# WHAT ARE YOU MADE OF?

Choosing the right titanium dioxide to enable the durability performance of *other* coating components

# The Central Roles of Paints are to Beautify and Protect.

While individual tastes may vary and beauty is very much in the eye of the beholder, we can all agree on what we want in terms of protection. No one wants their paint to discolor, peel, lose gloss or become chalky, and consumers expect their paints to resist these appearance and physical changes as the paint ages.

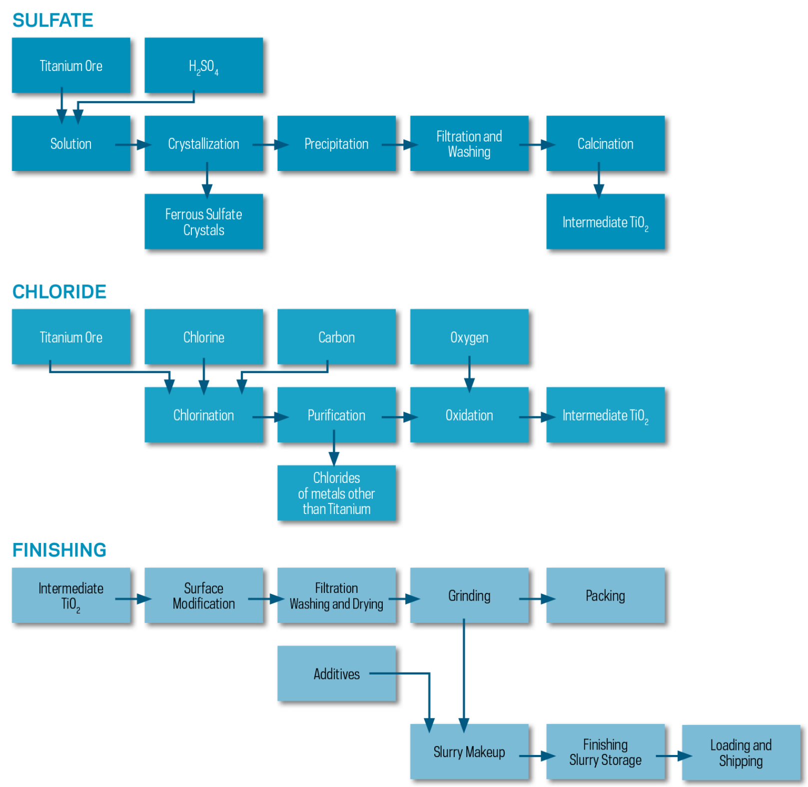
# The Complex Nature of Durability.

Formulating a highly durable paint is complex. Doing so requires a systems approach—all components of the paint must be optimized. The most important of these is the resin chemistry—some resins are more resistant to weathering than others. Generally speaking, the costs of the most durable resins are many times higher than the cost of their non-durable counterparts.  Because of this, it is important that all other paint components are optimized for high durability—otherwise some of the value of the expensive, high durability resin will be lost.

After resin, titanium dioxide (TiO2) is the next most important component of a highly durable coating. TiO2 has two opposing effects on paint durability, both of which are due to its very high ultra-violet (UV) light absorption efficiency. The first effect has to do with what happens when the resin is exposed to the high energy of UV light. Most resins will degrade through the absorption of UV light photons. These photons are energetic enough to break chemical bonds in the resin and initiate changes in both appearance and physical performance (for example, peeling). Formulators can lessen the damage from UV light by adding UV light absorbers to the paint. These materials tend to be costly, and the level that they are added to paints tends to be limited by these costs.

TiO2 also absorbs UV light, and in fact is such a strong absorber of UV radiation that essentially all of this component of sunlight is removed after striking a single 0.25 micron TiO2 particle. This

## TiO2 Manufacturing Processes



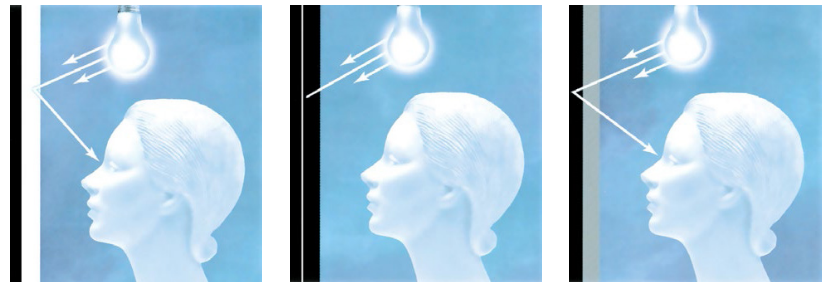
provides protection from UV degradation to the underlying resin molecules. The ability of TiO2 to protect paints is determined primarily by how well it is dispersed in the film, with good dispersion giving higher paint durability. Therefore it is incumbent on the TiO2 manufacturer to provide a pigment that disperses easily and is completely for durable paint applications.

The second impact of TiO2 on durability has to do with what happens after a TiO2 particle absorbs a UV light photon. Since energy must be conserved, the energy of the UV photon must be transformed to another form of energy.  In the vast majority of UV light absorption events, the energy absorbed by the TiO2 is changed into heat, and the film get warmer. However, the UV light energy is sometimes changed into chemical energy in the form of chemical radicals. These radicals form on the TiO2 surface, but are mobile enough to travel to resin molecules, where they initiate a series of degradation reactions that ultimately lead to film failure.

The rate at which radicals form and attack the resin is not the same for all grades of TiO2. Super durable grades have a layer of silica, alone or in combination with other materials, on their surface that prevents these radicals from

forming. This silica layer is applied by the TiO2 manufacturer during production of the pigment. The fact that different grades of TiO2 have different radical formation rates is reflected by the labeling of TiO2 grades as being “non-durable”, “durable” or

## Opacification of a Film



A: Complete Hiding—Light Scattering

B: Complete Hiding—Light Absorption

C: Incomplete Hiding

*“The ability of TiO2 to protect paints is determined primarily by how well it is dispersed in the film, with good dispersion giving higher paint durability.”*

“super durable”. Note that these designations do not apply to the pigment itself—TiO2 is titanium metal rust and as such is thermodynamically stable—but rather to the effect that the TiO2 grade has on film durability.

## Not all super durable pigments are created equal, and the paint formulator can choose between two pigment types.

The first type consists of well-known traditional or legacy grades. These are grades that have been in the market for decades and offer well known, consistent performance.They achieve their durability by greatly slowing the rate at which radicals form *(i.e. the second mechanism listed above)*. Paint formulators are generally quite familiar with these grades and with the durability performance that they provide, and as such these grades offer familiarity and confidence to the paint formulator.

The second type of super durable pigment are newer grades that, in addition to retarding the rate of radical formation, also provide for easier and more complete dispersion. As mentioned above, well dispersed TiO2 particles offer the best protection to resin from UV light. This two pronged strategy—better dispersion and low radical formation rates—provides a high level of durability, particularly with regard to gloss retention. These grades also have the advantage of being faster and easier to process, since they have been designed to disperse easily and completely. While these grades do not have the decades long durability track record that the legacy grades do, they are finding widespread acceptance in the coatings industry. This is particularly true in applications that require excellent gloss retention, since, all else being equal, well dispersed TiO2 particles have a higher gloss (and gloss retention) than poorly dispersed particles.

The formulator has a choice of ingredients when developing a new super durable paint or modifying an old one. The first choice is the correct resin, and super durable paints must use highly durable resin. Since these resins tend to be quite costly compared to their low durability counterparts, it is essential that the formulator select the other ingredients in a way that maximizes the durability performance and value of the resin. Using the right super durable TiO2 grade is a critical aspect of this, and in this regard formulators have the option of using familiar legacy grades of TiO2 or newer, more advanced pigments that combine low radical formation rates and a high degree of dispersibility. In either case the result is the same—the maximum value of the highly durable resin is maintained or even improved upon.

# Dr. Michael Diebold, Chemours Research Fellow

Dr. Michael Diebold is an inorganic chemist with a B.S. degree from the University of Illinois and a Ph.D. from Texas A&M University. He also served a year-long postdoctoral fellowship at Cambridge University before joining DuPont as a research chemist in the titanium dioxide group in 1988. In his current position as Research Fellow, Dr. Diebold is involved in product support, new product and process development, and the study of fundamental properties of TiO2 and light scattering in coatings.

Dr. Diebold is a recipient of Surface Coating International's Stern Award and a past FSCT Distinguished Lecturer. He was the ICE 2003 Technical Focus Keynote Speaker and a 2005 European Coatings Conference plenary lecturer. He has authored numerous papers for coatings journals and holds 10 patents on TiO2 pigment technology. He has recently published a book on the application of light scattering in coatings.

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