

Sustainable Manufacturing of NCM Cathode Material Specifically Designed for High Power + High Performance Lithium-Ion Battery Applications





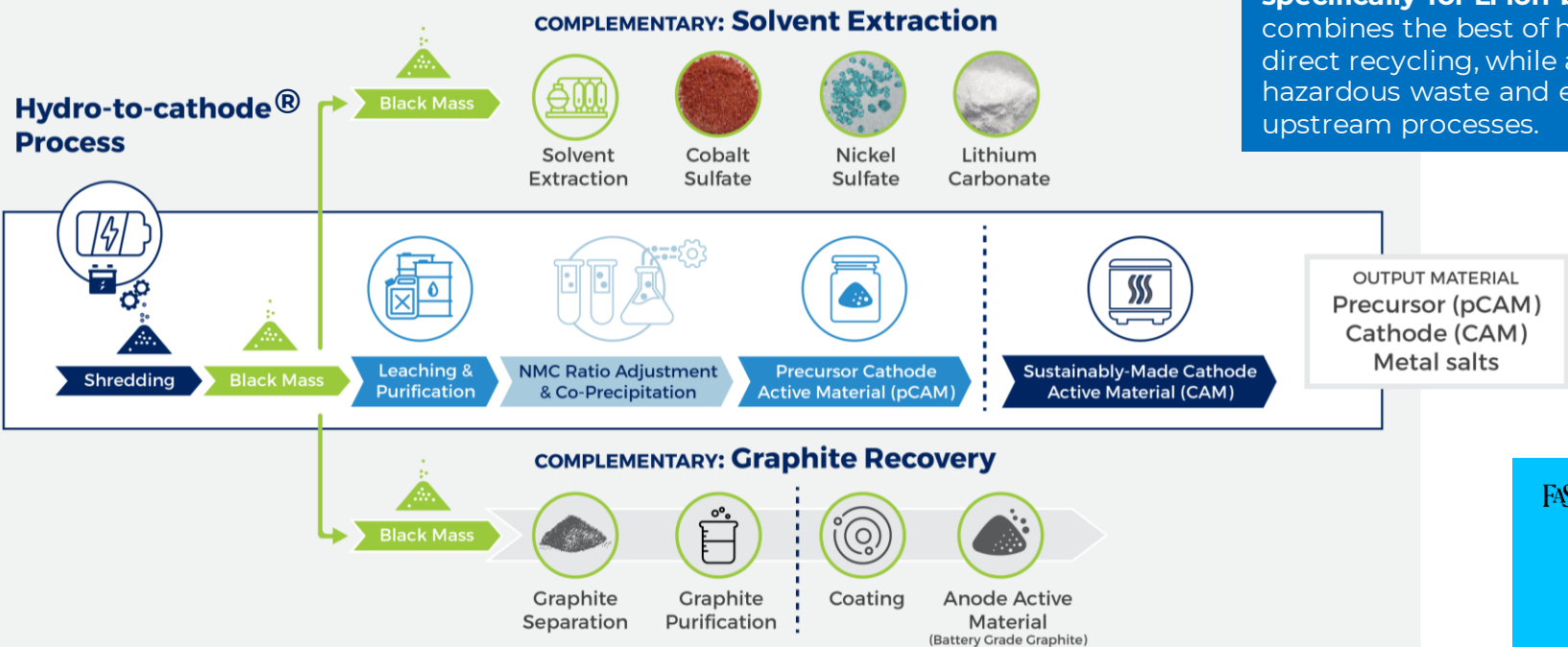
Ascend Elements

Company Overview



Hydro-to-Cathode[®] with Complementary Processes

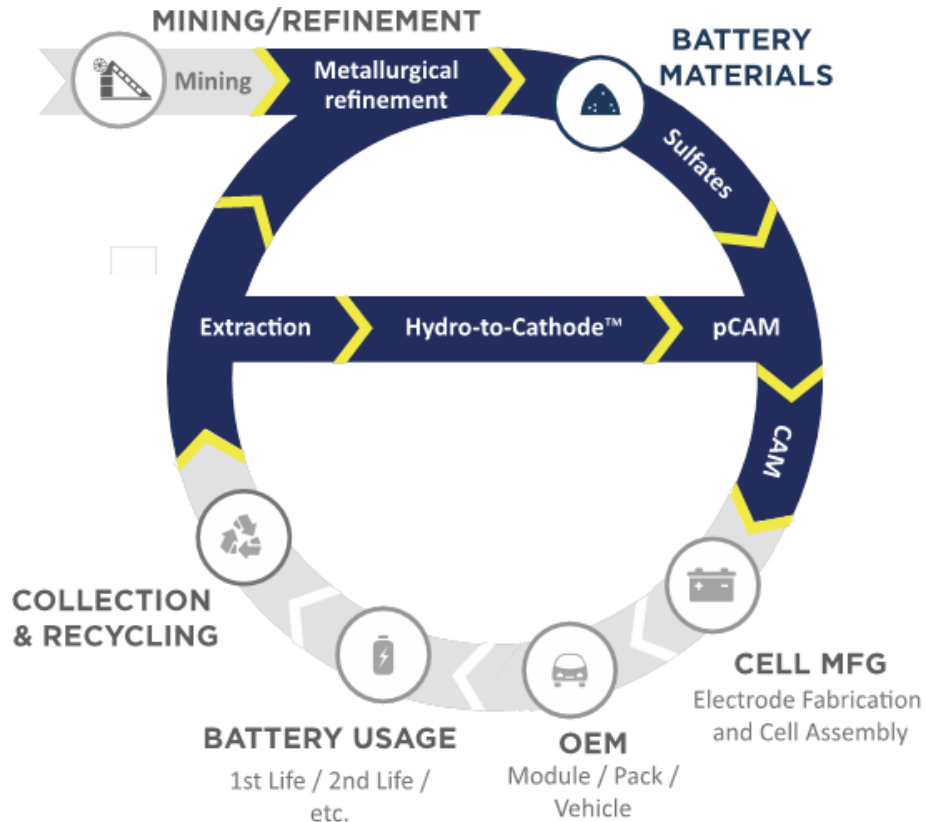
Graphite recovery and solvent extraction



Ascend Elements **Hydro-to-Cathode** process technology is **designed specifically for Li-ion batteries** and combines the best of hydro and direct recycling, while avoiding hazardous waste and emissions from upstream processes.



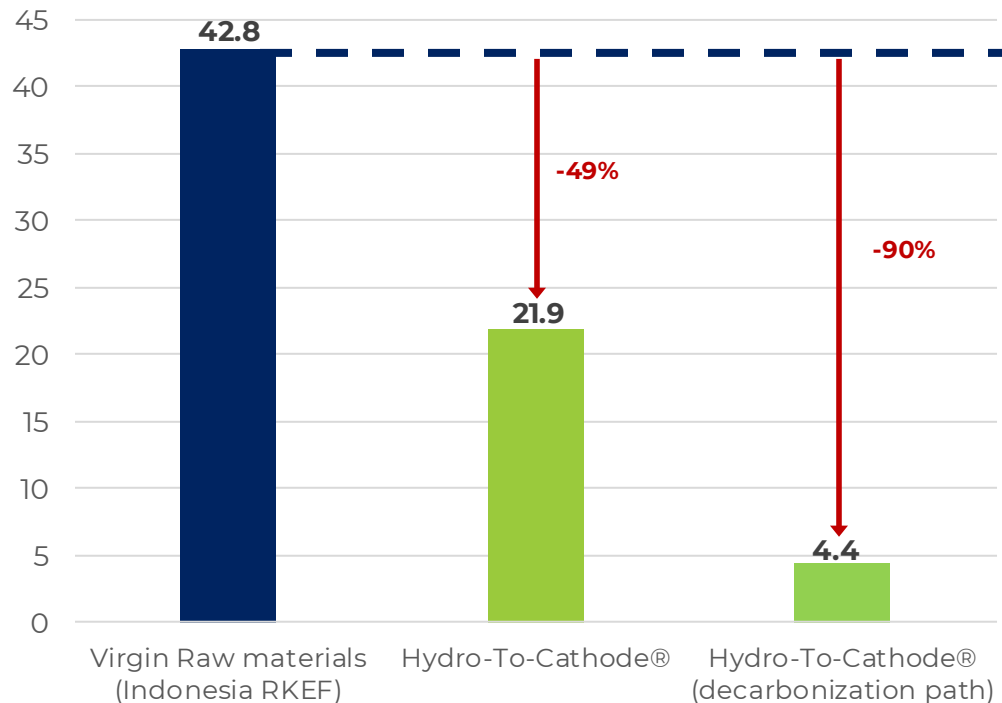
Beyond Closing the Loop



The **Hydro-to-Cathode®** direct precursor synthesis process goes beyond *closing* the loop – it *tightens* the supply chain loop to create the most efficient and sustainable source of lithium-ion battery materials.

NMC 622 CAM Life Cycle Assessment Results

Carbon footprint (kg CO₂e/kg NMC 622 CAM)

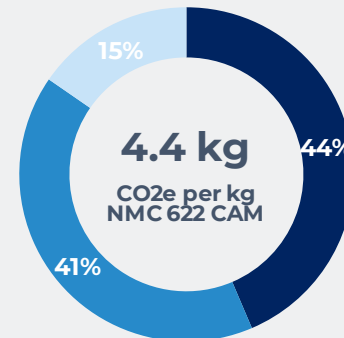


Source: This study was produced by Minviro in accordance with the ISO 14040:2006 and ISO 14044:2006 standards

Decarbonization Path:

Carbon footprint of producing **1kg of NMC 622 CAM** using Ascend Elements Hydro-to-Cathode® Technology:

- Processing
- Raw Materials
- Transport



Up to 90% Reduction
in CO₂ emissions
compared to virgin raw
material production

38,400 kg CO₂e avoided
for every one tonne of
NMC 622 CAM produced
by Ascend Elements

Robust Patent Portfolio

Cathode



4 patents granted
38 patents pending

Lithium

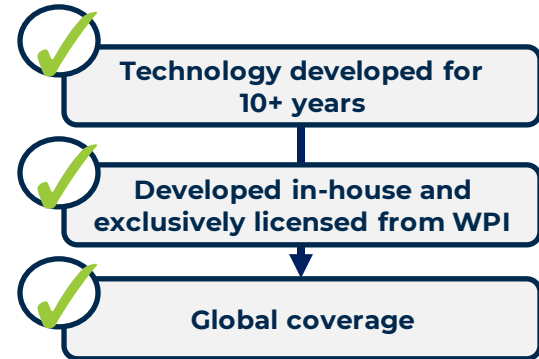


1 patent granted
17 patents pending

Others



17 patents pending



77 Patents granted or pending worldwide

Commercial-Scale Operations

Open in 2022

Base 1 Facility (Covington, Georgia)



Shredding scrap batteries into black mass and extracting lithium



Base 1 facility
\$50M investment
30,000 metric tonnes per year input capacity
180 high-quality jobs
Operational 2022

Black mass and recycled metal salts

Open in 2024

Apex 1 Facility (Hopkinsville, Kentucky)



Transforming black mass into high value materials via Hydro-to-Cathode® direct precursor synthesis

Material for **750,000** EVs per year



Apex 1 facility
Up to \$1B investment
Producing pCAM, CAM, and metal salts
Up to 400 high-quality jobs
Operational in Q4 2024

Sustainable NMC pCAM and CAM

2024 & Beyond: Expansion in North America and Europe

Hydro-to-Cathode®

Most efficient



Shredding



Leaching



Impurity Extraction and
Direct Precursor Synthesis



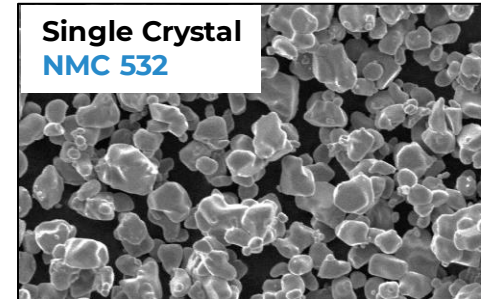
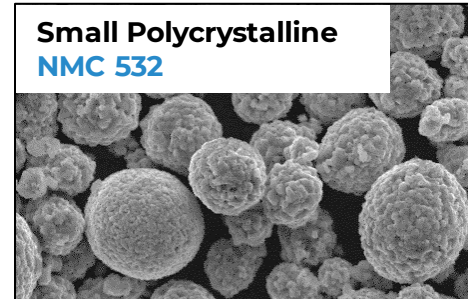
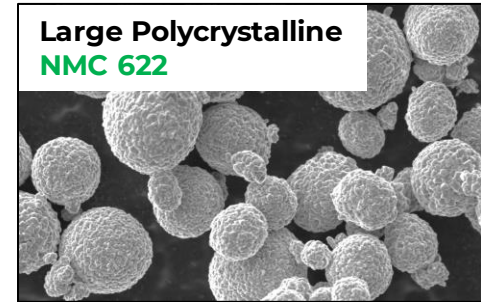
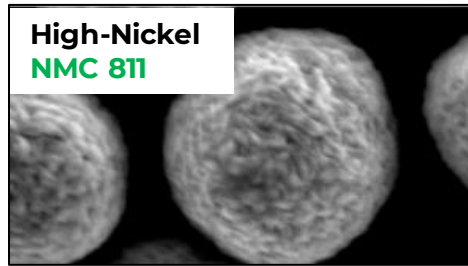
Cathode
Production

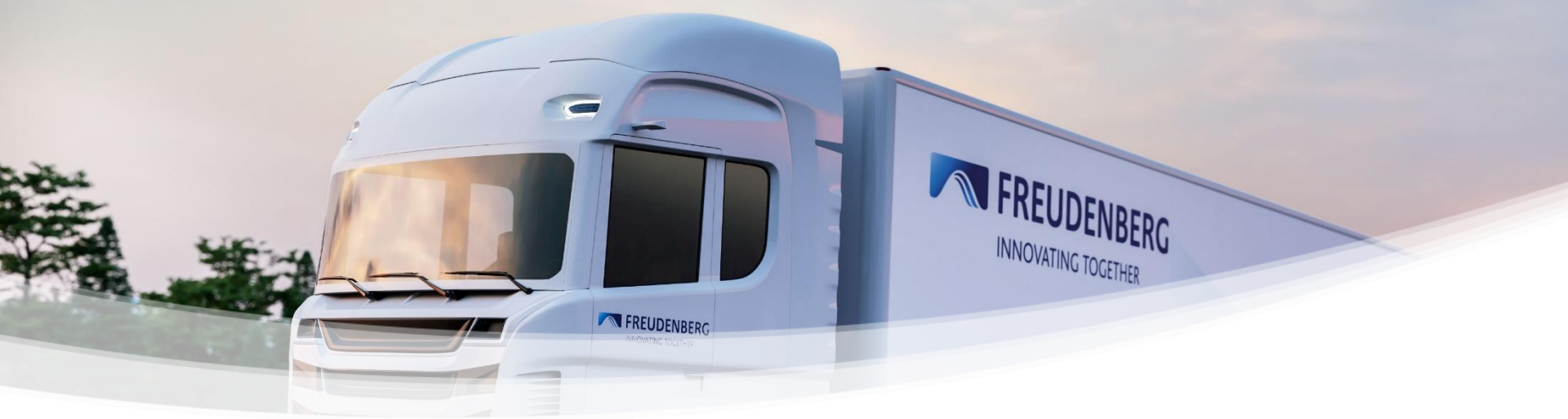


Battery
Manufacturing

Core IP

“The most **efficient** and **economical** way to return used Li-ion battery materials to the supply chain.”





FREUDENBERG e-POWER SYSTEMS

Ascend Elements NCM Cathode Material for High Power,
High Performance, Lithium-Ion Battery Applications

Who we are?

A Global Technology Champion with Long-term Focus

Freudenberg Business Groups



Sealing Technologies



Vibracoustic



EagleBurgmann



Performance Materials



Medical



Home & Cleaning Solutions



Chemical Specialties



Oil & Gas Technologies



Filtration Technologies



Japan Vilene Company



Facts & Figures
2022

~ €11.8bn
sales

100%
family owned

~ 60
countries

> 50,000
employees

~ 54%
equity

> 170
years history

FEPS Applications

**Battery Installation
in field started
2013**

**> 10 years of experience in
heavy-duty applications**

**>1200 applications
in field**

**Buses
Maritime
Heavy duty vehicles
Formula-E**

**>60 Million Miles
Driven with Freudenberg
battery systems
(Truck & Bus)**

Products
XALT Energy Cells
Modules
Packs
BMS
Systems
Telematics



POWERED BY XALT Energy



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FEPS Cell & Pack Roadmap Addressing Heavy Duty Market

2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

Power products

**Gen 1 43 SHP
XMP76P**

**Gen 2 54 SHP
XMP96P**

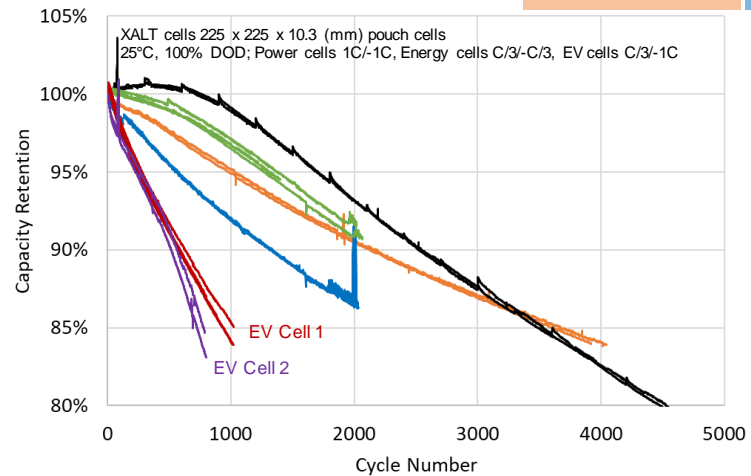
Gen 3 SHP

Energy products

**Gen 2 63 SE
XMP111E**

**Gen 3 70 SE
XMP123E**

XRANGE 1037E



We expect continued growing market interest in high performance cells with high safety, long lifetime, and high charge rate

Strong alignment between Ascend recycled cathode and next generation power cells

	Passenger EV	Truck/Heavy duty vehicles	Bus	Maritime
Lifetime (operating time over 15 years)	8,000 hr	30,000 hr	50,000 hr	> 60,000 hr
Charge Rate (100% SOC)	0.3-1C	0.3-1C	0.3-1C	2C
Safety		R100 (EU) IEC 62660 (EU) UL 1973, 1642, 2580 (US)		IEC 62619 (EU) Class society approval (EU) UL 1973, 1642, 2580 (US)
Sustainability		(EU) 2023/1542 – battery passport, CE IRA (US)		(EU) 2023/1542 – battery passport, CE

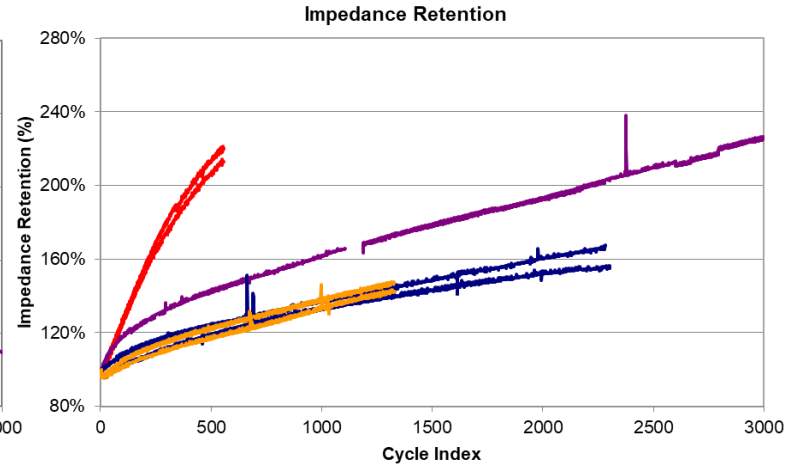
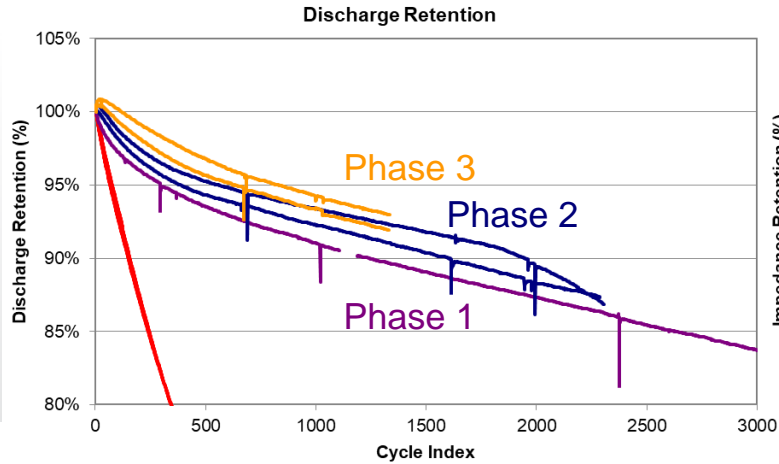
2C-3C for fuel cell hybrid

30,000 FCE!

Development of NCM-523 with High Cycle Life and High Thermal Stability

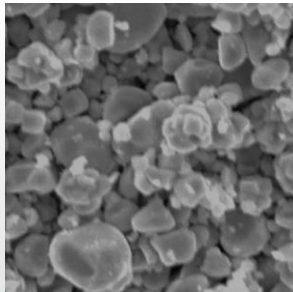
Ascend Elements cathode materials in > 0.2 Ah XALT prototype pouch cells

Test conditions:
45°C, 1C/-1C,
100% DOD



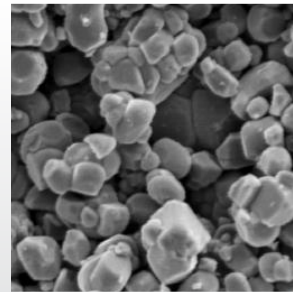
Phase 1

Cycle life
Scale to 1 kg



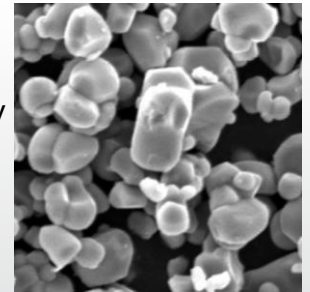
Phase 2

Repeatability
Scale to 20 kg



Phase 3

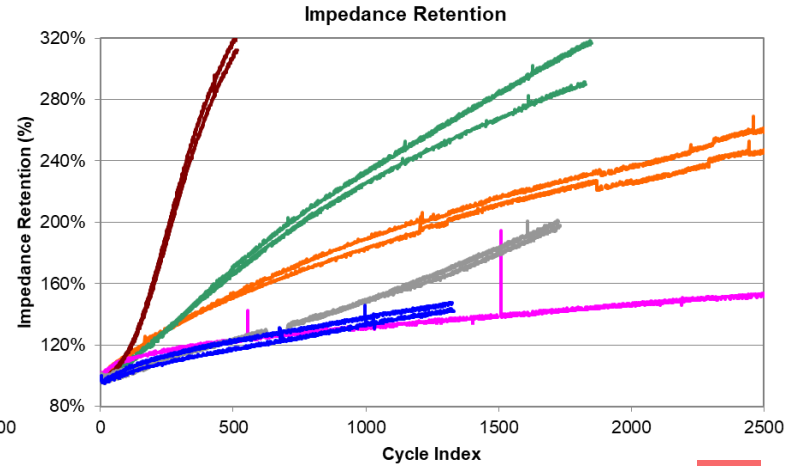
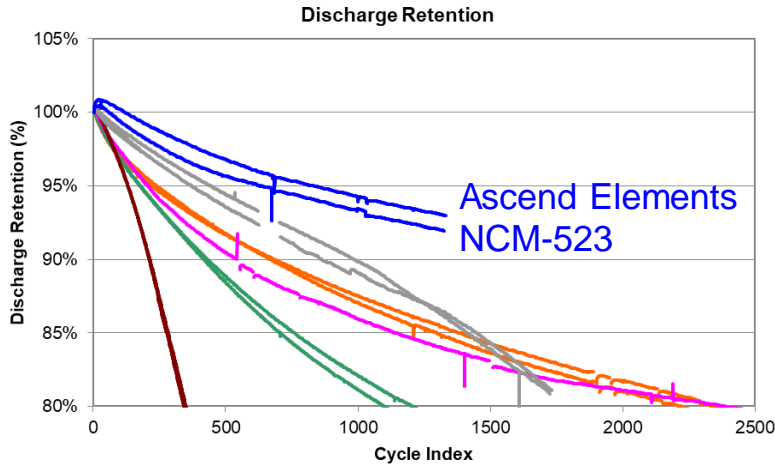
Thermal stability
Scale to 100 kg



Benchmarking Ascend Elements NCM-523

Ascend Elements cathode material in > 0.2 Ah XALT prototype pouch cells

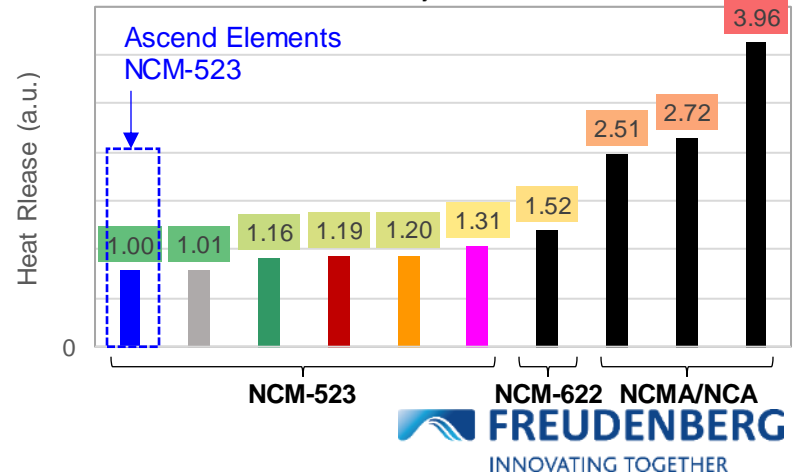
Test conditions:
45°C, 1C/-1C,
100% DOD



Ascend Elements Phase 3 NCM-523 has best cycle life and thermal stability of NCM-523 grades evaluated

Thermal stability of cathode materials

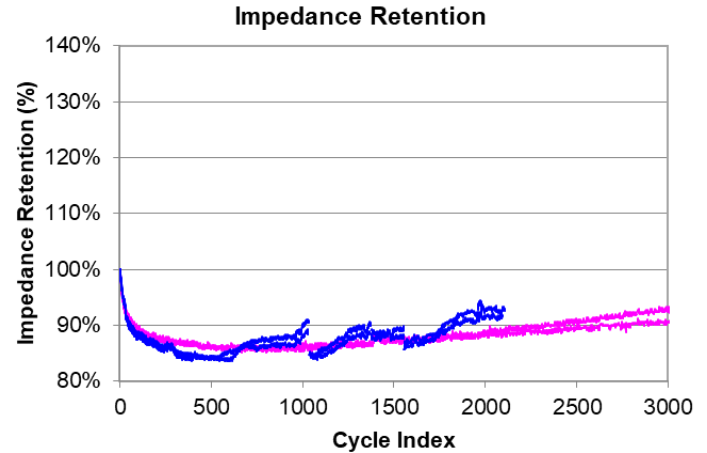
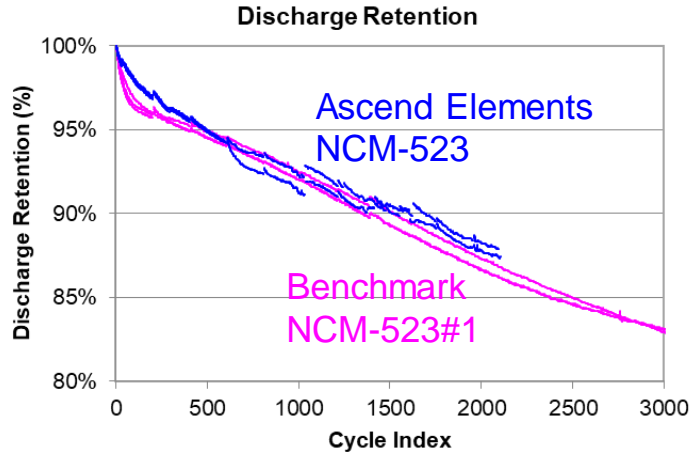
Test conditions:
Materials charged to 4.2V in > 0.2 Ah XALT prototype pouch cells



Ascend Elements NCM-523: Cycle Life in > 2 Ah Pouch Cells

Ascend Elements
cathode material
in > 2 Ah XALT
prototype pouch
cells

Test conditions:
25°C, 2C/-2C,
100% DOD

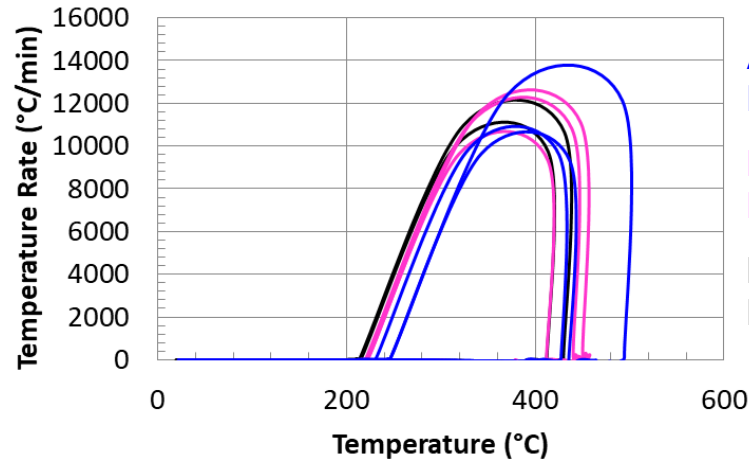


Ascend Elements NCM-523 grade performs similar to benchmark NCM-523 in > 2 Ah pouch cells, on track to achieve 4,000 2C/-2C 100% DOD cycles.

Ascend Elements NCM-523: Thermal Stability in > 2 Ah Pouch Cells

**Ascend Elements
cathode material in
> 2 Ah XALT
prototype pouch cells**

ARC test conditions:
**Cells charged to 4.2V, 5°C
increments, 30 min wait**



Ascend Elements
NCM-523

Benchmark
NCM-523#1

Benchmark
NCM-622#1

**Ascend Elements NCM-523 grade had higher
decomposition temperature than benchmark NCM-
523 and NCM-622 in > 2 Ah pouch cells**

Looking Forward

Continued Partnership



Sustainable cathode material made from recycled Li-ion batteries offers exceptional cycle life and safety for heavy duty applications

WESTBOROUGH, Mass., (September 12, 2023) — Heavy-duty electric trucks, buses, and maritime vessels in North America and Europe may soon be powered by recycled battery materials. [Ascend Elements](#), a U.S.-based manufacturer of sustainable, engineered battery materials, today announced a contract to engineer sustainable cathode active material (CAM) for [Freudenberg e-Power Systems](#). At their [XALT Energy](#) battery plant in Midland, Mich., Freudenberg manufactures battery cell, pack, and system solutions for applications with particularly high performance requirements for lifetime, charge time, and safety. These solutions are suitable for marine, fuel cell hybrid, heavy duty commercial transportation, and other specialty electrification applications.

Production scale trial underway:

>58 Ah XALT Energy 225x225 (mm) pouch cells using Ascend Elements Phase 3 cathode material

- Currently mixing and coating



XALT Energy pouch cells
225x225 (mm)

**Sustainable Manufacturing of NCM Cathode Material
Specifically Designed for High Power + High Performance Lithium-Ion Battery Applications**

THANK YOU!

