

Improving Electrode Slurry Filtration in Lithium-ion Battery Manufacturing

Technical Brief

The filtration of cathode and anode active material slurry is the critical unit process for high quality coating on current collectors. Cathode slurry is coated onto the aluminum foil, and the anode is coated onto the copper foil. The layers coated on the metal electrodes should be uniform, free from any defects, otherwise it could affect overall energy density of the battery and may cause electrical shorts, leading to the failure of the battery, short battery life and overall battery performance.

To provide high assurances and to minimize any defects which can result from large particles or gel-like agglomerates, multiple-stage filtrations of slurry are needed before and after the buffer tank. Usually, capsule type filters are used as the final filtration stage.

The filters/capsules used in the coating process are needed to allow only active materials smaller than the specified particle size to pass through while the large particles are held back. Without effective filtration, defects will form on the electrode surface.

Authorised Distributor in UK & Ireland:

Criteria for slurry filter selection

Rigid self-supporting structure: Both cathode and anode slurries have very high viscosity: about 5–10K cP. Therefore, a rigid filter cartridge is necessary to avoid cartridge deformation and collapse resulting from high pressure drop associated with the flow of viscous fluids.

Depth filter: The slurry also contains gel-like contaminants in the cathode/anode slurries. The gels are produced from premature curing or drying of the binders in the slurry. The best approach for removing gel-like impurities is to use a rigid depth filter. If the gel-like contaminants are not removed or extruded through the surface filters, they will deposit onto the cathode or anode electrodes leading to diminished battery performance.

Target pore size: In the slurry filtration process, a filter with a sharp (classifying) cutoff will be required to stop the oversized particles and let the small size active ingredients to pass through. The classifying filter only removes large particles while maintaining the effective particles in the slurry.

Betapure AU series filter cartridges meet the particle classification requirements for the slurry coating application. In addition, the Betapure AU series filter cartridges are offered in an encapsulated form as 3M™ CTG-Klean Encapsulated Filter System 1GPJ and GPK Series Capsules.

Contaminants in the electrode slurries

The electrode slurries usually contain:

- Agglomerated large particles
- High molecular weight organics forming gel-like contaminants
- Corrosion byproducts from mixers, pipes and hardware



3M™ Betapure™ AU Series Filter Cartridge 1GPJ

Advantages of CTG-Klean 1GPJ/GPK series capsules

- **Easy to use:** The CTG-Klean 1GPJ and GPK series capsules are easy to install into the stainless-steel housing.
- **Low odor release:** No slurry materials are exposed to the environment or operators who are involved in changing filters. This also helps minimize the emission of Volatile Organic Compounds (VOCs).
- **Less cleaning and labor cost:** The filter is encapsulated in a liner during operation, which prevents the slurry from coming into contact with the housing. This helps eliminate a very labor-intensive process of cleaning which is associated with the use of solvents and their disposal. This design significantly reduces operation, waste and disposal costs.
- **Materials recovery:** The electrode slurries are of high value and their recovery is a must after filtration or during filter changes. The design of the CTG-Klean 1GPJ and GPK capsules allow for easy recovery by cutting the liner and draining and recovering the valuable slurries for reuse.

The CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges have shown promising performance for the electrode slurry coating process in the production of lithium-ion batteries.

Lithium-ion battery production case 1

The customer uses a competitor’s hard capsules in their coating process as the electrode slurry filters. After understanding the advantages of 3M™ CTK-Klean Encapsulated Filter System 1GPJ Series Capsules and Betapure AU series filter cartridges, they decided to perform the field trial with CTK-Klean 1GPJ series capsules with Betapure AU series filter cartridges. In this case, the CTK-Klean 1GPJ series capsule with Betapure AU series filter cartridge was compared with another filter for the anode slurry coating process, which lasted 11 days. The average defect with the CTK-Klean 1GPJ series capsule with Betapure AU series filter cartridge was 0.08%, while that of the competitor was 0.11%. This comparison showed a 27% defect reduction when using CTK-Klean 1GPJ series capsules with Betapure AU series filter cartridges.

	Competitor	CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges	Defect Reduction - CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges
Defect Rate	0.11%	0.08%	27%

Furthermore, the filter service life of the CTG-Klean 1GPJ series capsule with Betapure AU series filter cartridge was longer than the competitor while providing a higher-quality coating. The curves of pressure drops versus time is shown in Figure 1. Since the removal efficiency of CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges is better (as shown in this study) than the competitor, the 150 µm and 175 µm CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges were tested for comparison, although the CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges were rated at much higher micron rating than the competition, both provided longer filter life and better coating quality.

On average, the CTG-Klean 1GPJ series capsule with Betapure AU series filter cartridge provided

1.5x

longer filter service life*

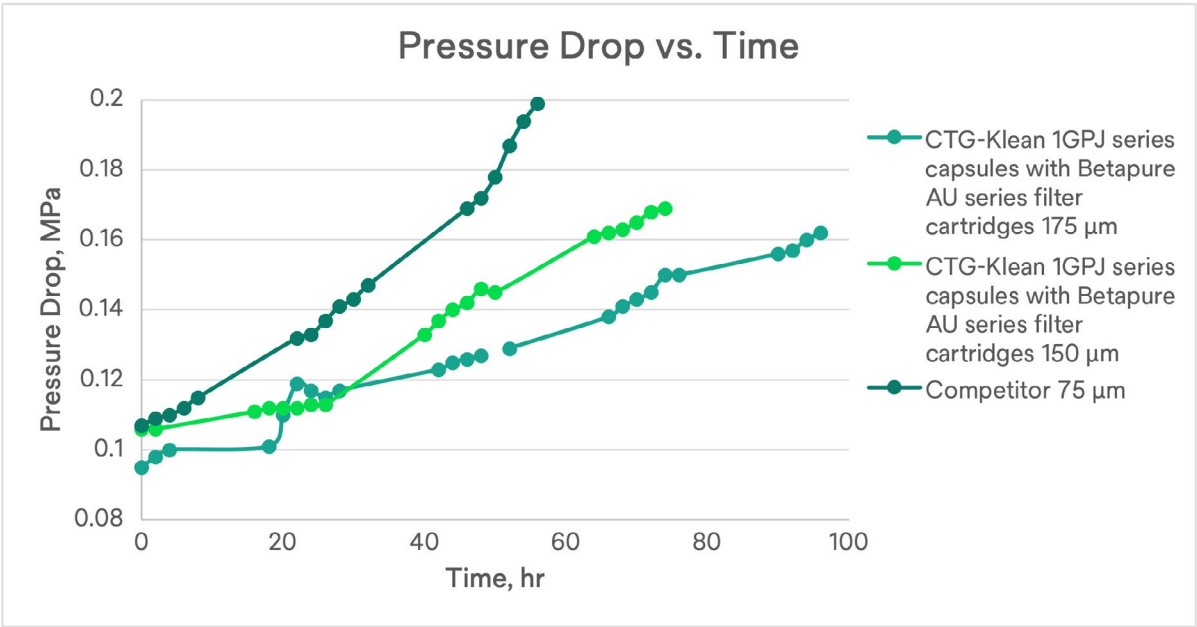


Figure 1. Comparing filter service life of CTG-Klean series capsules with Betapure AU series filter cartridges with a competitor’s filter for anode slurry filtration*

	Competitor–75 µm	CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges–150 µm	CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges–175 µm
Service life/(hr.)	56	74	96
Defect rate level	Pass	Pass	Pass

Lithium-ion battery production case 2

For this case, Betapure AU series filter cartridges were used in the anode slurry filtration. The results showed that the service life of a Betapure AU series filter cartridge is much longer on average than the competitor, and the defect rate of a Betapure AU series filter cartridge is less than the competitor filter. The results of the trial are summarized in the table below.

Item	Competitor	Betapure AU series filter cartridge
Rating of the filter	75 µm	100 µm
Filter life	3 days	12 days
Coating dark marks	A small amount	A small amount
Coating defect rate	0.14%	0

Comparison of trial results of a Betapure AU series filter cartridge with a competitor for anode slurry

Lithium-ion battery production case 3

In this case, the customer compared the service life of different capsules. 3M™ CTG-Klean Encapsulated Filter System 1GPJ Series Capsules with 3M™ Betapure™ AU Series Filter Cartridges were used in the anode slurry filtration. The combination of two stages of 175 µm CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges replaced the competitor filters which were a solution of 95 µm as a prefilter along with a 75 µm capsule. Two rounds of trial results showed that at the same defect rate, the service life of the CTG-Klean 1GPJ series capsule with Betapure AU series filter cartridge was 1.4 and 2 times longer compared with the competitor.

	Competitor	CTG-Klean 1GPJ series capsule with Betapure AU series filter cartridge Round 1 trial	CTG-Klean 1GPJ series capsule with Betapure AU series filter cartridge Round 2 trial
Filtration solution	95 µm + 75 µm	175 µm + 175 µm	175 µm + 175 µm
Service life	~5 days	10 days	7 days
Defect rate level	Pass	Pass	Pass

Comparison of trial results of CTG-Klean 1 GPJ series capsule with Betapure AU series filter cartridge with competitor for anode slurry

Lithium-ion battery production case 4

A cathode slurry filtration trial was performed with CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges for this case and the customer wanted to compare the performance of CTG-Klean 1GPJ series capsule with Betapure AU series filter cartridge with the product currently in use. Two stages of 150 µm CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges were compared to a competitor's filter with the same arrangement. The trial result showed 2.3 times the filter life with CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges; at the same time, the defect rate with CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges was slightly better than the competitor.

	Competitor	CTG-Klean 1GPJ series capsules with Betapure AU series filter cartridges
Filtration solution	150 µm + 150 µm	150 µm + 150 µm
Service life	~13 days	30 days
Defect rate level	Pass	Pass

Comparison of trial results of CTG-Klean 1GPJ capsule with Betapure AU series filter cartridge with competitor for cathode slurry

Conclusion

The quality of the cathode and anode coatings onto the electrode collectors is paramount to the reliability and the operation of the lithium-ion batteries. The coating process involves applying a viscous cathode or anode slurry through a thin slot die. The slurry should be free of any large particle or agglomerate larger than the die opening, otherwise part of the die will be clogged, and a streak of uncoated line will appear on the electrode surface. In addition, if these large particles are extruded through the die, a raised point will appear on the electrode surface that could cause high current flow resulting in over heating or at its worst cause shorting of the battery. To help ensure high efficiency battery manufacturing, these particles should be captured prior to reaching the die. The best approach is to filter out these large particles. The filter should not deform under high viscosity fluid flow, should provide reasonable filter life to minimize disruption of the production line and only remove large particles and leave the desired particles in the slurry.

Betapure AU series filter cartridges are designed to provide high porosity and strength capable of resisting deformation under very high-pressure drops enabling a very efficient screening of the large particles and providing long filter life. Furthermore, these filters are encapsulated in a liner that can be used in a stainless-steel housing providing a sustainable solution. Moreover, these filtration solutions offer high quality coatings and extended filter life when compared to competitive filtration solutions.

Intended Use and Product Selection: 3M™ CTG-Klean Encapsulated Filter Systems GPJ Series are intended for use in industrial filtration applications of aqueous fluids in accordance with the applicable product instructions and specifications. CTG-Klean encapsulated filter systems GPJ series products are also intended for use with non-aqueous fluids where materials of construction are compatible. Since there are many factors that can affect a product's use, the customer and user remain responsible for determining whether the Solventum product is suitable and appropriate for the user's specific application, including user conducting an appropriate risk assessment and evaluating the Solventum product in user's application.

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