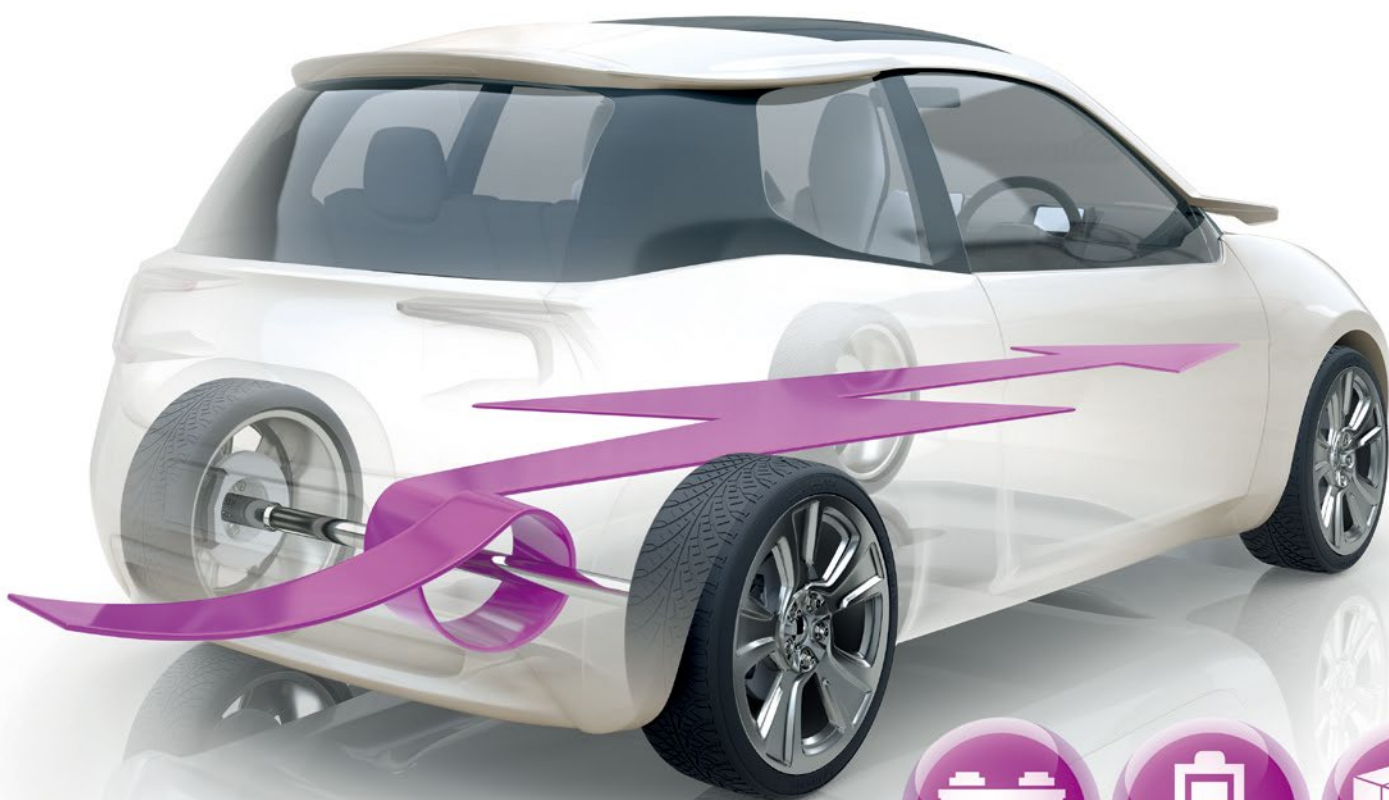
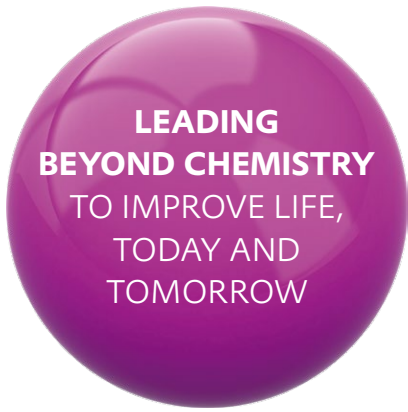


EVONIK SOLUTIONS FOR BATTERY ELECTRIC VEHICLES

**INNOVATE MOBILITY –
WE PROVIDE THE CHEMISTRY.**





Evonik is one of the world leaders in specialty chemicals. The company is active in more than 100 countries around the world. Evonik goes far beyond chemistry to create innovative, profitable and sustainable solutions for customers. More than 32,000 employees work together for a common purpose: **We want to improve life, day by day.**

NEXTGEN

Evonik is embarking on the next phase of its strategic transformation.

The electric vehicle market has seen significant growth around the world, helping to further achieve carbon neutrality goals for a greener future. The shift from traditional petrol-powered combustion engines to hybrid and full EVs has placed lithium-ion batteries at the heart of modern e-mobility solutions.

Evonik's product portfolio for electric vehicle batteries includes a wide range of chemistries and high-performance materials. With raw materials, additives, process enablers and ready to use products, our products improve the performance of our customers' offerings across the entire electric vehicle battery value chain, anywhere it is needed: battery packs, battery cells and battery management systems and battery recycling. And with our next generation solutions, we make the electric vehicle batteries safer and long-living.



Learn more about how we support to boost EV batteries and our chemistry solutions for automotives, please visit:

<https://automotive.evonik.com/en>



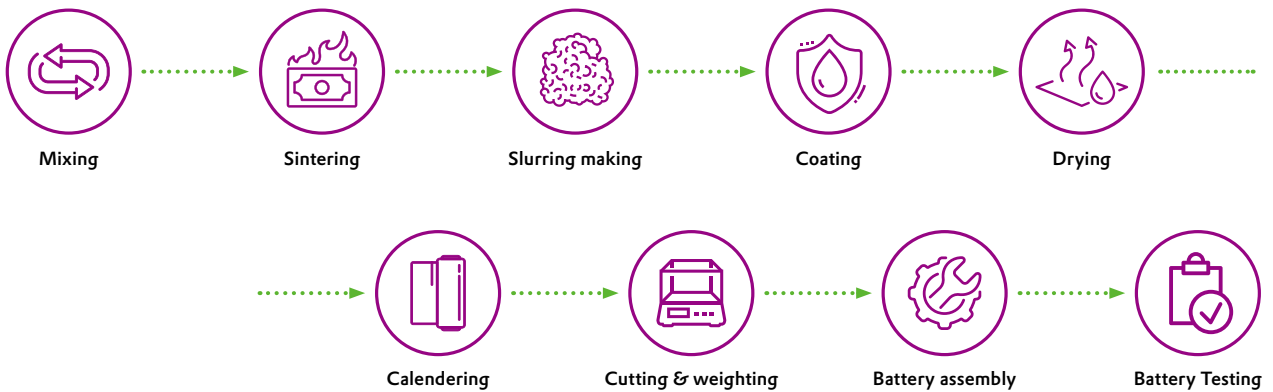
EVONIK GLOBAL LITHIUM-ION BATTERY CENTER (LIB-C)

Enhancing service and develop tailor-made solutions for the fast-developing EV battery industry

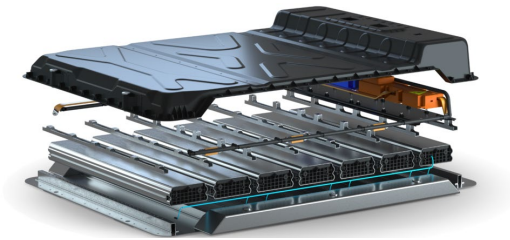
Evonik global Lithium-ion Battery Center (LIB-C) located in its Shanghai Innovation Park, was put into operation in 2022. As the first global facility for the lithium-ion battery industry, the center develops innovative materials for batteries with higher energy density, safer performance and longer life.

The new Shanghai lithium-ion battery center is part of Evonik's global R&D network. It merges the expertise across various businesses on innovations for cathode, anode and separator materials and electrode preparation technologies. The center is equipped with state-of-the-art facilities including material preparation and characterization, coin- and pouch-cell pilot lines and battery test equipment, where Evonik experts are able to conduct the research and development work on next-generation battery materials, cells and technologies.

The center is equipped with state-of-the-art facilities to conduct research and experiment of key steps for the battery making process from material preparation to performance testing.



EVONIK MAKES THE ELECTRIC VEHICLE BATTERIES SAFER AND LONG-LIVING



BATTERY PACK

ANCAMIDE® and ANCAMINE® 2K epoxy curing agent

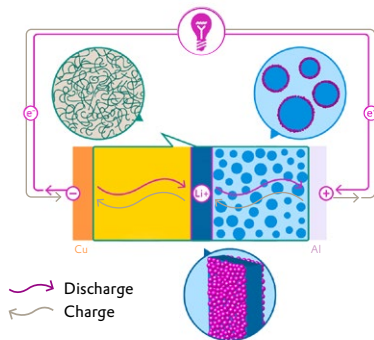
Provide excellent adhesive and mechanical property in EV battery structural adhesives and thermal conductive adhesives.

NOURYBOND® 392

Adhesion promoter of PVC plastisol for EV battery underbody coating, specially designed for Aluminum alloy substrate.

VESTALITE® S, the new curing agent

Allows using optimized epoxy SMC technology for structural lightweight applications.



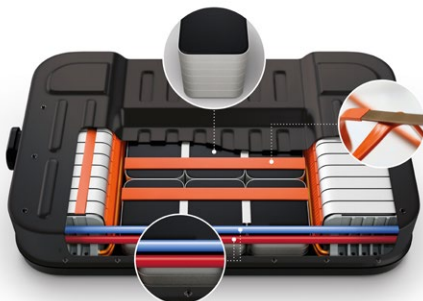
BATTERY CELL

Anode

- Carbon-based materials with addition of silicon.
- TEGO® Surten E series dispersant and flexing agent.

Cathode

- Cathode active materials dry coated with AEROXIDE® improve performance and life-time of Li-ion battery cells.
- TEGO® Surten E series dispersant and flexing agent.



BATTERY MANAGEMENT SYSTEM

AEROSIL® fumed oxides

Provide excellent rheological and reinforcement properties in EV battery structural adhesives.

AEROXIDE® fumed metal oxide

Functional additives for silicones, adhesives & sealants, and thermal insulation for EV battery pack assembly.

Dynasylan® organofunctional silanes

Provide excellent adhesion and crosslinking properties in structural adhesives and thermal conductive adhesives.

AEROSIL® fumed oxides

Provide excellent rheological and reinforcement properties in EV battery structural adhesives.

Dynasylan® organofunctional silanes

Provide excellent adhesion and crosslinking properties in structural adhesives and thermal conductive adhesives.

KOSMOS® and DABCO® series

Organo-tin and bismuth metal catalysts can optimize material properties and curing behavior.

POLYVEST®

Liquid rubber used as highly reactive crosslinking binders or additives for 2K PU for gap filler or thermal conductive adhesive for EV-battery assembling.

VESTOPLAST®

APAO for hotmelt adhesive for cell structure bonding, welding point protection and electrode tab bonding etc.

Separator

- Microporous membrane coated with AEROXIDE® to improve safety of Li-ion battery cells.
- TEGO® Surten E series wetting agent.

Gel polymer electrolyte

- Immobilized by functional AEROXIDE®.

VESTAMID® PA12

The UL94 flame retardant polymer provides excellent high-voltage insulation properties for power busbar applications according to future safety requirements in EV.

VESTAMID® PA12 tubing systems

Contribute to an ideal thermal management of HV battery, e-motor, inverter and a well-tempered overall ambience of the car.

Polymer VS and TEGOSIL®

Silicone raw materials and additives for thermal management.

TEGOSTAB® and POLYCAT®

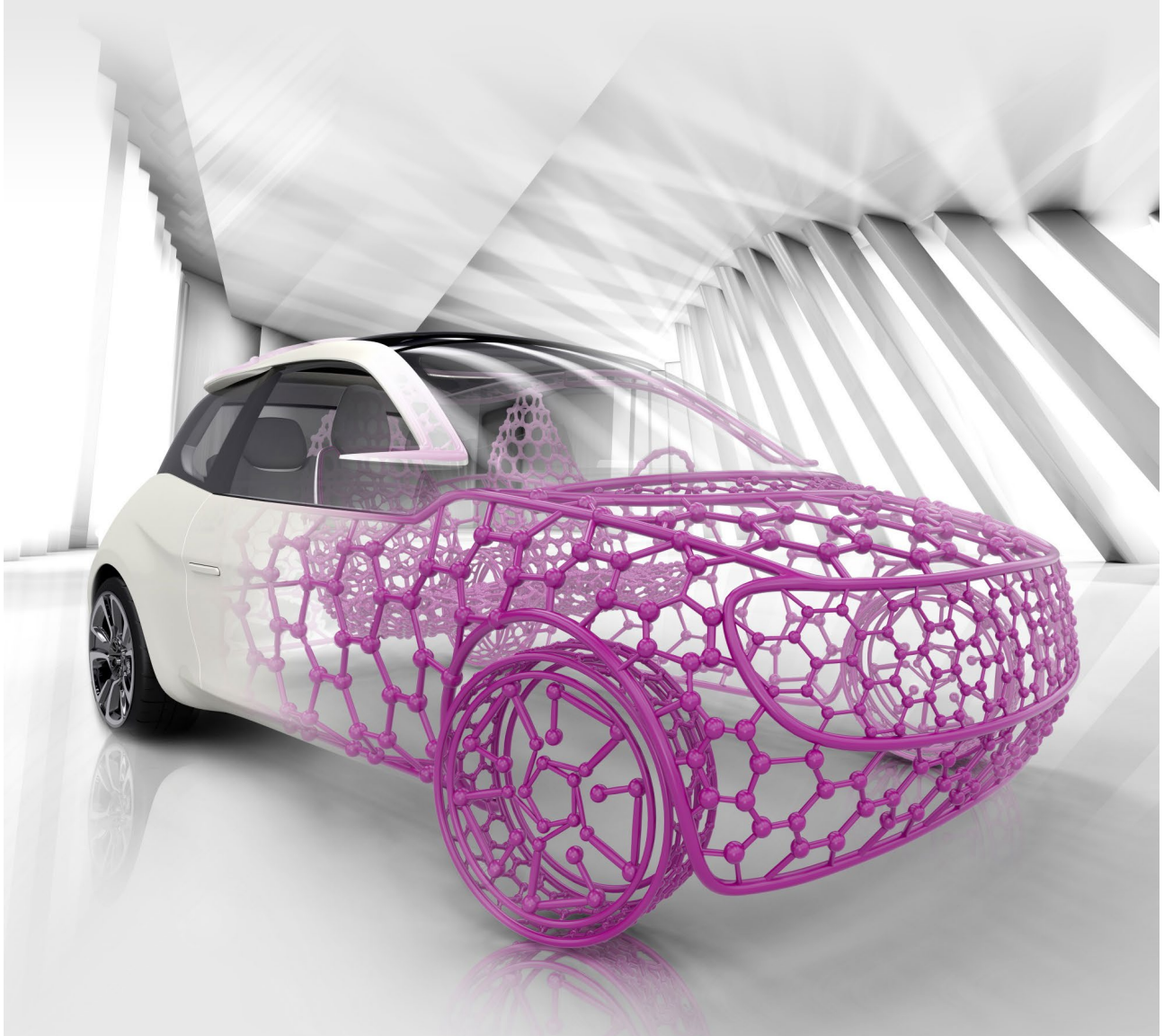
Silicone surfactants and amine catalysts to produce polyurethane froth foam for the protection of EV battery.

VISCOBASE®

Dielectric thermal management fluids for improved battery lifetime, thermal efficiency and safe operation.

EVONIK FOR AUTOMOTIVE.

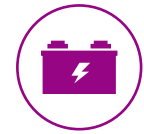
INNOVATE MOBILITY —
WE PROVIDE THE CHEMISTRY



EVONIK PROVIDES VARIOUS SOLUTIONS FOR ELECTRIC VEHICLE BATTERY INDUSTRY

Area	Products	Applications	Benefits	Page	
Battery Pack	Battery Box	Curing agent	Epoxy SMC based battery enclosure	Easy processing, lightweight design and low emissions	8
		Epoxy curing agent	Epoxy 2k curing agent	Low viscosity, excellent adhesion and flexibility, fast curing speed	9
		Adhesion promoter	PVC plastisol adhesion	Excellent adhesion to aluminum alloy surface, low temperature baking, low odor, phthalates and arene free	
		APAO	Hotmelt adhesive for cell structure bonding, welding point protection, electrode tab bonding etc	Excellent electrolyte resistance, high thermal stability, excellent adhesion and hot tack properties, good hydrolytic and UV stability, bonding to various substrates especially on PP without pretreatment	10
		Liquid rubber	2K PU for gap filler or thermal conductive adhesive for EV-battery assembling	Low viscosity, adjusted thixotropy, excellent chemical resistance to acids and bases, high water resistance, low moisture and oxygen permeability, good flexibility	11
		Silane adhesion promoter	EP, PU, SMP and other adhesives and sealants	Excellent adhesion and curing properties	
		Polyurethane catalysts	PU adhesives & sealants	Help to tailor reaction profile for desired open-time and fast post-curing	
Battery Cell	Cathode	Fumed metal oxides (Al ₂ O ₃ , TiO ₂)	Cathode Active Material (CAM) coating / doping	Protection of CAMs to enhance capacity retention / battery life	13-15
		Dispersant	Cathode slurry	Slurry viscosity reduction and stability improvement	
		Flexing agent	Cathode	Increasing cathode electrode layer flexibility	
	Anode	Dispersant	Anode slurry	Slurry viscosity reduction and stability improvement	
		Flexing agent	Anode	Increasing anode electrode layer flexibility	
	Separator	Fumed metal oxides (Al ₂ O ₃)	Separator coating / incorporation	Improvement of thermal stability of separator	
		Low foaming, wetting agent	Ceramic slurry	Ceramic slurry surface tension reduction	
Electrolyte	Fumed metal oxides (Al ₂ O ₃)	Gel / polymer electrolyte	Realize semi-solid electrolyte for safety improvement		
Battery Management System	Power Management and Connectivity	PA12	Power busbars	For perfect electric insulation	16
		PA12	Cooling and heating line and connectors	Excellence performance together with production efficiency, lightweight and competitive system cost	17
	Protection and Thermal Management	Dielectric fluid	Immersive cooling	Efficient cooling performance that enables fast charging	18
		Fumed silica and metal oxides	Silicones, adhesives & sealants, and thermal insulation for EV LIB pack assembly	Functional additives to improve processibility, increase thermal conductivity and electrical insulation, improve long-term stability, and anti-settling as well rheology and reinforcement	19
		Silicone and filler treatment portfolio	Gap filler and thermal interface material	High flexibility of silicone formulation, improved thermal performance	20
		Polyurethane surfactants and catalysts	Compression pads, cushioning, and vibration absorption for battery packs	Enabling the production of high performance PU cushioning / compression pads	21
Battery Recycling	H ₂ O ₂	Recycling of Ni, Co, Mn, Li	As the reducing agent to recover Li, Co, Ni, Mn in the leaching process	22	
Contact Us				23	

EPOXY SMC BASED BATTERY ENCLOSURE



Battery Pack

VESTALITE® S curing agent is a high performance solution for sheet molding compound (SMC) material with low VOC when combined with a liquid epoxy resin.

Its unique properties make it suitable for automotive applications in large scale automated manufacturing (e.g. battery enclosure).

CONSORTIUM APPROACH

Joint development of Evonik's Joint Venture Vestaro and further partners including Forward Engineering, Lorenz, Lion Smart and Minth.

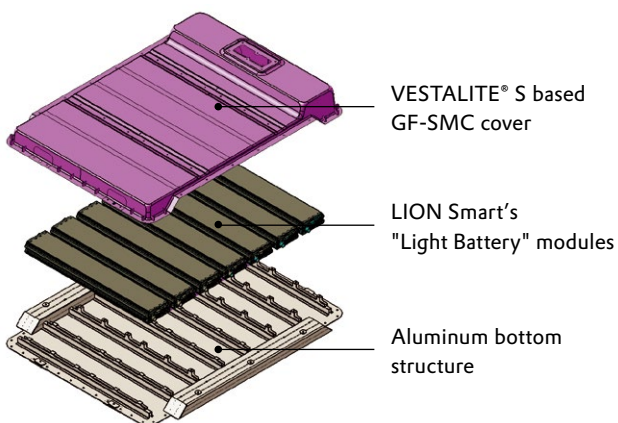
HARDWARE DEMONSTRATOR

Epoxy SMC based on VESTALITE® S enables easy processing as the material shows excellent mold flow combined with fast curing.



CONCEPT DEVELOPMENT

Multi-Material-Design to address all relevant functions and requirements of an integrated battery system.



CONCEPT USP_s & BENEFITS

Efficient material usage

- Complex geometric shape for part reduction and optimal system packaging
- Multi-material usage to address different requirements like fire resistance or EMC
- Best in class mechanical performance of EP-SMC and local reinforcement materials enables low battery weight

Functional integration

- Integration of module connection parts and further battery system relevant components (e.g. E/E-architecture)
- Integration of sealing and venting elements

Cost effective design and manufacturing

- Modularity of battery system sizes due to specific tooling concept and adjustable "Light Battery" module sizes
- Outstanding energy and power density at low costs

More solutions available:

Structural adhesives for Electric & Electronics

Ancamine® cyclo-aliphatic amine and Ancamide® polyamide curing agents offer a wide product range to modify T_g, viscosity, latency, cure speed and toughness of 2K adhesives for ambient and heat cure applications for battery enclosures and structural applications in electric vehicles.

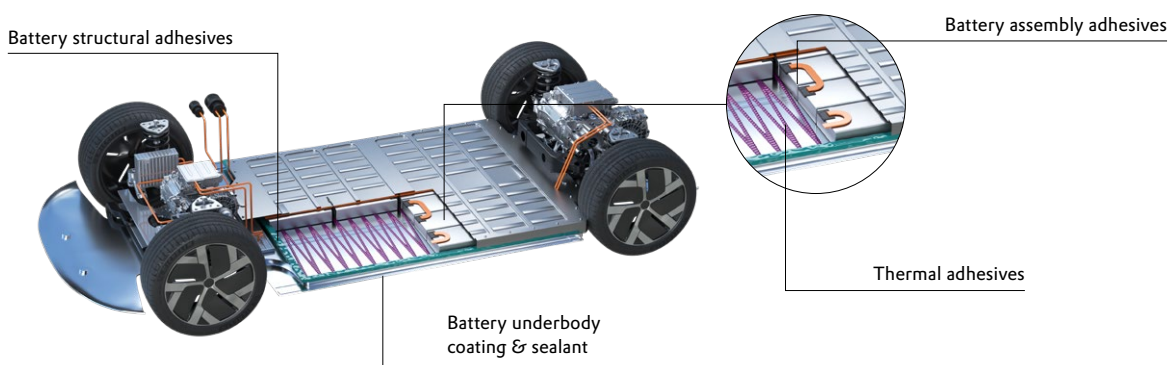
EPOXY CURING AGENT FOR BATTERY ADHESIVES AND SEALANTS



ANCAMIDE® offers a range of polyamides and adducts to be used in EV battery adhesives with improved adhesion, lower viscosity and faster cure speed.

ANCAMINE® with modified aliphatic and cycloaliphatic curing agents provide various choices in EV battery adhesives, such as pot-life, viscosity, cure speed, and chemical resistance.

NOURYBOND® is the broadest range of high-performance adhesion promoters for automotive PVC and acrylic plastisols in the world. The Nourybond® polyamide-based and blocked isocyanate-based technologies provide solutions to the most demanding performance requirements.



Epoxy 2K curing agent

Product	Viscosity	AHEW	PHR	Gel Time	Features
ANCAMIDE® 910	6,000	230	110-125	120 min	<ul style="list-style-type: none"> Outstanding flexibility Better adhesion on dissimilar substrates Lower viscosity
ANCAMINE® 1922A	10	55	229	57 min	<ul style="list-style-type: none"> Produces exceptional toughness, resiliency Thermal shock resistance and outstanding impact resistance Good electrical properties
ANCAMINE® 2914UF	300-2,000	95	50	8 min (20 g mix)	<ul style="list-style-type: none"> Ultra-fast cure speed at room temperature Excellent mechanical properties Can be used as accelerator

Adhesion promoter in PVC plastisol

Product	Viscosity	Amine Value	Features
NOURYBOND® 392	28,000-45,000	280-320	Excellent adhesion on mainly Al alloy surface used in EV car battery packs with low temperature (120 °C) baking circle

Viscosity:
Brookfield RVTD,
Spindle 4,
mPa.s at 25 °C

PHR:
With bisphenol-A based epoxy resin
(EEW=190)

Gel Time:
Techne GT-3 gel timer,
150 g mix at 25 °C
(unless indicated otherwise)

Amine Value:
Perchloric acid titration,
mg KOH/g

Crosslinkers

APAO AND LIQUID RUBBER FOR EV BATTERY ADHESIVES & SEALANTS

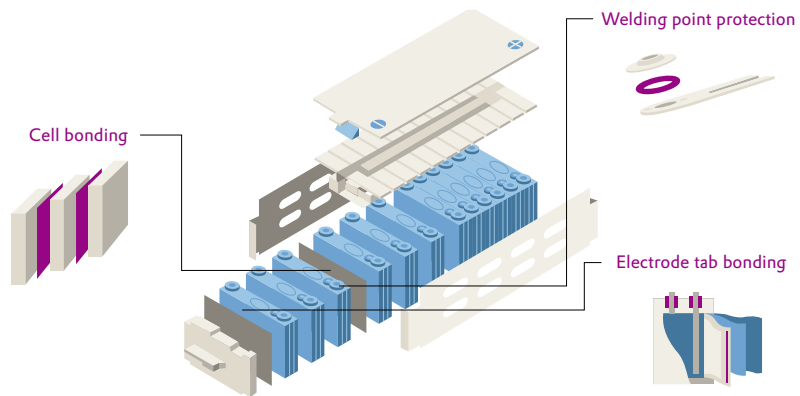


VESTOPLAST® and POLYVEST® products are widely used as binders/additives for adhesives and sealants in battery cell and pack, enhancing the performance of lithium-ion batteries.

Product	Application
VESTOPLAST® series	Raw material with superior electrode resistance for hotmelt adhesive for cell structure bonding, welding point protection, electrode tab bonding etc
POLYVEST® HT, POLYVEST® HT LV, POLYVEST® MA series, POLYVEST® MAT, POLYVEST® ST-E 60	2K PU for gap filler or thermal conductive adhesive for EV-battery assembling

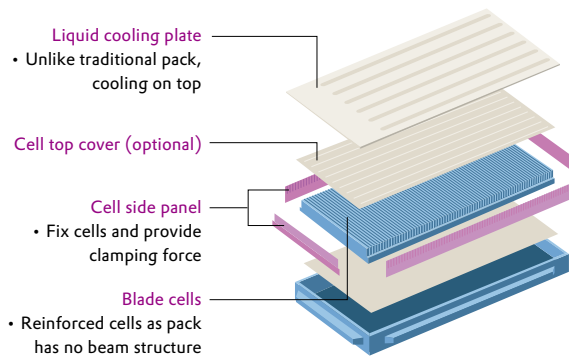
VESTOPLAST® are characterized by the following product properties and show great performance in EV battery system applications.

- Excellent electrolyte resistance
- High thermal stability
- Excellent adhesion and hot tack properties
- Very good hydrolytic and UV stability
- Bonding to various substrates, especially on PP without pretreatment



Due to its microstructure POLYVEST® grades are highly reactive crosslinking binders or used as additives providing properties including:

- Low viscosity
- Adjusted thixotropy
- Excellent chemical resistance to acids and bases
- High water resistance
- Low moisture and oxygen permeability
- Good flexibility



DYNASYLAN® ORGANOFUNCTIONAL SILANES AS ADHESION PROMOTERS



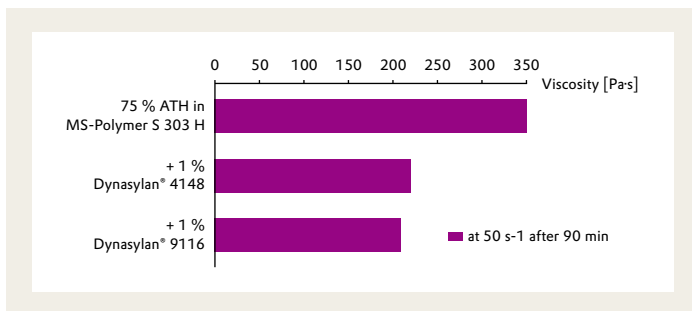
Dynasylan® organofunctional silanes act as adhesion promoters in various EV battery adhesives and sealants. In addition, special Dynasylan® grades can help to adjust the filler loading and rheological properties.

Adhesion promoter in various polymer systems

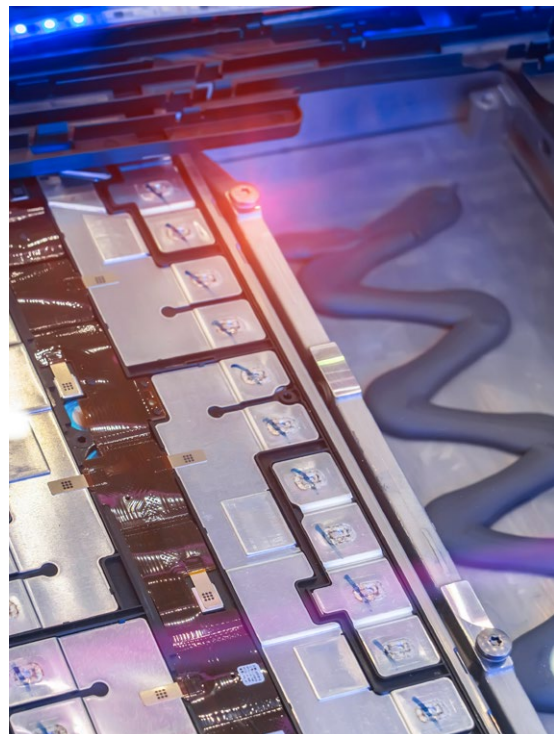
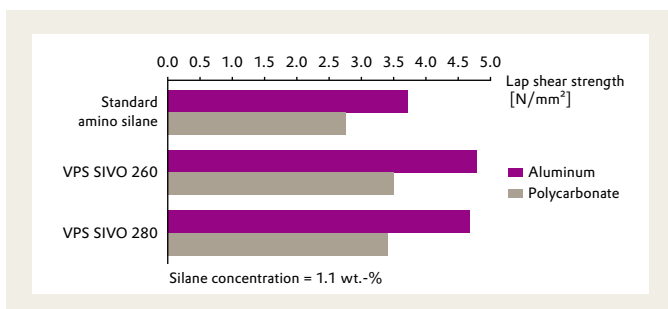
Product	Characteristics	Application
Dynasylan® 1124	Secondary aminosilane	High crosslinking potential for 2K PU, 2K EP, SMP and special primers
Dynasylan® 1146	Oligomeric aminosilane	Suitable for 2K PU, 2K EP, SMP, imparting outstanding hydrophobicity and reduced VOC
VPS® SIVO 260	Oligomeric aminosilane	Excellent adhesion on substrates and recommended for 2K PU, 2K EP, SMP
VPS® SIVO 280	Oligomeric aminosilane	
VPS® 4721	Oligomeric epoxysilane	Suitable for PU, EP, and various other polymer systems
VPS® 7163	Isocyanurate silane	High crosslinking potential for PU, EP and other polymer systems
Dynasylan® 9116	Alkyl silane	Able to adjust the filler loading and rheological properties
Dynasylan® 4148	Polyether silane	

* PU = polyurethane systems, EP = epoxy systems, SMP = silane modified polymer systems

Improve the filler loading and systems workability by reducing the viscosity at higher shear rates



Enhance the primerless adhesion on aluminum and polycarbonate in STPU systems

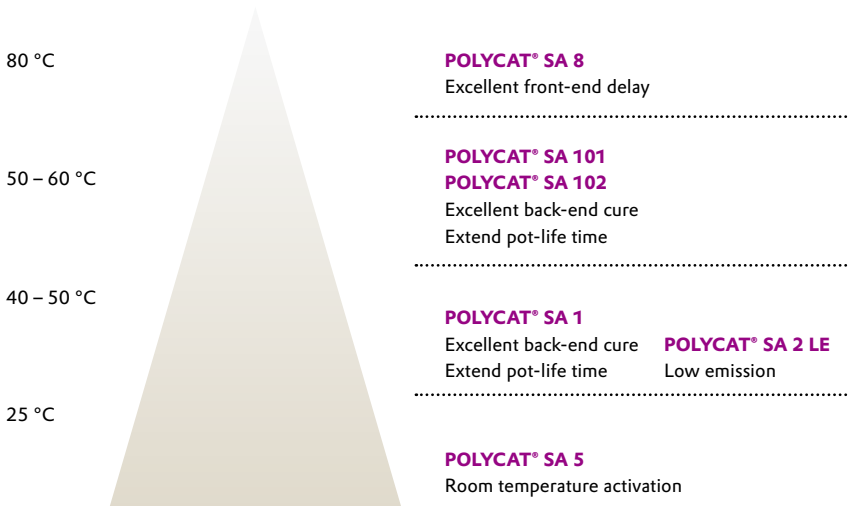


POLYURETHANE ADDITIVES FOR ADHESIVES, SEALANTS AND POTTING COMPOUNDS



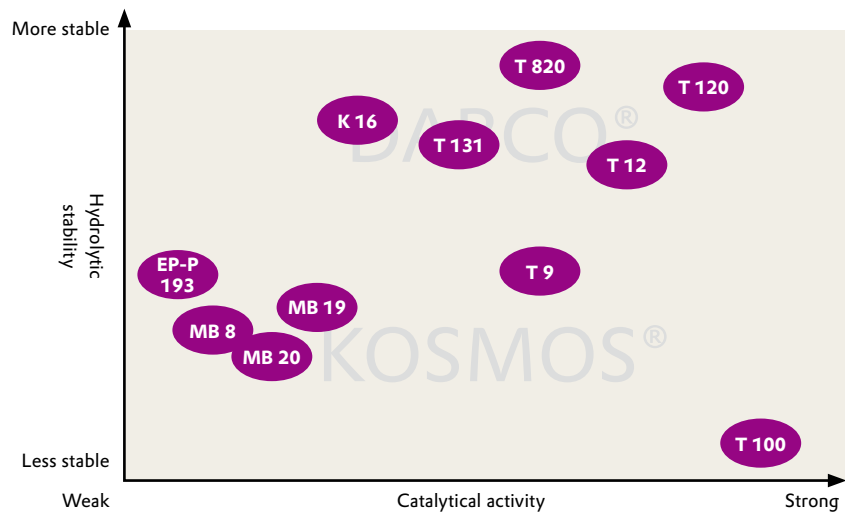
An increasing amount of adhesive and sealant are being used in EV battery pack for bonding, sealing and potting. Polyurethane is widely adopted due to its high performance over a wide temperature range and the ability to customize and tailor products for specific applications.

Evonik specializes in polyurethane additives and we will strive to work with our partners to accelerate the innovation and advancements in EV battery technologies.



POLYCAT® SA catalysts can be activated at different temperatures. By choosing the right catalyst you can tailor a delayed reaction and achieve both long pot-life and fast post-curing.

KOSMOS® and DABCO® series organotin and bismuth metal catalysts can optimize material properties and curing behavior.



TEGO® SURTEN E AS PROCESS ENABLER FOR LIB ELECTRODE AND SEPARATOR MANUFACTURING



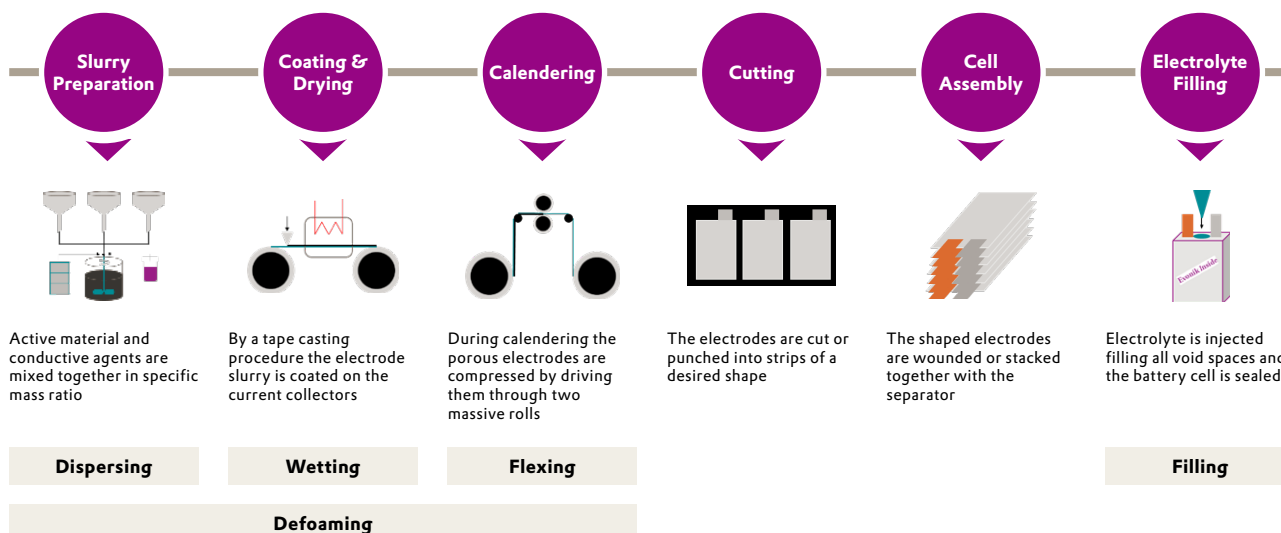
TEGO® Surten E series are the process enablers which help contribute to further improvements in the production of LIB's which yield better electrical performance and lower overall costs. Evonik broad surfactant technology platform allow us to offer a wide range of products from wetting and dispersing agents to defoamers as well as flexing agents.

- NMP based dispersant for cathode
- Water based dispersant for anode, separator
- Evonik provides broad wetting technologies
- Evonik provides all types of antifoam

Product	Application
TEGO® Surten 400 E series dispersant	Cathode slurry, slurry viscosity reduction, uniform distribution of active materials Cathode slurry, viscosity reduction and uniform distribution of conductive materials
TEGO® Surten 800 E series flexing agent	Electrode, improve electrode layer flexibility and reduce electrode layer cracking
TEGO® Surten 200 E series low foaming, wetting agent	Separator, surface tension reduction for ceramic slurry

Applications and key benefits

Separator coating	Wetting agent to ensure uniform coating and adhesive promo
Anode coating	Dispersant for slurry viscosity and grinding time reduction and uniform coating
Cathode coating	Dispersant for slurry viscosity reduction and uniform coating; flexing agent as anti-crack and swelling prevention
Electrolyte fillers	Liquid dispersant for next generation solid state electrolyte system
Calendering	Defoamers to help avoid foaming and air-entrapment



AEROXIDE® FUMED METAL OXIDES AS PERFORMANCE ADDITIVES



Battery Cell

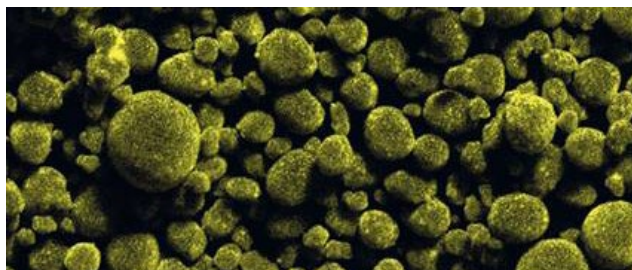
AEROXIDE® fumed metal oxides are produced by flame hydrolysis (AEROSIL® process), the loose white powder consists of nano-structured aggregates. AEROXIDE® metal oxides are used as additives in Li-ion batteries to increase the **performance**, **life-time** and **safety** of the battery.

Product	Application
AEROXIDE® Alu 130, AEROXIDE® TiO ₂ P 25	Protective dry coating for cathode active materials
AEROXIDE® Alu 45, AEROXIDE® Alu C 805 AERODISP® Ready to use dispersions	High performance LIB separator as coating or filler
VP AEROXIDE® Alu C 711	Functional additive in new electrolyte formulations

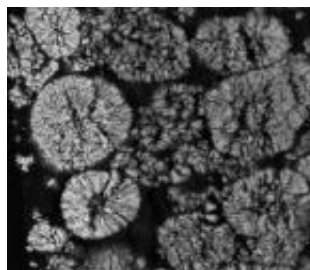
Dry coating for cathode active materials

AEROXIDE® is used for cathode material surface coating to stabilize cathode active material particles and to avoid cracks during charge/discharge, resulting in an increased capacity retention and enhanced battery life.

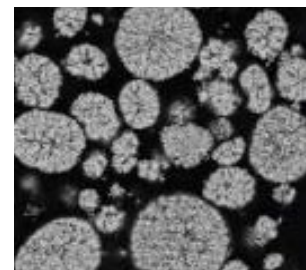
SEM: Al mapping of AEROXIDE® coated NMC particles



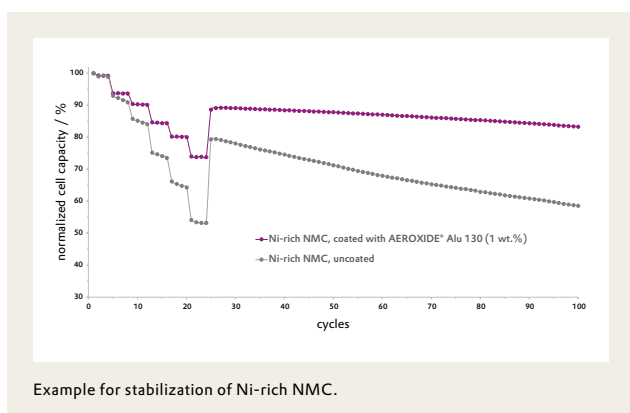
Cross section SEM imaging of cycled electrodes after 250 cycles



Ni-rich NMC, uncoated



Ni-rich NMC, AEROXIDE® coated



AEROXIDE® fumed metal oxides (Al₂O₃ and/or TiO₂) as **dry coating** on cathode particles leads to a significant increase in rate capability and capacity retention of LIB cells.

Preferred AEROXIDE® products:

- AEROXIDE® Alu 130
 - AEROXIDE® TiO₂ P 25
- } Mixture of both oxides is beneficial

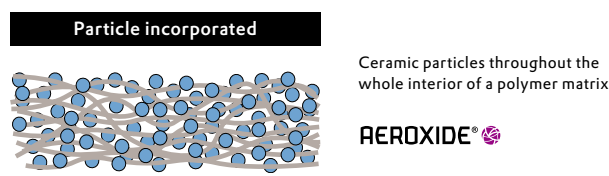
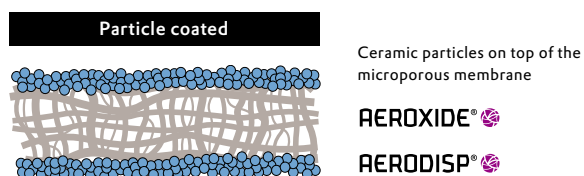
High performance LIB separator as coating or filler

AEROXIDE® fumed alumina enables the use of ultra-thin ($\leq 1 \mu\text{m}$), homogeneous ceramic coatings or is applied as ceramic filler inside the membrane, resulting in improvement of thermal stability of separator.



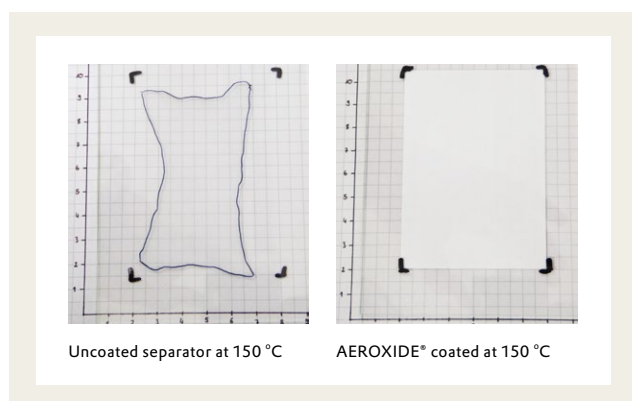
Battery Cell

Evonik also offers AERODISP® – Ready to use alumina dispersions, tailor made for specific coating application and compatible with a variety of different binders.



Coating on separator

A thin ceramic coating made of AEROXIDE® fumed alumina strongly reduces the thermal shrinkage of separator and thus leads to an increased cell safety.



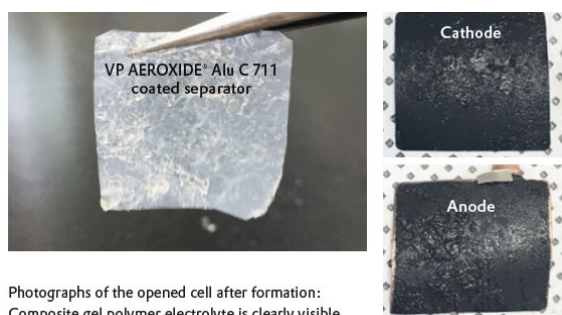
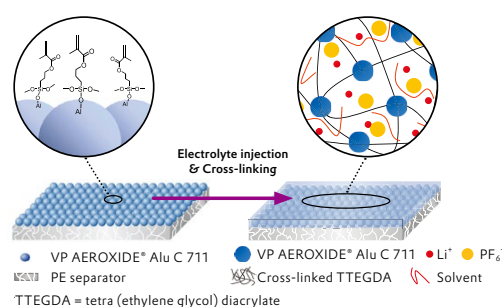
Ceramic filler inside separator

AEROXIDE® fumed alumina can also be used as ceramic filler inside separators, leading to excellent mechanical and thermal membrane properties combined with a high porosity.

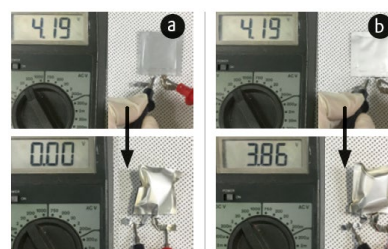


Functional separator coating: Formation of gel polymer electrolyte

VP AEROXIDE® Alu C 711, a specially designed surface modified fumed alumina, is applied as thin ceramic coating on top of separators, to be triggered a cross-linking reaction with tetra (ethylene glycol) diacrylate (TTEGDA) additive in electrolyte to form electrolyte gelling. The formed gel polymer electrolyte with 3-dimensional network strongly enhances the contact between separator and electrodes.



Photographs of the opened cell after formation: Composite gel polymer electrolyte is clearly visible



Photographs show the open-circuit voltage of cells assembled with (a) pristine PE separator + liquid electrolyte and (b) VP AEROXIDE® Alu C 711 coated separator + gel polymer electrolyte, measured before and after thermal exposure at 200 °C for 1 h.

Detailed information available: <https://doi.org/10.1016/j.jpowsour.2020.228519>

INSULATION FOR HIGH VOLTAGE POWER BUSBARS WITH VESTAMID® POLYAMIDE 12



Battery Management
System

Efficient management of electric power and permanently effective insulation of electrical components are key elements in e-mobility. The challenges include management of high voltage, high temperatures, and fire protection.

For more vehicle safety, a high level of fire protection is expected of the plastics. Basically, the Evonik PA12 insulative materials provide outstanding and constant dielectric properties over the entire vehicle lifetime. This applies to power busbars in the high voltage network, at HV charging and in particular, in high-voltage batteries. Powerbusbars are preferably insulated with polyamide 12 (PA12).

Evonik VESTAMID® PA12 is available at UL fire protection levels and includes halogen-free variants in the portfolio. The PA12 materials are in durable RAL signal color.

Evonik assists customers from setting up parameters for PA12 busbar co-extrusion to the bending of coated busbars and finishing of busbar components. In addition we support with specific polymer testing.



VESTAMID® for xEV power busbars

Properties	VESTAMID® PA12 compounds
Application voltage	High voltage up to 1000 V and more
Busbar metal core	Copper, aluminum, steel, ... (also tin/nickel plated)
Coating material	PA12, various grades available, grades UL94 certified
Coating thickness	0.5 – 1 mm
Coating process	Co-extrusion, injection overmould
Color	Orange RAL 2003, RAL 2004, RAL 2008, natural
Flame resistance acc. UL 94 (IEC 60695-11-10)	V0, V2, HB
Halogen-free	Yes
Temperature resistance	Up to +125 °C
Volume resistivity (IEC 62631-3-1)	$10^{13} \Omega\text{m}$
Electric strength (acc. to IEC 60243-2, ISO 6722/19642)	AC > 25 kV/mm, DC > 40 kV/mm
CTI (IEC 60112)	600

PA12 co-extrusion

forming and finishing

polymer testing

THERMAL MANAGEMENT WITH TUBING SYSTEMS FROM VESTAMID® POLYAMIDE 12

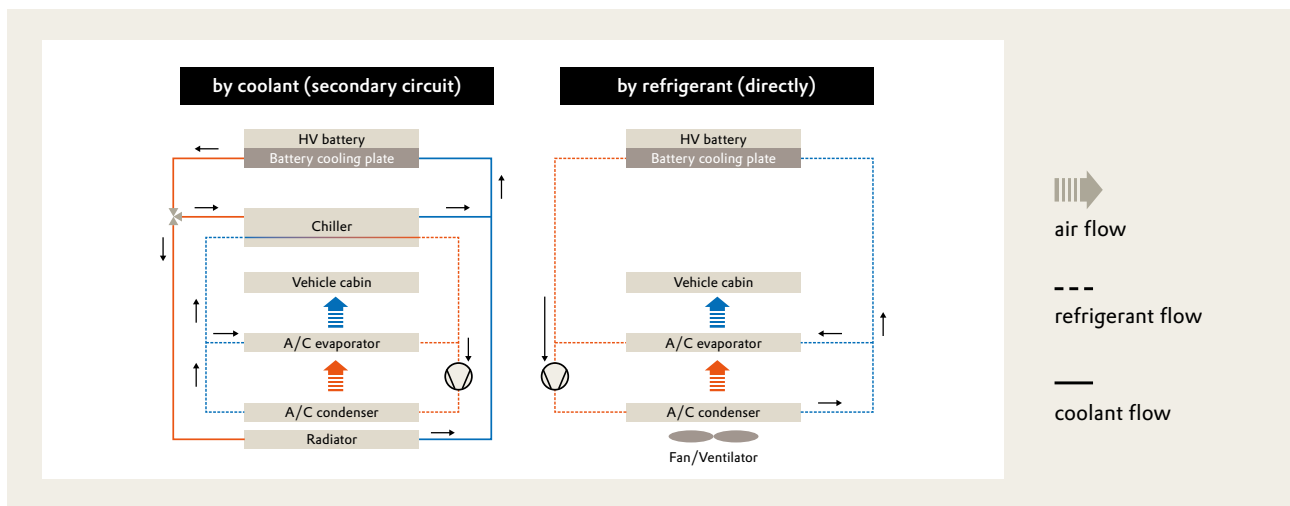


Battery Management System

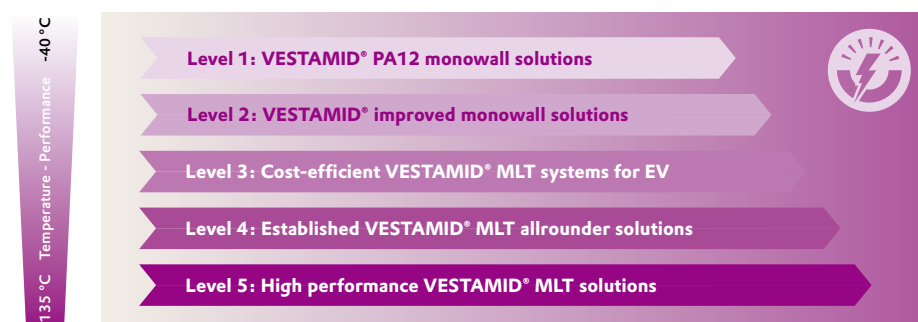
During the high power charging cycles, or while driving (battery discharging), or even while being parked, the temperature of EV battery can exceed the given limit. With lines made from VESTAMID® we provide the suitable solution for both, **water glycol** or **refrigerant** used in the cooling cycles, to enable an effective thermal management and keep the temperature in your car battery at the desired level.

The performance of EV batteries, electric motors, and other high power components benefits from our specialized **mono- and multilayer tubing systems** by keeping its temperatures within the required limits.

xEV battery cooling architectures



Temperature range



Evonik cooling line solutions based on VESTAMID®

- Production efficient: Extrusion of MLT, thermoforming and insertion of quick connectors
- Lightweight: 30% to 50% weight reduction of complete system (MLT 8000 vs. AL/rubber)
- Performance: Excellent mechanical and chemical behavior as well as good anti-hydrolysis properties
- System material cost: Significant advantages compared to current concepts
- Packaging benefit: Less package space needed than for rubber hoses
- Excellent performance: Qualified for both, inside and outside battery pack application
- Proven: Serial use at OEMs globally

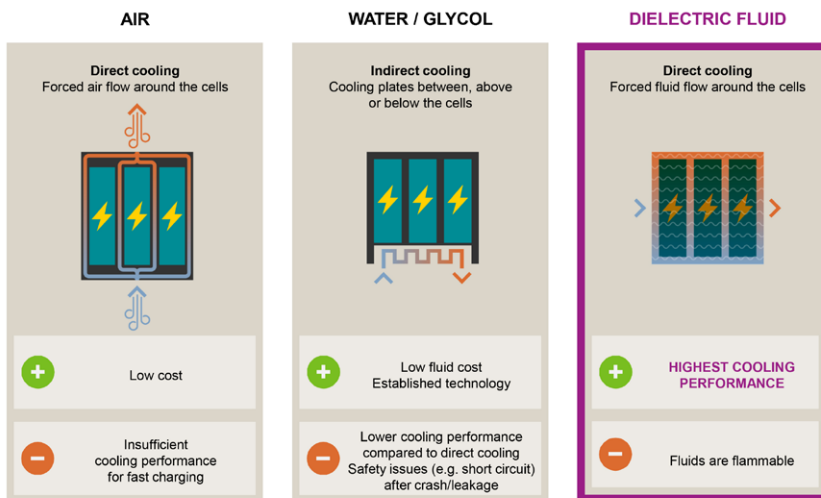
DIELECTRIC THERMAL MANAGEMENT FLUIDS FOR EV APPLICATIONS



Battery Management System

For the performance, durability and safe operation of a traction battery, it is essential to ensure operation in the optimal temperature range. This requires a powerful thermal management system, which can be achieved with submerging the battery cells in a dielectric fluid. Compared to air or water/glycol cooling systems cooling with dielectric fluids offers numerous design advantages.

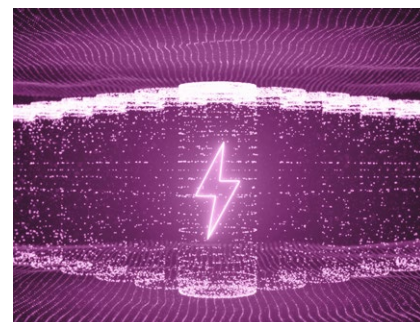
Product	Application
VISCOBASE® 11-416	Ultra-low viscosity synthetic hydrocarbon fluid that combines good heat capacity and thermal conductivity with low electrical conductivity and superior low temperature flow performance
VISCOBASE® 11-150	Low viscosity synthetic ester fluid that combines high heat capacity and thermal conductivity with low electrical conductivity and excellent low temperature performance.



Dielectric cooling allows

- Faster charging
- Prolonged battery life
- Electrical efficiency for increased vehicle range

	Unit @ 40 °C	VISCOBASE® 11-150	VISCOBASE® 11-416
Density	kg/l	0.88	0.78
Viscosity	mm ² /s	4.3	4.1
Specific Heat	kJ/(kg·K)	1.9	1.9
Thermal Conductivity	mW/(m·K)	137	123
Electrical Conductivity	nS/m @ 25 °C	0.01	0.20



Oil Additives

FUMED OXIDES FOR BATTERY ADHESIVES & SEALANTS, SILICONES, AND THERMAL INSULATION **AS WELL EXCELLENT RHEOLOGY AND REINFORCEMENT**



Battery Management System

Products	Features	Requirements
AEROSIL® R 202 / R 208 / R 805	Structural adhesives	Thickening thixotropy, and reinforcement
AEROXIDE® Alu 45 / 65 / 130 AEROXIDE® Alu C 805 AEROSIL® R 711	Thermal conductivity	Rheology control
AEROXIDE® TiO₂ P 25 / PF2	Thermal stability	Silicone degradation at high temperatures, e.g. in silicone cables, sealants, and gaskets
AEROSIL® 200 / 300 / 380	Thermal insulation	Cost-effective inorganic fillers Highly porous inorganic fillers
AEROSIL® R 104 / R 106 (D4 treated)	Low volatiles	Safe usability on production lines

Additives for highly filled thermally conductive formulations


- Anti-settling for micron sized spherical alumina
- Lower viscosity for boron nitride filler
- Improved thermal conductivity in addition to the role as rheology modifier
- Reducing thickening, featuring with our low surface area fumed alumina e.g. AEROXIDE® Alu 45 and 65

Additives for silicones

- AEROXIDE® TiO₂ PF 2 is a unique fine particle mixed oxide consisting of titania and iron oxide, manufactured analogous to the AEROSIL® process
- Hydrophobized silica such as AEROSIL® R 104 / AEROSIL® R 106 offers a safe production environment due to low content of D4 volatiles


Anti-settling demonstration:
No visible settling of large particles after 2 days

Without fumed alumina



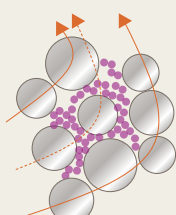
Visible settling in 4 hours

With fumed alumina



No settling in 2 days

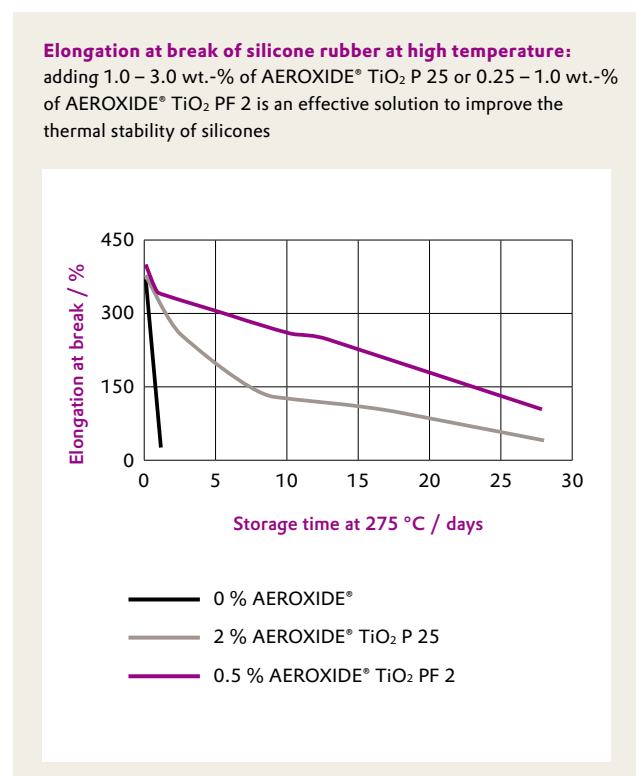
Reference formulation: 60% 40 μm spherical alumina, 2% AEROXIDE® Alu with Silicone VS 200



Improving thermal conductivity

● AEROXIDE® Alu

○ μm scale alumina



SILICONE AND FILLER TREATMENT PORTFOLIO FOR BATTERY ASSEMBLY

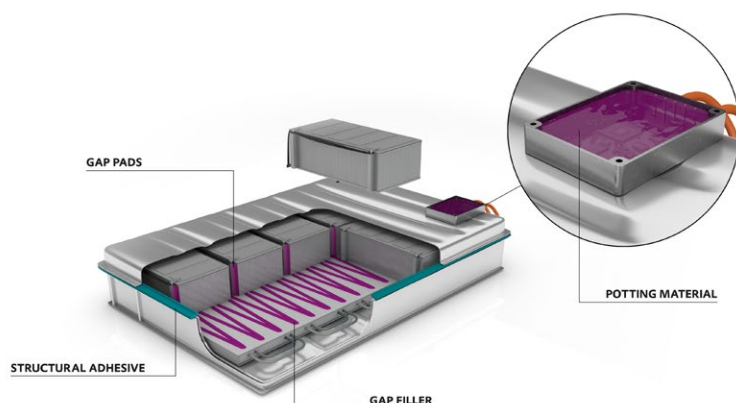


Battery Management
System

Silicone portfolio

Product	Application
Polymer VS silicones	Vinyl-terminated silicone portfolio with broad range viscosity starting from 20 mPas
Crosslinkers	Full range with different SiH contents & viscosity
Modifier 700 series	Di-functional SiH structure to archive low process viscosity and high elongation properties
VQM 900 series	Vinyl-functional QM resin for high mechanical properties and transparent formulations
TEGOSIL® Heatban	Heat stabilizer to improve formulation heat resistance up to impressive 300 °C
TEGOSIL® FR 1000	Flame retardant co-compound for higher flame retardancy standard

Our full portfolio of silicone raw materials give high flexibility to build your formulation with desired viscosity, curing speed, hardness and high performance. Guiding formulations and technical exchange with our experts upon request.



Evonik solutions include: Raw materials and additives for

- Gap fillers
- Thermal interface materials
- Battery assembly adhesives

Filler treatment portfolio for better thermal conductivity and flame retardancy

Product	Application
TEGOPREN® 6875 & 6879	Organo-modified siloxane chemistry for hydrophobic treatment of functional filler. Can also be used as in-situ dispersion additive
TEGOMER®	Broad chemical portfolio for filler treatment and in-situ additive in matrix

TEGOPREN® and TEGOMER® products enhance the functionality of different fillers in silicone, urethane, epoxy, acrylic and thermoplastics. Filler treatment benefits include:

- Improved filler distribution in the matrix leading to higher thermal conductivity, better flame retardancy and lighter weight
- Reduced formulation and processing viscosity and lower water uptake
- Further increase of functional filler dosing level which enables even higher performance

For other matrices, we also offer high performance raw materials including NANOPOX®, NANOCRYL®, ALBIFLEX®, ALBIDUR® for the flexibilisation and long-term performance of epoxy and acrylic.

Interface & Performance

SURFACTANT AND CATALYST FOR POLYURETHANE FROTH FOAM AS BATTERY PAD MATERIALS



Battery Management System

Polyurethane froth foam is the ideal EV battery pad material

Battery Pad cushions, or compression pads must be firm enough to hold components in place and compressible enough to withstand dimensional changes to the pouch cells over the life of the battery. PU Froth foam is excellent for this application and helps to providing the breathability, cushioning, and high performance across a broad range temperatures in a harsh environment.



Polyurethane froth foam surfactants and catalysts

Evonik is the global leader in polyurethane additives. Our extensive product portfolio includes the innovative silicone surfactants and catalysts (amine and metal) needed for successful froth foam systems.

Product	Application
TEGOSTAB® B 8984	Highly potent froth surfactant that provides superior froth stability with a very fine and homogeneous cell structure. Ideally suited for low density froth foams with densities down to 200 kg/m ³ .
TEGOSTAB® B 89120	Low VOC froth surfactant for low density froth foams with densities down to 200 kg/m ³ . Provides superior froth stability with a very fine and homogeneous cell structure. Ideally suited for all polyurethane froth foam applications where VOC is an issue.
TEGOSTAB® B 89177 and B 89178	Froth surfactant for medium and high-density froth foam applications (400 – 800 kg /m ³). Can also be used as co-surfactant in combination with TEGOSTAB® B 8984 or TEGOSTAB® B 89120. Free of VOC.
POLYCAT® SA series	Heat activated catalyst with an excellent front-end delay with a wide range of thermo- activation temperatures. By choosing the right catalyst you can help to tailor a delayed reaction to optimize the formulation.
DABCO® and KOSMOS® series	Broad variety of different metal-based catalysts including tin- and bismuth-based products.



Polyurethane frothing technologies require a unique set of additives. Surfactants need to be engineered to help stabilize the polyurethane system, while ensuring the proper frothing during the foaming process. These innovative surfactants help to regulate cell size and uniformity in the cell distribution of the foam. In additions, delayed action catalysts are required to improve the processing latitudes, process stability, and curing time. Using delayed action catalysts ensure that no reaction occurs during the frothing, delivery and final lay-down of the polyurethane mixture. Once the froth coating is applied, rapid curing is possible under heat.

LIB RECYCLING USING HYDROGEN PEROXIDE AS ECO-FRIENDLY REDUCTION AGENT



Battery Recycling

Lithium-ion Battery (LiB) is widely used in Electric Vehicles (EV) and smart portable devices, with more and more of them reaching its life expectancy, it is getting more and more critical to recycle the LiB in order to reuse the precious and rare metals (eg. Lithium, Cobalt) as well as addressing the sustainability and environmental protection perspectives.

The global LiB recycling market is expected to grow very fast.

Product	Application
HYPROX® 350, HYPROX® 500	Recovery of Li, Co, Ni, Mn in the leaching processes of LiB recovery process
CLAMARIN® 350, CLAMARIN® 500	Wastewater treatment to breakdown organics to reduce COD

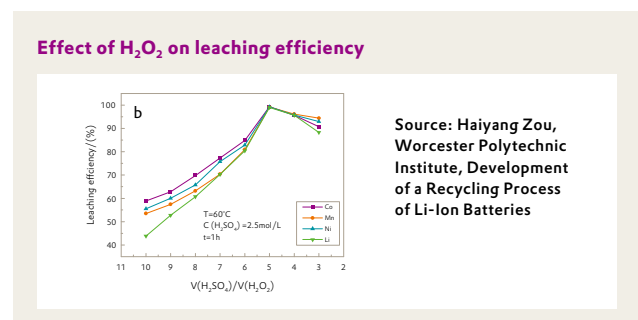
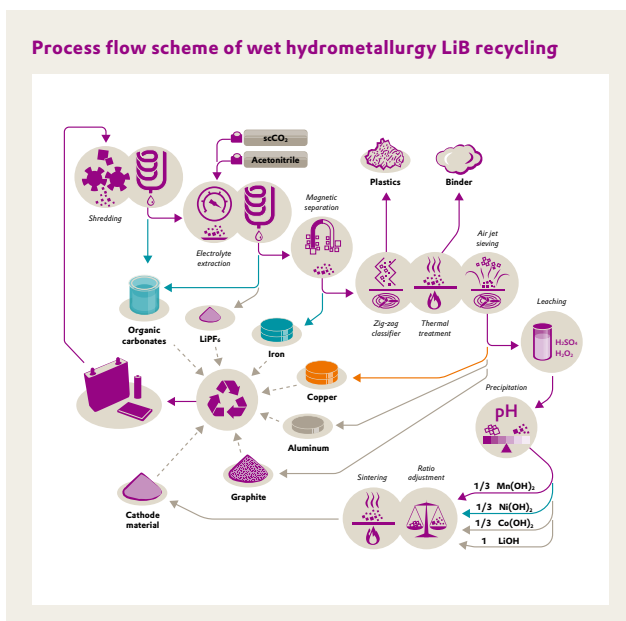
Application overview

Among the various LiB recycling technology, a commonly widely implemented process is the so-called "Wet Hydrometallurgy" process. In this process hydrogen peroxide (H_2O_2) is used as a reduction agent in the leaching process, together with other acids (eg. H_2SO_4 , HCl or HNO_3) to:

- Transfer all $Co(III)$, $Mn(III)$, $Ni(III)$ to $Co(II)$, $Mn(II)$, $Ni(II)$, allowing better dissolution in the solution;
- Transfer all $Fe(II)$ to $Fe(III)$, allowing easier separation of iron from the solution;
- Increase leaching efficiency and shorten leaching time.

Compared with other reduction agent, hydrogen peroxide decomposes only into water and oxygen, therefore is considered more eco-friendly.

Hydrogen peroxide, with its activated radical group ($-OH$), can be used alone or in combination with Advanced Oxidation Process (AOP) technologies (eg. Fenton, UV, Ozone), to breakdown organics chains to reduce the COD of waste water.



Evonik offers

- Different grades of hydrogen peroxide used in LiB processes (leaching, water treatment);
- Wide availability of hydrogen peroxide supply from our 18 plants around the world;
- Applied technology and tech services;
- Design, build and inspect H_2O_2 storage tank and dosing units;
- Safety training and handling guideline.

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Battery Recycling

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04/2023