US SILICA®

White Paper

EverWhite® Pigment (EWP-5)
PATENT PENDING

Liquid Applied Roof Coatings Evaluation with Substitution of Everwhite® Pigment*

THE WORLD HAS CHANGED

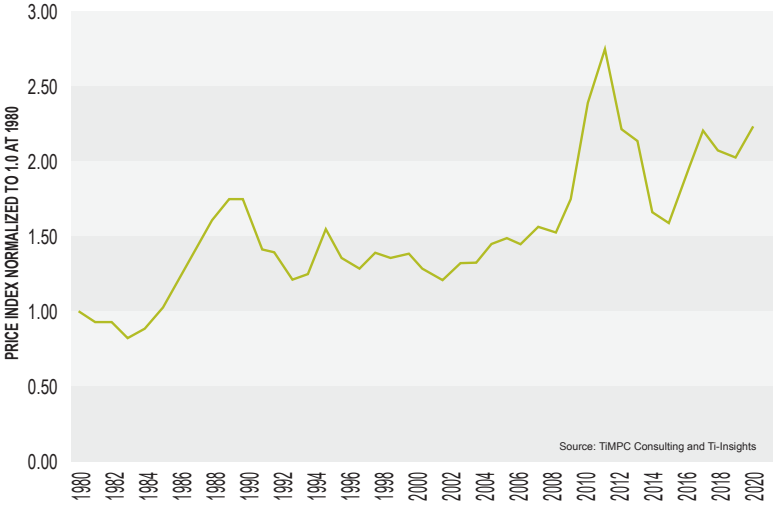
Reliable global supply chains of key ingredients have become brittle and broken by competing tariffs, by recurring virus outbreaks and even by war. Case in point, the supply of titanium dioxide (TiO_2), which is used in numerous applications from sunscreen to paints to countertops to paper applications. Even though this extremely important global commodity is serviced by several multi-billion-dollar manufacturers, the supply of titanium dioxide has become unstable over the last few years, resulting in more uncertainty and volatility in pricing.

To understand the magnitude of this shift, a consulting firm with over 30 years experience has highlighted some of the key dynamics facing companies who are purchasing titanium dioxide in North America. For most of 2021 and 2022 the price of titanium dioxide spiked to an all-time high for many markets, followed by a nine month drop. This drop in price will not last long; volatility will come back with increased pricing going into 2023 and beyond. Due to the regulatory hurdles and the large capital needed to increase capacity, no new supply is likely to come online in Europe or North America any time soon.

To address the challenges of titanium dioxide supply, many innovative companies have begun reformulating to reduce titanium dioxide through the use of alternative white pigments. These new white pigments offer relief by partially replacing a portion of titanium dioxide needed in an end application. Substituting out 10% or 25% can lead to hundreds of thousands of savings and ensure their manufacturing assets can continue to operate without any supply chain disruption.

“The substitution with EverWhite® Pigment at even 25% replacement would save coatings manufacturers $100,000s annually, if not more.”

Titanium Dioxide (TiO_2) Global Price Indexed to 1980 Average Price[1]



This white paper examines the proof of concept of using ***EverWhite® Pigment, (EWP-5)*** as an extender for liquid applied roof coatings, showing that its use not only provides a cost savings over TiO_2, but offers performance advantages in the form of weatherability, durability and solar reflectivity.

HOW TO DEAL WITH A CHANGED WORLD

Just because our world has changed, and once reliable global supply chains of key ingredients have become brittle and broken, does not mean that innovative companies cannot adapt. Many manufacturers are seeking out and commercializing new white pigments that are described in this white paper. Materials like EverWhite® Pigment address many of the costly concerns of both price and supply stability.

EverWhite® Pigment is a highly refined silica-based white mineral used to replace other inorganic pigments like titanium dioxide. This ultra-white pigment produces a consistent color foundation for coating, plastic, or concrete products.

EverWhite® Pigment is specially formulated with a high solar reflectivity and has a weatherability equal to other specialty minerals like titanium dioxide-based pigments.

COMPLEMENT TO TITANIUM DIOXIDE USING EVERWHITE® PIGMENT

To demonstrate the efficacy of using EverWhite® Pigment as an extender for titanium dioxide in a Liquid Applied Cool Roof Coating, a coating development expert with over 40 years' experience ran a series of trials.

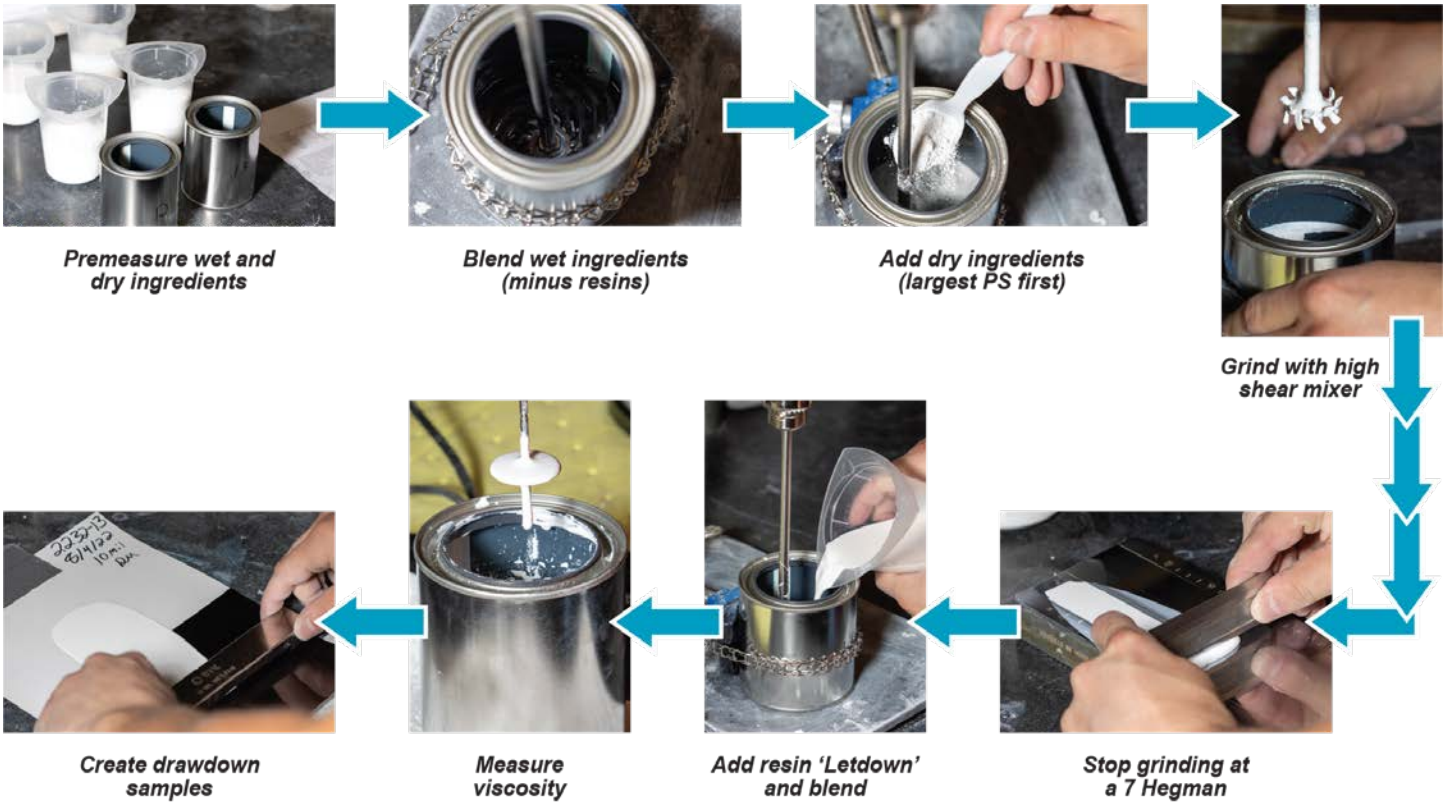
Stage One of the project developed an acrylic elastomeric coating system, that meets the requirements of cool roof coating, in which EverWhite® Pigment could be tested. After development of the system, EverWhite® Pigment was substituted for the titanium dioxide (TiO_2) in a ladder study from zero to fifty weight percent. The ladder study was evaluated for processability and a series of paint and coatings properties. ***Stage Two*** of the project studied a down selected subset of formulations that showed commercial promise for more extensive properties. This part of the project evaluated the direct comparisons between EverWhite® Pigment and current TiO_2 extenders. These properties included pertinent roof coating criteria. ***Stage Three*** evaluated exterior weathering in two locations and third party accelerated testing.

STAGE ONE - SYSTEM DEVELOPMENT AND SCREENING EXPERIMENTS

The system development stage studied several iterations of liquid applied cool roof coatings with the objective of developing a system similar to current commercial cool roof coatings, a level of TiO_2 that equitably evaluated the EverWhite® Pigment and could be studied in such a manner to determine differences between EverWhite® Pigment and TiO_2. The test formulation is displayed below.

EVERWHITE™ PIGMENT (EWP-5) EVALUATION - GRIND PROCESS			
SUPPLIER	***RAW MATERIALS***	***FUNCTION / DESCRIPTION***	***WEIGHT %***
Municipal	Water	Solvent	12.14
Lyondell	Propylene Glycol	Freeze and thaw stability	0.91
Byk Chemie	Disperbyk 199	Wetting and dispersing agent	1.27
Ricca	20% NH_4OH	Coagulation prevention/pH Modifier	0.46
Chemours	Ti-pure R960	Pigment	20.65
MinTech Inc.	Marblewhite 325	Filler	20.65

EVERWHITE™ PIGMENT (EWP-5) EVALUATION - LETDOWN PROCESS			
SUPPLIER	***RAW MATERIALS***	***FUNCTION / DESCRIPTION***	***WEIGHT %***
Arkema	Encor Flex 1361	All-Acrylic elastomeric latex	44.45
Eastman	Texanol	Ester alcohol, coalescent	0.54
		Sum Weight of Raw Materials	**100.00**



EVERWHITE® PIGMENT FORMULATION DEVELOPMENT PROCESS STEPS

The ladder study of EverWhite® Pigment (EWP) was done at 0%, 12.5%, 25% and 50% substitution for the Chemours Ti-pure R-960 TiO_2 pigment in the formulation. The coatings manufacturing process was evaluated for pigment loading time, pigment wet-out time, pigment grind to 7+ Hegman and batch energy input. The data revealed equal processability throughout the experimental ladder series. The completed coatings were evaluated for the following properties: Brookfield™ viscosity, and 14 and 28-day heat-aged stability. Stability was equal across the ladder series and the advantage of potentially using less surfactant (which is a costly chemical) was discovered, based on viscosity. The data tables below reveal that with the addition of EWP5, the viscosity is lowered linearly based on EWP amount. The second table further displays cost reduction with lower dispersant amounts.

BROOKFIELD VISCOSITY™ *(cps@rpm) #4 spindle*

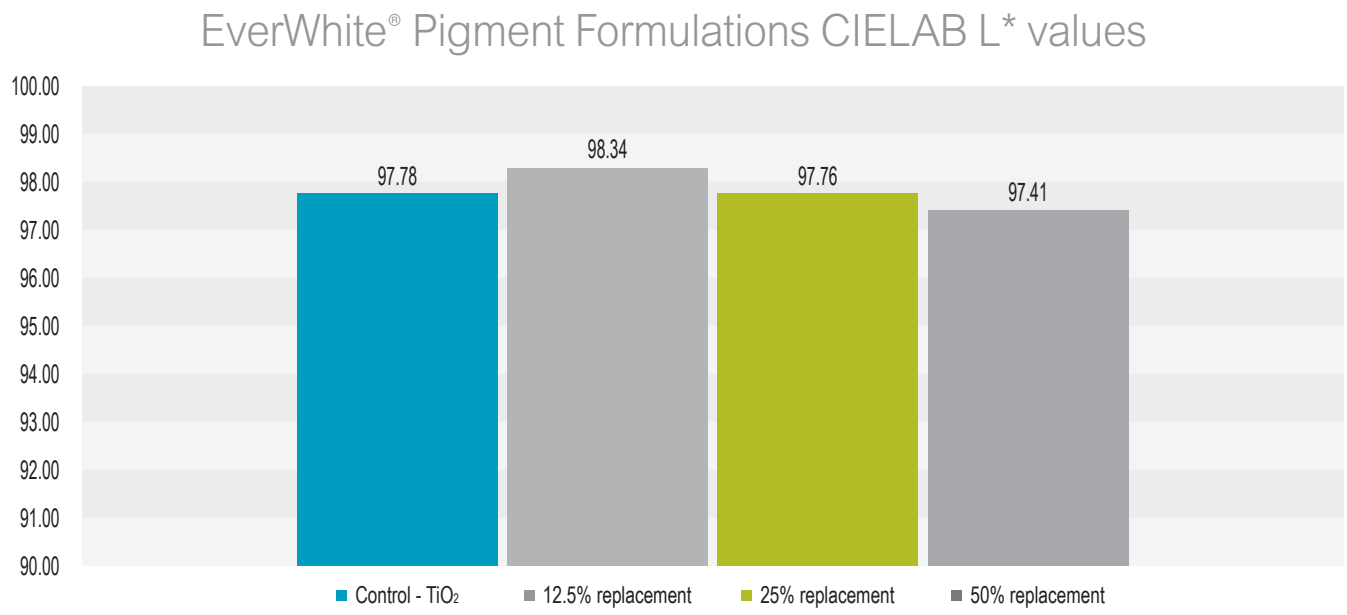
	10 rpm	20 rpm	50 rpm
0% EWP replacement	4700	1640	290
12.5% EWP replacement	1300	520	85
25% EWP replacement	200	120	20

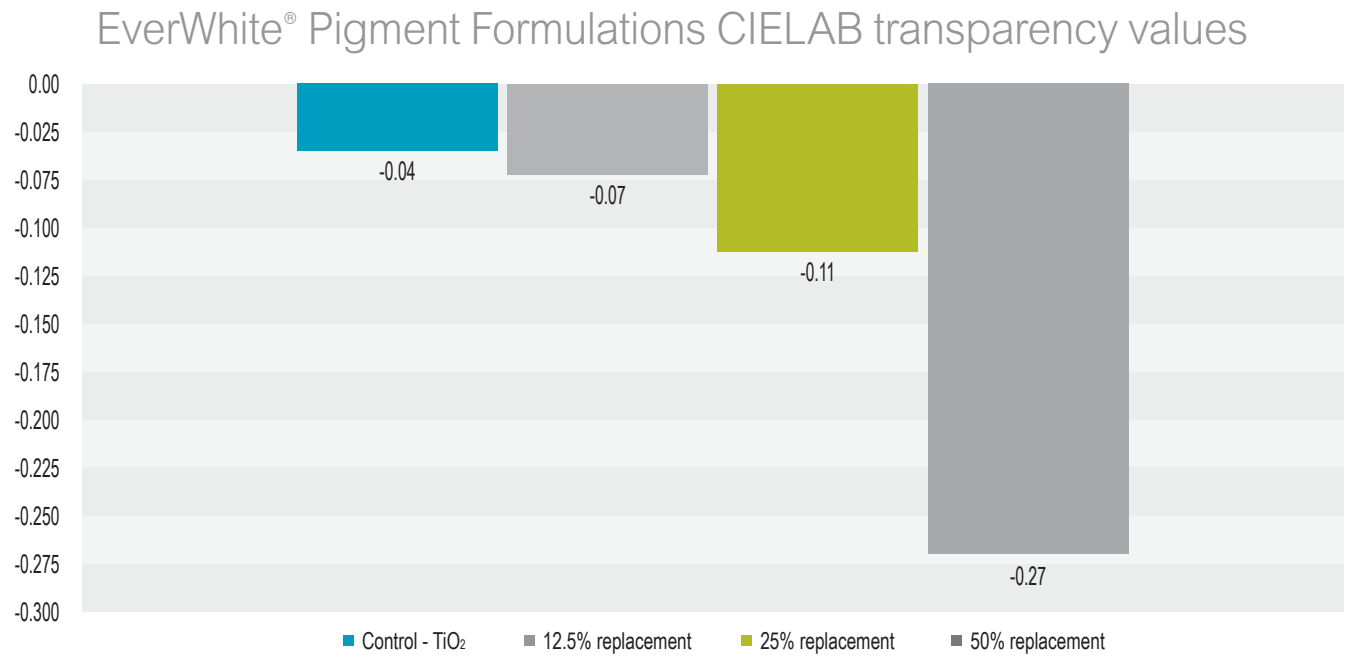
BROOKFIELD VISCOSITY™ *(cps@rpm) #4 spindle*

	10 rpm	20 rpm	50 rpm
0% EWP replacement	4700	1640	290
12.5% EWP replacement *[-20% dispersant]*	4000	1700	285
25% EWP replacement *[-35% dispersant]*	5000	1700	320

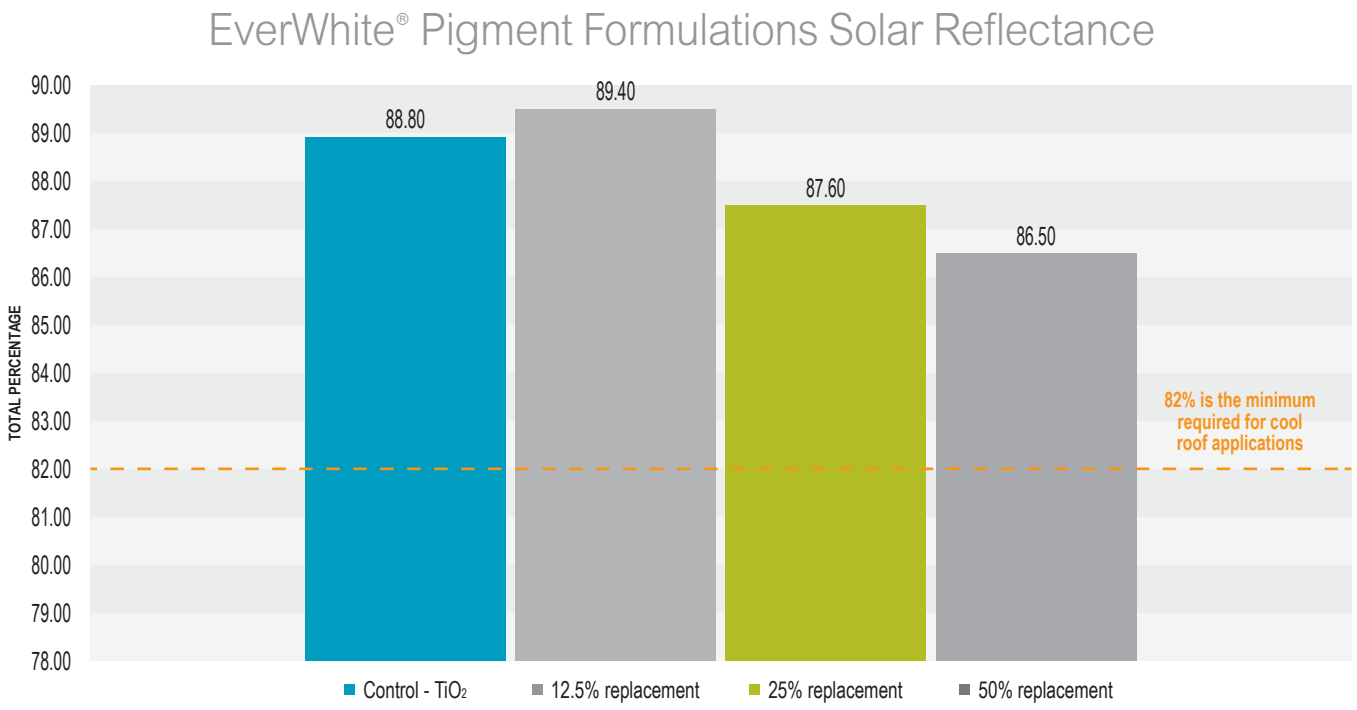
“Each operation should consider up to 25% reduction of titanium dioxide when replaced with EverWhite® Pigment...where in other reformulations up to 50% reduction was achieved.”

The applied and cured coatings were tested for CIELAB color and transparency, and solar reflectance/thermal emittance. The following graphs show that replacing the TiO_2 with EverWhite® Pigment up to 25% does not significantly affect transparency and there is no brightness lost when using EverWhite® Pigment.





The graph below shows that solar reflectance is minimally affected by EverWhite® Pigment substitutions, at 12.5% solar reflectance is slightly higher and at 50% it remains well above the 82% minimum by regulation.



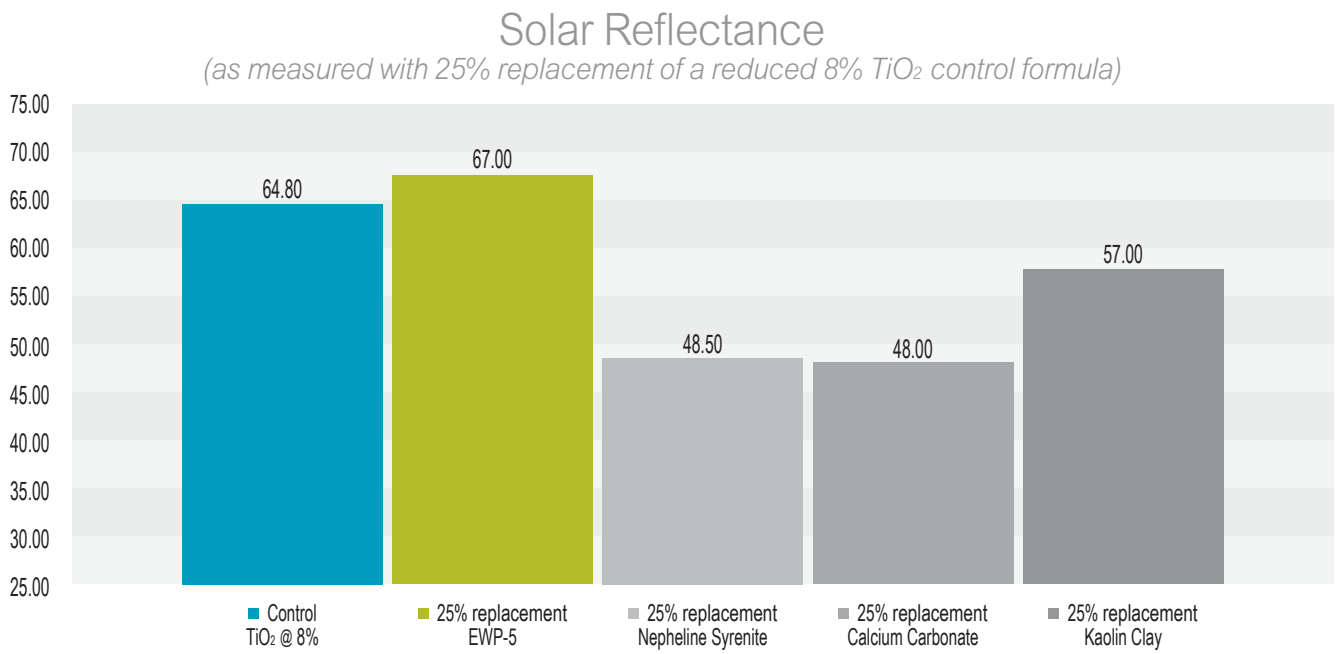
STAGE TWO - EXTENSIVE TESTING

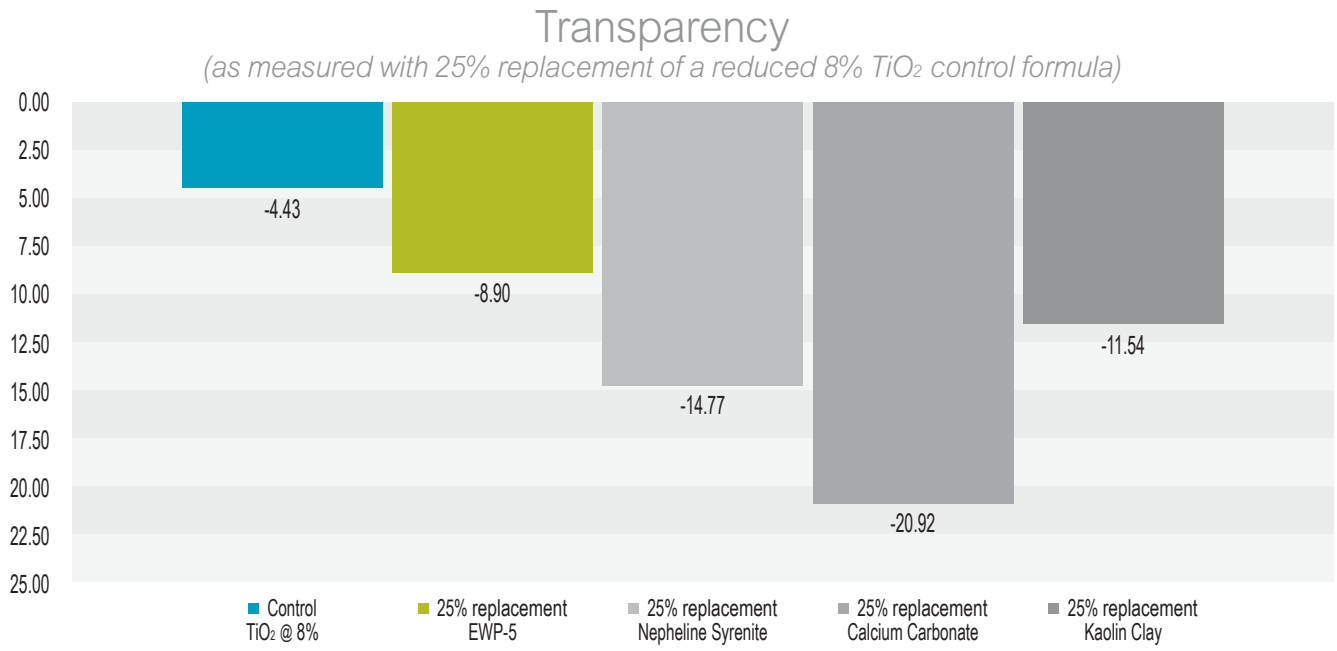
In this stage of the project, properties pertinent to roof coating, elastomeric systems and cool roof attributes were evaluated. The properties are cross hatch adhesion, water swelling, dry time and dirt pickup. Water swelling, dry time, and dirt pickup were found to be equal throughout the ladder series. The cross hatch adhesion was also equal amongst the ladder series sample set, as demonstrated in the following table.

ASTM D903 CROSS HATCH ADHESION	
EVERWHITE® PIGMENT TEST SAMPLE	**RESULT** *(5A=NO DELAMINATION, 0A=COMPLETE DELAMINATION)*
Control -TiO_2	5A - No Delamination
12.5% replacement	5A - No Delamination
25% replacement	5A - No Delamination
50% replacement	5A - No Delamination

Comparisons were also completed to current pigment extenders that are used in cool roof coating. To maximize the diffractive properties of TiO_2 and to eliminate TiO_2 particulate 'crowding', the TiO_2 pigment concentration was reduced in the control formulation by more than half, reducing it from 20% down to 8%. To better isolate additive performance benefits, EWP and other common extenders replaced 25% of the TiO_2 in the new 8% control formula.

The results displayed in the following graphs reveal better transparency and solar reflectance with EverWhite® Pigment versus current pigment extenders nepheline syenite, calcium carbonate and kaolin clay at the reduced 8% TiO_2 level in the control formula. It is apparent from the data that EWP is best in class when evaluating solar reflectivity and opacity.

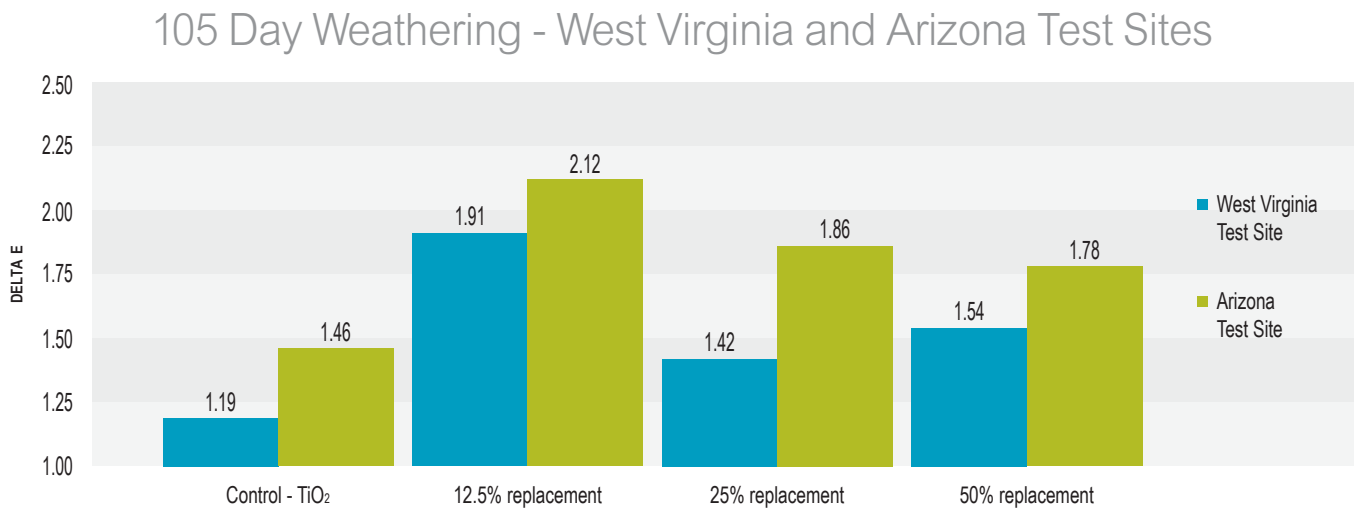




STAGE THREE - WEATHERING

Liquid applied cool roof coatings are an exterior paint application. The substrate is either flat or low slope roofs. This roof configuration is subject to intense solar radiation. The coating must withstand the sun's intensity and other weather events. Functionally, both components of the applied coating, the polymer, and the pigments, play a role in weatherability.

In this study, the experimental ladder formulations were tested for this weatherability at two locations, West Virginia and Arizona. The following graph is data for 105 days weathering at both test sites for comparison. Accelerated weathering was also evaluated by placing the samples in a QUV chamber for 1,000 hours and measuring elongation and abrasion.



The graph reveals minimal color difference between the test coating without EverWhite® Pigment and the test coatings with the EverWhite® Pigment substitutions.

The table below contains the results of the QUV acceleration weathering study. Tensile and elongation (before and after 1000 hours of QUV) passed the ASTM requirement.

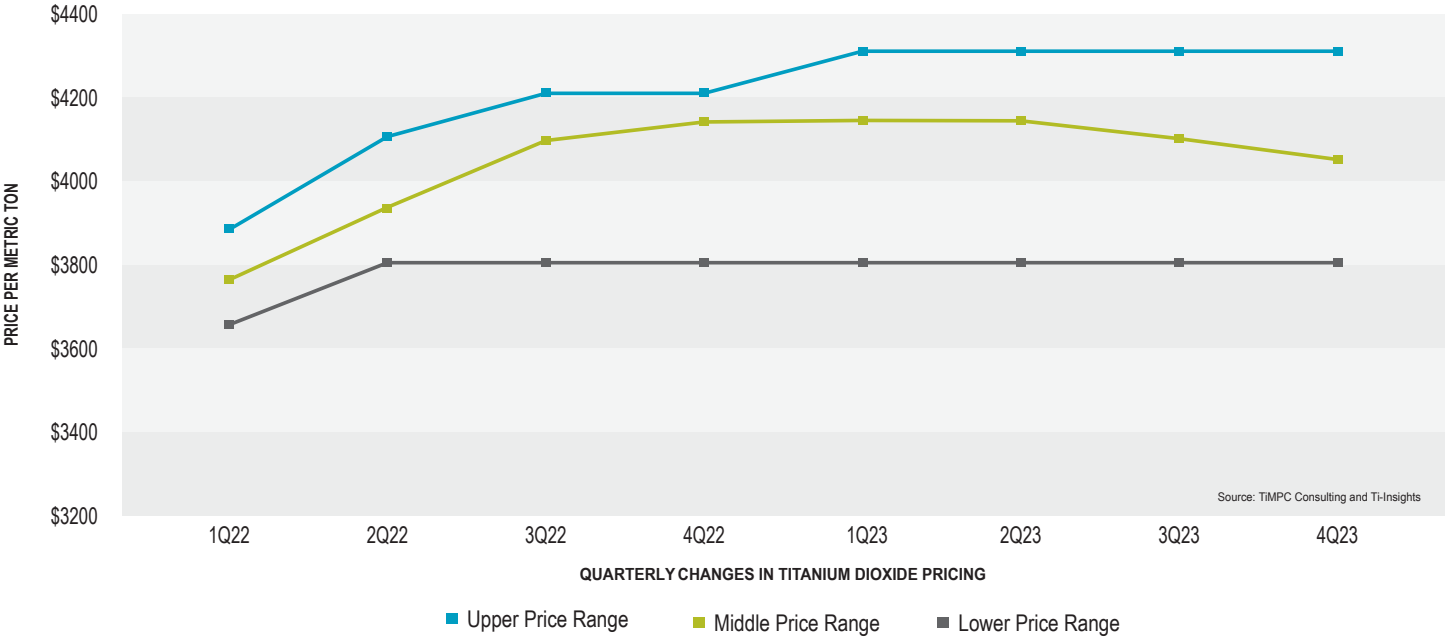
QUV ACCELERATION WEATHERING STUDY

DESCRIPTION	ELONGATION	TENSILE	ELONGATION QUV *(1000 hours)*	ABRASION
Standard formulation analog with R-960	415	249	278	0.95
12.5% R960 replacement with EWP-5	482	239	236	1.10
25% R960 replacement with EWP-5	475	230	260	1.60
Passing Criteria	***>100%***	***>200%***	***>100%***	

COATINGS COMPANIES CONTROLLING THEIR DESTINIES

The outlook for titanium dioxide supply appears to have challenges in the future. Chinese production is strong and growing but is facing issues around logistics, covid, and tariffs. Even when these issues are resolved in the near future, the growth of Asia will keep key minerals in that region. This market reality will contribute to cost increases in North America. Complicating matters, the major supply shortages in the raw materials, like chlorine and sulfuric acid to make titanium dioxide, are also becoming constrained in this new world we are living in. A result will be pricing for titanium dioxide, independent of surcharges, is expected to rise an additional 5-10% from current levels.

North American Titanium Dioxide (TiO_2) Pricing Estimates for 2022 and 2023[2]



The initial work outlined by a seasoned industry expert shows a path for coatings manufacturers to better control their destiny with impactful economic benefit. Jim Will states, "The substitution with EverWhite® Pigment at even 25% replacement would save coatings manufacturers $100,000s annually, if not more!"

ILLUSTRATIVE EXAMPLE

- Assume **25% substitution** results in up to **40 tons a month** with EverWhite® Pigment
- Assume the savings would be **$1,000 / ton**
- Assume production is averaged over **12 months** in a year
- Calculate **40 tons a month** replaced with EverWhite® Pigment x **12 months** x **$1000 / ton** savings

= $480,000 savings annually by substituting titanium dioxide with EverWhite® Pigment

FOOTNOTES

* Patent Pending

1 The pricing index is based on average pricing on an annualized basis. The data set is derived from TiMPC consulting global data set on prices for titanium dioxide from 1980 to 2021.

2 This chart was developed with the permission of Ti Observer™ publication, which outlined the forecasting price for 2022 and 2023 of titanium dioxide in the March 2022 issue.

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