Coating Solutions Enabling Advanced Automotive Technologies

By Cynthia Chaukeor, CoatingsTech Contributing Writer

The automotive industry is undergoing a significant transformation. Conventional internal combustion engines (ICEs) are being replaced by batteries in electric vehicles (EVs), and drivetrains will ultimately become passenger engines in autonomous vehicles. Coatings have an important role to play in making these new technologies possible. Beyond their traditional jobs of protecting automotive components from corrosion, abrasion, and ultraviolet (UV) degradation and providing a unique and striking appearance, automotive coatings are already providing additional functional capability. This includes sound-dampening and interior-surface self-healing and easy-to-clean exterior surfaces. Additional performance capabilities are being achieved on a continual basis, with some technologies adapted from other industrial applications and others developed specifically to meet the needs of the evolving automotive sector.

The future of the automotive industry will be heavily dependent on electric and hybrid vehicles, as well as autonomous vehicles, according to Christopher M. Seubert, research engineer in the Paint and Coatings Research Group at the Ford Research and Innovation Center. "As we look at the current industry transformation, the focus is on CASE solutions—connected, autonomous, shared, and electric. Electric, hybrid, and electric vehicles have a future in the automotive industry that will be enabled by technologies that improve performance and efficiency."" Seubert notes, "The new technologies for electric and hybrid vehicles are being developed to meet the needs of the evolving automotive sector. These technologies include advanced coatings that are tailored to meet the specific needs of electric and hybrid vehicles.

Energy Conservation Crucial for Electric/Hybrid Vehicles

Electric and hybrid vehicles are already here today and are expected to represent an increasingly large proportion of the global fleet going forward. Hybrid and EVs, however, carry a higher price tag than ICE vehicles. To make the case for EVs and hybrids more compelling to consumers, car makers are focusing on maximizing range and fuel efficiency. As such, Seubert notes that energy conservation is very important, and the coating of a hot vehicle using air conditioning is a very energy-intensive process. In addition to contributing to reducing energy consumption, coating, when applied to EVs and hybrids, will help handle the heat management requirements around batteries and electric motors, according to Seubert. "External coatings with infrared-reflective pigments will keep the cabin cooler to reduce the need for extra energy to power air conditioning. That helps the electric car go farther on a single charge," he says. Of particular interest are dyes that can increase the total solar reflectivity (TSR) of the exterior paint system, such as those that can provide black metal similar to that achieved from standard carbon black pigments, adds Seubert. "Development of advanced reflective coatings must, in fact, be achieved while meeting consumer expectations for color and overall appearance. Car makers follow color trends very closely, looking to industries such as fashion and interior design to determine the options that should be developed," explains Paul Czormij, BASF design manager in charge of color and trends. "Each year, BASF creates 65 novel "and innovative designs to capture color trends that may be seen on the road three to five model years in the future. We expect automakers to ask for more deeply saturated colors—like rich blues—to help them claim their place in the market. Developments in pigments and dispersions are making these new chromatic colors possible. In addition to reducing fuel consumption, the use of metallic shades to be more eye-catching, playful, and evocative. A car's character lines and body style become even more expressive with these colors," he says.

Under the hood of these electric and hybrid vehicles are other opportunities for the coatings industry, according to Michael T. Venturini, marketing director for Coatings at Sun Chemical. "The use of coatings and materials on the exterior of these cars is already increasing, as components on the exterior of these cars are exposed to harsher conditions and require a more durable protective coating," he says. "This is especially true for the exhaust systems, which require a coating that can withstand high temperatures and exposure to corrosive gases. The use of coatings on the exterior of these cars is also increasing, as the exterior of these cars is exposed to harsher conditions and requires a more durable protective coating." "There are somewhere on the order of two to four times the coating opportunities in EVs compared to conventional combustion engine vehicles. The coatings must provide functionalities for fire protection, corrosion, and mechanical resistance and thermal conductivity, and to ensure long-term battery cycle performance. Thermal control systems that help moderate the temperature at the interfaces between the battery systems and battery management system rely on coating and adhesive technologies as well. The need to seal and protect battery pack coatings provide opportunities for fire protection materials. Coatings that provide protection against electromagnetic interference are needed to shield electronics in vehicle communication systems from the large magnetic field generated by vehicle batteries, according to Votrubca-Dral. Positive temperature coefficient coatings, meanwhile, offers creative solutions when there is no large heat source available from an internal combustion engine. These coatings can be deposited in a pattern on surfaces, such as seats, door panels, and floors, enabling localized heat when a current is applied. Thermoelastic coatings, meanwhile, take advantage of temperature differences generated over all electric cars, from the sun on the vehicle panels, inside the cabin, to motor parts and electrical batteries—and can generate electric current. "While flexible thermoelectric materials and coatings are at their early stages, if these coatings are low-cost, there could be an opportunity to use them to generate an electrical current for the vehicle," Venturini explains. "Coating manufacturers are also challenged by the use of thick metal sections in EVs and hybrids to not only support the heavy battery systems but also protect them from collision. These sections have significant thermal mass, and it takes a lot of energy and time in the oven to heat these sections to traditional cure temperatures (400°F). Formulators are actively developing coatings that cure at lower temperatures, allowing the use of existing oven configurations while reducing energy consumption and CO2 emissions, and increasing efficiency and productivity, according to Votrubca-Dral. "With these new coating systems, it is possible to use existing wet-on-wet and other compact approaches," he comments.

Mixed Substrates Are Becoming the Norm

Lightweighting of EVs and hybrid structural components is another approach to energy conservation. Many new and dissimilar materials are being used to assemble these vehicles to allow for the incorporation of heavy battery packs. Newer vehicles, regardless of the powertrain, and, in fact, being constructed of lighter-weight materials to achieve lower fuel economy. The goal, according to Todd Taggert, technical manager Surface Treatment Processes—Metal Pretreatment with Hendel Corporation, is to reduce car weights by 10% to 20% to drive efficiency improvements of five to eight percent. The use of lighter-weight metals and various types of composites is increasing dramatically. "These new metals and composites cannot be joined using traditional spot welding; however, structural bonding and reinforcement, as well as noise vibration and harshness, must be achieved using novel adhesives and sealants," Votrubca-Dral observes.
Advanced Automotive Technologies

By Cynthia Chatkoer, CoatingsTec Contributing Writer

The automotive industry is undergoing a significant transformation. Conventional internal combustion engines (ICEs) are being replaced by battery-electric vehicles (BEVs), and drivers will ultimately become passengers in autonomous vehicles (AVs). Coatings have an important role to play in making these new technologies possible. Beyond their traditional jobs of protecting automotive components from corrosion, abrasion, and ultraviolet (UV) degradation and providing a unique and striking appearance, automotive coatings are already providing additional functional benefits.

ENERGY CONSERVATION CRUCIAL FOR ELECTRIC HYBRID VEHICLES

Electric and hybrid vehicles are already here and are expected to represent up to 20% of new car sales by 2025. In order to meet the goals of lower emissions and greater fuel efficiency, electric and hybrid vehicle manufacturers are focusing on improving the efficiency of their existing models and developing new technologies.

There are somewhere on the order of two to four times the coating opportunities in EVs compared to conventional combustion engine vehicles.

By Michael T. Venturelli, marketing director for Coatings at Sun Chemical. Three examples include thermally conductive coatings, fluids for battery pack control, and coatings that insulate the layers of wires and cables required in these cars.

We expect automakers to ask for more deeply saturated colors to help them claim their place in the market.

MIXED SUBSTRATES ARE BECOMING THE NORM

Lightweighting of EV and hybrid structural components is another approach to energy conservation. Many new and dissimilar materials are being used to assemble these vehicles for the incorporation of heavier battery packs. All new vehicles, regardless of the powertrain, are, in fact, being constructed of lighter-weight materials to achieve better fuel economy.

The goal, according to Todd Saggers, technical manager Surface Treatment Processes—Metal Pretreatment with Hendel Corporation, is to reduce car weights by 10% to 20% and to drive efficiency improvements of five to eight percent. The use of lighter-weight metals and various types of composites is increasing dramatically.
Coating systems must also now be formulated with the ability to adhere to these very different substrates—as well as provide solar reflectivity, corrosion protection, and the desired appearance—at the same time as these systems are becoming thinner and designed with fewer layers. "As automakers change their products, coatings will have to adapt," asserts Sean McKen, BASF vice president of Global Key Account Management. "New coatings will be used to resist corrosion more than ever, while reducing overall weight and cost," he adds. There is also a desire to reduce the temperature required to cure exterior coating systems used on these vehicles, because many of the new substrates cannot survive the current cure temperatures. BASF, for instance, has developed coating systems with reduced cure requirements that allow the OEMs to utilize one paint system to paint the entire mixed-substrate vehicle," McKen says.

Surface treatment coatings are also very important for newer vehicles manufactured using more lightweight metals. The unique properties of lightweight coating pretreatments are available, according to Coggin, electro-ceramic coatings, zincum coatings, and titanium base. Battery-heavy and electric vehicle coatings require the lightweighting that aluminum and magnesium offer while still benefiting from corrosion protection and the excellent base they establish for adhesives and paints," he says. He notes that the biggest challenge that these coatings must overcome is the inconsistent surface cleaning and de-oxydizing observed for the different lightweight metals used today. "A key focus at Henkel, therefore, is the development of coating technologies that keep pushing the boundaries of providing uniform surfaces prior to coating," Coggin notes. He also says that Henkel is consistently investigating new additives for performance and durability leveraging various sustainable sources. One example of a new offering is the company's electro-ceramic coatings, which are produced using a patented plasma deposition process. To date, cericium coatings and titanium base have experienced the widest adoption because they have been around the longest, are the least expensive to use, and the production part approval process is available online, according to Theresa Niemi, technical manager Surface Treatment Processes—Light Metal Pretreatment with Henkel Corporation. "Electro-ceramic coating, she says, offers outstanding features of corrosion protection, friction reduction, heat resistance, and it provides an excellent base for paint, adhesives, and coatings. It is designed specifically to be applied to aluminum, magnesium, and titanium. The key is to choose the right materials for the metal基 and Lindar units and cameras do. There is, however, a push to locate them behind solid parts, such as bumper fascias, to hide them from view. These locations, however, require the radiator waves to pass through the fascia substrate, as well as the front paint system. Even so, it is imperative that the single intensity of the emitted and returned signal does not attenuate so much that detection distance or fidelity is compromised, according to Seubert. "Bumper fascias and coatings must, therefore, be formulated and applied such that the RADAR signal does not significantly diminish during operation," he explains. Metallic pigments in the basecoat are the greatest concern, because they can cause significant attenuation, and thus currently OEMs are limiting the quantities of aluminum and other metallic flakes contained within paint systems used on AVs, Seubert notes.

Ultimately, the biggest challenge to developing coating technologies for autonomous vehicles in the fact that the performance targets are still unknown for both the sensor systems and the coatings used on them, according to Seubert. "Both technology and design are changing, and the coatings used on these sensors must also adapt to those changes. In addition, the government has yet to decide what, if any, requirements and restrictions can be put on AVs and the sensors/materials used. Without industry-wide or governmental requirements, each AV manufacturer will continue to develop their AV platforms to the best of their abilities," he explains.

**CONNECTED AND SHARED OPPORTUNITIES**

In the connected vehicle space, PPG has observed an exponential increase in the number of antennas and communication inputs to vehicles. There is a growing interest, notes Votrub-Drazal, in the use of conductive coatings to form antenna patterns that serve as RFID antennas. "Using conductive inks and coatings, makes it possible to print an antenna into the configuration of the car," he notes. Votrub-Drazal stresses, again, that for antennas and sensors placed behind body panels, the coatings cannot have obstructive properties that could interfere with the antenna/sensor technology. "For instance," he notes, "metallic effect pigments may interfere with certain wavelengths, while pearlescent pigments are less obstructive. The former may, therefore, find higher usage in vehicle coloration as vehicles-to-vehicle communication becomes more widespread.

"Shared ridership and autonomous vehicles as well—will affect coatings used in vehicle interiors. The focus in these cases will be less about the driver experience and more about the passenger experience, according to Votrub-Drazal. A host of coating opportunities are emerging as a result. "Much larger touch screens for vehicle displays and the coatings used in LIDAR applications, incorporation of NIR pigments into coatings can dramatically increase the reflectivity of dark colors, even to the point where black reflects similarly to white..." The enhanced reflectivity of the vehicle improves the reliability of LIDAR sensors in inclement weather and challenging light conditions.

Coating systems must also now be formulated with the ability to adhere to these very different substrates—"as well as provide solar reflectivity, corrosion protection, and the desired appearance."
The use of lighter-weight metals and various types of composites is increasing dramatically. The biggest challenge to note is that these coatings must overcome the inconsistent surface cleaning and de-oxidizing observed for the different lightweight metals used today.

**SENSOR CHALLENGES FOR AUTONOMOUS VEHICLES**

It is expected that AVs will be used 24 hours a day, 7 days a week, unless repairs or maintenance are needed, to haul both people and products/goods, according to Seubert. “At this usage rate, the realistic lifetime of these vehicles is three to five years,” he notes.

While AVs are further out on the development timeline, they have their own set of coatings challenges, most notably related to supporting the uninterrupted transfer of data between the computer driver, sensors, and the communication system. One of the main types of sensors are employed on AVs cameras, light detection and ranging (LIDAR), and radio detection and ranging (Radar) systems. “Coatings will have to reflect LIDAR, not interfere with and not absorb Radar, and interact seamlessly with various sensor assemblies, adding to the reliability of the entire transportation ecosystem,” says Cranfill. When selecting a pigment for AVs, therefore, the reflective signature of the pigment in relationship to the wavelengths being used by the detectors is important. “It is necessary to understand these parameters. Finding the right balance of coating reflectivity, transparency, and adhesion is key to successful AVs,” he says.

In AV applications, incorporation of NIR pigments into coatings can dramatically increase the reflectivity of dark colors, even to the point where black reflects similarly to white. The enhanced reflectivity of the vehicle improves the reliability of LIDAR sensors used on them, according to Seubert. “Both technology and design continue to change, and the coatings used on these sensors must also adapt to those changes. In addition, the government has yet to decide what, if any, requirements and restrictions they will have on the sensors/materials used. Without industry-wide or governmental requirements, each AV manufacturer will continue to develop their AV platforms to the best of their abilities,” he explains.

**CONNECTED AND SHARED OPPORTUNITIES**

In the connected vehicle space, PPG has observed an exponential increase in the number of antennas and communication inputs to vehicles. There is a growing interest, notes Vorhauer, in the use of conductive coatings to form patterns that serve as RFID antennas. “Using conductive inks and coatings makes it possible to print an antenna into the configuration of the car,” he notes. Venturiello stresses, again, that for antennas and sensors placed behind body panels, the coatings cannot have obstructive properties that could interfere with the antenna/sensor technology. “For instance,” he notes, “metallic effect pigments may interfere with certain wavelengths, while pearlescent pigments are less obstructive.”

In LIDAR applications, incorporation of NIR pigments into coatings can dramatically increase the reflectivity of dark colors, even to the point where black reflects similarly to white. The enhanced reflectivity of the vehicle improves the reliability of LIDAR sensors in inclement weather and challenging light conditions.

Coating systems must also now be formulated with the ability to adhere to these very different substrates—as well as provide solar reflectivity, corrosion protection, and the desired appearance.
Several sustainability trends continue to drive market innovation, including low-temperature cure and integrated processes to compress the paint shop footprint and reduce energy usage.

On personal consumer electronic products—anti-glare, anti-scratch, anti-fingerprint—it will need to be translated to vehicles. Liquid-applied sound damping (LASD) and liquid-applied sound barrier (LASB) technologies are also emerging as major trends in the automotive industry. These technologies can help reduce unwanted noise experienced by drivers and passengers inside the cabin, providing a more comfortable driving experience.

GROWING POPULARITY OF CONTRAST-COLOR CANOPIES

Two-tone styling has become increasingly popular and has moved from side panels and fender wells to the full vehicle. The latest trend in car styling is contrast-color canopies, which set the roof apart from the rest of the vehicle. This trend has been gaining popularity, especially in luxury and performance vehicles.

SUSTAINABILITY CONTINUES TO BE AT THE FOREFRONT

Several sustainability trends continue to drive market innovation, including low-temperature cure and integrated processes to compress the paint shop footprint and reduce energy usage, according to Carrelli. Governments around the world are also recognizing the importance of sustainability and are establishing new standards for vehicle emissions. By applying these technologies, automakers can help reduce the environmental impact of their vehicles and move towards a more sustainable future.
Several sustainability trends continue to drive market innovation, including low-temperature cure and integrated processes to compress the paint shop footprint and reduce energy usage.

Growing popularity of contrast-color canopies

Two-tone styling has become increasingly popular and has moved from side panels and window trim to vehicle roofs. The latest trend in car styling is contrast-color canopies, in which the roof of the car is a different color than the body. This design trend has taken off quickly. There is always a push to differentiate the look of vehicles, and contrast-color canopies are one of the latest ways to achieve that goal. However, there are also cost and performance problems, particularly with regard to adhesion of the roof paint. New products are being developed specifically for the automotive market.

There is a recognition by paint shops that the use of robots that can apply paint with high precision, which should make it possible to perform two-tone applications inline, and dramatically increase throughput.

Sustainability continues to be at the forefront

Several sustainability trends continue to drive market innovation, including low-temperature cure and integrated processes to compress the paint shop footprint and reduce energy usage, according to Cantrill. Governments around the world also sense the need to establish new standards for lower VOCs.

“Cantrill says the increased environmental consciousness of consumers is driving the demand for lower-VOC products.”

“Cantrill says the increased environmental consciousness of consumers is driving the demand for lower-VOC products.”

There is a recognition by paint shops that the use of robots that can apply paint with high precision, which should make it possible to perform two-tone applications inline, and dramatically increase throughput.

Many design concepts

That overlap is reflected in BASF’s most recent trend predictions, which Cantrill says aim to visually relate to the new technology focus in the automotive market and reflect responsibility for the environment. “New coatings containing materials from renewable resources while minimizing environmental impact and carbon footprint will help automakers connect with this part of their consumer base,” he says. PPG is energized by the opportunity to leverage specialized coating technologies that have developed for the automotive market. “What is most exciting is the way our technology is evolving very rapidly, with new groups within the OEMs trying to understand what they can do today,” he says. “It’s a paradigm shift, and value in the future as the industry moves away from the size and power of the engine as the determining factor to autonomous, connected, electrified vehicles.”

In fact, the greatest difficulty may be the large number of possible design concepts. “With so many appearances, it is essential to understand the risks associated with each in order to determine which ones to focus on,” he concludes. Clearly, it is a challenge the coatings industry welcomes.