Exterior Durable Hardcoats for Specialty Markets

By Shawn Jackson and Pat Peach

The automotive industry has long been a dominant market for weatherable coatings. Specific niche applications, such as automotive lighting, are dominated by UV-curable technology requiring reduced cycle times, extended weatherability, scratch and abrasion resistance, and optical clarity. This has pushed UV into the mainstream as a viable option. However, automotive lighting is not the only application demanding these high-performance standards and reduced cycle times. Traditional thermal markets (such as architectural building materials, plastic films and glazing) are among those turning to UV-curable protective hardcoats.

New markets for high-performance coatings bring with them new methods of application and a variety of substrates. Some of these markets are switching to plastic substrates because of added benefits—such as weight reduction and increased part design flexibility. However, popular plastic substrate options often are not inherently scratch resistant or weatherable and UV curable coatings are increasingly being utilized in these instances. One challenge facing UV technology in these instances is the balancing of formulation changes for ease of application, while continuing to provide the high performance standards and broad adhesion characteristics of the current thermal technologies.

High-performance ultraviolet hardcoats have been standard in the automotive lighting industry since the 1990s. As mentioned earlier, these coatings are required to pass stringent weathering and durability testing due to the location and long life of the parts to which they are applied. To achieve these properties, both the inherent coating properties and processing conditions must be examined. Processing requirements ultimately dictate the coating formulation and application, but there are several similar basic characteristics that allow for quick custom-formula modifications.

Although UV is touted as green technology, automotive lighting coatings are solvent-based systems applied at low percent solids (%s) or low percent non-volatile materials (%NVM) because of the complexity of part designs. This has been acceptable practice, but also adds a flash-off step after application and prior to UV cure in order to evaporate solvent contained in the coating.

Specialty Markets

As previously mentioned, high-performance UV coatings are rapidly gaining acceptance in specialty applications. As each new market emerges, it brings with it new application methods, specifications and challenges. Within these specialty markets, customers still demand superior weatherability and durability, but that is where the similarities end. Where automotive coatings are generally low %NVM, coatings for specialty markets are at or near 100% solids. This accentuates the green advantage of UV. However, increased solids formulas with robust properties typically yield higher viscosity materials, which can cause application challenges. With the absence of solvents in a coating, application equipment footprints shrink further and include little to no heated flash. While the primary use of a heated zone is for solvent flash off, it also adds other benefits, such as flow, leveling and adhesion. Thus, with little or no heat available, a formulator must be a bit more creative in choice and blend of materials.

Another characteristic of specialty applications is focus on increased line speed, which can influence coating formulation and application setup. Faster line speeds increase through-put and decrease work-in-process, but

the drive for smaller equipment footprints works to limit the exposure time of the parts to UV energy. If a UV coating is not properly cured, it could remain tacky and unable to be handled and, potentially, the performance characteristics will not be optimized. Thus, the formulator must use unique combinations of photoinitiators, resins and UV bulbs to successfully crosslink the final film. Substrate type and thickness is sometimes another reason for the absence of a heated zone and less exposure to the UV light. Standard UV lamps emit a considerable amount of IR heat along with UV energy. To avoid warping and cracking, lower cure energies or newer, cooler running lamps are beneficial.

Those are just a few of the reasons why it can be potentially difficult for automotive-grade coatings to function for non-automotive applications. Overall, many specialty markets will require the same performance standards. The key is to look at each application and customize the coating for that individual application, while still maintaining the ground work that gives the coatings their specific properties.

Plastic Films

Any application where the substrate thickness is less than 30 mils (.030") is generally considered a film application. Hardcoats are often applied to polycarbonate and PET films used in electronics, consumer goods and optical display industries, among others. Coating requirements for films can range from highly weatherable to non-weatherable, with varying degrees of gloss, scratch resistance, pencil hardness and flexibility. Film coatings are typically applied via gravure processes common to the printing industry.

Optical clarity is a key feature in the films market. Film coatings are typically applied at between two and 15 microns, depending on the type of coating and the end use of the coated film. Therefore, these coatings must have excellent leveling across that range to achieve a good appearance at all film builds. Optical properties are important for coatings requiring a reduced gloss as well. Typical requirements of a coated film intended for outdoor exposure might be: >five years weatherability, low percent haze after abrasion testing, high pencil hardness and excellent adhesion after all environmental testing.

In addition to natural Florida and Arizona weathering, SAE J2527 Xenon with Boro/Boro daylight filters is the most commonly used accelerated weathering method because it best simulates natural weathering. Taber abrasers are commonly used for abrasion testing, and environmental testing is usually conducted in a high temperature/high relative humidity cabinet.

As one might expect, formulating a coating to high performance standards

Figure 1

Typical properties of an acceptable exterior, durable coated film

Initial Appearance	Taber (CS10F Wheel 500g Load x 100 Cycles)	Chemical Resistance (Post Appearance and Adhesion)	Water Soak (65°C x 10 days)	Pencil Hardness	Artificial Weathering (SAE J2527 Xe B/B Filters x 3,000 hours)
-Haze: <1% -YI: <1 -%T: 93%+	-Haze: <5%	-Cleaners -Solvents -Food Stains	-Good Appearance -Post Adhesion	H+	-Haze: <5% -YI: <3 -Good Appearance -Post Adhesion

at thicknesses as low as two microns can present several challenges. It is the formulator's task to incorporate novel resin and additive packages to achieve these standards.

Sheet

Sheet applications are coatings on semi-rigid substrates greater than 30 mils thick. Sheet applications also require the high weathering with scratch and abrasion resistance, but with less flexibility needed due to the more rigid nature of the substrate. Sheet applications are generally found in areas where the substrate itself is required to be more durable.

Requests for high %NVM or 100%NVM are more common in the sheet industry. Dip coating applications are often employed, but these require high volumes of coating and cause film build gradients, thus varying performance across the sheet. Rollcoating and curtain coating are two other methods used for high %NVM coating application. Again, without the presence of solvents, innovative blends of low viscosity resins must be used. Additionally, application of heat to the coating reservoir or application head (or both) during the application

process can be used to lower the viscosity to a workable level and assist with performance characteristics.

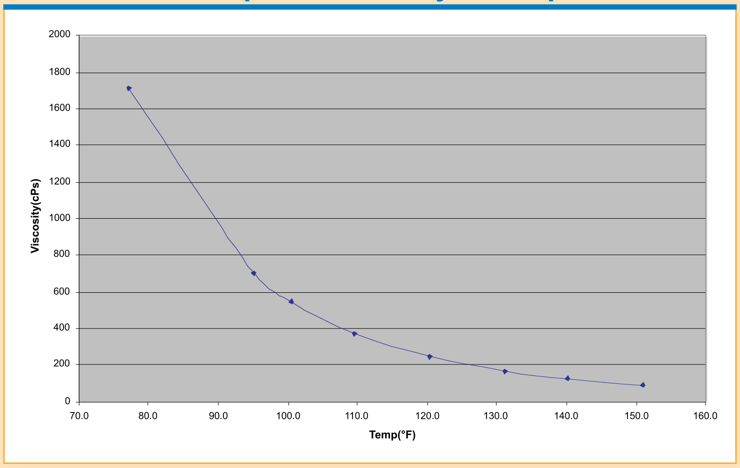
Building Materials

Weatherable UV hardcoats are increasingly being utilized in architectural applications, such as protective coatings on decorated steel and aluminum, PVC and fiberglass-reinforced plastics (FRP). This market typically requires a high degree of weatherability and environmental durability due to constant exposure to elements. Abrasion resistance is a somewhat secondary consideration in many of these applications.

As many of the above substrates are supplied in sheet form, application methods are generally similar to those described in the section describing sheet applications. Standard spray application processes are often used in some PVC applications. To minimize glare from sunlight, many of these types of hardcoats are supplied at a reduced gloss. Also, there is increasing interest in coatings with true anti-graffiti and/or self-cleaning attributes.

Figure 2

100% NVM UV Topcoat Viscosity v. Temperature



Conclusion

UV technology has been proven to meet the standards of the automotive industry. Even though modifications are needed to meet the application and performance requirements of specialty markets, the base technology exists to expand UV coating technology into these markets as well as many others.

— Shawn Jackson is a UV commercial products chemist, and Pat Peach is a UV project manager at Red Spot Paint and Varnish Co., Evansville, Ind.