Sodium-Ion Battery Recycling: Metals Recovery from Layered Transition-Metal Oxide

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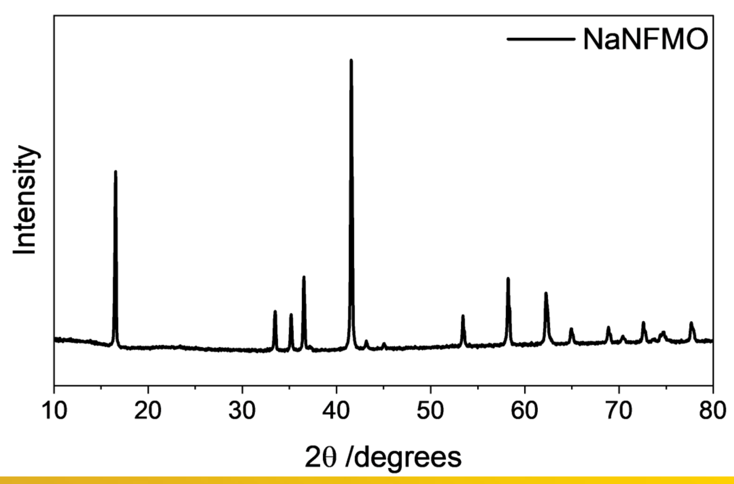
RENOVATE

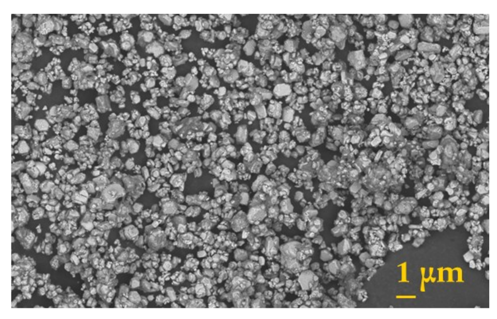
Introduction and rationale

Since Sodium-ion Batteries (SIBs) are emerging as alternatives to Lithium-ion Batteries (LIBs), it is necessary to develop circular economy models tailored to SIBs. Hydro/solvometallurgical methods are promising for this purpose thanks to their versatility, lower environmental impact, and compatibility with EU battery regulations. [1]

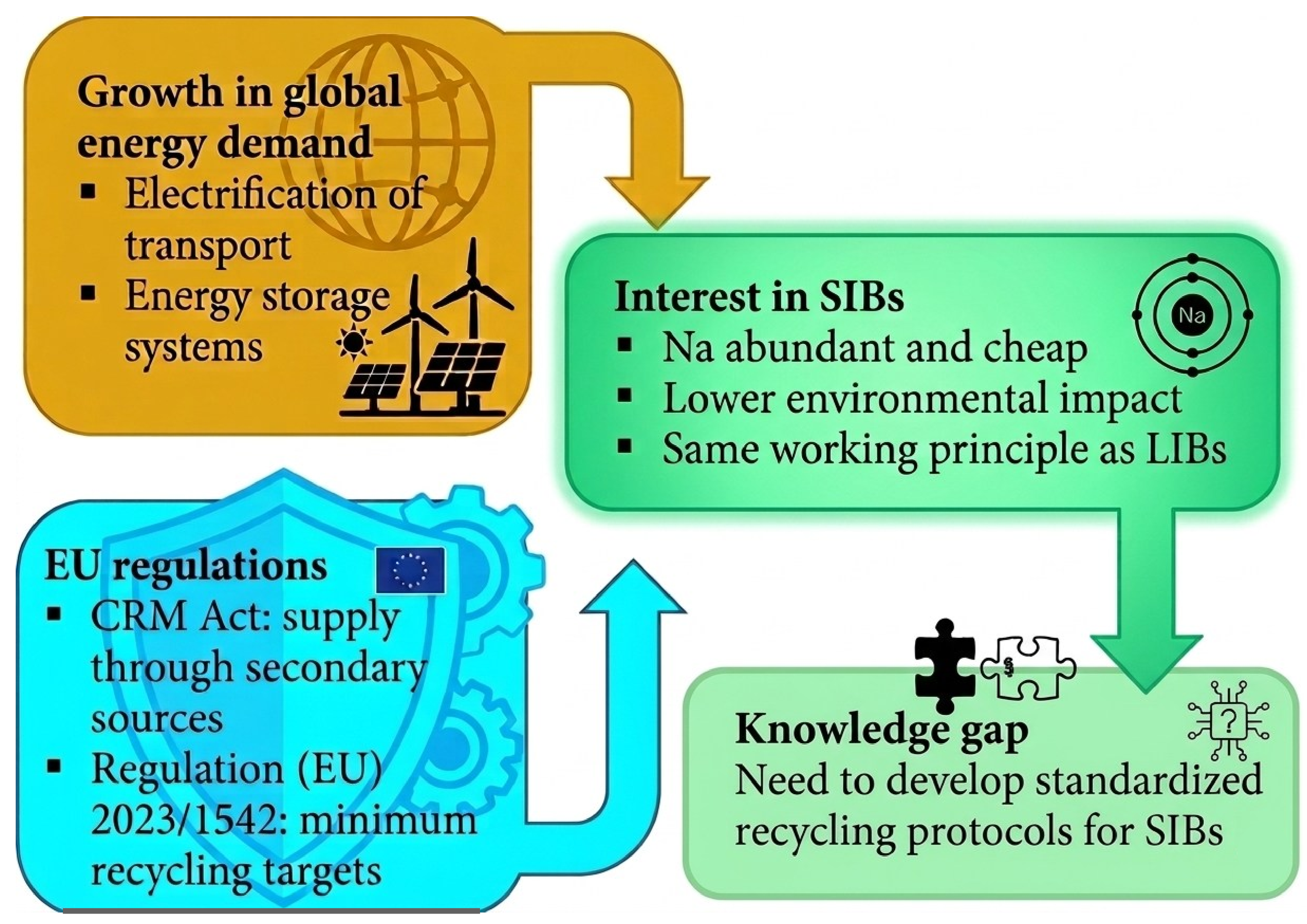
AIM OF THE PROJECT

Evaluating SIBs recycling approaches by adapting optimized LIBs strategies and assessing their transferability to $NaNi_{0.33}Fe_{0.33}Mn_{0.33}O_2$ (NaNFMO)



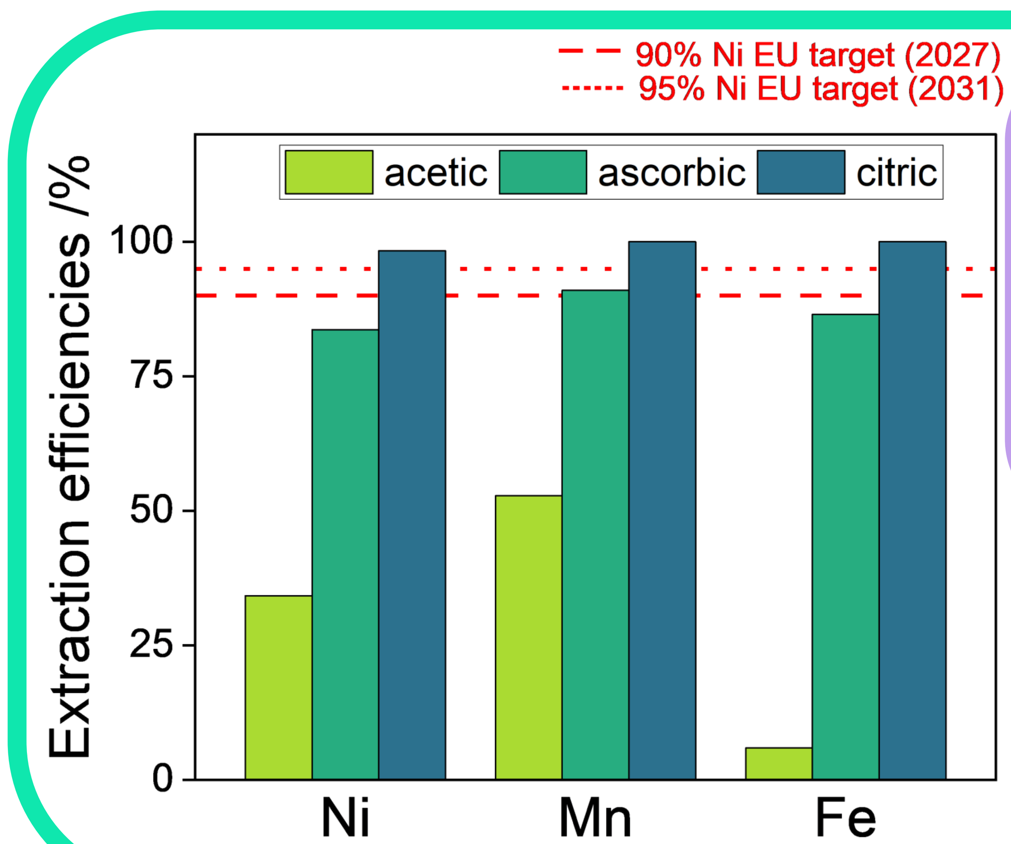


NaNFMO pristine layered oxide



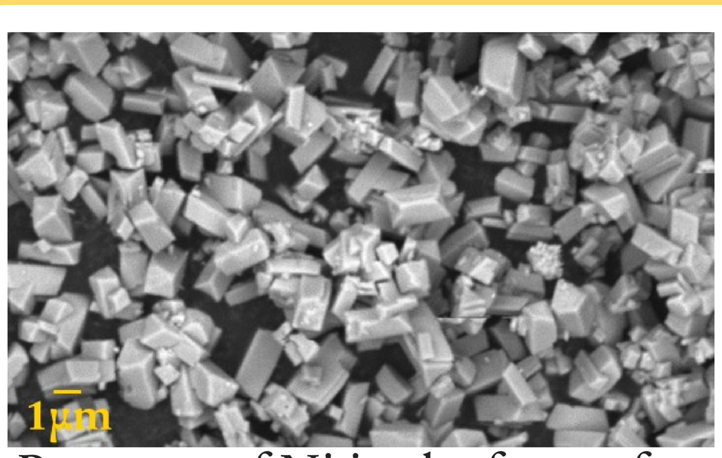
Organic acid leaching: CRMs' recovery

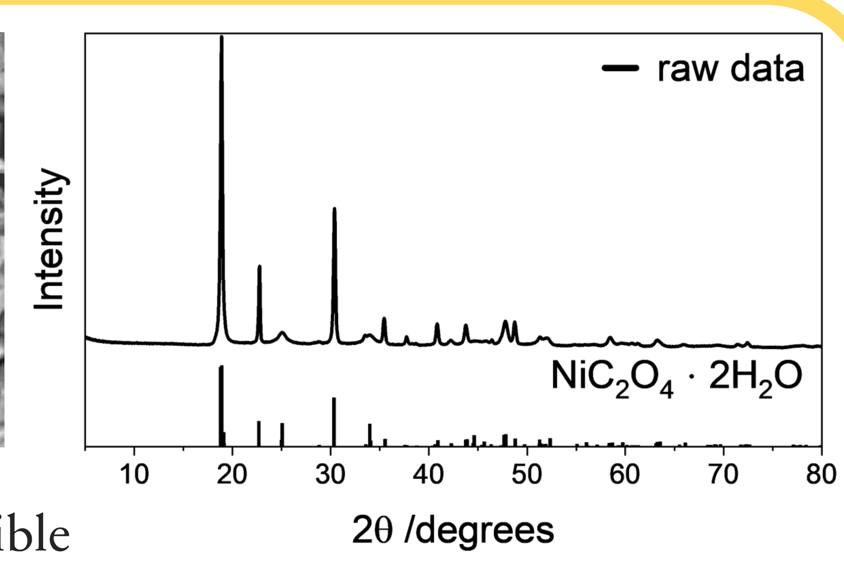
- **Screening of pre-existing LIB leaching recipes**
- **Leaching with organic acid (transfer of LIB optimized recipes)** ICP
- **Precipitation with oxalic acid: obtaining of a precursor** XRD, ICP, SEM



- 3.5 M, 4vol% H_2O_2, 1h @ 60°C, 40g/L [2]
- 1.25 M, 0.3h @ 70°C, 25g/L [3]
- 1.25 M, 1vol% H_2O_2, 0.5h @ 90°C, 20g/L [4]

A preliminary screening of recipes optimized for Li-based layered oxides lead to choose **citric acid** as the most performant extractant.

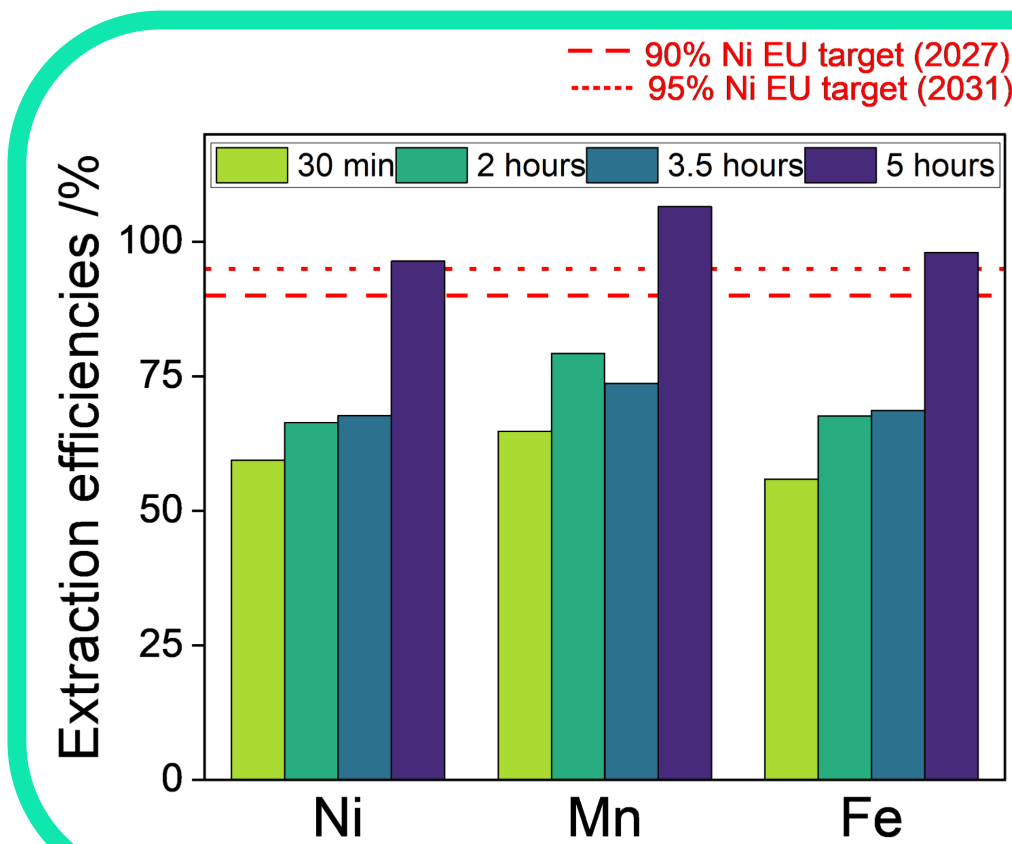




Recovery of Ni in the form of a (mixed) hydrated oxalate as possible precursor for resynthesis.

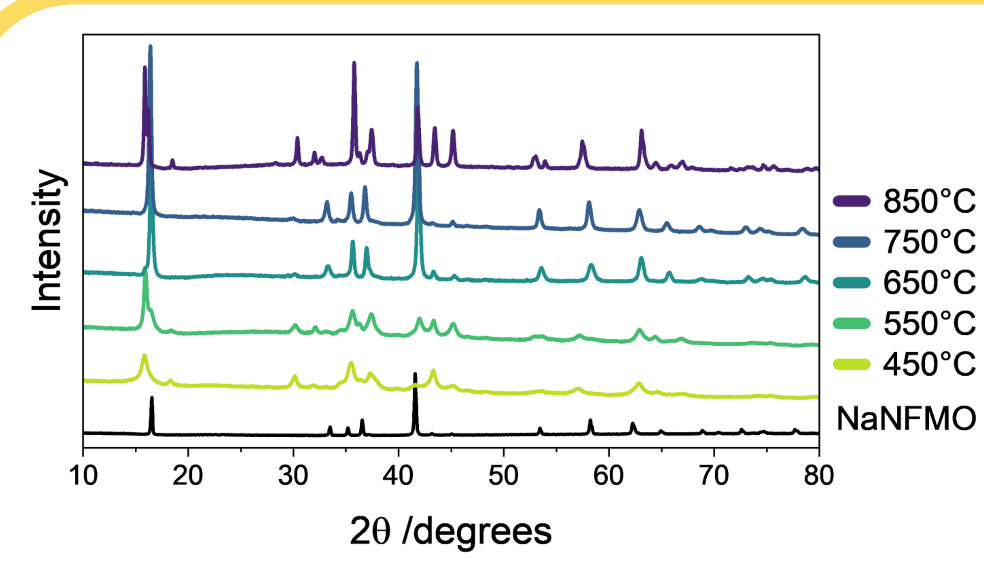
DES leaching: a closed-loop approach

- **Adapting the pre-existing patented LIB leaching recipe**
- **Leaching with DES Choline Citrate based: recipe optimization** ICP
- **Direct resynthesis: obtaining of the cathode** XRD, ICP, SEM



DES composition [5]
Choline Citrate : Ethylene Glycol (1:2)

DES leaching for 5h @ 120°C guarantees to meet the Ni recovery target; DES degraded matrix is the ideal matrix for sol-gel-like resynthesis.



10 h treatment in a muffle furnace at different temperatures

The resynthesis protocol is under study, to assess the best experimental parameters (isotherm and holding time); up to now, 650°C 10 h appear as the most promising conditions.

CONCLUSIONS

The explored approaches guarantee the **recovery of CRM**, coherent with the EU legislative requirements. In particular:

- CRM recovery through oxalate precipitation → possibility of repurposing the oxalate e.g. synthesis of different SIB or LIB cathodes
- DES-driven direct resynthesis → closed-loop approach, from NaNFMO dissolution to cathode resynthesis without precipitation steps

References:
[1] doi.org/10.1002/bte2.70082 [2] doi.org/10.1016/j.jclepro.2018.01.040 [3] doi.org/10.1016/j.jpowsour.2012.06.068 [4] doi.org/10.1016/j.jhazmat.2009.11.026
[5] Patent: Procedimento per il riciclo di batterie al litio (n° 102023000022644)

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