Today's Automotive Coatings Are Thankfully Not What They Used To Be!

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For as long as there have been automobiles, there have been coatings on them for both aesthetics and protection. Over the past 100+ years, cars have undergone broad and continuous changes in styling, engineering, materials, etc. At the same time, the coatings have undergone an equivalent evolution in technology. This article will cover some of those changes and how they influence the automotive coatings that stylize and protect today's vehicles.

In the early days, cars featured a lot of wood in their construction. As a result, the air-dry varnishes were the same coatings used on wood furniture and horse-drawn carriages. These were brush applied in multiple coats and often took days to fully dry – hardly a problem when cars were hand-built in small volume.

In the 1920's, nitrocellulose lacquer systems were developed. These coatings were a major step forward over the air-dry varnishes in terms of appearance. Because they were "thermoplastic", that is become soft and pliable when heated, they could easily be buffed to remove dirt, scratches, and other mars on the painted surface. Unfortunately, this "soft" nature did not give these coatings the best chemical resistance, meaning that they were very prone to being damaged if they came in contact with gasoline during refueling. By the mid-1950's, though, acrylic lacquers were developed, providing much improved chemical resistance and durability. They also offered a much wider range of colors than previously available, including metallics. Because these lacquer coatings were spray applied, they also helped facilitate the evolution of the mass-produced cars. While lacquers were air-dried, this process could be sped up with the application of some low-level heat.

Concurrent with the development of lacquer coatings was the advent of alkyd enamel paints. Enamels formed a very durable film through a chemical reaction after they were sprayed and then baked in an oven. These coatings are "thermoset", in that the heat catalyzes a molecular reaction that results in a 3-D network of bonds – giving the coating better chemical and heat resistance than thermoplastic coatings because they can not be "re-melted" like lacquers. Unfortunately, those alkyd enamels did not have the best resistance to sunlight – fading and/or dulling in a matter of months. The introduction of "acrylic" enamels in the early 1960's addressed this problem.

As Figure 1 illustrates, in spite of the conversion to acrylic-based technology in both lacquers and enamels, these "mono-coat" systems still lacked a degree of durability when it came to retaining gloss and overall appearance over the long-term. While better than their predecessors, the fact that the pigment and metallic flake was not far

from the surface still remained a problem. For those old enough to remember, you might recall that your rag matched the color of your car once you got done waxing it back then. That is because you rubbed off some of that pigment that was just below the surface!

The next major step in automotive coatings development came in the 1970's when basecoat/clearcoat systems were developed and introduced. The major difference here from previous systems is that the majority of the base polymer is separated from the pigments and/or metallic flakes – leaving just enough to allow them to be sprayed. The bulk of the base polymer is instead used to create a clear enamel finish that is sprayed over the base color coat. As shown in Figure 2, this clearcoat "insulates" the pigments and metallics flakes from adverse environmental factors. The addition of UV absorbers and scavengers to the clearcoat further protects the pigments from the harmful effects of UV rays in sunlight. This technology has been refined over the ensuing years such that very few vehicles today are coated with anything other than basecoat/clearcoat systems.

As the car companies began to differentiate themselves with new technical features (e.g. ABS brakes) and sleek, stylized car bodies, the full impact of the color of the car also began to be appreciated. In fact, it is now estimated that as many as 40% of car buyers will switch brands if they can't get the color that they want. As a result, today's buyers have an enormous number of colors and special effects from which to choose – from bright vibrant colors, to shiny metallized appearances, to elegant subtle pearls. While many of these colors and effects are certainly the result of advancements in pigment technologies, it all has been made possible by basecoat/clearcoat systems because of the protection that it gives these newer pigments and flakes. In addition to providing protection, clearcoats also add to the visual appearance by refracting light more and by creating a "depth of image", much like a picture looks when under glass.

So, is there anywhere else for automotive coatings to go? The answer is a definite "yes", but sometimes in not very obvious ways. The first area is to develop even more durable coatings. As the manufacturers have improved the performance and durability of their engines, drive trains and vehicle bodies from wear, tear and corrosion, they have been able to offer longer and longer warranties. Thus, the coatings system is also expected to offer increased durability and resistance to such adverse factors like acid rain, tree sap, bird droppings, pollen, etc. To that end, the industry has focused on not only improving existing technologies, but also is investigating alternative "clearcoats". For example, clear powder coatings have successfully been applied over basecoats resulting in ceramic-like finishes with excellent aesthetics

and performance characteristics. The lamination of both clear and colored films to exterior body components has also been demonstrated. While there are many notable advantages associated with these new concepts, there are also enough drawbacks at this point in time to unfortunately keep these out of the mainstream. Yet, you cannot assume that these issues will go unresolved, as there are benefits to productivity, performance and aesthetics.

Another emerging field is nanotechnology, which is the use of raw materials and additives that are 10 microns or smaller. These extremely small particles are able to do things that their more standard-sized cousins are not. For example, nano-sized pigments yield more chromatic colors, thus giving the automotive color stylists more color options to offer their customers. There are also nano-sized additives that are being used to improve the mar and scratch resistance of clearcoats – something that everyone who has ever parked a car at a mall parking lot will appreciate. An even more appealing nano-based development being pursued is a clearcoat that is "self-healing" and actually "repairs" day-to-day scratches by re-flowing the clearcoat when exposed to warm temperatures.

A lot of time here has been spent talking about automotive topcoats because that is what the consumer sees. Yet, we should spend a few moments talking about the primers underneath these coatings, as they perform equally valuable roles. Like any building, its strength begins with a foundation that is sturdy, well-built and securely-attached to the ground. The same can be said for primer coatings. As shown in Figure 3, it all starts with the electrodeposition primer, or E-coat, which is a unique epoxy-based coating providing complete coverage at low film builds and excellent film properties. Because the car body is immersed in this primer, there is complete coverage. In addition, the paint particles are positively charged and are attracted to the negatively-charged body resulting in superb adhesion between the primer and the metal, as well as outstanding corrosion resistance. In conjunction with today's double galvanized steel, E-coat primers have significantly reduced the rust spots that used to develop around a scratch or gouge. The adhesion and the corrosion resistance are so good that it now inhibits migration of moisture from the scratch to the adjacent areas where rust used to readily form – forming unsightly and damaging blisters.

As the illustration shows, there are also primers that are used in areas vulnerable to stone chipping, for example lower rocker panels. While the basecoat/clearcoat might be damaged from severe stone impingement, the anti-chip primer helps to minimize chipping all the way down to the bare metal. Primer-surfacers are used throughout the

rest of the vehicle to provide a smooth surface for the subsequent basecoat/clearcoat. In some cases, this primer-surfacer may also be tinted to a color compatible with the basecoat to assist in its color development, as well as to provide a more appealing undercoat than the light gray of traditional primers should the basecoat/clearcoat be damaged at that shopping mall parking lot.

No discussion about automotive coatings would be complete if we did not cover vehicle repainting. As one would surmise, auto refinish coatings have had to keep pace with the many changes to OEM coatings that have been described here. At one time, refinish coatings were also based on nitrocellulose, which degraded fairly quickly on exterior exposure and suffered from the same lack of gasoline resistance. Later, modified or synthetic alkyds were used, as were acrylic lacquers. All these systems were readily used by autobody repair shops everywhere because they were easy to spray. Today, refinishing is almost entirely done with polyurethane-based basecoat/clearcoat systems. While not exactly the same chemistry as the original factory finish, these new aftermarket systems provide comparable quality. The addition of a wider range of available pigments and flakes, coupled with a required high level of training, has all but eliminated color mismatches when a repair is done.

A final factor that has and will continue to impact the automotive coatings – both OEM and aftermarket – is the industry's desire to develop maximum performing products with the least impact on the environment. The early coating systems were all formulated with high levels of petroleum-based solvents, as that was the only way for these systems to be sprayed. Many of these solvents have since been designated as being harmful to the environment, so efforts have been made to greatly reduce, if not eliminate, them. Today's coatings instead have very little of these solvents (known as high-solids systems), or no solvents at all (known as 100% solids). In many cases, these petroleum-based solvents have been replaced all together by water as the diluent. Advancements in application technology have also aided the industry by improving the transfer efficiency of the paint to the car body – thus reducing the amount of paint particles that go "up the stack" and lessening overall waste. This is taken to an even higher level with E-coat (where the excess primer falls back into the tank for reuse), and with powder coatings (where the overspray is collected and reused).

The phrase "the good old days" is not one that seems to apply to automotive coatings. The industry has greatly evolved – from cars made with wood and steel to ones made with aluminum and plastics. So, too, have the coatings changed. As consumers' taste for vehicle

colors has become more sophisticated, the industry has responded with an almost limitless array of colors and special effects to dazzle us. Finally, as expectations for performance and durability have grown higher and higher, the industry continually has developed coatings technologies that meet those expectations while being mindful of its obligation to the environment. In many ways, the "good new days" are yet to come.

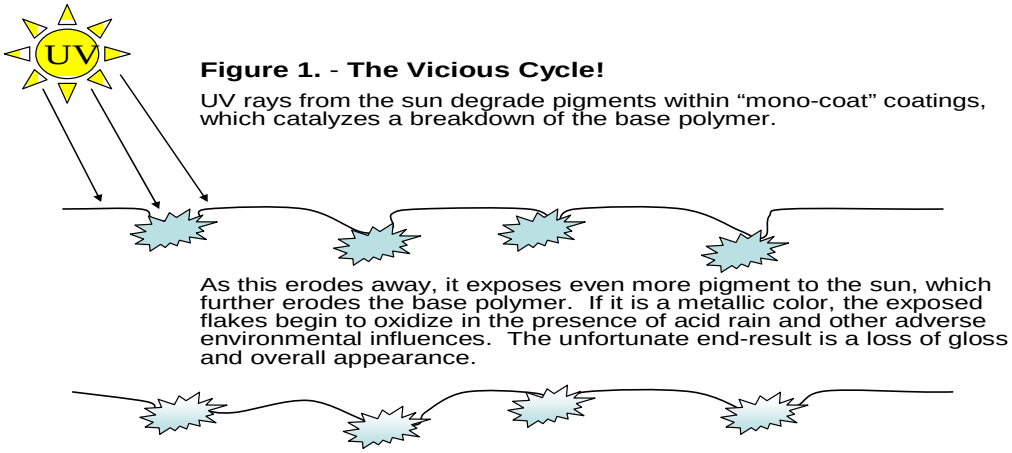


Figure 1. - The Vicious Cycle!

UV rays from the sun degrade pigments within "mono-coat" coatings, which catalyzes a breakdown of the base polymer.

As this erodes away, it exposes even more pigment to the sun, which further erodes the base polymer. If it is a metallic color, the exposed flakes begin to oxidize in the presence of acid rain and other adverse environmental influences. The unfortunate end-result is a loss of gloss and overall appearance.

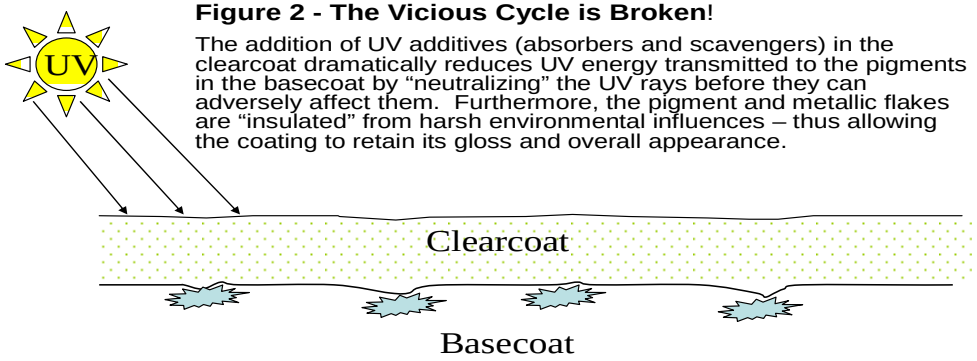
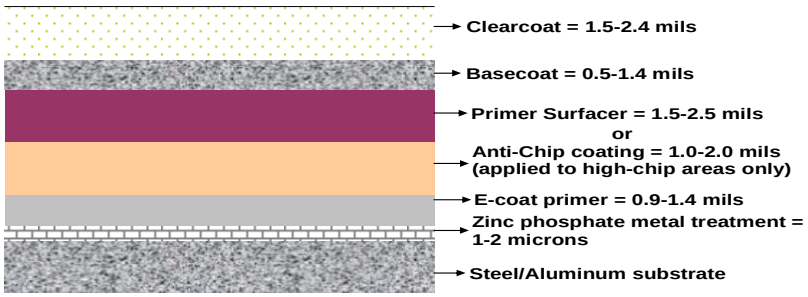


Figure 2 - The Vicious Cycle is Broken!

The addition of UV additives (absorbers and scavengers) in the clearcoat dramatically reduces UV energy transmitted to the pigments in the basecoat by "neutralizing" the UV rays before they can adversely affect them. Furthermore, the pigment and metallic flakes are "insulated" from harsh environmental influences – thus allowing the coating to retain its gloss and overall appearance.

Figure 3 - Typical Automotive OEM Exterior System



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Rick Jones joined The ChemQuest Group, Inc. as Vice President in 2006. He spent the previous twenty-nine years in the coatings and adhesives industry working for PPG Industries, Valspar Corporation, Lord Corporation and Sovereign Specialty Chemicals/Henkel Corporation. His entire career has focused on business management, marketing and technical sales within automotive, aerospace, industrial and wood markets. Rick has extensive knowledge and experience in creating successful business strategies, and successfully launching profitable sales and marketing programs for technical products into domestic and international OEM markets. Rick is a member of the Adhesives and Sealants Council, National Paint and Coatings Association, Society of Protective Coatings and RadTech. He holds a B.S. degree from Allegheny College (Meadville, PA).

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The ChemQuest Group, Inc. is a strategic management consulting firm that has been a respected source of information pertaining to the coatings, adhesives and sealants markets since 1980. It has continually monitored the changes in market size, technology developments, raw material trends and the emergence of growth opportunities in these complex, fragmented industries. The firm is "top-line" focused, offering such services as strategy development, market analysis and mergers & acquisitions. ChemQuest is headquartered in Cincinnati, OH and has offices in Raleigh, NC; Boston, MA; London, England; Düsseldorf, Germany; and Guangzhou, China.

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