

# Materials for Thermal Runaway

## How pressure-sensitive adhesive tapes enable advanced thermal-runaway barrier design

An Avery Dennison White Paper

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### Executive summary

The electric vehicle (EV) market is proliferating and is forecast to continue to do so throughout this decade and beyond. With this growth comes an increasing demand for EV batteries that are reliable, safe, and cost-effective. However, additional design challenges are emerging as EV battery packs become integrated into vehicle structures. These include fitting functional materials – such as those that mitigate thermal runaway – into the tight spaces inside modern battery packs.

This white paper will explain one promising solution to the thermal-runaway mitigation challenge – a solution offering engineers high levels of flexibility when working with modern battery designs. It involves the use of pressure-sensitive adhesive tapes integrated with functional materials.



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## The EV and EV battery marketplace: Current state and forecasts

Malcolm Gladwell defines a tipping point as “the moment of critical mass, the threshold, the boiling point.” The EV marketplace has surpassed 5% market share, which is largely considered a tipping point milestone. It’s driven partly by consumers’ changing tastes and their continued concern over the impact of their choices on the environment. It’s also driven by governmental regulation in the EU, Asia, and some U.S. states. It may eventually be challenging to buy, own, and operate a vehicle with an internal combustion engine (ICE) in those regions.

Carmakers, meanwhile, have responded by committing more than \$500 billion to EVs by 2030, according to Reuters. Tesla accounts for about a fifth of that commitment. Established OEMs such as GM, Ford, Stellantis, Honda, and Volkswagen are making significant investments.

The EV marketplace is thus forecast to reach 25.5 million sales globally by 2030. This is up from 2.3 million vehicles sold globally in 2020, representing a CAGR of 27%. Hybrid and plug-in hybrids are expected to account for another 21 million vehicles sold by the end of the decade.

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Source: Avicenne Energy

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By 2030, EV, HEV, and PHEV will require 2 million MWh of battery power. This is up from less than 500,000 MWh in 2022, according to Avicenne. Global battery production capacity will grow from 450 GWh in 2020 to 2,800 GWh in 2030. North America will account for 12% of that production by the decade’s end.

And as more OEMs set goals and make commitments for EV production and sales, EV vehicle designs are evolving beyond those of their ICE vehicle predecessors’.

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## EV battery demand: Implications for battery pack design

While the EV marketplace projects rapid growth, lingering engineering challenges remain. These challenges must be solved for EVs to continue on their path to mass consumer and regulatory acceptance.

Among the most significant of these challenges is fire and thermal-runaway mitigation. It affects all areas of the EV battery segment, including shipping, charging, crash safety, and end-of-life. China has set the standard for EV battery fire safety regulations, followed by the EU. Multiple types of materials will likely be needed to address this issue across the industry and world.

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## Thermal-runaway mitigation remains a significant engineering challenge for EV battery packs. Functional materials integrated with pressure-sensitive adhesive tapes are a potential solution.

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Meanwhile, EV battery design is evolving toward structural packs in prismatic, cylindrical, and pouch-cell formats. These packs are integrated into the car’s structure and are much thinner than previous-generation packs. This thinness leaves limited space for non-cell materials, including those for fireproofing and thermal-runaway mitigation.

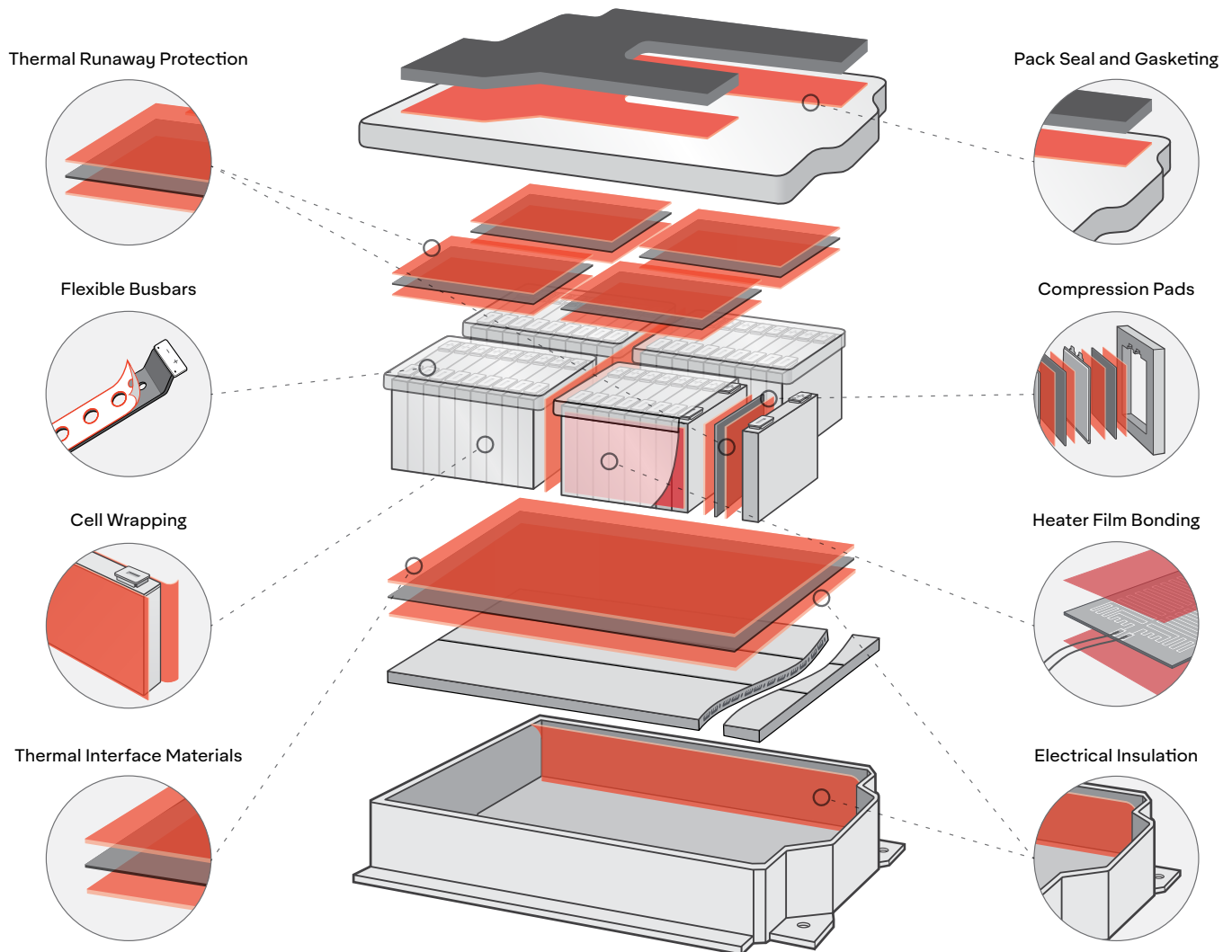
And while lithium iron phosphate (LFP) battery technology has been touted by many as a safer option, flammability is still a concern. A dramatic example occurred in China in May 2021. [An electric bus being charged in Baise City, Guangxi province, caught fire](#) after its LFP battery overheated. The blaze quickly spread to and destroyed four other buses. Fortunately, none of the buses were occupied and no one was injured.

As OEMs and their suppliers grapple with this challenge, fireproofing and thermal-runaway mitigation materials featuring pressure-sensitive adhesive tapes are a potential solution.

## What are pressure-sensitive adhesive tapes?

Pressure-sensitive adhesives form bonds with other materials upon brief contact and light pressure. They are available in multiple formats, including label constructions and tapes.

When presented as part of a tape, the adhesive is often laminated to a carrier made of film, foam, or other material. This carrier may provide functionality — an example would be a fire-retardant foam. Pressure-sensitive adhesive tapes are used across a range of industries, including automotive, aerospace, building and construction, electronics, general industrial, and print and packaging. They may also be used in various applications for EV batteries, including thermal-runaway mitigation.



*Pressure-sensitive adhesive tape applications for EV battery packs.*

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## How pressure-sensitive adhesives work

Upon contact with a substrate, a pressure-sensitive adhesive forms a bond with only light pressure applied. The pressure causes adhesive flow over the substrate and activates interlocking, chemical, or Van der Waals intermolecular forces. The adhesive's viscosity also allows elongation, which absorbs energy to help hold the tape in place.

Tapes thus present several advantages over other securing methods:

- Lower tooling costs
- No need for fasteners
- Uniform coverage
- Slim profiles
- Design flexibility
- No curing or drying time
- One- to two-year shelf life
- Enable multi-layer functionality

There are hundreds of pressure-sensitive adhesive chemistries, but certain chemistries are better suited to EV battery applications than others.

The Avery Dennison portfolio features three adhesives and three film carrier materials for EV battery applications.

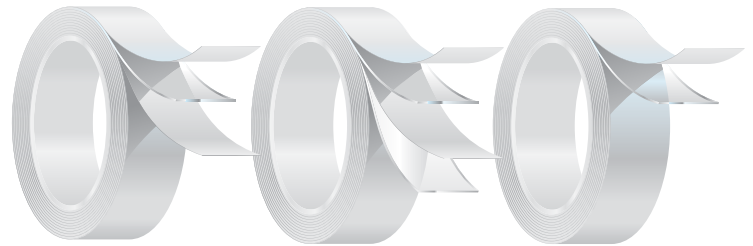
### Pressure-sensitive adhesives for EV battery applications

- **General purpose acrylic** — Automotive-grade adhesive meeting FMVSS 302 requirements
- **Flame Tough™ acrylic** — Flame-retardant adhesive meeting UL® 94 VTM-0 and V-0 performance
- **Flame Tough™ rubber** - Halogen-free, flame-retardant adhesive with higher tack than the Flame Tough acrylic
- **Flame Tough™ silicone** — Flame-retardant adhesive meeting UL® 94 VTM-0 and V-0 performance; for extra-low-surface-energy substrates and high-temperature environments

### Films for EV battery applications

- **Polyester** — Features 6+ kV/mil dielectric strength
- **Flame Tough™ polyester** — Features 3.13+ kV/mil dielectric strength, plus flame-retardant properties
- **Flame Tough™ polyimide** — Features ~7 kV/mil dielectric strength, flame-retardant properties, high-temperature applications

EV battery tape constructions may be single-coated with adhesive on one side of the carrier, double-coated with adhesive on both sides, or produced as a transfer tape that delivers the adhesive to the substrate without a carrier. The former is primarily used in protective applications. The latter is typically used to bond materials together. Depending on the specific application within the battery pack, the carrier film can provide flame or dielectric protection. A construction typically includes a release liner that protects the adhesive and film before application.



*Tapes are offered in single-coated, double-coated and transfer tape constructions.*

Various combinations of these three adhesives and these three films — in single- or double-coated constructions, or as transfer tapes — result in more than 20 tape products for EV batteries currently in the Avery Dennison portfolio.

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## How pressure-sensitive tapes address EV battery engineering challenges

EV battery packs present a wide range of engineering challenges for those involved in their design and manufacture. Such concerns are shared broadly by consumers who are anxious about EV safety, range, and affordability, among other issues.

### Challenge #1: Safety

Battery pack designs must include materials that prevent or mitigate fire and thermal runaway and prevent electrical arcing and shorting. They must also reduce the effect of impacts, protect cell materials during regular service, and protect thermal materials from damage due to vibration.

#### Solution:

Avery Dennison Flame Tough™ acrylic, silicone and rubber-based adhesives can be combined with flame-retardant films. This allows composites to meet UL® 94 V-0 and VTM-0 requirements.

Pressure-sensitive adhesives can be combined with dielectric films to reduce electrical conductivity and arcing. Avery Dennison tests its tapes for breakdown voltage and dielectric strength using GB/T 1408.1-2016 and ASTM D149 and D3755 test methods.

### Challenge #2: Production efficiency

OEMs and suppliers seek to manage costs by improving throughput and efficiency. Battery pack designs should accommodate this need.

#### Solution:

Pressure-sensitive adhesive tapes enable fast assembly and automation while helping reduce waste. They can be placed automatically and repositioned as needed. They feature easy-to-remove liners that protect delicate carrier materials.

These adhesives create an immediate fixation, with no curing or drying time. This helps improve manufacturing cycle times and throughput.

### Challenge #3: Durability

Vibration from the road and movement of the vehicle can concentrate stress on attachment points. This vibration and its resulting fatigue can contribute to failures.

#### Solution:

Pressure-sensitive adhesive tapes have viscoelastic properties that help absorb and damp vibrations. Furthermore, single-coated protection tapes provide dimensional stability and material encapsulation of delicate battery materials. Materials can be encapsulated (wrapped) in a protective film using pattern-coated tape.

### Challenge #4: Sustainability

Battery pack designs should enable recyclability and pack repowering.

#### Solution:

Pressure-sensitive adhesives do not require curing and can be removed easily at the end of the battery pack's life, helping improve its overall recyclability. They're easily repositionable, reducing assembly waste.

### Challenge #5: Functionality

Battery pack designs should include material solutions that address multiple engineering needs.

#### Solution:

Pressure-sensitive tapes can be a single solution for addressing these multiple pain points. They can be integrated into the design of EV batteries and vehicles that are safer, longer-lasting, more sustainable, and more cost-effective to own.

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## How pressure-sensitive tapes can be used with thermal-runaway prevention materials

As stated above, thermal-runaway mitigation remains among the most urgent engineering challenges for EV batteries. Meanwhile, the move to a more structural battery design leaves less space between and around cells for effective fireproofing using traditional methods.

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**Pressure-sensitive adhesive tapes integrated with functional fire prevention materials can help provide an effective solution for thermal runaway mitigation throughout a battery pack.**

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Inherently thin tapes integrated with functional fire protection materials can help provide an effective solution for thermal-runaway mitigation throughout a battery pack.

Specific applications and advantages include the following:

### **Bonding**

Double-coated tapes bond thermal runaway materials to each other and within the pack. They also provide additional design flexibility, enabling functional materials to fit in narrow spaces.

### **Assembly aid**

Pressure-sensitive adhesive tapes help hold thermal runaway materials in place during module assembly.

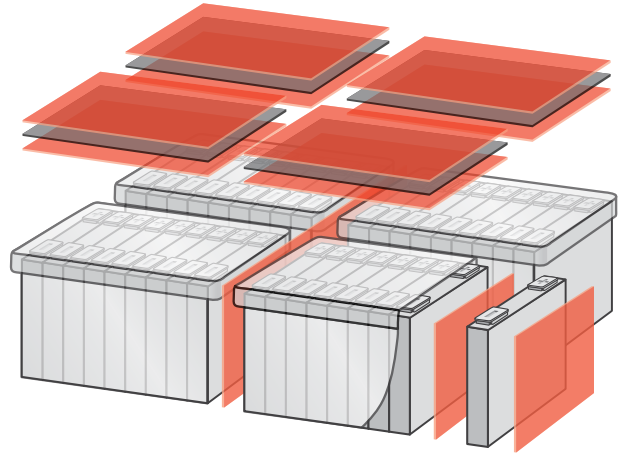
### **Material protection**

Single-coated pressure-sensitive adhesive tapes encapsulate and protect delicate, fibrous, flaky, thermal runaway materials for the vehicle's life.

### **Dielectric strength**

Pressure-sensitive adhesive tapes containing dielectric films help prevent electrical arcing and shorting.

Tapes can be used throughout a battery pack, including in the narrow spaces between cells and modules, and beneath the top cover.



*Pressure-sensitive adhesive tapes, mated to thermal runaway mitigation functional materials, can be placed throughout the battery pack, and between packs.*

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## The combination of pressure-sensitive adhesive tapes and functional materials for EV batteries

Pressure-sensitive tapes are purchased and used as is by automotive OEMs and tier suppliers. They may also be integrated with functional material manufacturers' products, including innovative fireproofing solutions.

Engineers choose any of a wide variety of functional materials to prevent thermal runaway in battery packs and modules. Each of these materials has advantages and trade-offs. Most can benefit from integration with pressure-sensitive adhesive tapes.

Some examples of thermal runaway functional materials that can be integrated with tapes are the following:

- **Ceramic papers** provide excellent thermal barriers and good compression properties. These thin papers are often encapsulated in a pressure-sensitive adhesive tape to ensure dimensional stability and an excellent seal on the paper.
- **Aerogel composites** feature incredibly low thermal conductivity, which helps isolate cells from each other within a pack. Aerogel composites often are sealed or encapsulated with single-coated pressure-sensitive adhesive tapes.
- **Mica** is used as a thermal barrier and an electrical insulator. It is a delicate material that is often held in place in the pack or module with pressure-sensitive adhesive tapes. Selecting the right tape for assembly is critical to prevent delamination of the mica while removing the tape's release liner.
- **Foamed compression pads** are used primarily to extend the life of battery cells as they expand and contract. They're also being formulated with excellent thermal properties to help mitigate thermal runaway. Pads are applied to cells using double-sided pressure-sensitive adhesive tapes.

These thermal runaway barriers are used in multiple applications, which include:

- Module separators
- Lid or case insulation
- Wire and hose protection
- Busbar and busbar connection protection
- Cell separators with compression and thermal properties
- Thermal barrier and fire resistance
- Suitable for pouch, prismatic or cylindrical battery packs

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## Turnkey solutions for thermal-runaway mitigation in EV batteries

These materials can be a game-changer for thermal-runaway mitigation in EV batteries. As this is such a quickly evolving space, Avery Dennison recognizes our broader role in working with functional material manufacturers to help OEMs and suppliers develop real-world thermal-runaway solutions.

We offer support beyond our product portfolio. This includes extensive application and 3D design support, plus testing capabilities that include flame and dielectric performance, environmental, compression testing and battery cycling simulation, and bulk property testing (peel, tack, and shear). All testing is completed in ISO-certified laboratories.

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### Summary

Critical engineering challenges threaten the growth of EV batteries in the next decade and beyond. Among these challenges is thermal-runaway mitigation. Yet, traditional fireproofing methods and materials may not be fully compatible with evolving EV battery pack design.


Functional materials integrated with pressure-sensitive adhesives have emerged as a solution. Easy to use, versatile, and effective, they may be an ideal choice for many OEMs and suppliers.



#### Contact Avery Dennison to learn more

If you're an OEM, automotive tier supplier or converter representative looking to better understand the potential for pressure-sensitive adhesive tapes in electric vehicle batteries, please contact me directly at [max.vanraaphorst@averydennison.com](mailto:max.vanraaphorst@averydennison.com).

To learn more about Avery Dennison Performance Tapes' solutions visit [www.tapes.averydennison.com/evbattery](http://www.tapes.averydennison.com/evbattery).

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