TiO_2 Reduction in Polyester:TGIC Powder Coatings

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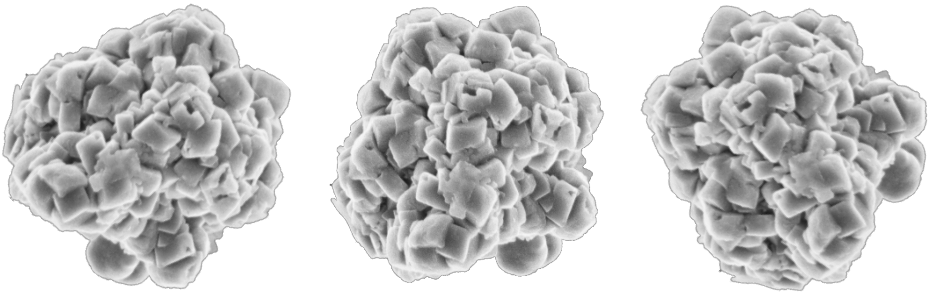

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FP PIGMENTS

Introduction

Working with the Powder Coatings Research Group (PCRG), FP-Pigments evaluated the performance of FP-480 Opacity Pigment™ as a partial replacement for TiO_2 in a Polyester:TGIC powder coating.

Evaluation

The following Polyester:TGIC powder coating recipe was provided by the PCRG for the comparison evaluation.

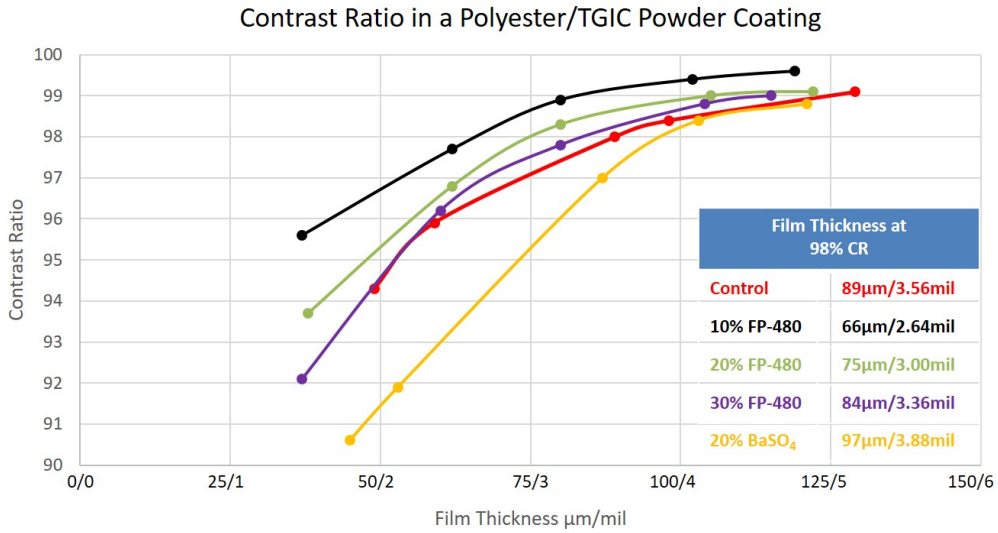
Material	Grade	Percentage	Supplier
Polyester Resin	Crylcoat 2441-2	63.7	Cytec
Crosslinker	Triglycidyl Isocyanurate	4.8	Huntsman AdMat
Flow Agent	Resiflow P-67	1.0	Estron Chemical
Degassing Agent	Benzoin	0.5	Various
TiO_2 Pigment	KRONOS® 2160	25.0	KRONOS Worldwide Inc
Barium Sulphate	Blanc Fixe Micro	5.0	Venator
FP-Opacity Pigment™	FP-480		FP-Pigments

The formulation was modified by replacing 10, 20 and 30% of the TiO_2 pigment with an equivalent weight of FP-480 Opacity Pigment™, all other raw materials remaining constant. In addition to the FP-Opacity Pigment™ evaluation a second control replacing 20% of the TiO_2 with the same weight of Blanc Fixe Micro was also made for comparison.

The resulting powders were then sprayed at various film thicknesses ranging from 30µm to 120µm the average film thickness across eight areas of the panel being calculated. Measurements of reflectance over the black and white parts of the panels were made and the results plotted against film thickness to produce a set of reflectance curves from which contrast ratio at any given film thickness could be estimated (Further information on our CR test method can be obtained through the contact us section of the Website). In addition to the opacity, colour (CIE Lab), gloss and tests were made on panels with a film thickness close to 60µm. Tint reducing power in a grey coating and accelerated durability QUV(A) were also evaluated. Finally a Pill Flow test was carried out on the powder.

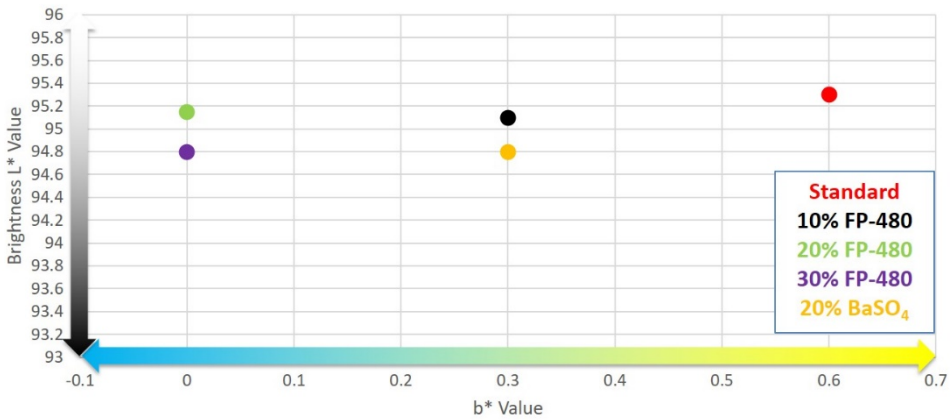
Results

Contrast Ratio



As can been seen in the graph above, at normal film thicknesses (50 to 75µm) it is possible to replace up to 30% of the titanium dioxide pigment and maintain opacity compared to the standard; this is not possible when using 20% barium sulphate. Replacement levels of 10 and 20% appear to give a small improvement in opacity over the standard, although this is not our intention and usually the replacement level would be optimised to give an equivalent performance and the maximum cost saving. Film thicknesses required to achieve a 98% contrast ratio are also given in the table with the graph. Again it can be seen that replacement levels of up to 30% are possible.

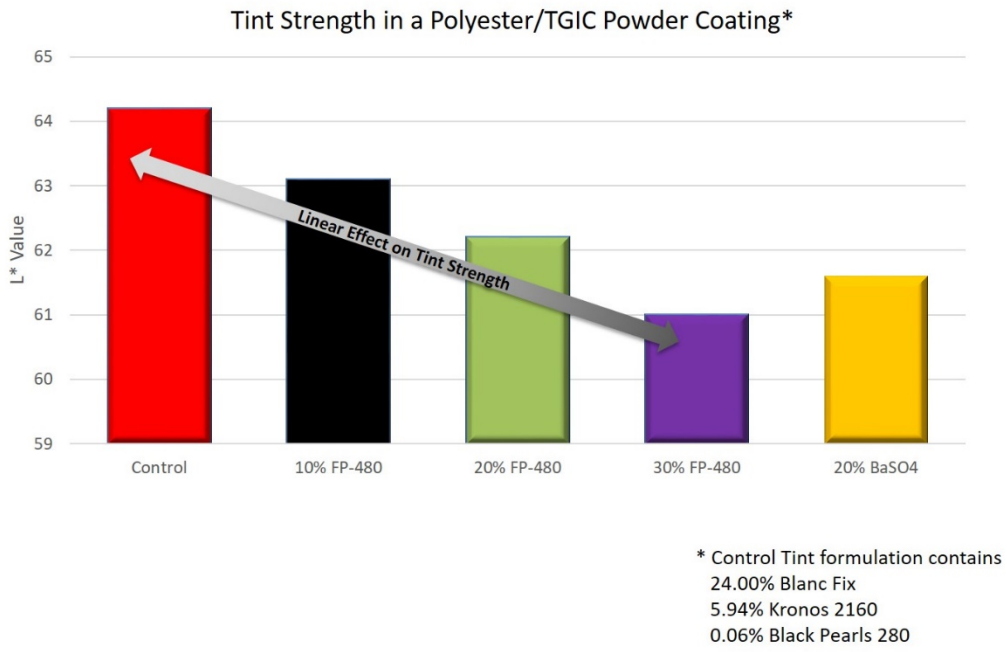
Colour



For colour, there is a small improvement in blueness to the powders made with FP-Opacity Pigment™, with brightness remaining at similar levels to the standard up to a 20% replacement– this gives the visual impression of a cleaner, bluer white. Brightness begins to decline more noticeably after 20% - this is largely due to the lower tint reducing power of the FP-Opacity Pigment™ compared to TiO_2. This lower strength means that at higher replacement levels the FP-Opacity Pigment™ does not mask the yellow tone of the resins as well as the TiO_2 does.

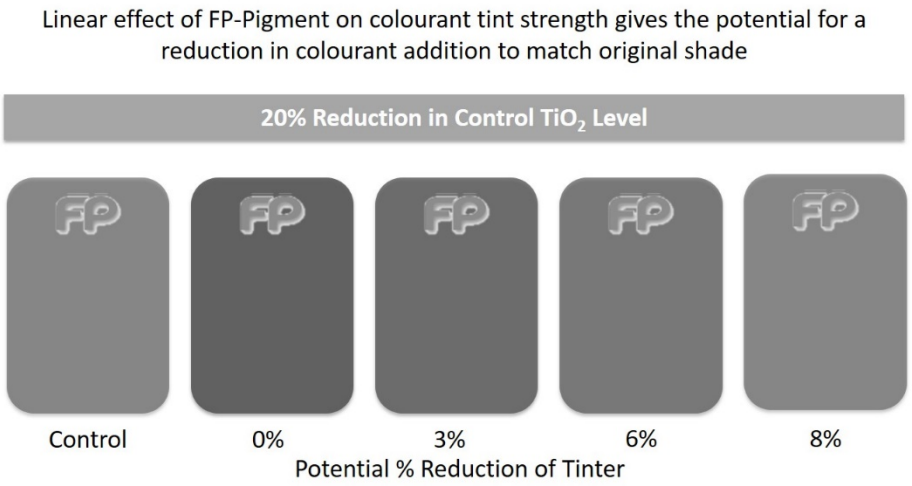
Tint Reducing Power

Although FP-Opacity Pigments™ contain spacing-optimised TiO_2 their tint reducing power is still significantly lower than that of the equivalent weight of TiO_2. When replaced, weight for weight in any coating at levels above 5% to 10% there will be a noticeable drop in tint strength. While this can be an issue for Point of Sale (POS) tint bases and already established colour libraries, it does present a significant opportunity for further raw material cost savings through the potential reduction in colourant addition. Put simply, in factory made colours, it should be possible to use FP-Opacity Pigments™ and then reduce the colourant levels used to obtain a colour match. Additional work is being carried out by FP-Pigments to determine the potential colourant reductions for a number of common powder coating colours and this work will be reported on separately. In this report you will see the initial findings on tinting strength and the potential reduction seen with a black/grey tint.



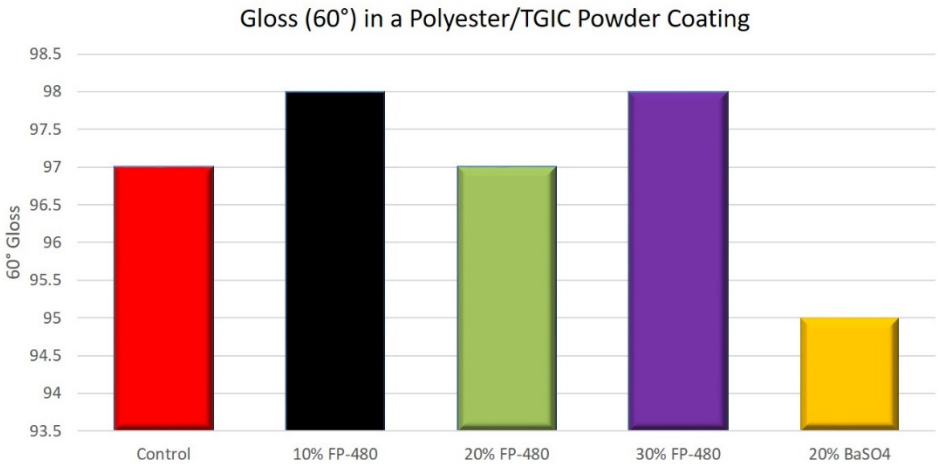
As can be seen in the graph above, the addition of FP-Opacity Pigment™ to the Polyester:TGIC powder coating (this time with 5.94% KRONOS® 2160 and 24% Blanc Fixe) produces a linear reduction in tinting strength. The effect of the TiO_2 encapsulated within the FP-Opacity Pigment™ can be seen by comparing the 20% FP-480 result with the 20% BaSO4 result; the latter having a significantly lower performance.

Given the linearity of the reduction in relation to the FP-Opacity Pigment™ level we can use this as a gauge to help match the original colour through colourant reduction. The table below shows the initial effect of replacing 20% TiO_2 with FP-480 on the tint strength – the panel having a much darker appearance.



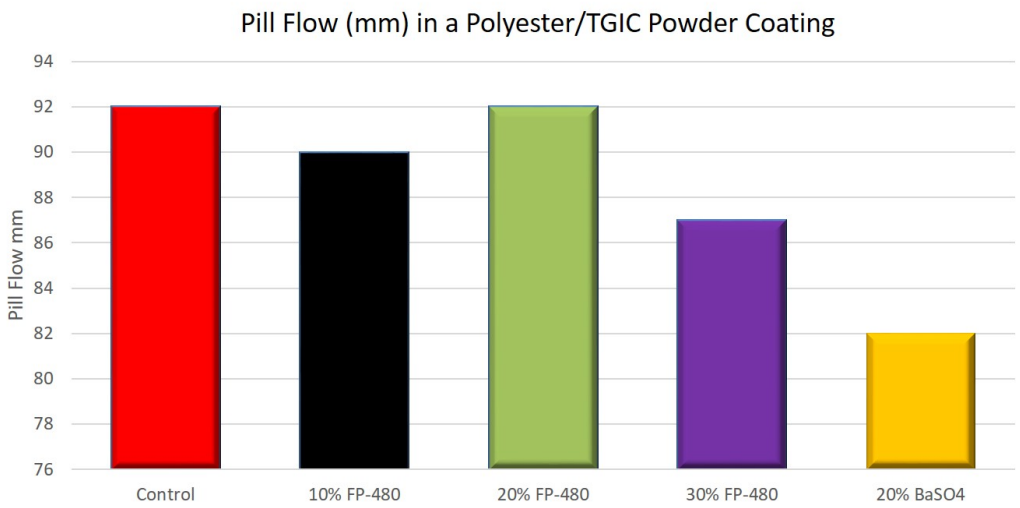
By incrementally reducing the black tinter we are able to match the brightness and hue of the original coating and in many cases improve the chroma value (due to the reduction in TiO_2 which dampens chroma).

Gloss



This is a very high gloss finish and the presence of FP-Opacity Pigment™ did not have any significant effect on the 60° - indeed the gloss levels rose very slightly when FP-Opacity Pigment™ was present. In comparison, with 20% TiO_2 replaced by barium sulphate, the 60° gloss level dropped slightly.

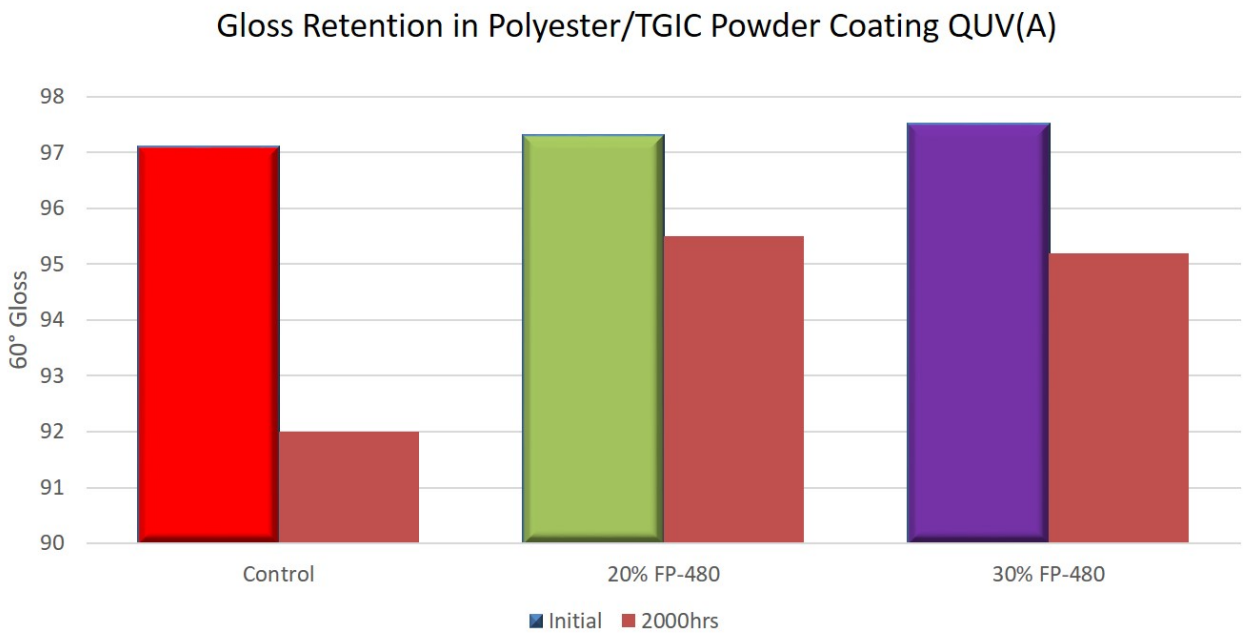
Pill Flow



Similar levels of pill flow were seen with the addition of FP-Opacity Pigment™ up to 20% replacement. The results declining slightly as the addition level increased to 30%. In comparison, the pill flow of the second control replacing 20% TiO_2 with barium sulphate showed a more marked decline in pill flow.

Accelerated Durability

While FP-Opacity Pigments™ are generally intended for use in interior powder coatings they can also be used to reduce TiO_2 in some exterior formulations. The following chart shows the results of gloss retention on panels exposure to 2000 hours of UV light from a QUV(A) light source.



As can be seen above, the gloss retention when FP-Opacity Pigments™ are present can be improved compared to the Control. This effect is most likely due to the overall reduction in TiO_2 pigment particles which act as radical generators – these radicals attacking the binder and causing a reduction in gloss – the photocatalytic effect.

Note in some situations the TiO_2 pigment can also act as a UV light absorber, thus protecting the resin from photochemical degradation. While FP-Opacity Pigments™ also act as UV absorbers they are not as efficient as the same weight of TiO_2 pigment and so high replacement levels of TiO_2 with FP-Opacity Pigment™ may lead to photochemical degradation of the binder (where it is susceptible to this). Testing with QUV(B) bulbs, may indicate which systems are most likely to be affected, however care should be taken in interpreting QUV(B) data as all UVB lamps emit unnatural, short-wavelengths of UV that are below the solar cut-off of 295nm and anomalous results can occur.

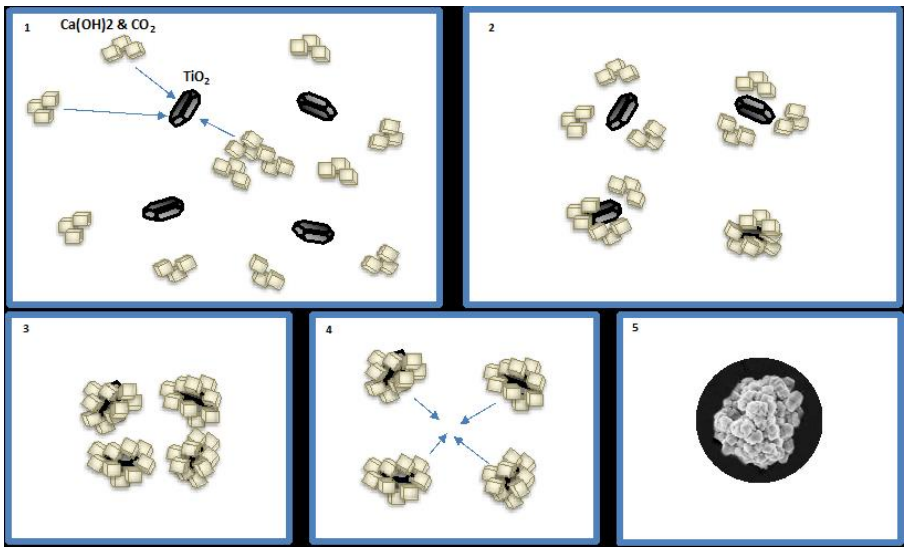
Conclusion

Working with the Powder Coatings Research Group, FP-480 Opacity Pigment™ has been shown to be a suitable partial replacement for titanium dioxide pigment in Polyester:TGIC powder coatings. Replacement levels of up to 30% can be possible, although the optimum replacement level, taking into account both opacity and colour, would be more likely between 15 and 20%.

Appendices

What is FP-Opacity Pigment™?

Our products use commercially available TiO_2 pigments and a proprietary process that locks in an improved state of TiO_2 dispersion in a shell of high quality precipitated calcium carbonate.



These white pigment composites have an average particle size of 1 micron with a particle of FP-Opacity Pigment™ containing between 3 and 6 TiO_2 particles, each statistically space from each other by the optimum distance for scattering of 280nm.

The nature of the "special structure" of the calcium carbonate shell produced means that this product will maximise the light scattering and hence the whiteness and opacity by several mechanisms.

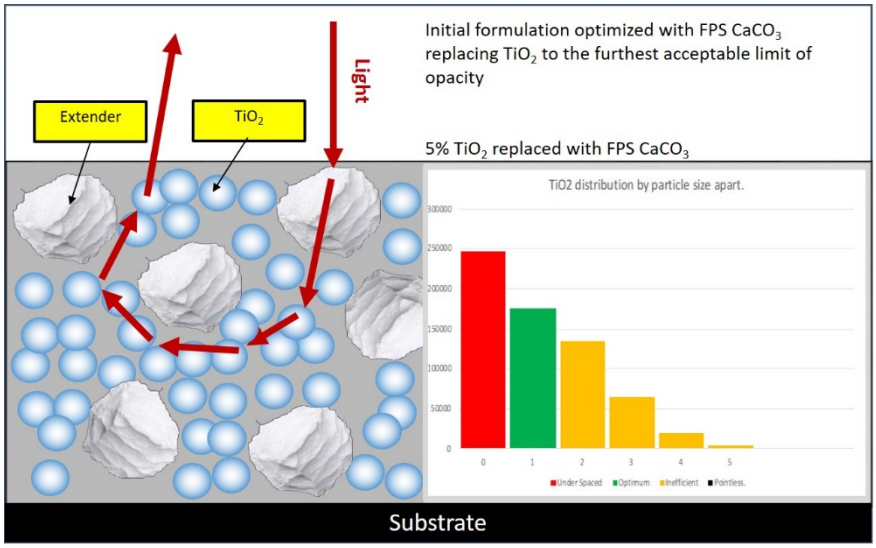
- Optimally spacing TiO_2 inside the FP-Opacity Pigment™ particle.
- Spacing loose TiO_2 around the particle.
- Air voids inside and at the surface of the particle.
- Diffraction from the rough surface of the particle.

As a white pigment, out FP-Opacity Pigments™ have an inherent light scattering functionality and a refractive index between 1.8 and 1.9, unlike extenders and fillers.

The FP-Opacity Pigments™ are used as simple, weight for weight, partial replacements for your existing TiO_2. Depending on the application and formulation type, FP-Opacity Pigments™ can normally replace between 5% and 30% of the TiO_2 without reducing your product quality or performance.

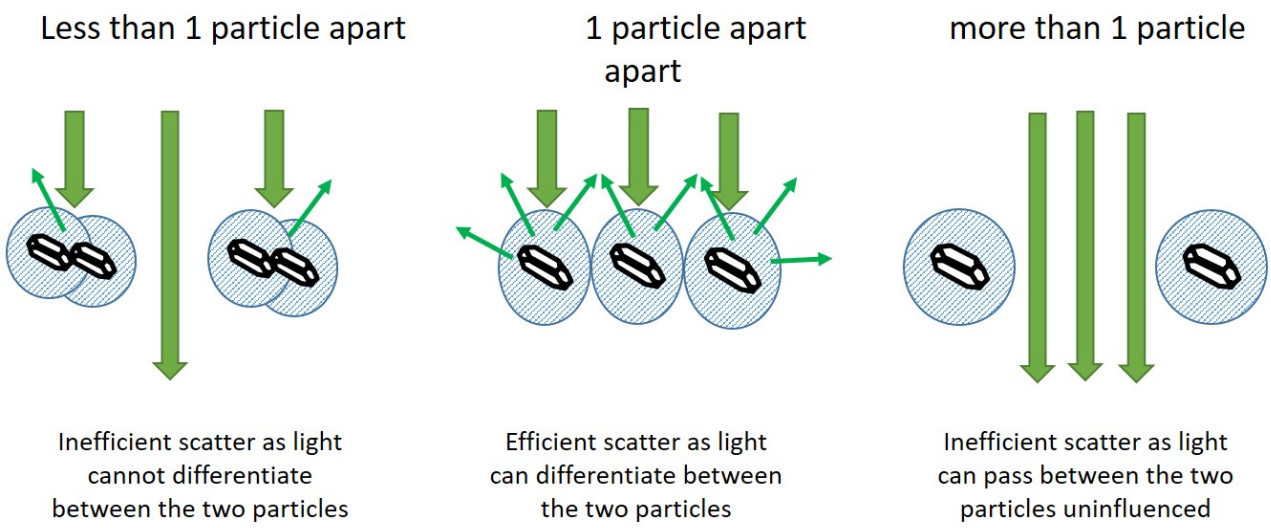
How FP-Opacity Pigments™ Work

In a coating there will usually be a continuous binder phase with TiO_2, extenders and other raw materials dispersed efficiently, yet randomly in that phase. The extenders have a similar refractive index to the binder and, as the TiO_2 cannot occupy the same volume as the extender, the presence of the extenders will create "windows" within the coating through which light can pass without significant scatter. Extenders are also typically much larger than TiO_2 and so TiO_2 is prevented from accessing a significant volume within the coating – this can be considered as TiO_2 crowding, the TiO_2 being forced into the spaces between the extenders and binder which coupled with the random nature of its dispersion leads to only about 30% of the TiO_2 particles having the optimum 280nm spacing.



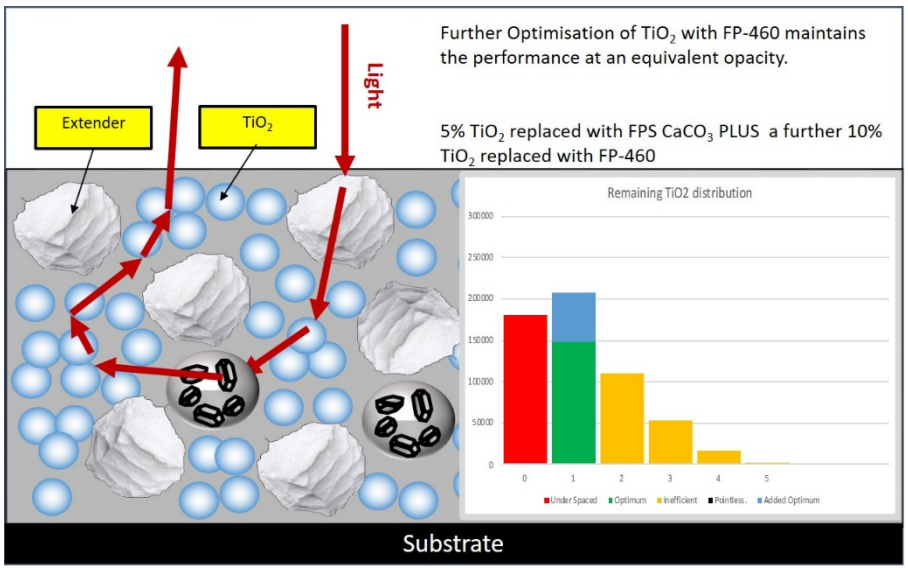
It is well documented that TiO_2 is inefficient if particles are too close together, or in lower concentrations, too far apart.

Inter-particle distance



By replacing a portion of the TiO_2 with FP-Opacity Pigment™ we increase the average distance between TiO_2 particles by a “dilution effect” (fewer particles occupying the same volume) while at

the same time we introduce optimally spaced TiO_2 particles within the FP-Opacity Pigment™ structure. This effect can be clearly seen in the statistical model.



By utilising these performance changes, FP-Opacity Pigments™ can be used in coatings, plastics, inks and paper and board to replace between 5% and 30% of the TiO_2 without significantly reducing the opacity and mechanical properties.

Why Use FP-Opacity Pigments™?

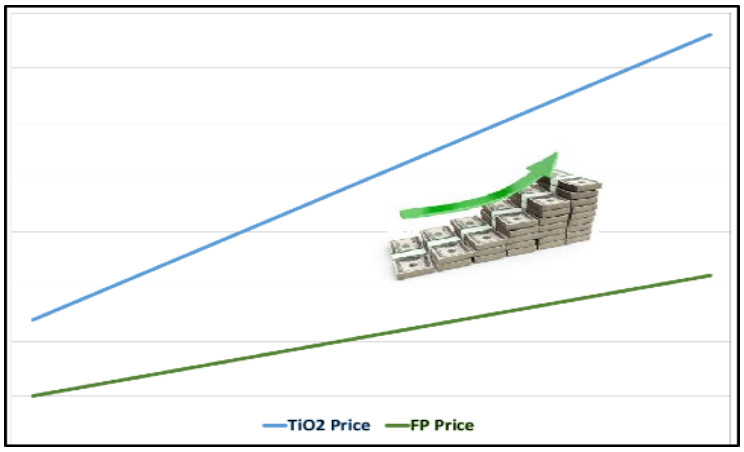
The main reason for using FP-Opacity Pigments™ can be given in three words – "Significant Cost Savings". For every kilogram of TiO_2 pigment replaced by FP-Opacity Pigment™ you will make a significant raw material cost saving while maintaining your product performance and quality. Since

Price Δ between TiO_2 and FP € per ton	Annual € savings, per 100 tons of TiO_2 replaced with FP	Annual € savings, per 500 tons of TiO_2 replaced with FP	Annual € savings, per 1000 tons of TiO_2 replaced with FP
€600	€60,000	€300,000	€600,000
€1000	€100,000	€500,000	€1,000,000
€1400	€140,000	€700,000	€1,400,000

you are only replacing TiO_2 with FP-Opacity Pigment™ you can also keep the functionality and cost benefit of your current extender package.

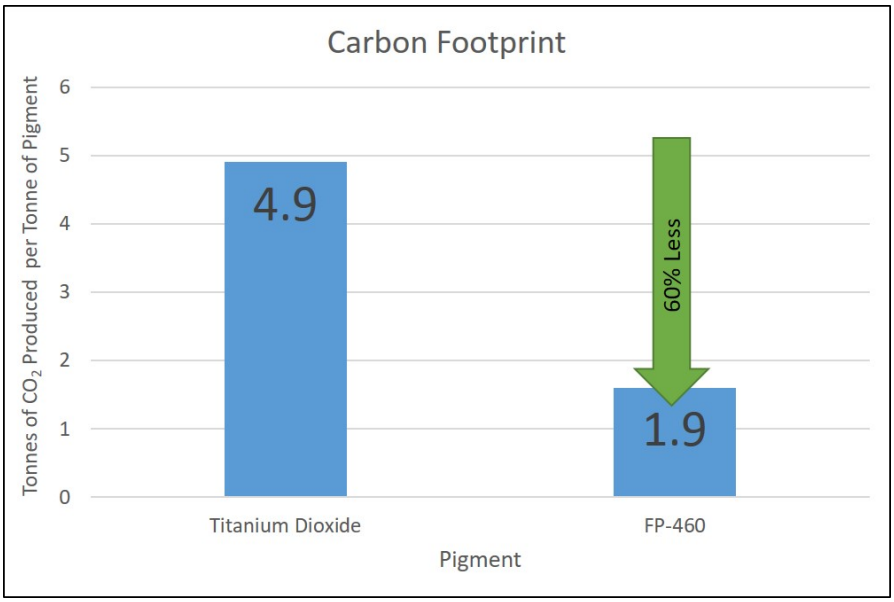
On average, FP-Opacity Pigments™ are 600 to 1000 Euro per tonne lower in price than normal TiO_2 pigment (and this can be even higher in some regions). SO, if your business can avoid using 100 tonnes of TiO_2 pigment by replacing it with FP-Opacity Pigment™ you could save up to €100,000 per year.

In addition, for the same whiteness and opacity produced, FP-Opacity Pigments™ utilise much less TiO_2 and so as TiO_2 prices vary with market conditions, the price of FP-Opacity Pigments™ is more immune to these commodity related price fluctuations.



The graph opposite shows how, as the price of TiO_2 increases, the cost of FP-Opacity Pigments™ rises at a significantly lower rate, helping to minimise the impact of raw material price increases.

Finally, cost savings aren't the only benefit of FP-Opacity Pigments™. For the same opacity product, weight for weight, FP-Opacity Pigments™ have a 60% lower carbon footprint than TiO_2.



The process used by FP-Pigments facilitates a reduction in CO_2 emissions by recycling CO_2 gas throughout our manufacturing route, thus reducing CO_2 losses to atmosphere. We also reduce water usage by having a closed water recirculation system, recycling and reusing process water. All of this as well as our ethical business practices which are regularly audited and qualified by Ecovadis who have awarded FP-Pigments their Silver Medal in both 2018 and 2020.