
Image courtesy of Dow Chemical Company.

WHITE PAPER

# IMPROVING ADHESIVES & APPLICATION PROCESSES FOR ELECTRIC VEHICLES

Adhesives, sealants, and coatings are widely used in electric vehicle (EV) components and systems. These adhesives must not only be capable of developing strong bonds between surfaces, but they must also be capable of withstanding extreme environmental and operational conditions to ensure high reliability and failure-free operation. Furthermore, since automobile manufacturing and assembly is an inherently high-volume production process, the adhesives must be quickly and easily applied and cured with a high degree of repeatability during manufacturing. This article will discuss the special challenges posed by different applications in the EV industry during manufacturing, assembly, and operation. The article will also discuss how Ellsworth Adhesives, a global distributor of adhesives, specialty chemicals, and dispensing equipment, can assist designers and engineers in the selection, formulation, and application of adhesives in the EV industry.

## ADHESIVE REQUIREMENTS IN EVs

Adhesives, sealants, and coatings are used extensively in EVs in numerous components such as the power electronic modules, battery packs, advanced driver assist systems (ADAS), and electric motors as seen in Figure 1. These applications pose numerous challenges for both design and manufacturing engineers. For example, many of these components operate at very high voltages, requiring dielectric strength and high thermal conductivity while remaining thermally stable over a wide temperature operating range. The adhesives must also provide reliable performance under harsh environmental conditions, including extreme shock, vibration,

temperature, and moisture environments. During manufacturing, the adhesives must exhibit good flow, wetting, adhesion, and cure properties to facilitate rapid assembly and curing. These challenges require that the design and manufacturing engineers match the adhesives to the applications in which they are used and manufacturing operations in which they are dispensed.


Figure 1. Ellsworth Adhesives applications for EVs. Image courtesy of Dow Chemical Company.

## ADHESIVE APPLICATIONS IN EVs

Adhesives are used in various forms in EVs to perform a variety of functions, such as potting and encapsulants, gels and foams, gap fillers, conformal coatings, and thermally and electrically conductive adhesives. A description of these applications is provided below.

### GAP FILLERS, POTTING COMPOUNDS, AND ENCAPSULANTS

Gap fillers, potting compounds, and encapsulants are typically used to surround battery packs and connect heatsinks to other components. Gap fillers are usually made from flexible silicone materials, resins, or polyimide-based phase-change materials that are suitable for use where high dielectric strength and temperature management is needed. They are ideal for use in high-heat applications like battery packs and module assemblies where a high degree of thermal management is required. In fact, thermal management during charge and load is critical to EVs, making quick charging and fact acceleration possible. These materials can be used in the harsh thermal and vibration environments found in transportation vehicles, as they also provide vibration resistance and flexibility without putting stress on internal components. Many chemistries can be varied to meet specific needs, such as UL94 flammability standards.

### CONFORMAL COATINGS

Conformal coatings are often used to help protect components such as control modules since they are so critical to advanced battery operation, particularly in demanding environments. With a broad range of durometers and very low modulus options, silicone conformal coatings deliver stress relief on delicate circuit board components during thermal cycling. A variety of epoxy, acrylic, and urethane-based solutions can also be used depending on specific design needs.

### SEALING AND BONDING

Sealing and bonding solutions include silicone-based form-in-place or liquid gaskets, specialized adhesives for EMI shielding, and more conventional adhesives that must adhere well to the advanced materials used in battery-pack construction. There are a broad range of sealing

applications in battery packs, including sealing the battery module itself, as well as sealing and bonding individual components inside modules. These materials are critical to increasing the strength and reducing the weight of bonded assemblies, increasing passenger safety, and enabling long range.

### LOW-PRESSURE MOLDING

Low-pressure molding is used in some assemblies in the battery module to encase individual components or entire assemblies in thermoplastic materials. While providing a high degree of protection, low-pressure molding can also provide the dielectric insulation needed to meet IP69K standards.

### CONDUCTIVE COATINGS

Conductive coatings are used particularly in lithium-ion construction to improve the performance of electrical contacts. Typically, these materials are self-priming, re-workable, and solventless, and provide fast and durable adhesion for applications requiring heat and electrical transfer.

Each of these applications pose special challenges during manufacturing and assembly, which may affect their performance during operation under extreme environmental conditions.

### ADHESIVE CHEMISTRIES

Various adhesive-based chemistries are available to choose from when using adhesives for EV applications. These must be formulated and selected to meet the specific design, manufacturing, and performance goals, as described below.

### EPOXY

Epoxies feature excellent chemical resistance as well as a high level of ruggedization. They make a good choice for environments where chemical exposure is expected including environmental factors, as well as in constructions that expect heavy use or physical shock.

### SILICONE

Silicone-based adhesives can withstand high-temperature exposure and are flexible even when cured. This allows their use in environments with extreme conditions and can be a good choice where other adhesives would put too much stress on components, or where vibration resistance is needed.

### URETHANE

Urethanes can be formulated with various-hardness cures while providing excellent adhesion in constructions where those considerations are paramount.

### POLYAMIDE

Polyamides are a go-to choice for molding operations and are a low-cost option, making them attractive for a wide range of applications.

Manufacturers must match the appropriate adhesive chemistry to the application to ensure reliable performance when exposed to the wide range of temperature, moisture, and vibration environments encountered during vehicle operation.

## AUTOMATED ADHESIVE DISPENSING TECHNOLOGIES

Adhesives are applied using either manual or automated processes. Manual processes are ideal for low-volume applications and new products. These manual processes range from small hand-held dispensers, such as syringes to larger gantry-mounted dispensing tools (Figure 2). On one hand, manual dispensing processes are advantageous since they have low up-front tooling costs,


Figure 2. Fisnar F6123N Gantry robot.

and the process can be easily optimized as the technology or product design matures. On the other hand, the use of manual dispensing processes may result in excessive waste material, lack of accuracy or consistency, additional training for the workforce, and greater assembly time. As a result, it may be difficult to maintain or increase manufacturing efficiency as production volumes increase.

Automated dispensing processes can help alleviate some of the problems that are inherent with manual dispensing processes. The numerous advantages of such systems include:

**Higher repeatability and accuracy:** Automated dispensers are programmed to accurately dispense the same amount of adhesive in the same location. This will ensure minimal assembly-to-assembly variability.

**Faster production and curing time:** Automated dispensers require minimal set-up time and adhesives can be applied and cured faster than manual processes. Depending on how the process is designed, more parts can be processed in a shorter amount of time.

**Higher quality/fewer rejects, waste, and rework:** Because automated dispensers can be programmed to dispense the correct amount of adhesive at the precise location, there is less waste of product due to error, and the number of rejects and rework will be also be reduced.

**Lower production costs:** Automated dispensers can reduce material costs by using an optimum amount of adhesive resulting in less waste. Labor costs can also be cut by reducing the number of skilled laborers required per assembly. While automated dispensers may require an initially high capital equipment investment, this investment can eventually pay for itself in the ROI of more accurate dispensing and a faster production time.

**Higher organizational expertise:** While additional training may be needed to enable employees to properly operate and maintain automated dispensers, higher organizational efficiency can be achieved by retaining highly skilled employees who can be used on more complicated tasks.

**Lower maintenance costs/production downtime:** Automated dispensers can operate continuously around-the-clock with limited production downtime with regularly scheduled routine preventive maintenance.
Manufacturers in the vehicle industry can benefit by transitioning over to modern adhesive technologies and application systems as production volumes increase.

## ELLSWORTH ADHESIVES AND ROBOTIC APPLICATION SYSTEMS

Ellsworth Adhesives offers the total adhesive solution, including a full range of services, materials, and equipment to suit customer needs through our Fisnar®, Fluid Research®, and MoldMan Systems™ brands. Our engineering sales representatives (ESRs) have extensive knowledge and training, and together with our large network of partners, Ellsworth Adhesives can help select the appropriate adhesive or custom-formulate adhesives for any application.

We have a wide range of meter-mix-dispense solutions and equipment (MMD), with dispensers as small as tabletop robots, to large gantry-style robots. In fact, our equipment can be custom integrated in a variety of ways to create solutions ranging from the most basic to the most complex systems (Figure 3). We can also teach customers how to handle adhesive inventory using the ePlus cloud-based inventory management program, which can provide customers with real-time inventory visibility while specifically focusing on managing shelf life.

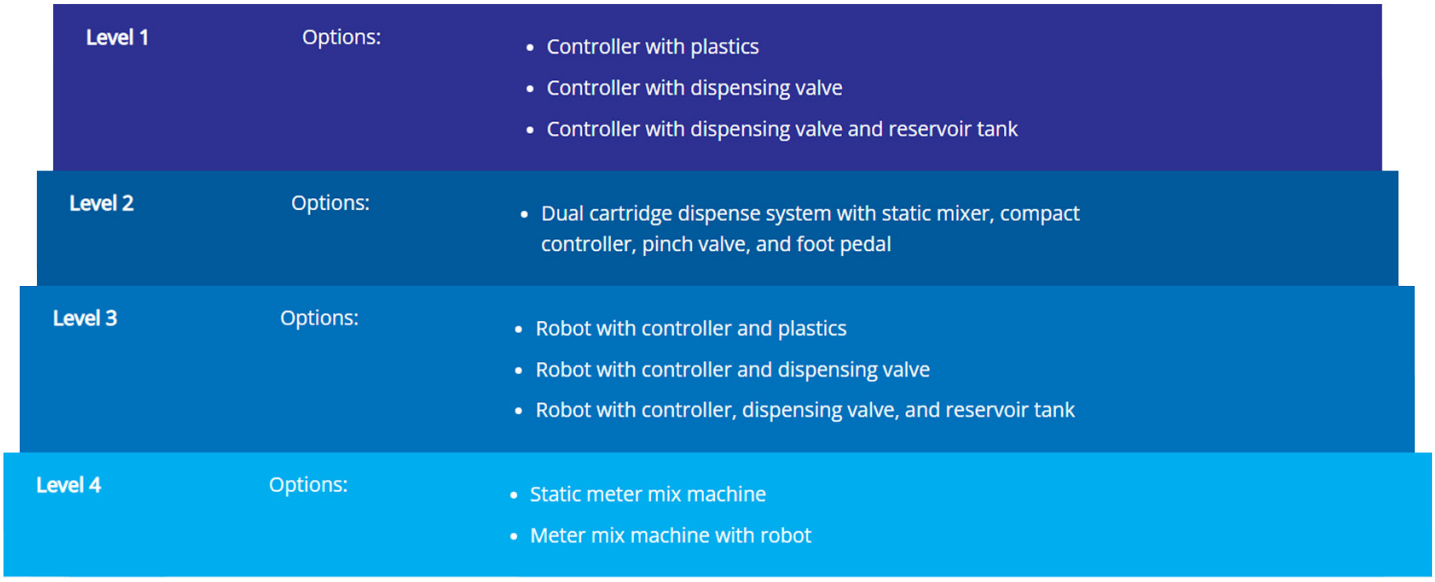


Figure 3. Ellsworth Adhesives offers adhesives and applications systems with various levels of complexity.

## CASE STUDY: LITHIUM-ION BATTERY PACK GASKETS

Ellsworth Adhesives worked with a manufacturer of lithium-ion battery packs to develop a sealing solution using form-in-place gaskets (FIPGs) and cure-in-place gaskets (CIPGs). These gaskets presented numerous manufacturing challenges since the materials ranged from very thin to very thick, and adhesive reaction times varied considerably. The material selection process addressed many environmental and performance requirements, including solvent exposure, thermal swings, adhesion, low compression-set, and self-extinguishing properties.

During the prototype phase, a manual application process was used while optimizing the adhesive chemistry. However, for high-volume production, manual processes were deemed unsustainable due to lack of consistency, speed, reliability, and quality. After a thorough assessment, it was determined that a robotically applied bead utilizing a precision metering pump within an operator-assisted work cell was the optimum solution. This solution provided higher quality, higher performance, and consistent assemblies. This “tool” also offered future design flexibility, as it was not dependent on a pre-formed or die-cut gasket and allowed this approach to be leveraged to other products that were not originally considered.

This solution illustrates how Ellsworth Adhesives products and technology successfully met all customer design criteria and provided unforeseen financial gains along with a differentiated position in the marketplace.

Image courtesy of Dow Chemical Company.

## ELLSWORTH ADHESIVES

Ellsworth Adhesives is a global distributor specializing in the supply and logistics of specialty chemicals and equipment. Besides providing a full product line of meter, mix, and dispensing equipment, Ellsworth Adhesives collaborates with customers to increase efficiency on product lines by improving manufacturing speed and quality, reducing waste and chemical exposure, and cutting costs. Our services include custom formulation, custom labeling and documentation, custom packaging, low pressure molding services, and converting services.

To learn more about additional services offered by Ellsworth Adhesives, visit: https://www.ellsworth.com/services/.

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