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

APPLICATION PAPER

PIAPCAMLFPEN

Introduction

The global demand for lithium-ion batteries continues to surge, driven by the rapid expansion of electric vehicles (EVs) and renewable energy storage systems. At the heart of these batteries lies the **Cathode Active Material (CAM)**—a critical component that determines the battery's energy density, cycle life, and overall performance. CAMs are the electrochemically active substances in the cathode that store and release lithium ions during charge and discharge cycles.

Among various CAM chemistries, **Lithium Iron Phosphate ($LiFePO_4$ or LFP)** is gaining prominence due to its thermal stability, safety profile, and cost-effectiveness. To meet performance and reliability standards, LFP CAMs must be produced with high purity and consistent particle size distribution.

Pall Corporation offers advanced filtration and separation solutions tailored to each stage of the LFP CAM production process, helping manufacturers achieve the required quality and consistency.

Cathode Active Materials – LFP Chemistry

The synthesis of LFP CAM involves a multi-step chemical and mechanical process designed to achieve high purity, optimal particle size distribution, and consistent performance for lithium-ion battery applications.

1. Precursor Formation

The process begins with the reaction of iron salts—typically **iron sulfate ($FeSO_4$)**—with **phosphoric acid (H_3PO_4)** and an oxidizing agent such as **hydrogen peroxide (H_2O_2)**. Ammonium /sodium hydroxide is introduced to facilitate the precipitation of **ferric phosphate**, the precursor to LFP CAM. This reaction generates process streams rich in solids and impurities, making **filtration essential** for ensuring product quality and process efficiency.

To address these challenges, Pall's filtration solutions are strategically applied at key stages of the synthesis. Specifically, feed filtration is used to remove undissolved salts and contaminants from the iron sulfate, hydrogen peroxide, and phosphoric acid mixture, as well as from the sodium or ammonium hydroxide neutralization streams (1,2,3,4).

The resulting **ferric phosphate slurry** is initially filtered using **plate frame filters or filter presses**. However, conventional filters with ≥5 µm precision often fail to capture fine particles, leading to material loss and potential downstream contamination. To overcome this, **high-efficiency Pall filters** are deployed to improve capture rates and reduce yield loss.

After initial filtration, the collected ferric phosphate is rinsed with **deionized (DI) water (5)** to remove residual sodium and soluble impurities. The **wash water and mother liquor (7,8)** still contain recoverable ferric phosphate and ammonium phosphate, which, if not properly filtered, can lead to yield loss and environmental discharge violations.

To enhance recovery and protect downstream systems, **Pall regenerable candle filters**, with <1 µm removal efficiency, are employed. These advanced filters effectively capture fine particles, reduce manual maintenance, and safeguard ultrafiltration membranes in water treatment units—ensuring both operational efficiency and environmental compliance.

2. Lithiation and Activation

The rinsed ferric phosphate precursor is dried using a **rotary vacuum dryer** to eliminate residual moisture. It is then mixed with **lithium carbonate** and subjected to **high-temperature kiln treatment**, initiating the lithiation and activation process. This thermal step transforms the precursor into the final **LFP CAM**, imparting the electrochemical properties required for battery performance.

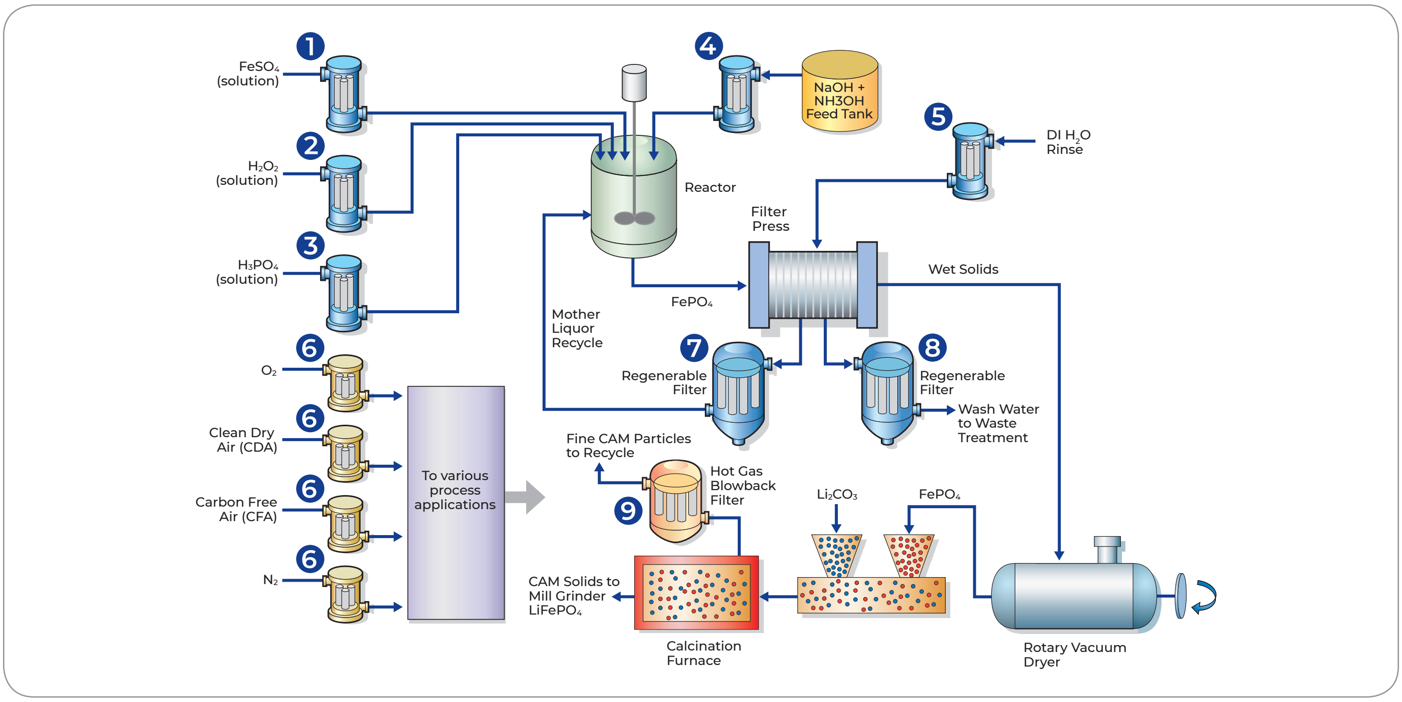
During kiln operation, **off-gas streams** containing fine CAM particles are generated. To prevent material loss and protect downstream systems, **hot gas blowback filtration (9)** is used. Pall's advanced filtration systems recover these fine particles, contributing to higher yield and cleaner emissions.

Following activation, the CAM is **ground to a specific particle size distribution**, a critical parameter for slurry formulation and optimal electrode coating. This ensures consistent performance in battery manufacturing and enhances the overall quality of the final product.

3. Gas Filtration Integration

Gas streams such as **O_2, N_2, Carbon Free Air (CFA), and Clean Dry Air (CDA)** play a vital role in transporting active materials and maintaining process integrity. Pall's advanced gas filtration solutions (6) are integrated at multiple stages to ensure:

- **Ultra-High Purity:** It prevents contamination during material transport and processing, which is critical for achieving a consistent crystal structure and reliable battery performance.
- **Low Differential Pressure:** Pall filters operate efficiently under pressure constraints, helping reduce energy consumption and extend filter life.
- **Operational Efficiency:** Minimised filter changeouts reduce downtime and lower operational costs.
- **Quality Assurance:** Enhanced gas purity supports optimal CAM characteristics and improves production yields.



Filtration Applications in the LFP CAM Process

	Process Step	Filtration Objective	Pall Filtration Solution
1	$FeSO_4$, Feed solution	Remove undissolved salts and contaminants	0.5 Micron Filter
2	H_2O_2, Feed solution	Remove undissolved salts and contaminants	0.5 Micron Filter
3	H_3PO_4 Feed solution	Remove undissolved salts and contaminants	0.5 Micron Filter
4	Ammonia/ Sodium Hydroxide neutralisation	Purity control and reaction efficiency	0.5 Micron Filter
5	DI Water rinse	Remove undissolved salts, iron oxides and other solid contaminants	0.2 to 10 Micron Filter
6	Process gases (O_2, CDA, CFA, N_2)	Remove fine particles from gases	0.003 to 1 Micron Filter
7	Mother liquor	Recover fine Iron Phosphate particles	Regenerable Filter
8	Wash water	Recover fine Iron Phosphate particles	Regenerable Filter
9	Off-gas from kiln	Recover fine CAM particles	Hot Gas Blowback Filter

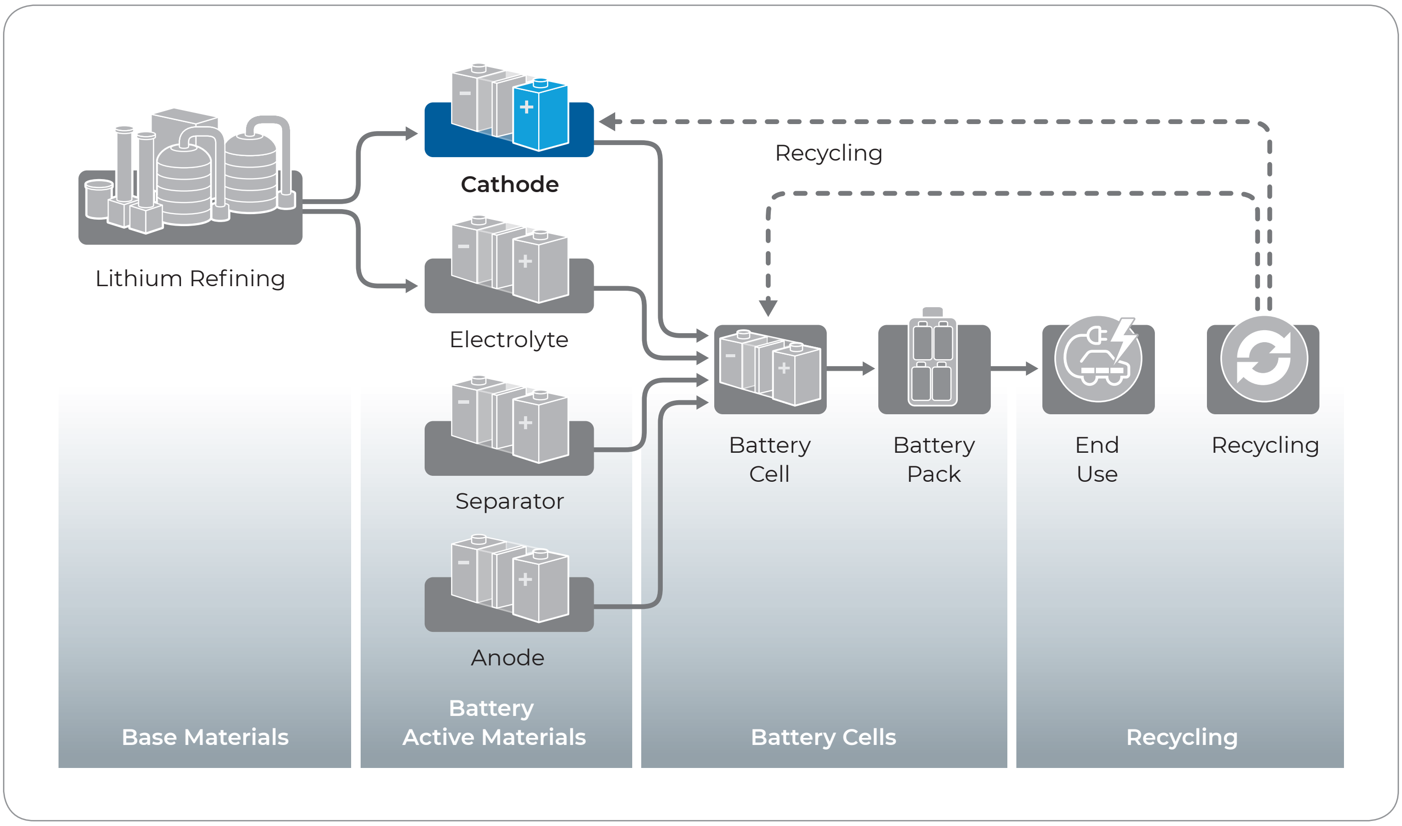
Conclusion

The production of high-performance LFP CAMs demands precise control over purity and particle characteristics. Pall's filtration technologies ensure reliable separation at every stage, enabling manufacturers to meet stringent quality standards and scale efficiently. With deep expertise and global support, Pall is your partner in advancing lithium-ion battery innovation.

EV Battery Value Chain Integration

Filtration and separation are critical across the EV battery value chain—from raw material processing to CAM production, cell assembly, and recycling. Pall Corporation supports each segment with:

- Prototype and pilot testing
- Process optimisation and audits
- Contaminant analysis and troubleshooting
- Validation services and technical training



Dr. Thomas H. Wines is a Director at Pall Corporation's Application Development Team with over 36 years' experience in Separation Technologies. He is focused on the Energy Market including Lithium-Ion Batteries, Upstream and Midstream Oil & Gas Processes, and Downstream Refining Operations. For more information, Dr. Wines can be reached by email at tom_wines@pall.com.

Anoop Suvarna is the Global Battery Materials Manager at Pall Corporation, with more than 20 years of experience in the energy and industrial sectors. He can be contacted via email at anoop_suvarna@ap.pall.com.

PALL CORPORATION

Corporate Headquarters
Port Washington, NY, USA
+1-800-717-7255 toll free (USA)
+1-516-484-5400 phone

European Headquarters
Fribourg, Switzerland
+41 (0)26 350 53 00 phone

Asia-Pacific Headquarters
Singapore
+65 6389 6500 phone

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Contact us at www.pall.com/contact

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August 2025