Beyond the Bling

PVD/UV Coating Systems that offer more than Beauty and Brawn

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This history of coatings for plastics, like that of paint itself, is an evolutionary story. Paint used by cavemen on the walls of their caves or decorating the faces of Indian warriors was formulated for decorative purposes. As more durable goods were developed, some paint also filled a more functional purpose. Today's automotive paints combine spectacular pigments and resin systems for good looks and durability. The rusted out car is a thing of the past thanks in part to better coatings.

Coatings for plastics have followed this same arc – from decorative and functional purposes to the latest coatings that combine the best of both. Today's cell phone for example is a fashion statement for many teen owners; but its hard, clear topcoat is engineered to withstand scratching by coins and keys in their pockets at the same time.

New applications that rely on both the beauty and brawn of coatings continue to evolve. A case in point is the intense interest in coatings used in metal sputtering or physical vapor deposition (PVD). This hubbub of activity is occurring because hexavalent chrome, used in the chrome plating process, has been found to be a health risk and is being eliminated from many uses. The resulting search for "chrome alternatives" has led to PVD. What's more, plastics can be made to look like their metal counterparts, thereby reducing weight and opening up new designs for a wide range of automotive, household, and industrial products.

The quest to find a suitable chrome alternative has led to a process combining metal deposition with a sandwich of base coats (that provide a smoother surface), and top coats that provide a hard, durable finish – once again, providing both strength and beauty. But is there a chance to be more than just a chrome "replacement"? More generally, can coatings be more than just decorative paints and durable surfaces? Today's chemistry is allowing paint formulators to provide added value to paint – transforming the role of coatings from decoration and protection to an even higher status in a product's function. Some of these product attributes include the following:

1. Easy-to-clean coatings. Shiny, high-gloss products look great. A TV bezel painted piano black looks great on the plasma

TV but not so attractive when it's smudged. Oleophobic coatings designed to resist oils from the skin not only make this surface harder to smudge, but the oils wipe off almost effortlessly. Anti-fingerprint and fingerprint-resistant coatings are attractive for PVD items, kitchen appliances, car trim, and consumer electronics where retaining appearance on shiny surfaces is important.

2. Antimicrobial coatings. Not only can the surface of the countertop toaster look prettier, or the handle on the fridge look like chrome – but the PVD/coating system can help fight invisible germs by incorporating antimicrobial additives into the top coating. Efficacy testing reliably concludes that these coatings can be effective in helping to kill organisms that commonly grow on these surfaces.

3. Extreme scratch/mar resistance. New additive technology and advanced resin systems now facilitate top coats that provide surfaces that are much harder and scratch-resistant than ever before.

4. Anti-theft coatings. Coatings can now contain additives that make them easily identifiable as OEM-applied materials. Technology that is nearly impossible for counterfeiters to replicate helps protect brand identity and offers consumer safety.

Developments Leading to PVD

Slow to adopt new technology, it has been frustratingly difficult to convert end users from the traditional high-solvent paints in favor of waterborne, UV and other new materials ▶

despite cost and performance benefits that might be expected to sway manufacturers to use them.

Until their hand is forced by regulations, many manufacturers hold fast to the old methods of painting. Even as production shifts to Asia and a chance to begin anew, we see children's toys arrive coated with decades-old lead-paint technology.

Now, two forces have collided which have spurred interest in new coating systems. The insatiable consumer demand for "bright metal" finishes combined with environmental pressure by regulatory authorities has kicked off a search for chrome alternatives in markets ranging from alloy wheels to cell phones. The following factors have contributed to this current situation:

Chrome plating, though popular, is being affected by new regulations that limit the use of carcinogenic hexavalent chrome.

• Hexavalent chrome has been labeled a potential carcinogen and regulations to eliminate its use. Hard chrome plating has faced enormous pressure due to health and safety concerns.

• Strong consumer demand for chrome appearance. The proliferation of personal electronics and teletronics has created new markets for attractive goods where bright metal appearance is desired.

• Migration from metallic substrates to plastics for greater design flexibility and weight reduction, but where heat-sensitive substrates limit the processing options.

• The drive to lower cost. Pressure to find ways to make parts cheaper is at odds with plating processes that are notoriously energy-intensive and inefficient.

Manufacturers faced with the need to eliminate hexavalent chrome from their manufacturing have explored a range of alternatives. These alternatives include minimizing hex chrome with new, improved methods: Trivalent chrome systems; PVD with no top coating; and 'chrome-colored' paints. Without addressing the details, each of these alternatives has its own merits and limitations. But as alternatives have been explored, the use of PVD metallization has gained a lot of traction and there has been significant commercial success in combining PVD and specialized coatings to provide an acceptable chrome replacement.

Basecoats: Adhesion and Leveling

While it would be desirable to metallize directly to the plastics, this has not been practiced in most applications since, even when produced with high quality molds, plastic surfaces are too rough for direct metallization. The variability of the substrate (sometimes made of virgin resin, but often a blend of regrind and virgin resin) along with noticeable defects in the molding process make metallizing bare parts too difficult. The tolerance and maintenance of molds smooth enough for producing parts that can be metallized directly is prohibitive.

Instead, a base coat is applied to the substrate. This base coat frequently provides three benefits:

It ensures good adhesion of the metal layer.

It provides a smooth, level surface upon which to metallize.

It provides added protection to the underlying substrate against effects such as UV degradation of the material.

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Top Coats: Protection and Added Appearance Options

A smooth base coat topped with a microscopically thin layer of bright metal has a beautiful lustrous appearance – but little in the way of durability. The time, expense, and inherent difficulties of depositing metal PVD layers typically results in metal films only angstroms thick, certainly much thinner than a typical paint film. This does not provide an adequate, weatherable barrier nor is it sufficiently tough enough to stand up to physical abuse.

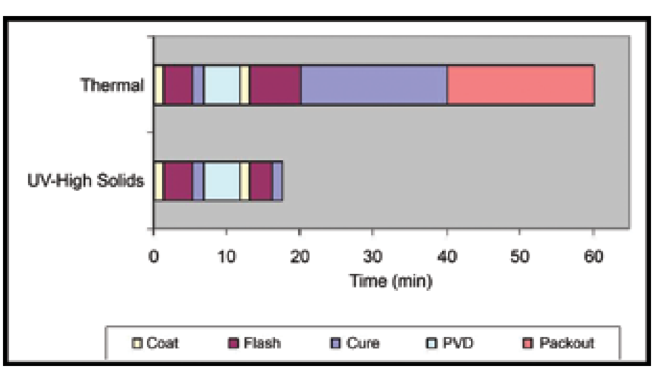
To protect the metal layer, a protective top coat is ordinarily applied. The top coat provides the necessary properties common to a wide range of painted goods. When the bright metal PVD layer has the desired appearance, the top coat might be formulated to be a water-clear coating, providing a protective but transparent barrier for the fragile metal layer.

The top coat also can be formulated with tints, metallic flake, and other effects that alter and enhance the appearance of the PVD film. Top coats can provide color shifts, tinted chrome appearance and sparkle to an otherwise lustrous finish. Along with modifications to the target material and process gases used in the PVD process, the top coat can provide another tool for designers looking for unique appearances.

Many PVD applications benefit from top coats that can be applied as thin as possible while still achieving the needed performance specifications. Sometimes this is due to functional aspects of parts, which must fit other mating parts. Generally a thinner coating provides the greatest bright metallic effect at the lowest manufacturing cost.

Processors have turned to ultraviolet-cured (UV) coatings for thin top coats. UV coating chemistry is ideal for providing exceptionally clear, mar resistance at lower film builds. UV coatings provide several other significant benefits:

Clarity. UV coatings are used for coating optical devices from eyeglass lenses to precision optics. These water-clear coatings are a perfect complement to bight metal PVD layers where luster is desired.



Scratch and mar resistance. UV coatings are noted for tough surface properties stemming from the very high crosslink density common in UV curing. Hardwood flooring is a common example of material that utilizes UV coatings to resist scratches.

Speed of cure. UV coatings cure nearly instantaneously. An obvious advantage of fast cure is productivity and reduced floor space required for production. But importantly, time also means dirt. The longer a mirror-like surface is exposed to airborne contaminants the more likely is contamination. UV permits a lean production cell where components are metallized and then moved directly to a compact UV coating line where only moments later the part is coated and fully cured.

Low energy requirements. While energy consumption was a 'soft' cost issue only a few years ago, the current skyrocketing costs of energy have many producers revisiting the low energy cure requirements of UV coatings.

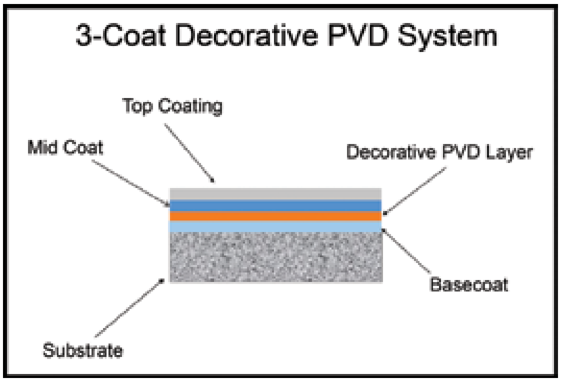
But while UV top coats offer significant thin film benefits, simultaneous demands for the coating (scratch, mar, clarity, flexibility, deep colors, anti-fingerprint, anti-microbial, hydrophobicity, and anti-theft) force formulators to consider tradeoffs between various properties or compromises on the customer's wish list.

Introducing the Mid-Coat: Opening New Doors

Constantly asking the top coat to do more has its limits. Tradeoffs exist between competing properties such as extreme scratch resistance and enhancing deeper, high chrome colors or special effect appearances. A solution to this formulation tug-of-war is to introduce another coating layer or 'mid-coat' to the paint process.

A mid-coat can provide another layer of opportunity to achieve looks and functionality difficult to produce in a single protective top coat. Use of the mid-coat system has already produced commercial successes unavailable from conventional two coat systems. For example, top coats can be formulated with extreme scratch-resistant properties, while mid-coats can be formulated to enhance the appearance of deeper metallized color choices. The color palette has been expanded significantly while the surface properties are simultaneously enhanced.

As consumers continue to clamor for products that sport bright, chrome appearance in a wide range of industries, producers actively seek alternatives to a chrome process being regulated out of existence. Other technologies are being trialed, but one of the most promising may be a combination of physical vapor deposition and a system of base and top coatings which offers both appearance and performance.



A groundswell of development in nanotechnology, new coating additives, and resin systems now enables coatings to provide a range of specialized functions. Coatings can resist water, fingerprints, and bacteria. Not only will future parts satisfy the cosmetic and durability requirements of customers but also, they may provide functions not attainable with any other production method.

The combination of a base coat to provide adhesion and a mirror smooth surface for metallization along with a clear or tinted top coat can provide a part that has a lustrous bright metal appearance along with robust mechanical properties.

The latest introduction of three-coat systems utilizing mid-coats provides manufactures with greater flexibility and choice. By freeing the formulator to develop coating properties difficult to achieve in a single layer, a greater range of color, gloss, physical performance, flexibility, and other cosmetic and physical properties can be provided. But even more exciting is that in addition to PVD/coating systems providing a bona fide "chrome replacement", they also can provide new functionality. Coated parts not only can have a beautiful and tough finish but also, can fight germs and resist water, fingerprints, and dirt. These coatings can provide new special effects or provide value such as brand identity protection. In the 2000s, paint continues to evolve from the decorative purposes that date back to cave walls to a truly integral aspect of a part's form and function. ■

Kalcor Coatings Company, Willoughby, Ohio, specializes in custom paint formulations for a range of automotive and industrial markets including a complete line of decorative coatings for plastics. Kalcor also is the designated North American partner of Cashew Company Ltd. of Japan, a global supplier of coatings for plastics. For more information about Kalcor, call Pam Thrall at (440) 946-4700, email pthrall@kalcor.com or visit www.kalcor.com.