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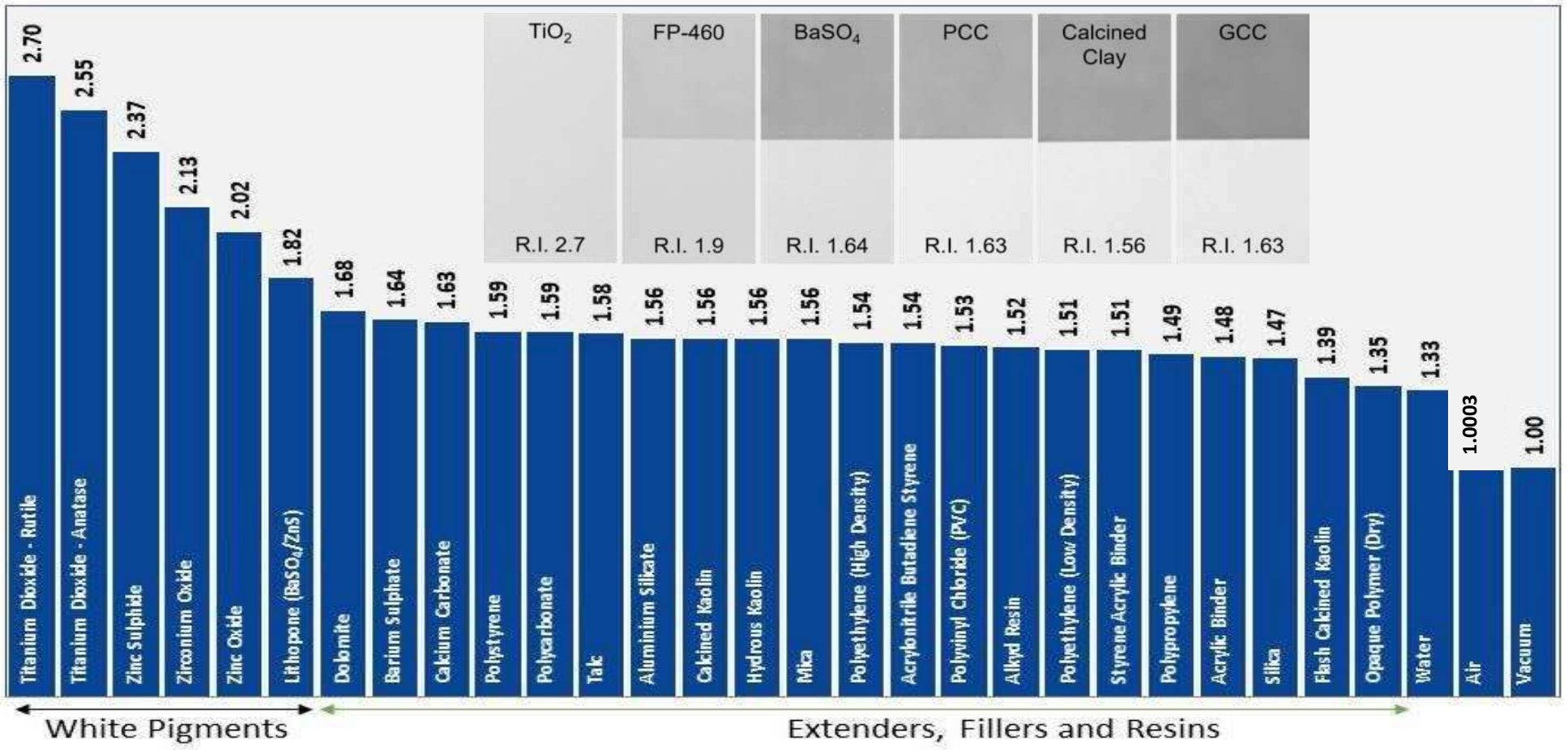
CONGRESS

Understanding wet opacity in water-based matt decorative paints and how to make your TiO_2 work harder.

Andy White
FP-Pigments OY

Opacity Wet or Dry – The Importance of Refractive Index



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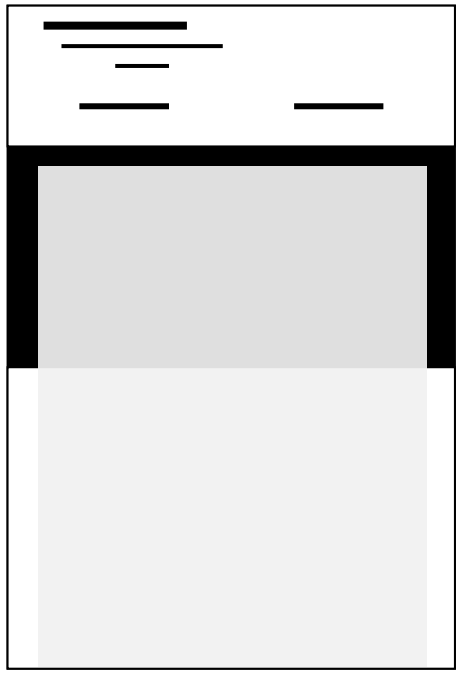
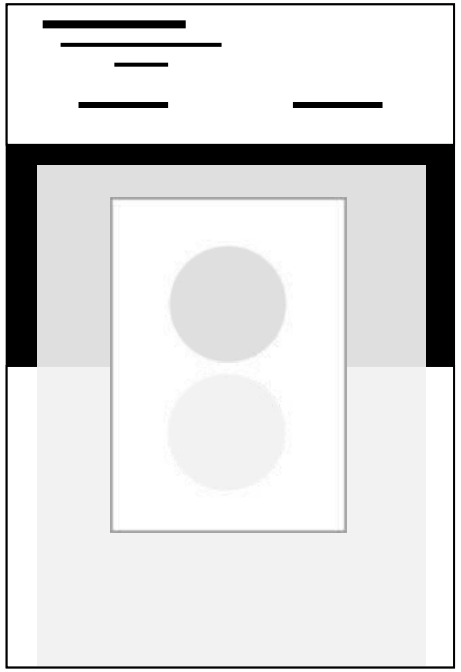
Wet opacity - Simple Measurement Method



Each paint is drawn down at 100µm WFT onto a standard black and white opacity chart. Careful control of the room conditions should be maintained throughout the measurements (Temp, Humidity, no drafts, no direct light etc)

Important to take readings as quickly as possible, ideally within 20 seconds of completing the drawdown.



A PTFE mask is applied to the panel and measurements over black and white taken.
(though reflectance over black is only required for comparative purposes.)

Process is repeated several times on new drawdowns with the same paint and the results averaged.

The more repeats the better the accuracy.

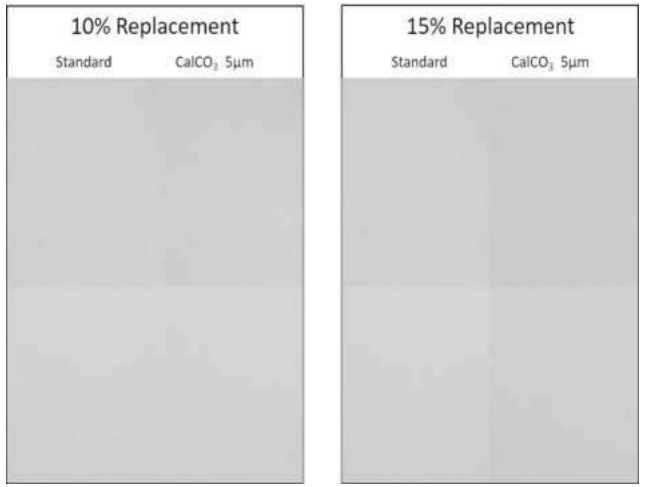
Wet Opacity - High Quality Interior Matt

Category	Ingredient	%
Water	Water	35.50
Millbase Additives	HEC Thickener	0.55
	pH Adjustment	0.15
	Defoamer	0.60
	Surfactant	0.10
	Dispersant	0.70
	Biocide	0.15
	Coalescent	1.40
Sub Total	Additives	3.65
Pigments/Extenders/Fillers	FP-Opacity Pigment™	0.00
	Titanium Dioxide	12.00
	Hydrous Kaolin	8.00
	Calcined Kaolin	6.00
	Calcium Carbonate (5µm)	15.40
Sub Total	Pigments/Extenders/Fillers	41.40
Let Down	Binder (Styrene Acrylic)	14.00
	pH Adjustment	0.10
	Open time modifier (Glycol)	1.10
	Opaque Polymer	1.20
	HASE Thickener	0.45
Sub Total	Let Down	16.85
Water	Water	2.60
Total	Paint	100.00
Basic Paint Properties	Volume Solids %	31.10
	Weight Solids %	51.50
	pvc %	69.00
	TiO_2 vc %	14.00
	TiO_2 wt %	12.00

Typical European High quality Matt Paint system

Ingredients have been generified to simplify the formulation

TiO_2 reduction with 5µm Ground Calcium Carbonate

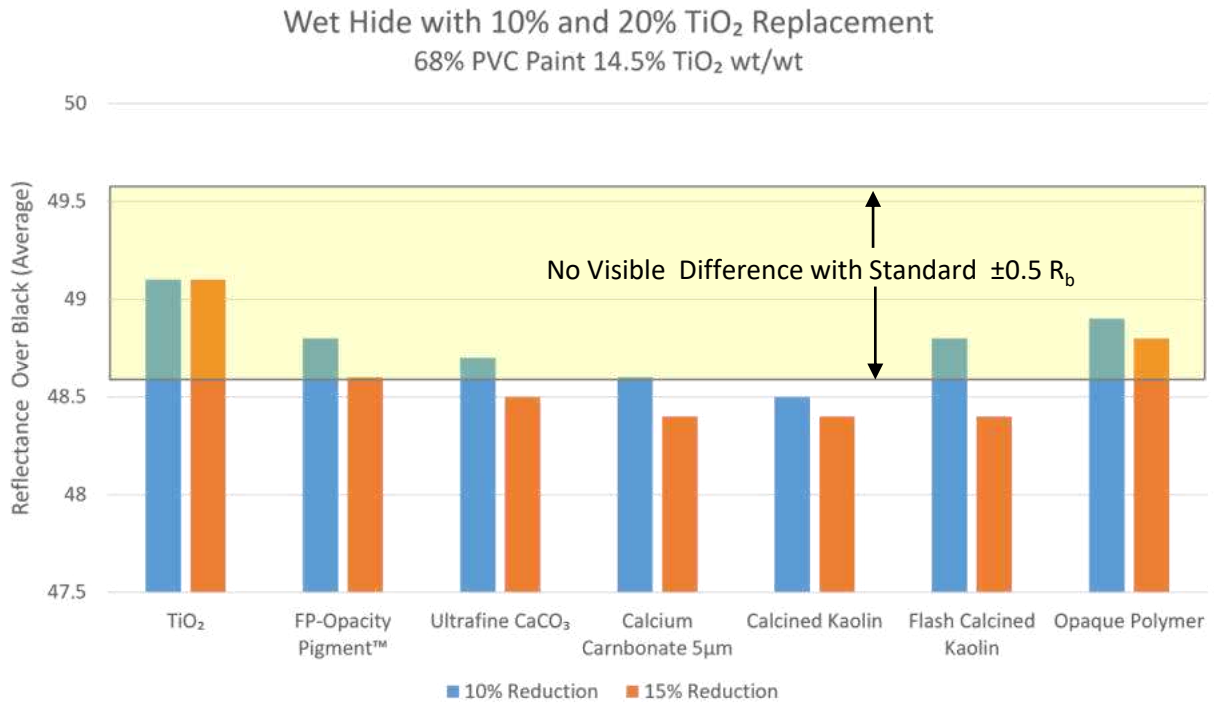


	Std	10%	Std	15%
R_b	49.1	48.6	49.1	48.4

Based on an average of 5 measurements, SDev= ~0.25. Human Eye +/- 0.5

Dominance of TiO_2 in Wet Hide and effect of alternatives

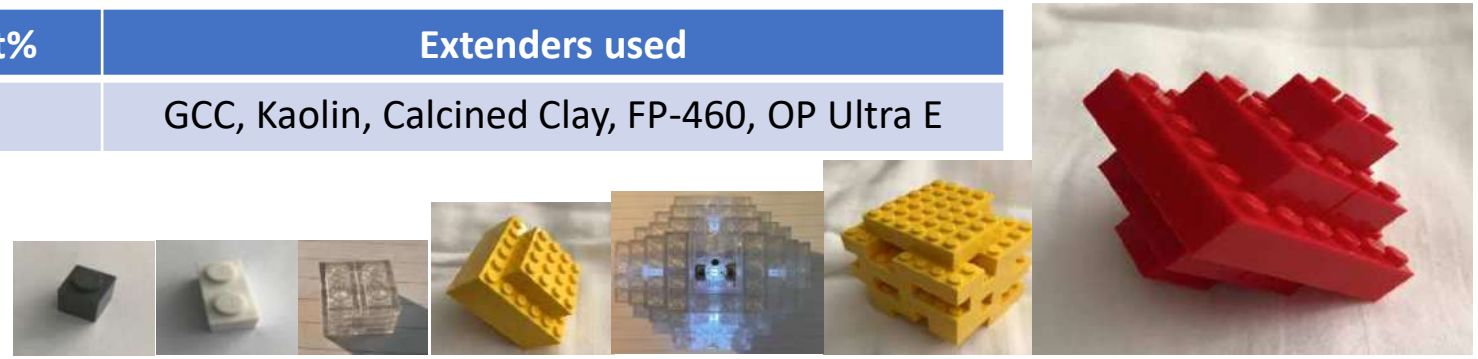
The dominance of TiO_2 in developing wet hide is so significant that, as we all know, reducing the level of TiO_2 when trying to optimise a formulation while possibly maintaining dry opacity will almost inevitably result in a loss of wet hide.



FP-Pigments (due to scatter) and Optical Polymer (due to number of particles) offer the best routes to higher TiO_2 replacement, though exchanging extenders or fillers will have very little effect.

What is going on? – A theoretical Approach

PVC	TiO_2 wt%	Extenders used
69%	12%	GCC, Kaolin, Calcined Clay, FP-460, OP Ultra E



Particle	Latex	TiO_2	OP	China Clay	FP Pigment	Calcined Clay	Calcium Carbonate
Size (D50)	0.15 µ	0.28 µ	0.4 µ	0.5-1.0 µ	1-1.1 µ	1-1.2 µ	~5µ
Dimensions (Lego)	1x1x1	1x1x2	2x2x2	6x6x4	6x6x6	8x8x6	33x33x33
Relative volume	1	2	4	150	350	400	36000
% of paint as Solid	6.1%	10.7%	0.4%	7.3%	1.2%	6.5%	16%
Particles in 150 µ wet	**~350M**	**~8.5M**	**~2.4M**	**~60k**	**~30k**	**~50k**	**~4k**
Refractive Index	1.51	2.7*	1.51*	1.56	1.85*	1.56	1.63
Refraction Angle at interface	N/A	25*	5.5*	7	14*	7	9
Est Contribution to wet hide	**N/A**	**97.5%**	**1.3%**	**0.01%**	**1.2%**	**0.01%**	**<0.01%**

Conclusions – Wet Opacity

We have shown that we have a simple and reliable method of instrumentally measuring wet opacity in liquid paints. This method could be used in a variety of scenarios to optimise or measure the paints performance.

In this specific study, however, we have shown that in a high quality medium PVC water based matt paint that the TiO_2 dominated the wet opacity results.

Our theoretical investigation has concluded that this is due to…

- The high refractive index of TiO_2
- Its multiple scattering properties and
- The sheer number of small particles in the paint.

We also showed that materials which have higher scattering abilities and/or high particle numbers will also have a greater effect on wet opacity than those which don't. EG **Opaque Polymer** and/or **FP-Pigment**

In contrast, bigger particles with likely lower numbers and often lower refractive indices will have little or no effect on wet opacity, hence being more exposed when looking to reduce TiO_2 usage.

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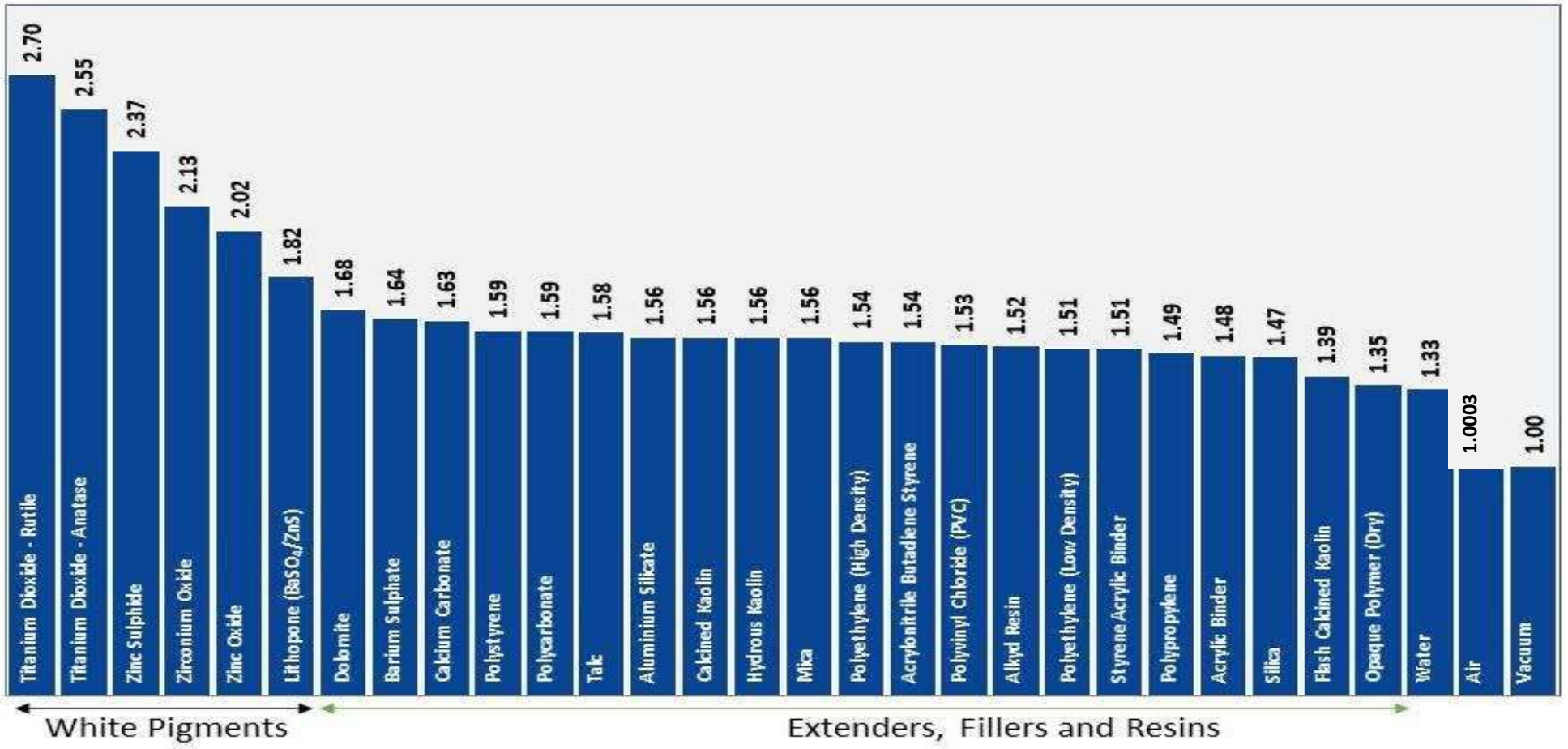
Optimising Dry Opacity while Maintaining Wet Hide and Paint PVC.

The Importance of Refractive Index



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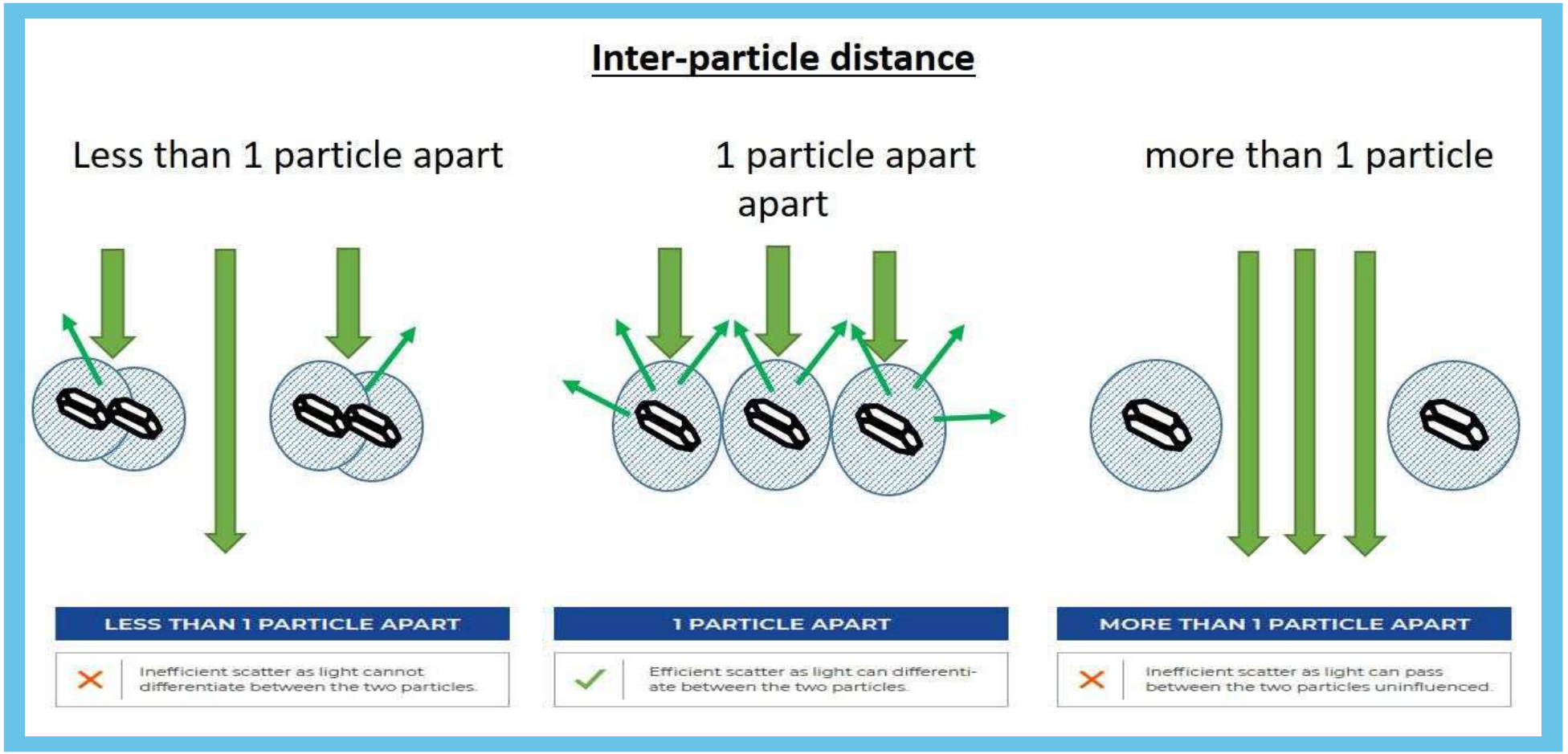
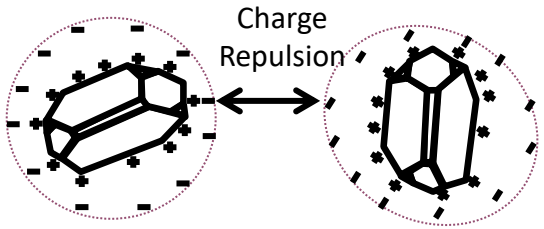
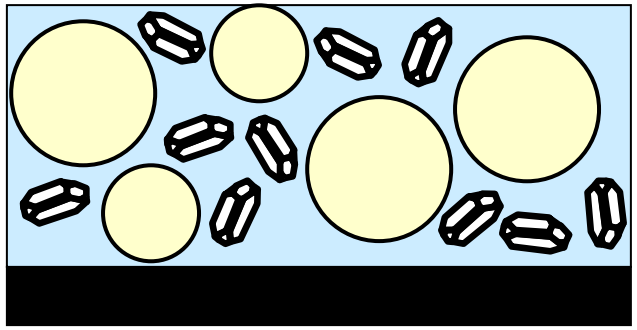
Importance of “Spacing” TiO_2

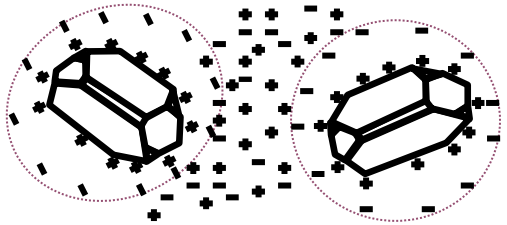


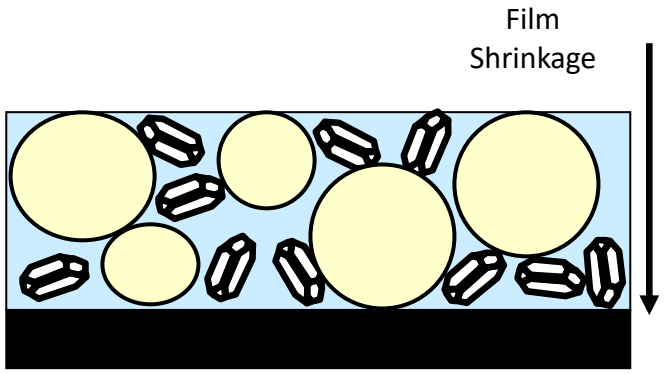
Maintaining the TiO_2 Distribution in Application



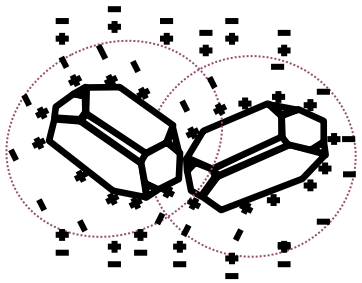


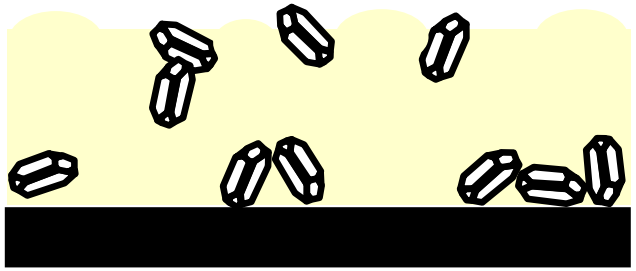
Dispersion in the wet coating is good with electrostatic forces keeping the pigment particles and emulsion droplets apart.





As the water evaporates the ionic strength increases, reducing the effective repulsion and allowing the pigment and emulsion droplets to homo- and hetero-flocculate

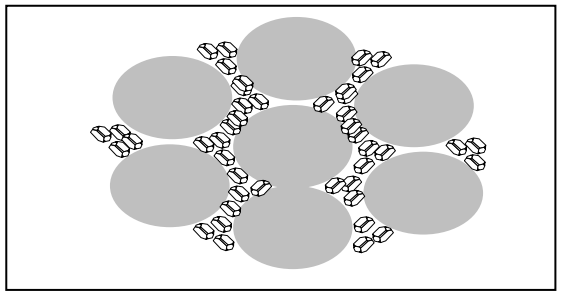




On drying the pigment remains locked into it's flocculated state with pigment-free windows left in the coalesced emulsion

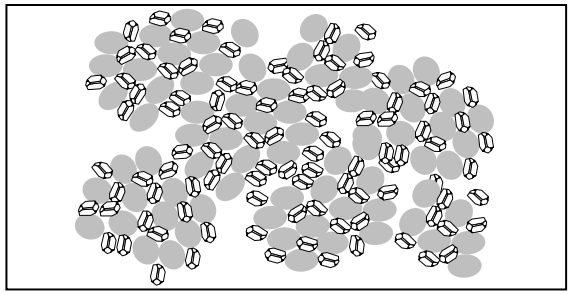
TiO_2 Crowding and “windows”in matt paint films

Cheap, coarse fillers



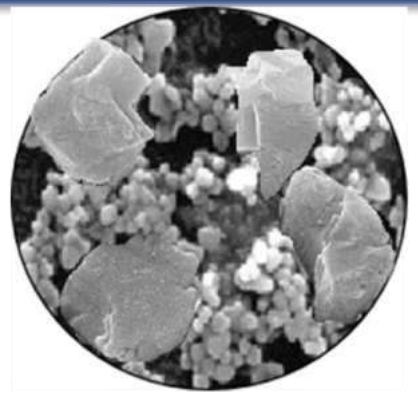
5µm Extender

More Expensive, fine extenders

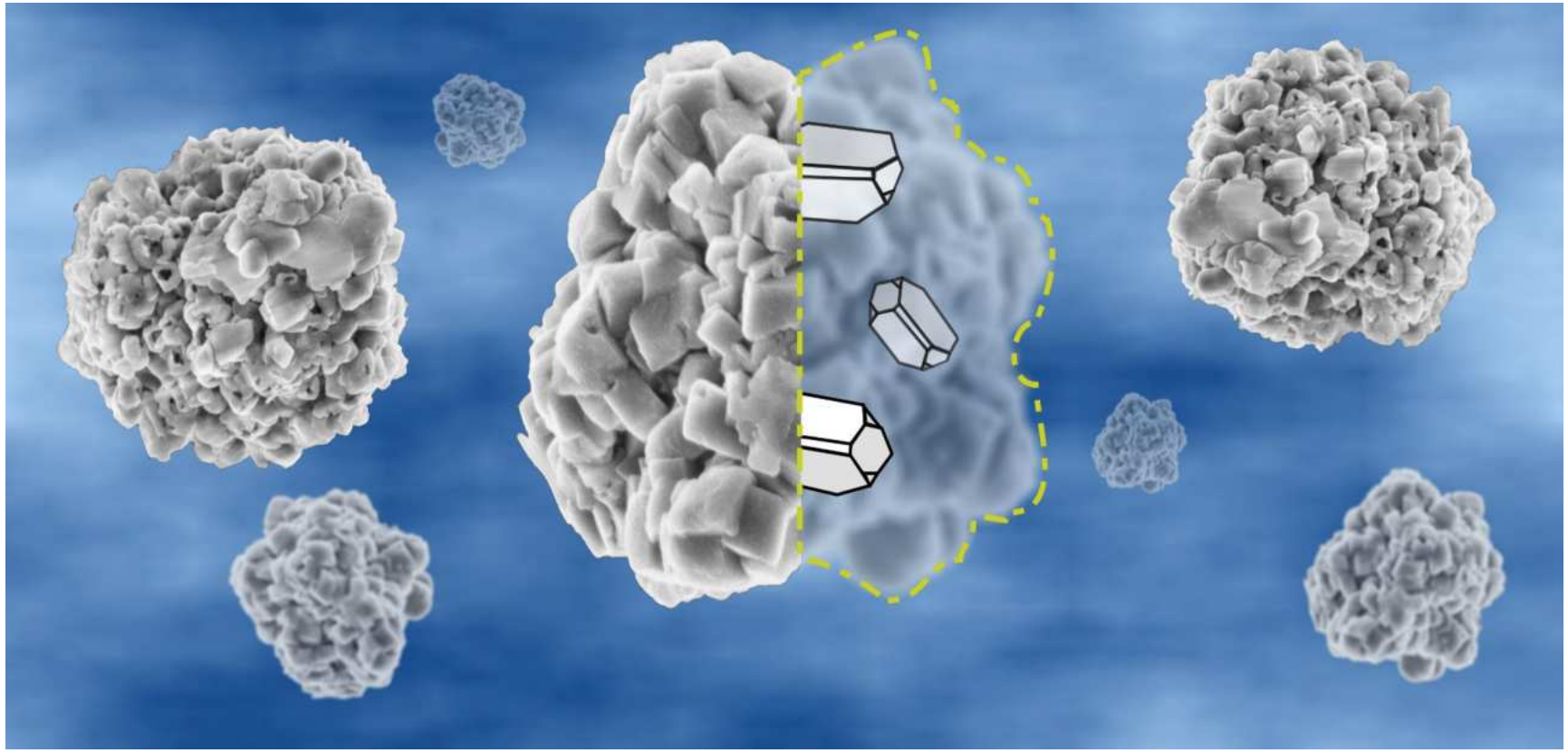


1 µm Extender

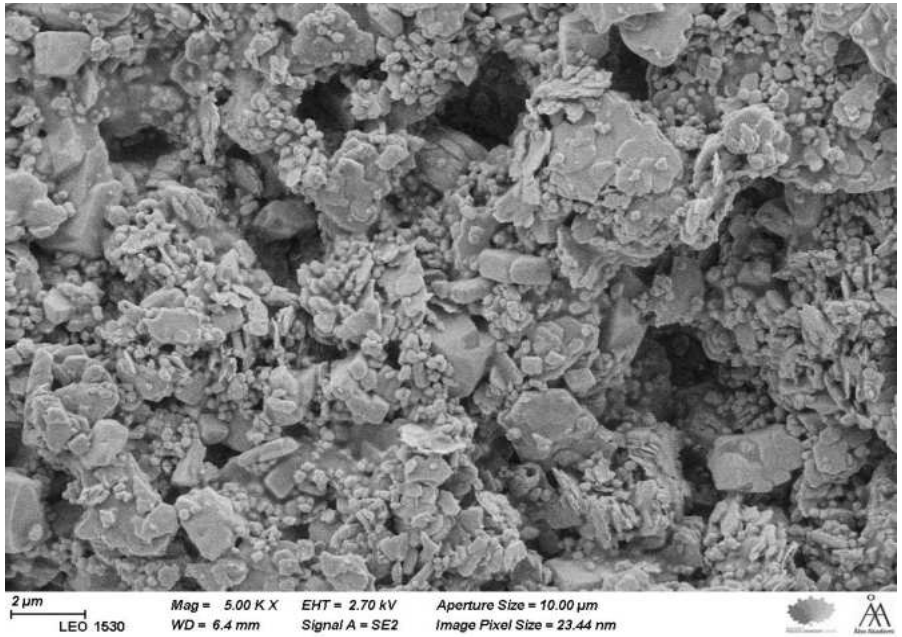
Pigment crowding reduces as Extender particle size decreases



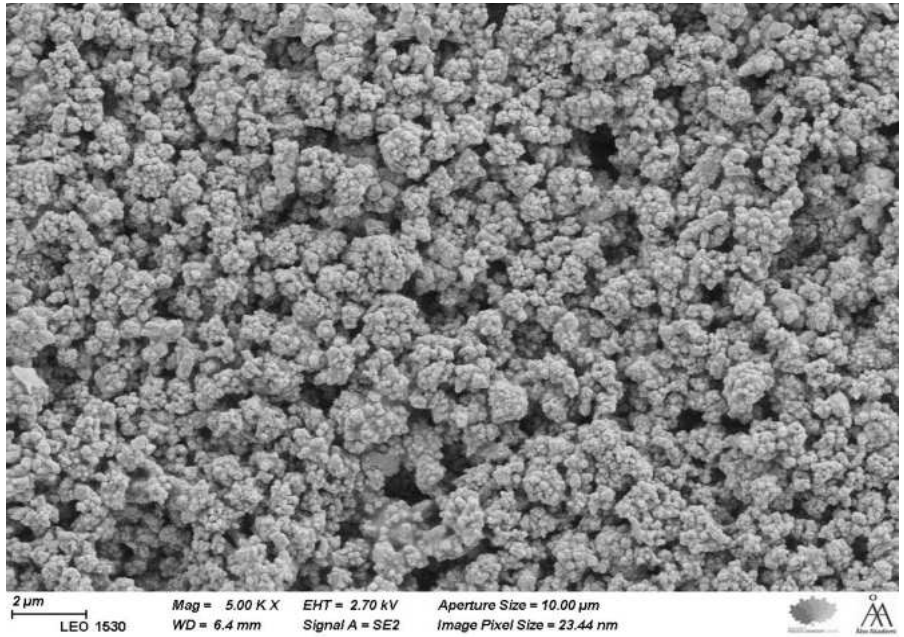
FP-Opacity Pigment™ - Product Concept



SEM Images of Standard and Model Paints



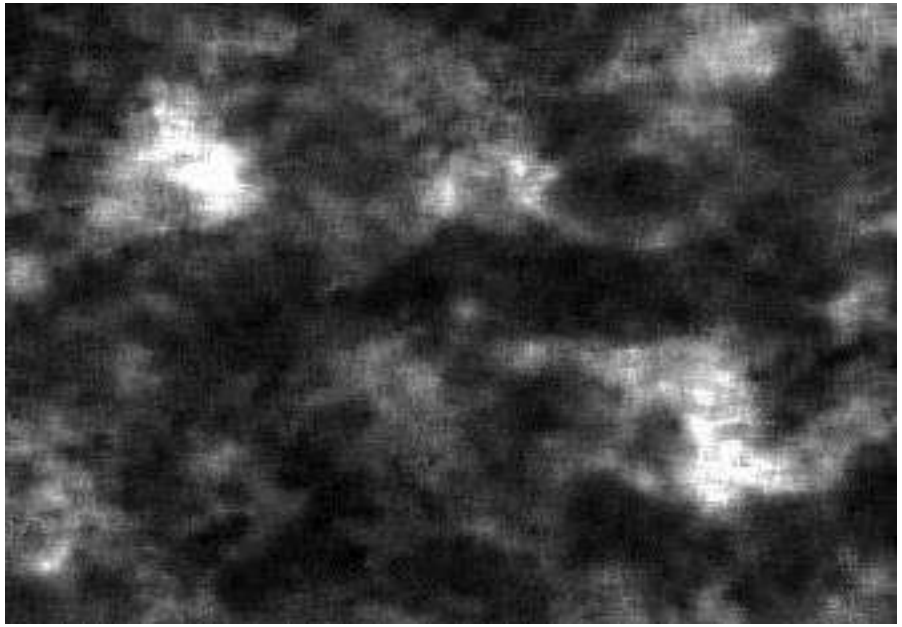
High Quality Matt Paint
75% PVC, 10% TiO_2 vc 65% Extender vc: Chalk and Calcined Clay



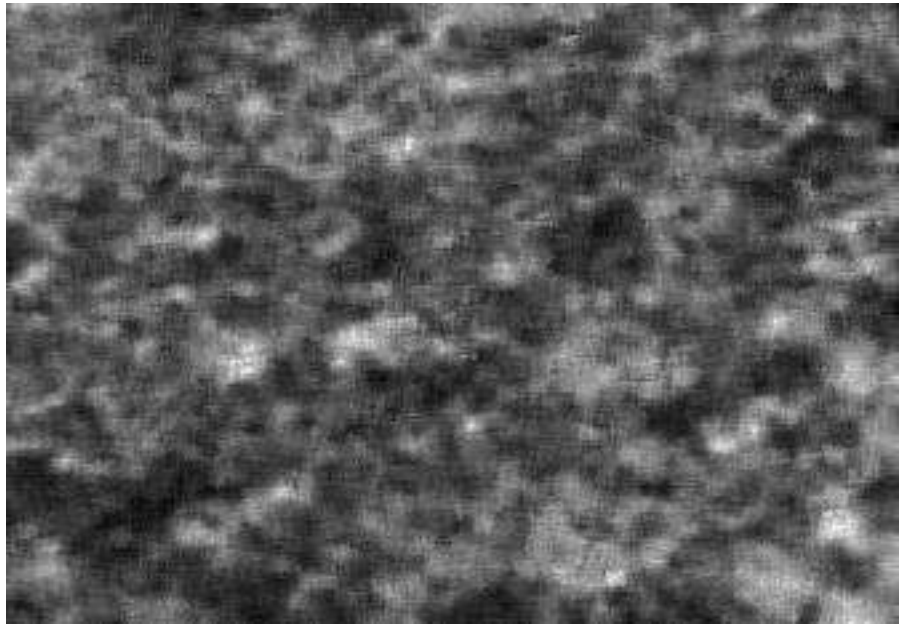
FP-Opacity Pigment™ Model Paint
75% PVC, 10% TiO_2 vc, 65% Extender vc: PCC from FP-Opacity Pigment™ Composite

	Standard	FP-Opacity Pigment™
Contrast Ratio @15m^2/l	96.7	98.2
Spreading Rate @ CR=98%	11.4	15.9

TiO_2 Distribution Analysis (of same formula films)



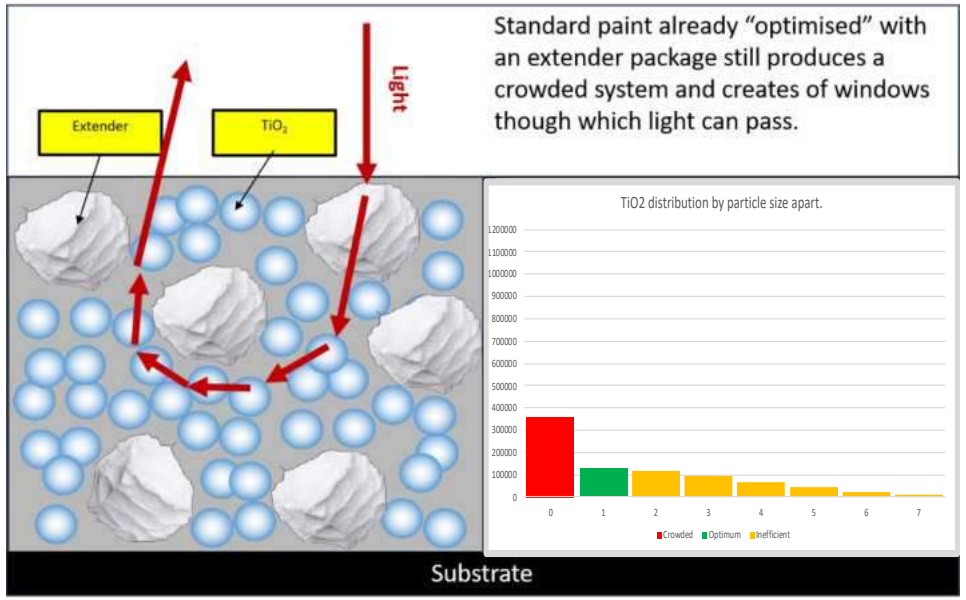
High Quality Matt Paint
Elemental Mapping (Ti Analysis)

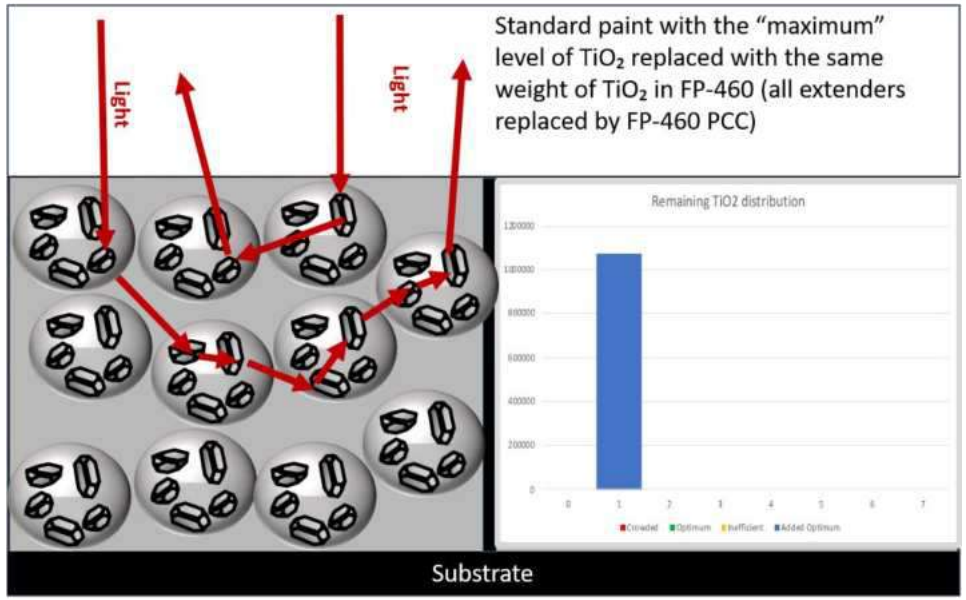


High Quality Matt Paint
Elemental Mapping (Ti Analysis)

	Standard	FP-Opacity Pigment™
Contrast Ratio @15m^2/l	96.7	98.2
Spreading Rate @ CR=98%	11.4	15.9

What is going on? - Model paints





Standard paint already "optimised" with an extender package still produces a crowded system and creates windows through which light can pass.

All TiO_2 inside the FP-Pigment composite is therefore perfectly spaced. (the same weight of TiO_2 applied)

Enhancing Opacity at Constant Wet Hide

What would happen if we took a real paint formulation and kept the overall TiO_2 level constant but exchanged the loose, random TiO_2 for more effective, spaced TiO_2.

You would expect to see an increase in dry opacity due to the more efficient TiO_2 and, since the TiO_2 level is kept constant, no degradation in wet hide.

Making the TiO_2 “work harder” in the dry

High Quality Interior Matt Paint Formula

Category	Ingredient	%
Water	Water	35.50
Millbase Additives	HEC Thickener	0.55
	pH Adjustment	0.15
	Defoamer	0.60
	Surfactant	0.10
	Dispersant	0.70
	Biocide	0.15
	Coalescent	1.40
Sub Total	Additives	3.65
Pigments/Extenders/Fillers	FP-Opacity Pigment™	0.00
	Titanium Dioxide	12.00
	Hydrous Kaolin	8.00
	Calcined Kaolin	6.00
	Calcium Carbonate (5µm)	15.40
Sub Total	Pigments/Extenders/Fillers	41.40
Let Down	Binder (Styrene Acrylic)	14.00
	pH Adjustment	0.10
	Open time modifier (Glycol)	1.10
	Opaque Polymer	1.20
	HASE Thickener	0.45
Sub Total	Let Down	16.85
Water	Water	2.60
Total	Paint	100.00
Basic Paint Properties	Volume Solids %	31.10
	Weight Solids %	51.50
	pvc %	69.00
	TiO_2 vc %	14.00
	TiO_2 wt %	12.00

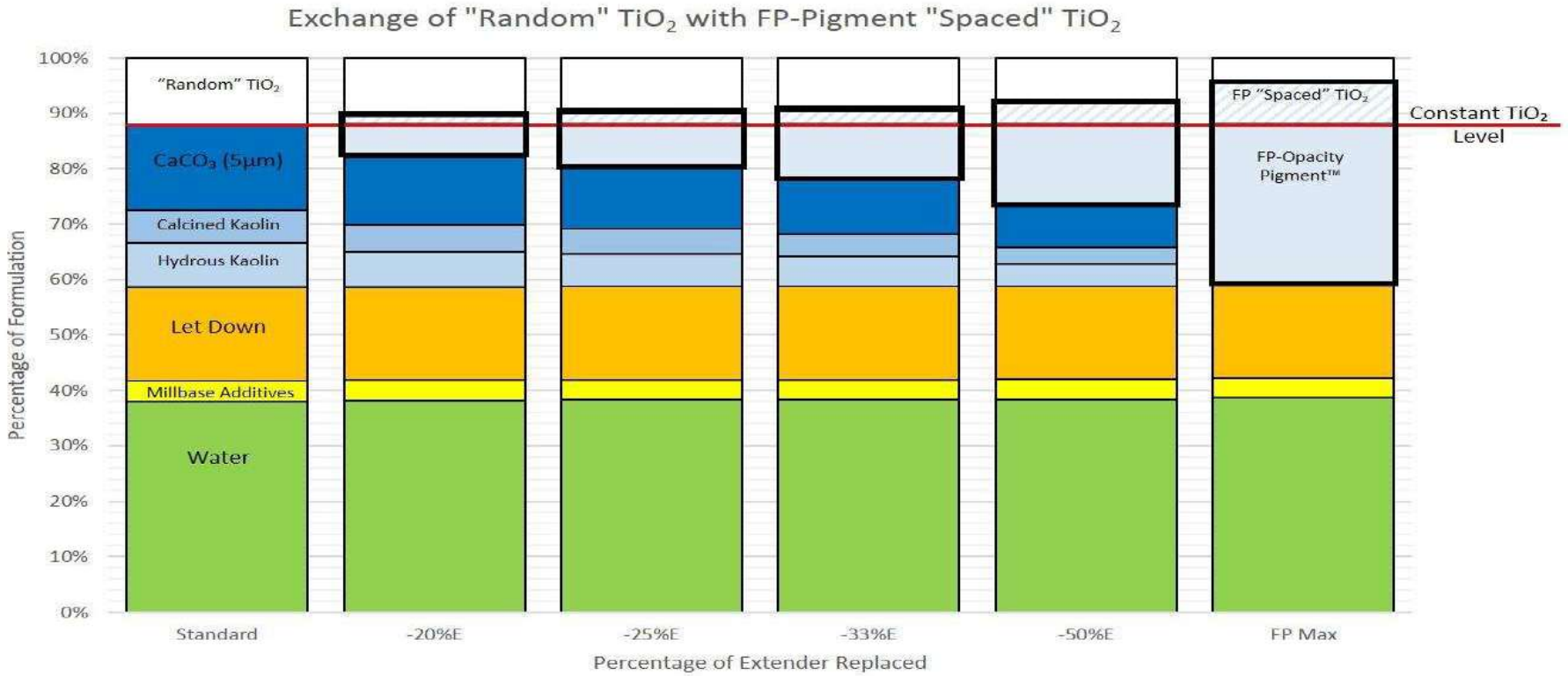
Typical European High quality Matt Paint system

Ingredients have been generified to simplify the formulation

Minerals are the only items that will be changed

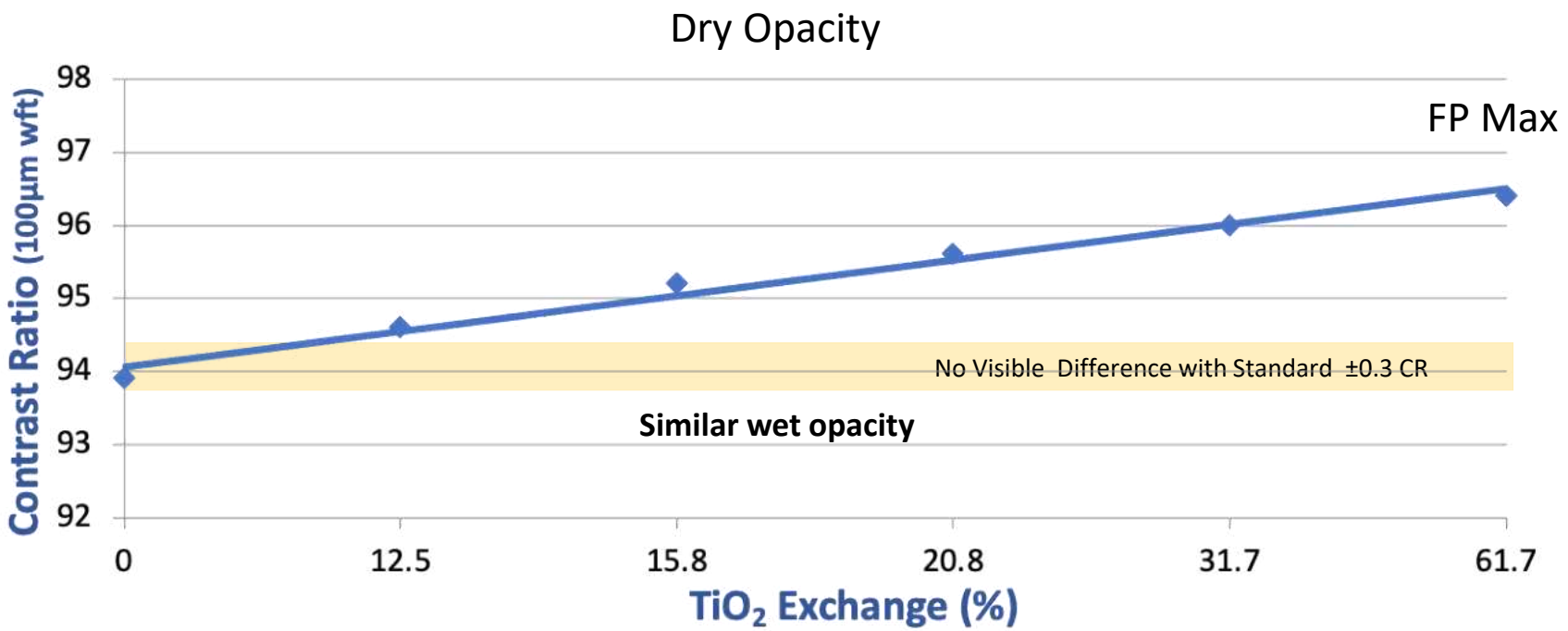
With Polymer levels and hence PVC unchanged overall.

TiO_2 Exchange - High Quality Interior Matt



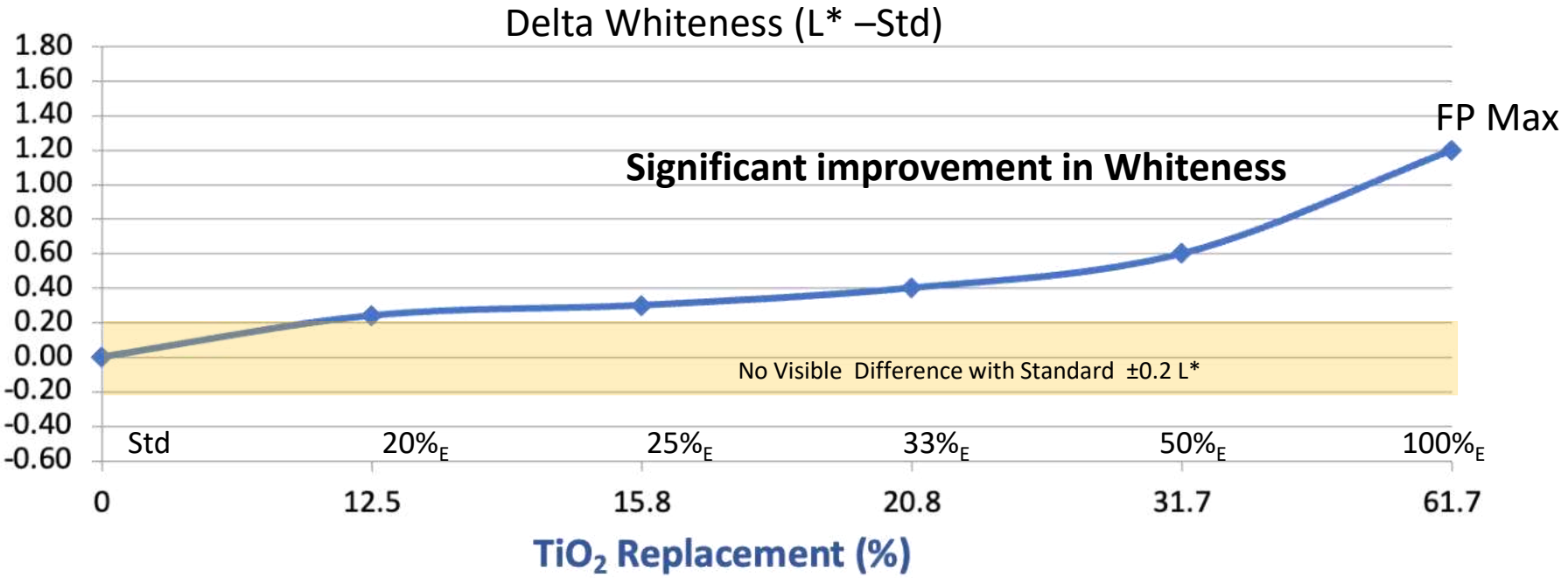
	Standard	-20%E	-25%E	-33%E	-50%E	FP-MAX
Volume Solids %	31.1	31.1	31.1	31.1	31.1	31.1
pvc %	69.0	69.1	69.2	69.2	69.3	69.6
TiO_2 wt %	12.0	12.0	12.0	12.0	12.0	12.0
% TiO_2 Exchanged	0.0	12.3	15.3	20.3	30.7	61.3

TiO_2 Exchange Results - Opacity



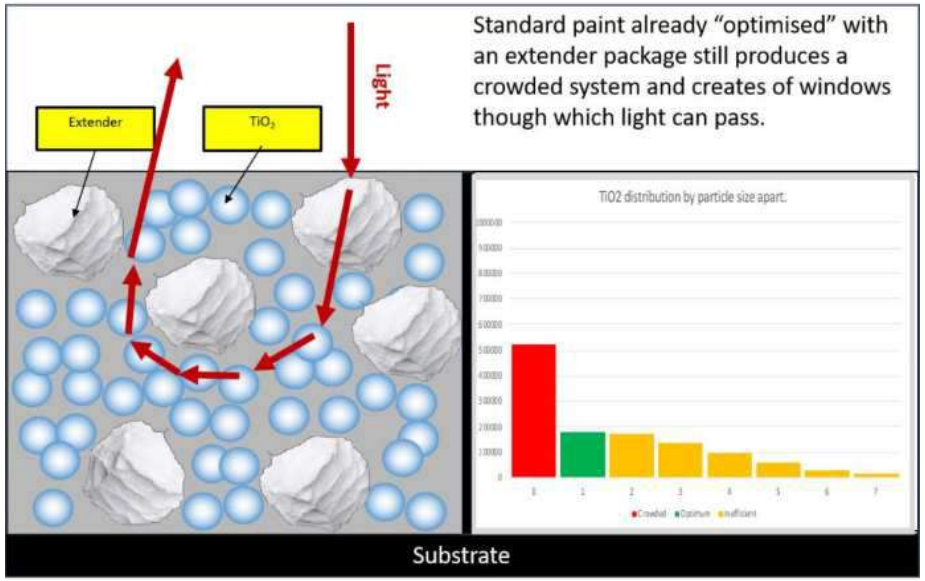
	CR STD	CR 20%$_E$	CR 25%$_E$	CR 33%$_E$	CR 50%$_E$	CR 100%$_E$
Dry Opacity	93.9	95.2	95.2	95.4	96.0	96.4
Wet Hide	50.37	=	=	=	=	50.43

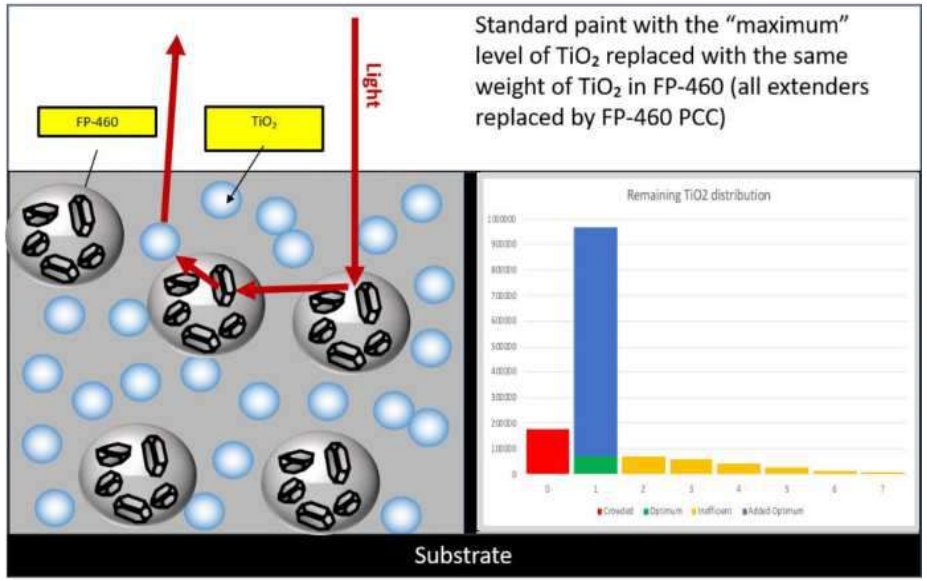
TiO_2 Exchange Results – Brightness



Delta L*	L* STD	L* 20%$_E$	L* 25%$_E$	L* 33%$_E$	L* 50%$_E$	L*100%$_E$
Std	0	0.24	0.30	0.40	0.60	1.20

What is going on?

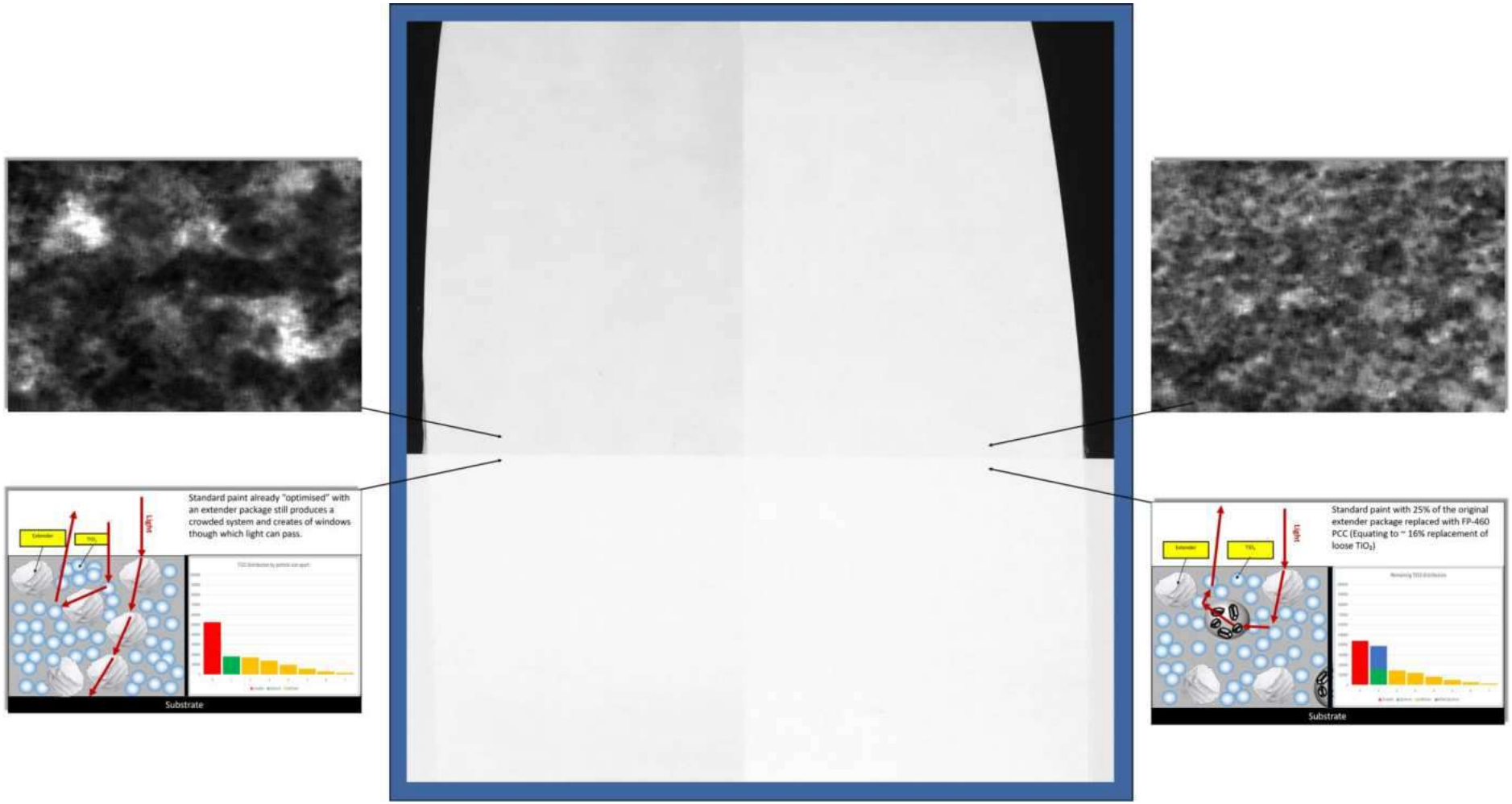




Using FP-Pigments to exchange for TiO_2 and extender presents a triple opportunity to increase dry opacity.

- By introducing ideally space TiO_2 inside the FP-Pigment particles, which cannot flocculate or be crowded on drying
- By reducing the "window effect" created by the lower refractive Index extenders.
- By reducing the crowding of the remaining free TiO_2 which is present in a more dilute form, distributed randomly in the film.

How does this look in Reality



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Unlocking the Potential of TiO_2 to increase opacity and deliver greater formulating flexibility at equal wet opacity

Potential for thinner films/increased spreading rate

Potential for cost savings at equal dry opacity

Thank You!