



# Powder Coatings

## additives

*New antioxidant and UV absorber deliver performance.*

**T**he high performance of powder coatings is further increased by the use of additives. Additives are designed to improve properties such as prevention of discoloration during powder coating resin synthesis and curing, ease of spraying the powder onto the substrate, enhanced durability of the coating during service life through light stabilization, and improved corrosion resistance.

### Major Powder Coatings Additives

Aside from additives like matting, leveling and degassing agents, other classes of additives are frequently used in powder coatings, such as tribo-charging additives, antioxidants, and light stabilizers. This article discusses the newest laboratory results in this field.

### Tribo-Charging Additives

There are presently two techniques to apply powder onto a substrate. The major one in North America is the corona process, where the sprayed powder particles are forced through an electrical field to become negatively charged. The charged particles are attracted and deposited on the grounded object to be painted, generally a metallic substrate. The second application is the so-called tribo-static process. In this

case, the particles are forced through a Teflon tube and are charged positively by friction with the tube walls. The tribo-charging spray process has some benefits over the corona one, such as more uniform and thinner layers and less overspray. Depending on their composition, tribo-static powders require additives to improve their chargeability. Certain hindered amine light stabilizers (HALS) improve tribo-charging in addition to their light stabilization properties.<sup>1</sup> The chemical structure of the HALS used in this study is shown in Figure 1.

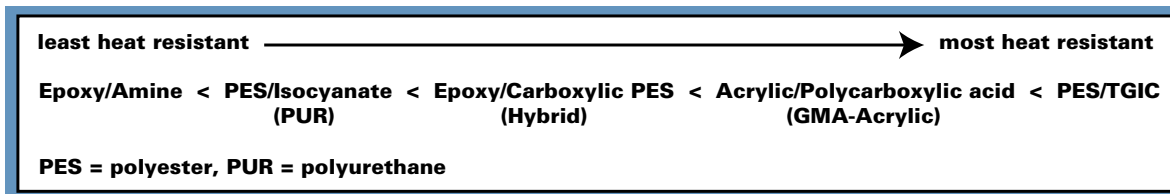
The tribo-chargeability of white coatings based on various combinations of polyester systems with different hardeners was studied by addition of different concentrations of the HALS product (see Figure 2). None of the polyester resins contains any tribo-additive, which was pre-added during the resin production.

Good tribo-chargeable powder values (charge to mass ratio) are 500–1000  $\mu\text{C}/\text{kg}$ .<sup>2</sup> Even very low concentrations of HALS, especially in hybrid systems, can significantly increase the tribo-value of various powder systems. Depending on the system that is used, an acceptable tribo-value (in this case, 800  $\mu\text{C}/\text{kg}$ ) can be reached with a HALS concentration of 0.1–0.3%, based on total formulation.

### Heat and Processing Stabilization of Powder Coatings

The type of the resin(s) and the hardener(s) used determine significantly the heat resistance during the processing and the curing of a powder coating. A ranking in the heat resistance is as follows.<sup>3</sup>

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The heat resistance of PES/ $\beta$ -Hydroxyalkylamide, an alternative to PES/TGIC, approximates a hybrid system.<sup>2</sup>

Heat stabilizers are required to be thermally stable and not volatile during high temperature powder extrusion and curing processes (electric and direct fired gas ovens), and to show no discoloration.

The resin producer usually carries out basic stabilization with antioxidants and processing stabilizers during synthesis. But most powder coating formulations need further stabilization during extrusion and curing of the coating. This is why powder producers should know the characteristics of a given stabilizer system.

The chemical formulae of the antioxidants discussed in this article are shown in Figure 3. Various classes of antioxidants have different thermal stabilization mechanisms. The classic high-molecular-weight hindered-phenolic antioxidant, AO-1, is effective as an oxygen centered radical scavenger, but can suffer from "pinking" in the presence of combustion gases like NO<sub>x</sub>, which can be found in gas oven exhaust.<sup>4</sup> The phosphite antioxidant, AO-2, acts as a decomposer of hydroperoxides and provides protection during high temperature processing and/or curing cycles. The new lactone antioxidant, AO-3, functions as a carbon or oxygen centered radical scavenger and inhibits auto oxidation. The development of a high performance "phenol-free" antioxidant blend, AO-4, exploits synergistic effects between phosphite and lactone properties, while eliminating the possibility of pinking.

Figures 4-5 show a comparison between various antioxidants in a white powder coating (formulation in Table 1) based on PES/  $\beta$ -Hydroxyalkylamide by overbaking at 200°C and 220°C. All antioxidants used alone show more or less a lower yellowness value (b\*) than the blank. Nevertheless, the best value is obtained when using the blend AO-4 in the powder coating. This illustrates the synergistic effect of the different antioxidants when they are used together.

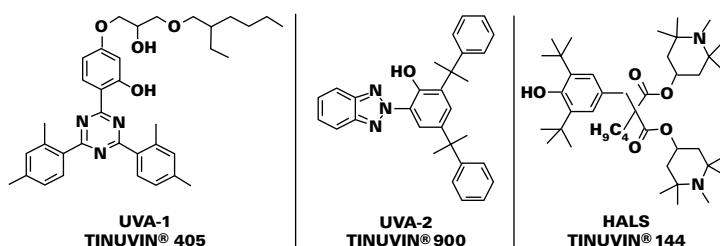
Figure 6 shows the effect of these antioxidants on the gas fading of the same white powder coating exposed to NO<sub>x</sub>-gases produced in an electric oven by 1 g sodium nitrite and 1.5 g 30% acetic acid.<sup>5</sup> AO-4 gives the best result in this test. Here one can see again the synergistic effect of AO-2 and AO-3 together. As mentioned before, the phenolic antioxidant AO-1 causes more "pinking" than the sample without stabilizer.

### Light Stabilization of Powder Coatings

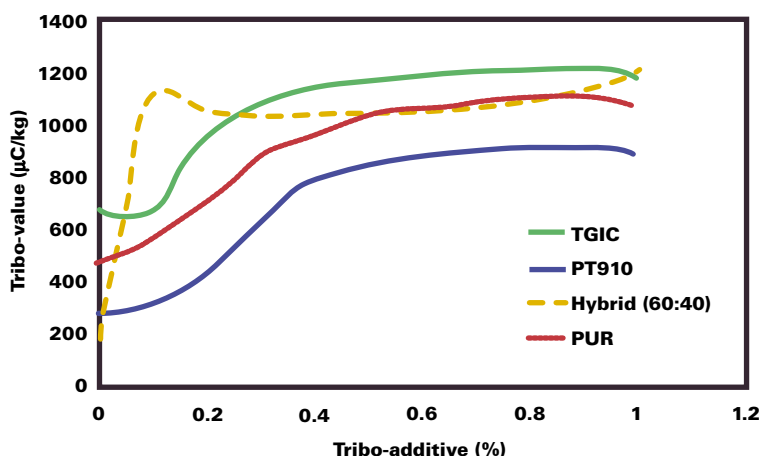
High resistance against UV degradation is necessary in all exterior applications. This is achieved through a synergistic combination of UV absorbers and HALS.

UV absorbers work by absorbing detrimental UV radiation and harmlessly releasing the energy as heat before it can cause polymer degradation. The degree of protection is a function of

**Figure 1 / Chemical Structure of Light Stabilizers**



**Figure 2 / Tribo-Chargeability vs. Tribo-Additive (HALS) Concentration of Various White-Pigmented Powder Coating Systems**



TGIC: Crylcoat® 430 (UCB Chemicals) and Araldite® PT810 (Vantico)  
 PT910: Alftalat® 9936 (Solutia) and Araldite PT910 (Vantico)  
 PUR: Alftalat AN745 (Solutia) and Vestagon® BF1540 (Degussa-Hüls)  
 Hybrid (60:40): Crylcoat® 360 (UCB Chemicals) and Araldite GT7004 (Vantico)

**Table 1 / Formulation of a White Pigmented Powder Coating Based on PES/Primid System**

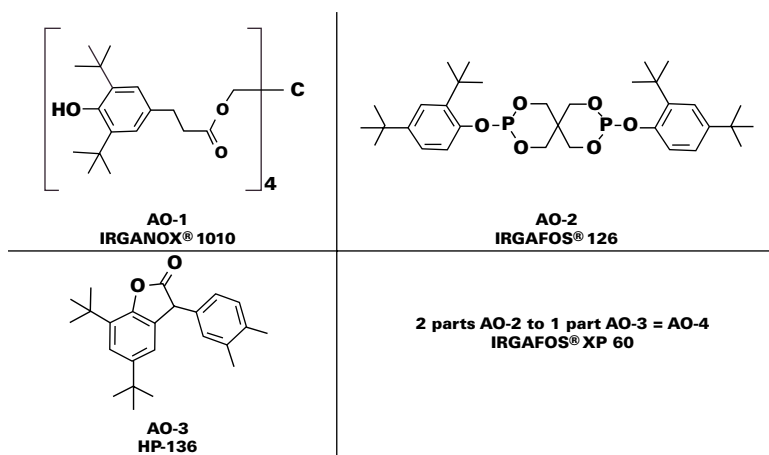
Crylcoat 2532 / Primid® XL552	68.50
Flow agent	0.70
Degassing agent	0.30
TiO <sub>2</sub>	30.00
Antioxidant	0.50
Sum	100.00

**Table 2 / Formulation of a Powder Clearcoat Based on GMA/Acrylic System**

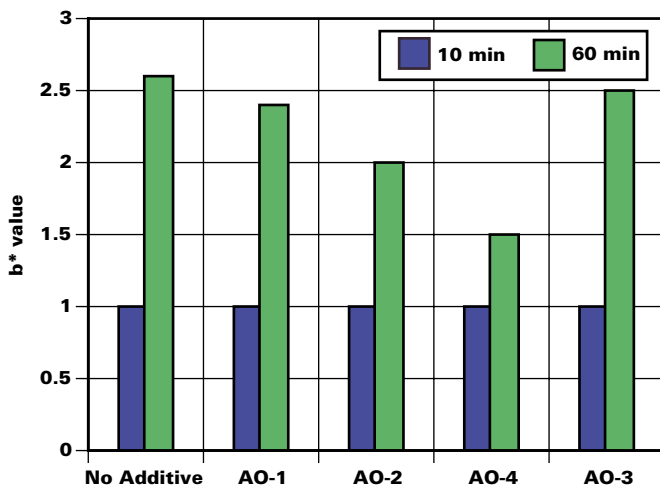
Almatex® PD7610 (Anderson) / Dodecanoic acid	94.50
Flow agent	1.50
Degassing agent	1.00
UV absorber	2.00
HALS	1.00
Sum	100.00

## Powder Coatings Additives

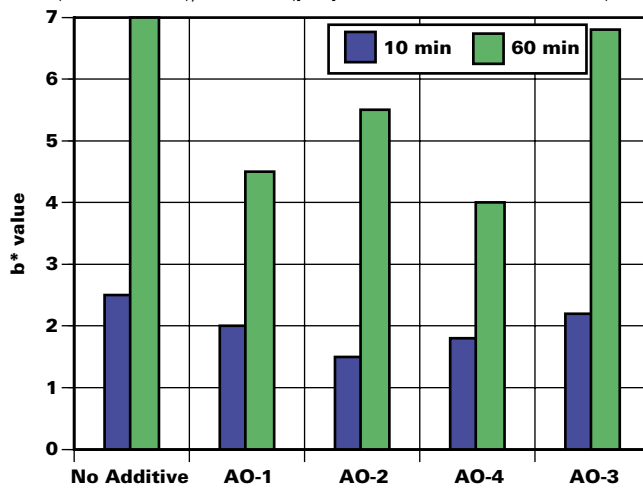
**Figure 3** / Chemical Structure of Antioxidants



**Figure 4** / Thermal Stabilization of a White Pigmented Powder Coating, PES / Primid XL552 (EMS-Chemie), at 200°C ([AO] = 0.5% on Total Formulation)



**Figure 5** / Thermal Stabilization of a White Pigmented Powder Coating, PES / Primid XL552 (EMS-Chemie), at 220°C ([AO] = 0.5% on Total Formulation)



absorber concentration, coating thickness and the extinction or "efficiency" of the absorber, as summarized in Beer's Law.

Although absorbers provide a lot of protection, some UV light can still initiate polymer degradation by creating free rad-

icals. These can also originate from heat energy. HALS neutralize any free radicals, thereby preventing polymer degradation. HALS are not dependent on coating thickness for their efficacy.

In two-coat automotive coatings, the combination of UV absorbers and HALS is state of the art.<sup>6</sup> Here the filter effect of the UV absorber (added to the clearcoat) protects the basecoat/clearcoat system against discoloration and photochemical degradation, which could otherwise lead to delamination. HALS trap any radicals formed and are mainly responsible for the protection of the coating against loss of gloss and cracking.

Powder clearcoats are becoming increasingly important in automotive OEM applications.<sup>7</sup> The following work shows results of a newly developed UV absorber in a powder clearcoat based on GMA-acrylic (see Table 2).

The chemical formulae of the light stabilizers used in this study are shown in Figure 1. UVA-1 is an advanced triazine especially for use in powder coatings because of its solid form, ideal melting point (74-77°C). This allows easier extrusion than with UVA-2 (benzotriazole), which has a higher melting point (141°C). Another advantage is that UVA-1 is slightly blue-shifted in comparison to a benzotriazole UV absorber, thereby minimizing the risk of initial color (see Figure 7), and unlike the benzotriazole UV absorber, the triazine UV absorber is free from the risk of color-forming interactions in amine and/or metal catalyzed coating systems and coatings applied on base-coats or substrates containing such catalysts. UVA-1 is both thermally permanent and resistant to photodegradation.

In this study, the two UV absorbers were tested in combination with a HALS used in the powder coating industry. Figure 8 shows that UVA-1 in combination with HALS significantly decreases the yellowing upon standard baking and overbaking, in comparison to UVA-2. The contribution of thermal stability of the triazine in comparison to the benzotriazole is a significant advantage, such as when body parts are repaired and where color matching is very important.

Figure 9 shows the Florida outdoor exposure data of a powder clearcoat over a waterborne metallic basecoat stabilized with 2% UVA-1 in combination with 1% HALS or non-stabilized. The non-stabilized coating shows cracks and loss of gloss after just six months of Florida exposure. With the combination UVA-1 + HALS, 80% of the initial gloss is still retained after five years of exposure.

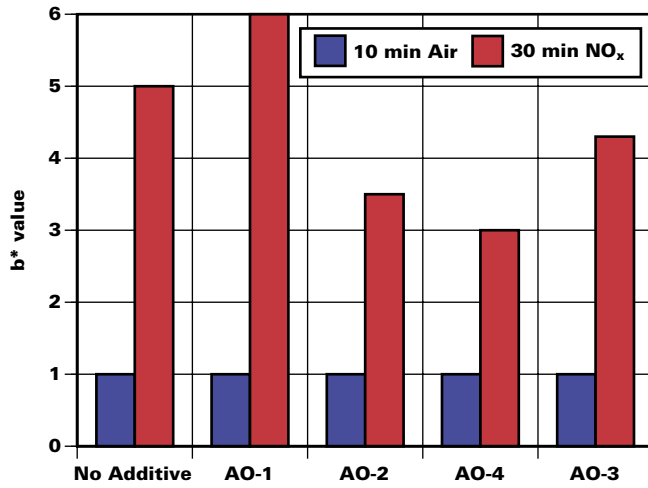
These very good stabilization properties of UVA-1 are confirmed by the results obtained after artificial exposure in a WOM-CAM 180 device (see Figure 10). Gloss retention is still 70% after 5,500 hours of exposure, whereas the non-stabilized sample is completely delaminated after 3,000 hours.

## Conclusion

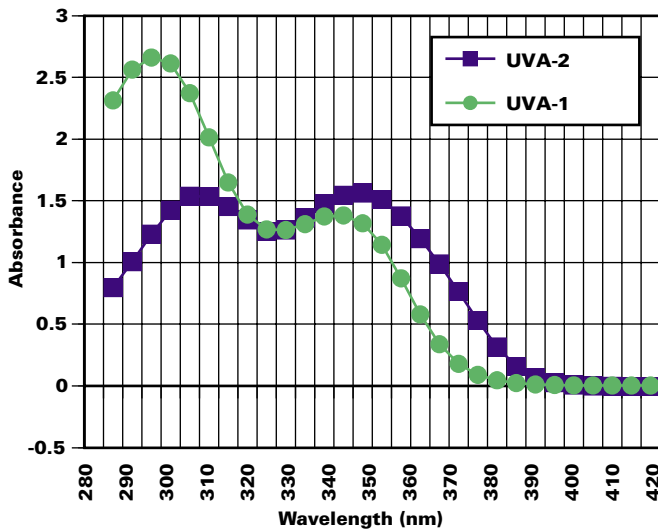
The addition of HALS to powder coating formulations can enhance the tribo-chargeability of the powder, which is important for the coating of geometrically complex objects. The combination of different antioxidants in a blend, such as AO-4, can meet the heat and processing stability requirements. A newly developed triazine UV absorber, UVA-1, in combination with a suitable HALS, can deliver a pronounced improvement in exterior coating durability and prevention of yellowing during processing. ☉

**Powder Coatings Additives**

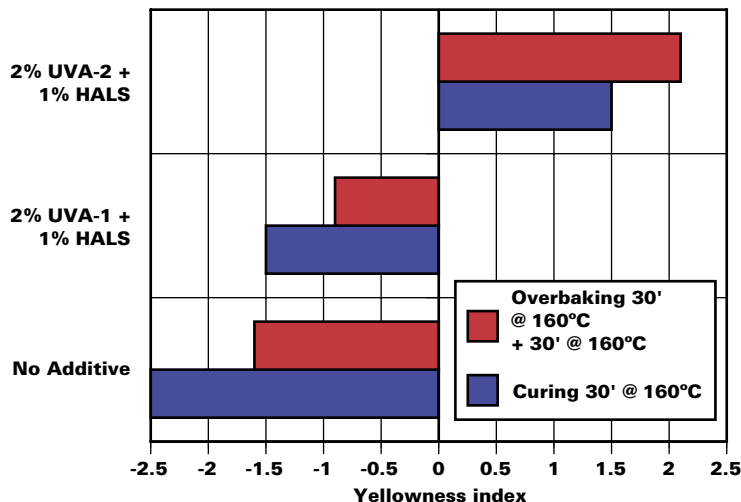
**Figure 6** / Thermal Stabilization of a White Pigmented Powder Coating, PES / Primid XL552 (EMS-Chemie), at 200°C in Air, Without and With NO<sub>x</sub> Gas at 200°C ([AO] = 0.5% on Total Formulation)



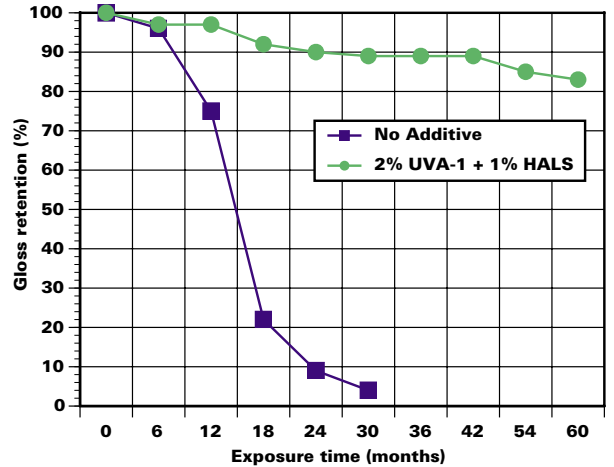
**Figure 7** / Absorbance Spectra of UVA-1 and UVA-2 in a Thermoset Acrylic Clearcoat (2% of Solid Content)



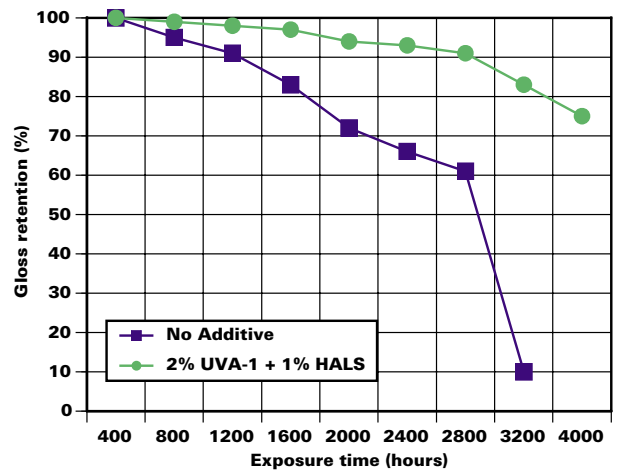
**Figure 8** / Influence of Light Stabilizers on Thermal Stabilization, GMA / Acrylic Powder Clearcoat over Waterborne Metallic Basecoat



**Figure 9** / 20°Gloss Retention of a GMA / Acrylic Powder Clearcoat over Waterborne Metallic Basecoat after Florida Exposure



**Figure 10** / 20°Gloss Retention of a GMA / Acrylic Powder Clearcoat over Waterborne Metallic Basecoat after WOM-CAM 180 Exposure



For more information on powder coating additives, contact Ciba Specialty Chemicals, 540 White Plains Road, Tarrytown, NY 10591; phone 800/431.2360; fax 914/785.4533; or visit [www.cibasc.com](http://www.cibasc.com).

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