Accelerated and Natural weathering of Rigid PVC

September 2021
PVC Case Studies – Window Profiles

- **Case study 1**
  - Formulation 1a - Equal colour retention.
  - Formulation 1b - Equal colour and impact strength retention.

- **Case study 2**
  - White and Clay coloured plaques perform equally for colour retention with up to 20% substitution of TiO$_2$.

**Conclusions**

FP-Opacity Pigments™
- are a partial replacement for TiO$_2$.
- are significantly lower cost than TiO$_2$.
- provide significant annual raw material costs savings.
- give equal to slightly improved weathering performance.
Case Study 1 – Window Profile

Equal Durability, Brightness and Opacity at Lower Cost
Case Study 1: Rigid PVC Window Profile Study - DOW

1a) Formulation 1 (phr):
- 100 PVC-U
- 3.5 Ca/Zn stabiliser
- 8.0 CaCO₃
- 6.0 Impact modifier (AIM)
- 3.8 TiO₂ OR 3.2 TiO₂ + 0.6 FP-510

~16% TiO₂ replaced with FP-510

1b) Formulation 2 (phr):
- 100 PVC-U
- 3.5 Ca/Zn stabiliser
- 8.0 CaCO₃
- 6.0 Impact modifier (AIM)
- 4.0 TiO₂ OR 3.2 TiO₂ + 0.8 FP-510

20% TiO₂ replaced with FP-510
Rigid PVC Window Profile Study
~16 % TiO₂ replacement - CL 3000 Xe-arc weatherometer, EN 513

Formulation 1a (phr): 100 PVC-U, 3.5 Ca/Zn stabiliser, 8.0 CaCO₃, 6.0 impact modifier, 3.8 TiO₂ OR 3.2 TiO₂ + 0.6 FP-510
Rigid PVC Window Profile Study
20% TiO₂ replacement

CI 3000 Weatherometer (20% TiO₂ replacement)
Accelerated Weathering Program According to EN513

Formulation 1b (phr): 100 PVC-U, 3.5 Ca/Zn stabiliser, 8.0 CaCO₃, 6.0 impact modifier, 4.0 TiO₂ OR 3.2 TiO₂ + 0.8 FP-510
Formulation 1b (phr): 100 PVC-U, 3.5 Ca/Zn stabiliser, 8.0 CaCO₃, 6.0 impact modifier, 4.0 TiO₂ \textbf{OR} 3.2 TiO₂ + 0.8 FP-510
Rigid PVC Window Profile Study
Natural weathering – 20% TiO₂ replacement

Formulation 1b (phr): 100 PVC-U, 3.5 Ca/Zn stabiliser, 8.0 CaCO₃, 6.0 impact modifier, 4.0 TiO₂ OR 3.2 TiO₂ + 0.8 FP-510
**IMPACT STRENGTH RETENTION - ISO 179-1/1fA (KJ/m²)**

<table>
<thead>
<tr>
<th>Impact Strength</th>
<th>Standard</th>
<th>20% FP-510</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS2782/359</td>
<td>12.0 ± 0.3</td>
<td>12.7 ± 0.3</td>
</tr>
<tr>
<td>DIN53753</td>
<td>60 ± 1</td>
<td>57 ± 1</td>
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Case Study 2
Weathering Test of White and Coloured PVC Plaques

FP-510 Maintains Performance up to 20% Substitution
A customer asked FP-Pigments to test a range of white and beige PVC-U plaques for colour stability during exposure to accelerated weathering test conditions (Xenon-arc, ASTM D2565 Cycle 1/ISO4892-2).

The control plaques contained 8 or 10 phr of TiO$_2$, and two had extra toner. In the experimental plaques, 2phr of FP-510 was added in combination with 6 or 8 phr of TiO$_2$. Of particular concern was resistance to yellowing.

Colour (CIE L*, a* and b*), and combined colour change indices (CIE ΔE*) were measured in accordance with ASTM D2244. 4122 hours of weathering have been completed.
FP-Pigments tested white rigid PVC plaques for colour stability.

Panels exposed to accelerated weathering test conditions (Xenon-arc, ASTM D2565 Cycle 1/ISO4892-2).

Control plaques contained 8 or 10 phr of TiO₂.

Experimental plaques contained 2phr of FP-510 Opacity Pigment™ in combination with 6 or 8 phr of TiO₂ (giving a 20% replacement for the 10 phr standard and 25% replacement for the 8 phr standard).

** Main target was to find out if the use of FP-510 Opacity Pigment™ changes the colour stability.
White Plaques – L*

![Graph showing the brightness (L*) of white plaques over time for different TiO2 and FP-510 concentrations.]

- 10phr TiO2
- 8phr TiO2
- 8phr TiO2, 2phr FP-510
- 6phr TiO2, 2phr FP-510

**Time (hours)**

0 500 1000 1500 2000 2500 3000 3500 4000 4500
White Plaques – b*

White - Tone, b*

Time (hours)

10phr TiO2
8phr TiO2
8phr TiO2, 2phr FP-510
6phr TiO2, 2phr FP-510
White Plaques – Delta E*

White - Combined Color Change – DE*

- 10phr TiO2
- 8phr TiO2
- 8phr TiO2, 2phr FP-510
- 6phr TiO2, 2phr FP-510
FP-Opacity Pigments™ tested in clay coloured rigid PVC plaques for colour stability.

Panels exposed to accelerated weathering test conditions (Xenon-arc, ASTM D2565 Cycle 1/ISO4892-2).

Control plaque contained 10 phr TiO$_2$.

Experimental plaque contained 2phr of FP-510 in combination with 8 phr of TiO$_2$ (giving a 20% TiO$_2$ replacement).
Clay Plaque - $L^*$

**Clay - Brightness, $L^*$**

- **10phr TiO2**
- **8phr TiO2, 2phr FP-510**

**Time (hours)**

- 0
- 500
- 1000
- 1500
- 2000
- 2500
- 3000
- 3500
- 4000
- 4500
Clay Plaque - a*

Clay - Tone, a*

Time (hours)

10phr TiO2

8phr TiO2, 2phr FP-510
Clay Plaque - \( b^* \)

Clay - Tone, \( b^* \)

- 10phr TiO2
- 8phr TiO2, 2phr FP-510
Clay Plaque - Delta E*

Clay - Combined Color Change, DE*

Time (hours)

Clay 10 phr TiO2 8 phr TiO2, 2phr FP-510

Plaque Delta E*
FP-Opacity Pigment™ Benefits in Weathering Testing:

- L* and b* in white panels showed slower degradation than the TiO$_2$ only standard.

- There was less colour change in the clay coloured panels that contained FP-510 Opacity Pigment™.
Conclusions

FP-510 Opacity Pigment™ was able to replace up to 20 – 25% of the TiO₂ achieving a significant cost reduction.

The addition of the FP-510 Opacity Pigment™ had no effect on the speed or ease of manufacture of the product.

The finished product showed equal or slightly better results for physical properties and weathering compared with the standard.

The use of FP-510 Opacity Pigment™ in PVC products can also provide a reduction in carbon footprint compared to the TiO₂ only standard.