CYTEC

CRYLCOAT® Resins for Superdurable Powder Coatings

PRODUCT PERFORMANCE GUIDE

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version 06/10

Introduction 1

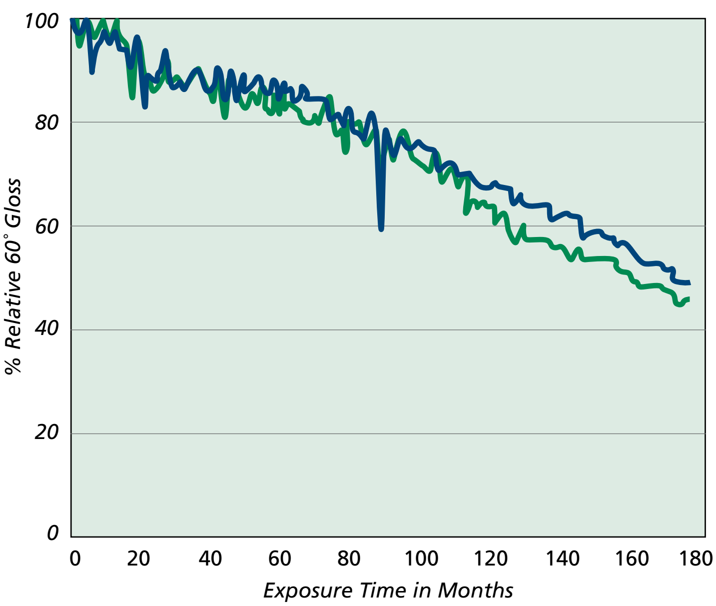
The purpose of this guide is to define superdurable powder coatings and highlight the benefits that these products bring to the coating industry. This information will cover every area of superdurability for the purpose of supplying the powder coating formulator with a complete understanding of this technology. This will give users advanced options for utilizing powder coatings in applications with exposure to tropical and sub-tropical climates or any market where excellent outdoor durability is required.

This information packet will cover the following topics:

- The differences between durable and superdurable powder coatings
- Instrumentation used to measure outdoor durability
- The effects of raw materials on outdoor durability
- Polyester resin technology from Cytec for use in superdurable powder coatings

Cytec has a comprehensive portfolio of products for use in high-performance weather resistant coatings. CRYLCOAT® 4488-0 symbolizes this high performance. This polyester resin, made in powder coatings formulated with TGIC, surpassed 13 years of Florida exposure while retaining more than 50% of its gloss. CRYLCOAT® 4488-0 is regarded as the global reference for superdurable powder coating technology.

RAL 6005 – Moss Green Formulation



45° Exposure-Washed
5° Exposure-Washed

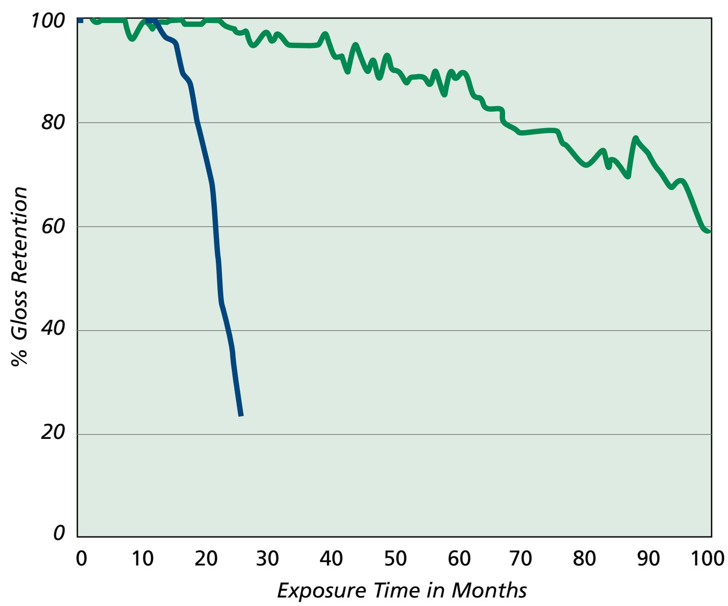
Raw Material	Weight
CRYLCOAT® 4488-0	623.1
TGIC	46.9
Sicomin®* Yellow L1523 (BASF)	8.8
Heliogen® Blue K7080D (BASF)	125.9
Flammruss™ 101 (Degussa)	17.9
Blanc Fixe F® (Sachtleben)	6.0
Durcal 5™ (Omya)	82.9
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

** Sicomin is a lead-containing pigment. Please consult your pigment supplier for lead-free alternatives.*

2 From Standard Durable to Superdurable Binder Systems

Polyesters used in exterior durable powder coatings are primarily based on two molecules—terephthalic acid (TPA) and neopentyl glycol (NPG). When reacted with a weatherable crosslinker, coatings based on these resins provide acceptable resistance to the outdoors as long as the climate is mild and ultraviolet light exposure is kept to a minimum. However, in tropical and sub-tropical climes, the visual appearance of these coatings degrades rapidly, especially in darker colors. To offset this effect, TPA is replaced by isophthalic acid (IPA) as the main di-acid constituent in the polyester resin. IPA has a different chemical configuration compared to TPA which results in a significant improvement in UV and hydrolysis resistance. Comparative studies of medium-brown (RAL8014) powder coatings placed in Florida exposure testing show that formulations with IPA-based polyester resins last four to five times longer than powders containing TPA-based polyester. A graph of this comparison is depicted below:

RAL 8014 Sepia Brown Formulation at 45° Florida Exposure, Washed



CRYLCOAT® 2441-2	
CRYLCOAT® 4488-0	

Raw Material	Weight
Resin	735.0
TGIC	55.0
Bayferrox® Red 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Degussa)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

There are four different types of weather resistance test criteria currently being used. Each system has distinct advantages and disadvantages. However, all of the systems can adequately forecast the outdoor durability when comparing different powder systems. The tests used to determine outdoor weathering resistance are:

Natural Florida Weathering—This test consists of exposing coating samples to the indigenous Florida climate. Sites in South Florida evaluate gloss loss, color change and degradation of coatings as they are exposed to long periods of high temperatures, humidity and salt concentration. The main advantage of this method is that it offers a true glimpse of what a coated part would be exposed to in the field. However, this testing takes years to complete. Therefore, data for highly weatherable samples are typically not available for 10 years or more.

EMMAQUA—This is an accelerated exposure test protocol that is performed in Arizona. The test employs a series of Fresnel mirrors to intensify the sunlight that falls on a sample during the day while incorporating a spray cycle in the evening. The benefit of this system is that it provides results five to six times faster than Florida exposure on average. The drawback to EMMAQUA is that the intensity of the light energy used for exposure is very high. This may cause artificial degradation that would not be consistent with a field-tested coating.

Xenon-Arc—This apparatus uses glass filters around a xenon arc to deliver a spectrum of light that mimics natural sunlight. This testing also utilizes cycles of light and moisture to deliver the accelerated weathering results required. The benefit of this type of testing is the spectrum produced by this equipment mimics that of natural sunlight better than all other forms of accelerated testing. The drawback of utilizing this system is the high cost of buying this equipment and longer test duration.

Testing for Outdoor Durability

QUV—This is an instrument that exposes samples to cycles of ultraviolet light and condensation. The ultraviolet light is produced by sets of light bulbs set in the QUV machine. Although there are several types of bulbs that can be used in this apparatus based on the wavelength of the light emitted, there are two common types used for testing in the coatings industry. These bulbs are QUV-A340 and QUV-B313. The differences between these two bulb types are illustrated at the bottom of the page.

Also, depending on the test method being used, the light/moisture cycles for the two bulb configurations will be different. An example of this is provided:

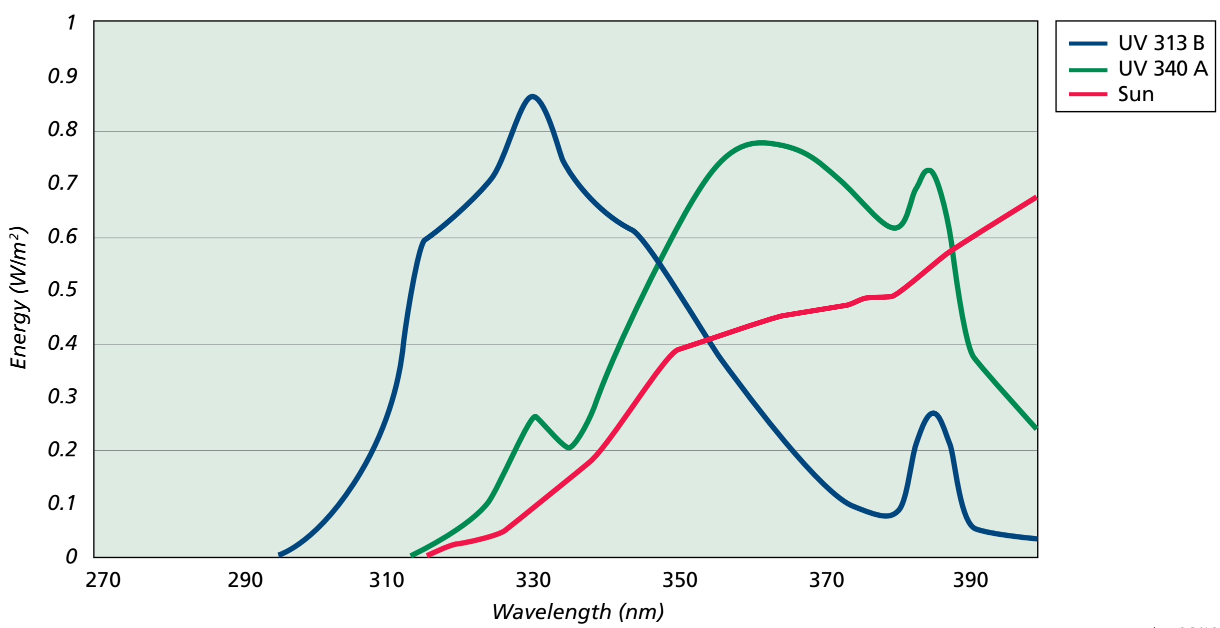
QUV Testing Protocol	QUV-A340	QUV-B313*
Light Cycle (hours)	8	4
Cycle Temperature (°C)	60	50
Condensation Cycle (hours)	4	4
Cycle Temperature (°C)	50	40

* Denotes GSB Standard

The benefit of these systems is the speed of testing. QUV-B313 testing can be complete in 2000 hours or less while most QUV-A340 tests are complete after 10,000 hours or less, compared to 10 years in Florida.

The disadvantage of using these systems is that the type and intensity of the light being exposed to the panels does not accurately depict the same wavelengths that natural sunlight exhibits. Also, QUV-B313 is an extremely harsh test that can produce false failure results.

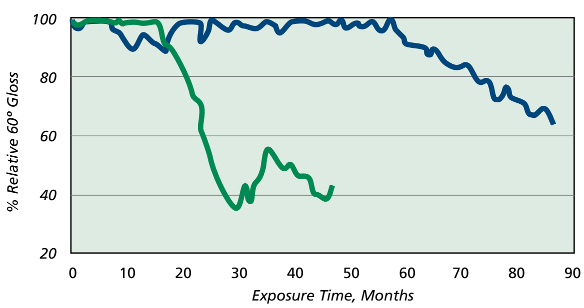
Spectral Output of Natural Sunlight, QUV-A340 Bulbs, and QUV-B313 Bulbs



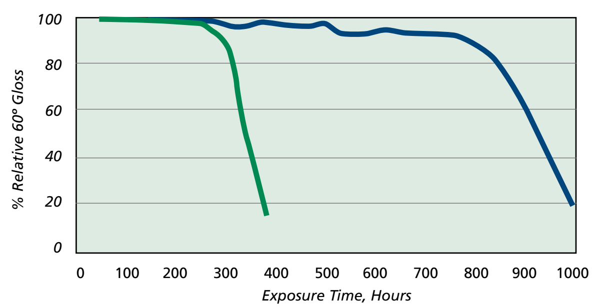
In order for accelerated weathering tests to be a viable source of weather resistance information, it is useful to determine if these tests have correlation to Florida outdoor exposure while verifying an acceptable acceleration factor. Cytec has tested TGIC-based powder coating systems using a durable resin and a superdurable resin (for a more detailed explanation on resin durability, turn to page 4). Below are test results based on an RAL brown formulation. Please note that due to availability, accelerated testing using Xenon-Arc is not shown:

RAL 8014 Sepia Brown Formulation

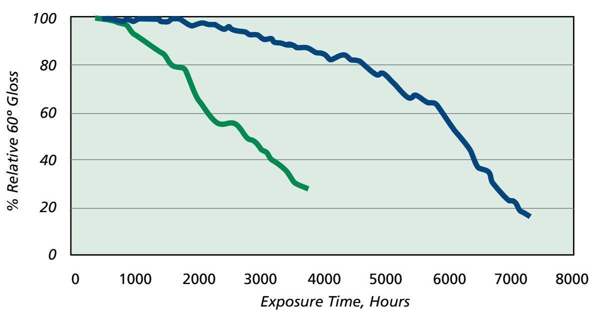
Florida Data



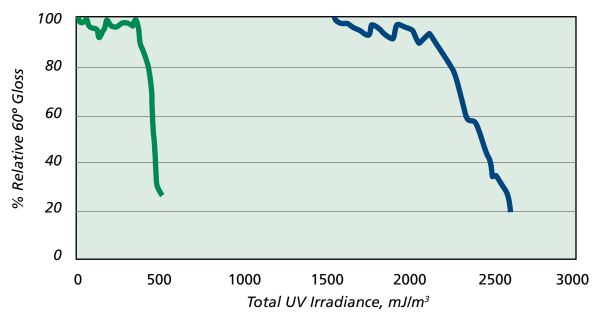
QUV-B313 Data



QUV-A340 Data



EMMAQUA Testing



CRYLCOAT® 2441-2	(green)
CRYLCOAT® 4488-0	(blue)

Raw Material	Weight
Resin	735.0
TGIC	55.0
Bayferrox® Red 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Degussa)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

Based on these results and available test data for other durable and superdurable systems, there is a good correlation between QUV-A340 and Florida natural exposure. QUV-B313 and EMMAQUA data is poorly correlated. Note that this correlation is only valid for the RAL 8014 formulation and not for other colors. Reasons for this will be discussed in "Formulating for Superdurable Powders" on Page 6.

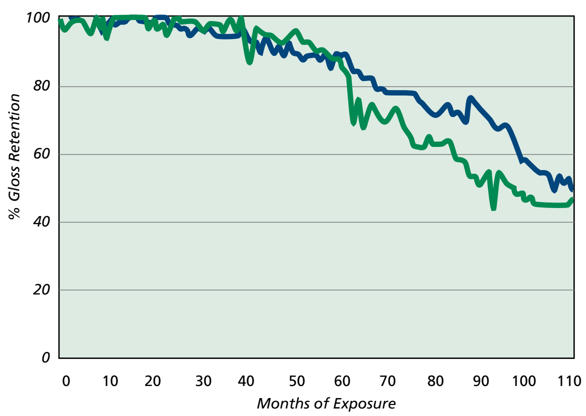
Formulating for Superdurable Powders

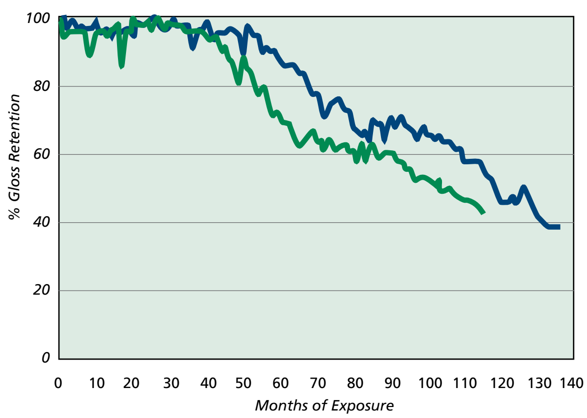
There is more to superdurability than just polyester resin. The powder coating manufacturer needs to consider each component of a formulation and evaluate its effect on weathering resistance. The following section will look at some of these components and how they effect superdurable powder coatings.

Crosslinkers

It is an understatement to say that a crosslinker is very influential in the weatherability of a coating. The crosslinking efficiency of a particular product or its functionality compared to another reactant can make a difference in a coating's ability to resist degradation. The following shows examples of different crosslinkers in acid functional and hydroxy functional resin systems:

RAL 8014 Sepia Brown Formulation at 45° Florida Exposure, Washed





Raw Material	Weight	
Acid Functional System		
CRYLCOAT® 4488-0	735.0	750.5
TGIC	55.0	–
Primid® XL-552	–	39.5
Bayferrox® Red 130 (Lanxess)	45.0	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0	140.0
Farbruss® FW2 (Degussa)	11.0	11.0
MODAFLOW® Powder 6000	10.0	10.0
Benzoin	4.0	4.0
Hydroxyl Functional System		
CRYLCOAT® 4890-0	695.2	671.5
Vestagon® B-1530 (Evonik)	94.8	–
Crelan® EF 403 (Bayer)	–	118.5
Bayferrox® Red 130 (Lanxess)	45.0	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0	140.0
Farbruss® FW2 (Degussa)	11.0	11.0
MODAFLOW® Powder 6000	10.0	10.0
Benzoin	4.0	4.0

Pigments

Pigments affect weather resistance in a variety of ways. The main drivers that determine a pigment system's viability in a powder coating are:

- Darker shades tend to degrade faster than lighter shades due to their ability to absorb more UV radiation and heat. There is a direct correlation between higher energy absorption rates and film degradation.

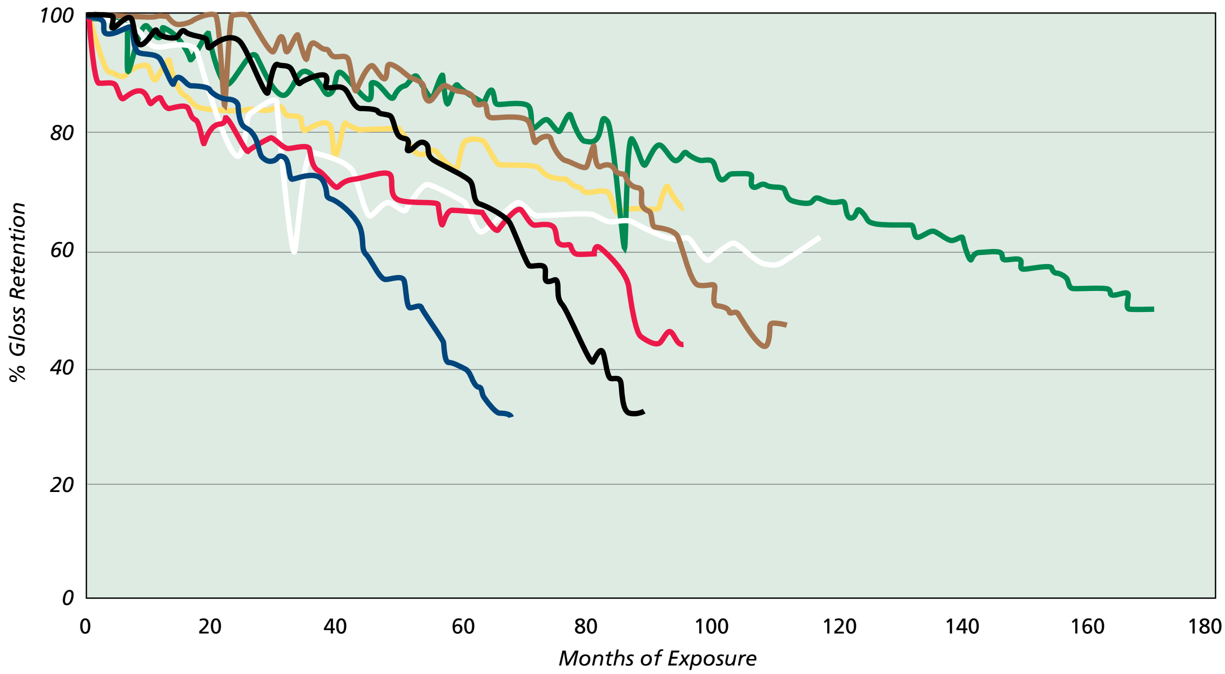
- Different pigment packages alter the resin/crosslinker content in a powder coating. Where a green powder coating may have a resin/crosslinker content of 85%, a white powder coating may only have a content of 60% due to a higher concentration of titanium dioxide. This results in a lower overall wetting of the pigments with the binder and a lower resin/binder percentage in the formulation, which can allow easier penetration of the film by weather elements.

- Care must be taken to choose the correct type of pigment for the correct application. Not all pigments are made for superdurable powder coatings and can cause a superdurable resin system to fail in the time it takes for a durable resin system to fail. When researching pigments, it is imperative to contact the suppliers to verify the ability of these pigments to withstand outdoor conditions.

Page 8 provides an example of how pigmentation can affect resin systems.

8 Formulating for Superdurable Powders

Effects of Pigment on CRYLCOAT® 4488-0 in Various Colors



RAL 1021 Yellow	
CRYLCOAT® 4488-0	609.8
TGIC	45.9
Sicomin®* Yellow 1630S (BASF)	158.7
Chrome Oxide Green 9996 (BASF)	1.0
Sicomin®* Red L 3130S (BASF)	1.5
Blanc Fixe F® (Sachtleben)	165.0
Kronos® 2160 (Kronos)	4.1
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

RAL 3005 Wine Red	
CRYLCOAT® 4488-0	731.0
TGIC	55.0
Paliogen® Red K4180 (BASF)	18.0
Paliogen® Red-Violet K5011 (BASF)	2.0
Bayferrox® 180 (Lanxess)	28.5
Blanc Fixe F® (Sachtleben)	150.0
Kronos® 2160 (Kronos)	1.5
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

RAL 6005 Moss Green	
CRYLCOAT® 4488-0	623.1
TGIC	46.9
Sicomin®* Yellow L1523 (BASF)	8.8
Heliogen® Blue K7080D (BASF)	125.9
Flammruss™ 101 (Degussa)	17.9
Blanc Fixe F® (Sachtleben)	6.0
Durcal 5™ (Omya)	82.9
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

RAL 9010 Pure White	
CRYLCOAT® 4488-0	638.0
TGIC	48.0
Kronos® 2160 (Kronos)	300.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

RAL 8014 Sepia Brown	
CRYLCOAT® 4488-0	735.0
TGIC	55.0
Bayferrox® Red 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Degussa)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

RAL 5010 Gentian Blue	
CRYLCOAT® 4488-0	545.0
TGIC	41.0
Sico® Fast Black L0064 (BASF)	1.4
Heliogen® Blue K7090D (BASF)	18.0
Hostaperm™ Violet RL (Clariant)	0.6
Blanc Fixe F® (Sachtleben)	340.0
Kronos® 2160 (Kronos)	40.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

RAL 7021 Black-Gray	
CRYLCOAT® 4488-0	610.1
TGIC	45.9
Bayferrox® Black 318M (Lanxess)	132.0
Kronos® 2160 (Kronos)	33.0
Blanc Fixe F® (Sachtleben)	165.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

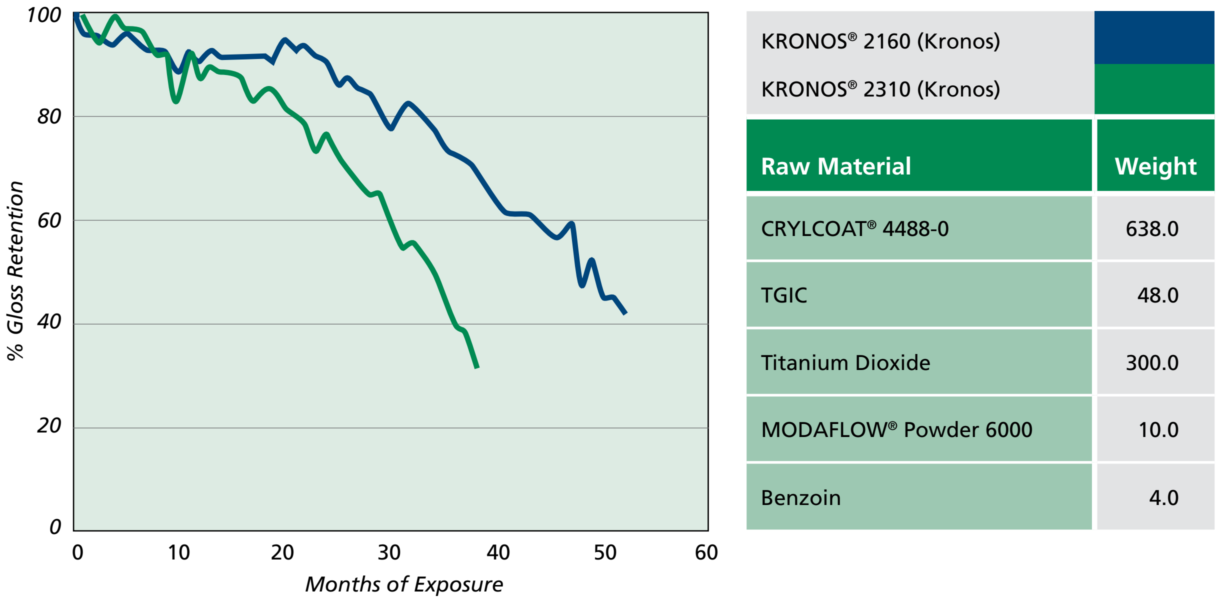
** Sicomin is a lead-containing pigment. Please consult your pigment supplier for lead-free alternatives.*

Titanium Dioxide

The second example of pigment effects centers around titanium dioxide. As with all raw materials, no two grades of titanium dioxide are alike.

The following graph shows the effect of using two different grades of titanium dioxide made by the same manufacturer:

RAL 9010 Pure White Formulation at 45° Florida Exposure, Washed



Raw Material	Weight
CRYLCOAT® 4488-0	638.0
TGIC	48.0
Titanium Dioxide	300.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

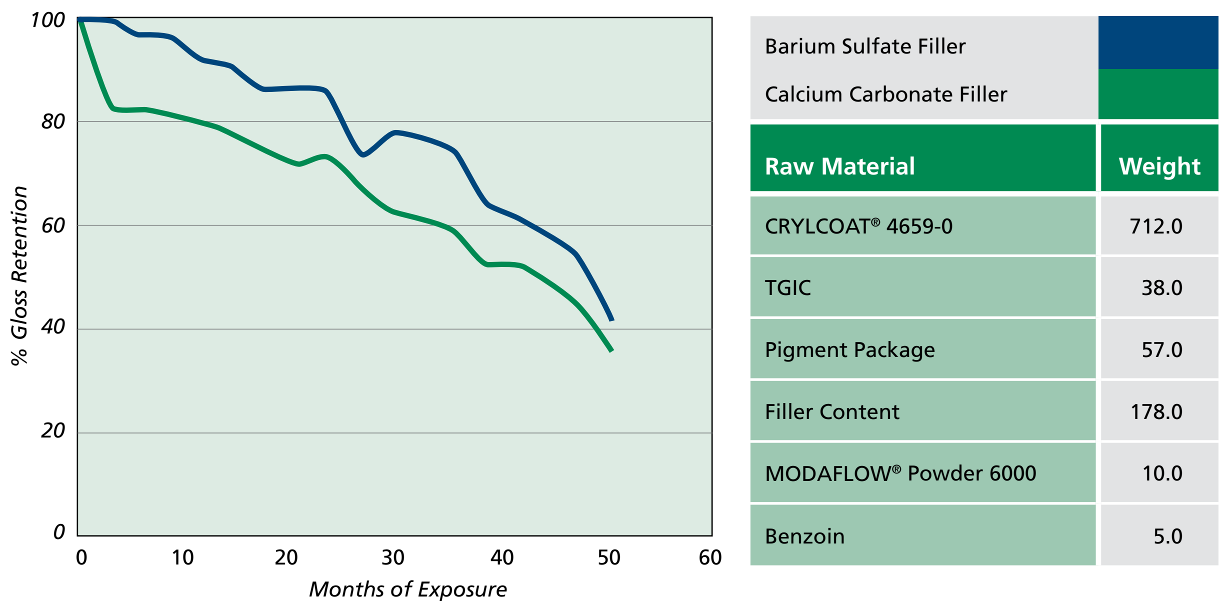
Fillers

Fillers are used in powder coatings for a variety of reasons. However, the main reason is to reduce the overall cost of the powder coating. Adding higher amounts of filler to a superdurable powder coating can negatively affect its weathering resistance properties because it reduces the total amount of resin and crosslinker.

However, if a superdurable formulation requires the use of filler, it is important to note that the type and quality of the filler can also have a dramatic effect on weathering performance.

This example illustrates the difference in outdoor resistance of a formulation when different types of filler are used. For the purpose of this illustration, two well known types of filler, barium sulfate and calcium carbonate are compared in a standard RAL red formulation based on Crylcoat® 4659-0:

RAL 3016 Coral Red Formulation at 5° Florida Exposure, Washed



Raw Material	Weight
CRYLCOAT® 4659-0	712.0
TGIC	38.0
Pigment Package	57.0
Filler Content	178.0
MODAFLOW® Powder 6000	10.0
Benzoin	5.0

Besides choosing the best resin, it is obvious that the proper crosslinkers, pigments, fillers and other pigments are of major importance for optimal outdoor durability. It is up to the formulators to consult with raw material suppliers about the weathering performance of their products in order to successfully develop a superdurable powder coating.

Cytec's Superdurable Product Line

Cytec offers the highest quality resins for superdurable powder coatings. The chart below details Cytec's product offering:

TGIC	HAA High Gloss	HAA Low Gloss	Araldite® PT-910	Urethane
CRYLCOAT® 4430-0	CRYLCOAT® E36988	CRYLCOAT® 4641-0	CRYLCOAT® 4540-0	CRYLCOAT® 4890-0
CRYLCOAT® 4659-0	CRYLCOAT® 4659-0	CRYLCOAT® 4420-0	ADDITOL® P 966	CRYLCOAT® E04290
CRYLCOAT® 4488-0	CRYLCOAT® 4642-3	CRYLCOAT® E04229		CRYLCOAT® E04174
CRYLCOAT® 4420-0	CRYLCOAT® 4626-0	CRYLCOAT® E04251		
ADDITOL® P 966		CRYLCOAT® E04193		
		CRYLCOAT® E04245		

Product Guide

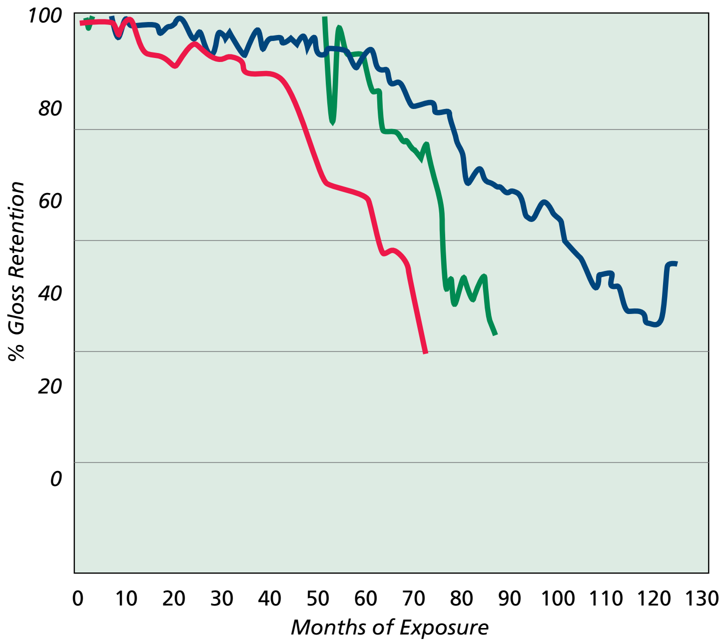
High Gloss	For Clear Coatings	Matte Dry Blend	One-Shot Matte	Catalyst Masterbatch

The next section provides weathering data for each of these products. An overview of the resin characteristics can be found in the Annex in the back of this guide.

Resins for Superdurable TGIC Powder Coatings

Cytec offers several resins for TGIC crosslinked powder coatings. These resins have varying degrees of durability and smoothness. CRYLCOAT® 4488-0, as previously mentioned, has the best durability of the three resins. CRYLCOAT® 4659-0 has the best smoothness. CRYLCOAT® 4430-0 is the best balance of flow and durability:

RAL 8014 Sepia Brown Formulation at 45° Florida Exposure, Washed

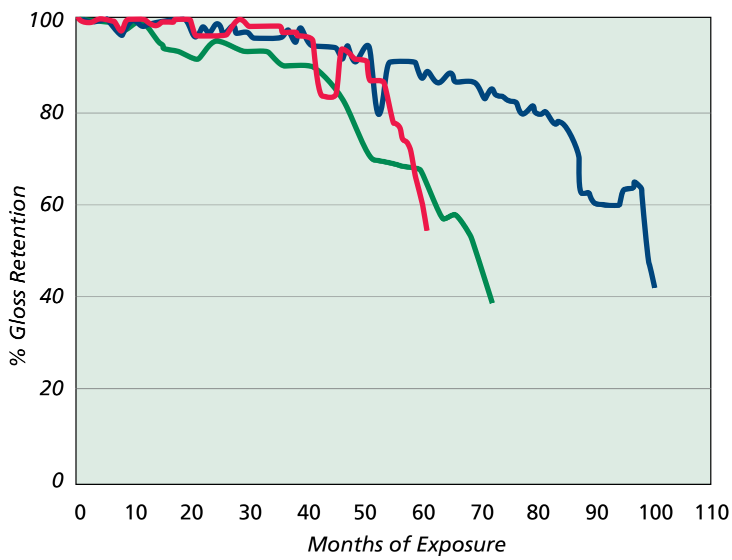


CRYLCOAT® 4488-0
CRYLCOAT® 4430-0
CRYLCOAT® 4659-0

Raw Material	Weight
Resin	735.0
TGIC	55.0
Bayferrox® Red 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Degussa)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

Cytec specializes in TGIC-Free superdurable powder coating resins. The following resins can be used with hydroxyalkylamide (HAA) crosslinkers such as Primid® XL-552. These three resins for TGIC-Free coatings are produced with the same idea as the TGIC crosslinked resins. One resin is made specifically for the highest superdurability, one is produced with smoothness in mind and the other has the right balance of the two properties:

RAL 8014 Sepia Brown Formulation at 45° Florida Exposure, Washed

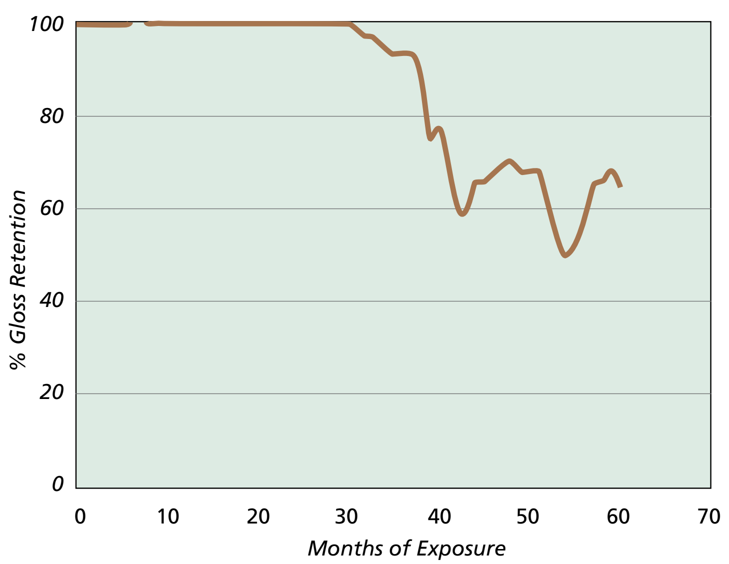


CRYLCOAT® 4626-0	
CRYLCOAT® 4642-3	
CRYLCOAT® 4659-0	

Raw Material	Weight
Resin	750.5
Primid® XL-552 (EMS)	39.5
Bayferrox® Red 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Degussa)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

Cytec also has a resin that can be crosslinked with Araldite® PT-910. The Florida data for this resin system can be found below.

RAL 8014 Sepia Brown Formulation at 45° Florida Exposure, Washed

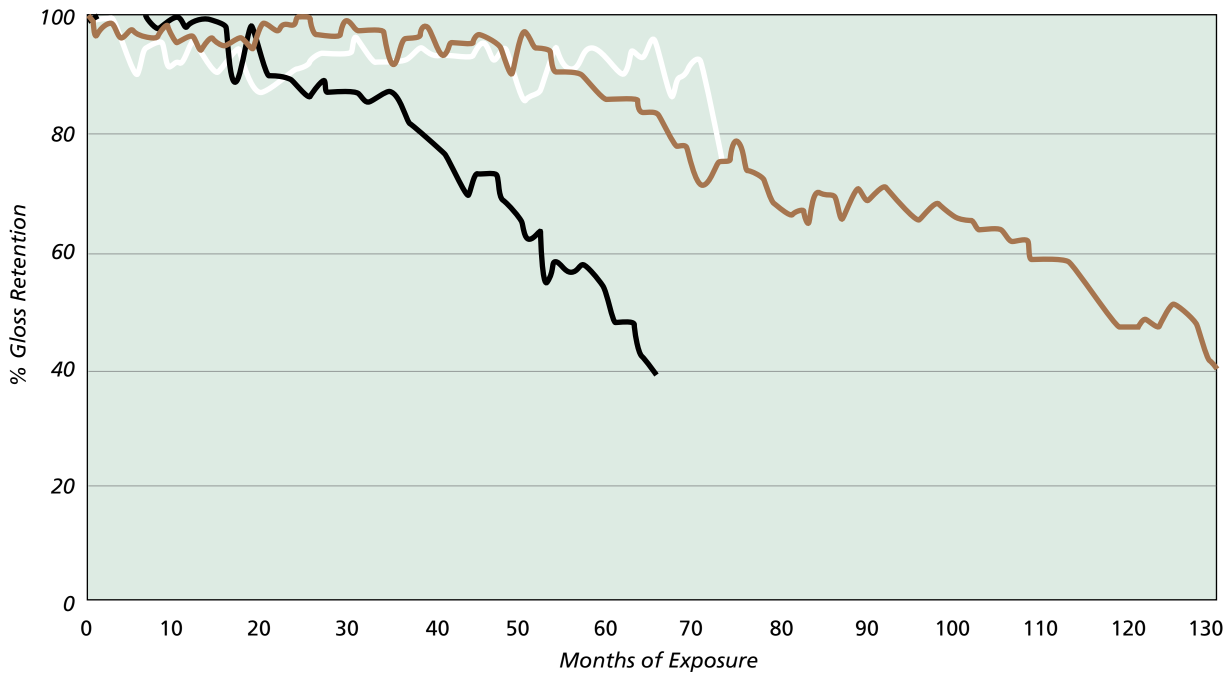


Raw Material	Weight
CRYLCOAT® 4540-0	735.0
Araldite® PT-910	55.0
Bayferrox® Red 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Degussa)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

Superdurable Resins for Polyurethane Systems

CRYLCOAT® 4890-0 is a hydroxyl functional superdurable polyester for use with caprolactam-blocked isocyanates (such as Vestagon® B-1530 from Evonik) and internally blocked uretdiones (Crelan EF-403 from Bayer). CRYLCOAT® 4890-0 has a hydroxyl number of approximately 30mg KOH/g and exhibits superior smoothness while being resistant to Florida weathering for almost 10 years:

45° Florida Exposure, Washed



RAL 8014 Sepia Brown	
Raw Material	**Weight**
CRYLCOAT® 4890-0	695.2
Vestagon® B-1530 (Evonik)	94.8
Bayferrox® Red 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Degussa)	11.0
MODAFLOW® Powder 2000	10.0
Benzoin	4.0

Clear Coating	
Raw Material	**Weight**
CRYLCOAT® 4890-0	867.7
Vestagon® B-1530 (Evonik)	118.3
MODAFLOW® Powder 2000	10.0
Benzoin	4.0

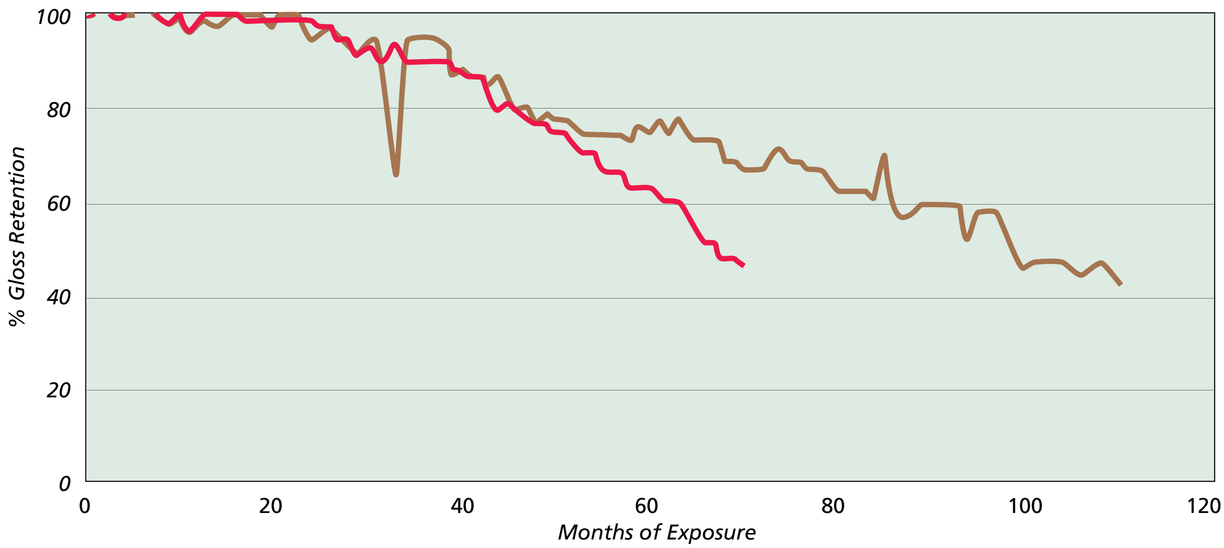
RAL 7014 Black-Gray	
Raw Material	**Weight**
CRYLCOAT® 4890-0	577.3
Vestagon® B-1530 (Evonik)	78.7
Bayferrox® Black 318M (Lanxess)	132.0
Kronos® 2160 (Kronos)	33.0
Blanc Fixe F® (Sachtleben)	165.0
MODAFLOW® Powder 2000	10.0
Benzoin	4.0

Until now, the descriptions of superdurability have dealt solely with high gloss coatings. However, for certain applications such as aluminum frames and architectural extrusions, lower gloss finishes are more desirable. Cytec has systems for matte dry blend (separate extrusions of two different powder coatings mixed in a 1:1 ratio) and one shot matte (one extrusion of a two resin powder system).

Matte Dry Blend

Cytec has two systems for matte dry blend. One that utilizes TGIC as a crosslinker and the other that uses hydroxyalkylamide. The TGIC system is based on CRYLCOAT® 4430-0 and CRYLCOAT® 4420-0. Coatings based on this system can achieve a 60° gloss ranging from 25-40 units. The gloss can further be adjusted by adding ADDITOL® P 966 into the formulation.

RAL 8014 Sepia Brown and RAL 3005 Wine Red Formulation at 45° Florida Exposure, Washed



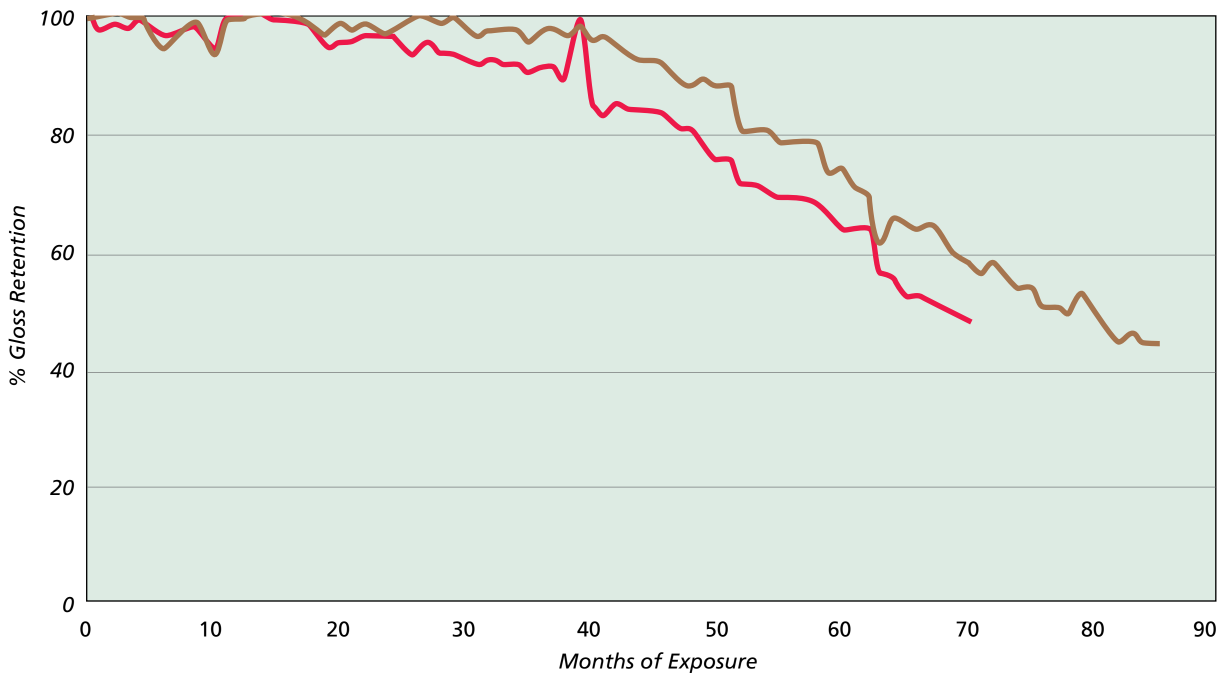
Raw Material	Weight (brown)	
CRYLCOAT® 4420-0	711.0	–
CRYLCOAT® 4430-0	–	735.0
TGIC	79.0	55.0
Bayferrox® Red 130 (Lanxess)	45.0	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0	140.0
Farbruss® FW2 (Degussa)	11.0	11.0
MODAFLOW® Powder 6000	10.0	10.0
Benzoin	4.0	4.0

Raw Material	Weight (red)	
CRYLCOAT® 4420-0	707.4	–
CRYLCOAT® 4430-0	–	731.0
TGIC	78.6	55.0
Paliogen® Red K4180 (BASF)	18.0	18.0
Paliogen® Red-Violet K5011 (BASF)	2.0	2.0
Bayferrox® 180 (Lanxess)	28.5	28.5
Blanc Fixe F® (Sachtleben)	150.0	150.0
Kronos® 2160 (Kronos)	1.5	1.5
MODAFLOW® Powder 6000	10.0	10.0
Benzoin	4.0	4.0

Superdurable Powders for Low Gloss Powder Coatings

Cytec has a TGIC-Free option for matte dry blends. The following graph depicts the Florida exposure of CRYLCOAT® 4420-0 and CRYLCOAT® 4641-0. This system can achieve a 60° gloss between 30 and 35 units when mixed at a 1:1 ratio:

RAL 8014 Sepia Brown and RAL 3005 Wine Red Formulation at 45° Florida Exposure, Washed



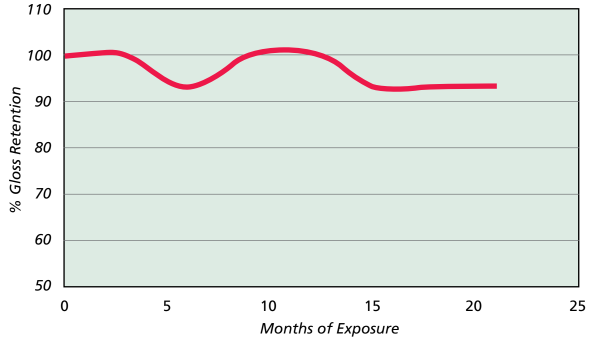
Raw Material	Weight	
CRYLCOAT® 4420-0	726.8	–
CRYLCOAT® 4641-0	–	766.3
Primid® XL-552 (EMS)	63.2	23.7
Bayferrox® Red 130 (Lanxess)	45.0	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0	140.0
Farbruss® FW2 (Degussa)	11.0	11.0
MODAFLOW® Powder 6000	10.0	10.0
Benzoin	4.0	4.0

Raw Material	Weight	
CRYLCOAT® 4420-0	723.1	–
CRYLCOAT® 4641-0	–	762.4
Primid® XL-552 (EMS)	62.9	23.6
Paliogen® Red K4180 (BASF)	18.0	18.0
Paliogen® Red-Violet K5011 (BASF)	2.0	2.0
Bayferrox® 180 (Lanxess)	28.5	28.5
Blanc Fixe F® (Sachtleben)	150.0	150.0
Kronos® 2160 (Kronos)	1.5	1.5
MODAFLOW® Powder 6000	10.0	10.0
Benzoin	4.0	4.0

One Shot Matte

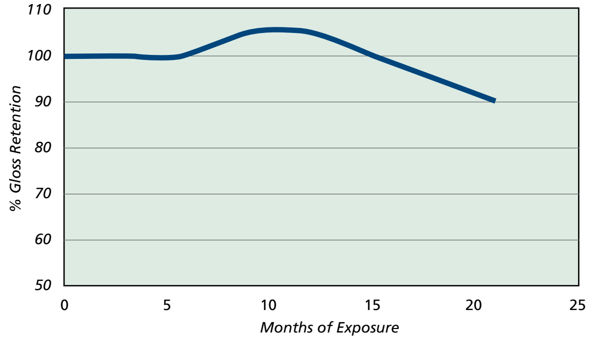
Cytec has introduced new co-extrudable low gloss powder coating resins. The systems, referred to as One Shot Matte systems, offer the powder coating formulator raw material and process savings when compared to low gloss acrylic and matte dry blend technology. Cytec offers three different one shot matte systems for superdurable powder coatings. Because these systems are new, there is very little Florida data to show their weathering resistance.

- CRYLCOAT® E04290-E04174—A hydroxy-functional system that achieves a gloss range of 8-30 units



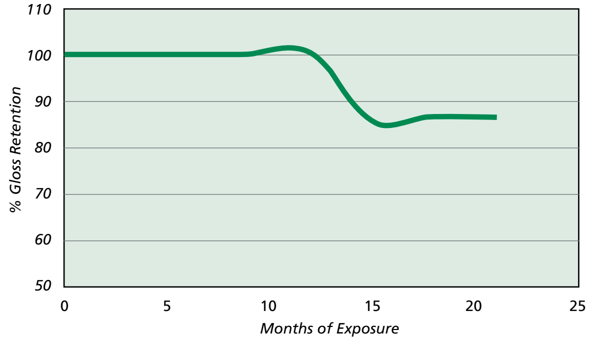
RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight
CRYLCOAT® E04174	256.7
CRYLCOAT® E04290	256.7
Vestagon® BF-1540 (Evonik)	276.6
Bayferrox® Red 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Degussa)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

- CRYLCOAT® E04193-E04251—An acid-functional system for use with hydroxyalkylamide crosslinkers that achieves a gloss range of 6-16 units



RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight
CRYLCOAT® E04193	363.4
CRYLCOAT® E04251	363.4
Primid® XL-552 (EMS)	63.2
Bayferrox® Red 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Degussa)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

- CRYLCOAT® E04229-E04245—An acid-functional system for use with hydroxyalkylamide crosslinkers that achieves a gloss range of 25-40 units



RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight
CRYLCOAT® E04245	365.3
CRYLCOAT® E04229	365.3
Primid® XL-552 (EMS)	59.4
Bayferrox® Red 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Degussa)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

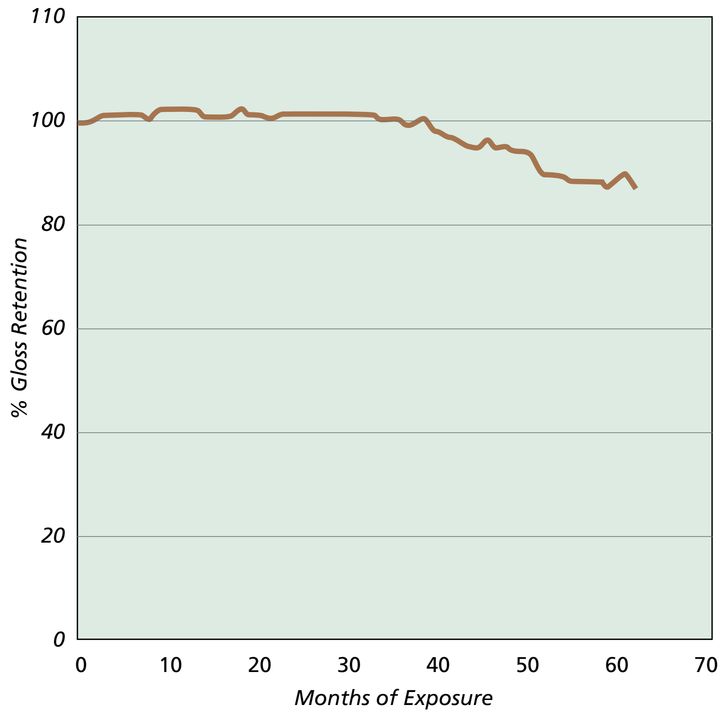
Superdurable Resin with Flexibility

A negative characteristic of using IPA based polyester resins in powder coatings is the resulting film's inability to withstand high amounts of rapid deformation. This deformation, known in the powder coating industry as impact resistance, is measured by dropping a weight directly (or indirectly) onto a coated part.

Typically, a coating made with a TPA-based polyester resin can withstand impact resistance of 160 inch-pounds (an industry standard maximum) while the same coating with an IPA-based resin cannot withstand any impact on a consistent basis.

Cytec has developed a polyester resin which can withstand up to 80 inch-pounds while still maintaining its superdurable characteristics. The Florida data for this resin, named Crylcoat® E36988, is listed below:

RAL 8014 Sepia Brown Formulation at 45° Florida Exposure, Washed



Raw Material	Weight
CRYLCOAT® E36988	750.5
Hydroxyakylamide Crosslinker	39.5
Bayferrox® Black 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Degussa)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

Resin	Acid Number, mg KOH/g	Hydroxyl Number, mg KOH/g	Brookfield VIscosity @ 200°C, mPas	Tg (DSC), °C	Hardener Used	Polyester/ Hardener Ratio	Reference Page(s)
CRYLCOAT® 4420-0	50	< 3	2000	62	TGIC/HAA	TGIC 92/8 HAA 93/7	14, 15
CRYLCOAT® 4430-0	33	< 3	2000	62	TGIC	93/7	11, 14
CRYLCOAT® 4488-0	33	< 3	5400	64	TGIC	93/7	1, 2, 4, 6-9, 11
CRYLCOAT® 4540-0	25	< 3	9000	67	Araldite® PT-910	93/7	12
CRYLCOAT® 4626-0	50	< 3	4500	64	HAA	92/8	13
CRYLCOAT® 4641-0	22	< 3	4300	62	HAA	96.5/3.5	15
CRYLCOAT® 4642-3	33	< 3	1900	62	HAA	95/5	11
CRYLCOAT® 4659-0	31	< 3	3900	59	TGIC/HAA	TGIC 93/7 HAA 95/5	11, 12
CRYLCOAT® 4890-0	< 3	30	5000	61	Isocyanate	88/12 to 85/15	6, 13
CRYLCOAT® E04193 CRYLCOAT® E04251	85 21	< 5 < 1	3000 4000	57 59	HAA	93/7*	16
CRYLCOAT® E04229 CRYLCOAT® E04245	32 85	< 2 < 5	2200 4300	59 59	HAA	93/7 or 92/8*	16
CRYLCOAT® E04174 CRYLCOAT® E04290	< 3 < 3	290 30	3000 5500	52 56	Isocyanate	60/40*	16
CRYLCOAT® E36988	30	< 3	5500	54	HAA	95/5	18
ADDITOL® P 966	35	< 3	1900	N/A	TGIC/ Araldite® PT-910	N/A	14

** Recommended ratio*

Qualification for Architectural Applications

In different regions of the world, it is possible to have powder coating systems certified for architectural applications. Here is a short overview of the important standards:

- AAMA[1] 2604-05 is a severe specification for high-performance organic coatings on architectural aluminum extrusions and panels. Florida natural exposure is the only standard accepted for testing the durability of the coating; a gloss retention of at least 30% and a color retention not exceeding 5ΔE units is required after an exposure time of five years at a 45°angle facing south. One definition of superdurability is defined as passing the AAMA 2604-05 standard.

- In Europe, Qualicoat[2] Class 1 and GSB[3] are known as the standard specifications for quality labels in powder coatings used in architectural applications on aluminum. Besides an accelerated weatherability test (Xenon-Arc for Qualicoat and QUV-B for GSB), the systems have to show a relative gloss retention greater than 50% after one-year exposure in (5° south) Florida to qualify.

- Because of the demands for increased weathering resistance (e.g. rigorous architectural projects), Qualicoat has introduced a new standard. Qualicoat Class 2 requires gloss retentions of at least 90%, 75% and 50% after one, two and three years exposure respectively in Florida.

- An overview of the main requirements of AAMA 2604-05, Qualicoat Class 2, and GSB Master Class is given in the table on page 21. For passing these requirements in different formulations (pigment, gloss), the use of superdurable polyester type chemistry is recommended.

[1] AAMA = American Architecture Manufacturers Association • www.aamanet.org
[2] Qualicoat = Association of Quality Control in the Lacquering, Painting and Coating Industry • www.qualicoat.net
[3] GSB = Gütegemeinschaft für die Stückbeschichtung von Bauteilen • www.gsb-international.de

Architectural Requirements for AAMA 2604-05, Qualicoat Class 2, and GSB Master Class

Test	AAMA 2604-98	Qualicoat Class 2	GSB Master Class
Pretreatment	Chrome or Non-Chrome Conversion Layer	Yellow Chromated Test DIN 50939	Yellow Chromated Test DIN 50939
Thickness	≥ 30 microns	≥ 60 microns	60-120 microns
Adhesion Apparatus Qualified Result	Tape Pull Adhesion 1 mm Crosshatch No Detachment	Tape Pull Adhesion 2 mm Crosshatch No Detachment	Tape Pull Adhesion 2 mm Crosshatch No Detachment
Impact Resistance Apparatus Qualified Result	Tape Pull Adhesion 16 mm Impact Tester No Detachment	Tape Pull Adhesion 2.5 mm Direct Deformation No Detachment	Tape Pull Adhesion 2.5 mm Direct Deformation No Detachment per DIN2409
Humidity Resistance Conditions Blistering Qualification Creepage Qualification	ASTM C2247/4585 38°C, 100% RH for 3000 hrs No blisters No qualification	ISO 6270-2 40°C, 100% RH for 1000 hrs No blisters 1 mm maximum	ISO 6270-2 40°C, 100% RH for 1000 hrs No blisters 1 mm maximum
Corrosion Resistance Conditions Blistering Qualification Creepage Qualification	ASTM B117 3000 hrs in 5% NaCl Solution No blisters 2 mm maximum	ISO 9227 1000 hrs in Acetic SS Solution No blisters 4 mm or 16 mm^2 infiltration	ISO 9227 750 hrs in Acetic SS Solution No blisters 1 mm maximum
Boiling Water Conditions Result	1 mm tape pull adhesion 20 min in 100°C Water No Detachment	2 mm tape pull adhesion 120 min in 100°C Water No Detachment	2 mm tape pull adhesion 120 min in 100°C Water No Detachment
Pressure Cooker	None	2 mm tape pull adhesion 60 min in pressure cooker No detachment	2 mm tape pull adhesion 60 min in pressure cooker No detachment
Accelerated Weathering Test Time Gloss Retention	None	Xenon Arc (ISO11341) 1000 hours 90%	QUV-B (ISO11507) 600 hours 50%
Florida Exposure Exposure Angle Test Time Gloss Retention Color Change	 45° 60 months 30% Maximum ΔE change of 5	 5° 12, 24, and 36 months 75, 65, and 50% Coating color dependent	 45° 36 months 50% Coating color dependent