SAFETY AND LONG DRIVING DISTANCE

EV battery components with fumed silica and metal oxides from Evonik

Car manufacturers are constantly optimizing their electric vehicles (EV) to bring forward climate-friendly electromobility. The design and functionality of the battery systems are being improved to increase the safety and longevity of lithium-ion batteries (LIBs) by improving the design and functionality of the battery systems. Evonik's AEROSIL® and AEROXIDE® products contribute to innovative formulations for thermal stability, thermal conductivity, and thermal insulation within battery packs.

Evonik's research and development teams continuously work on clever solutions for next generation mobility. One focus here is on lithium-ion batteries (LIBs), as they are the drivers of electromobility. Evonik supports EV and battery manufacturers in pursuing their most important goals: reduce weight, increase energy density, increase safety, lower costs, and simplify manufacturing. One promising approach are new battery pack designs, that battery manufacturers are exploring, such as, "cell-to-pack" (CTP) design without module housings.

Evonik's silica 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 dispersions, our products improve the performance of our customers' battery components across the entire value chain for EV batteries, wherever it is needed: inside of battery cells, in battery packs, and in battery management systems. They also contribute to the eco-friendly recycling of batteries. Evonik's Next Generation Solutions make electric batteries safer and more durable.

LITHIUM-ION BATTERIES (LIB): POWER FOR A GREENER FUTURE

There is no doubt among analysts that the global demand for batteries is rapidly increasing, driven by the shift to renewable energies in general and electric mobility in particular. "Batteries are a key technology to drive the green transition, support sustainable mobility and contribute to climate neutrality by 2050", reads an article on the European Union's new Batteries Regulation for safe and sustainable batteries, which are an indispensable energy source within the strategy of the European Green Deal.

According to the global market outlook ***"Battery 2030: Resilient, sustainable, and circular"*** by McKinsey, "global demand for Li-ion batteries is expected to soar over the next decade, with the number of GWh required increasing from about 700 GWh in 2022 to around 4.7 TWh by 2030. Batteries for mobility applications, such as electric vehicles, will account for the vast bulk of demand in 2030 – about 4,300 GWh."

A trend report on "The Rechargeable Battery Market and Main Trends 2020 – 2030" by Avicenne Energy assumes that 25 million EV will be sold worldwide in 2030 and that the total demand for lithium-ion electric vehicles in general (xEV) will increase by 28%, up to 2,000,000 MWh.

The growing demand for batteries goes hand in hand with a growing demand for research and development of enhanced battery technology. Whether they are used in a smartphone or an electric vehicle, the function of lithium-ion batteries is always the same – and so are the demands: handling high energy density, enabling fast charging ability, offering a long service life with thousands of charging cycles while meeting stringent safety requirements. Above all, the safety of lithium-ion batteries in private and public electric transportation is crucial, as safety issues can be a limiting factor in terms of user acceptance and market development.
Evonik's high-quality pure AEROSIL® fumed silica and AEROXIDE® fumed metal oxides increase the performance and safety of LIBs in many ways.

AEROSIL® AND AEROXIDE® – SMALL AMOUNT, SIGNIFICANT IMPACT

Even the tiniest components can make a big difference: small amounts of Evonik's fumed silica and metal oxides as additives in battery systems have a huge impact on the overall battery safety and charging cycle service life.

Find more technical details in our brochure **"Evonik solutions for battery electric vehicles"**

Functions	Requirement	AEROSIL® and AEROXIDE®
Structure Adhesive	Thickening, thixotropy, and reinforcement	AEROSIL® R 202 / R 208 / R 805
Thermal Conductivity	Anti-settling additives in thermally conductive compounds	AEROXIDE® Alu C / 65 / 130 / VP Alu 45 AEROXIDE® Alu C 805 / AEROSIL® R 711
Thermal Stability	Silicone stabilization at high temperatures, e.g. in silicone cable applications, sealants, and gaskets	AEROXIDE® TiO_2 P 25 / PF 2
Thermal Insulation	Low thermal conductivity; mechanical strength during thermal runaway	AEROSIL® 200 / 300 / 380
Low Volatiles	Low level of unwanted extractable chemicals	AEROSIL® R 104 / R 106 (D4 treated)

AEROSIL® AND AEROXIDE®: EXTREMELY POWERFUL IN THE BATTERY PACK

During more than 80 years of experience with AEROSIL® and 70 years with AEROXIDE®, Evonik and its predecessor companies have been involved in various battery applications from an early stage.

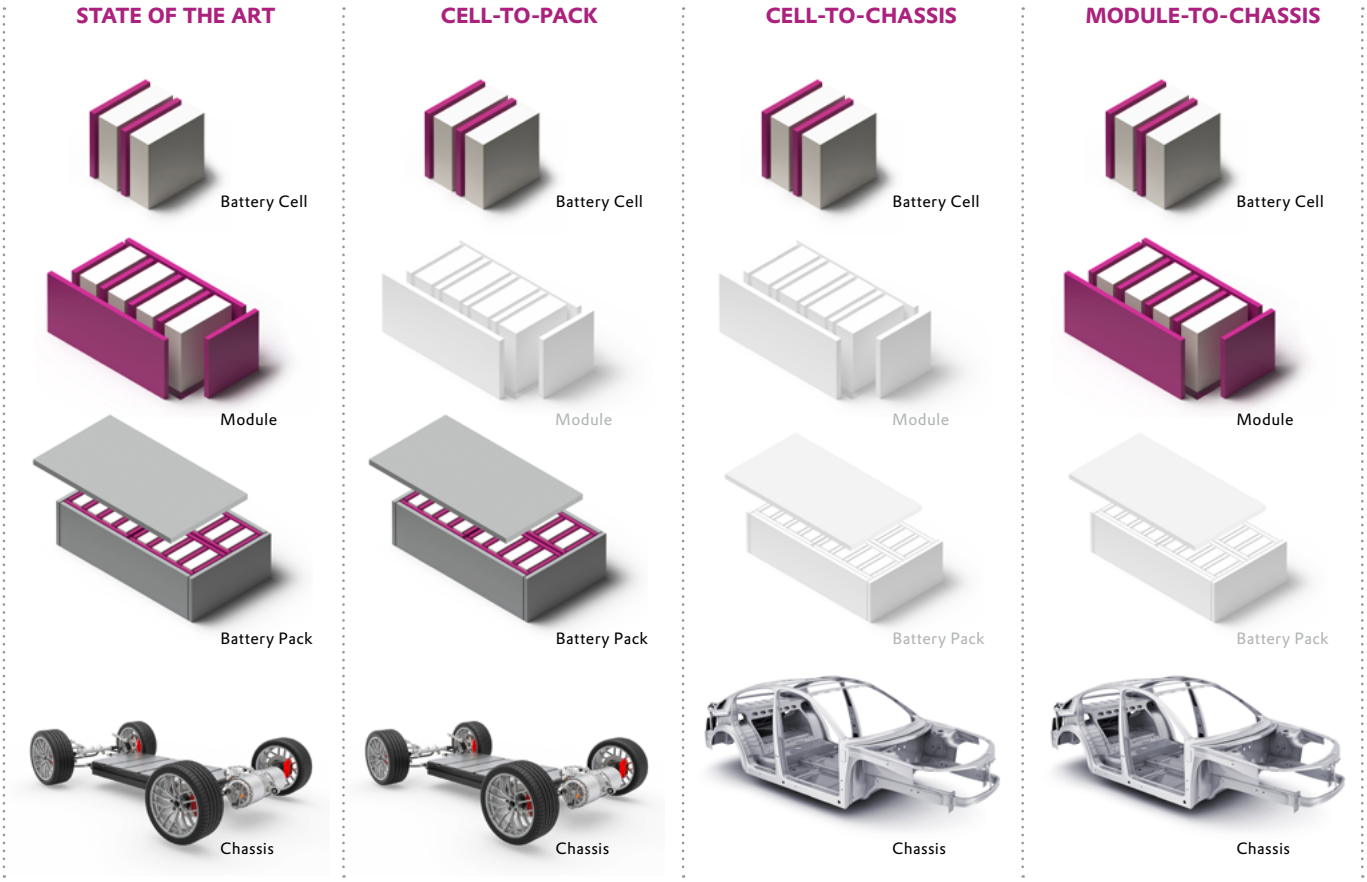
AEROSIL® and AEROXIDE® are additives that enhance the performance of thermally stable silicones, thermal insulation materials and thermally conductive adhesives (made of silicones, polyurethanes, silane modified polymers, acrylic and epoxy systems).

> *"Our AEROSIL® and AEROXIDE® products ensure long lifetimes coupled with high reliability and safety of lithium-ion batteries. Depending on the application and the selected AEROSIL® or AEROXIDE® grades, they provide either thermal insulation or enhance thermal conductivity and thermal stability."*
>
> **Wojciech Pisula** Director Applied Technology Silicone

AEROSIL® fumed silica is well-known for its low thermal conductivity and for improving the rheology and mechanical strength of silicone rubber formulations as well as other adhesives and sealants. AEROSIL® is specifically an important additive to adjust rheological and mechanical properties in structural adhesives for battery housings.

AEROXIDE® Alu and AEROXIDE® TiO_2 fumed metal oxides control rheology, increase thermal conductivity, and improve thermal stability.

The battery pack as the heart of the powertrain is a complex system that requires careful engineering and design to ensure safety and reliability of the electric vehicle. It is made up of modules, each of which contains several battery cells. These modules are usually enclosed in a housing to protect them from damage and to provide thermal management. The housing is designed to be lightweight and to allow for easy replacement of the battery modules if necessary.



EVONIK Leading Beyond Chemistry

HEAT PROTECTION EXTENDS BATTERY LIFE

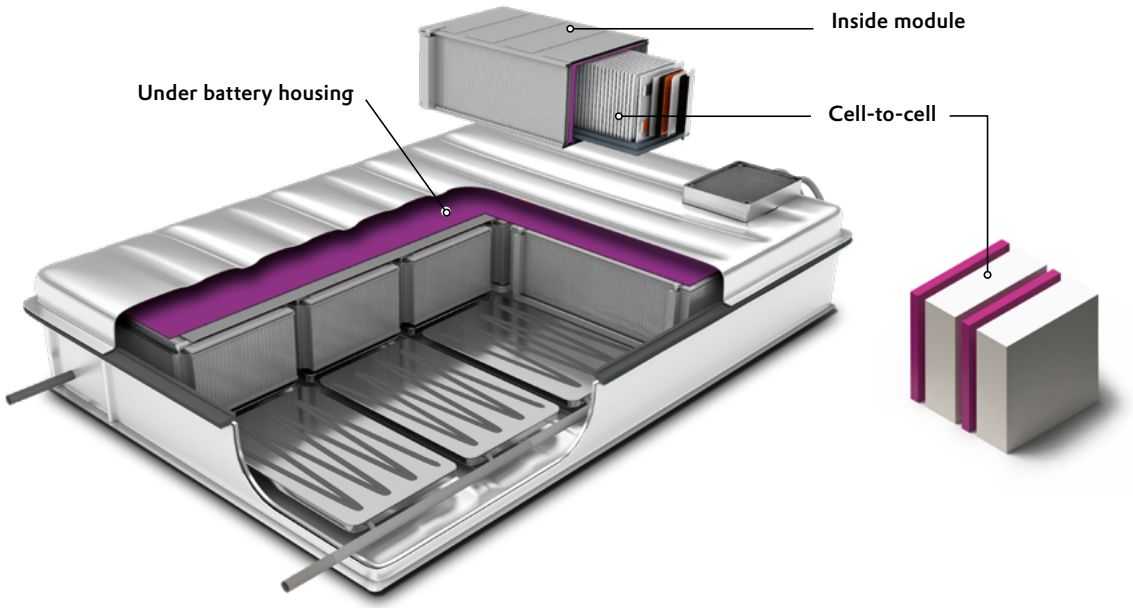
There are three main types of battery cells with different shapes: cylindrical (round), prismatic (rectangular), and pouch (flat and thin). Cylindrical cells are currently the most common type in Europe. Although these cylindrical, round cells cannot be inserted as compactly as angular cells, they have one major advantage: the heat generated when the batteries are under load can dissipate through the gaps. Square cells, on the other hand, can be inserted more compactly but require a solution for temperature equilibration. Reliable thermal management poses an even greater challenge in battery pack designs without module housings, known as 'cell-to-pack' (CTP).

Innovative formulations of thermally stable silicones, thermal conductive adhesives and sealants, and thermal insulation materials help master these challenges:

- **Thermally stable silicones and other adhesives and sealants ensure excellent thermal management by filling in the gaps between the cells and the cooling plate. They also provide adhesion, flexibility, and dielectric strength.**
- **Thermally conductive adhesives offer a unique combination of thermal conductivity and structural strength, as well as fast curing with automated dispensing.**
- **Thermal insulation materials protect battery cells from fire propagation in case of a thermal runaway.**

> *"Structural adhesives based on AEROSIL® are crucial for the protective housing of the batteries. In addition to silicones, there is also a rapidly growing market for thermal conductive polyurethane, SMP, acrylate and epoxy adhesives, sealants, and foams to set the desired final properties in battery applications and support the success of these technologies".*
>
> **Jürgen Fritz**
> Director AT Adhesives & Sealants Silanes and Silica

Read more technical data in our Factsheet **FS 62 "AEROXIDE® Fumed Metal Oxides"**



EVONIK Leading Beyond Chemistry

THERMALLY STABLE SILICONE WITH AEROXIDE® TiO_2 PF 2

Silicones improve the performance and lifespan of batteries by preventing overheating and thermal degradation. Fumed silica, titania, and alumina can enhance their thermal stability, mechanical strength, electrical insulation properties and resistance to chemicals and moisture:
Adding 1.0–3.0 wt.-% of AEROXIDE® TiO_2 P 25 or 0.25–1.0 wt.-% of AEROXIDE® TiO_2 PF 2 is an effective solution to improve thermal stability of silicone formulations, while the mechanical properties are maintained on an excellent level at high temperatures. Thermal stabilization depends on the type and concentration of the AEROXIDE® TiO_2 fillers. Due to iron oxide doping, the efficiency of AEROXIDE® TiO_2 PF 2 is higher in comparison to AEROXIDE® TiO_2 P 25.

"The increasing use of silicone in battery applications is driven by the growing demand for high-performance batteries with improved safety and longer lifespan. Silicones are also being used in the development of next-generation batteries, such as solid-state batteries. The use of silicone in battery applications will significantly contribute to the growth of the silicone market in the coming years."

Harald Herzog Head of Global Marketing Silicones at Evonik's Silica business line

THERMAL INTERFACE MATERIALS WITH AEROXIDE®

Thermal interface materials (TIMs) help dissipate heat in batteries, generated during fast charging. Applying TIMs avoids excessive heat formation and thus decreases the risk for a thermal runaway. That is how TIMs improve the safety and extend the lifetime of batteries.
Many TIM products are based on silicone rubber or other polymers like polyurethanes, silane modified polymers (SMP), acrylates and epoxies, known for their low thermal conductivity of around 0.2 W/mK.

To achieve meaningful increases in thermal conductivity, it requires high loading levels of large micron-sized thermally conductive fillers of 70% or even higher. Such large fillers are very heavy and tend to settle in the compound which is detrimental to thermal conductivity and storage stability. This issue can be corrected with AEROXIDE® fumed alumina which serves as a very efficient anti-settling agent for thermally conductive fillers.

ADVANTAGES:

- **Efficient additive requiring only very low dosage (typically less than 2 wt%)**
- **Tailored rheology: high thixotropy provides anti-settling of large filler particles but has very low impact on viscosity at higher shear.**
- **No reduction of thermal conductivity (in contrast to non-alumina-based anti-settling agents such as fumed silica)**

BENEFITS:

- **Formulations with high shelf-life, stability and reproducible thermal conductivity**
- **Improved processibility of the formulation without segregation or settling in dosing units**

Read more technical data in our fact sheet **FS 62 "AEROXIDE® Fumed Metal Oxides"**

Read more technical data in our fact sheet **FS 58 "AEROXIDE® in Electric Vehicle Application"**

THERMAL INSULATION WITH AEROSIL® AND AEROXIDE®

Thermal insulation materials, such as fumed silica, can be used in separator coatings and as ceramic fillers inside separators to create a barrier between the battery cells and the surrounding environment, reducing heat transfer by conduction. This helps maintain stable temperature within the battery, preventing thermal runaway, and improving its overall performance and safety.

FEATURES

- **Hydrophilic AEROSIL® and AEROXIDE® fumed oxides are fully inorganic and thus nonflammable**
- **Low thermal conductivity, excellent thermal insulation**
- **Further increased thermal stability with Al_2O_3 containing AEROSIL® and AEROXIDE® grades**

BENEFITS

- **Thin design of insulation and protective layers**
- **Reduced risk of thermal runaway**
- **Improved safety for passengers**

EVONIK SILICA SOLUTIONS FOR NEXT GENERATION BATTERY PACKS

Requirement	Solution
Increase safety	Thermal stability Thermal conductivity Thermal insulation Reinforcement
Increased sustainability	Thermal stability Thermal conductivity Thermal insulation Low volatiles (VOC) Weight reduction
Increased durability	Anti-settling Thermal conductivity
Increased driving distance	Anti-settling Thermal conductivity Weight reduction

PROSPECT: DEMAND FOR SMART AND SUSTAINABLE SOLUTIONS

If batteries are the key technology for advancing the energy transition and achieving global climate targets, and the demand for batteries is multiplying, then it is essential that the entire value chain becomes more sustainable and environmentally friendly.

Future technologies to improve ranges, fast charging capability and charging infrastructure are one thing. Solutions for production costs, resources and access to raw materials are just as important. Industry experts agree that, particularly due to the scarcity of resources and the CO_2 footprint, the entire value chain should be considered, from materials and production technology to efficient battery use and recycling. A law to this effect came into force in the European Union in 2023:

"***The new Batteries Regulation*** will ensure that, in the future, batteries have a low carbon footprint, use minimal harmful substances, need less raw materials, and are collected, reused and recycled to a high degree in Europe. This will support the shift to a circular economy, increase security of supply for raw materials and energy, and enhance the EU's strategic autonomy."

> *"Evonik experts have in-depth knowledge to conduct the research and development work on next-generation battery materials, cells, and technologies. They look forward to working with our customers on sustainable battery solutions."*
>
> **Susanne Pellengahr** Director Sustainability, Business Development & Processes, Silica

Read more technical data in our fact sheet
FS 65 "AEROSIL® and AEROXIDE® in EV Battery Thermal Protection & Insulation

From sand to silica: silica is a natural component of rock and sand. Evonik manufactures different types of silica with specific properties for various industrial applications.

Different silica samples

WHAT IS SILICA?

Sand is the starting material for *silica*. The particles are based on silicon dioxide, a natural mineral. The two components in this compound, oxygen (approx. 47%) and silicon (approx. 27%) are some of the most common elements in the Earth's crust when measured by weight.

Evonik creates silica from these compounds with custom *properties* for *industrial applications*. It truly is a product with many talents: It is common in many everyday applications, for example as an anti-caking agent in powders, as a carrier substance for catalysts or active ingredients, as reinforcement fillers for polymers or as insulation materials. They optimize the flow capability of fluids and improve the storage properties of powders.

AEROSIL® is a fumed silica, synthesized in a 1,200 degrees Celsius hydrogen flame likewise AEROXIDE® fumed metal oxides. Both Evonik products are characterized by their high chemical purity and large specific surface area.
AEROXIDE® fumed metal oxides are highly pure aluminum oxides or titanium dioxides applied in a wide range of applications. Evonik's portfolio also consists of a growing range of hydrophobic and mixed oxides grades.

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The Silica specialists at Evonik - Inside to get it right.