GIORNATE dell'ELETTROCHIMICA ITALIANA
17-21 September 2023, Cefalù, Italy

Low-temperature co-pyrolysis process to recover valuable metals from spent cathode materials

UNIVERSITÀ DEGLI STUDI BICOCCA 1998 | 2023

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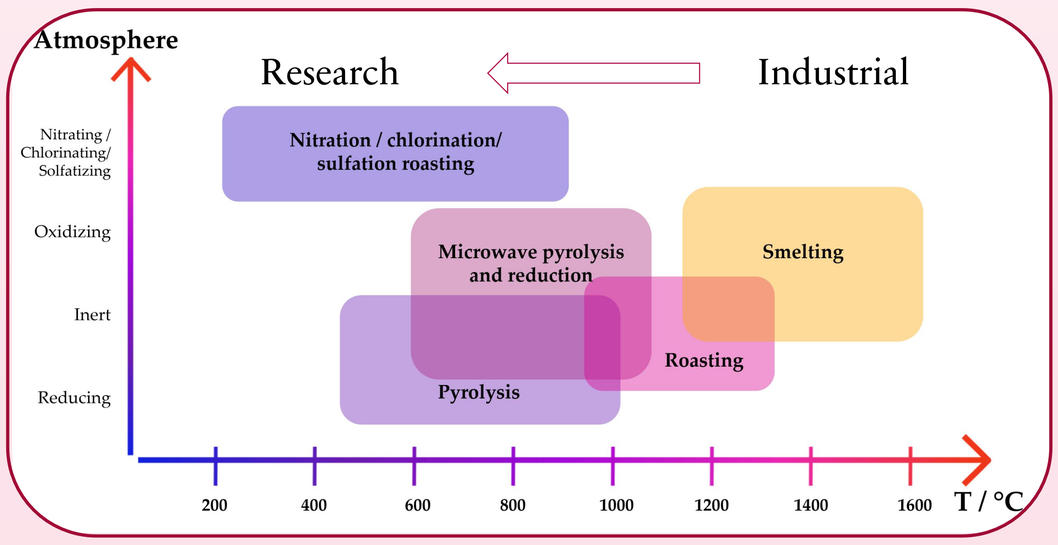
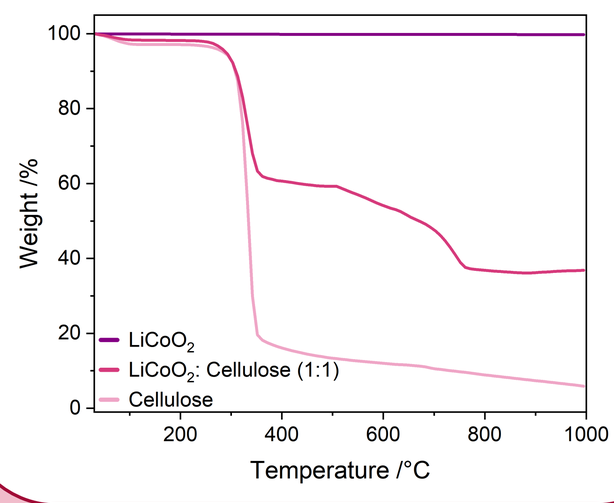


Waste lithium-ion batteries (w-LIBs) recycling at industrial level is dominated by pyrometallurgy and specifically by the roasting and smelting processes. [1,2] Although simple, with high capacity, and requiring simple plants, these processes are strongly energy demanding, allow for the recovery of only a fraction of critical raw materials (i.e. Co, Ni, Cu) and today no possibility to recover Li is present. [3]

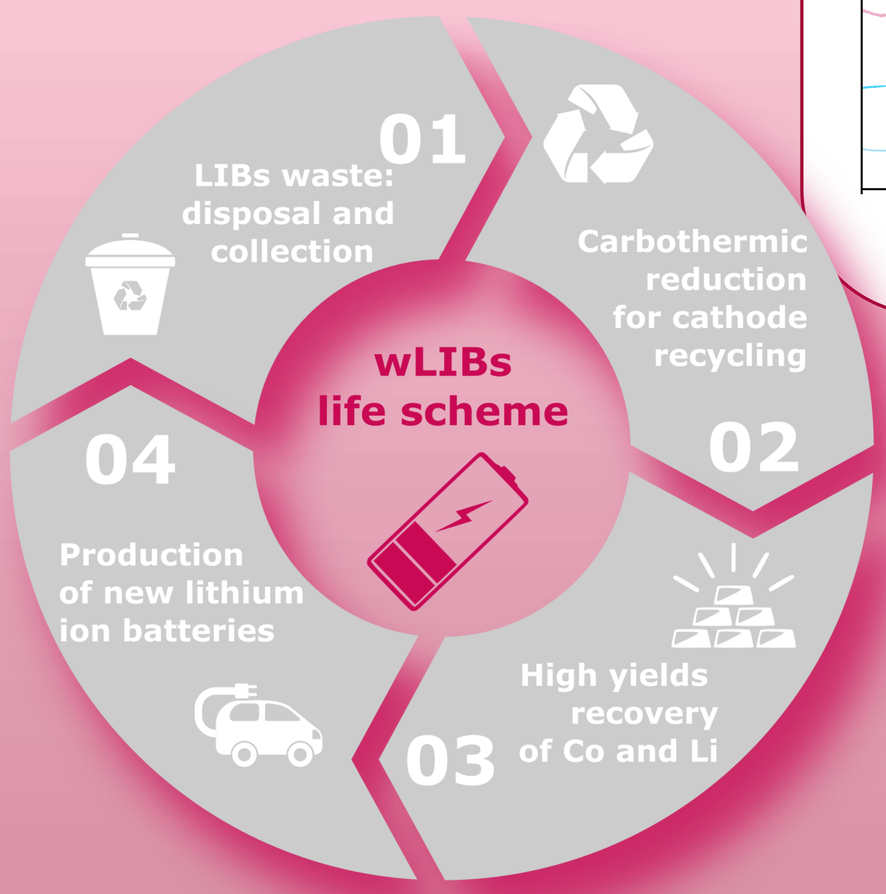
We here propose as alternative a **low-temperature carbothermic reduction process of $LiCoO_2$** [4] (the most common cathode material) that address all the mentioned limitations, as it enables for:

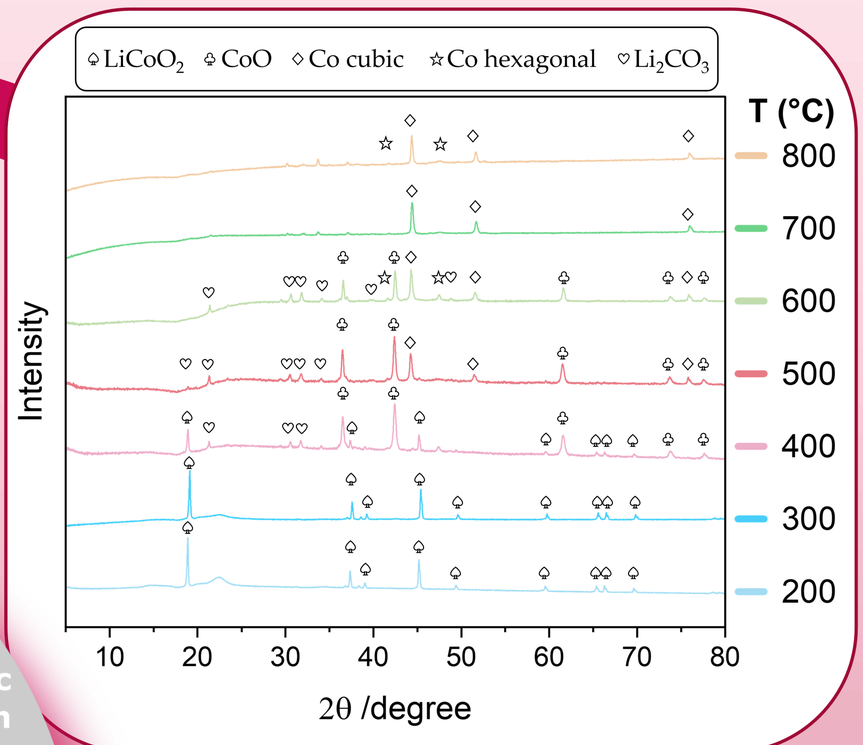
- ✓ **Lowering of the operating temperatures**
- ✓ **Reduction of the energy demand**
- ✓ **Higher Co recovery yields**
- ✓ **Recovery of Li with high yields**



Identification of carbothermic reduction conditions
The addition of a carbonaceous material allows to lower the degradation temperature and to tune the obtained products

Carbothermic Reduction Protocol
$LiCoO_2$:Cellulose (1:1 w:w)
1h under N_2 flux in
T range 200 °- 800 °C

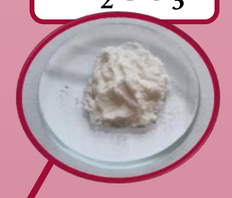




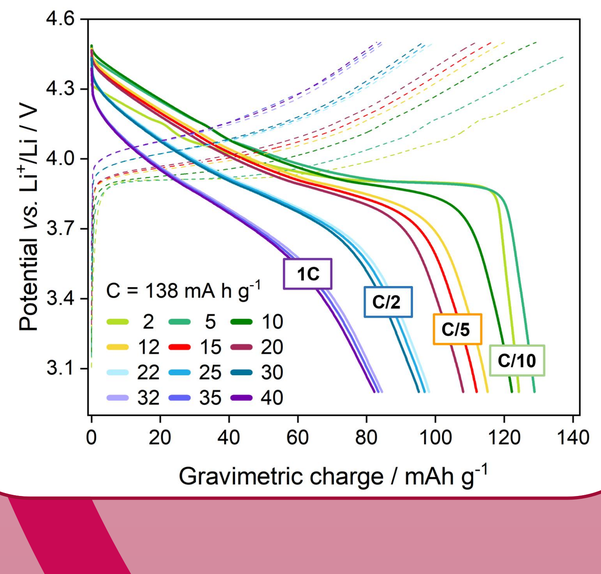
Post-pyrolysis product

Water leaching for easy separation

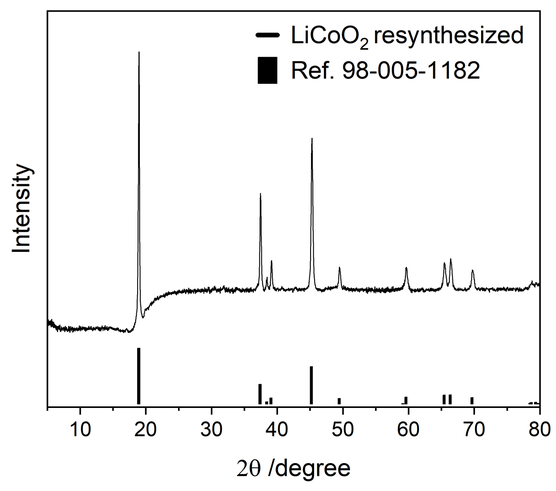
Li_2CO_3



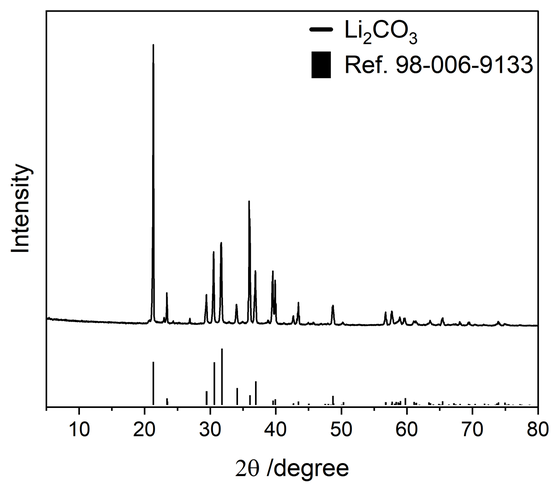
CoO/Co

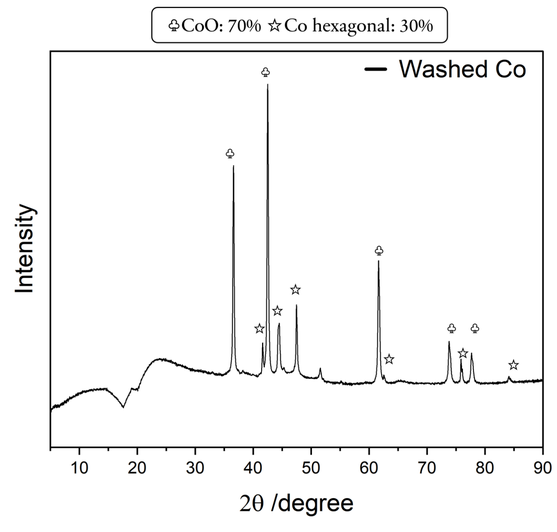


Microwave re-synthesis of $LiCoO_2$ cathode
The recovered Co and Li are used in a 1:1.1 ratio (n_{Co}:n_{Li}) at 800 W for 40 min.
This obtained LCO is tested in a Li|LP30|LCO coin cell at different C-rates.



800 W
600°C
40 min.





Bibliography
[1] Harper et al. *Nature*, **2019** 575,75
[2] Makuza et al. *J. Power Sources*, **2021**, 491, 229622
[3] Ferrara et al. *Adv. En. Sus. Res.* **2021** 2, 2100047
[4] Carena et al. *Batteries*, under submission

C.F. acknowledges financial support from the **Fondazione Cariplo** through the grant "**Cathode Recovery for Lithium-Ion Battery Recycling, COLIBRI**" and the financial support from **Regione Lombardia** for the project Regional Hub for Circular Economy, **R2BAT Laboratory**.