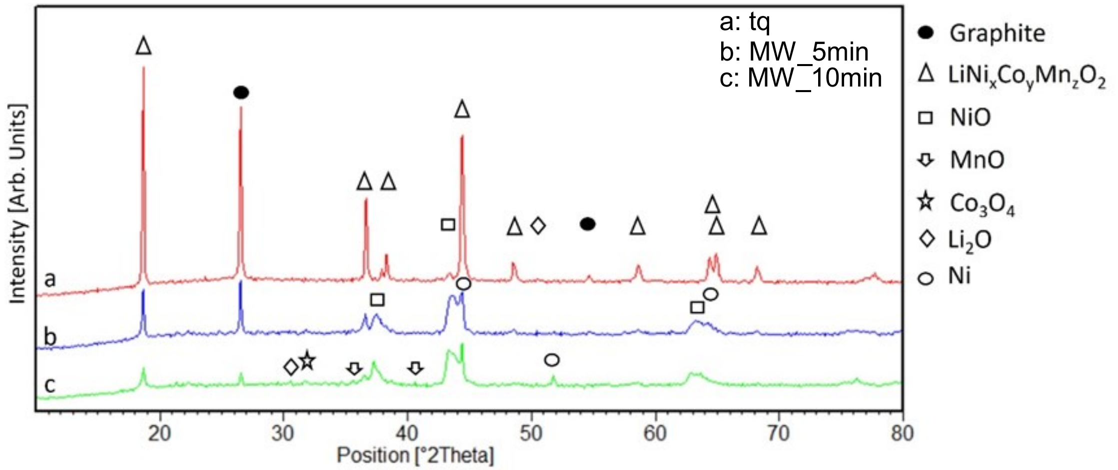
BEFORE

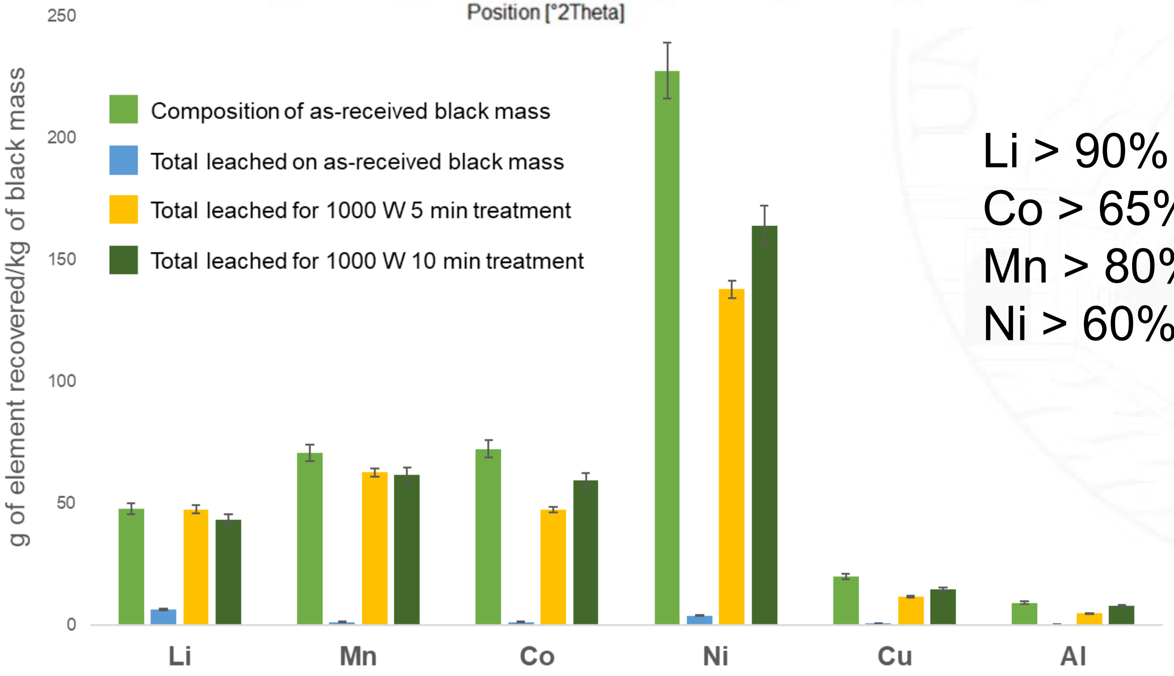


AFTER MW



NMC ($LiNi_xCo_yMn_zO_2$)





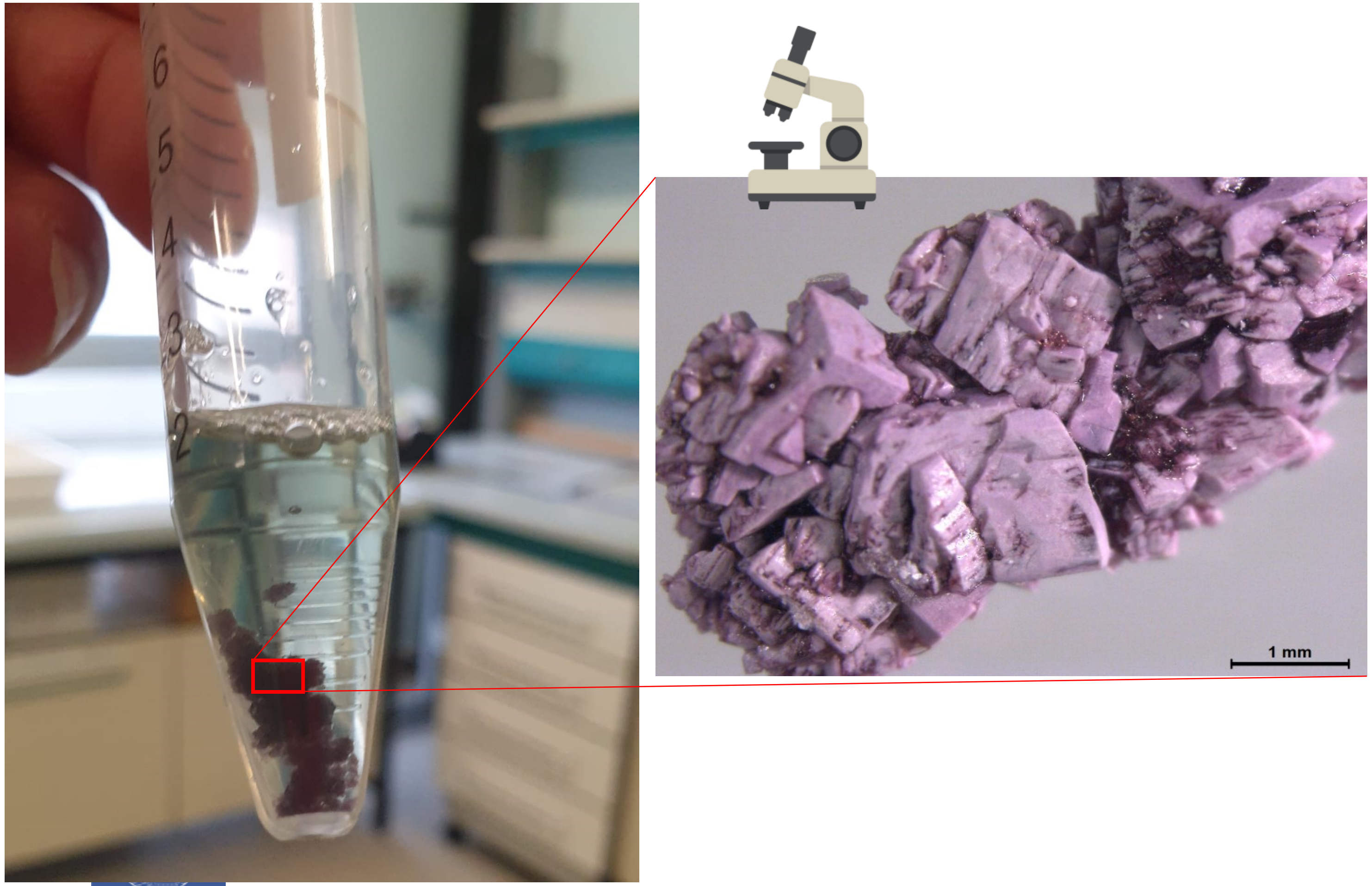
Li > 90%
Co > 65%
Mn > 80%
Ni > 60%

Energy Storage Materials, 2024, 103703

Some results

NMC
($LiNi_xCo_yMn_zO_2$)

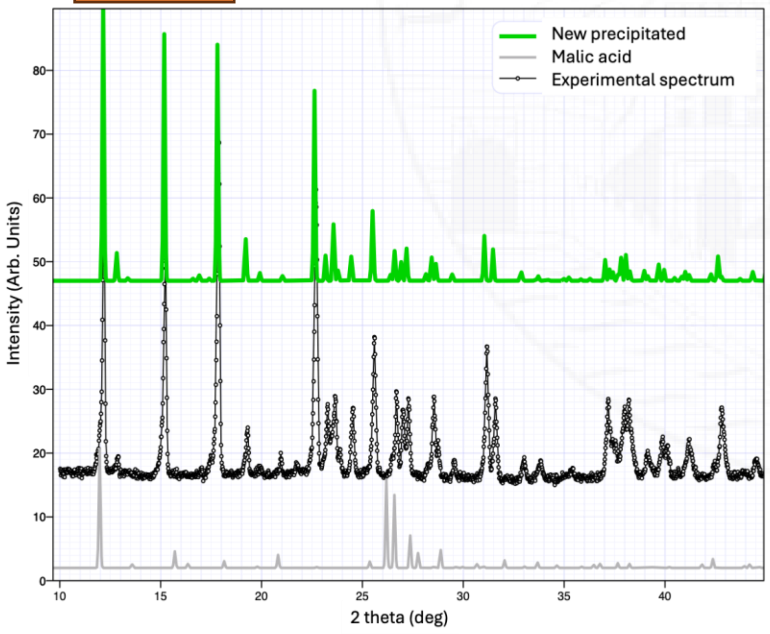
Microscopio



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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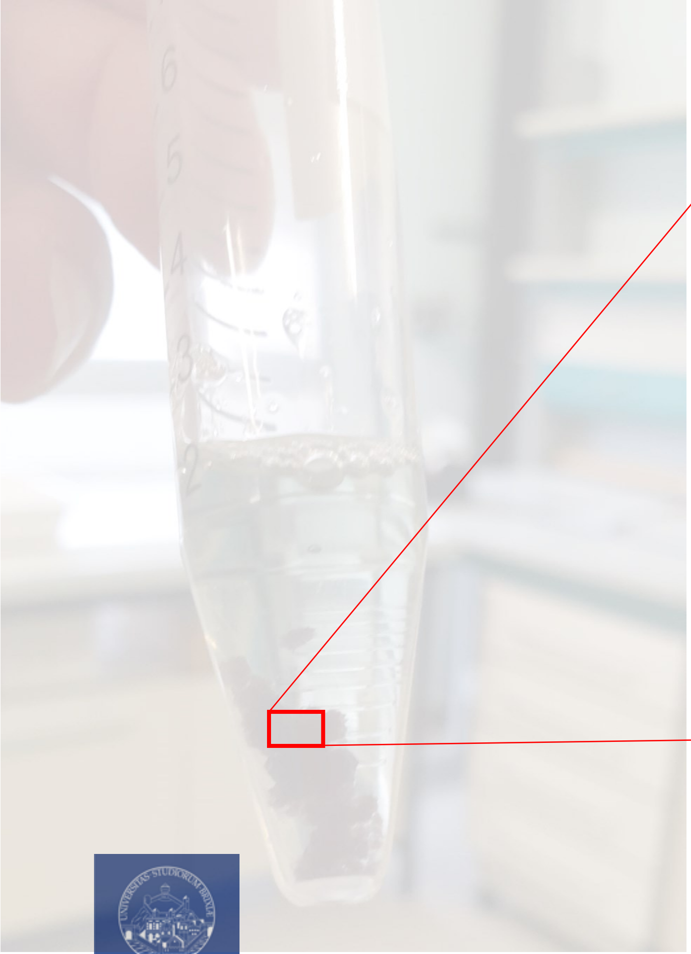
Environmental Research, 2025, 120709

Some results

NMC ($LiNi_xCo_yMn_zO_2$)

Microscopio



@UniBS.official #ElzaBontempi @UniCTcomunica @UniMiB #serendipità #scienzadeimateriali #CO2 #riciclo #batterieesauste #microonde #nickel #manganese #cobalto #litio #chimica #riciclodeirifiuti #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. Complimenti per il vostro eccellente lavoro!

1 h Piace a 2 persone Rispondi

Visualizza le risposte (1)

unictcomunica

2 h Mi piace: 1 Rispondi

Piace a chem4technologies e altri 80

2 ore fa

Aggiungi un commento...

Environmental Research, 2025, 120709

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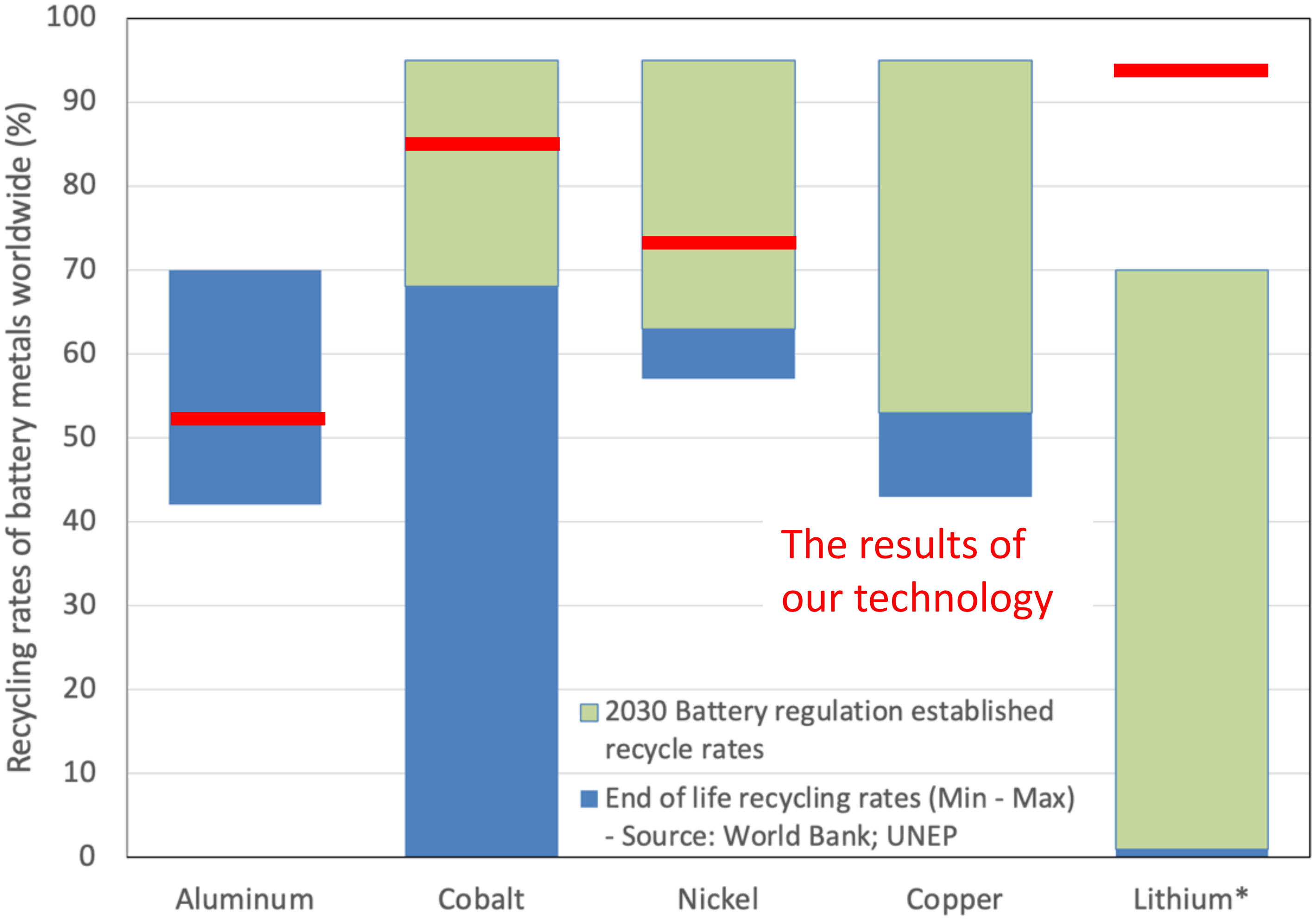
Regulation constrains

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%

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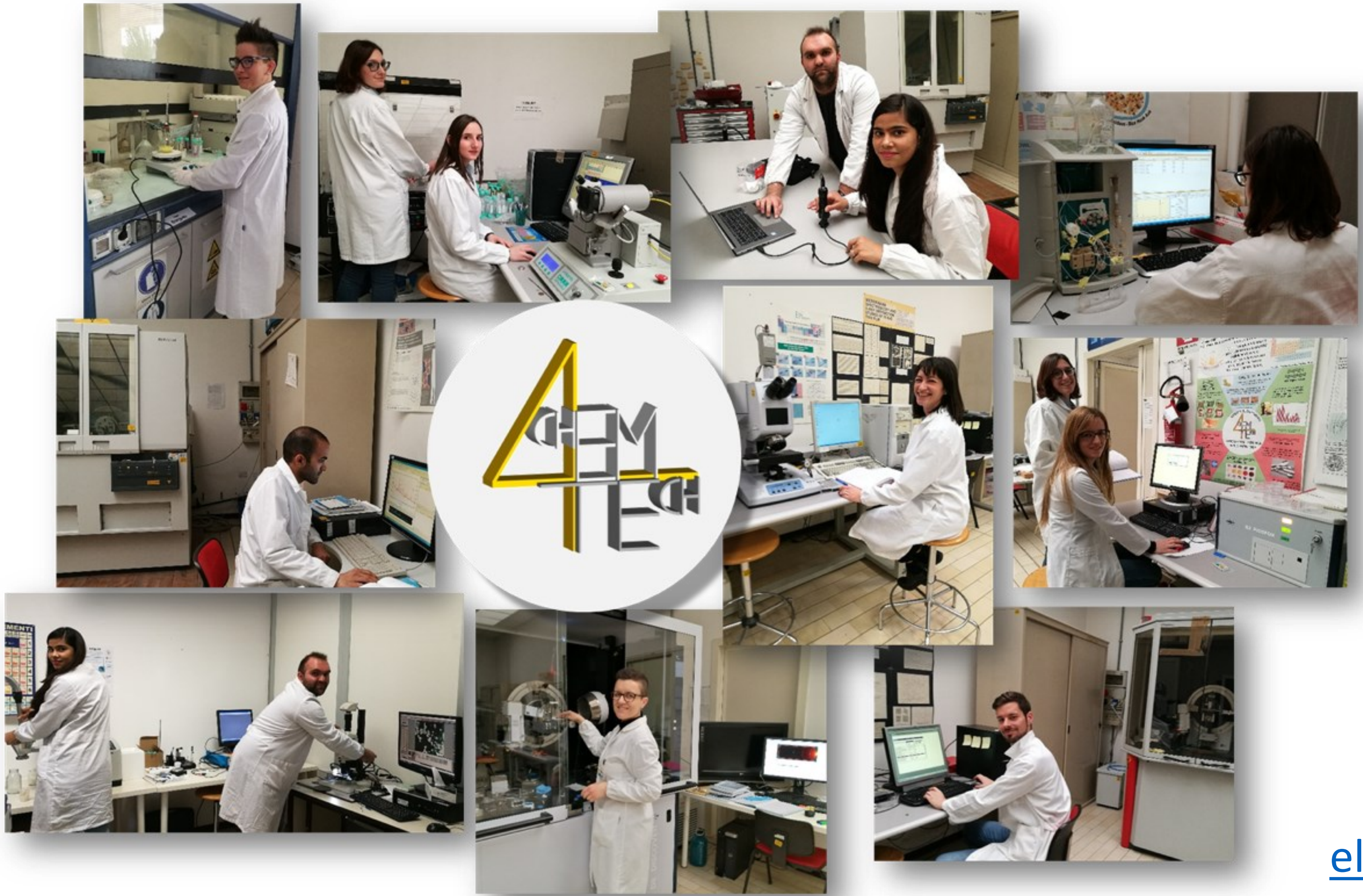
Conclusioni

- 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.



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Laboratorio di Chimica per le Tecnologie

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