How Color Is Affected by the Ingredients of PAINT

Color is integral, and indispensable, to architecture and design. It follows that the architect can benefit from an understanding of how color is achieved with paint, and how paint ingredients can affect color — both initially and over time.

The components of paint were presented in a general way in the first module in this series, "The Ingredients of Paint and Their Impact on Paint Properties" (Architecture, October 1999). In this module, the focus narrows to explain the effect of paint components on color performance, and factors the architect should take into account when specifying paint colors.

Every paint has four basic components:

ADDITIVES: low-level ingredients that provide specific paint properties such as mildew resistance, defoaming, and good flow and leveling.

BINDER: "binds" the pigment together and provides film integrity and adhesion.

LIQUID: provides appropriate consistency and makes it possible to apply the pigment and binder to the surface being painted.

PIGMENTS: *prime pigments* provide color and hiding; some pigments (*extender pigments*) are used to impart bulk at relatively low cost.

The two most important components in determining paint color performance are the pigments and the binder.

The type, and amount, of pigments — and the degree and stability of their dispersion — can determine whether the paint color will look the way it is supposed to when it is applied.

And, the type and amount of pigments and binder can determine whether the paint color will change over time … and how quickly. The reason is that both of these components can suffer different types of deterioration over the life of the paint, which can cause significant color change.

COLOR & PAINT TRAINING COURSE LEARNING OBJECTIVES

At the end of this course, you will:

- Understand how two of the four basic components of paint — pigments and binder — help determine the color performance of a paint.
- Appreciate the different implications and aspects of a paint's color performance.
- Understand why addition of tinting color to a paint must be done as prescribed by the paint manufacturer.
- Know what color problems can arise if care is not taken in specifying paint.
- Understand what factors can impact on an exterior paint's tendency to chalk and thus, fade.

To take the Paint Color Training test, log on to **www.architecturemag.com**. Upon successful completion of the Paint Color Training test, you will earn 3 AIA learning credits.

PIGMENTS

Most prime pigments fall into one of the following four categories:

1. **ORGANIC COLOR PIGMENTS**, which typically produce brighter colors.
2. **INORGANIC COLOR PIGMENTS**, many of which produce more muted colors ("earth tones").
3. **TITANIUM DIOXIDE (TiO_2)**, which provides whiteness.
4. **CARBON BLACK**, which provides darkening to create deeper shades of color.

The color performance characteristics of organic and inorganic pigments are extensive and diverse.

ORGANIC PIGMENTS are based on several different chemical families, including: azo compounds, phthalo compounds, quinacrodones, condensation acids, and perylenes.

Generally speaking, organic pigments are more subject to deterioration (particularly by ultraviolet radiation from sunshine) than inorganic pigments. Still, there are significant differences *among* organic pigments. They are detailed in the following chart:

SELECTED ORGANIC PIGMENTS AND PROPERTIES

PIGMENT FAMILY → / **PROPERTIES ↓**	PHTHALOCYANINE blues, greens (e.g., phthalo blue, phthalo green)	QUINACRODONE reds, oranges, violets (e.g., Violet 19)	CONDENSATION ACID (e.g., alkali blue)	PERYLENE (e.g., perylene red)	AZO yellows, reds (e.g., Hansa yellow, nickel azo yellow, toluidine red)
LIGHTFASTNESS, or a pigment's ability to withstand the deteriorative effects of sunshine, particularly ultraviolet radiation. Lightfastness plays a key role in determining whether a paint color will continue to look the way it should. This property is of particular concern with exterior paints.	Good	Good – Very Good	Moderate	Good – Very Good	Vary Within the Family
COLOR INTENSITY, or the brightness of a pigment.	Good	Good – Very Good	Good	Good – Very Good	Vary Within the Family
HIDING STRENGTH, or a pigment's ability to obscure a surface over which it has been applied uniformly. This is key when determining whether a paint color will look the way it is supposed to when first applied.	Good	Good – Very Good	Moderate	Good – Very Good	Vary Within the Family
CHEMICAL RESISTANCE, or a pigment's ability to resist the deteriorative effects of chemicals present in harsh cleaners, solvents, industrial atmospheres, etc.	Good	Good – Very Good	Moderate	Good – Very Good	Vary Within the Family
COST	Moderate	High	Moderate	High	Moderate – High

INORGANIC PIGMENTS are generally based on metal oxides. Iron oxide is the most commonly used, and it is available in both natural and synthetic forms. Other families of inorganic pigments are chrome pigments and mixed metal oxides. In general, the oxides provide less color intensity than organic pigments, but they have better resistance to the damaging effects of sunshine. The significant differences among inorganic pigments are detailed in the following chart:

SELECTED INORGANIC PIGMENTS AND PROPERTIES

PIGMENT FAMILY → PROPERTIES ↓	SYNTHETIC IRON OXIDE reds, browns, yellows (e.g., red iron oxide, etc.)	NATURAL IRON OXIDE ochres, umbers (e.g., burnt umber, raw umber)	MIXED METAL OXIDE yellows, browns, gray (e.g., nickel titanate yellow)
LIGHTFASTNESS	Excellent	Excellent	Good
COLOR INTENSITY	Low	Low	Low
HIDING STRENGTH	Very Good	Very Good	Vary
CHEMICAL RESISTANCE	Good	Good	Good
COST	Low	Low	Moderate – High

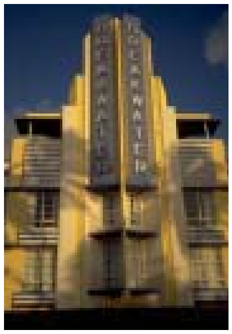
Note: Chromium oxide green, made without lead, is used to some extent in architectural paints.

THE BLACK & WHITE OF IT

While white and black are not classified as colors or hues, the main pigments used to achieve "whiteness" and "blackness" (**titanium dioxide** and **carbon black**, respectively) are employed to alter color value and intensity, creating lighter "tints" and darker "tones" of a hue. Here are some points to keep in mind about these prime pigments:

TITANIUM DIOXIDE: While offering outstanding hiding and whiteness, this pigment tends to foster chalking and, thus, color fading in exterior paints, especially when compared to the effect of many other pigments and extenders. This is one reason why it is important to specify a high quality latex paint when using lighter colors for exterior applications. This is also why, for example, a very deep red iron oxide paint, containing no TiO_2, will generally resist chalking much better than a light red iron oxide paint, made with no TiO_2, all else being equal.

CARBON BLACK: The addition of very low levels of black pigment (or of certain other dark pigments) can markedly improve the hiding power of white paints. This practice is known as "toning" the paint, and many white paints are made this way. A toned white paint can have a satisfactory appearance, so long as it does not have a noticeable dark cast. This can be problematic, though, if a heavily toned paint is applied in proximity to a brighter white or very light color surface.



OTHER PIGMENT CONSIDERATIONS

Paint is either manufactured to a given color, or is "tinted" at the point of sale. In the latter case, a liquid tinting color or colors, called "colorants," are added to a paint designed to "accept" the particular colorant.

Manufacturers provide a series of tintable paints — called "bases" — to accept different quantities of colorant: either one color alone, or more than one. If the base and the colorant(s) are not compatible, the precise color that is desired will not develop. The following are designations used for tintable paints, in order of increasing level of colorant to be added, and decreasing level of titanium dioxide: Tintable White; Pastel Base; Light Base; Medium or Mid-Base; Deep Base; Accent Base; Ultra-Deep Base and Neutral Base. (The container will be short-filled so as to accommodate the intended level of colorant.) Generally, a line of paint will have four or five of these bases, to cover the full range of tinting. A tintable white or pastel base may accept up to about 3 fluid ounces of colorant per gallon; a neutral base may be designed to take up to 16 fluid ounces, or more.

It is essential that the colorant be used in the tint base designed for that line and level of colorant in order to achieve color that:

1. matches the color chip or standard;
2. will not tend to change while the paint is stored;
3. will be consistent with different methods of application (e.g., brush vs. roller).

The proper tint base will have the appropriate level of titanium dioxide to provide correct depth of color and hiding; and it will have the surfactants (i.e., specialized soaps) needed to ensure good *color acceptance*, that is, to minimize pigment particle agglomeration, or "flocculation." This is essential for developing full depth of color and hiding, as well as uniformity of color. A paint with inadequate color acceptance will typically turn out darker when applied with higher, rather than lower, shear stress. "Shear" (i.e., mixing action) is least with roller application, intermediate with brushing, and generally the highest with spraying. Thus, for example, a blue paint applied to a wall by roller, but cut in at the corners by brush, may have a noticeably darker blue brushed "frame" if the paint has poor color acceptance.

EXTERIOR COLOR RETENTION

For exterior applications, it is important to specify colors recommended by the paint manufacturer for exterior use, in order to avoid use of certain organic pigments that will fade excessively. However, if a paint **chalks** prematurely or excessively on exposure to the weather, the resulting whiteness will, in effect, fade the paint, no matter how stable the color pigment is. Some paint ingredients that impact chalking rate are:

- Overall level of pigments (particularly extenders) relative to binder. This becomes a factor with economy *flat* paints that may have a very high PVC [see Module #1], which "overwhelms" the binder, and in turn leads to chalking.

- Extender pigments in the paint formulation. Some extenders are particularly good for chalk resistance, including moderate- to large-particle-size calcium carbonate, silicas and silicates. However, calcined clay and very small particle extenders of other types can foster chalking. (Interior paints rely more on these extenders, and should not be used for exterior applications.) Be aware that when choosing extenders, particularly for flat and satin paints, the paint formulator has to balance various properties, including hiding, mildew resistance, sheen, chalk rate, and economy.

- Type and level of titanium dioxide. This pigment offers unequaled whiteness, but will foster more chalking, compared to more durable extenders; for this reason, a quality latex paint in a very dark color with little or no titanium dioxide offers potential for minimized chalking.

- Type of binder. In general, quality latex exterior paints resist chalking far better than do oil-based or alkyd paints, particularly in sunny exposures. Latex binders with styrene as a significant part of their composition can chalk excessively. When used for interior applications, alkyd paints can eventually yellow significantly in areas not receiving sunshine, whereas quality latex paints tend not to yellow.

Quality latex paints in deep earth tones, as shown here, exhibit excellent color retention.

The successful use of multiple colors can bring interesting architectural details to life.

Quality exterior latex paints resist chalking and fading better than oil-based paints, particularly in sunny exposures.

In conclusion, many different formulation factors affect paint color performance, including:

- nature and level of prime pigment used
- type of extender pigments used
- proportion of pigment to binder
- type of binder
- proper combination of colorant and tint base
- general quality of the formulation

Information provided by The Rohm and Haas Paint Quality Institute
www.paintquality.com