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E-coat Technologies and Where They Fit

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Electrocoat has been used for years in the automotive and industrial markets. But in the years since its introduction, new E-coat products have been developed for end uses requiring different properties, such as UV resistance, low-temperature cure, and corrosion and UV resistance combined with bulk application.

Electrocoat is increasingly being used to finish products that require a combination of durability and corrosion resistance. (Photos courtesy of PPG Industries)

The Ford Motor Co. first used anionic E-coat to paint steel wheels and automotive bodies. Ford wanted a primer that could be applied uniformly over the entire surface and provide improved performance. At the time, most primers were applied by spray application, which was not able to apply a coating into the recessed areas of the car body with consistent coverage. The E-coat process allowed the entire body to be uniformly coated in about two minutes.

After many years of development work, cationic E-coat was patented and commercialized in 1971 by PPG Industries. The appliance industry became the proving ground for the new E-coat process. Washing machines and dryers were primed with a low-film-build cationic epoxy coating that withstood the rigors of detergent testing and provided the manufacturer with a controlled film build and a corrosion-resistant product in a short application time.

The automotive industry began testing this new product and soon found that corrosion performance could again be improved. In 1976, the automotive industry followed the appliance industry and began using cationic epoxy E-coat technology.

Expanding markets

In the 1980s, the automotive industry began using high-film-build systems, which applied a thicker coating of E-coat and eliminated the need for the primer surfacer. This improved process time and provided a more uniform substrate for the top-coating process.

This decade also saw the introduction of cationic acrylic technology. Once only available in the anionic process, cationic acrylic technology provided excellent outdoor durability. Applications that required durability properties could utilize the processing improvements that E-coat provided.

In the 1990s, the technology continued to develop, but was pushed by environmental concerns over VOCs and HAPs. Although E-coat was always ahead of other technologies environmentally, new legislation forced the continued elimination of solvents, heavy metals and film modifiers typically used in E-coat technologies.

Some coating manufacturers chose to stay their ground and utilize “end of stack” technologies to deal with their emissions rather than change their process. Other manufacturers found new solvents that provided similar rheology characteristics and met the limits on VOCs and HAPs.

With these changes in the environmental requirements, performance requirements were pushed to the limit. Increased corrosion protection, cycle testing, durability and other performance criteria were pushed to improve. As the environmental and performance requirement bar was raised, E-coat technologies were there to provide a process to meet industry demands.

Understanding the technologies

There are two specific electrocoat processes, anionic and cationic, both of which are commonly used. The anionic process involves placing a positive charge on the part while the paint bath is negatively charged. This process is commonly used in the general metal industry where low cost, color control and ease of operation are the driving forces. Many parts that are in noncorrosive environments are processed through this type of system.

The cationic E-coat process is used to provide a more corrosion-resistant film. The part to be coated has a negative charge; the paint bath, a positive charge.

The process involves driving charged particles out of a water suspension to a part capable of conducting a charge. It is a rather simple electrical process of positive and negative charges being attracted to each other while like charges repel.

The electrical charge seeks out the path of least resistance and coats the exterior portions of the part or parts nearest to the counter electrode. As the process continues, the charged particles resume their search for uncoated portions of the part and begin coating areas that are not as easily reached. This ability to coat hard-to-reach areas of the part is known as the paint’s throw power.

During the deposition process, the part's electrical resistance begins to build as the E-coat film is deposited, driving the coating process to another portion of the part or another part on the rack. The film build is controlled by the amount of voltage applied and is self-limiting. After a short dwell time, all conductive areas of the part have been coated.

There are many process advantages of electrocoating, including total coverage of densely loaded racks and complex parts with a uniform film build; transfer efficiency routinely in the 95 to 99% range; highly automated systems with high throughput and low operating costs; environmental compliance for air and wastewater emissions; high line speeds; heavy-metal-free formulas; and workplace safety.

E-coat formulas are typically based on either epoxy or acrylic chemistry. Epoxy chemistry is used in environments where corrosion protection is paramount. It inherently provides superior results in salt-spray and cycle-corrosion testing.

Acrylic systems are used in applications requiring outstanding durability or color control. Recently, coating requirements have focused on providing both superior corrosion protection and durability. These hybrid systems are finding more use in the industrial market as coating requirements change.

Automotive end-use gains

The automotive uses of E-coat continue to focus on epoxy technology for corrosion protection. OEMs continue to use new generations of cationic epoxy technology for car and truck bodies. Lower HAP- and VOC-containing systems continue to be developed to meet stringent environmental regulations. The OEM, looking to provide longer warranties against rust, utilizes higher-edge-coverage coatings systems.

The automotive parts and accessories market continues to use cationic epoxy technology. This market segment is unique in that hundreds of different parts are processed through a single coating system. This requires skillful rack design and unparalleled system maintenance.

Advances in OEM product technology are used by the APA custom coater to provide corrosion performance on underbody and underhood parts and aftermarket parts. For example, edge coverage has always been a source of premature corrosion because as the paint begins to cure, it tends to flow away from sharp edges. By modifying the rheology of the coating, manufacturers are able to keep more paint on part edges.

Low-shrinkage and lower-temperature-cure E-coat products provide the custom coater with additional operational control and also save paint. Other technology advances have increased the coating's environmental compliance.

The automotive market accounts for a large portion of E-coat users. Advances have been made in the coating of frames, engine cradles and chassis; fasteners; radiators; and assemblies.

Cationic epoxy technology is replacing hot-wax applications used for more than 20 years on frames. The epoxy technology provides improved corrosion protection, extending warranties from three years with hot wax to 10 years with E-coat, by improving the edge protection and coating uniformity on the frames. This coating also reduces vehicle weight and does not require the frame to be shielded from the exhaust system, as is necessary with the hot-wax coating. Engine cradles and chassis are reaping the same advantages.

Fastener manufacturers are now using anionic and cationic E-coat to replace dip and spin application processes. Application methods for fastener coatings include barrel, bulk or belt. This provides improved processing of the fasteners, which are able to be coated in a single pass compared to multiple passes with the dip and spin processes. There are fewer touch marks, and individual fasteners are not stuck together in clumps.

New fastener coating systems with improved edge coverage also provide improved corrosion protection on the threads and slotted heads. These advantages have improved the quality of the coated fastener and reduced the overall coating cost.

Currently coated with a low-cost spray, radiators are a natural fit for cationic epoxy E-coat. It is nearly impossible to provide a uniform film with a spray application because the fins of the core are so dense. The E-coat process provides uniform coverage of the entire core and added corrosion protection. Formulas with high edge coverage protect the sharp edges of radiator fins. Market applications include automotive, heavy machinery, and residential and industrial air conditioning units.

As manufacturing processes change, more heat-sensitive components are being assembled prior to coating. These assemblies are either not painted or coated with an air-dry product that provides minimal, if any, properties. Lower-temperature-cure E-coat products are now used on these assemblies, improving processing and providing improved corrosion protection. Although cure temperature is the driving criteria for product selection, E-coat products are available that cure as low as 200°F for these applications.

Industrial applications

The industrial, or general metal finishing, market has also seen advances in E-coat products and processes. The market is driven, like automotive, by cost and environmental compliance. Permitting issues for air and water discharge can limit the product selection for these coaters. However, the multiple E-coat technologies offered today have provided some of the best available technology for this market segment. These include anionic epoxy, anionic acrylic, cationic epoxy and cationic acrylic.

The industrial coater usually manufactures its own product and has a set production schedule. Parts are of similar design, which eliminates some of the challenges of part racking. Finishing system control is also somewhat easier because the complete system processing can be controlled to very specific requirements.

The durable finishes market, which includes HVAC, lawn and garden, and agriculture and construction equipment, is a leader in acrylic technology. Although this represents a wide array of manufacturers, they all have a common thread: durability. While the majority of these coatings are supplied as a cationic coating, interior durable products, such as metal office furniture and air handling equipment, utilize anionic acrylic technology.

The durable and corrosion-resistant market is one of the fastest growing segments within general metal finishing. These “hybrid-type” systems are employed in locations that require outstanding outdoor durability and protection from mildly corrosive environments. They typically compromise some corrosion protection to achieve the durability requirements and give up some durability to match corrosion needs.

These coatings are used in home laundry, electrical switchgear, commercial refrigeration units, HVAC and automotive. Coating systems requirements are much more stringent to maintain the high quality demands of the coatings. Phosphate coatings are optimized to provide an added measure of corrosion protection, E-coat bath parameters need to be controlled within finite ranges, and curing systems must be tightly maintained to ensure color control.

Products used in severe corrosion environments typically were given a primer and a spray topcoat to meet durability requirements. Two-coat E-coat is a perfect fit for this environment. An E-coat primer, typically a cationic epoxy, is initially applied to the part. It becomes conductive when cured, providing the corrosion resistance of the finishing system. The topcoat can be either another cationic epoxy or a cationic acrylic, depending on the durability requirement.

This high-film-build, two-layer coating has been a perfect fit for several markets. Companies in the transformer market are able to apply a controlled film build into the recessed areas of the transformer, which is very difficult to achieve with a spray coating.

The marine industry has found two-coat E-coat the answer for continuous exposure to wet environments. Construction equipment manufacturers have used this application on equipment that is exposed to unique environments. However, this finishing system may be limited because it requires two separate E-coat tanks and post rinses.

Film build control of the conductive primer is critical to ensure a uniform topcoat application. Topcoat UV transmittance is important for the overall longevity of the coating package. If UV is allowed to permeate through the topcoat and degrade the epoxy primer, premature failure will occur.

E-coat formulas are also being developed as a decorative finish for plated or extruded products. These parts are currently finished with a spray-applied clear or lacquer to protect the finish. Clear and colored clears are used in the hardware and plumbing fixture market to replace these finishes. Clear anionic acrylic finishes allow the base metal finish to show through.

Automotive aluminum trim is also now finished with a similar coating for running boards and support pillars. These coatings must provide excellent adhesion to the aluminum substrate and be durable for the life of the vehicle.

Moving forward

The use of cationic and anionic E-coat continues to grow in all metal-finishing markets. With advances in product performance, application techniques and environmental compliance, E-coat will continue to raise the bar in the coatings industry.

Cationic epoxy research continues to improve corrosion performance, weight loss and operational efficiencies. The use of acrylic technology will expand as durability and corrosion performance is improved. Anionic development continues to be used to meet increasingly tougher color and performance requirements.

Equipment developments, too, are expanding the use of E-coat. The general trend in new-equipment installations has been smaller systems with more versatility. All of these advancements will help the E-coat industry to grow.

/ Jim Gezo is PPG's customer service manager, Industrial Electrocoat.

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