

Advanced Materials and Coatings for Electric Vehicle Battery Packs



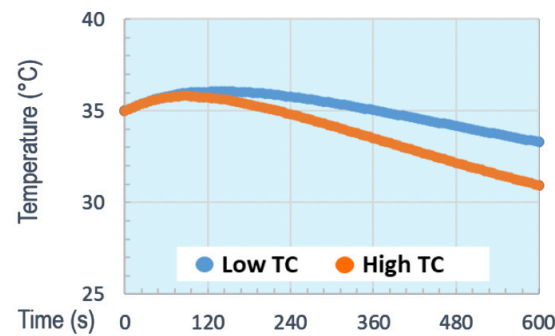
DIELECTRIC PROTECTION

Dielectric coatings systems from PPG deliver performance consistency, durability and enhanced safety with millions of battery components already coated in the last decade. Customers such as OEMs and battery manufacturers use PPG dielectric coatings in place of film and/or tape solutions to eliminate gaps and bubbles, reduce seam failures, increase adhesion for cell-to-pack designs, and support high throughput and automated applications.

The following coatings can be used to insulate battery cells, metal module housings, pack shells, cooling system components and other critical parts:

ENVIROCRON® Dielectric Powder Coatings

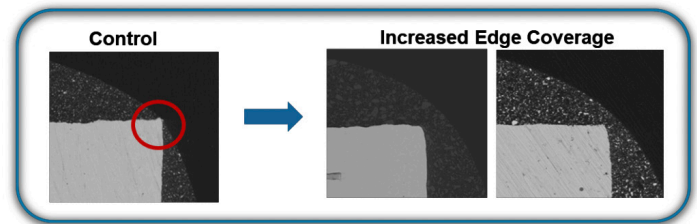
- High-temperature process for metal components (cooling plates or tubes, prismatic cells [unfilled], and other components)
- Outstanding dielectric performance
- Great thermal conductivity that may enhance pack cooling
- Increased edge coverage, allowing for thinner film requirements and reduction of material required for protection
- 100% solids



Computer modelling indicating the impact of thermal conductivity on pack cooling

RAYCRON® UV-Cure Dielectric Coatings

- Low-temperature process for temperature sensitive components (prismatic cell cans [filled], cooling plates, module separators)
- 1 - 2 seconds takt time
- Outstanding dielectric performance
- 100% Solids



Cross section of increased edge performance powder solution

Fit for Purpose Solutions								
Component	Substrate	PreTreatment	Ecoat	RAYCRON® Dielectric UV	ENVIROCRON® Dielectric PRO	ENVIROCRON® Dielectric BOND	ENVIROCRON® Dielectric THERM	ENVIROCRON® Dielectric EDGE
Battery lid	Alu/Steel	Chemical	x		o	x	o	x
Battery tray	Alu/Steel	Chemical	x		o	x	o	x
Frame Plates	Alu/Steel	Chemical	x*		o	x	o	x
Module Racking	Alu/Steel	Laser/plasma Chemical	x*	o	o	x	o	x
Module Housing	Alu/Steel	Chemical	x*		o	x	o	x
Cooling Plate	Alu/Di-Cast	Chemical	x*	o	x	o	x	o
Cooling Tube	Alu	Chemical			x		o	
Cell (Filled)	Alu	Laser/plasma		x				
Cell Can (Unfilled)	Alu	Chemical			o	x		

Legend / Notes:

X Recommended applications

O Suitable applications

* Not a stand-alone system

FIRE PROTECTION

PPG's Fire Protection solutions provide safety and performance standards for a wide range of applications, including battery pack assemblies and energy storage devices. CORACHAR® and CORAGUARD™ coatings, which leverage PPG's proven experience with both industrial and commercial fire protection, improve light-weighting, increase battery performance, and support passenger and first-responder safety by providing a shield to the substrate helping to contain and minimize thermal events.

Thermal Isolation

CORACHAR® and CORAGUARD™

- 1K and 2K Solvent-free* conformal liquids
- Intumescent or low intumescent solutions
- Fit for narrow spaces in the battery pack
- Demonstrated fire performance tailorable by needs
- Lightweight
- Supports thermal management and high dielectric isolation

High Blast Resistance

CORACHAR® Anti-Blast**

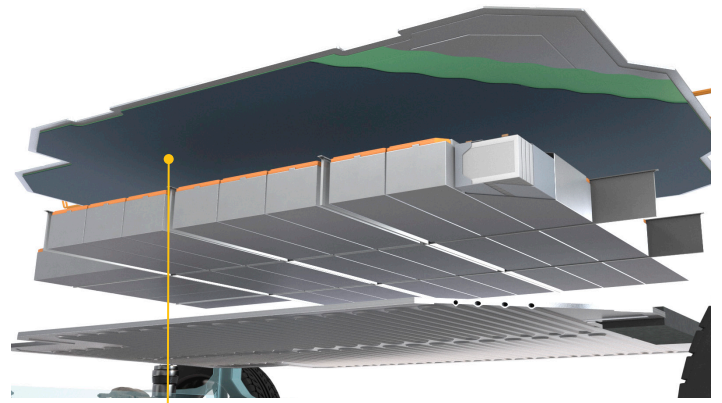
- 2K Solvent-free* conformal liquid
- Ideal Mica sheet replacement
- Designed to protect against thermal runaway
- Dielectric protection and protection against erosion

Mitigation Against ECoat Self Ignition

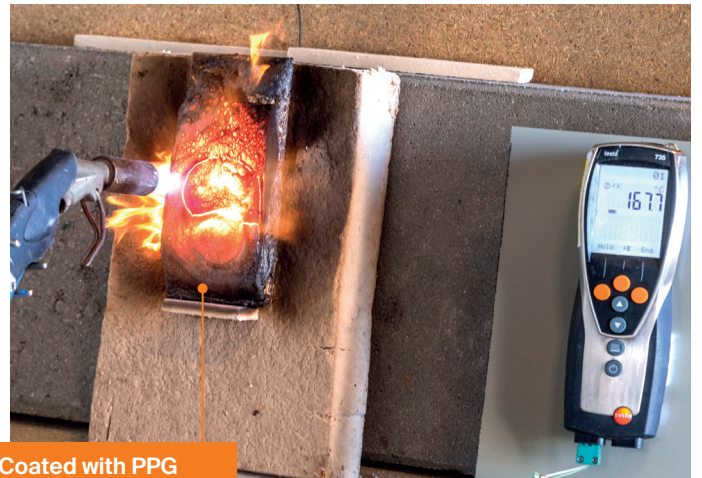
PPG is developing solutions to mitigate against ecoat fire self-ignition on the battery enclosure. A novel electrocoat technology, Powercron HD, is being developed to improve the flame resistance of ecoat and samples are ready for testing today. Both the flame-retardant powder coating and PPG Powercron HD ecoat system may significantly reduce the risk of flammability.

ENVIROCRON® Flame Retardant Powder and PPG ecoat

- Maximum corrosion protection with added fire retardance
- Ideal for the battery enclosure
- Applied via automatic or manual device
- Reduced OEM and tier complexity
- Offers global, sustainable solution
- Low thickness and less material required
- Meeting ECE R100 - no flame longer than 1 second



Pack Fire Protection



Coated with PPG Battery Fire Protection

*No intentionally added solvent as supplied. Zero-VOC according to Directive 1999/13/EC, EPA Method 24, EUR Directive: 2004/42/IIA (i) (500)

** Samples ready for testing



Flame Retardant Powder against ecoat ignition

THERMAL MANAGEMENT

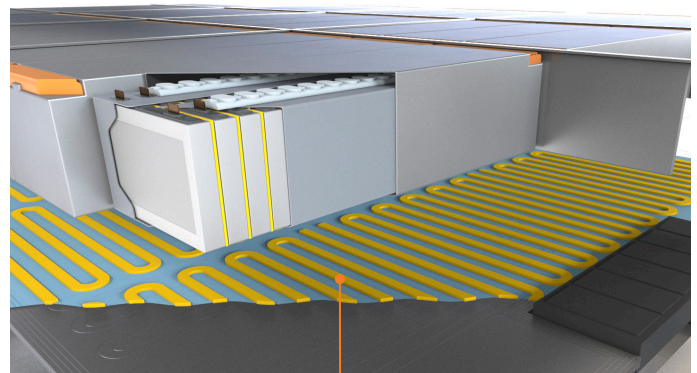
PPG's Thermal Interface Materials can support and enhance all Battery Thermal Management System (BTMS) strategies. Common solutions and applications include thermal conductive gap fillers and thermal conductive adhesives between modules/cells and the battery plates. Our solutions offer tailorable attributes: thermal conductivity, weight (low density), viscosity, vibration damping, adhesion, dielectric protection and fire resistance. These solutions include:

CORATHERM® Thermally Conductive Gap Fillers

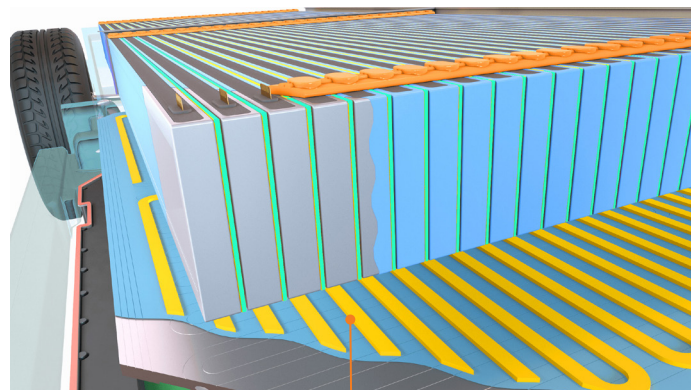
- 1K and 2K silicone-free* options
- Low hardness and long-term stability
- Low-density
- Shear thinning rheology – efficient dispense and workability
- Low press-in force for fast battery assembly and conformability
- Thin bond line, very good compressibility
- Excellent serviceability
- Excellent vibration absorbing properties
- Ambient cure

CORATHERM® Thermally Conductive Adhesives

- 2K silicone-free*
- Low-density options
- Shear thinning rheology – efficient dispense and workability
- High mechanical properties
- High and adjustable bonding strength, to various substrates
- Flexibility and low storage modulus - absorb vibrations, thermal stress
- Low press-in force for fast battery assembly and conformability
- Ambient cure



Thermally Conductive Gap Filler



Thermally Conductive Adhesive

Application

- High throughput, low defect application, low abrasion
- Open time and handling time compatible with mass production takt times

* No intentionally added silicone as supplied.

ADHESIVES & SEALANTS

PPG's latest proven adhesive and sealant technologies are ideally suited to a variety of EV battery pack needs, including sealing of pack shells and components, fixing of cells and modules into packs, structural reinforcement, and impact resistance.

Solutions include:

CORABOND® **Epoxy Structural Adhesives**

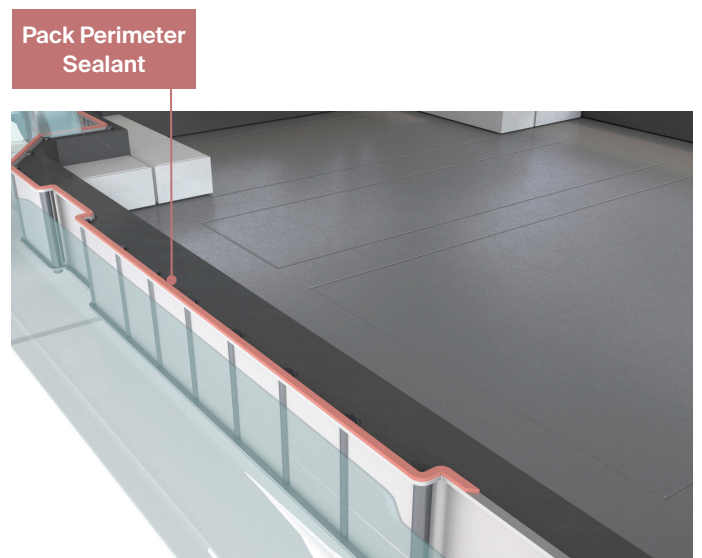
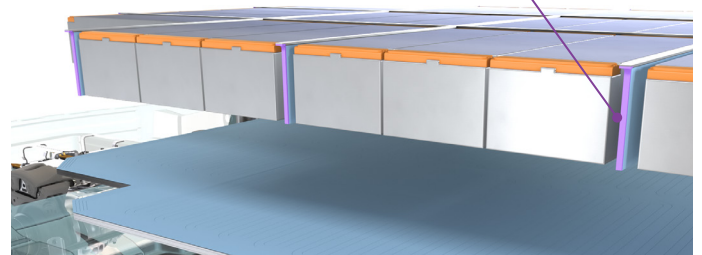
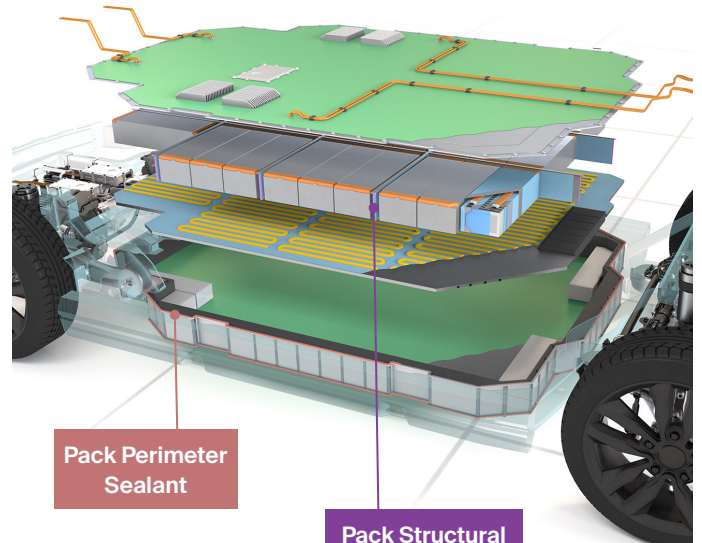
- Superb shear strength
- High durability
- Outstanding corrosion and hygrothermic resistance
- Excellent impact peel strength

CORABOND® **Polyurethane Structural Adhesives**

- Excellent mechanical properties with tunable bonding strength
- Good adhesion to multiple substrates
- Low storage modulus for vibration absorption
- Proven application equipment compatibility
- Maintains performance under harsh environmental conditions
- Biobased component options for alignment with sustainability initiatives

CORASEAL® Sealants

- Good compressibility, tightness
- Good serviceability
- Self-extinguishing
- Non-expanding, non-reactive
- Compatible with different substrates



CORROSION & IMPACT PROTECTION

PPG offers a comprehensive mix of industry-proven electrocoat, powder coating and polyurea coating solutions for Li-ion battery shells. Each can be applied through cost-effective, high-volume automated processes. These solutions include:

POWERCRON® Electrocoats

- Ideally suited to metal surfaces
- Uniform film build
- High yield rates
- Highly automated

ENVIROCRON® Extreme Protection Powder Coatings

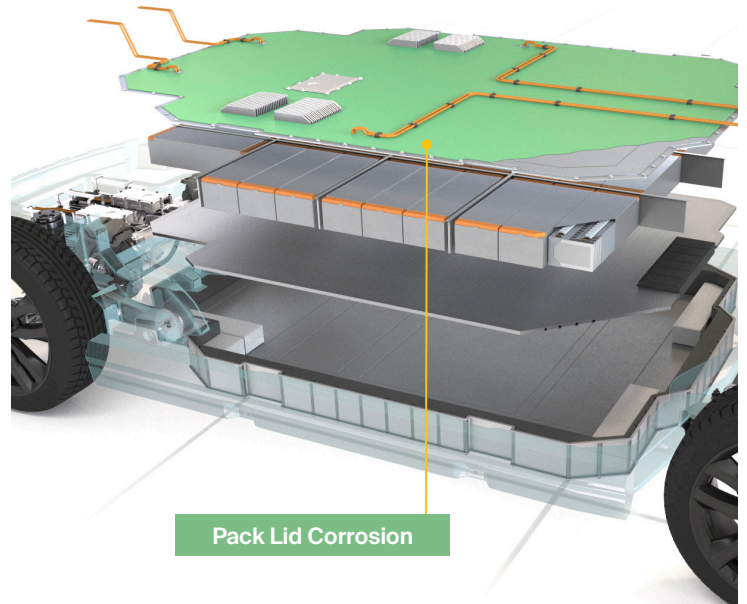
- Combines corrosion and impact protection
- Appropriate for metal battery shells
- Widely used on wear-intensive underbody components

ENVIROCRON® Extreme Protection EDGE Powder Coatings

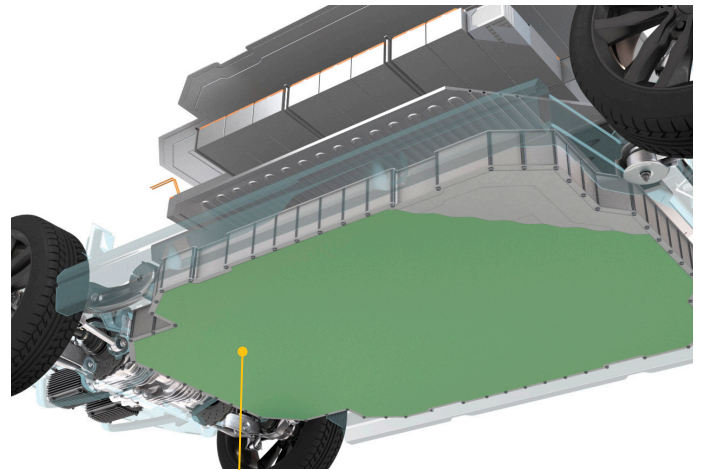
- All the benefits of ENVIROCRON® Extreme Protection Powder Coating
- Plus protects hard-to-cover sharp edges

Polyurea Coatings

- Formulated to protect shell pack surfaces exposed beneath vehicle
- Outstanding chip and chemical resistance capabilities



Pack Lid Corrosion

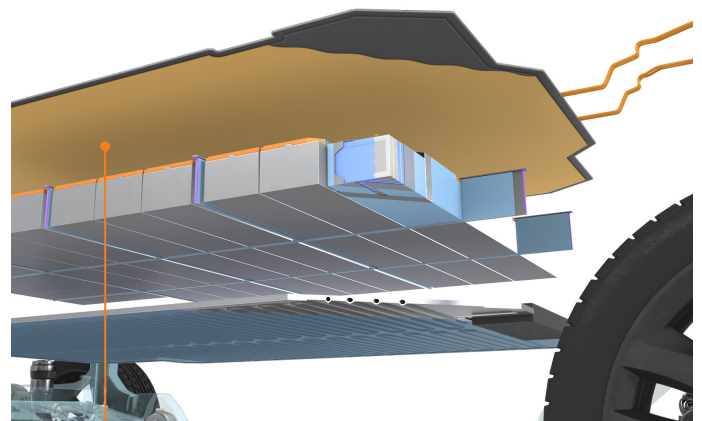


Pack Tray Corrosion & Impact Protection

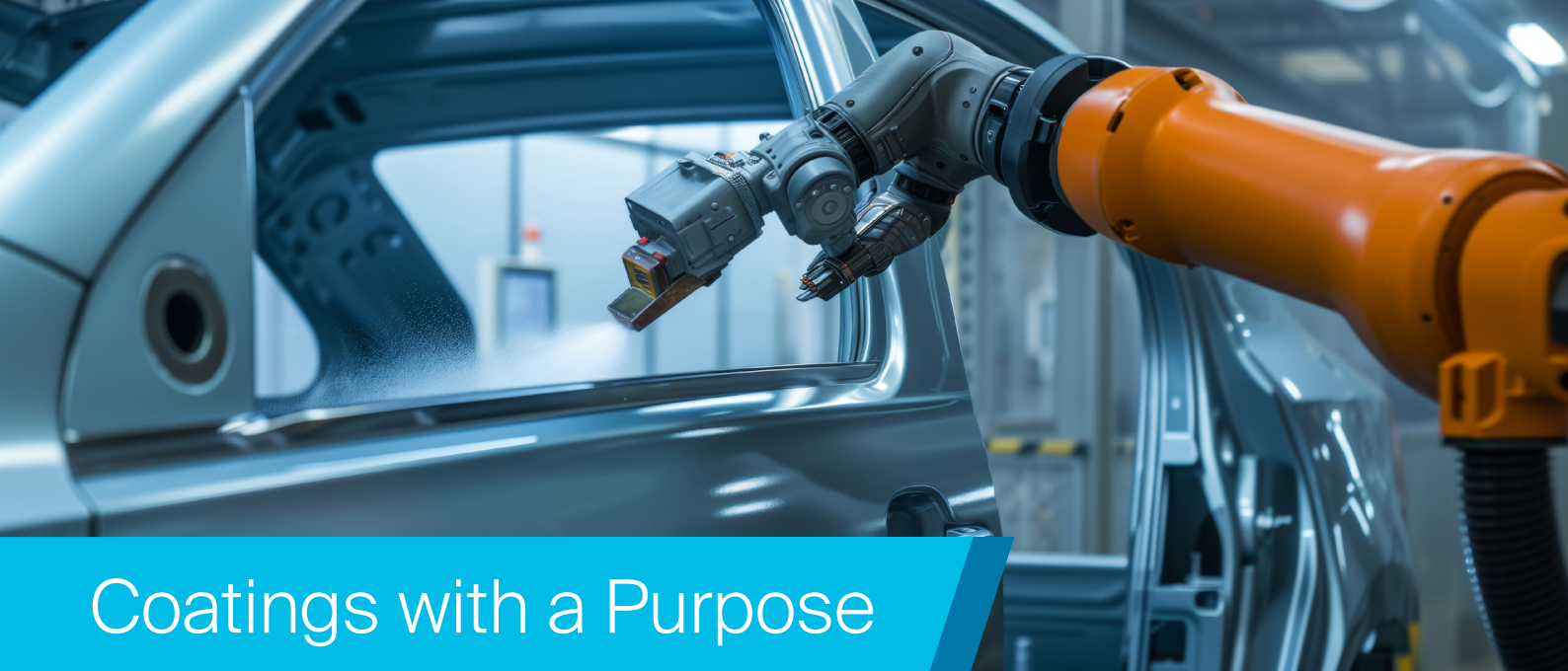
EMI/RFI SHIELDING

PPG is a leader in EMI and RFI shielding solutions for the transportation and consumer electronics industries. Shielding applications in electric vehicles include electronic hub cases, HMIs, telemetric systems, ADAS sensors, AV sensor fusion systems, plastic/composite battery enclosures/covers, battery management system cases, and battery chargers and inverters. PPG has both nickel and silver-coated copper sprayable conductive coating solutions which provide:

- Effective shielding in EV applications
- Compatible with sensitive plastics
- Excellent abrasion resistance
- Fast cure



Pack Conductive Shielding



Coatings with a Purpose

Our broad-based materials expertise and ability to tailor critical properties – developed over 140 years of leadership in the transportation, aerospace, industrial and consumer electronics industries touches virtually every area of battery design and construction.

We help customers:

- Improve electrical and thermal safety using PPG's proven coating technologies
- Deliver safety through proven research and development on electrical and thermal properties
- Automated application technologies allow cost-effective manufacturing
- Reduce manufacturing cost and increase throughput using PPG multi-function coating solutions

Along with protecting and beautifying these vehicles, PPG is helping OEMs and battery and component manufacturers accelerate the development of tomorrow's automotive and commercial vehicle energy storage solutions. PPG delivers innovative and customer specific lithium-ion battery pack solutions.

Coatings Services

As a provider of comprehensive EV battery coatings and surface preparation solutions, PPG works with customers around the world to identify opportunities to enhance battery performance, durability and safety while reducing total system cost. In addition to identifying and customizing coatings solutions to specific application requirements, PPG partners with customers to ensure successful, high-volume application and exceptional product consistency and quality.

Collaborating with a global leader like PPG can help you successfully implement reliable, high-volume, automated production of battery cells, modules and packs. Our automotive coatings service experts can provide skilled on-site support at any time, in any location.

PPG – delivering solutions for the design, construction and production of Li-ion battery cells, modules and packs

- Dielectric Protection
- Fire Protection
- Thermal Management
- EMI/RFI Shielding
- Corrosion & Impact Protection
- Adhesives & Sealants
- In Plant Services

Available services include:

- Application equipment design and construction
- Process optimization and troubleshooting
- End-to-end coatings operation management



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beautify the world®

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