CYTEC

CRYLCOAT® Resins for Superdurable Powder Coatings

10+ Years Florida Exposure

PRODUCT PERFORMANCE GUIDE

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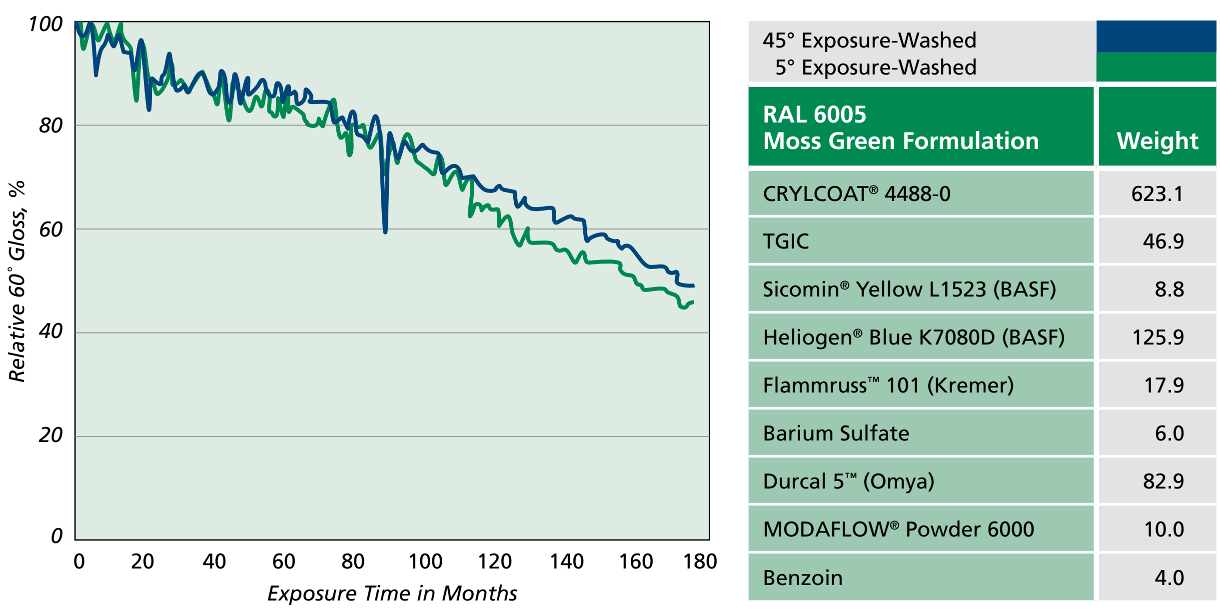
Introduction 1

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

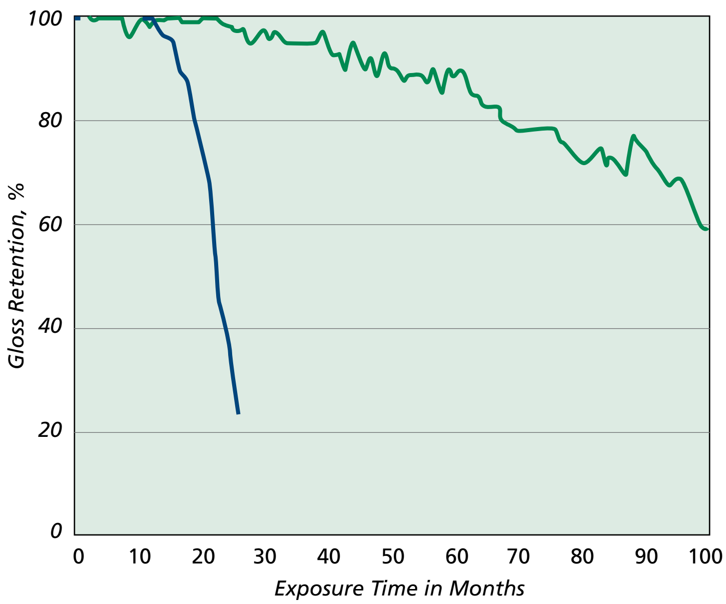
Cytec has a comprehensive portfolio of products for use in high-performance weather resistant coatings. CRYLCOAT® 4488-0 symbolizes this high performance. This polyester resin, made in powder coatings formulated with TGIC, surpassed 13 years of Florida exposure while retaining more than 50% of its gloss.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



RAL 6005 Moss Green Formulation	Weight
CRYLCOAT® 4488-0	623.1
TGIC	46.9
Sicomin® Yellow L1523 (BASF)	8.8
Heliogen® Blue K7080D (BASF)	125.9
Flammruss™ 101 (Kremer)	17.9
Barium Sulfate	6.0
Durcal 5™ (Omya)	82.9
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

From Standard Durable to Superdurable Binder Systems

Polyesters used in exterior durable powder coatings are primarily based on two molecules—teraphthalic 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:



CRYLCOAT® 4488-0	(blue)
CRYLCOAT® 2441-2	(green)
RAL 8014 Sepia Brown 45° Washed Florida Exposure	**Weight**
Resin	735.0
TGIC	55.0
Bayferrox® Black 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Algol)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

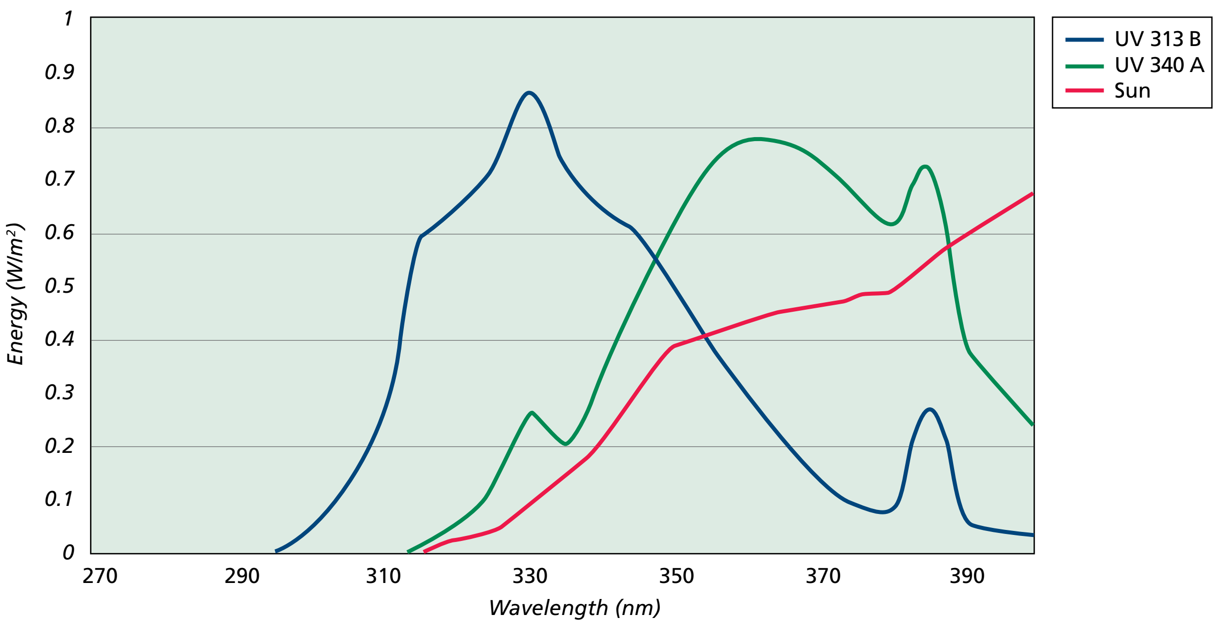
There are four different types of weather resistance test criteria currently being used. Each system has distinct advantages and disadvantages. However, all of the systems can adequately forecast the outdoor durability when comparing different powder systems. The tests used to determine outdoor weathering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

Natural Florida Weathering—This test consists of exposing coating samples to the indigenous Florida climate. Sites in Miami and Jacksonville 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.

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 here as it compares to natural sunlight:

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



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, compared to 10 years in Florida.

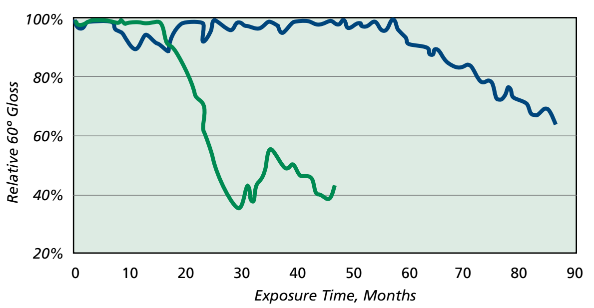
The disadvantage of using these systems is that the type and intensity of the light being exposed to the panels does not accurately depict the same wavelengths that natural sunlight exhibits. Also, QUV-B313 is an extremely harsh test that can produce false failure results.

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.

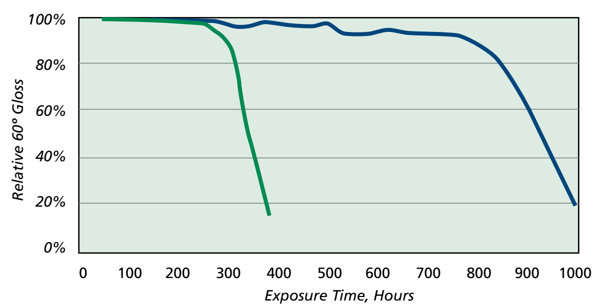
Correlation of Accelerated Weathering Tests to Natural Weathering

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:

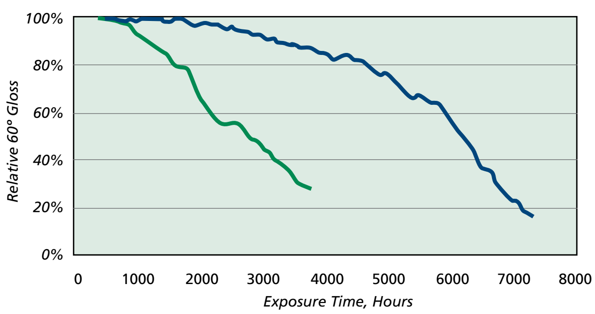
Florida Data



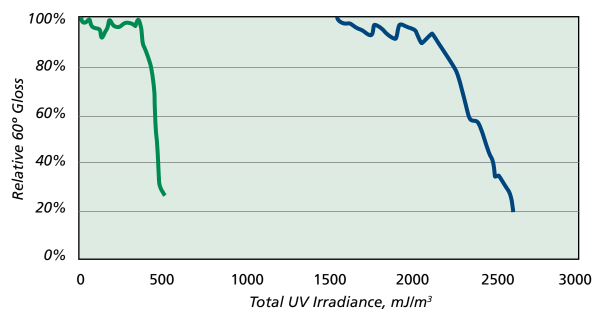
QUV-B313 Data



QUV-A340 Data



EMMAQUA Testing



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

RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight
Resin	735.0
TGIC	55.0
Bayferrox® Black 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Algol)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

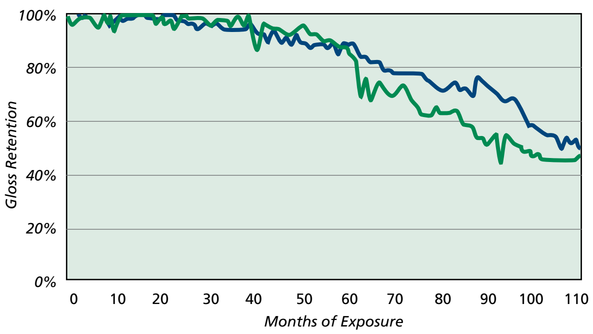
Based on these results and other available test data for other durable and superdurable systems, there is a good correlation between QUV-A340 and Florida natural exposure. QUV-B313 and EMMAQUA data is poorly correlated. Note that this correlation is only valid for the RAL 8014 formulation and not for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

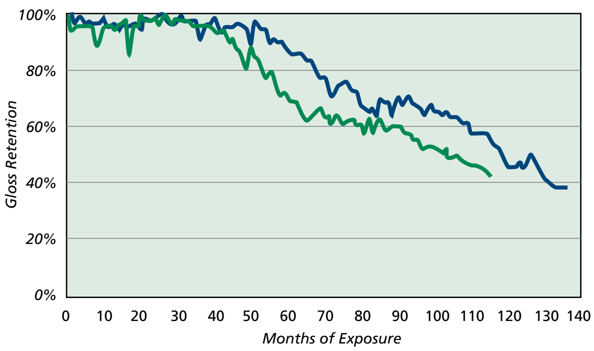
Formulating for Superdurable Powders

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 45° Washed Florida Exposure	Weight	
Acid Functional System		
CRYLCOAT® 4488-0	735.0	750.5
TGIC	55.0	–
Primid® XL-552	–	39.5
Bayferrox® Black 130 (Lanxess)	45.0	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0	140.0
Farbruss® FW2 (Algol)	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® VP LS-2147 (Bayer)	–	118.5
Bayferrox® Black 130 (Lanxess)	45.0	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0	140.0
Farbruss® FW2 (Algol)	11.0	11.0
MODAFLOW® Powder 6000	10.0	10.0
Benzoin	4.0	4.0

Pigments

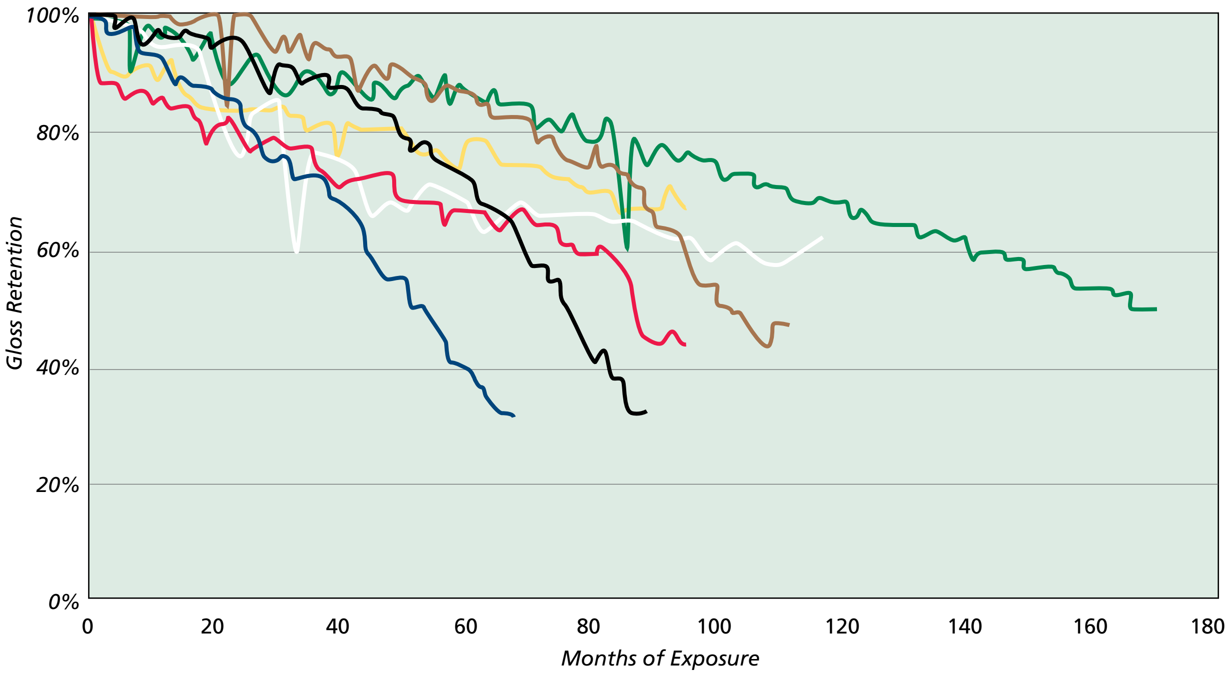
Pigments affect weather resistance in a variety of ways. The main drivers that determine a pigment system's viability in a powder coating are:

- The differences between durable and superdurable powder coatings
- The actual color can have an adverse effect on coating durability since darker colors absorb more heat. As temperature exposure to a powder coating increases, so does the speed of coating 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 55% due to a higher concentration of titanium dioxide. This results in a cured powder with fewer and shorter polymer chains which can allow weather elements to penetrate and degrade the powder coating.
- 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.

Formulating for Superdurable Powders

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



Non RAL Yellow	
CRYLCOAT® 4488-0	609.8
TGIC	45.9
Sicomin® Yellow 1630S (BASF)	158.7
Chrome Oxide Green 9996	1.0
Sicomin® Red L 3130S (BASF)	1.5
Barium Sulfate	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
Barium Sulfate	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 (Kremer)	17.9
Barium Sulfate	6.0
Durcal 5™ (Omya)	82.9
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

RAL 9001 White	
CRYLCOAT® 4488-0	638.0
TGIC	48.0
Kronos® 2160 (Kronos)	300.0
MODAFLOW® Powder 6000	10.0
Benzoin	0.4

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

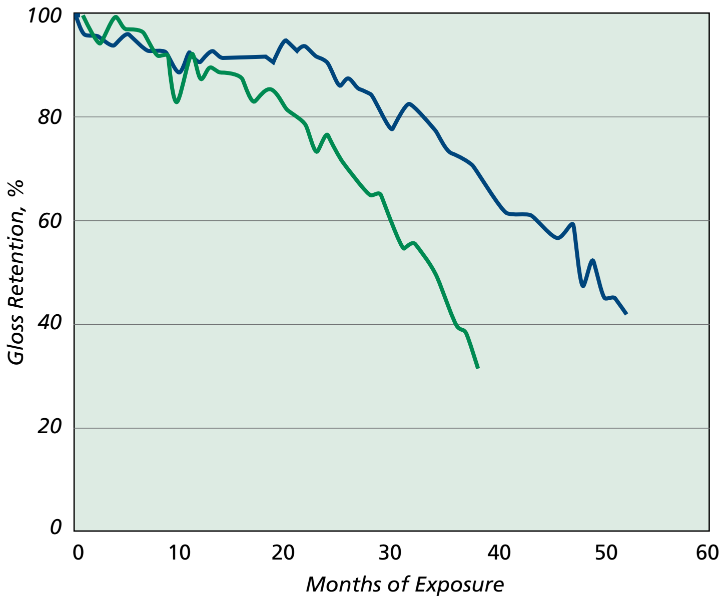
RAL 5010 Blue	
CRYLCOAT® 4488-0	545.0
TGIC	41.0
Sico® Fast Black L0064 (BASF)	1.4
Heliogen® Blue K7090D (BASF)	18.0
Hostaperm™ Violet RL (Clariant)	0.6
Barium Sulfate	340.0
Kronos® 2160 (Kronos)	40.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

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

Titanium Dioxide

The second example of pigment effects centers around titanium dioxide. As with all raw materials, no two grades of TiO2 are made alike.

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



KRONOS® 2160 (Kronos)	
KRONOS® 2310 (Kronos)	
RAL 9001 White 45° Washed Florida Exposure	**Weight**
CRYLCOAT® 4488-0	638.0
TGIC	48.0
Titanium Dioxide	300.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

It is obvious that, besides choosing the best resin, the proper crosslinker, pigments, and other additives present in the formulation is of major importance for optimal durability performance. It is up to the formulators to ask the 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:

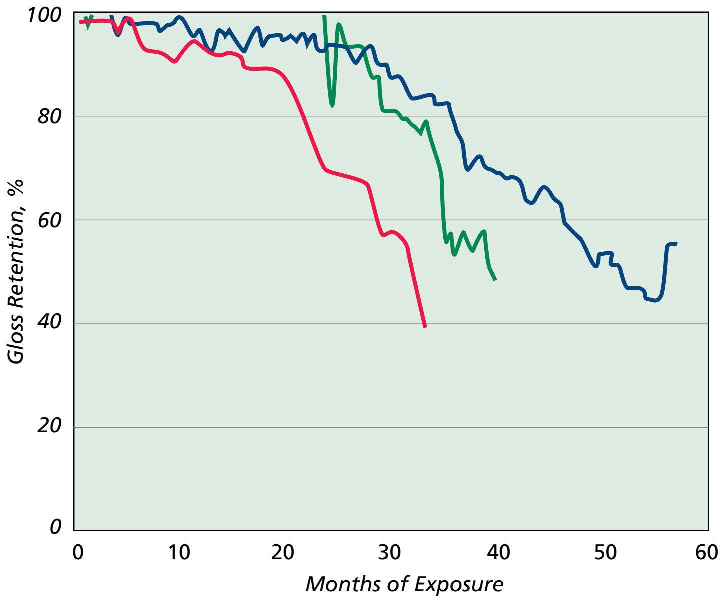
TGIC	HAA High Gloss	HAA Low Gloss	PT-910	Urethane
CRYLCOAT® 4430-0	CRYLCOAT® E36988	CRYLCOAT® 4641-0	CRYLCOAT® 4540-0	CRYLCOAT® 4890-0
CRYLCOAT® 4432-4	CRYLCOAT® 4659-0	CRYLCOAT® 4420-0	ADDITOL® P 966	CRYLCOAT® E04290
CRYLCOAT® 4659-0	CRYLCOAT® 4642-3	CRYLCOAT® E04229		CRYLCOAT® E04174
CRYLCOAT® 4488-0	CRYLCOAT® 4626-0	CRYLCOAT® E04251		
CRYLCOAT® 4420-0		CRYLCOAT® E04193		
ADDITOL® P 966		CRYLCOAT® E04245		

Product Guide

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

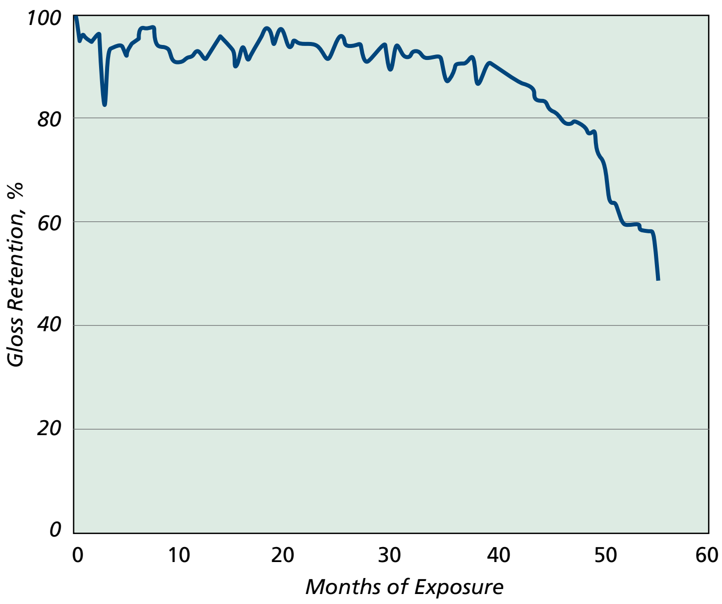
The next section provides weathering data for each of these products. An overview of the resin characteristics can be found in the Annex in the back of this guide.

Cytec offers several resins for TGIC crosslinked powder coatings. These resins have varying degrees of durability and smoothness. CRYLCOAT® 4488-0, as shown in other graphs, 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:



CRYLCOAT® 4488-0 CRYLCOAT® 4430-0 CRYLCOAT® 4659-0	
RAL 8014 Sepia Brown 45° Washed Florida Exposure	**Weight**
Resin	735.0
TGIC	55.0
Bayferrox® Black 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Algol)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

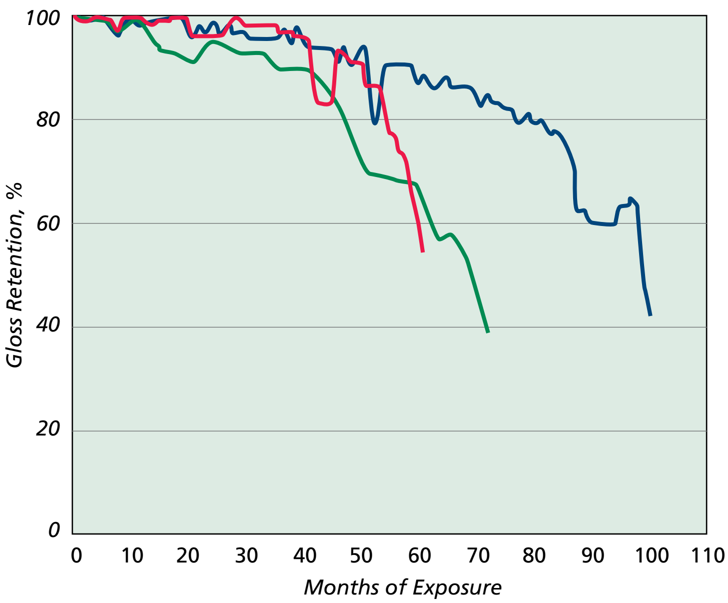
Cytec also has a superdurable resin, CRYLCOAT 4432-4, specifically manufactured for clear powder coatings crosslinked with TGIC.



CRYLCOAT® 4432-4	
Clear Formulation	**Weight**
CRYLCOAT® 4432-4	926.7
TGIC	69.8
Benzoin	3.5

Resins for Superdurable TGIC-Free Powder Coatings

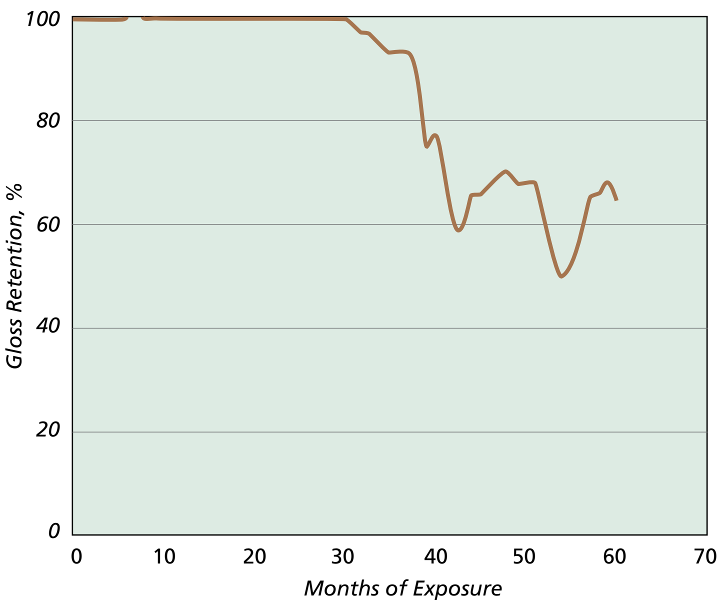
Cytec also specializes in TGIC-Free superdurable powder coating resins. The following resins can be used with hyroxyalkylamide (HAA) crosslinkers such as Primid® XL-552. These three resins for TGIC-Free coatings are produced with the same idea as the TGIC crosslinked resins. One resin is made specifically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



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

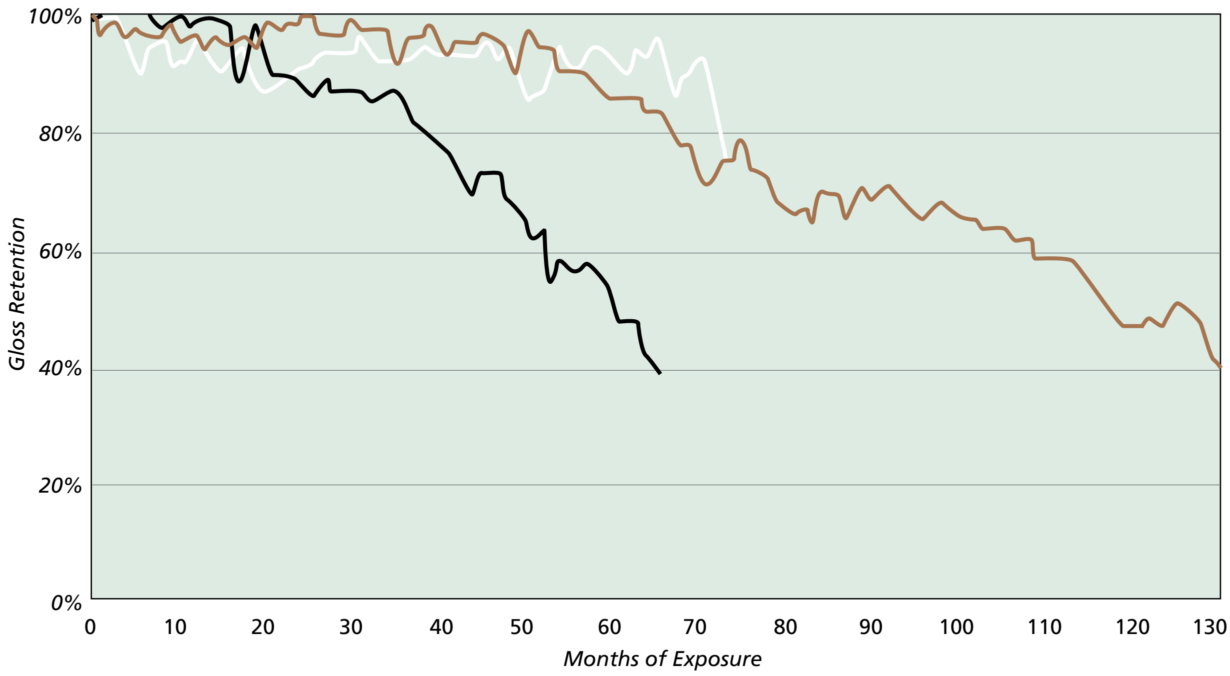
RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight
Resin	750.5
Hydroxyalkylamide Crosslinker	39.5
Bayferrox® Black 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Algol)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

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



RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight
CRYLCOAT® 4540-0	735.0
Araldite® PT-910	55.0
Bayferrox® Black 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Algol)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

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 LS-2147 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:



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

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

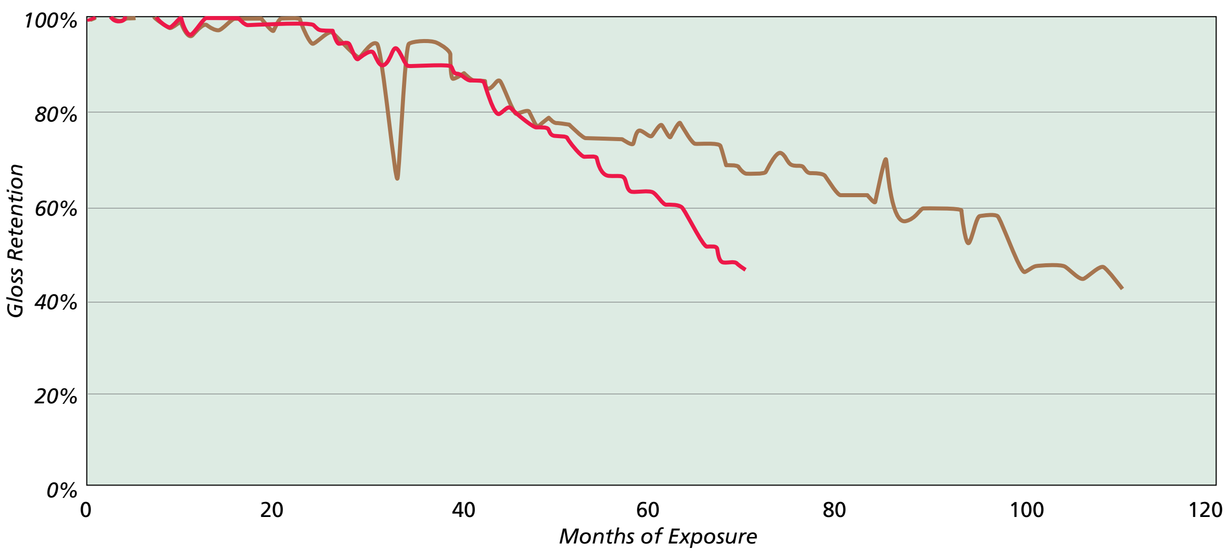
RAL 7014 Black-Gray	
CRYLCOAT® 4890-0	577.3
Vestagon® B-1530 (Evonik)	78.7
Bayferrox® Black 318M (Lanxess)	132.0
Kronos® 2160 (Kronos)	33.0
Barium Sulfate	165.0
MODAFLOW® Powder 2000	10.0
Benzoin	4.0

Superdurable Powders for Low Gloss Powder Coatings

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

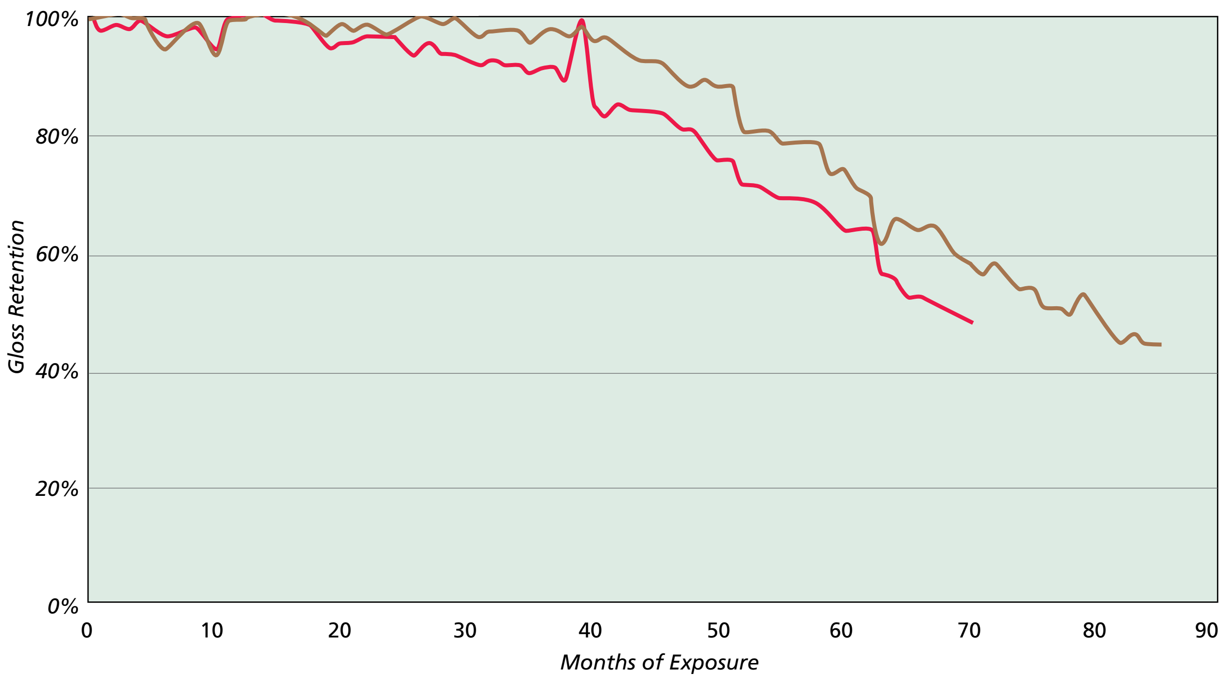
Cytec has two systems for matte dry blend. One that utilizes TGIC as a crosslinker and the other that uses hydroxyalkylamide. The TGIC system is based on CRYLCOAT® 4430-0 and CRYLCOAT 4420-0. Coatings based on this system can achieve a 60° gloss ranging from 25-40. The gloss can further be adjusted by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



RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight	
CRYLCOAT® 4420-0	711.0	–
CRYLCOAT® 4430-0	–	735.0
TGIC	79.0	55.0
Bayferrox® Black 130 (Lanxess)	45.0	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0	140.0
Farbruss® FW2 (Algol)	11.0	11.0
MODAFLOW® Powder 6000	10.0	10.0
Benzoin	4.0	4.0

RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight	
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
Barium Sulfate	150.0	150.0
Kronos® 2160 (Kronos)	1.5	1.5
MODAFLOW® Powder 6000	10.0	10.0
Benzoin	4.0	4.0

Cytec also 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 of between 30 and 35 when mixed at a 1:1 ratio:



RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight	
CRYLCOAT® 4420-0	726.8	–
CRYLCOAT® 4641-0	–	766.3
Hydroxyalkylamide Crosslinker	63.2	23.7
Bayferrox® Black 130 (Lanxess)	45.0	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0	140.0
Farbruss® FW2 (Algol)	11.0	11.0
MODAFLOW® Powder 6000	10.0	10.0
Benzoin	4.0	4.0

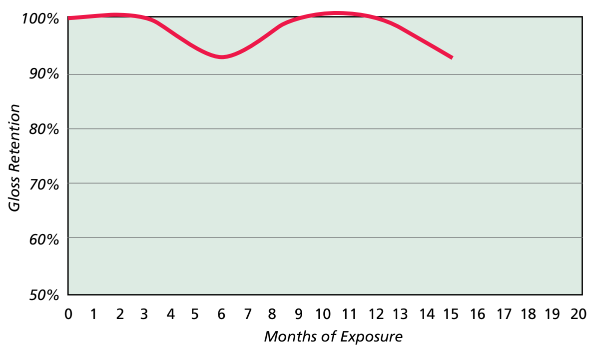
RAL 3005 Red 45° Washed Florida Exposure	Weight	
CRYLCOAT® 4420-0	723.1	–
CRYLCOAT® 4641-0	–	762.4
Hydroxyalkylamide Crosslinker	62.9	23.6
Paliogen® Red K4180 (BASF)	18.0	18.0
Paliogen® Red-Violet K5011 (BASF)	2.0	2.0
Bayferrox® 180 (Lanxess)	28.5	28.5
Barium Sulfate	150.0	150.0
Kronos® 2160 (Kronos)	1.5	1.5
MODAFLOW® Powder 6000	10.0	10.0
Benzoin	4.0	4.0

Superdurable Powders for Low Gloss Powder Coatings

One Shot Matte

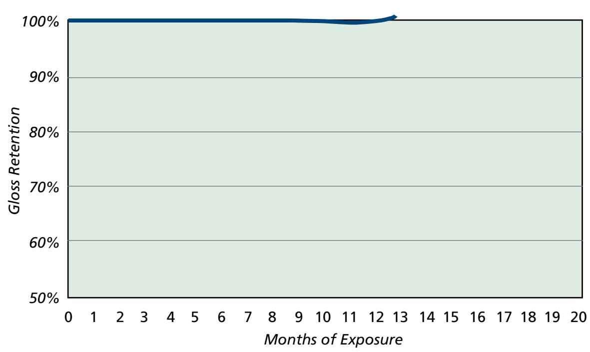
Cytec also offers new co-extrudable low gloss powder coating resins. The systems, referred to as One Shot Matte systems, offer the powder coating formulator raw material and process savings when compared to low gloss acrylic and matte dry blend technology. Cytec offers three different one shot matte systems for superdurable powder coatings. Because these systems are new, there is very little Florida data to show their weathering resistance. The graphs below depict 100% gloss retention after 15 months for each of the systems:

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



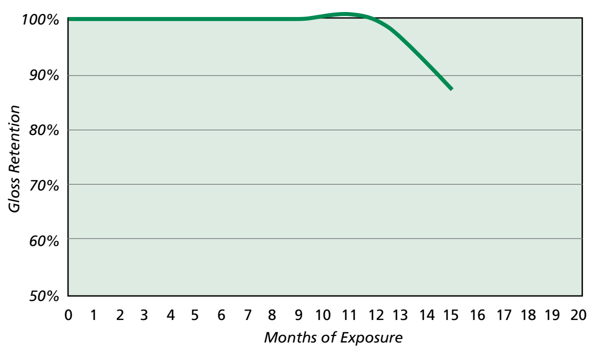
RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight
One Shot Matte OH 10 Gloss	
CRYLCOAT® E04174	256.7
CRYLCOAT® E04290	256.7
Vestagon® BF-1540 (Evonik)	276.6
Bayferrox® Black 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Algol)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

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



RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight
One Shot Matte HAA 10 Gloss	
CRYLCOAT® E04193	363.4
CRYLCOAT® E04251	363.4
Hydroxyalkylamide Crosslinker	63.2
Bayferrox® Black 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Algol)	11.0
MODAFLOW® Powder 6000	10.0
Benzoin	4.0

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



RAL 8014 Sepia Brown 45° Washed Florida Exposure	Weight
One Shot Matte HAA 30 Gloss	
CRYLCOAT® E04245	365.3
CRYLCOAT® E04229	365.3
Hydroxyalkylamide Crosslinker	59.4
Bayferrox® Black 130 (Lanxess)	45.0
Bayferrox® Yellow 3950 (Lanxess)	140.0
Farbruss® FW2 (Algol)	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® 4480-0	33	< 3	5400	64	TGIC	93/7	1, 2, 4, 6-9, 11
CRYLCOAT® 4430-0	33	< 3	2000	62	TGIC	93/7	11, 14
CRYLCOAT® 4659-0	31	< 3	3900	59	TGIC/HAA	TGIC 93/7 HAA 95/5	11, 12
CRYLCOAT® 4420-0	50	< 3	2000	62	TGIC/HAA	TGIC 92/8 HAA 93/7	14, 15
CRYLCOAT® 4432-4	33	< 3	1800	62	TGIC	93/7	11
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® 4540-0	25	< 3	9000	67	PT-910	93/7	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
ADDITOL® P 966	35	< 3	1900	N/A	PT-910	N/A	14

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] 2604-98 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 2604-98 standard.

- In Europe, Qualicoat Class 1 and GSB[2] are known as the standard specifications for quality labels in powder coatings used in architectural applications on aluminum. Besides an accelerated weatherability test (Suntest 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 2604-98 and Qualicoat Class 2 is given in the table on page 19. For passing these requirements in different formulations (pigment, gloss), the use of superdurable polyester type chemistry is recommended.

[1] AAMA = American Architecture Manufacturers Association [2] GSB = Gütegemeinschaft für die Stückbeschichtung von Bauteilen

AAMA 2604-98/Qualicoat Class 2 Main Requirements

	AAMA 2604-98		Qualicoat Class 2	
Pre-treatment	Chrome or non-chrome conversion layer		Yellow chromated (DIN50939)	
Thickness	≥ 30 µm		≥ 60 µm (ISO2360)	
Adhesion	1mm crosshatch; Tape pull adhesion	No detachment	2mm crosshatch; Tape pull adhesion	No detachment
Impact Resistance	Direct deformation 3mm; Tape pull adhesion	No detachment	Direct deformation, 2.5mm; Tape pull adhesion	No detachment
Humidity Resistance	3000hr, 38°, 100% RH (ASTMC2247/4585)	No blistering	Cross 1000hr, 40°, 100%RH	No blistering, max 1mm creepage
Corrosion/Salt Spray Resistance	Scored film; 3000hr, 5% NaCl (ASTM B117)	No blistering, max. 2mm creepage	Crosscut incision; 1000hr, Acetic SS (NaCl, acetic acid) (ISO9227)	Max. 4mm infiltration; max. 16mm over 10cm scratch length
Boiling Water	Tape pull adhesion; 1mm crosshatch; 20min in boiling H_20	No detachment	Tape pull adhesion 2hr in boiling H_20/ 1hr pressure cooker	No detachment
Accelerated Weathering Test	–	–	Suntest (Xenon Arc), 1000hr	90% Gloss (60°) (ISO11341)
Outdoor Exposure Test	Florida, 5 years at 45° angle south	30% Gloss; max 5ΔE units	Florida, 1, 2, 3 years 5° angle south	90, 75, 50% gloss retention; ΔE spec

Advantages of Superdurable Powder Coatings over PVDF Systems

Polyfluorinated polymers are known for their excellent UV resistance and are subsequently quite popular as the binder component in architectural coatings. Their excellent weatherability has been proven by long-term exposure in Florida, exceeding the AAMA-2604 requirements. Among the polyfluorinated coatings, PVDF solvent-based systems are the best known and are used commercially for the coating of aluminum window frames and claddings.

Powder coatings based on superdurable polyester resins, passing the same requirements, can be considered as an excellent alternative for PVDF-based coatings for the following reasons:

Cost

PVDF is an expensive polymer, resulting in high prices of the formulated coatings. The application area of PVDF solvent-based coatings is quite low compared to powder coatings; 7-8 m2/kg for PVDF applied at 35-40µ versus 10 m2/kg for powder applied at ±70µ.

Efficiency

Transfer efficiency is better for powder coatings, and thus can further lower overall cost. The oversprayed powder can be recycled up to 95%.

Ease of Use

PVDF polymers are characterized by poor dispersion that can result in film defects, such as color floating and flooding. Often, acrylic resins must be added to provide proper dispersion, and two layers must be applied to attain acceptable smoothness. Additionally, very slow evaporating solvents are sometimes required to ensure good film coalescence during cure.

A powder formulation is ready to use as delivered; the powder is easy to handle and can be applied with electrostatic spray guns. Attractive, defect-free, one-layer finishes can be achieved using powder coatings.

Energy Use

PVDF coatings requires higher curing temperatures and longer cycles than for powder coatings (220-240°C/20-30 minutes vs. 170-200°C/15-20 minutes for powders)

Visual Aspect

Powder coatings generally provide better edge coverage than do solvent-based PVDF coatings. Also, superdurable powder coatings are available in a wider choice of gloss levels and colors than are PDVF coatings.

Impact on Environment

Solid content of PVDF system is ±40-50%. Powder coatings contain 100% solids with no VOCs. The waste generation is minimal with powder coatings. This results in reduced waste/solvent costs.