Reducing TiO_2 Dependence in Thermoplastic Compound

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U.S. Silica
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AGENDA

1. EverWhite® Pigment Fundamentals
2. Reducing TiO_2 in Plastics
   a. White PVC
   b. White LDPE
   c. Yellow and Red LDPE
3. Looking Forward to Commercial Applications





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Headwinds for Titanium Dioxide – TiPMC Consulting

Fundamentals

2024: Demand Recovery: Uneven but strong demand improvement

•Asia: Strong Recovery •1H25: Restocking and Global Unrest support sales from Multi-National Producers(MNPs) •2H24: Slow underlying demand recovery outside Asia/ Anti-Dumping Takes Center stage

Market Segmentation between Chinese and MNPs Firmly Established

•Price differential remains large •Chinese segment larger and growing faster •Over-capacity among both Chinese and MNPs •Earnings Pressure on Everyone

Chinese Over-Capacity: Changing the dynamics of the recovery

•"Transition" volume from Chinese to MNP Product did not occur •China: More Expanded available capacity than sales growth – saturated export market •Growth for both Chinese and MNPs limited to organic growth •Anti-Dumping Tariffs attempt to force "Transition"

Multi-National Producers (MNPs) and other Regionals

•Critical Regional Markets have not seen recovery •More focused on Developed Markets – smaller and slower growth – for now •Despite closures: still struggling with over-capacity •Cost continue to limit flexibility and earnings

Feedstock markets feeling impact

•Chloride feedstock and Zircon markets have weakened •Tariffs could alter demand •Limits of Future Projects/Continued depletion •Over-capacity in beneficiation (Upgrading feedstocks from mined products)

Titanium Dioxide market volatility continues, both from a pricing and availability perspective; current oversupply could change "overnight"

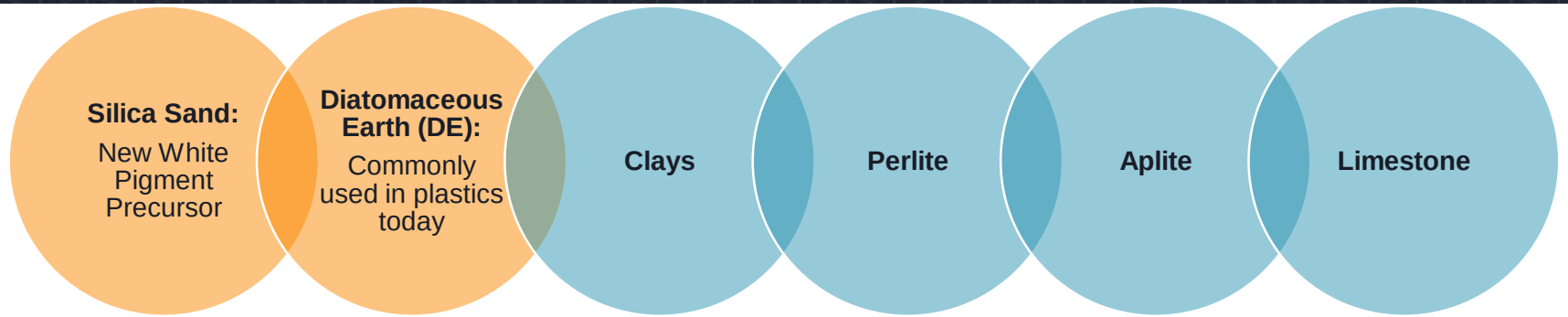
The Next Innovation in White Pigments: EverWhite® Pigment

Fundamentals

- **New White Pigment (EverWhite® Pigment)** is a high-white pigment for thermoplastics, coatings, and building products
- In **development since 2020**, it's been commercially successful in coatings, countertops, and cementitious applications
- EverWhite® Pigment is used to **complement** other pigments, like **titanium dioxide** or **colorants** across a wide variety of formulations
- By using EverWhite® Pigment, manufacturers can reduce titanium dioxide and pigment use by up to 50%, which can **reduce total pigment/filler costs by 30% or greater**

US Silica – Mines and Manufacturing

Fundamentals



- 23 plants and mines
- > 1,800 employees
- Products sold in 100 countries
- Corporate HQ in Katy, TX
- Innovation Center in Rochelle, IL

EverWhite® Pigment – for Plastics

Fundamentals

Cost Optimization

- TiO_2 Reduction
- Colorant Reduction
- Price Stability

Product Differentiation

- Mechanical Properties
- Density
- Color
- Opacity
- Inertness
- Weathering

Reducing Business Risk

- Shipping & Logistics
- Health and Safety
- Regulatory
- Security of Supply

EverWhite® Pigment 5 – New Pigment for TiO_2 Independence & Differentiation

Characteristics of EverWhite® Pigment & TiO_2

Fundamentals

	Talc	Kaolin (Clay)	Calcium Carbonate	Barium Sulfate	Titanium Dioxide (Rutile)	EverWhite® Pigment
Mohs Hardness	1	2 – 2.5	3	3 – 3.5	**6 – 7**	**6 – 7**
Typical Hunter L*a*b* Color Values	95 / 0.5 / 2	93 / 1 / 3	97 / 0.2 / 1	96 / 0.3 / 1.5	**99** / 0.1 / 0.7	**98** / 0.7 / 1.0

EverWhite® Pigment TDS:

TYPICAL PARTICLE SIZE (LASER DIFFRACTION)		TYPICAL MEASURED PROPERTIES	
D-90 (µm)	5.8	Hunter L	> 98.0
D-50 (µm)	2.4	a	0.7
D-10 (µm)	1.3	b	1.0
GENERAL PROPERTIES			
Mohs Hardness	6-7	Refractive Index	1.49
pH	9-10	Specific Gravity	2.33

EverWhite® Pigment is more similar to TiO_2 than other minerals based on whiteness and hardness

EverWhite® Pigment – Durable, White, and Light

Fundamentals

- A new mineral category – **Durable**, **White**, and **Lightweight** pigment that is **Domestically Produced**

Durable

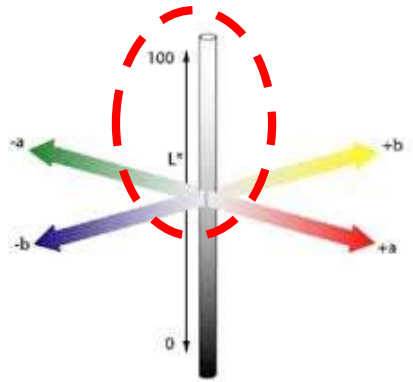
Mohs Hardness

Kaolin Clay	Calcium Carbonate
2 -2.5	3

Mohs Hardness

Titanium Dioxide	EverWhite® Pigment
6 - 7	6 - 7

White



Color	Measure
L	> 98
a	0.7
b	1.0

Lightweight

Material	Specific Gravity
TiO_2	4.26
EverWhite® Pigment	2.33

Domestically Produced

AGENDA

1. EverWhite® Pigment Fundamentals
2. **Reducing TiO_2 in Plastics**
   a. **White PVC**
   b. **White LDPE**
   c. **Yellow and Red LDPE**
3. Looking Forward to Commercial Applications





Replacing TiO_2 in PVC and LDPE – Critical Considerations

Using EverWhite® in PVC and LDPE Compound

White PVC

- Can I stay within my color specifications?
- How will this affect my impact strength?
- Will this increase the rate of outdoor weathering?
- Is this approved for NSF-applications?

White LDPE

- Will this significantly degrade my opacity?
- Is this going to change my color significantly?
- How will this influence overall mechanical properties?
- Will this increase my rate of outdoor weathering?

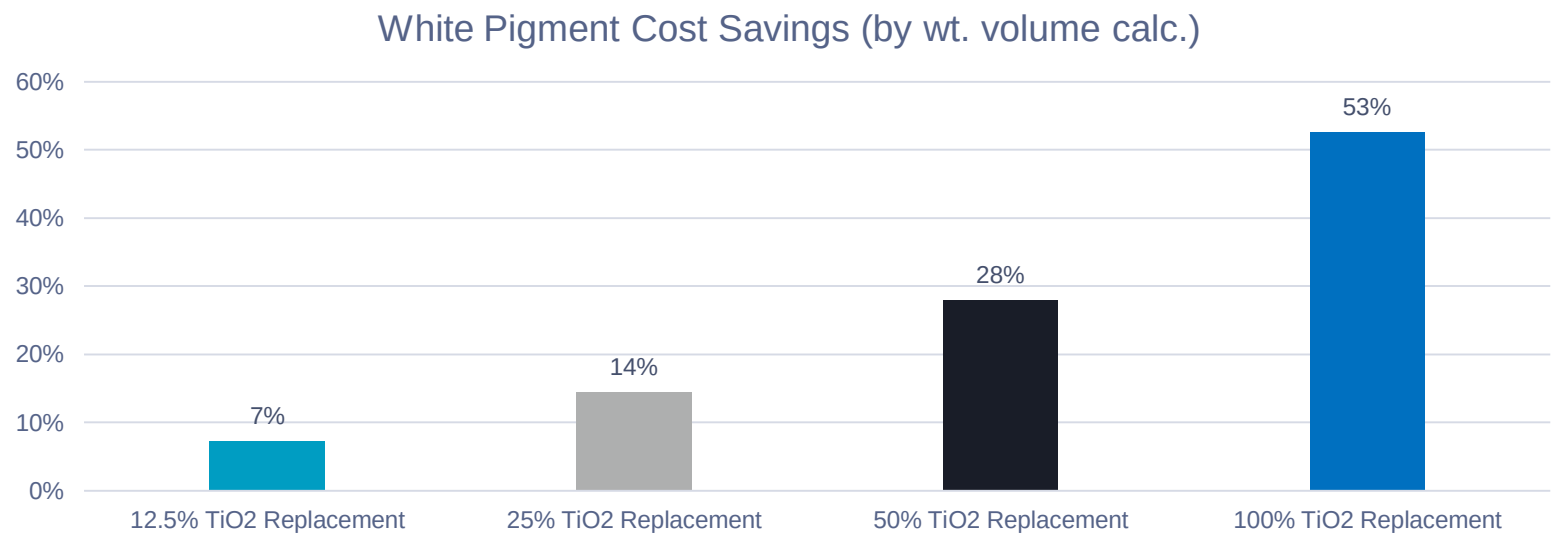
Yellow and Red LDPE

- Can I color-match?
- Will this allow me to use less of my more expensive non-white pigments?
- Does this have any negative interaction with colored pigments?

PVC Compound Summary: Reformulating with EverWhite® Pigment

Summary of Findings

Sample	Processing	Color	Accelerated Weathering	6-Month Outdoor Weathering	Izod & Charpy Impact Strength	Flex Strength	Tensile Strength	Cost
White - 12.5% replacement of TiO_2	✓	✓	✓	+	✓	+	+	+
White - 25% replacement of TiO_2	✓	✓	✓	+	✓	+	+	++
White - 50% replacement of TiO_2	✓	✓	+	+	✓	+	+	+++



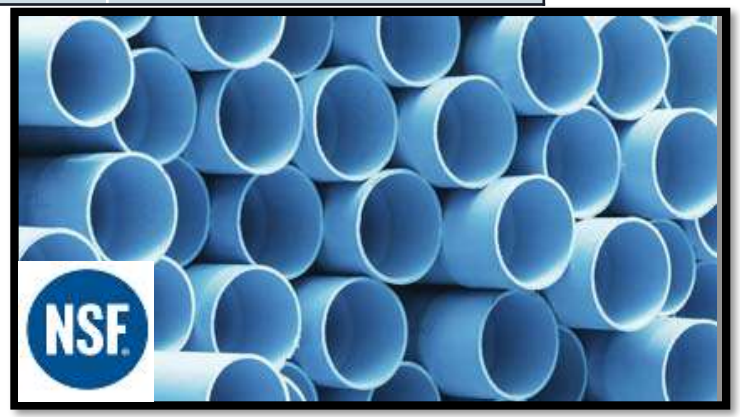
- **Negligible aesthetic or functional changes** when replacing up to 50% TiO_2 means that PVC industry can utilize EverWhite® Pigment to **improve price and supply stability**

PVC Compound Formulations

11 PHR White PVC Compound

PVC Formulations: Reduction of Titanium Dioxide (%)				
	Control White	12.5% TiO_2 Rep.	25% TiO_2 Rep.	50% TiO_2 Rep.
PVC (RMA 57A)	86%	86%	86%	86%
TiO_2	10%	8.75%	7.5%	5.0%
EverWhite® Pigment	0%	1.25%	2.5%	5.0%
Colorant	0%	0%	0%	0%
Plasticizer	2%	2%	2%	2%
Stabilizer	2%	2%	2%	2%
Specific Gravity	1.47	1.46	1.46	1.45

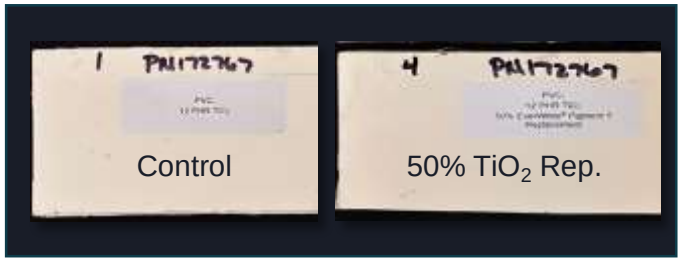
- 2% MARK QTS Ca/Zn **stabilizer** included at 2%
- TiO_2 and **outdoor rigid PVC** used in all formulations
- Pigment loading equivalent to **roughly 11-PHR**
  - Replaced 12.5%, 25%, and 50% of TiO2 with EverWhite® Pigment in **White Samples**



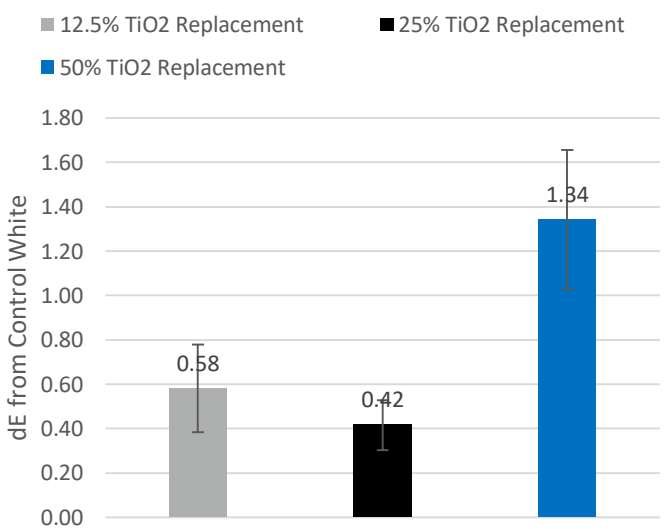
ASTM D2244 Color Measurements

11 PHR White PVC Compound

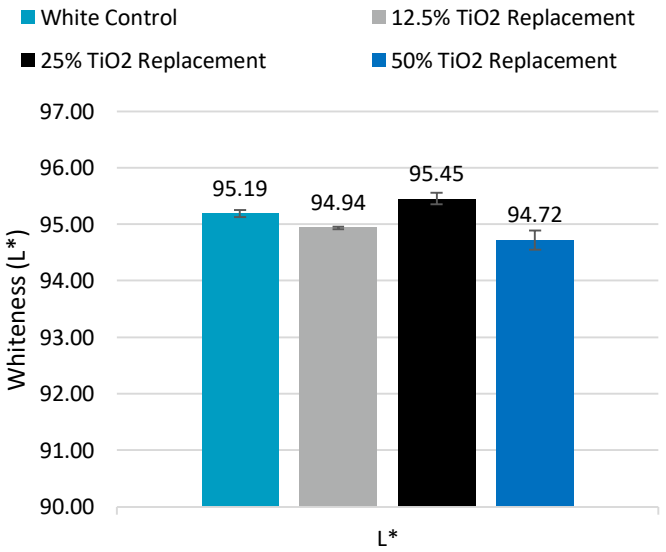
Color Shift upon Replacement of TiO_2 with EverWhite® Pigment			
Color	**L-value**	**a-value**	**b-value**
Control	95.19	0.61	8.41



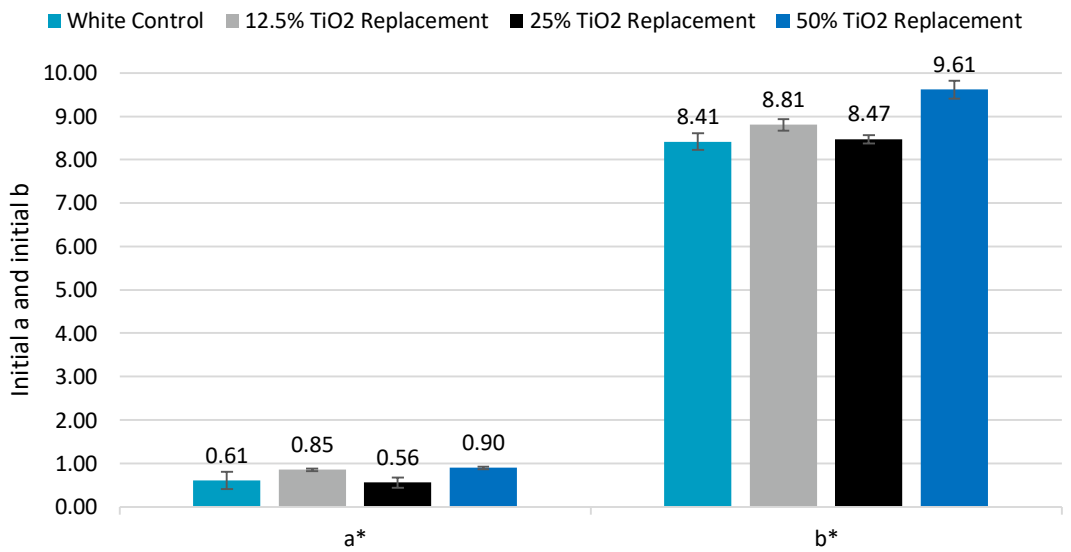
dE - EverWhite® Pigment Replacement Specimens vs. Control



Initial Color - L-value



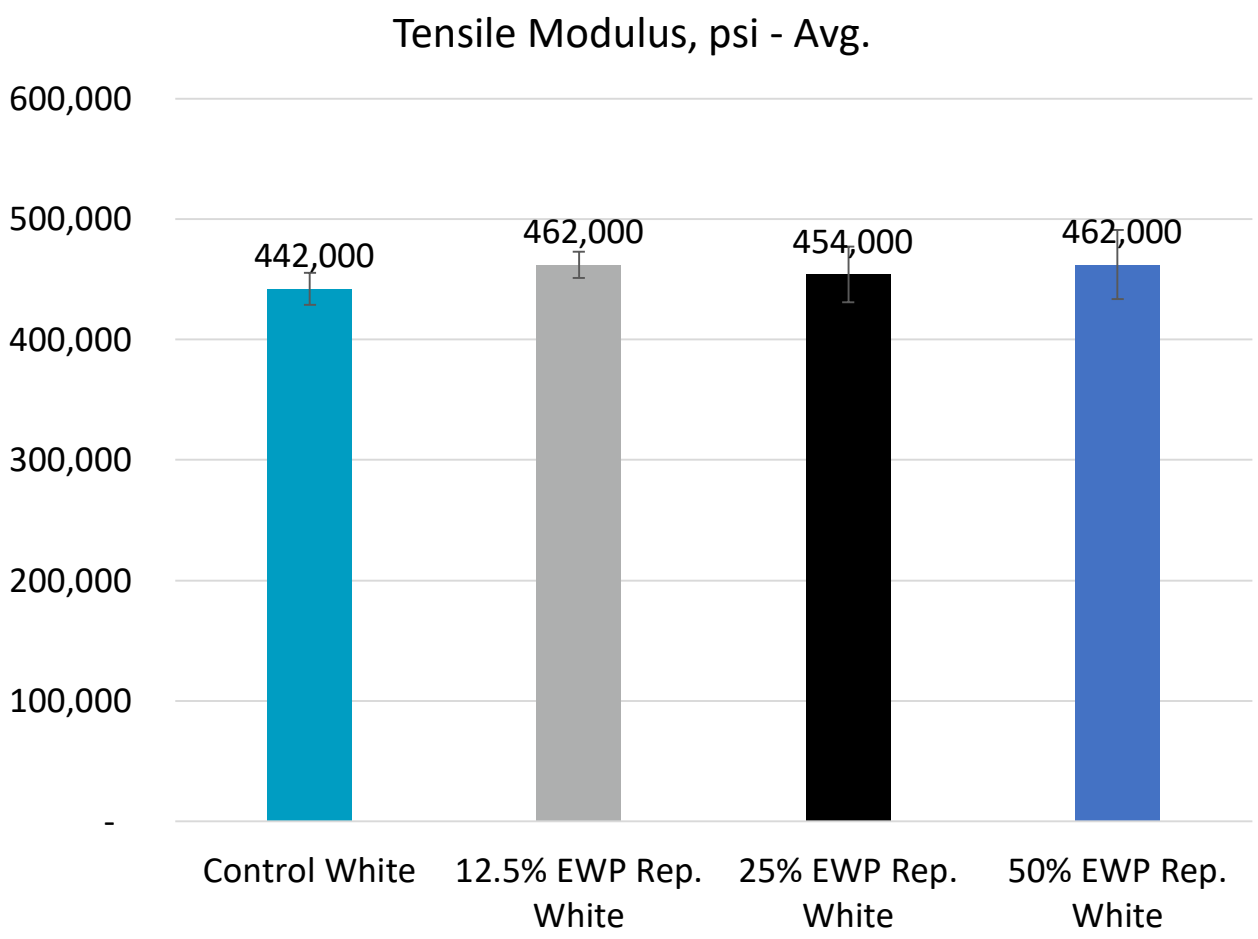
Initial Color - a-value and b-value

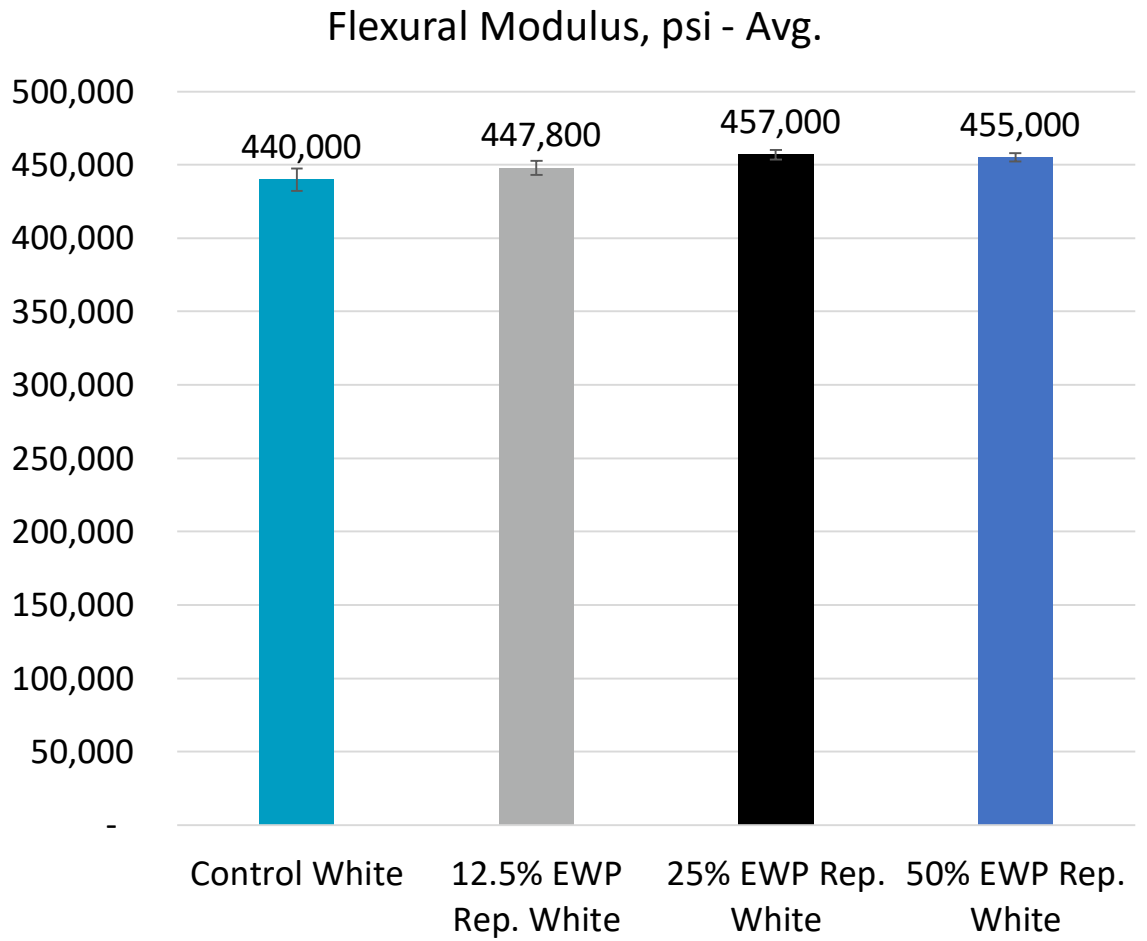


- Formulations with EverWhite® Pigment as a substitute for TiO_2 were able to achieve a **similar whiteness** along each step of the substitution ladder; also very little change in yellowness
- Color space results in a **delta E less of than 1.5 units**, indicating a close color match

ASTM D638 Tensile Strength & ASTM D790 Flexural Strength

11 PHR White PVC Compound

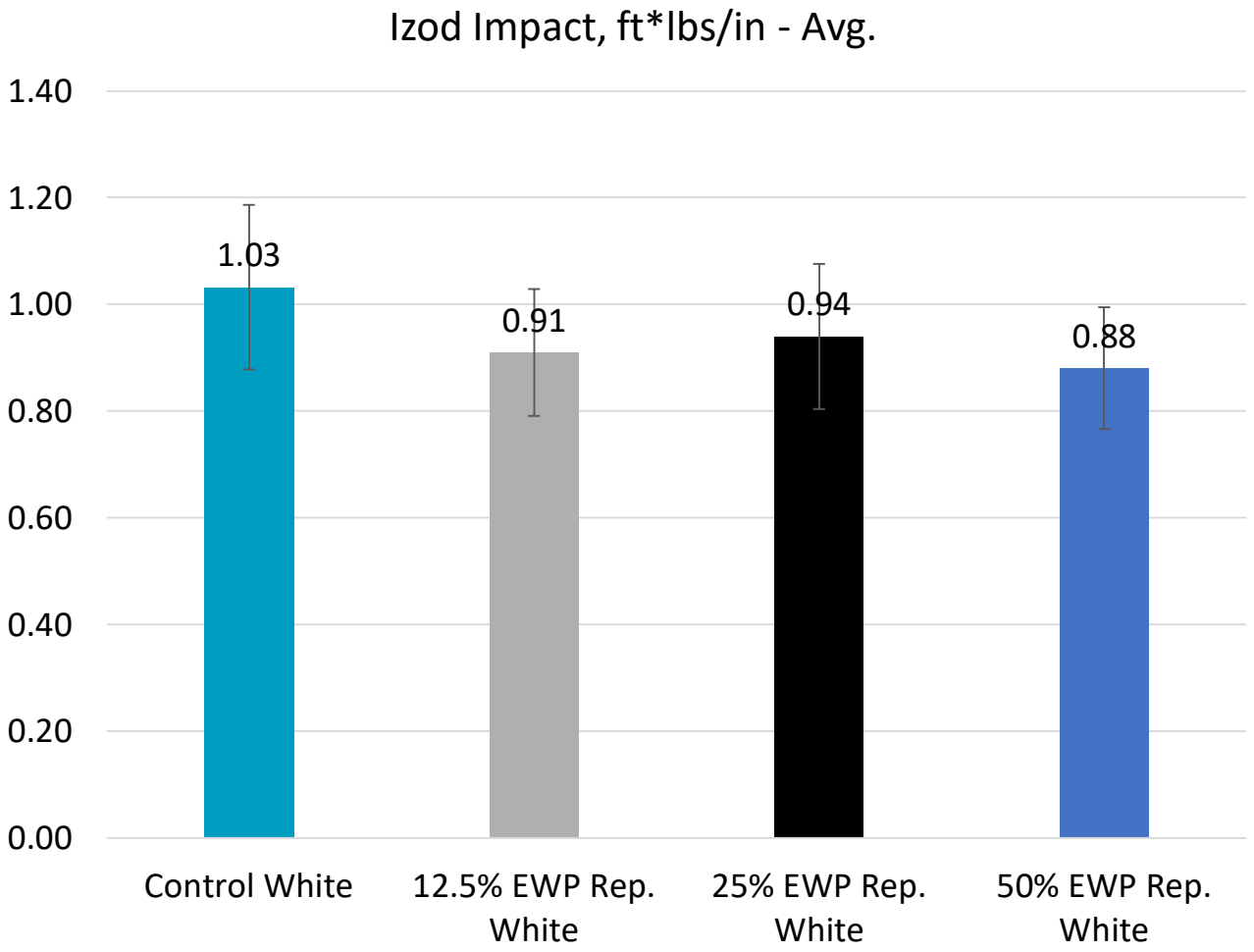


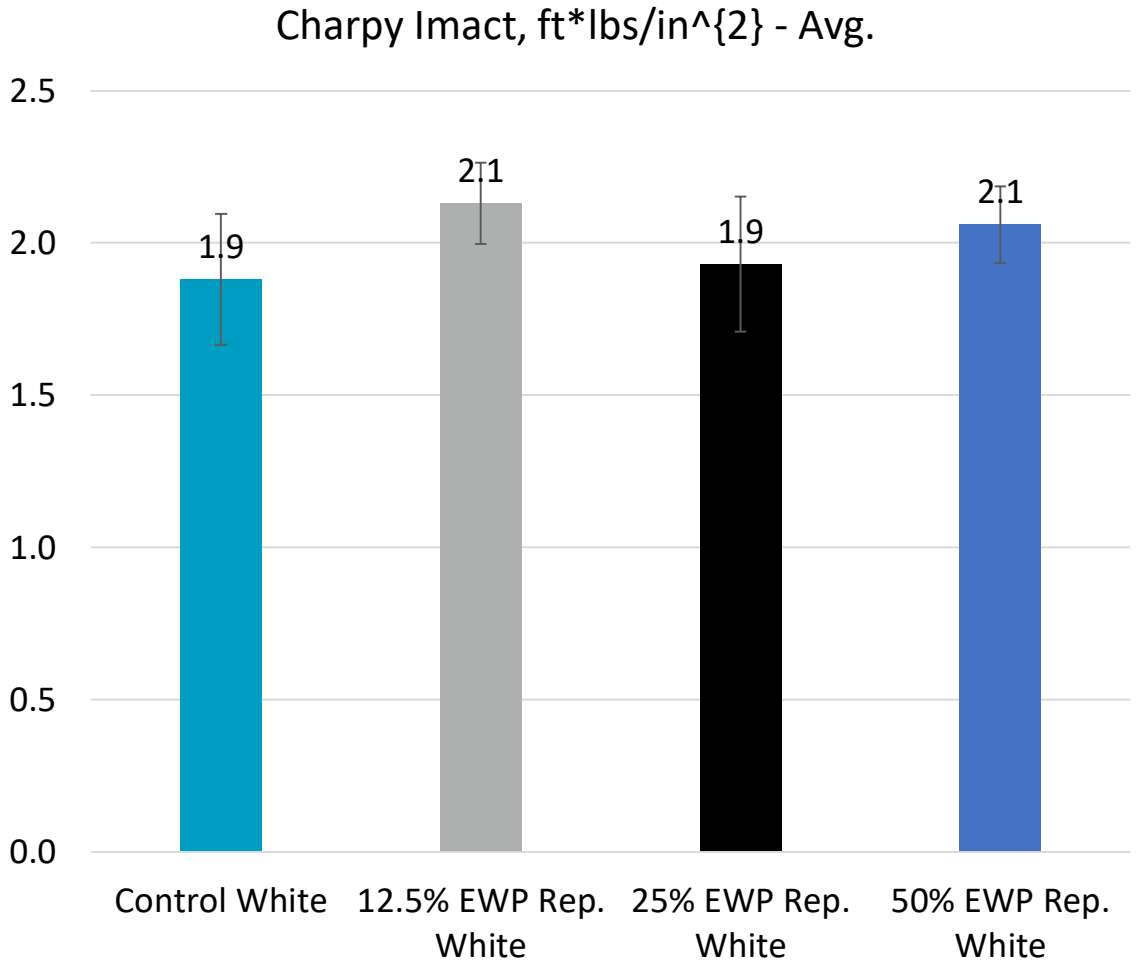


- Both white and beige samples show **minor improvements** when replacing TiO_2 with EverWhite® Pigment

ASTM D256 Notched Izod & ISO 179-1 Charpy Impact Resistance

11 PHR White PVC Compound

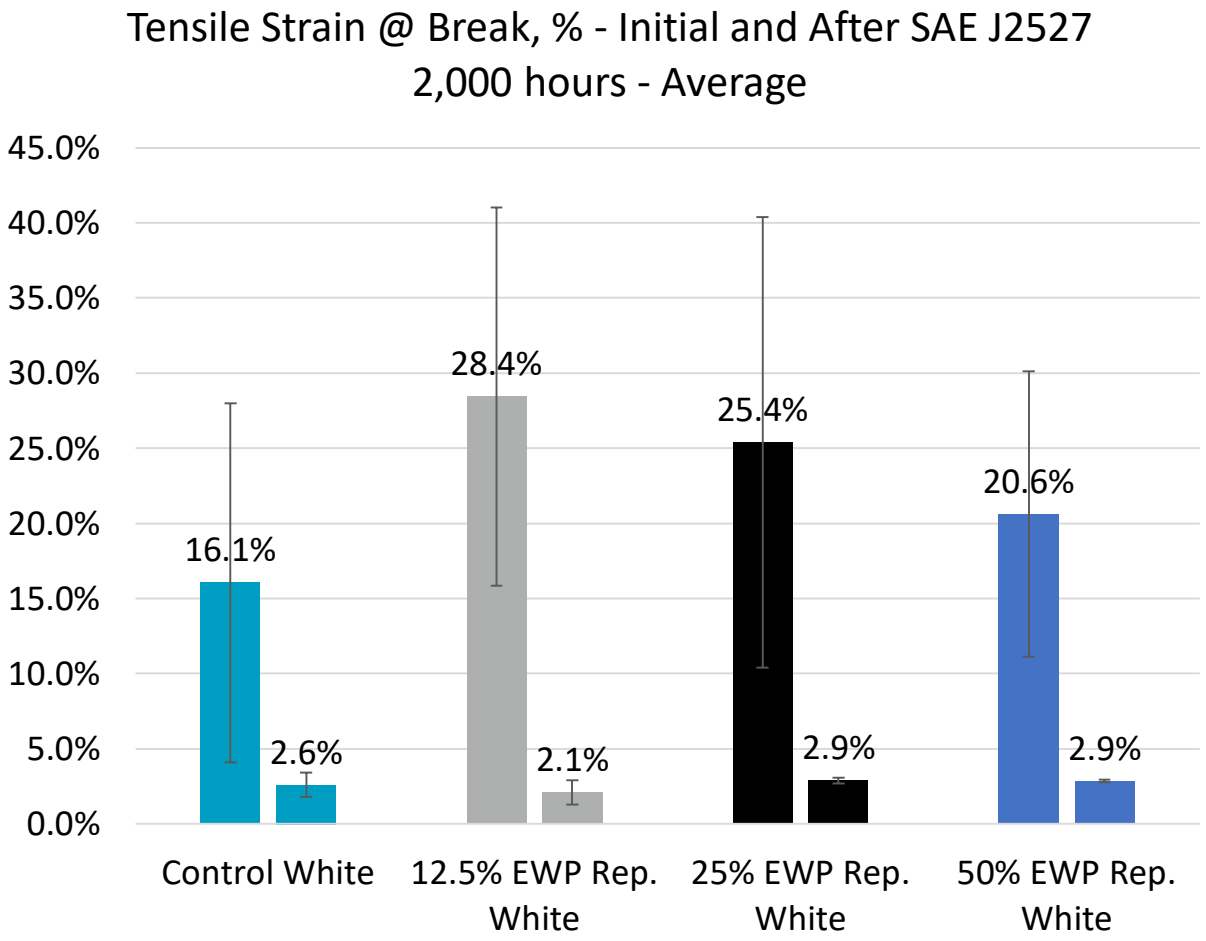


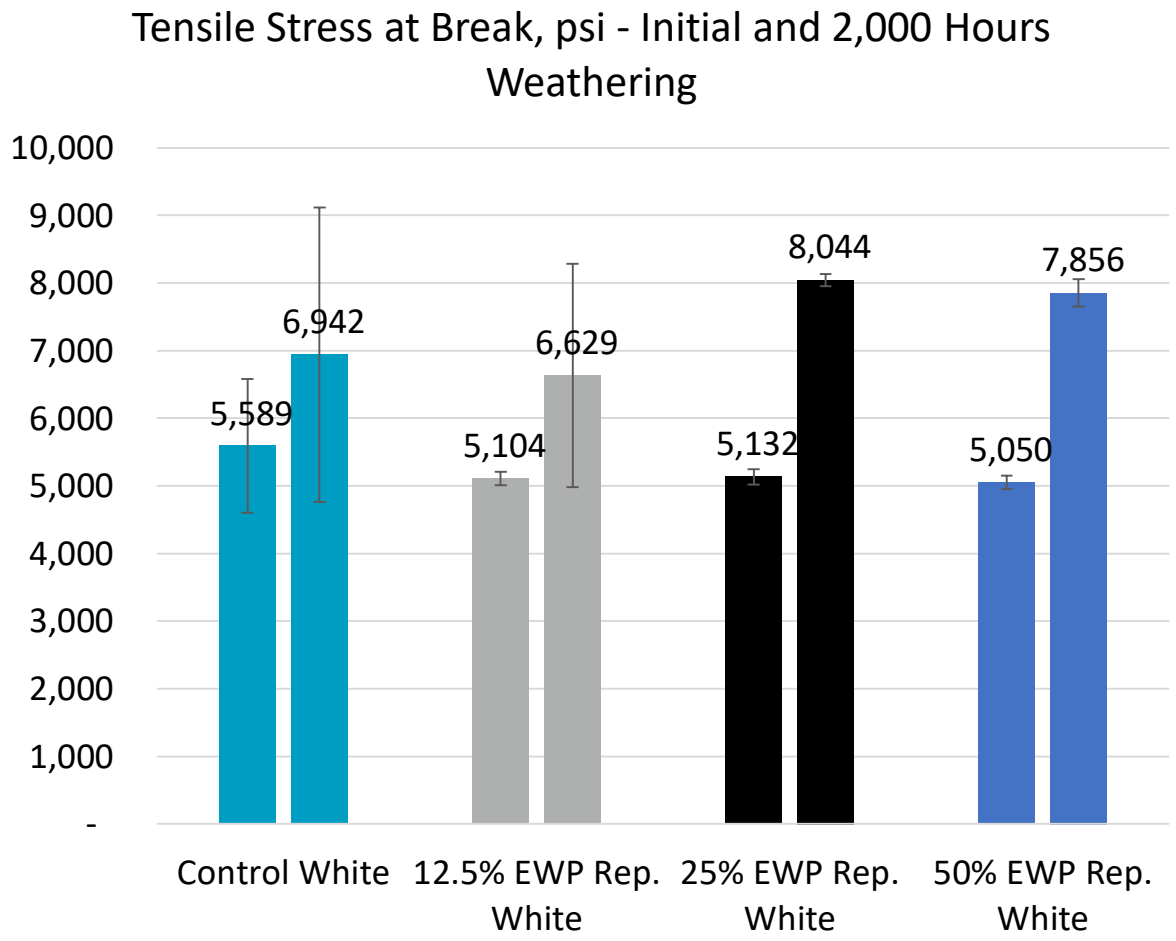


- **White samples** show a very minor **decrease in Izod impact resistance**, but error bars overlap significantly
- **White samples** show a very minor **increase in Charpy impact resistance**, but error bars overlap significantly

Xenon Weathering, SAE J 2527 – 2,000 Hours Mechanical Change

11 PHR White & Beige PVC Compound

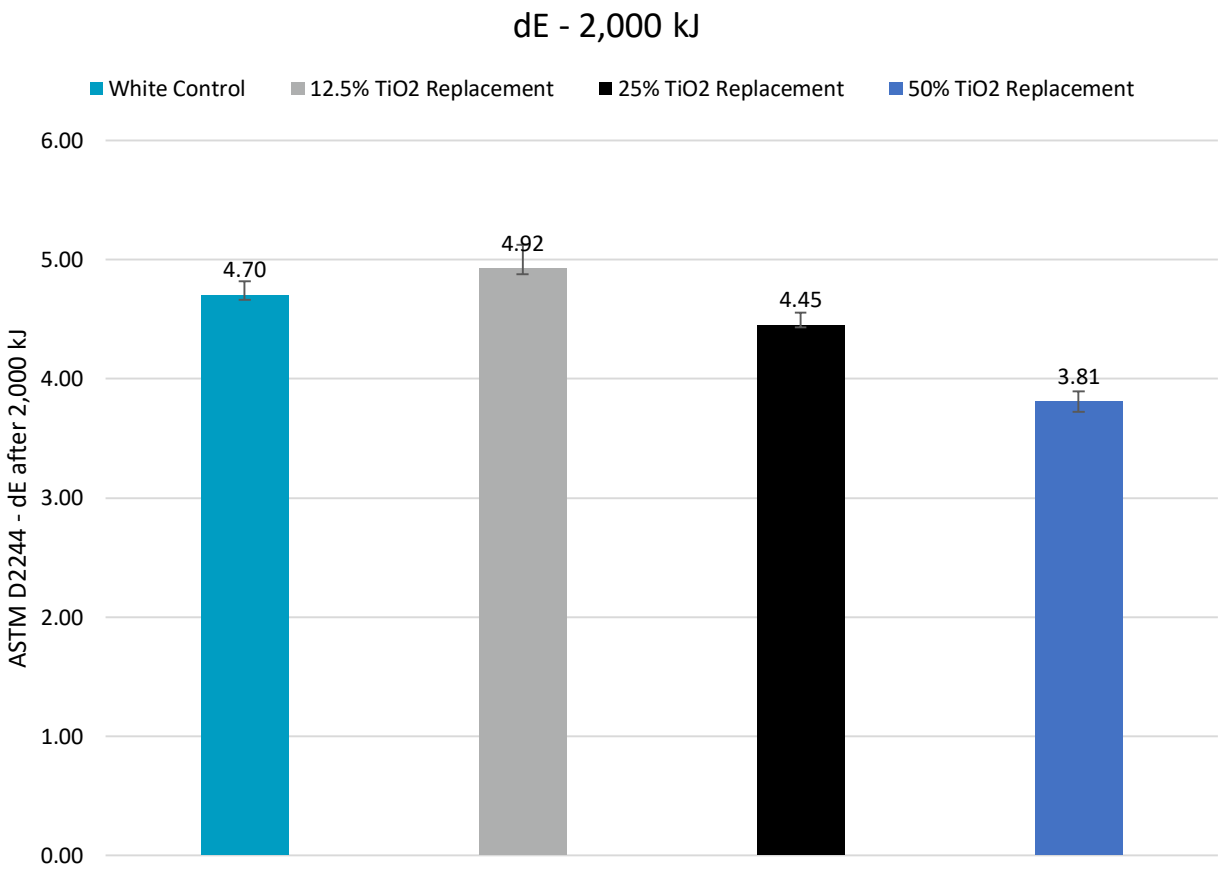


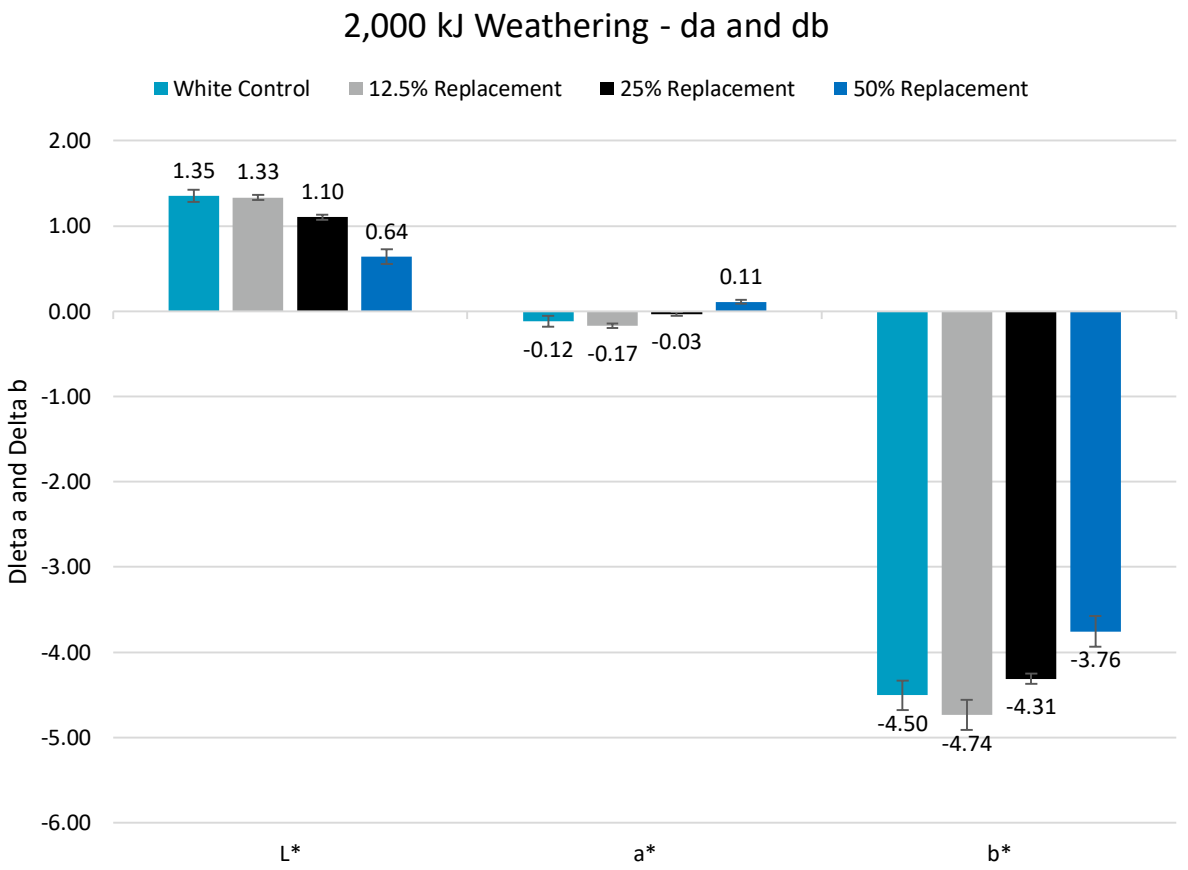


- First bar for each sample is **initial measurement**, second bar is measurement **after 2,000 hours of weathering**
- While there are significant changes in strain at break % and stress at break before and after weathering, there is **not a significant difference in the performance** with greater replacement levels with EverWhite® Pigment

Xenon Weathering, SAE J 2527 – 2,000 Hours Color Change

11 PHR White PVC Compound

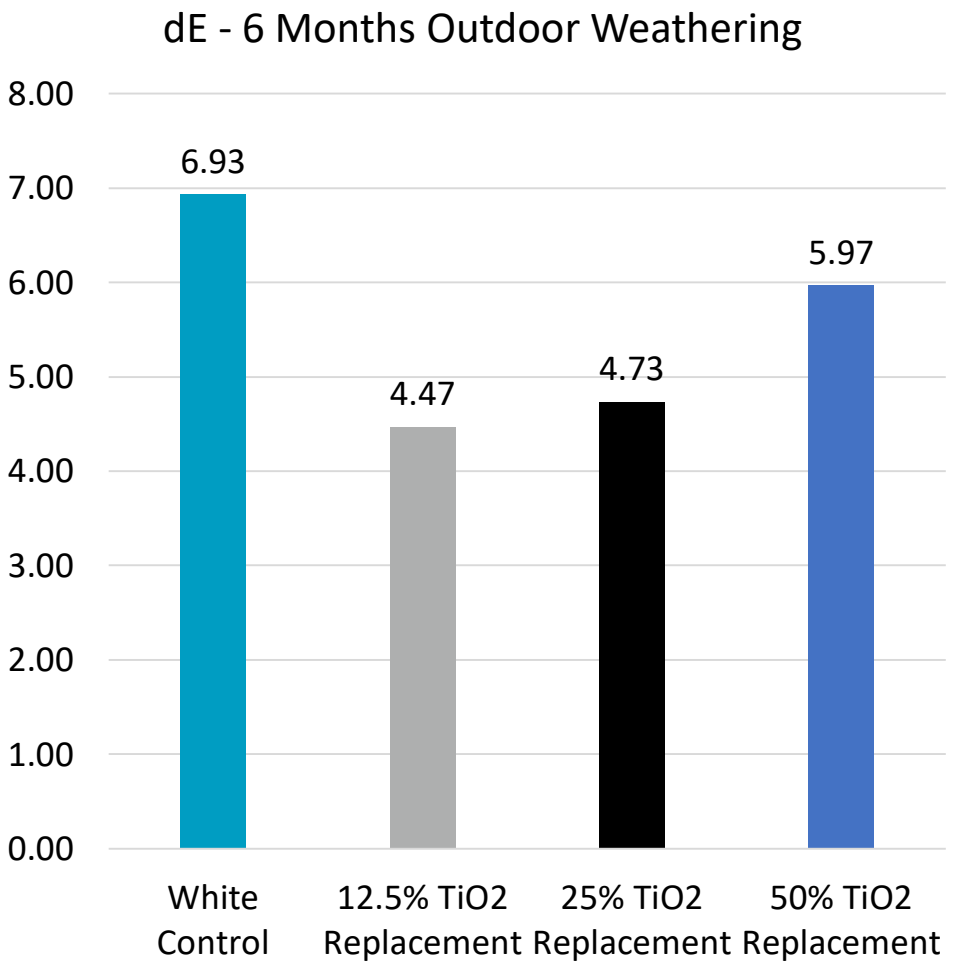


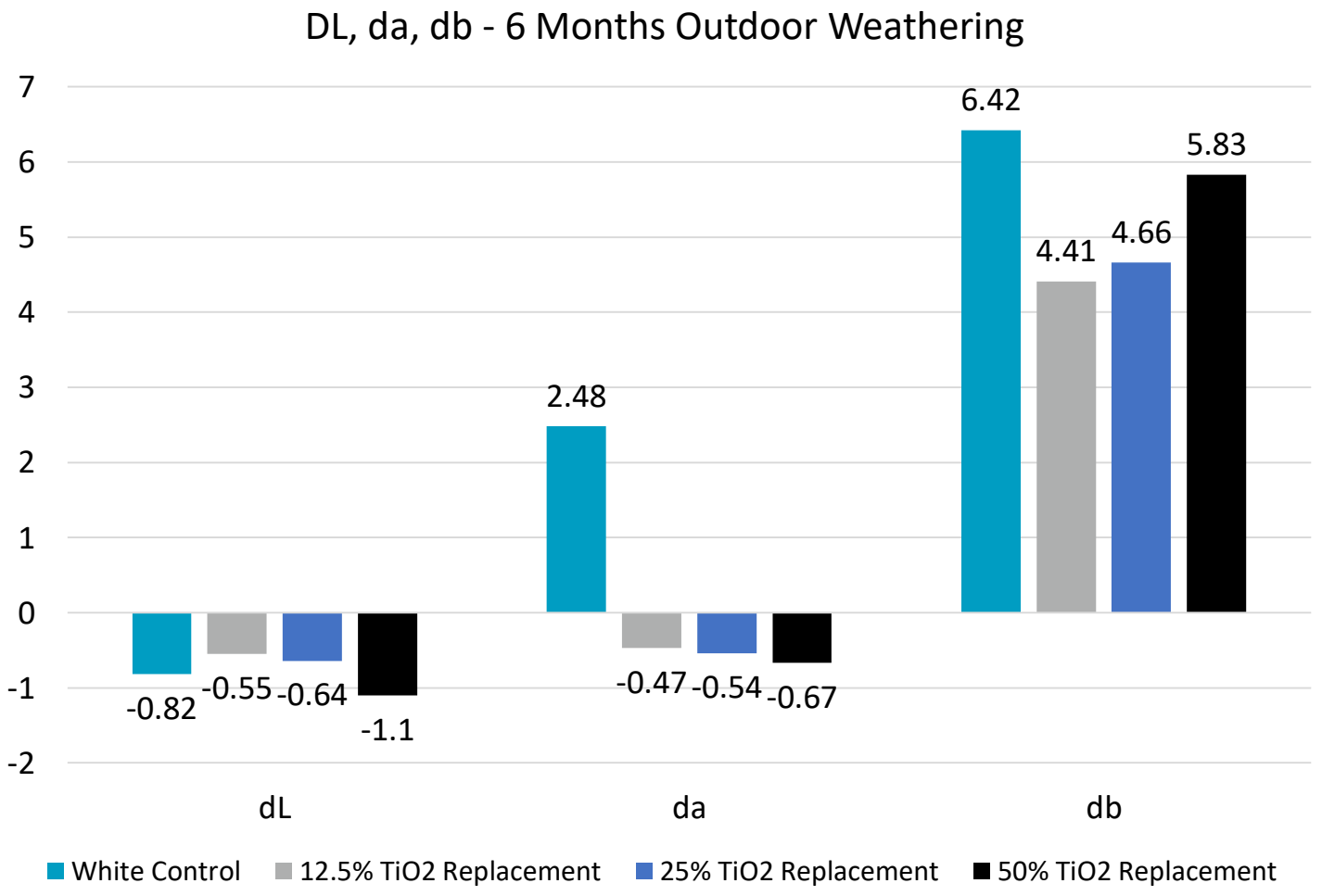


- White samples show little difference between dE after accelerated weathering, but there is potentially a **moderate improvement in the 50% TiO_2 replacement** specimen
- L-value shifts a little bit more in the white direction for the control; all samples move in blue direction per the b-value shift

ASTM D2244 Color Change with Outdoor Weathering, West Virginia 6-Months

11 PHR White & Beige PVC Compound



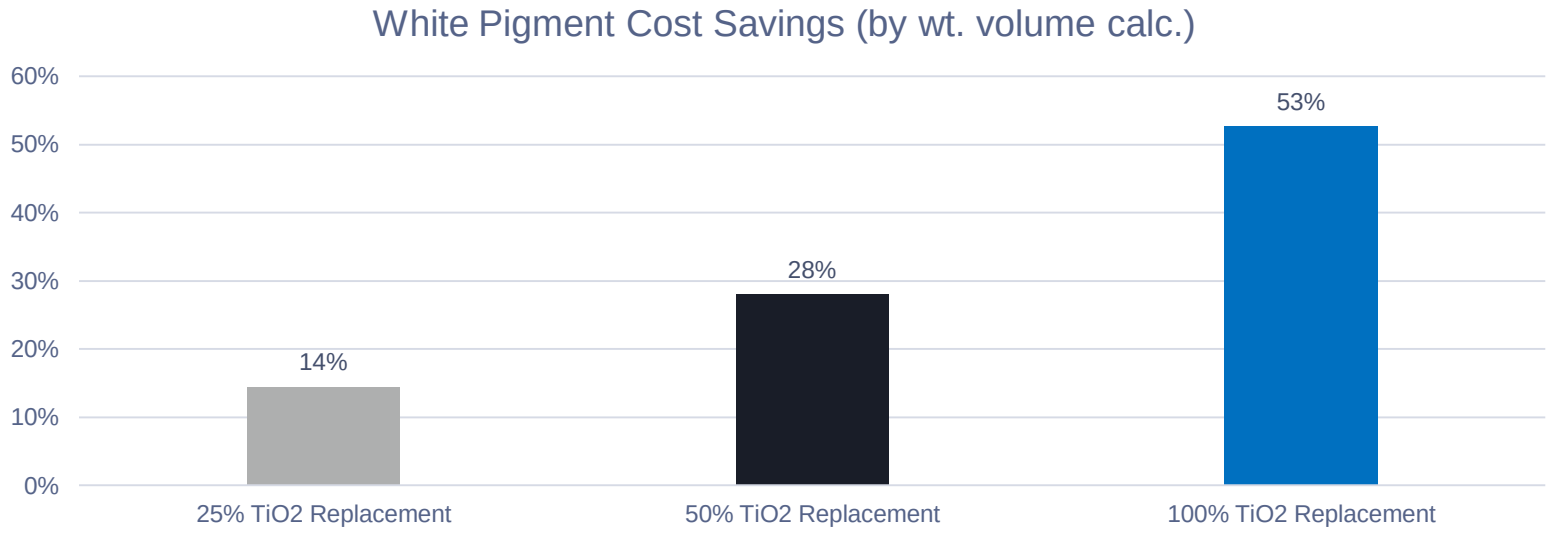


- **Control white samples seem to age the most**, as indicated by the largest reported dE and greatest yellow and red shift
- White control sample was the only one to grow more red, rather than green, after 6-months outside

3%LDPE Compound Summary: Reformulating with EverWhite® Pigment

Looking Forward

Sample	Processing	Color	Mechanical Strength	Accelerated Weathering	6-Month Outdoor Weathering	Opacity	Cost
White - 25% replacement of TiO_2	✓	✓	✓	✓	+	✓	+
White - 50% replacement of TiO_2	✓	✓	✓	✓	+	✓	++
White - 100% replacement of TiO_2	✓	-	✓	-	-	-	+++



- **Negligible aesthetic, mechanical, and weathering differences** when replacing up to 50% TiO_2 indicates plastics industry can utilize EverWhite® Pigment to **improve cost and supply stability**

White LDPE Formulation

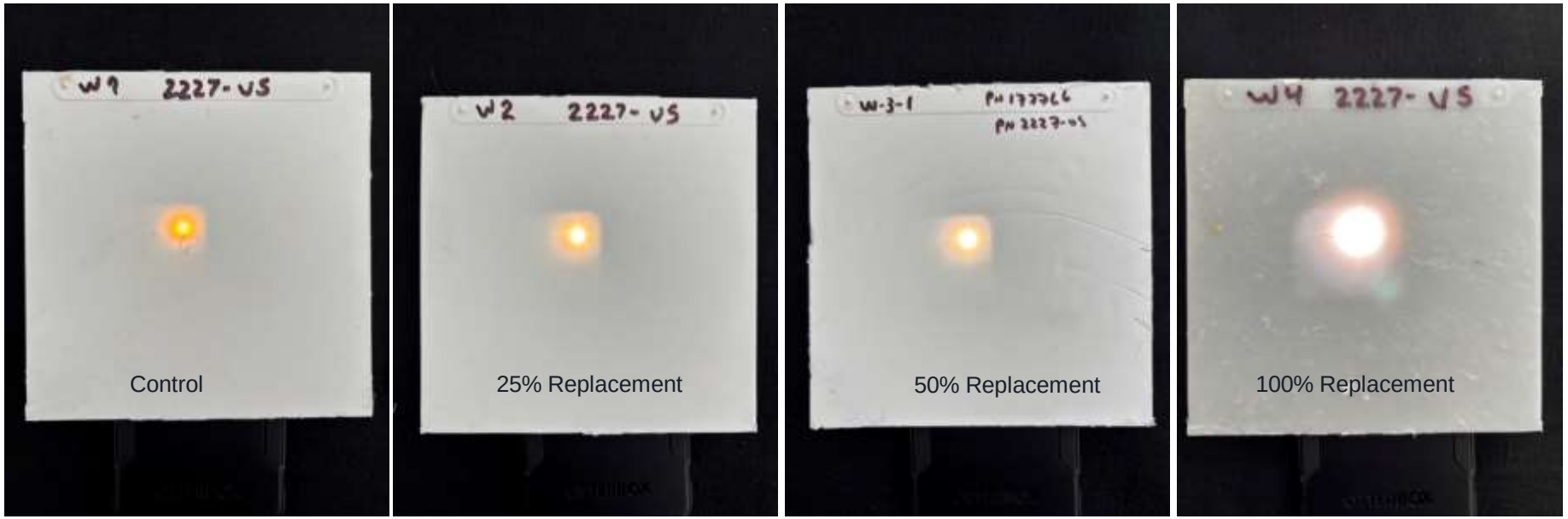
Reducing TiO_2 Dependence – 3% White LDPE

White Formulations: Reduction of Titanium Dioxide (%)				
	Control White	25% TiO_2 Rep.	50% TiO_2 Rep.	100% TiO_2 Rep.
LDPE	96%	96%	96%	96%
TiO_2	3%	2.25%	1.5%	0%
EverWhite® Pigment	0%	0.75%	1.5%	3%
Process Aid	1%	1%	1%	1%
Specific Gravity	0.947	0.943	0.937	0.938
% Change	0.0%	-0.4%	-1.1%	-1.0%

- Lowest pigment loading with basic white LDPE formulation – **3% pigment**
- **Replaced 25%, 50% and 100% of TiO_2** with EverWhite® Pigment
- **Small density/mass reduction** at these pigment loading levels

Opacity – Subjective and TAPPI T425 Standard

Reducing TiO_2 Dependence – 3% White LDPE

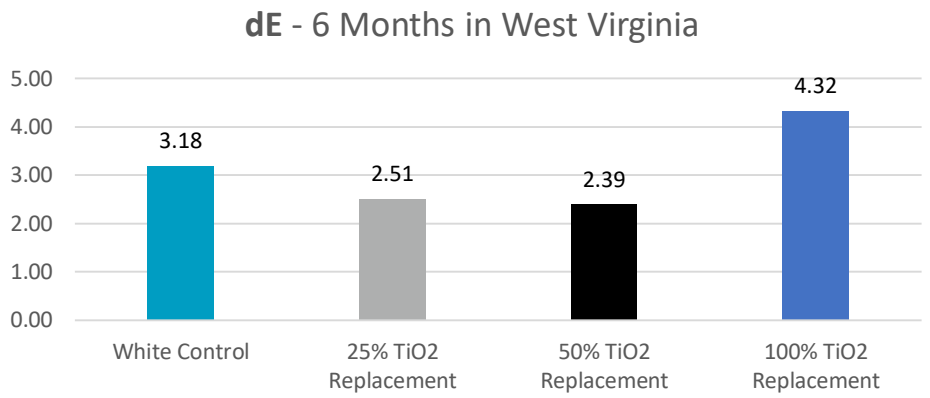


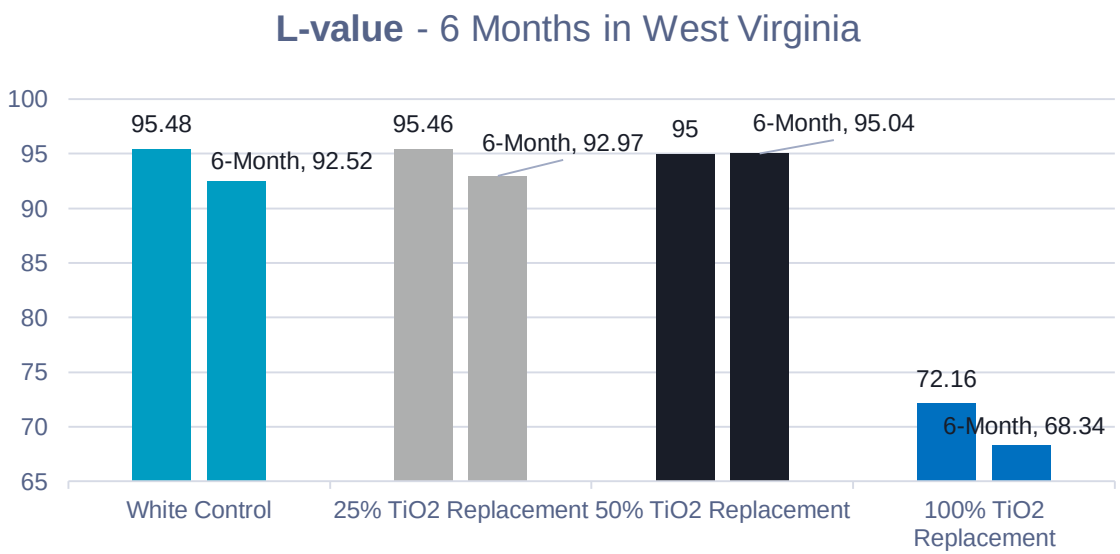
Appearance Metric	100% TiO_2	25% EverWhite® Pigment Replacement	50% EverWhite® Pigment Replacement	100% EverWhite® Pigment Replacement
TAPPI T425 Opacity (2 mm specimens)	99.84	99.24	99.01	56.52
dE	-	0.82	1.39	25.09

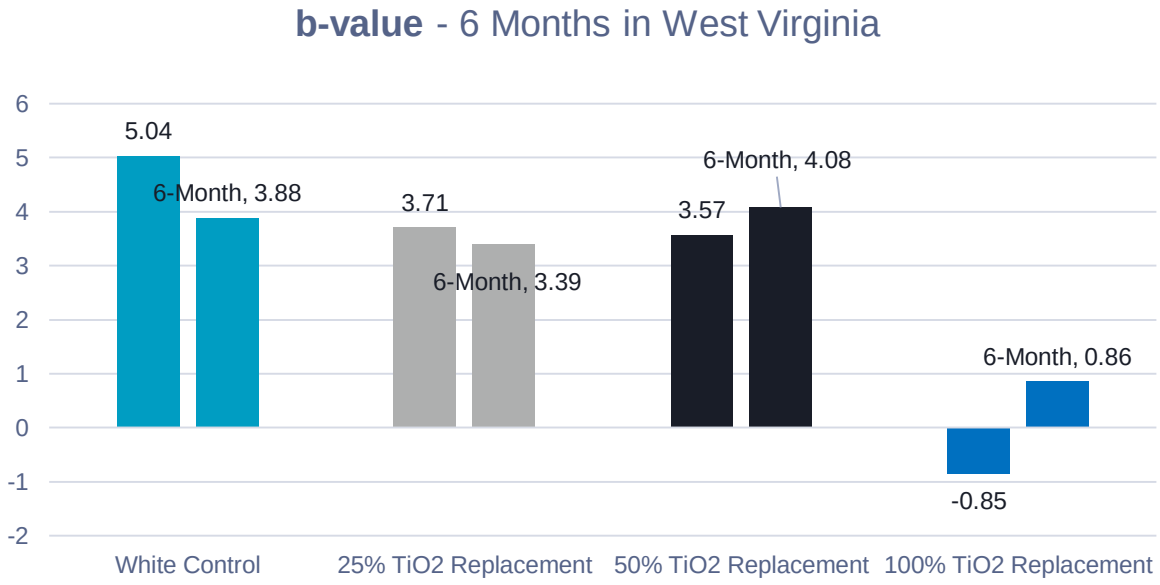
- **Nearly indiscernible differences in opacity** when replacing up to 50% of TiO_2 in these 2 mm injection molded LDPE samples

ASTM D2244 Color Change with Outdoor Weathering, West Virginia 6-Months

Reducing TiO_2 Dependence – 3% White LDPE







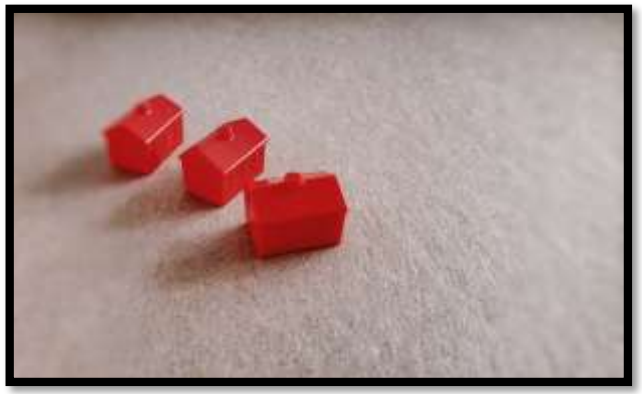
- Formulations with EverWhite® Pigment as a replacement for TiO_2 were able to achieve a **slightly improved weathering performance** from color standpoint when substituting up to 50% of TiO_2

Yellow LDPE Formulation

Reducing TiO_2 Dependence – 3% Red and Yellow LDPE

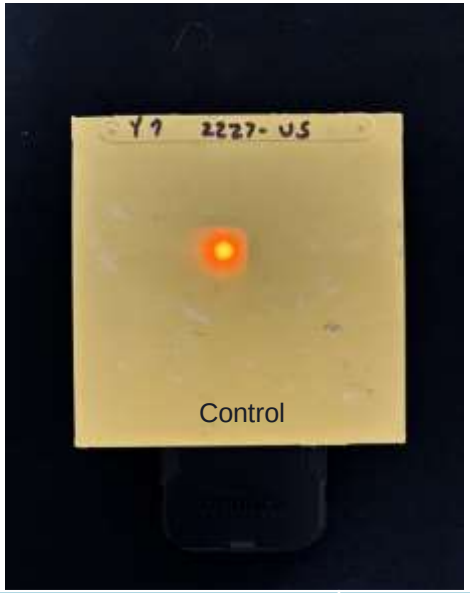
Red and Yellow Formulations: Reduction of Titanium Dioxide (%)				
	Control White	25% TiO_2 Rep.	50% TiO_2 Rep.	100% TiO_2 Rep.
LDPE	96%	96%	96%	96%
TiO_2	3%	2.25%	1.5%	0%
EverWhite® Pigment	0%	0.75%	1.5%	3%
Red Colorant	2%	2%	2%	2%
Process Aid	1%	1%	1%	1%

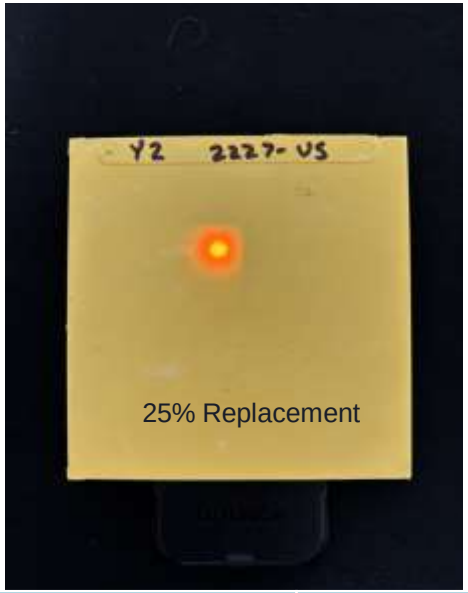
- Lowest TiO_2 pigment loading LDPE formulation – **3% white pigment and 2% colorant in carrier**
- **Replaced 25%, 50% and 100% of TiO_2** with EverWhite® Pigment
- **Small density/mass reduction** at these pigment loading levels

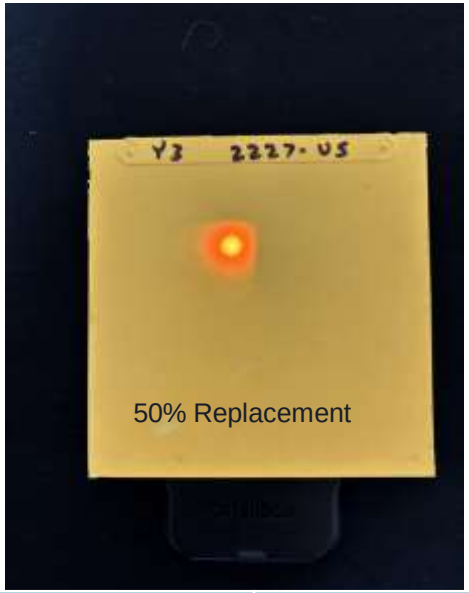


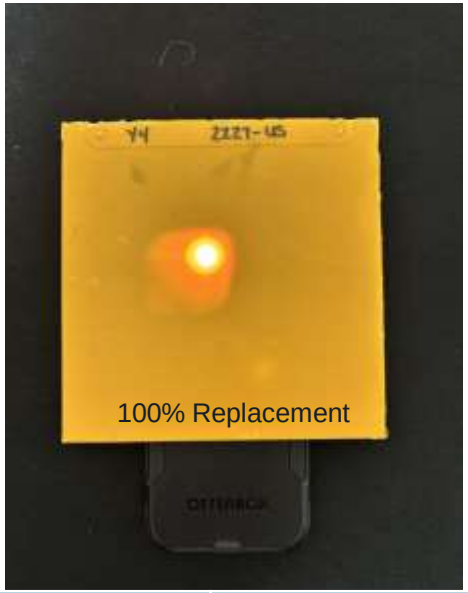
Opacity – Subjective and TAPPI T425 Standard

Reducing TiO_2 Dependence – 3% Yellow







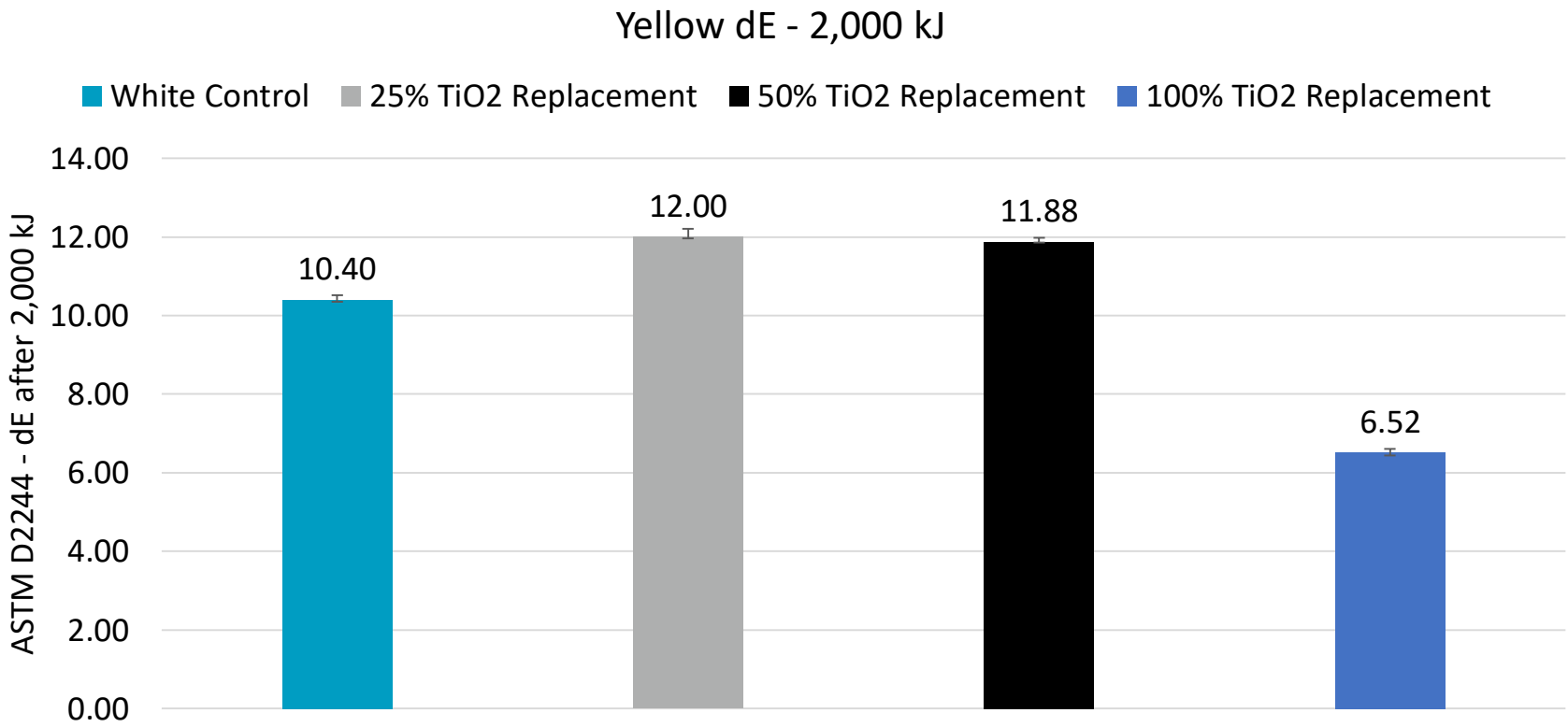


Appearance Metric	100% TiO_2	25% EverWhite® Pigment Replacement	50% EverWhite® Pigment Replacement	100% EverWhite® Pigment Replacement
TAPPI T425 Opacity (2 mm specimens)	99.96	99.81	99.62	89.87
dE	-	4.03	5.91	21.29

- **Nearly indiscernible differences in opacity** when replacing up to 50% of TiO_2 in these 2 mm injection molded LDPE samples
- **Increasing "chroma" in 3% LDPE with removal of TiO_2** – color changes indicate an opportunity to reduce costly non-white pigments as well (as long as opacity is not affected)

ASTM D2244 Color Change with Xenon Weathering, SAE J 2527 – 2,000 kJ

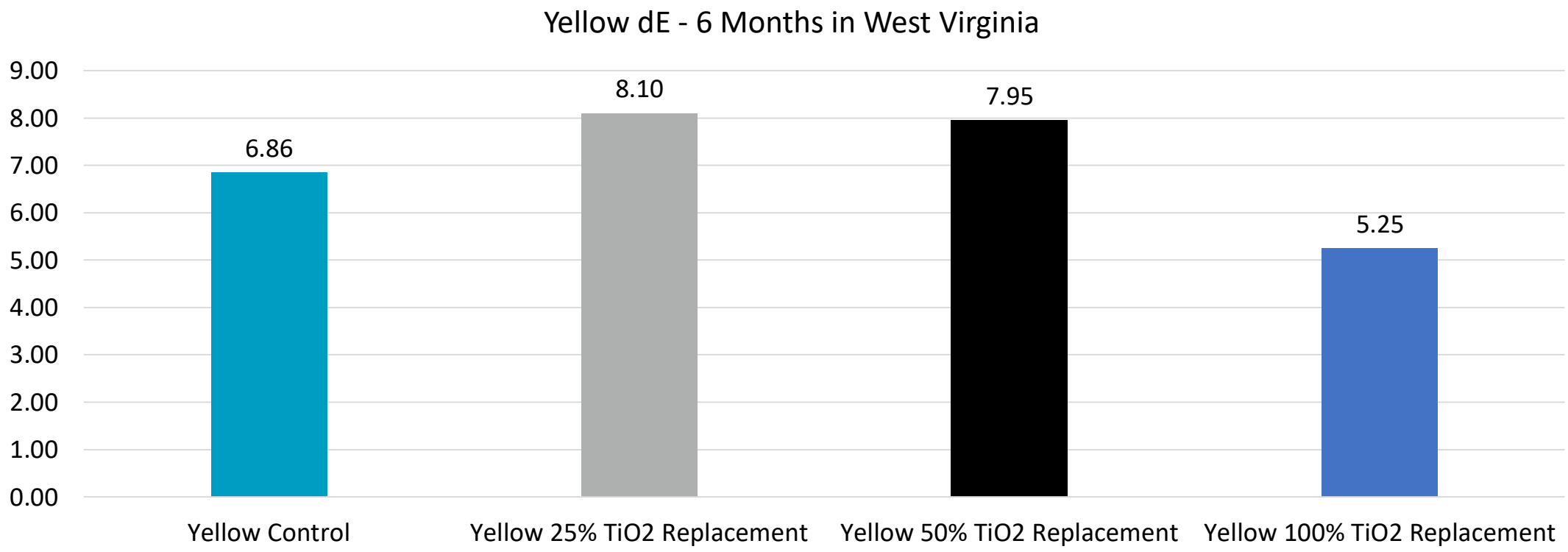
Reducing TiO_2 Dependence – 3% Yellow LDPE



- Formulations with EverWhite® Pigment as a replacement for TiO_2 were able to achieve a **similar weathering performance** with up to 50% substitutions, and less overall color change when utilizing only EverWhite® Pigment

ASTM D2244 Color Change with Outdoor Weathering, West Virginia 6-Months

Reducing TiO_2 Dependence – 3% Yellow and Red LDPE



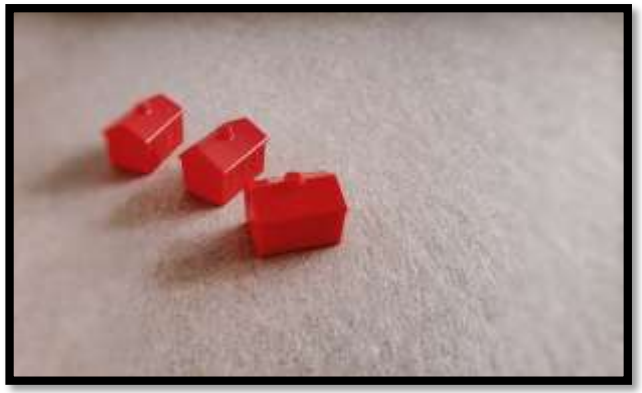
- Formulations with EverWhite® Pigment as a replacement for TiO_2 were able to achieve a **slightly improved weathering performance** from color standpoint when substituting up to 50% of TiO_2

Red Color Matched Masterbatch LDPE Formulation

Reducing TiO_2 Dependence – 19%TiO_2 with Red in LDPE

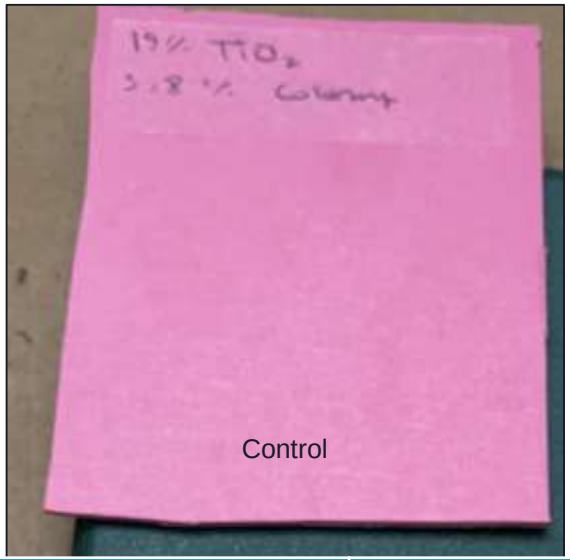
White Formulations: Reduction of Titanium Dioxide (%)			
	Control Red	Color Match: Colorant Reduction and 66% TiO_2 Replacement	1/16th Colorant and 100 wt.% Replacement of TiO_2
LDPE	76%	78%	78%
TiO_2	19%	6%	0%
EverWhite® Pigment	0%	13%	19%
Red Colorant	4%	1.3%	0.25%
Process Aid	1%	1%	1%
Specific Gravity	1.082	1.043	1.052
% Change	-	-3%	-4%

- **Color match study** with basic LDPE formulation for proof-of-concept
- **Replaced** 100% and 66% of TiO_2 with EverWhite® Pigment
- Also **reduced** colorant to take advantage of lower refractive index of EWP-5
- Confirmed **density/mass reduction**

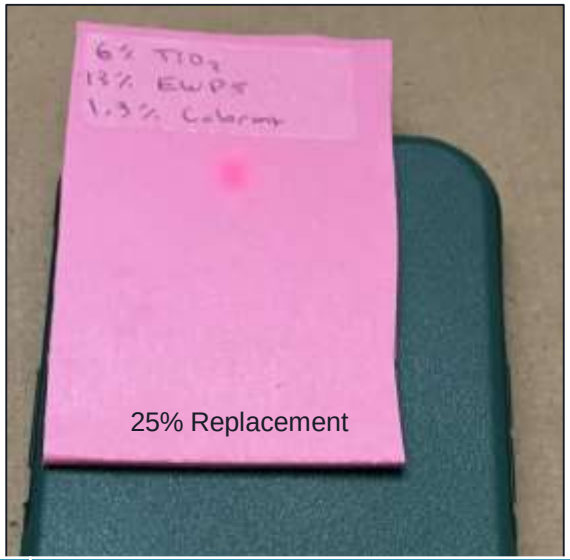


Opacity – Subjective and TAPPI T425 Standard

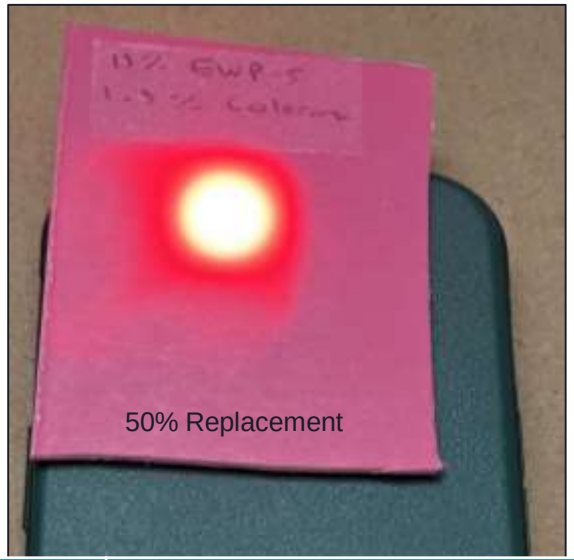
Reducing TiO_2 Dependence – 19%TiO_2 with Red in LDPE



Control



25% Replacement



50% Replacement

Appearance Metric	Control Red	Color Match: Colorant Reduction and 66% TiO_2 Replacement	1/16th Colorant and 100 wt.% Replacement of TiO_2
TAPPI T425 Opacity (2 mm specimens)	99.91	100.01	96.52
dE	-	1.02	13.73

- **Indiscernible differences in opacity and color** when replacing 66% of TiO_2 and reduction colorant by 66% in these 2 mm injection molded LDPE samples
- **Volume-cost ratio** improved as well

AGENDA

1. EverWhite® Pigment Fundamentals
2. Reducing TiO_2 in Plastics
   a. White PVC
   b. White LDPE
   c. Yellow and Red LDPE
3. **Looking Forward to Commercial Applications**





QUESTIONS?

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Appendix Placeholder