Separation Solutions for Cathode Active Materials Used in Lithium-Ion Battery Production

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APPLICATION PAPER

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Introduction

Widespread adoption of Lithium-Ion Batteries for the Electrical Vehicle (EV) market is forecasted with the demand for lithium ion battery is projected to increase to 4900 Gwh in 2030 as compared to 1500 Gwh in 2024[1]. To meet this challenge, Cathode Active Materials (CAM) have strict purity requirements and should be almost entirely free of unwanted impurities with well-defined particle size properties that are consistent and reproducible.

The preparation of both electrodes (Anode and Cathode) will involve the mixing of various solid materials, water, and additives to form particle – liquid slurries. Once prepared additional processing is performed to obtain desired properties for viscosity, particle size distribution, conductivity, and ability to stick to the base electrode substrate material (Aluminum or Copper) to form a cake layer for further processing.

Cathode Active Materials

At the heart of the Lithium-Ion Battery are the Cathode Active Materials (CAM) that provide the high charge density and service life required to meet the demanding battery performance of electric vehicles and renewable energy storage. These materials will vary depending on the type of battery and consist of metal hydroxides (Nickel, Cobalt, Manganese) mixed with Lithium hydroxide. The most common form known as NMC has a structure of $Li(Ni_xMn_yCo_z)O_2$ with $x+y+z=1$. Other forms exist as well such as $LiFePO_4$ (Lithium iron phosphate).

CAM Base Processing

Cobalt, Nickel, and Manganese typically originate from mines and the raw ores undergo various processing steps including grinding, flotation, calcination, acid extraction, and purification steps using flotation, magnetic separators, chemical precipitation, liquid-liquid solvent extraction as well as electro-winning in some cases. Lithium is extracted from both brine lakes (Salars) and mining operations and separated out from contaminants before being chemically precipitated out as either Lithium Hydroxide or Lithium Carbonate.

Processing steps in the CAM manufacture are provided in Figure 1. Typical cathode materials, such as NCA and NMC, are produced through co-precipitation of transition-metal hydroxide precursor materials, followed by collection of the metal hydroxides by a filter press. The metal hydroxides are rinsed with DI water to remove sodium contaminants and are dried.

The dry metal hydroxides are then calcinated (lithiation and oxidation) in a series of furnaces with a lithium compound such as Lithium Hydroxide or Lithium Carbonate to form the final activated CAM materials. The CAM product is ground in a mill to create a specified particle size distribution and magnetic filters are used to remove iron particles. The final CAM materials are used for creating the slurry that is coated onto metal foil to form the electrode.

Filtration is used to remove undissolved salts, iron contaminants, and larger particles in the metal sulfate feeds (1), and after the offloading tanks (2). Filtration is also important for the sodium hydroxide and ammonia chemicals (3) used in the chemical reaction to form the metal hydroxides. It is also used in the deionized water (5) used for rinsing the collected metal hydroxides. A regenerable filter (4) can improve the overall efficiency by capturing fine particles of the metal oxides after the filter press in the mother liquor and in the wash-water coming from the rinsing stages. Various gases are used in the process, such as Oxygen, clean dry air, carbon-free air, and Nitrogen, that require fine filtration (6) to prevent contamination from entering the process and affecting the final product CAM quality. Off gas from the hot furnaces can be treated using hot gas blowback filtration (7) to recover fine CAM particles.

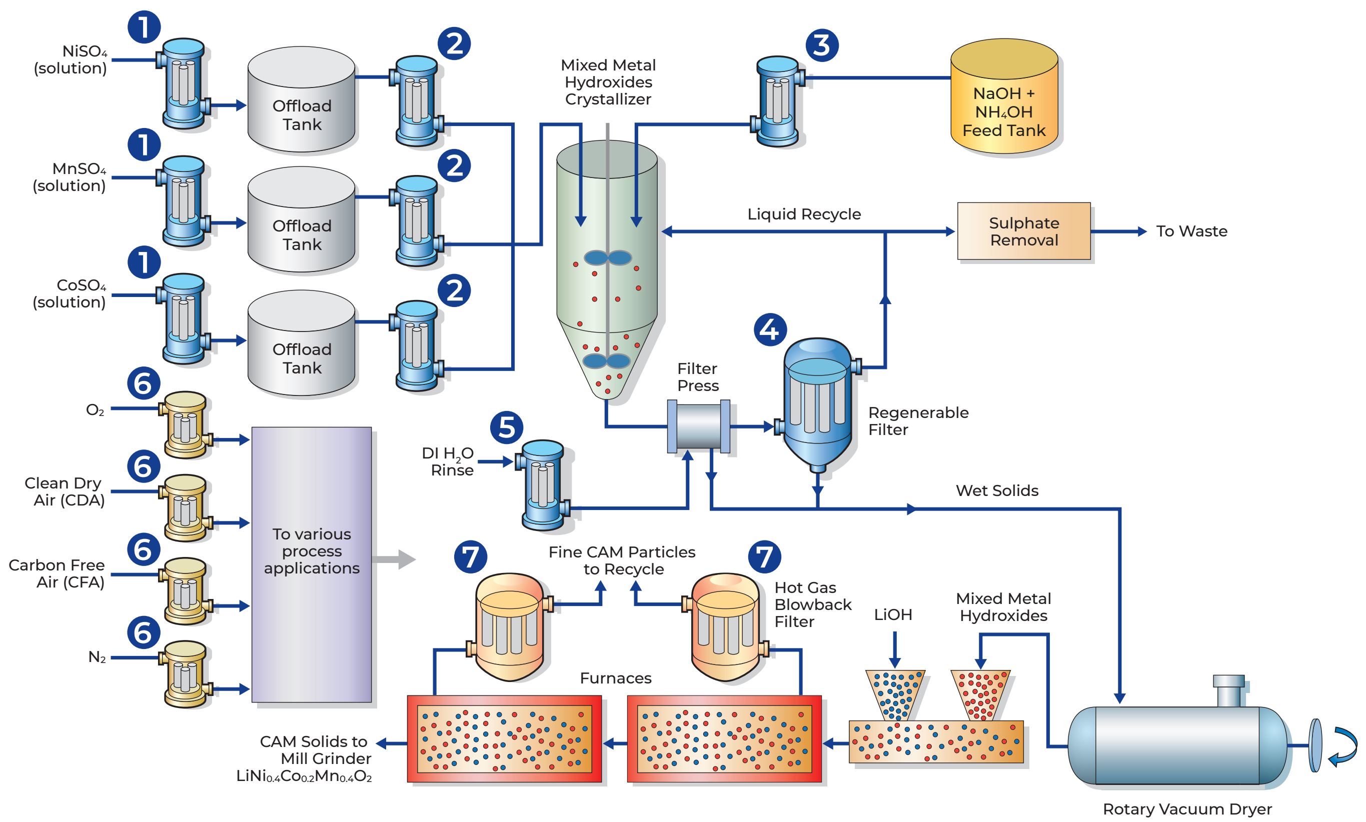

Figure 1: Typical Cathode Active Material (CAM) Processing Steps

Filter	Application	Filtration Value	Pall Product
1	Metal Sulfate Solutions to offload tank	Meet high purity specs for CAM Production	Poromesh® 500 µm
2	Metal Sulfate Solution to Crystallizer	Meet high purity specs for CAM Production	Polyfine® II 0.5 µm
3	NaOH + NH_4OH	Remove undissolved salts, iron oxides and other solid contaminants	Polyfine® II 0.5 µm
4	Mother Liquor and Water Wash	Recover mixed metal hydroxides	Regenerable Filter
5	DI Water	Reduce dissolved metals and solid fines in CAM slurry	IonKleen®, Profile II, Emflon (0.2µm to 10µm
6	Gas Filtration (O_2, CDA, CFA, N_2)	Remove fine particles from gasses	Aerolith® Ceramic, Dynalloy® metal, Profile® Coreless, Emflon® (0.3 to 1 µm)
7	Hot Gas from Furnaces	Recover fine CAM particles	Hot Gas Blowback Filter

Filtration Applications in the CAM Process

EV Battery Value Chain

The various stages in the Electric Battery (EV) value chain are given in Figure 2. For each segment, filtration and separation play a vital role in meeting process goals for yield, purity, and reliability. For base materials, mining and unique material processing are required for Nickel, Cobalt and Aluminum and Lithium as described in this paper. Active materials involve treating of chemicals, specialty chemicals and polymers to make the essential battery components consisting of the separator, electrolyte, and anode/cathode. The battery cells also use chemicals and specialty chemicals that must be at rigorous purity levels for preparing the casing, filling operations, and preparing slurries.

Pall Corporation is your partner for filtration and separation needs and has experience throughout the EV battery value chain. Pall has over 400 qualified Engineers and Scientists that can provide: prototype testing, on site pilot testing, best practice training, process optimization, audits, contaminant analysis, application troubleshooting, validation services, presentations at scientific forums, and journal publications.

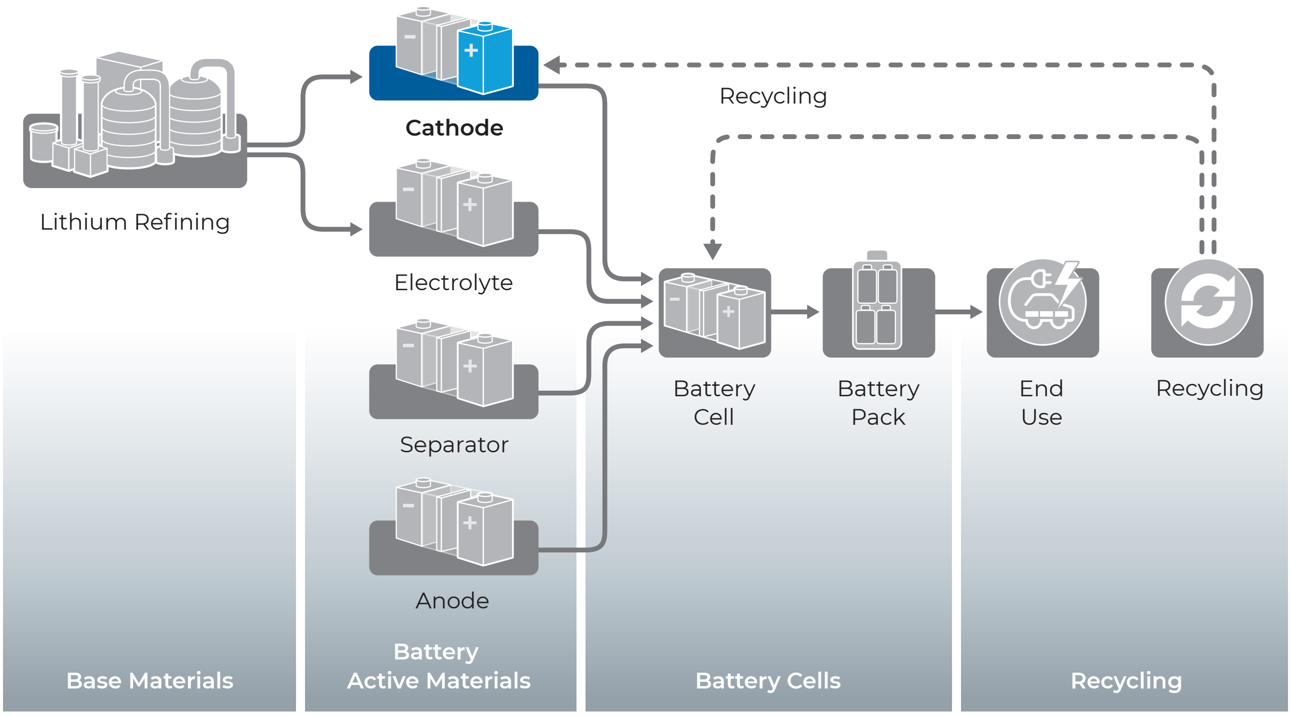

Figure 2: Applications in the EV Battery Value Chain

References

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