



# Technical Presentation Summary

## Measuring and Controlling Wet Hiding of Architectural Coatings



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Coatings Trends & Technologies, Lincolnshire, Illinois

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### Presenter

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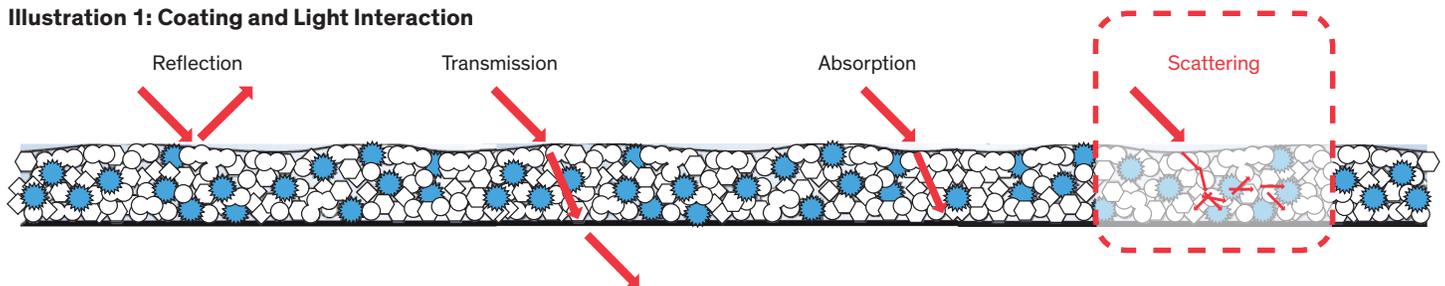
### Overview

Wet hiding can be drastically different from dry hiding for waterborne architectural coatings. Wet hiding is an often ignored property, however, it provides the important first impression of a paint, and can be a useful calibration point for application by contractors. Usually, lower wet hiding is reluctantly accepted by paint formulators when reducing  $\text{TiO}_2$  to control cost and supply, even when dry hiding is maintained through the use of other materials. A simple method was developed to measure wet hiding, in order to understand how wet hiding is affected by different components of paint, such as  $\text{TiO}_2$ , binder, opaque polymer, and inorganic extender. Three different reformulation strategies using different  $\text{TiO}_2$  reduction materials were presented, which offer paint formulators control of wet and dry hiding, as well as whiteness.

## Fundamentals of Hiding: Scattering, Hiding & Tint Strength

In common usage, hiding, scattering and sometimes tint strength are used interchangeably. For clarity, these terms can describe specific optical properties. For the purpose of demonstration, a tinted paint was used to show differences in hiding performance, as white color does not usually show good contrast in pictures. **Scattering** refers to the light scattering properties as first elucidated by the Kubelka-Munk Theory. When light comes into contact with a coating, it is reflected, transmitted, absorbed and/or scattered (see Illustration 1). Scattering is typically expressed as the scattering coefficient with the dimensions of S per unit thickness, either wet or dry, of a film. We will use the units of S/mil, with thickness referring to the resulting dry film thickness. Usually scattering is the dominant factor in determining the hiding performance of a white and pastel paint.

### Illustration 1: Coating and Light Interaction



**Hiding** more clearly defined is the ability of a paint to obscure the surface upon which it is applied (see example of good versus poor hiding in Image Series 1). For hiding we will use the dimensionless value of contrast ratio (reflectance over a nearly black substrate/reflectance over a nearly white substrate) referenced to the dimension of the applicable Bird Bar. This distinction will allow us to isolate the scattering from the pigments in the scattering coefficient (S/mil) versus the contribution of scattering and absorption, or undertoning, from all ingredients, which is contained in contrast ratio.

**Tint strength** serves a dual role as it can be used to determine color matching capability as well as relative scattering efficiency (see example of good versus poor tint strength in Image Series 2). Thus, for the more theoretical studies the focus remains on scattering and for the more practical reformulation the focus remains on contrast ratio and tint strength.

### Image Series 1: Good vs. Poor Hiding



### Image Series 2: Good vs. Poor Tint Strength



## What Determines Scattering Power?

Scattering power is affected by a variety of factors, including path length, concentration of scattering particles, difference in refractive index and distribution of scattering.

- Application of multiple coats of a paint results in thicker films and can improve scattering. However, other performance properties can be negatively affected, resulting in longer application time and cost inefficiencies because of the increased volume of coating required.
- Higher amounts of scattering particles, most commonly  $\text{TiO}_2$  and opaque polymer, result in higher scattering power, but  $\text{TiO}_2$  significantly increases cost.
- The difference in the refractive index between ingredients has a significant impact on scattering power.
- The distribution of scattering particles is also critical and is affected by proper dispersion (see Illustration 2).

### Illustration 2: Dispersion of Particles and Scattering



## What is Wet Hiding?

Wet hiding is defined as the hiding of a paint when it is first applied to a substrate, usually for white and pastel paints. However, it has long been observed that wet hiding is not a good predictor of dry hiding (see Image Series 3). This is especially important for both DIYers as well as contractors. For DIYers, the impression a paint gives when first applied to a substrate is critical; when a paint demonstrates good wet hiding it is assumed to be a high-quality paint. For contractors, wet hiding is used as a calibration point to ensure the proper amount of paint is applied.

### Image Series 3: Dry vs. Wet Hiding

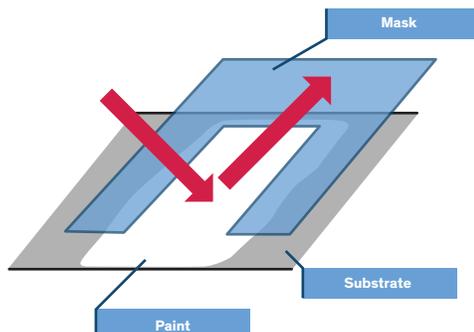


## How to Measure Wet Hiding

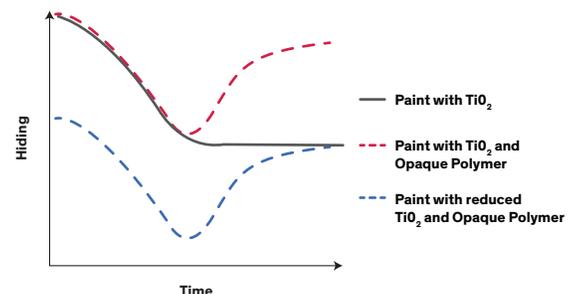
A simple method was developed to measure wet hiding, and the effects of different components of paint, such as  $\text{TiO}_2$ , binder, opaque polymer, and inorganic extender, on wet hiding were examined.

- A mask or spacer is used to keep the reflectometer from being stained by the wet paint. The measurement can be carried out immediately after paint is drawn down. The measurement is repeated at varying intervals during drying time to achieve the wet hiding profile (see Illustration 3).
- Results demonstrate typical hiding changes during drying (see Figure 1):
  - Paint with  $\text{TiO}_2$  only demonstrates initial high wet hiding value, which decreases over time before reaching a plateau for dry hiding.
  - Paint with  $\text{TiO}_2$  and opaque polymer demonstrates a similar initial wet hiding decrease equivalent to the  $\text{TiO}_2$  only paint. However, wet hiding increases at the time when the  $\text{TiO}_2$  only paint plateaus.
  - Paint with reduced  $\text{TiO}_2$  and opaque polymer shows matched dry hiding with  $\text{TiO}_2$  only paint, however, it demonstrates much lower initial wet hiding.

### Illustration 3: Idealized Illustration of How to Measure Wet Hiding



### Figure 1: Typical Hiding Changes During Drying



## Scattering Efficiency & TiO<sub>2</sub> Dependence

The dry and wet hiding and scattering of a paint are dependent on the concentration of TiO<sub>2</sub>. Pre-composite polymers demonstrate significant improvement of TiO<sub>2</sub> dispersion and increase in the dry and wet scattering coefficient (see Figure 2).

### Pre-Composite Polymer

- The wet scattering coefficient of two sets of paints at different PVC was measured and plotted at increasing levels of TiO<sub>2</sub>. One set was made with conventional polymers, while the other was made with pre-composite polymers.
- Results show wet scattering is driven by TiO<sub>2</sub> level and the use of pre-composite polymer offers improved wet scattering over the comparative conventional polymer.

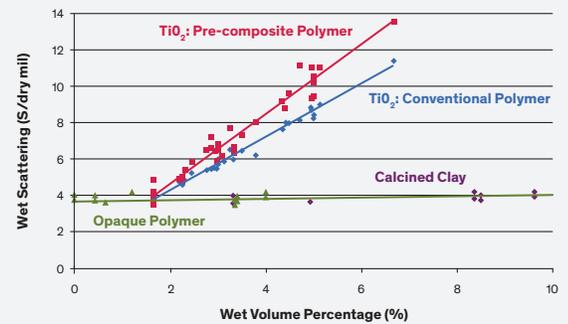
### Opaque Polymer

- Scattering efficiency of a paint formulated at 5% TiO<sub>2</sub> PVC was evaluated at increasing levels of opaque polymer wet volume percentage.
- The results show opaque polymer does not significantly affect wet scattering.

### Calcined Clay

- Scattering efficiency of a paint formulated at 5% TiO<sub>2</sub> PVC was measured at increasing levels of calcined clay wet volume percentage.
- The results show calcined clay does not significantly affect wet scattering.

**Figure 2: Scattering Efficiency & TiO<sub>2</sub> Dependence**



## Reformulation Strategies: Reducing TiO<sub>2</sub> While Maintaining Dry Hiding

The following results demonstrate how pre-composite polymer is effective in enabling TiO<sub>2</sub> reduction while maintaining both wet and dry scattering and hiding. Opaque polymer and calcined clay, two conventional materials used to reduce TiO<sub>2</sub> level, are included as comparatives.

### Testing

- A quality satin formulation at 40% PVC and 36% volume solids was used as a control.
- All paints were kept at the same PVC and volume solids as the control by maintaining the total binder level and adjusting the extender level.
- The paints were tinted with 2 ounces per gallon of Color Trend 888 Lamp Black.
- Color acceptance was tested on all paints and was within acceptable limits.
- The dry tint strength was calculated such that values greater than 100% indicate higher scattering capability.

### Results

- The objective was to reduce the TiO<sub>2</sub> level while maintaining the dry tint strength of the formulation. Dry tint strength was used to determine relative scattering matches for the paints.
- All of the values for dry tint strength were within about 3% of the control, showing that good dry hiding and color matches were obtained with each reduction strategy.
- In Trial 1, dry tint strength (see Figure 3A and Image Series 3A) and wet tint strength (see Figure 3B and Image Series 3B) were measured for the paints of 16% less TiO<sub>2</sub>.
- In Trial 2, dry tint strength (see Figure 4A and Image Series 4A) and wet tint strength (see Figure 4B and Image Series 4B) were measured for the paints of 24% less TiO<sub>2</sub>.
- The more conventional materials, opaque polymer and calcined clay, reduce wet tint strength, or relative scattering capability, proportional to the reduction in TiO<sub>2</sub>.
- Using pre-composite polymer can offer significant reductions in TiO<sub>2</sub> use level while maintaining both wet and dry tint strength and scattering capability.
- If some loss in wet hiding, say 10%, is tolerable, it is possible to use a combination of strategies to further reduce TiO<sub>2</sub> level.

## Trial 1: Dry and Wet Tint Strength at 16% TiO<sub>2</sub> Reduction

Figure 3A

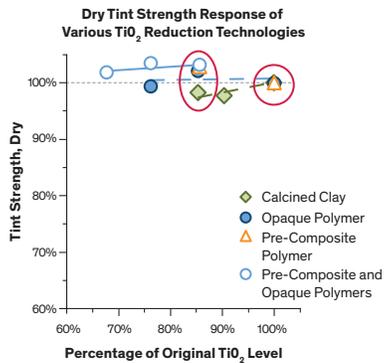


Image Series 3A

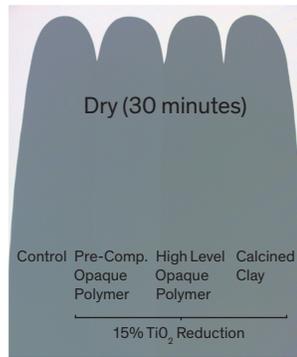


Figure 3B

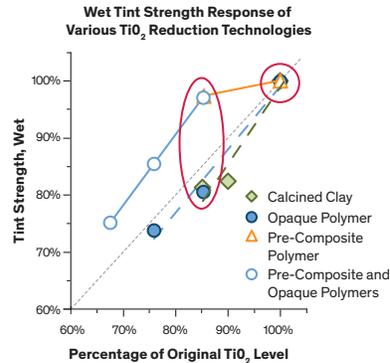


Image Series 3B



## Trial 2: Dry and Wet Tint Strength at 24% TiO<sub>2</sub> Reduction

Figure 4A

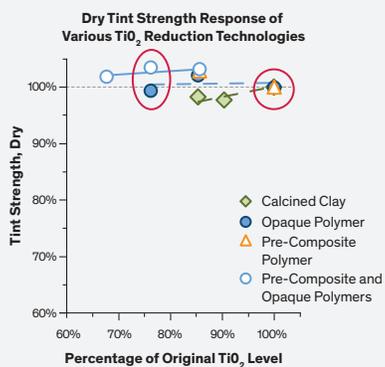


Image Series 4A



Figure 4B

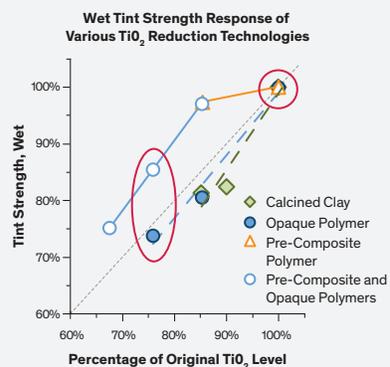


Image Series 4B



## Summary

Three different strategies for reducing TiO<sub>2</sub> in paint formulations were investigated with the primary focus being their effect on wet hiding. Pre-composite polymer, which increases the scattering efficiency of TiO<sub>2</sub> in both wet and dry paint films, offers a way to reduce TiO<sub>2</sub> and match wet and dry hiding and color. Opaque polymer, which is a scattering pigment, offers a way to reduce TiO<sub>2</sub> and match dry hiding and color, but with a decrease in wet hiding proportional to the reduction in TiO<sub>2</sub>. Calcined clay, which can reduce the crowding effect of larger extenders, offers a way to reduce TiO<sub>2</sub> and match dry hiding and color, but with a proportional loss in wet hiding and a decrease in whiteness or brightness (supporting data was not included in this short description). Using both polymeric (pre-composite and opaque polymers) strategies in combination may offer the best balance of maximum TiO<sub>2</sub> reduction with minimal decrease in wet hiding while maintaining or improving whiteness and brightness.

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