Inherently safe cells everywhere: Revolutionize battery safety with Soteria's technology and consortium

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How thermal runaway develops in today's lithium-ion batteries

All lithium-ion batteries are flammable because the reaction to store and release energy in the battery is the same as the reaction of burning—both are redox reactions and rely on having both a reduction agent and an oxidizing agent present. Batteries are controlled redox reactions—and if the measures used to keep them in control fail, flames and explosions can result. In the battery world this is known as "thermal runaway," or "TR" for short.

The problem of TR is exacerbated by the market's almost insatiable need to put more energy into a small package. We want thinner cell phones that last longer, tiny digital watches, and video game controllers that can last through an all-nighter. It is the same for larger applications—we want electric vehicles that will go 500 miles on a charge and solar storage that will run our homes all night on the energy stored from the noontime sunlight. For either scenario, putting more energy in a battery makes it more difficult to control, and more outrageously explosive when something internally or externally goes wrong.

More energy in a battery makes it more difficult to control, and more outrageously explosive when something internally or externally, goes wrong.

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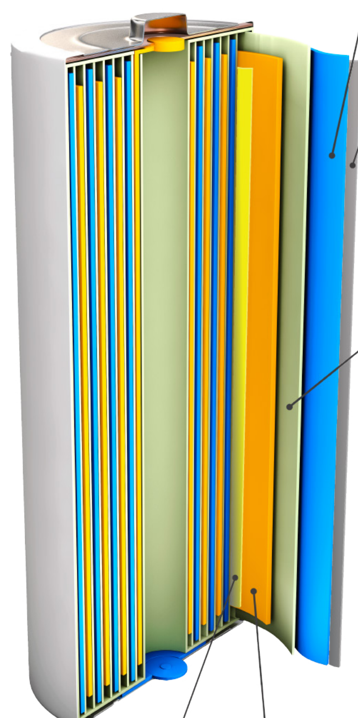
General safety approaches assume cells are potentially unsafe

There are several strategies to prevent or mitigate TR, which include:

Strategy	Examples	Weaknesses
Protection uses external means to protect the cell from the environment	Titanium plates on Tesla Model S, boxes around batteries, cooling systems	External to the cell and cannot shield against internal defects. The protection strategy will not prevent all damage to the cell.
Mitigation protects the external environment from the cell, if the cell goes into TR	Boxes built around batteries, thermally insulating materials, phase change materials	Only protects the environment (people) from a certain level of TR. Industry regulations exist that employ this strategy, but the defined limits may not approximate real-world situations.
Detection uses equipment or electronics to detect TR early, and takes measures to make it less likely to occur	Thermal sensors, gas sensors, voltage and current sensors	May not detect all events, and subsequent mitigation measures may not be enough to stop thermal runaway or could be applied too late.
Reduction involves replacing internal parts of the battery with materials that are not flammable, have reduced flammability, or are difficult to ignite	Ionic liquid electrolytes, solid electrolytes, graphite anode instead of lithium metal, lithium iron phosphate cathode instead of lithium cobalt oxide	The higher the energy density, the higher the density of reactive materials. They cannot be eliminated. Stated another way—eliminating reactive materials also eliminates the ability to store energy. And reactive materials will react—that is, burn.
Perfection involves the improbable process of producing millions of cells that are perfect, without defect	Manufacturing process control, CT scans of completed batteries	While the measures to make battery manufacturing more perfect have been fantastic, the battery itself is complex, and the defect required so small, that true perfection cannot be achieved. This is proven out by the ever-increasing number of battery recalls.
Control the flow of energy inside the cell, and stopping it if it goes above certain limits	Shutdown separators and current collectors, thermally stable separators	Control may not stop the flow of energy in all circumstances, allowing TR to initiate.

Given that each strategy is imperfect, battery manufacturers use multiple strategies to make thermal runaway events less likely and less frequent. In the past, the control strategy offered the fewest options, being historically limited to using shutdown separators. Shutdown separators, however, melt and shrink at relatively low temperatures, and thus are both a cure and a cause of TR. Now however, Soteria's battery safety architecture is one of the few technologies that utilizes the control strategy by using two new materials to keep energy in the battery from flowing to a defect and igniting the cell. The architecture also makes it compatible with all other strategies. This will be described in more detail later.

Conventional battery architecture is potentially unsafe



All lithium-ion batteries are made of six generalized components:

- **Aluminum and copper current collectors:** These thin metal foils distribute the flow of electricity within the battery, and also provides a pathway for the electricity to travel out of the battery for use in the device.
- **Anode:** The electrode where the lithium is stored when the battery is charged. It holds the lithium at a high energy state, so the lithium is very reactive when it is in the anode.
- **Cathode:** The electrode where the lithium is stored when the battery is discharged. It holds the lithium in a low energy state. The lithium is more stable when it is in the cathode.
- **Separator:** A layer between the anode and cathode that keeps them electrically isolated (electrons cannot pass through) but allows lithium ions to pass through.
- **Electrolyte:** a liquid that conducts lithium ions but does not conduct electrons directly. Generally, is it a solvent with a lithium salt at relatively high concentration.

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Soteria battery safety architecture addresses the root cause of thermal runaway

When fully implemented, the Soteria battery safety architecture will replace three components. These include:

- **Separator:** The porous polymer separator is replaced with a nanofiber-based nonwoven that is reinforced with aramid fibers such as Kevlar or Twaron. The aramid backbone (which is stable to >500 C) prevents melting and shrinking of the separator, keeping any short circuit from increasing in size.

- **Aluminum current collector:** The aluminum foil at the cathode is replaced with a metallized film consisting of a thin sheet of plastic with enough metal coated on it to run the battery, but not enough to carry the intense currents that would ignite the battery on fire.

- **Copper current collector:** Like the aluminum current collector, the copper foil at the anode is replaced with a metallized film consisting of a thin sheet of plastic coated with enough metal to run the battery, but again not enough to carry the intense current densities that would ignite the battery on fire. Because copper is heavy and expensive, there exists an opportunity for significant weight and cost savings in addition to safety.

For batteries using existing technology, every battery fire starts in the same way. Something damages or compromises the separator, which then fails and creates a small area of intense current that ignites the battery. This compromise to the separator can be from damage to the cell, a latent internal defect, or the growth of a lithium dendrite. The trend toward using thinner separators exacerbates this problem.

Existing Technology

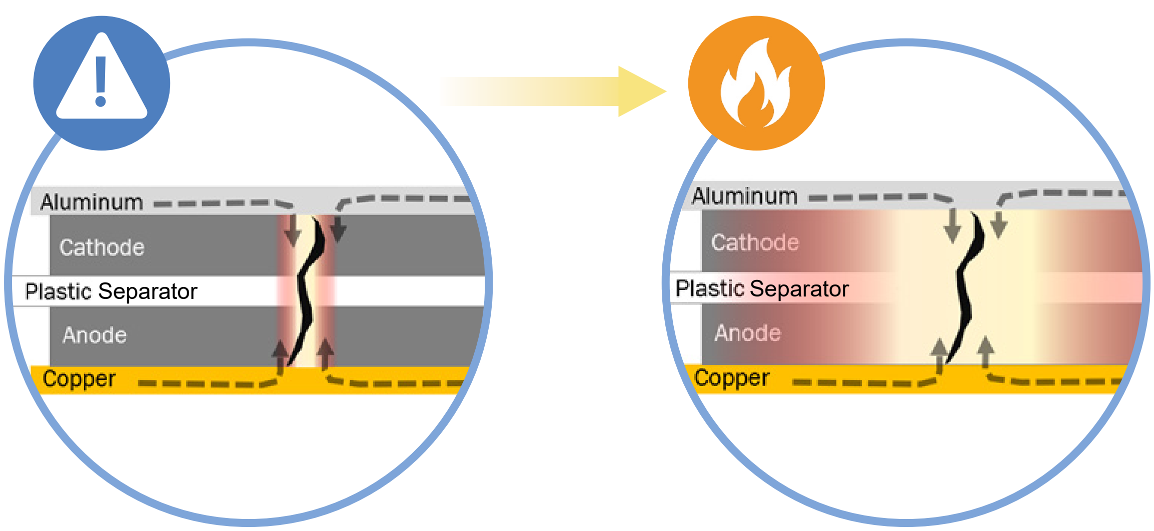

Figure 1 Existing lithium ion battery architecture. When a short circuit occurs, the separator melts and shrinks, opening up a bigger short.The energy of the battery then flows to the metal foil current collector "electron superhighway" creating an intense hot spot at the short circuit that ignites the battery.

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The Soteria architecture stops thermal runaway in two ways:

- **Separator:** The nanofiber-based nonwoven separator does not melt or shrink, which keeps any damage or compromise to the battery separator from getting worse. This is generally sufficient by itself to protect batteries from most internal defects and external damage, up to about 10 Ah.

- **Aluminum and copper current collectors:** When there is an internal short circuit, the current collectors respond to the brief current spike by burning out like a fuse around the short circuit, isolating it electrically from the rest of the battery and stopping the flow of energy. If any heat is created, the polymer base film shrinks, pulling the current collector away from the short circuit and increasing the isolation.

When the Soteria safety architecture is in place, the energy of the battery is unable to flow to the defect, so the battery does not ignite and the rest of the battery continues to function normally.

Soteria™ Technology

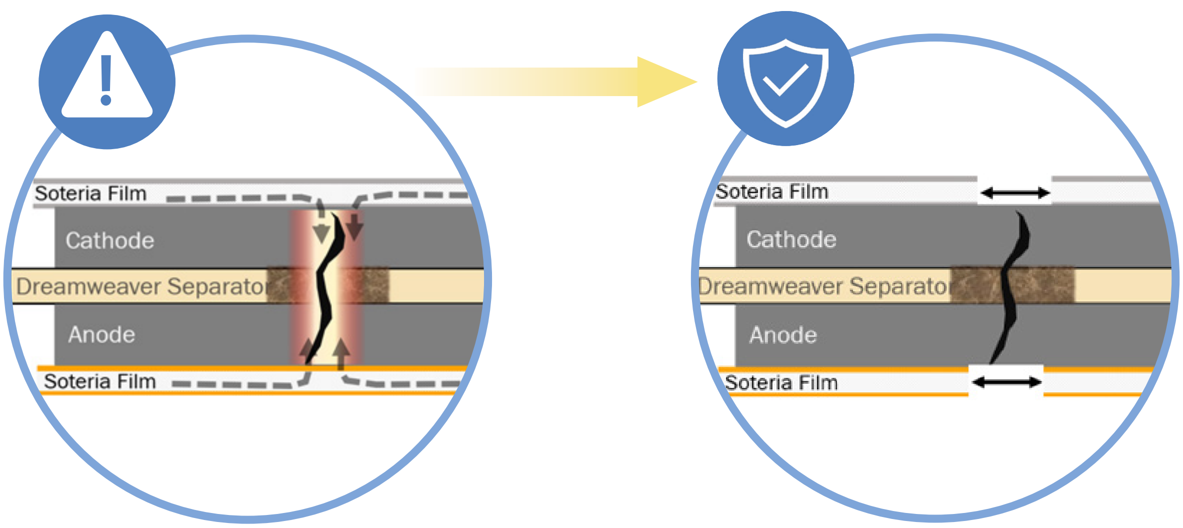

Figure 2 Batteries built with the Soteria architecture address the root cause of thermal runaway. The separator does not melt and shrink, so the energy flow through a compromised separator does not get worse due to heat. The current collectors burn out like fuses, stopping the flow of energy to the short circuit. This prevents any heat from flowing to the short circuit, and the rest of the battery continues to function normally

See the technology in action

In these videos showing side by side abuse testing, the cells on the left have foils and standard plastic film separators and ignite when damaged. The cells using Soteria materials survive the abuse without thermal runaway.

Nail penetration test

VIEW VIDEO

High energy density cellphone-sized cells (240 Wh/kg,5 Ah)

Nail penetration & 90-degree crush test

VIEW VIDEO

cylindrical 18650 cells

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Dreamweaver separator properties and performance in cells demonstrates enhanced stability

Dreamweaver separator properties

The Dreamweaver separator is made from textile-grade fibers that are fibrillated to nanofibers using specialty papermaking techniques. Each manufacturer of the Dreamweaver separator produces their own products based on their capabilities. Below is a table with a representative range of properties compared to competitive separators on the market today. As can be seen, the properties of the Dreamweaver separators made by the licensees have comparable properties to competitive separators except in three areas, which are: tensile strength, shrinkage and water uptake. These will be explored one-by-one in the sections below. In addition, the separator west out extremely well in electrolyte, which alone can make it the preferred separator for novel electrolytes.

Tensile Strength

Separator tensile strength is necessary for stacking and winding processes of battery production. Once inside the battery, there is little need for high tensile strength. Thus far, the Dreamweaver separators have been successful on automated production equipment and there are strategies to increase tensile strength if necessary.

Physical Property	Units	Test Methods	Performance Range	Competitor
Basis Weight	g/m^2	TAPPA T410	14 – 16	10 – 16
Thickness	µm	ISO 534:1988	14 – 20	12 – 20
Porosity	%		25 – 50	35 – 50
Gurley	Seconds		20 – 50	20 – 50
Tensile MD	N/m	TAPPI T494	600 – 800	2000
Elongation MD	%	TAPPI T494	1.9 – 3	>100
Tensile CD	N/m	TAPPI T494	400 – 600	200 – 300
Elongation CD	%	TAPPI T494	3 – 5	3 – 5
Shrinkage MD 90C	%		<1	1 – 7
Shrinkage CD 90C	%		<1	<1
Shrinkage MD160 C	%		<1	>10
Shrinkage CD 160 C	%		<1	>10
Shrinkage MD 200 C	%		<1	>50
Shrinkage CD 200 C	%		<1	>50
Water Uptake	g/g		0.016	0

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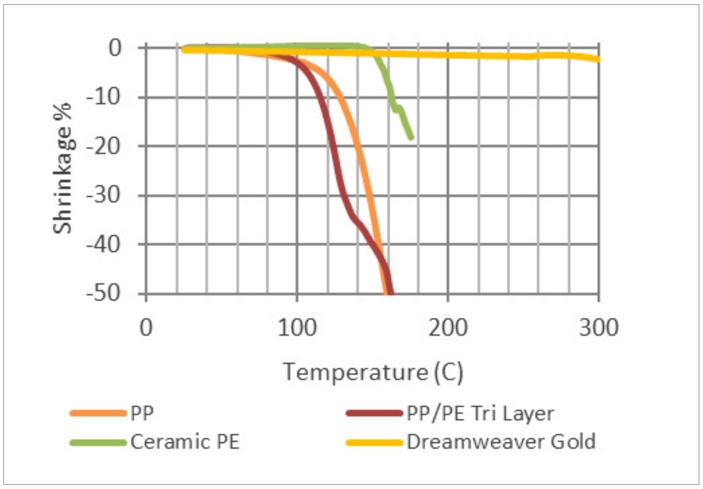

Figure 5 Shrinkage of various separators as a function of temperature. Uncoated plastic separators have catastrophic shrinkage at 100 - 150 C, while ceramic coated separators shrink at 150 - 170 C. Dreamweaver separator is stable to over 300 C

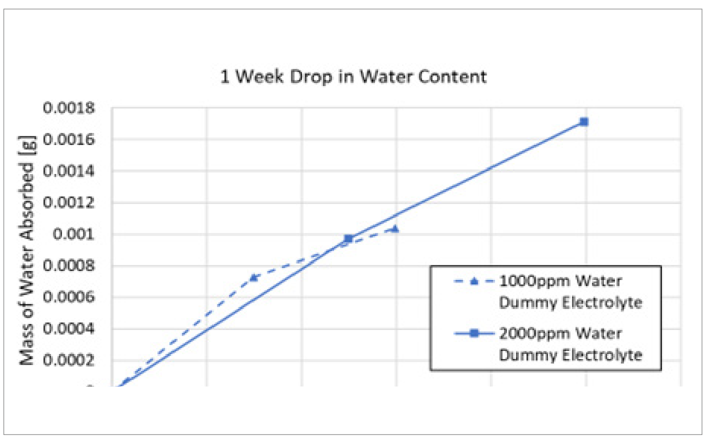

Figure 6 The water absorbed by the Dreamweaver separator when exposed to doped electrolyte solution. As shown in the next section, the water can increase the cycle life of a battery significantly.

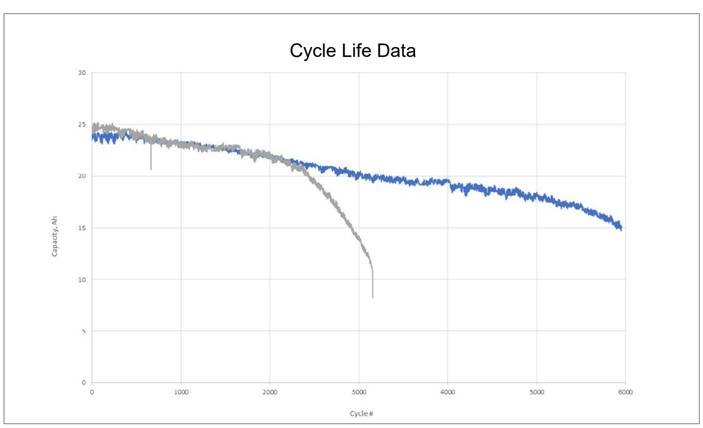

Figure 7 Cells with Dreamweaver Gold separator cycled to over 4000 cycle to 80% of original capacity, and over 6000 cycles for 60%, compared to 2,500 cycles and 3,000 cycles for the control polyethylene separator.

Shrinkage

Separators shrink in a battery when there is a hot spot, which is caused by an internal short circuit. The shrinkage increases the size of the short circuit, allowing more electrical energy to flow, which generates more heat and etc.—this vicious cycle is what causes most spontaneous ignition in lithium-ion batteries. Given that there is enough electrical energy in the battery to take the whole battery to over 1000 C, this is a relatively modest local event.

Electrolyte Water Uptake

The cellulose in Dreamweaver separators is naturally hydroscopic, and must be dried before being built into a battery. The water uptake in a cellulose nanofiber will be both adsorbed on the surface as well as absorbed into the polymer structure. While the separator is in the battery, it can act as a water getter, removing the water that can otherwise cause the cell to deteriorate over time. In a lithium-ion battery, water will react with the lithium salts in the electrolyte to create hydrofluoric acid, which then will react with the cathode to create water. This vicious cycle causes the cell capacity to fade over time, and the Dreamweaver separator can arrest this deterioration.

In experiments, Soteria has found that the amount of water absorbed by the Dreamweaver separator is proportional to the mass of the separator and is relatively immediate (on the scale of days), but is independent of the amount of water present. Interestingly, the cycle life of the cell can be improved by using a thicker separator.

Separator Performance in Cells

LiFun Technology, a Chinese battery company, made 25 Ah NMC cells using the Dreamweaver separator, The cells tested equivalent to the controls for capacity and slightly lower for impedance. Cycle life showed very big difference, as shown below in Figure 7. The control cells hit a knee shortly after 2,000 cycles, which is attributed to the creation of water in the electrolyte, which reacts with the electrolyte salt to create hydrofluoric acid, which then reacts with the cathode to create more water. The identical cells with the Dreamweaver separator cycled significantly longer, which is attributed to the separator absorbing water from the electrolyte, arresting the vicious cycle.

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Soteria current collector properties and performance in cells show improved abuse tolerance

Soteria Current Collector Properties

They physical properties of the current collectors are shown in Figure 8, below. The metallized films, originally started with polyester (PET) substrates, but found that thinner materials could be made based on DuPont's Kapton® films with a 4-micron substrate and 500 nm of metal on each side, for a total of 5 microns thickness. Made in both copper and aluminum, these represent the strongest and lightest current collectors available of any kind. Their properties are also shown in Figure 8.

	Traditional Aluminum Foil	Soteria Aluminum Film	Thin-film Aluminum Kapton®	Traditional Copper Foil	Soteria Copper Film	Thin-film Copper Kapton®
Substrate	N/A	9µm PET	4µm Kapton®	N/A	9µm PET	4µm Kapton®
Total Thickness	15µm	8µm	5µm	10µm	10µm	5µm
Weight	43 g/m^2	13 g/m^2	10g/m^2	90 g/m^2	22 g/m^2	14g/m^2
Tensile N/mm2	150 N/mm^2	120 N/mm^2	335 N/mm^2*	400 N/mm^2	120 N/mm^2	335 N/mm^2*
Elongation	4%	39%	55%*	4%	37%	55%*

Figure 8 Physical properties for Soteria metallized film current collectors compared to traditional foils. Soteria films are much lighter weight and can also be significantly thinner as well as providing enhanced safety.

The current collector's thin metal is about 80% less than the metal foils currently used. When there is an internal short circuit, the current density can be very, very high. As an example, an 18650 might normally carry 3A of current across its 65 mm current collector. However, if an internal short develops that is 100 microns in diameter, that same 3A now needs to travel through a length of only 314 microns, or 0.3 mm--200 times higher than the current density. The Soteria current ollector is made to function well under normal current conditions but burn out like a fuse under the intense short-circuit current densities. The polymer substrate also shrinks, pulling the metal farther away from the short circuit. This is shown in Figure 9.

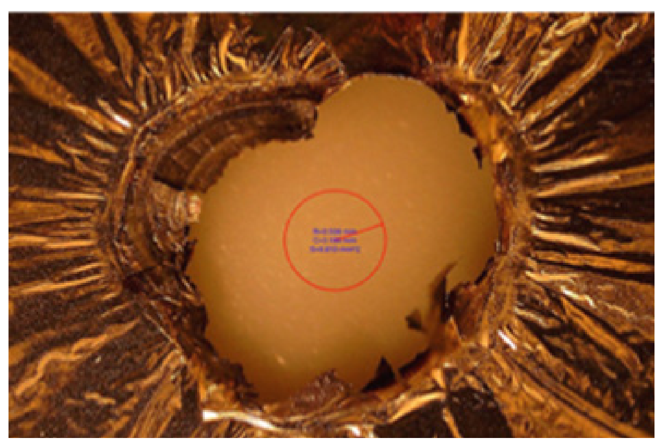

Figure 9 A hole created by a short circuit the size of the red circle. The missing burned-out metal is evident, as well as the wrinkled area where the polymer substrate shrank

Current Collector Performance in Cells

NASA 18650 NMC111 / Graphite

NASA has done several cell builds with both the separator and current collectors, all in the 18650 format with NMC 111 / graphite electrode systems and published the results in a scholarly paper, "Prevention of lithium-ion battery thermal runaway using polymer-substrate current collectors." As part of these experiments, they did many nail penetration tests, and all of the cells with the aluminum film current collector passed. One post-test image is in Figure 10, which shows the copper foil extending well past the anode, while the aluminum film current collector has retreated, leaving free standing cathode unsupported by the aluminum film current collector.

SVolt 5 Ah and 10 Ah NMC811 / Graphite

SVolt has built cells using NMC 811 / graphite and the Soteria aluminum film current collector. As seen in Figure 11, the cells perform well up to 5C, and also have been cycled to more than 2,000 cycles. The cells have an energy density of ~240 Wh/kg. The cells survive nail penetration, crush, overcharge, over discharge, hard short and hot box testing. After mechanical damage, they continue to function, delivering nearly equivalent energy after damage as they did prior to testing. Figure 12 shows several cells after mechanical abuse (left), and a discharge curve of the nail penetrated cell tested four hour after testing. The degree of mechanical abuse that the cells can withstand without going into thermal runaway is far above cells with standard plastic separator and metal foil architectures. In addition, the fact that the cells hold their charge for at least four hours after the abuse indicates that there are no latent effects in the cell that could cause it to go into thermal runaway after some delay.

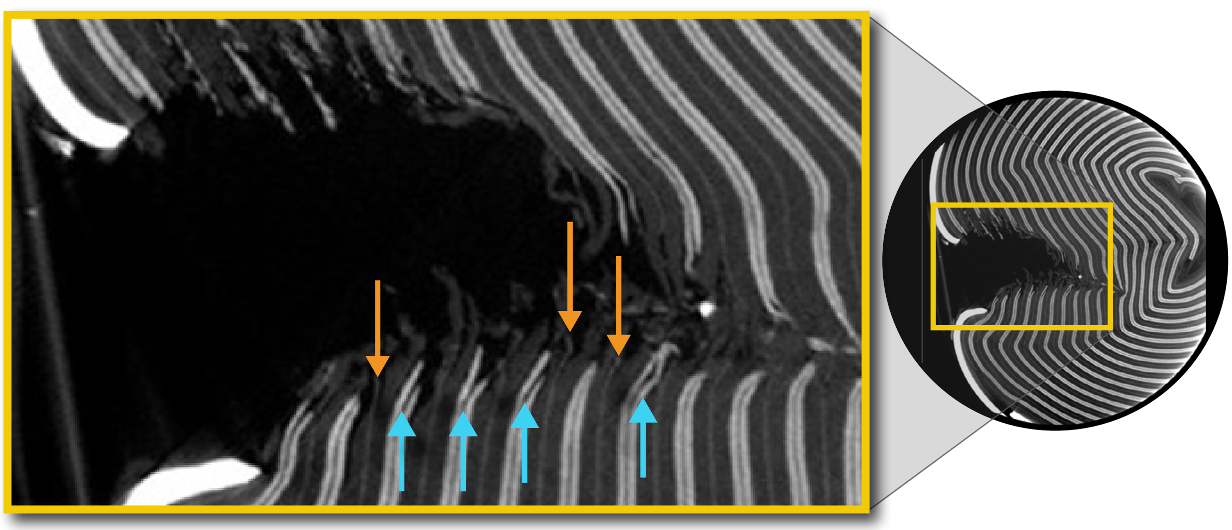

Figure 10 NASA CT Scan of 18650 battery after nail penetration. Battery had copper foils and Soteria aluminum metallized film current collector. The right image shows the slice of maximum nail penetration. The left image is a blow up of the lower edge where the nail penetrated. The orange arrows show the edge of the copper foil current collector. The blue arrows show the v-shape where the aluminum film current collector has retreated, leaving free standing cathode coating.

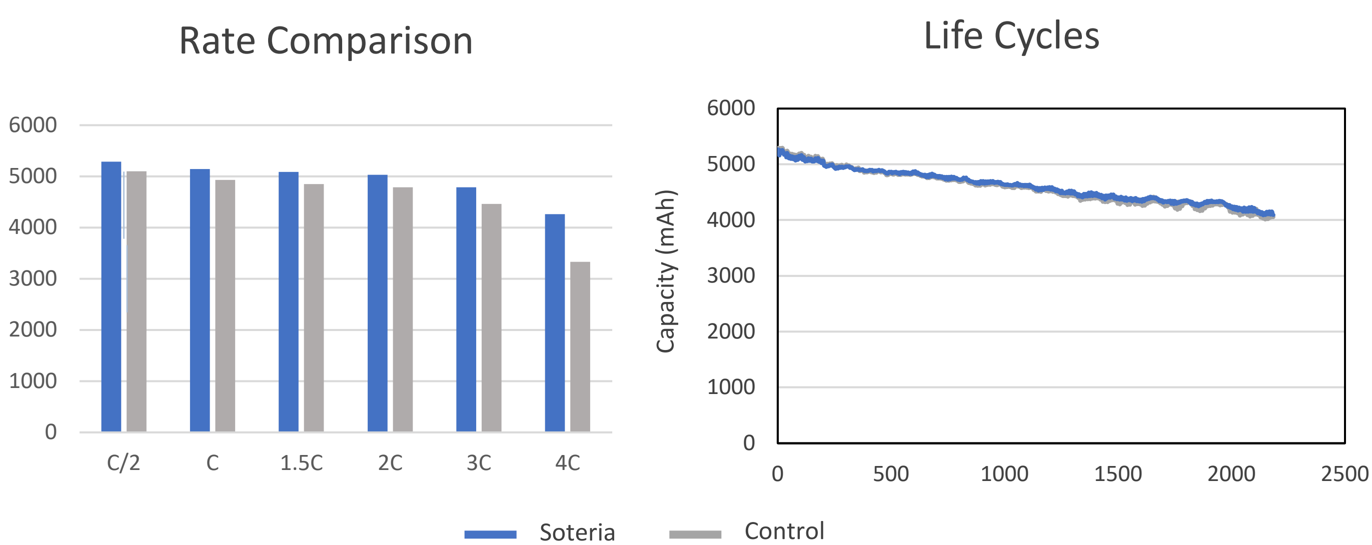

Figure 11 Rate capability and cycle life of the 5 Ah and 10 Ah cells produced by SVolt show that incorporating Soteria's technology does not compromise cell performance.

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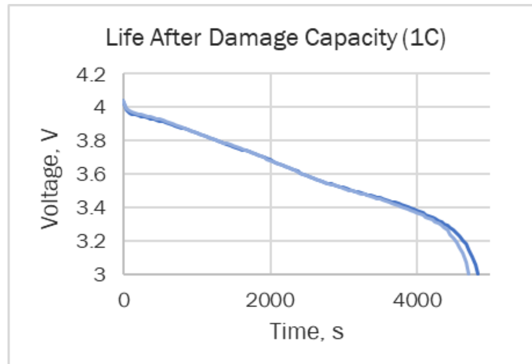

Figure 12 SVolt 5 Ah NMC811/graphite cells that have been mechanically abused without going into thermal runaway (left). The cell discharge curve taken on nail penetrated cells four hours after they were damaged, showing more than 90% retained capacity. The mechanical abuse in the cells on the left forms the basis of the mechanical abuse in the Soteria Safety Standard.

Polaris Cells with DuPont/SteinerFilm Kapton® Current Collector

In an effort to make very high energy density cells for the consumer electronics industry, DuPont worked with SteinerFilm to make versions of Soteria's aluminum and copper film current collectors based on their 4-micron Kapton® films, which are very strong and can withstand very high temperature metallization processes even at this very low thickness. They were successful in making the collectors, the properties of which are in Figure 11 above. Polaris Battery Labs then made 0.7 Ah stacked electrode pouch cells using LCO / graphite. These cells were 15% lighter and had 18% higher energy density using the Soteria films.

Cell	Capacity	Nominal Voltage	C/Rate	mass(g)	Wh/kg
Control	0.7091	3.851	C/7	14.41	189.5034
Soteria	0.7149	3.8479	C/7	12.31	223.4658

Figure 13 Properties of LCO / graphite cells made with the Soteria metallized copper and aluminum current collectors with Kapton(R) substrate. The capacities are nearly the same, but the mass is 15% lower and the energy density 18% higher using the Kapton(R)-based Soteria metallized film current collectors.

Additional 3rd Party Cells Subjected to Nail Penetration

Cells with the Soteria aluminum film current collector routinely pass nail penetration tests in a variety of formats and electrode configurations, from a variety of manufacturers. In this section, four are highlighted, with basic details in the table below.

Manufacturer	Format	Cathode	Anode	Capacity
Oak Ridge National Lab	Stacked pouch	NMC-NNN	Graphite	1 Ah
ETC	Wound pouch	NMC-523	Graphite	10 Ah
SVolt	Stacked pouch	NMC-811	Graphite	10 Ah
BAK	18650	NMC-523	Graphite	2.5 Ah

Figure 14 Basic details for four different cell builds by different manufacturers, using different manufacturing techniques using the Soteria aluminum film current collectors that all passed nail penetration testing

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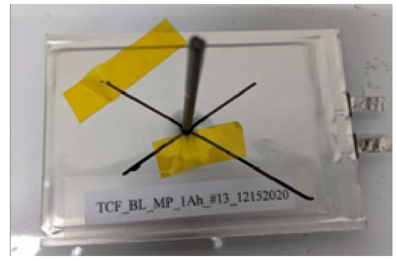
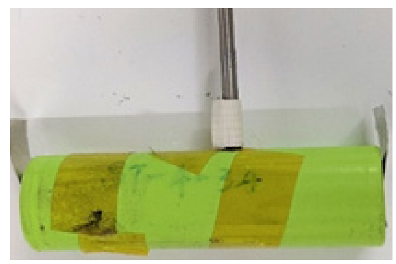
Soteria Test Standard Defines a Practical Safe Cell

Lithium-ion battery testing remains in a nascent state that is compliant with the practice of producing potentially-unsafe cells with the possibility of infrequent latent defects that can cause a spontaneous thermal runaway after the cells are put into the field. Cells and packs that have been put into the field and sold to the public that have passed current test standards such as UL 2054, UL 2580 and UN 38.3 have been the cause of hundreds of produce recalls based on spontaneous battery fires. The fact is that current test standards do not differentiate between a cell that is designed with robust abuse and defect tolerance and one that is not.



In response to this, Soteria formed a Test Standards Working Group within the Soteria BIG Consortium. This group, along with Soteria personnel, began testing cells under extreme abusive conditions, to see which ones could be met at this time and drafted a standard that included far more abuse than existing standards, and required the cells to remain in a far more pristine state for longer than the existing standards. The result is a standard that can be audited and certified with third-party labs, and which truly differentiates between fragile and abuse intolerant cell designs, and those that are far more robust and abuse and defect tolerant. The committee intends to update the tests standard biannually, further improving the standard level of Soteria-certified cells above those that are only certified to industry-approved standards.



Soteria Test Standard Test Requirements

Soteria testing is intended to check cell performance in response to various defects or abuse. Each type has specific tests enumerated as a means of checking cell response.

The tested categories are:

1. Latent Defects – Defects where the cell will pass manufacturing time testing but grow or develop over time as the cell is in use. Examples include metallic particles moving into dangerous positions, dendrites growing, and conductor burrs moving.
2. Electrical overstress – Electrical conditions applied to the cell that are beyond the intended design envelope of the cell but occur commonly due to accident or failure of related systems.
3. Mechanical abuse – Mechanical conditions applied to the cell that are beyond the intended design envelope of the cell but occur with some regularity.
4. The specific test procedures enumerated are chosen as being the best, most practical means of testing the cells response to the defect type.

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The tests composing the Soteria Certification are composed of 2 types of tests:

1. Adopted tests. These tests already exist in other cell testing specifications and are selected based on their suitability for covering an aspect of the safety domain.
2. Soteria specific tests. These tests are not available in the required form in existing standards. These will be developed and result in test specifications written and approved by the Soteria Test Standards Working Group.

Note that several tests require Life After Damage (LAD), which requires the cells to deliver most of their original energy four hours after surviving the abuse embodied in the test.

Figure 17 Cells tested under Soteria Safety Test Standard procedures, with control (standard architecture) cells on left, and cells containing Soteria materials on the right.

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Technology Features Summary

Revolutionary safety

Eliminates the root cause of thermal runaway

Soteria's technology addresses the root cause of thermal runaway in lithium-ion batteries by keeping a stable barrier to release of electrical energy and stopping the flow of the electrical energy by having the current collector burn out like a fuse. Unlike technologies that detect thermal runaway or mitigate the damage caused once thermal runaway is underway, the Soteria architecture addresses thermal runaway at the root cause—the internal short circuit that releases the electrical energy.

Cells Function After Damage

Because thermal runaway was stopped before it got started, the rest of the cell remains intact and continues to function. In addition, the fact that the battery maintains its ability to function is also a strong signal that the thermal runaway has been truly stopped, not just delayed. This is shown by the discharge curves taken after nail penetration in the above sections.

Full Compatibility

20-30% Weight Reduction

There are three sources of weight reduction in the Soteria architecture:

- **Less metal:** The Soteria current collector is made with only 20% of the metal of standard current collectors, resulting in current collectors that are between 60 – 80% lighter weight. This alone can result in a 10 – 20% weight reduction.

- **No heavy ceramics:** Today's plastic separators are coated with a thick layer of high purity ceramic nanoparticles. These layers can significantly increase the weight of the separator. Soteria's Dreamweaver separators achieve their thermal stability with lightweight aramid fibers such as Kevlar or Twaron, which are stable up to 500o C but weigh about half of ceramics.

- **Pack savings:** Potentially unsafe cells need to be protected in a heavy box and surrounded by expensive, heavy flame-resistant ceramic fibers and other fillers. Soteria's inherently safe cells can reduce or eliminate the need for these components. Battery pack builders have suggested the additional weight savings can be between 10 – 20% depending on the application

Lower Material Costs

Material costs are reduced primarily in three ways:

- **Reduced use of expensive metals:** Expensive copper and aluminum are reduced, greatly reducing the cost of the current collector materials. At high volumes, this should result in a cost reduction.

- **Efficient paper processing:** Today's separators use ultra-high-molecular-weight polyethylene, a plastic that is produced with expensive polymerization. This material is then mixed with mineral oils, extruded, and washed with harsh organic solvents to remove the mineral oils. The process is slow and involves large solvent recovery systems. Solvent-based coating of high purity fumed ceramic nanoparticles adds additional cost. Soteria's Dreamweaver separator is made on efficient, high-speed paper making equipment, running on clean water that is recycled throughout the process. The energy is less and there is no solvent recovery.

- **Pack savings:** The materials used to protect the potentially unsafe cells have cost in addition to weight. Reducing or eliminating these materials by using inherently safe cells will reduce the cost of the battery pack.

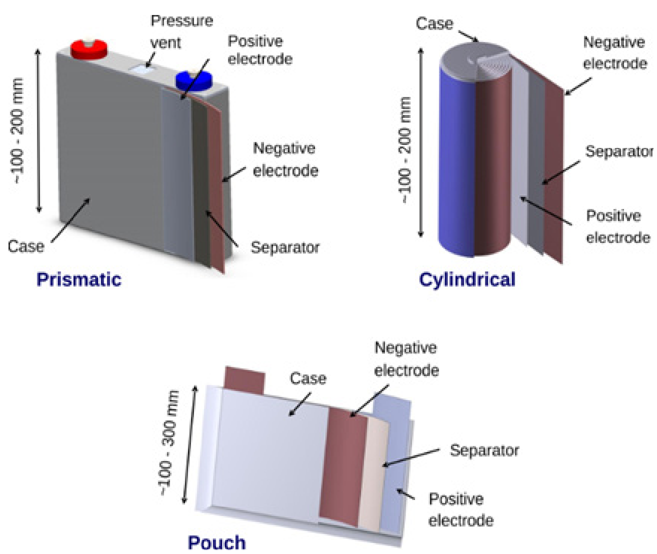

Figure 18 All lithium-ion form factors contain a separator and negative and positive electrodes, which are built on current collectors. Soteria's technology is a drop in at the component level in all lithium-ion battery geometries.

Drop-in to Manufacturing

Soteria materials replace existing components and are used in the same way. They are compatible with all cell form factors, sizes and shapes. They are compatible with all variations of anode and cathode and electrolytes. Soteria's 30+ cell builder consortium members are successfully building cells of almost every variety.

Electrical Performance

Soteria technology enables cells to be made that deliver equivalent performance to today's lithium-ion batteries for almost all applications. Soteria technology has been built into the highest energy density commercial cells available today, and in addition have shown to improve cycle life in certain situations, including improving one cell from 2,500 cycles to over 5,000.

The Consortium Builds an Ecosystem for Broad Adoption

To enable broad access to these safety-enhancing technologies, Soteria established a global consortium of over 120 companies throughout the supply chain. The consortium acts as an open-innovation hub, bringing together the expertise, market presence and brands of key advanced technology companies from material providers to cell and pack builders to end-users. Every company in the consortium has the right to advance and protect their own business using the Soteria technology. Soteria aims to understand each consortium member's unique value proposition and needs to identify technical and business development opportunities. Your success is our success. Through this collaboration and innovation, Soteria's consortium members are driving the lithium-ion battery industry forward.

If you are interested in joining this ecosystem of high-value strategic partners or developing an evaluation or commercialization plan, schedule a call with one of our experts so they can learn about your application or business.

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Delfort and Soteria sign marketing license agreement (December 17)

Diese Li-ionen-batterien funktionieren auch nach Beschädigung (November 30)

Partnerschaft von Svolt und Soteria Battery Innovation Group macht lithium-ionen-batterien noch Sicherer (November 24)

Innovatives Startup in Düren: Komponenten für Lithium-Ionen-Batterien (October 10)

Forge Nano joins Soteria Battery Innovation Group Consortium to improve battery safety, performance, and innovation (July 28)

Stellantis will use SVOLT's batteries from 2025 on (July 14)

Conductive polymer layer stymies li-ion battery thermal runaway (June 24)

Ahlstrom-Munksjo signs marketing license for fiber-based separator for lithium-ion batteries (April 28)

SVOLT implementiert Zell-Technologie von Soteria BIG (April 23)

Soteria and SVOLT will sell a thermal-runaway-free li-ion cell (April 22)

Prevention of lithium-ion battery thermal runaway using polymer-substrate current collectors (March 24)

NREL, NASA, & European researchers reveal path to even safer lithium-ion batteries (March 19)