How to Achieve One-Coat, High Hiding Power Paints by Optimizing Titanium Dioxide Pigments

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Basic Paint: Water, Resin & TiO₂
TiO₂ Optimization in Low VOC Paints, Promises Better:

- TiO₂ Grades / Extenders
- Dispersion
- Zeta Potential
- Particle Size
  - Instrument Pay Back in 3 months!
- Gold Standard

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TiO2 Quality Certificate of Analysis
(If you don’t’ ask, you don’t get)

1. **Particle Size Distribution (PSD)**
2. **GSD (Geometric Standard Distribution)**
3. **% Greater than 0.5 um**
4. **Compare to Gold Standard (GS)**
5. **Nibs or Scatts and distribution**
6. **Slurry Solids (76%)/pH**
7. **Rheology**
8. **Grit (wt.%)**
# Effect of % TiO$_2$ (alumina treated) on Hiding

<table>
<thead>
<tr>
<th>% Min. TiO$_2$</th>
<th>Oil Abs. (lb/100 lb)</th>
<th>20° Enamel Gloss</th>
<th>Average Hiding Low PVC</th>
<th>Average Hiding High PVC</th>
<th>Relative Chalk Resistance</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td>12</td>
<td>70</td>
<td>100</td>
<td>90</td>
<td>Good</td>
<td>General – High gloss</td>
</tr>
<tr>
<td>91</td>
<td>13</td>
<td>67</td>
<td>95</td>
<td>100</td>
<td>Very Good</td>
<td>Universal Interior/Exterior</td>
</tr>
<tr>
<td>89</td>
<td>17</td>
<td>60</td>
<td>90</td>
<td>95</td>
<td>Excellent</td>
<td>Exterior Durable</td>
</tr>
<tr>
<td>80</td>
<td>32</td>
<td>45</td>
<td>85</td>
<td>115</td>
<td>Good</td>
<td>Flat</td>
</tr>
</tbody>
</table>

- **Average Hiding Low PVC**
- **Average Hiding High PVC**
- **Relative Chalk Resistance**
- **Use**
High Opacity & Whiteness by Spacing

Less Color Absorption  Increased Whiteness

Better Spacing

TiO2 w/ poor b*
Green Glass Loses Color and Becomes Whiter by Grinding & Sieving to 2mm

850 m → 177 μm → μ

Beer Bottle Glass
Basic Paint: Water, Resin & TiO$_2$
Ideal Dispersion is Better than Random

(Ref: Diebold (2005))
NEED Dispersion Dispersion Dispersion

- BEST Dispersible & Durable R706 type coating alumina/silica better than SuperDurable – eg Roof Coatings
- BEST Gloss
- Effects Tint Strength, Contrast Ratio, Hiding Power, Whiteness
1. Light Degrades Resin Binder
2. Works with water, acid rain, environmental deposits and UV
3. Worst case Oxygen Free in the film

\[ \text{TiO}_2 \leftrightarrow \text{Ti}^{(+4)}\text{O}_2 + \text{Ti}_2^{(+3)}\text{O}_3 + \text{O}_2 \]

a) Particle size CONTROLLED
   Sulfate = Hydrolysis
   Chloride = Oxidation/ Pressure

b) Grind: Steam /Pigment control

c) High density TiO\(_2\) spacing
## TiO₂ for Low VOC Paint

<table>
<thead>
<tr>
<th>TiO₂ Grade #</th>
<th>Slurry Viscosity @ 80 wt. % (low Cp)</th>
<th>Particle % &gt; 0.5 um (low %)</th>
<th>Median Particle Size &amp; GSD</th>
<th>Draw Down Particle Size &amp; # Particles (low #)</th>
<th>Resin &amp; HEUR Comp.</th>
<th>Gloss (high)</th>
<th>Optical: Con. Ratio, Color Comp. &amp; Tint S (high)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#3 GS</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>#3</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>--</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Lab Equipment Need For TiO$_2$ Optimization

- Zeta Potential / pH Meter
- Rheometer
- Particle Size Analyzer
Zeta for TiO₂:
- In Paint: Avoid Dangerous pH Zones
- In Pigment Grind: Shift IEP w/ Dispersants
- Disperse Near IEP

Table 3—Characteristics of Different Surface-Treated TiO₂ Pigments

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Isoelectric Point (IEP)</th>
<th>Surface Area (m²/g)</th>
<th>Description of TiO₂ Pigments (Surface Concentration wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.0</td>
<td>15</td>
<td>4.5 Al₂O₃</td>
</tr>
<tr>
<td>2</td>
<td>6.3</td>
<td>15</td>
<td>3.6 Al₂O₃ - 6.5 SiO₂</td>
</tr>
<tr>
<td>3</td>
<td>4.51</td>
<td>12.2</td>
<td>1.25 ZrO₂</td>
</tr>
<tr>
<td>4</td>
<td>6.36</td>
<td>14.3</td>
<td>2.0 Al₂O₃</td>
</tr>
<tr>
<td>5</td>
<td>8.49</td>
<td>14.1</td>
<td>2.0 Al₂O₃</td>
</tr>
<tr>
<td>6</td>
<td>8.28</td>
<td>15.0</td>
<td>1.0 ZrO₂ - 1.0 Al₂O₃</td>
</tr>
</tbody>
</table>

(a) Surface composition of inorganic oxides is described according to the order of surface treatment, see text.
Universal Grade TiO$_2$ Slurry Zeta Potential as a Function of pH

- Zeta Potential, mv
- pH

- TiO$_2$ Only
- TiO$_2$ + Dispersant
Lab Equipment Need For TiO$_2$ Optimization

- Zeta Potential / pH Meter
- Rheometer
- Particle Size Analyzer
Horiba PSD Plots: iPhone Video Tracking
TiO2 Spacer Composite Agglomeration

Effect of mixing TiO2 slurry with CaCO3 coated TiO2
Demonstrate
- Real Time Particle Growth
- GSD Peak Broadening
- Final Finger Print

GSD 1.7 @ 0 min.  GSD 2.2 @11 min.  GSD 4.5 @45 min.
Two Types of Flocculation

1. **Bridging**: Polymer Molecules Connect TiO$_2$ Particles.

2. **Depletion**: TiO$_2$ get squeezed out of the thickener solution
   a) Lower Gloss & CR
   b) Poorer Film Strength
   c) Poorer Adhesion
Rheology Modifier / TiO2 Dispersant Phase Diagram

Idealized Dispersion Phase Diagram

<table>
<thead>
<tr>
<th>wt% Associative Thickener (on cont. phase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>1.5</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>wt% Added Dispersant (on pigment solids)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0.25</td>
</tr>
<tr>
<td>0.5</td>
</tr>
<tr>
<td>0.75</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>
Great GSD needs a hydrophobic micro-codispersant (Helps Rheology Chemicals)


Figure 2—Adsorption isotherms of hydrophilic and hydrophobic dispersants on interior and exterior TiO$_2$. Exterior TiO$_2$ adsorbs more dispersant, probably because of a higher surface area. Surfaces are close to being saturated at the 0.6–0.8% dispersant level.
Effect of pH on TiO$_2$ Median Particle Size
(Better is < 0.4um, AMP-95 pH adjusted)

Gold Standard (GS): Ideal Particle Size
Effect of pH on TiO$_2$ Particle Size GSD

(Lower numbers are better, AMP- 95 pH adjusted)

Gold Standard: Narrow Particle Size Over all pH’s
High Opacity VOC Paints
Requirements

● Minimize Thickeners & Surfactants

● High Solids Filler Slurries
✓ Target: 70 wt. % solids (min.)

● TiO$_2$ Slurry Properties
  1) Small Particle Size vs. pH
  2) Narrow – GSD vs. pH
  3) Zeta Potential vs. pH
  4) High Solids / Low Viscosity: 380-480 Cp @ 79% Solids (Brookfield: #3 spindle, 100 rpm)
  5) Compatibility Tests & Phase Diagrams