TiO$_2$ Reduction in Polyester/Epoxy Hybrid Powder Coatings

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Introduction

Working with the Powder Coatings Research Group (PCRG), FP-Pigments evaluated the performance of FP-480 Opacity Pigment™ as a partial replacement for TiO₂ in a 60:40 Polyester/Epoxy hybrid powder coating.

Evaluation

The following 60:40 hybrid powder coating recipe was provided by the PCRG for the comparison evaluation.

<table>
<thead>
<tr>
<th>Material</th>
<th>Grade</th>
<th>Percentage</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester Resin</td>
<td>Crylcoat 1626</td>
<td>41.1</td>
<td>Cytec</td>
</tr>
<tr>
<td>Epoxy Resin</td>
<td>DER 6224</td>
<td>27.4</td>
<td>DOW</td>
</tr>
<tr>
<td>Flow Agent</td>
<td>Resiflow P-67</td>
<td>1.0</td>
<td>Estron Chemical</td>
</tr>
<tr>
<td>Degassing Agent</td>
<td>Benzoin</td>
<td>0.5</td>
<td>Various</td>
</tr>
<tr>
<td>TiO₂ Pigment</td>
<td>KRONOS® 2160</td>
<td>30.0</td>
<td>KRONOS Worldwide Inc</td>
</tr>
<tr>
<td>FP-Opacity Pigment™</td>
<td>FP-480</td>
<td></td>
<td>FP-Pigments</td>
</tr>
</tbody>
</table>

The formulation was modified by replacing 10, 20 and 30% of the TiO₂ pigment with an equivalent weight of FP-480 Opacity Pigment™, all other raw materials remaining constant. 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. Finally a Pill Flow test was carried out on the powder.
Results

Contrast Ratio

The opacity achieved at both 40µm and 80µm suggested that a TiO₂ replacement level of up to 20% could be possible with FP-480.
For colour, there is no significant change up to 20% replacement. Brightness and yellowness begin to decline after 20% - this is largely due to the lower tint reducing power of the FP-Opacity Pigment™ compared to TiO₂. This lower strength means that at higher replacement levels the FP-Opacity Pigment™ does not mask the yellow tone of the epoxy resin as well as the TiO₂ does.
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 slightly when FP-Opacity Pigment™ was present.

Small improvements in pill flow were seen with the addition of FP-Opacity Pigment™, the improvement declining slightly as the addition level increased.
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:Epoxy hybrid 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 10 and 15%.
Appendices

What is FP-Opacity Pigment™?

Our products use commercially available TiO₂ pigments and a proprietary process that locks in an improved state of TiO₂ 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 TiO₂ particles, each statistically spaced 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 TiO₂ inside the FP-Opacity Pigment™ particle.
- Spacing loose TiO₂ 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 TiO₂. Depending on the application and formulation type, FP-Opacity Pigments™ can normally replace between 5% and 30% of the TiO₂ without reducing your product quality or performance.

**How FP-Opacity Pigments™ Work**

In a coating there will usually be a continuous binder phase with TiO₂, 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 TiO₂ 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 TiO₂ and so TiO₂ is prevented from accessing a significant volume within the coating – this can be considered as TiO₂ crowding, the TiO₂ 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 TiO₂ particles having the optimum 280nm spacing.

It is well documented that TiO₂ is inefficient if particles are too close together, or in lower concentrations, too far apart.
By replacing a portion of the TiO₂ with FP-Opacity Pigment™ we increase the average distance between TiO₂ particles by a “dilution effect” (fewer particles occupying the same volume) while at the same time we introduce optimally spaced TiO₂ 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 TiO₂ 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 TiO₂ pigment replaced by FP-Opacity Pigment™ you will make a significant raw material cost saving while maintaining your product performance and quality. Since you are only replacing TiO₂ with FP-Opacity Pigment™ you can also keep the functionality and cost benefit of your current extender package.

<table>
<thead>
<tr>
<th>Price Diff between TiO₂ and FP € per ton</th>
<th>Annual € savings, per 100 tons of TiO₂ replaced with FP</th>
<th>Annual € savings, per 500 tons of TiO₂ replaced with FP</th>
<th>Annual € savings, per 1000 tons of TiO₂ replaced with FP</th>
</tr>
</thead>
<tbody>
<tr>
<td>€600</td>
<td>€60,000</td>
<td>€300,000</td>
<td>€600,000</td>
</tr>
<tr>
<td>€1000</td>
<td>€100,000</td>
<td>€500,000</td>
<td>€1,000,000</td>
</tr>
<tr>
<td>€1400</td>
<td>€140,000</td>
<td>€700,000</td>
<td></td>
</tr>
</tbody>
</table>

On average, FP-Opacity Pigments™ are 600 to 1000 Euro per tonne lower in price than normal TiO₂ pigment (and this can be even higher in some regions). SO, if your business can avoid using 100 tonnes of TiO₂ 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 TiO₂ and so as TiO₂ 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 TiO₂ 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 TiO₂.

The process used by FP-Pigments facilitates a reduction in CO₂ emissions by recycling CO₂ gas throughout our manufacturing route, thus reducing CO₂ 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.