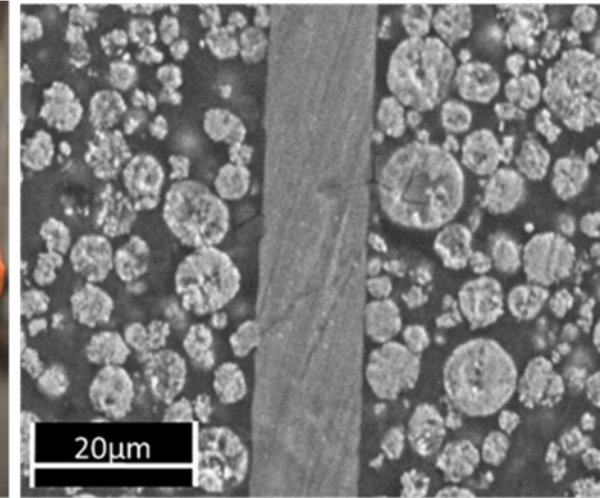
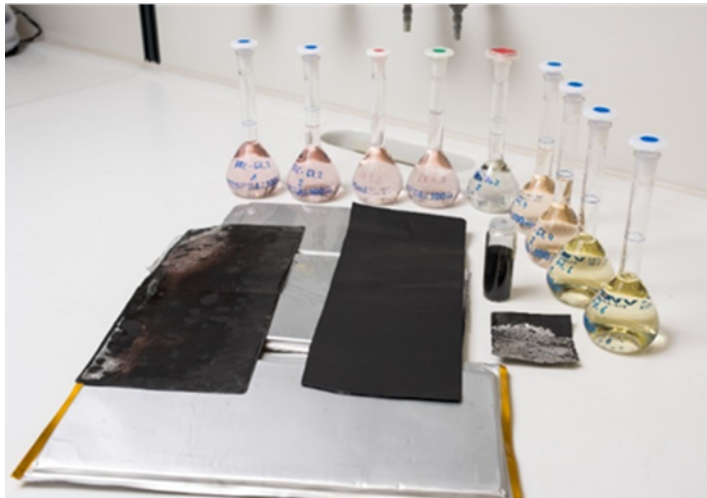


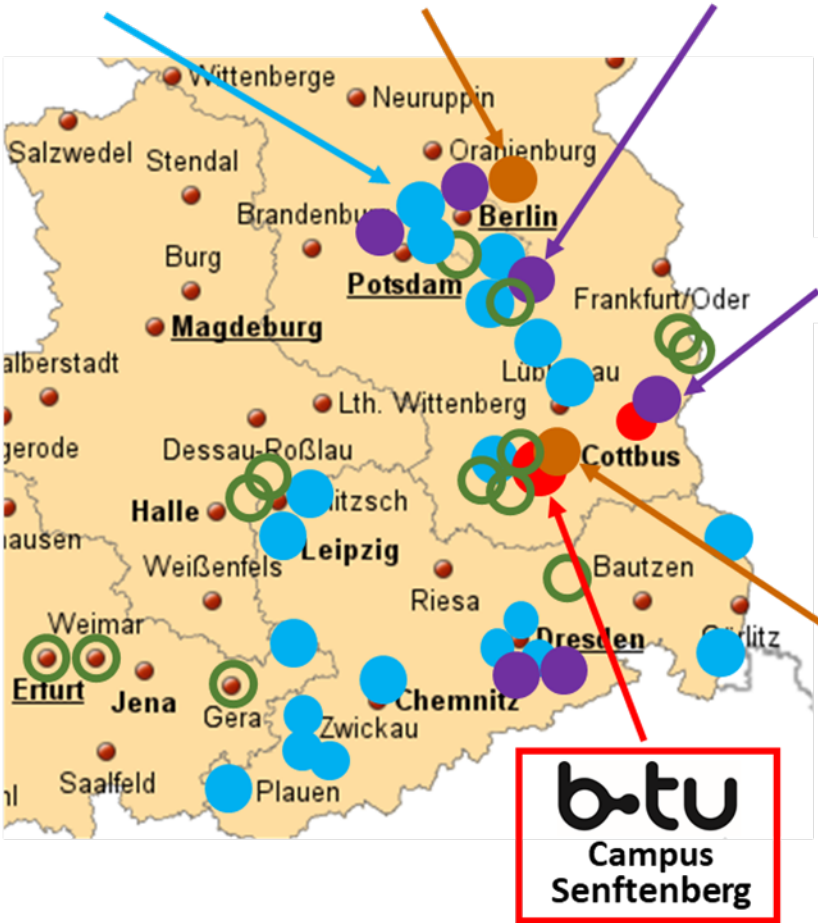
EXPERTISE IN THE RESEARCH FOR LITHIUM ION BATTERY RECYCLING



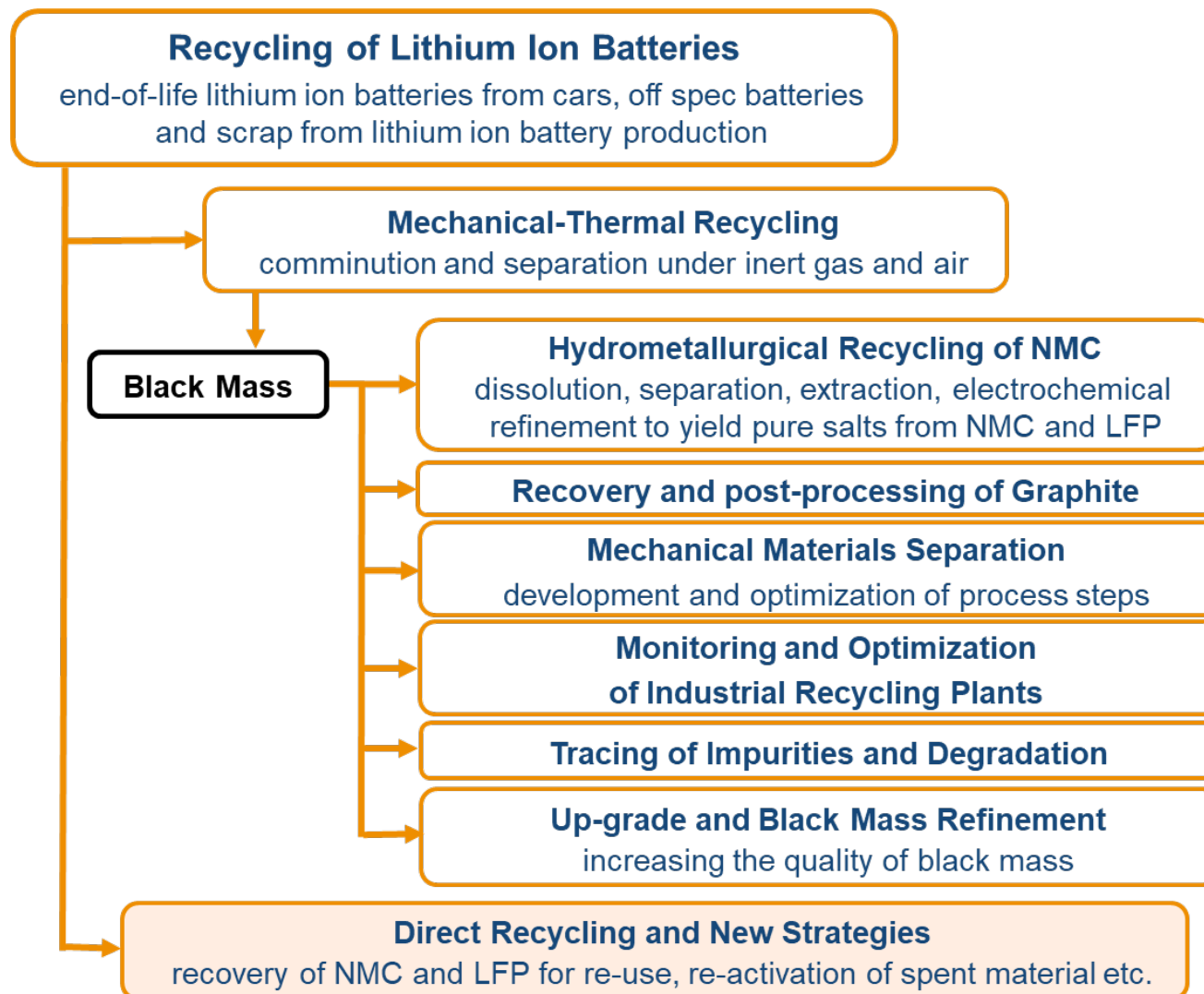
- BTU Cottbus-Senftenberg
- cooperation partner
- network partner
- cooperating research institution
- prospective industrial collaborator



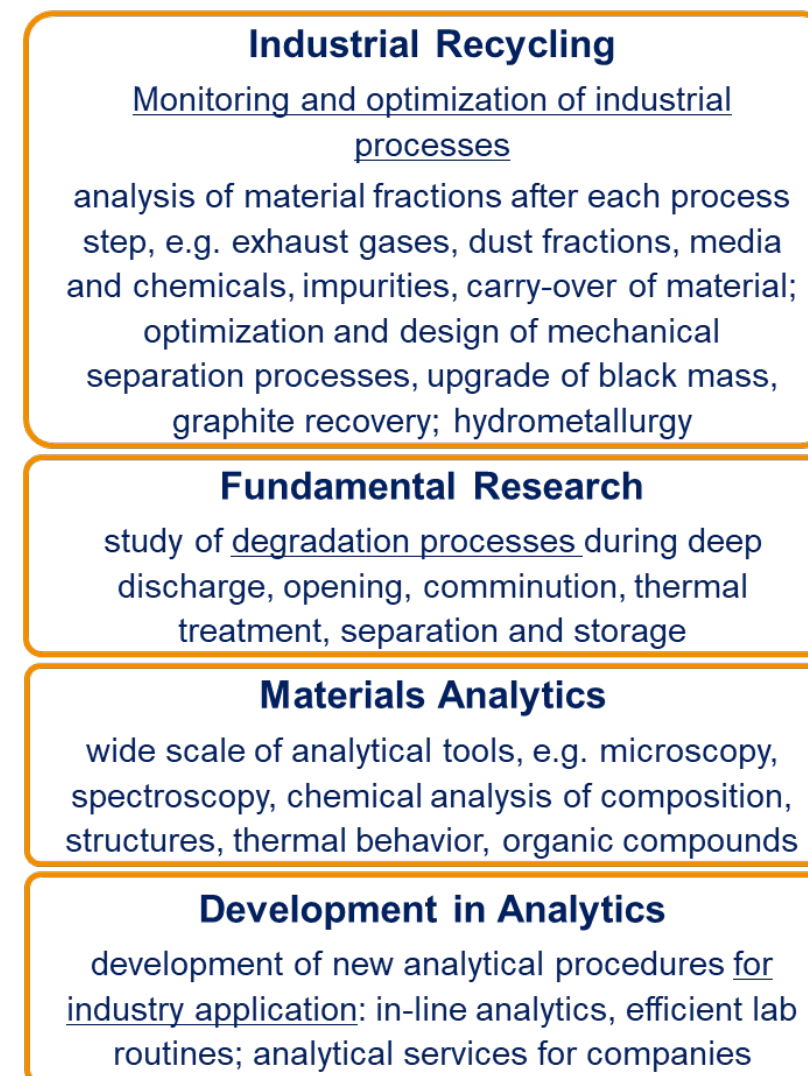
KOMBIH -
Kompetenzaufbau für
Batteriezellfertigung in
der Hauptstadtregion



Fields of Expertise

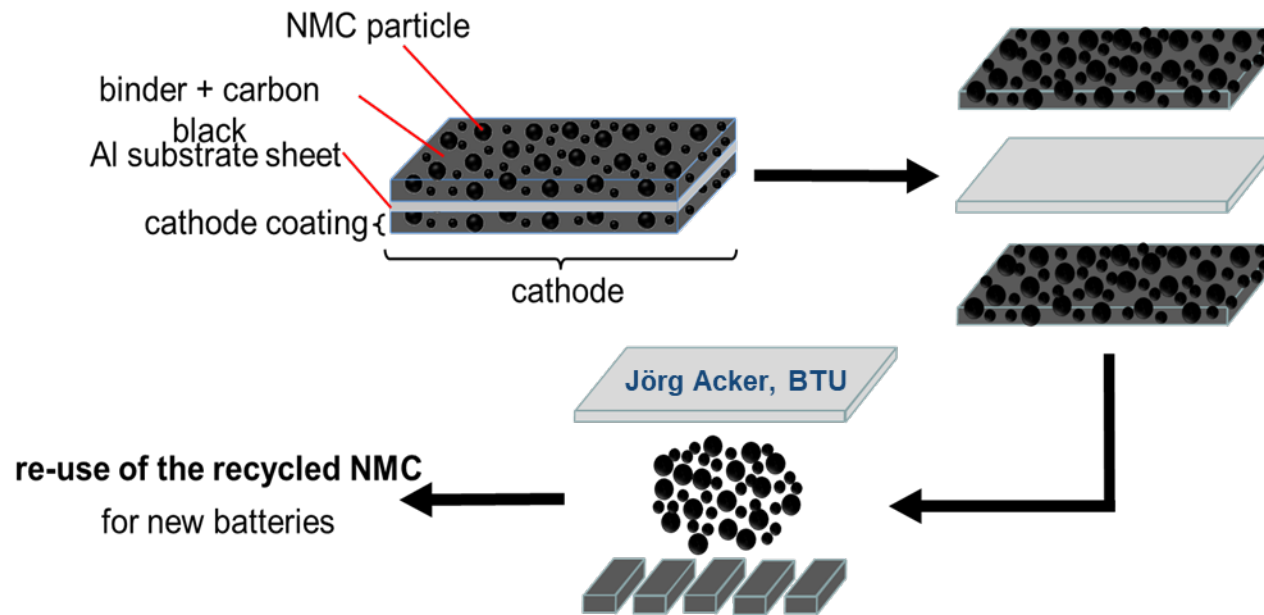


Fields of Activity



Functional recycling:

Recovery of a material while maintaining its
chemical and physical functionality.

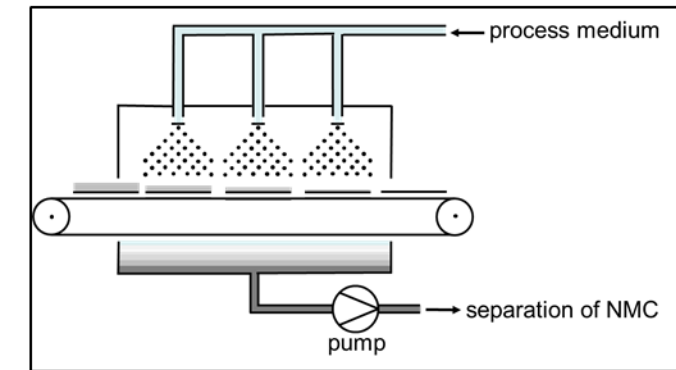


Recycling capacity: 1500 metric tons per year

Recycling efficiency: > 95%

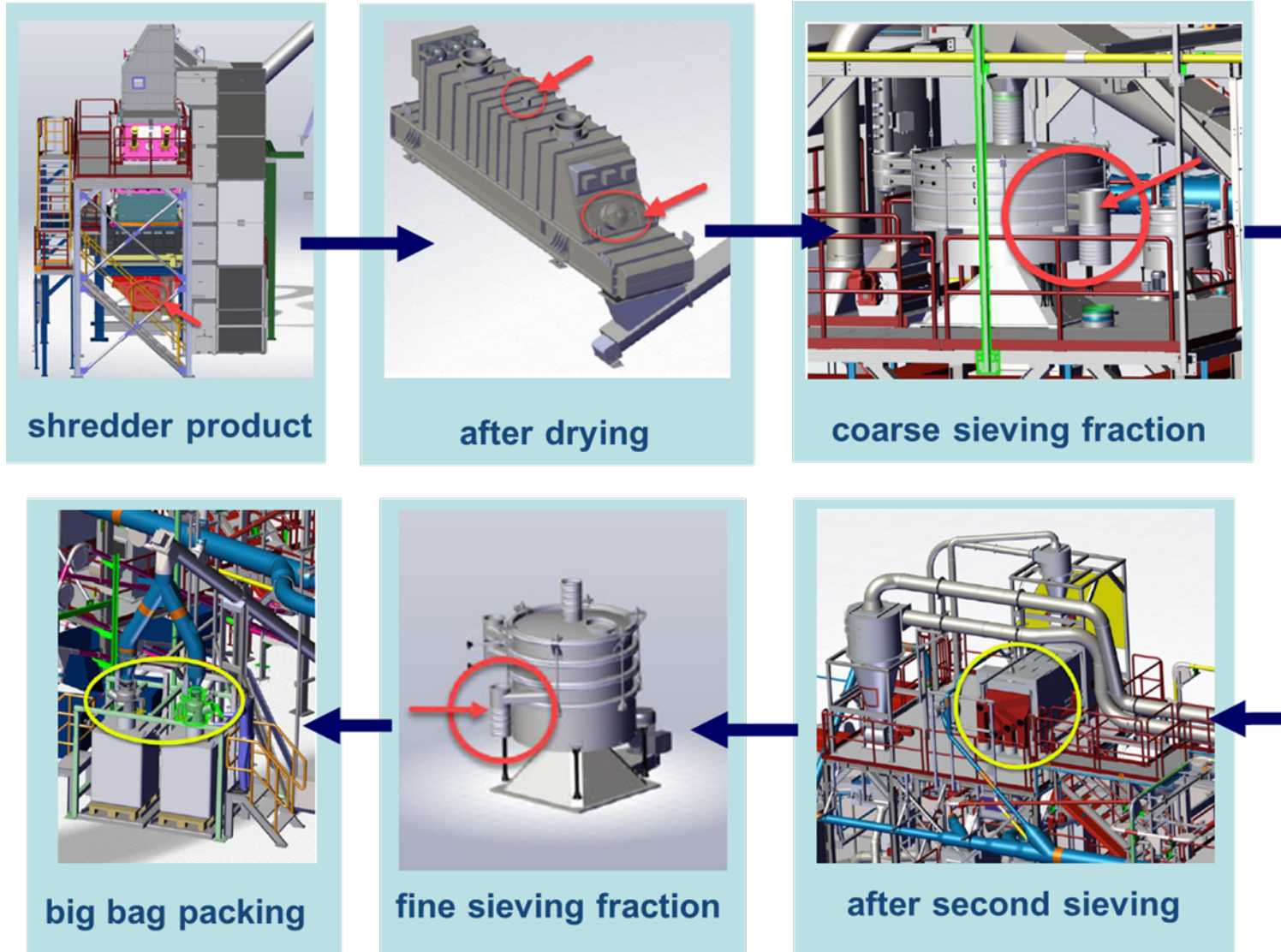
CO₂ savings with NMC reuse : up to 18% *

World's First Functional Recycling Line

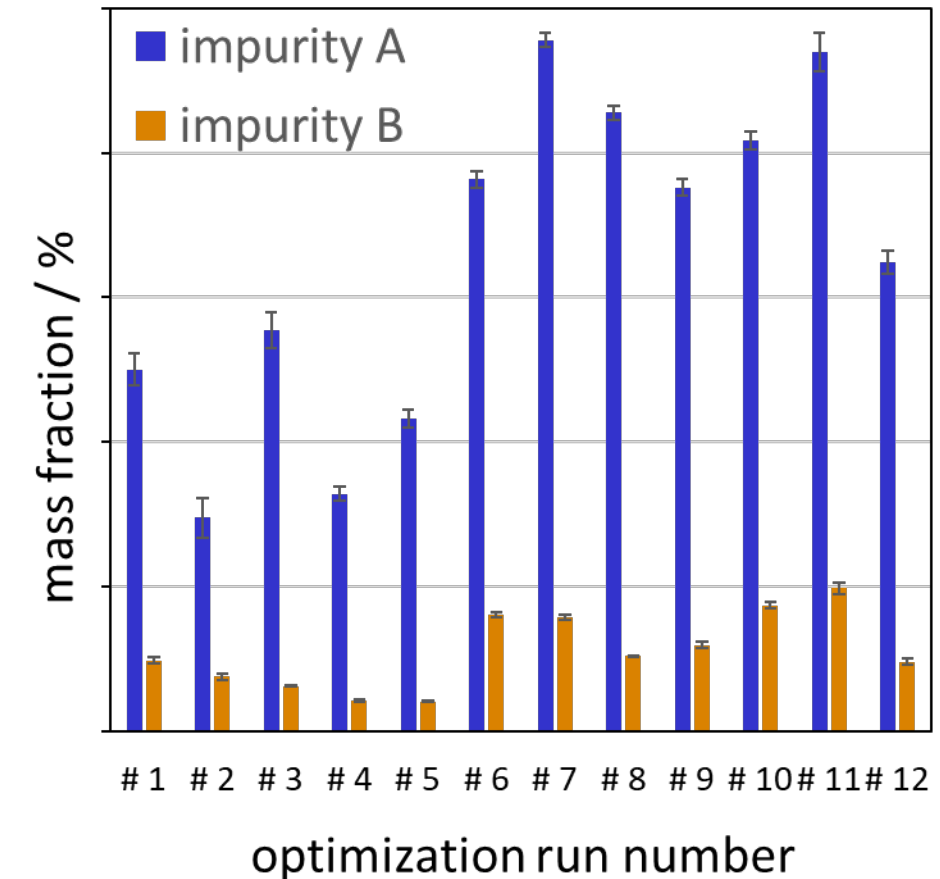


STEP-BY-STEP ANALYSIS OF AN INDUSTRIAL RECYCLING PLANT:

MONITORING AND TRACKING OF IMPURITIES

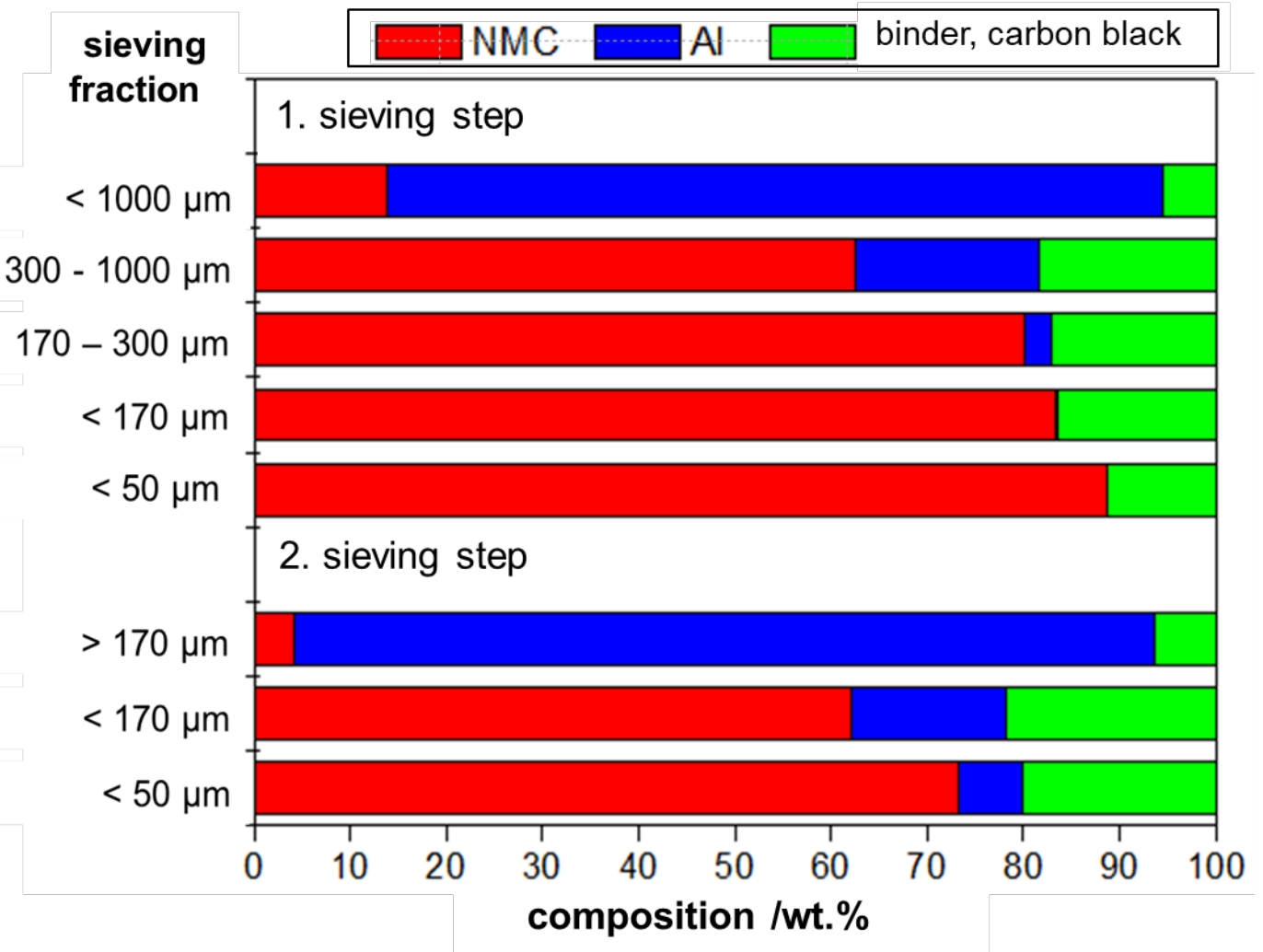
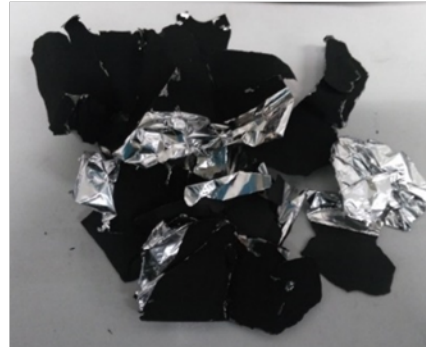
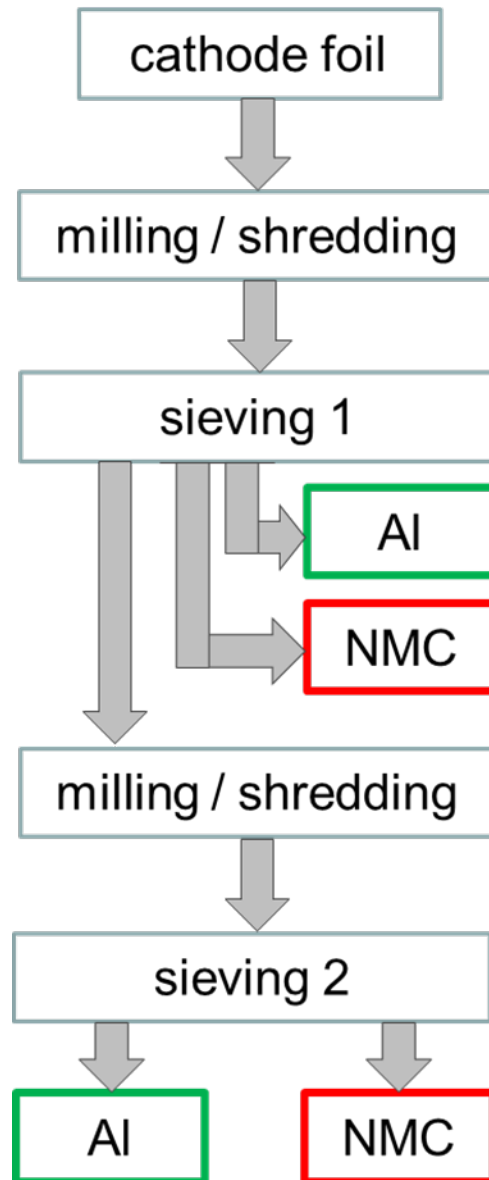


Monitoring and tracking of impurities

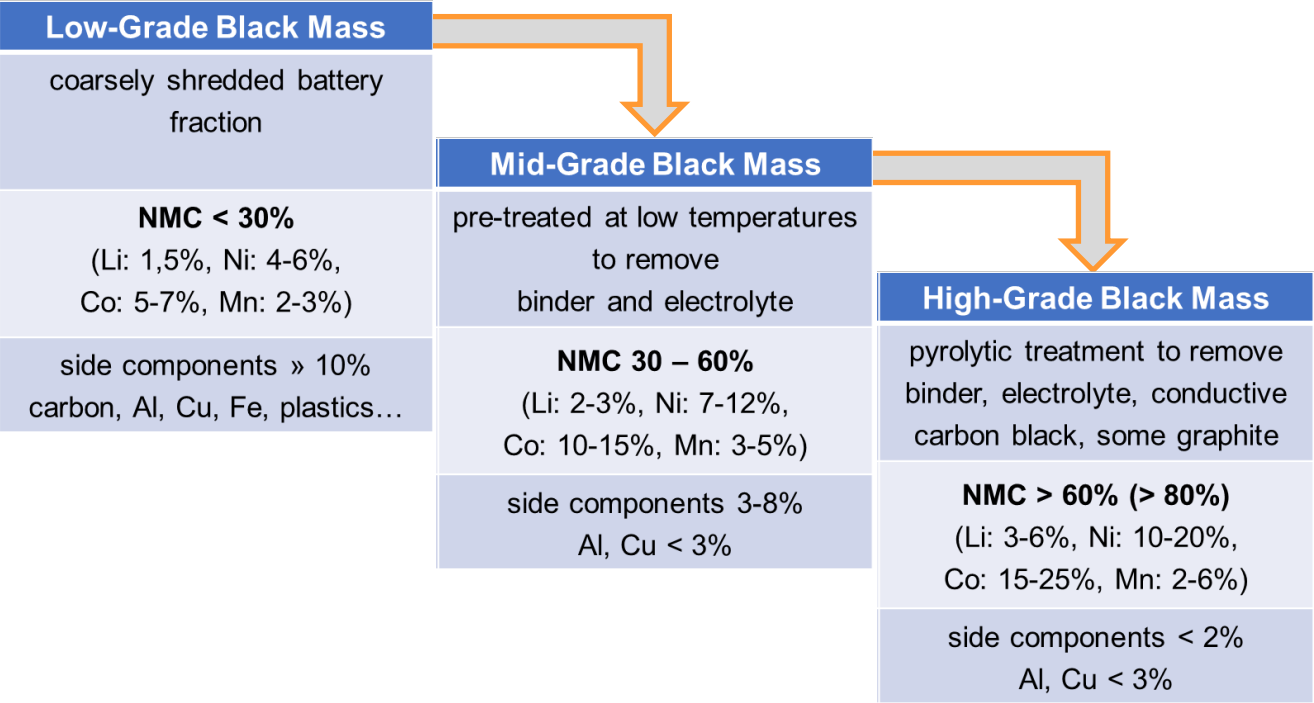


MECHANICAL PROCESSING OF SRAP CATHODE MATERIAL:

RECYCLING OF OFF-SPEC CATHODE SHEET ROLLS



Post-Processing Black Mass Refinement



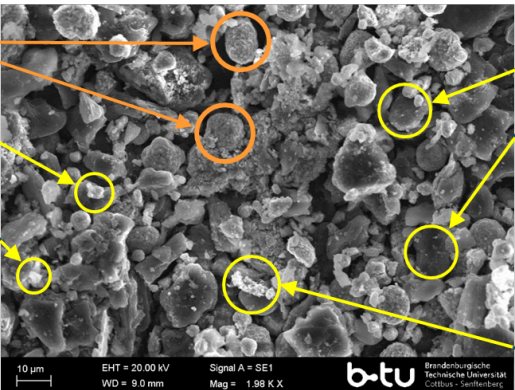
- cathode material
(NMC, NCA, LCO etc...)

carbon black

ceramic particles
separator coating

conducting salts
degradation products

aluminum
collector sheets



- anode material
mostly graphite

copper
collector sheets, cables

iron
construction elements

electrolyte residuals
high boiling compounds

organic binder

NMC Recovery from Secondary Material Streams

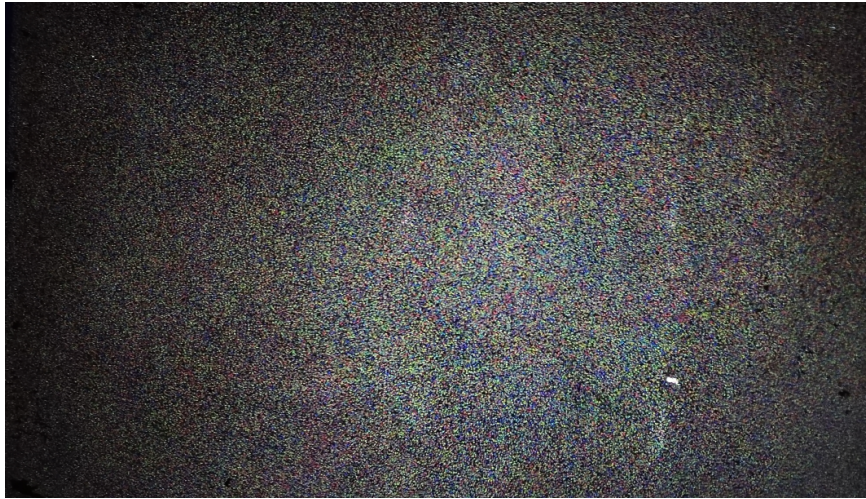


	light fraction			
materials fraction	Fe fraction	Al fraction	Cu fraction	plastics
NMC content	~ 40%	< 0.5%	~ 6%	10-15%
side components	~ 30%		95%	40-70%
after NMC removal				

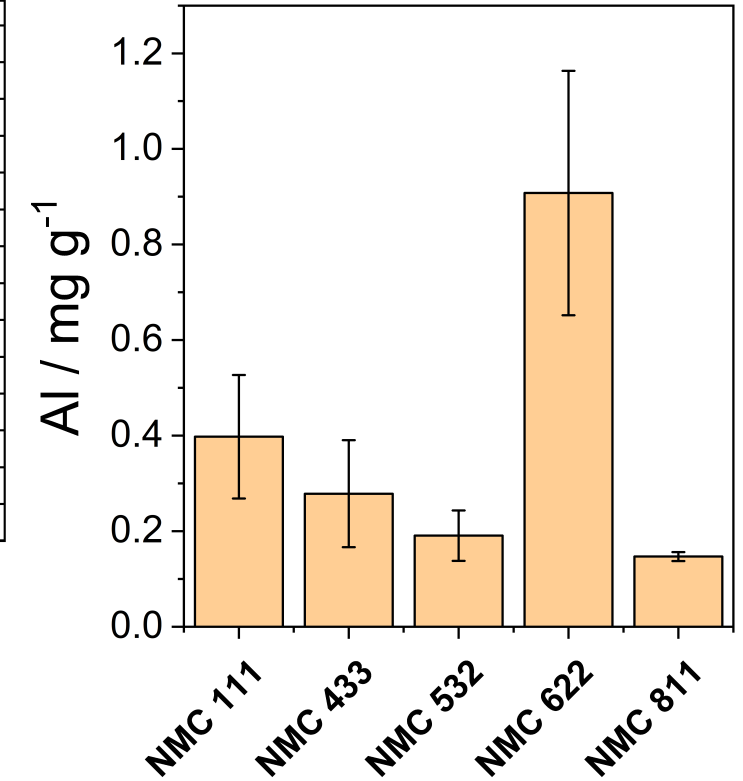
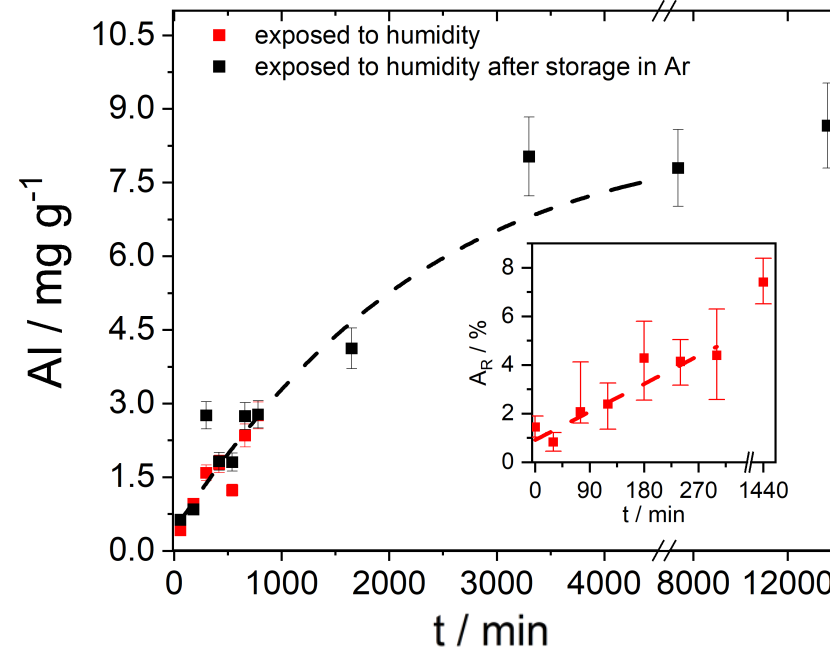
DEGRADATION OF A NMC CATHODE IN HUMID AIR

DISSOLUTION OF THE ALUMINUM SUBSTRATE: WHERE IS IT GONE?

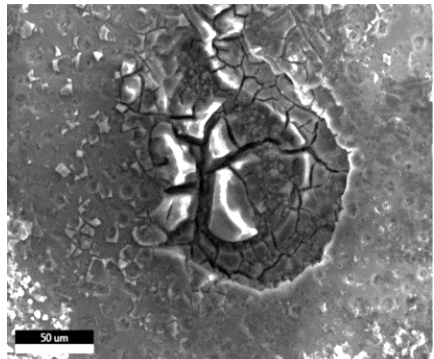
Pin holes etched into the Al substrate foil



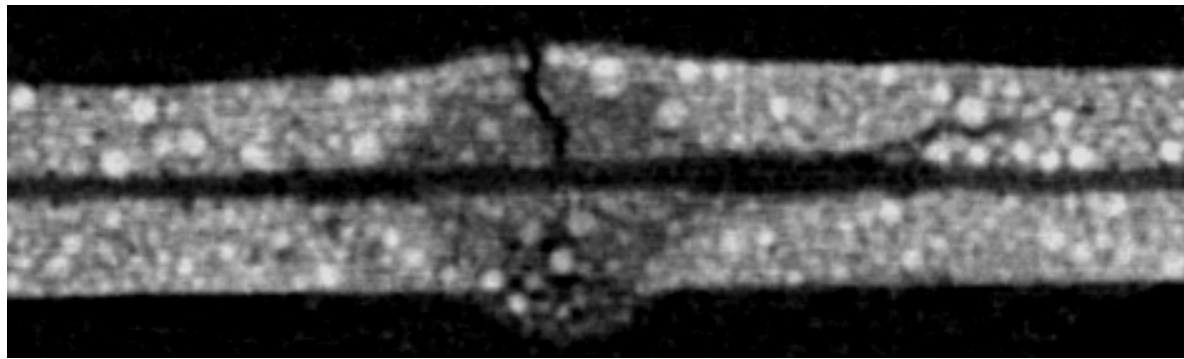
Dissolved aluminum spreads out and infiltrates the NMC coating



top view precipitate



X-ray tomography cross-section of a precipitate

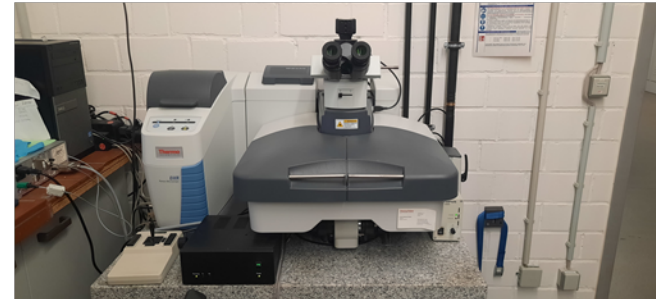


OUR CORE EXPERTISE: ANALYTICS!

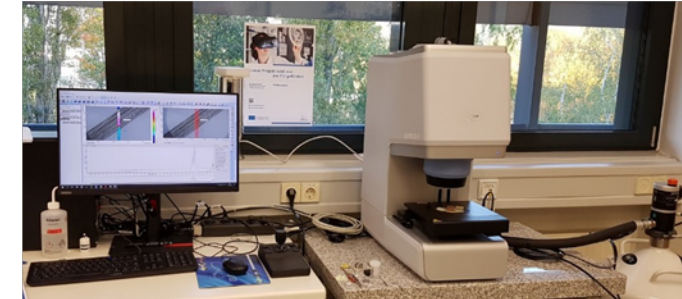
Analytical Techniques

high-precision compositional chemical analytics by ICP-OES, ETV, CS-AAS; ion chromatography, gas chromatography, mass spectrometry, infrared spectroscopy and infrared microscopy, Raman spectroscopy and Raman microscopy, confocal microscopy and interferometry, surface topography analysis, scanning electron microscopy incl. EDX and EBSD, thermal analysis, particle analysis, all electrochemical techniques

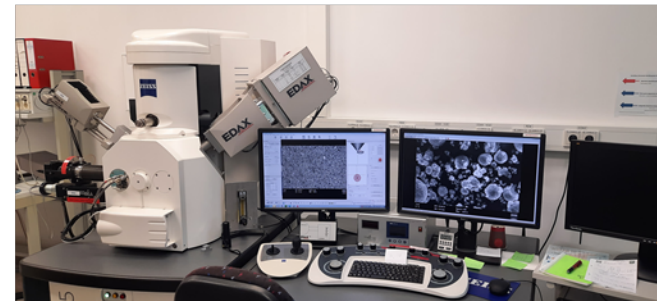
Raman microscopy



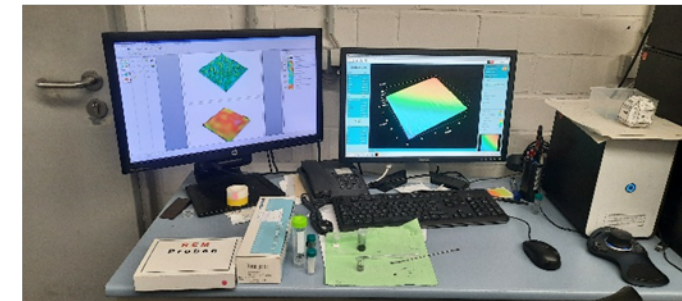
Infrared microscopy



SEM-EDX-EBSD



Confocal microscopy



ICP-OES



Sample Preparation



Term	Project Content
2012-2015	Processing of production waste to recover and recycle the active material
2018-2020	Automated processing, selective and single-type recovery of valuable metals from lithium-based traction batteries
2019-2021	Recycling of end-of-life lithium-ion batteries to obtain second-use anode and cathode material for reuse in recycled lithium-ion cells
2019-2022	Industrial dismantling of batteries and electric motors to securing economically strategic raw materials for e-mobility
2020-2022	Efficient recovery of raw materials from Li-ion battery waste
2022-2024	Recovery of spherical graphites from anodes of Li-ion traction batteries for reuse in recycling cells and other innovative industrial applications
2023-2027	Competence development and training programs for the battery cell production value chain
2023-2026	Recycling of next-generation automotive lithium-ion batteries for reuse in electro vehicle and stationary applications
2026-2028	Recycling and recovery of lithium from NMC and LFP lithium-ion batteries and production scrap

Publications
Sieber, T.; Ducke, J.; Rietig, A.; Langner, T.; Acker, J. Recovery of $\text{Li}(\text{Ni}_{0.33}\text{Mn}_{0.33}\text{Co}_{0.33})\text{O}_2$ from Lithium-Ion Battery Cathodes: Aspects of Degradation. <i>Nanomaterials</i> 2019 , 9, 246. https://doi.org/10.3390/nano9020246
Langner, T.; Sieber, T.; Acker, J. Studies on the deposition of copper in lithium-ion batteries during the deep discharge process. <i>Sci Rep</i> 2021 , 11, 6316. https://doi.org/10.1038/s41598-021-85575-x
Langner, T.; Sieber, T.; Rietig, A.; Merk, V.; Pfeifer, L.; Acker, J. A phenomenological and quantitative view on the degradation of positive electrodes from spent lithium-ion batteries in humid atmosphere. <i>Sci Rep</i> 2023 , 13, 5671. https://doi.org/10.1038/s41598-023-32688-0
Dommaschk, M.; Sieber, T.; Acker, J. Lithium-ion batteries: direct solid sampling for characterisation of black mass recyclates using graphite furnace atomic absorption spectrometry. <i>J. Anal. At. Spectrom.</i> 2024 , 39, 2522. https://doi.org/10.1039/D4JA00207E