Raw Materials – what goes in is important

“The first step is always the hardest”. This also applies when formulating a coating. The application of the final finish determines the selection of the raw materials. Not only are mechanical properties like abrasion resistance and adhesion important, but also optical attributes like color, gloss and opacity; and one cannot forget the overall costs of the formulation. In order to guarantee consistent quality a routine quality control system needs to be established at the very first production step.

Paint is a liquid or powdery coating that is applied on objects as a very thin layer. By means of chemical or physical processes, it converts to an adherent film. Paint normally consists of the following components:

- Pigments
- Binder
- Fillers
- Additives
- Solvents / Water (not in powder coatings)

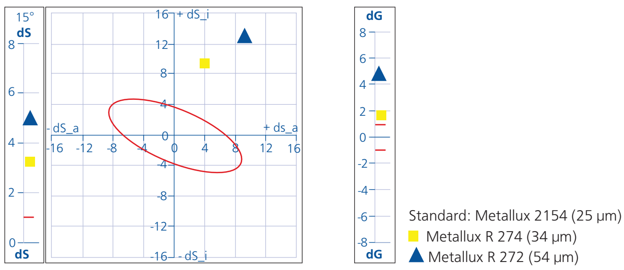
Pigments

Pigments are fine solid particles, which are substantially insoluble in the vehicle. They ensure hiding of the background and generate the color impression. In modern industrial coatings, solid absorption pigments, as well as metallic and pearlescent pigments are used.

Metallic pigments

Metallic pigments are very thin platelet-shaped particles made out of aluminum or bronze. They act like small mirrors and directly reflect the light causing a light-dark flop when changing viewing angle. Depending on the aluminum granulates and the process used, either irregular Cornflakes or round Silver Dollar particles are formed. Their properties, such as brilliance (sparkle and metallic gloss), flop, distinctness of image etc., are influenced by particle size / shape, particle-size distribution and smoothness of the surface. The coarser the pigments and the rounder their shape, the higher the proportion of reflected light and, thus, the more the metallic look is pronounced.

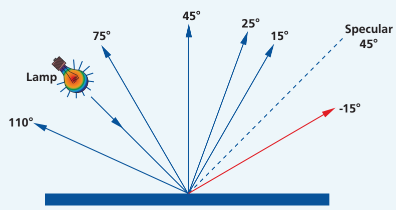
In the graph below a comparison of three silver dollar pigments with different flake size (25 µm – 34 µm – 54 µm) is shown. Visually, the silver finish with the coarser aluminum pigment appears more sparkling under direct illumination and grainier under diffused lighting.



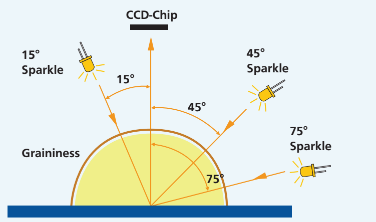
The BYK-mac i data correlate with the visual judgment: sparkle area, sparkle intensity and graininess increase with flake site.

BYK-Gardner Solution

Multi-angle Color & Effect
BYK-mac i



6-angle Color Measurement

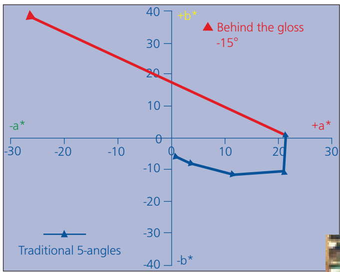


Sparkle and Graininess Measurement

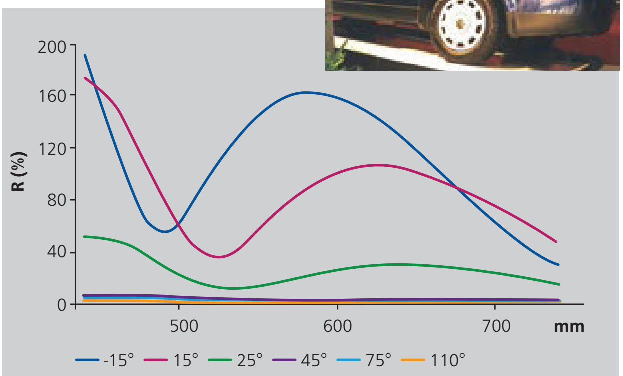
Pearlescent pigments

Pearlescent pigments usually consist of a transparent core material that is covered with different layers of metal oxide. A trick copied from nature is used: White light is refracted at the boundary layers and dispersed into its component – the colors of the rainbow. This causes an extraordinary color travel effect that depends on the differences of refractive indices between core material and metal oxide layer, the thickness of the metal oxide layer and the viewing angle. Typically the interference color can be seen on the opposite side of the specular reflection. Therefore, the BYK-mac i uses an additional measurement angle at -15°. The a*b*-chart on the right shows measurement data of the pigment Colorstream® Viola Fantasy. The color changes from purple to green. With the traditional multi-angle spectrophotometers (blue line) the shift to green cannot be captured. Only by taking an additional reading at -15° "behind" the gloss, the numbers agree with visual perception.

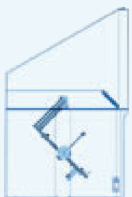
The color change from purple to green can also be seen in the spectral curves. It is typical for a pearlescent pigment that when using the same illumination angle, but taking readings at -15°, the reflection maximum is shifted to shorter wavelengths compared to the 15° measurement angle. Therefore, in this case, the color appears green.



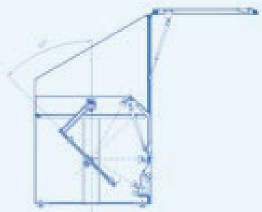
Courtesy of Merck



Objective Visual Evaluation
byko-spectra *effect*



Color Travel
Illumination and Sample pivot together



Sparkle Travel
Direct illumination under 15°/45°/75°

Color Measurement of Titanium dioxide (TiO_2)

Titanium dioxide is the brightest, whitest pigment available. Due to its high refractive index (even higher than diamond) it effectively scatters the light and provides maximum opacity for a coating. Rutile is the most common natural form of TiO_2 and preferred over anatase because of the lower photocatalytic activities and thus, better weather stability of the final coating.

The purity of TiO_2 is process related. The chloride process makes up purer and brighter grades than the sulfate process. Additionally, impurities introduced by treatment chemicals or extraneous metal ions within the crystallites can degrade brightness. They usually discolor the pigment towards grey or yellow.

One way to perform a color measurement is to incorporate the TiO_2 pigment into the coatings system of the final application. To ensure a smooth and homogeneous surface, the paint is applied to opacity drawdown charts with an automatic film applicator. The charts are made of black and white areas that are large enough to be measured with color instruments. An alternative is to take readings on dry pressed pucks. The pucks are made by applying high pressure to the dry TiO_2 which is contained by a ring. The pressure is essential as it is the driving force to compact the pigment and hold it together for measurement. The face of the puck is then measurement with a spectrophotometer.

The standardized CIE colorimetric values L* and b* are used to characterize brightness and undertone: the higher the L* value, the higher the brightness, the lower the b* value, the less yellow the appearance. In the table below, results for different grades of TiO_2 are displayed. The spectro2guide can be used to measure CIELab color numbers. The instrument stores and directly transfers measurement data to smart-chart data analysis Software.

	Grade 1	Grade 2	Grade 3	Grade 4
Brightness L*	96.6	97.4	97.3	97.2
Undertone b*	2.1	1.5	1.5	1.5

Besides brightness and undertone, optimum hiding power and tinting strength are properties that the TiO_2 pigment has to meet (see page 20 “Architectural Coatings” and page 28 “Industrial Coatings”).

BYK-Gardner Solution

Solid Color & Gloss
spectro2guide

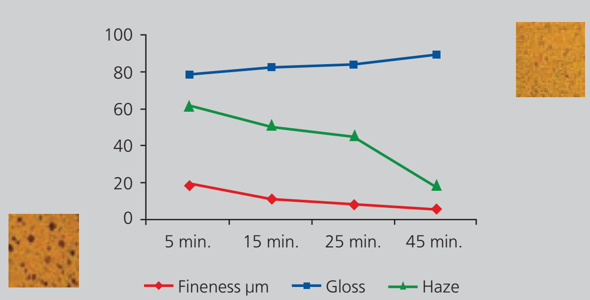
Gloss
micro-gloss

Gloss & Haze
haze-gloss

Gloss and Haze Measurement of Titanium dioxide (TiO_2)

Gloss and haze level of a TiO_2 pigment is mainly controlled by the primary particle size and the number of particles with a diameter larger than 0.5 µm. To achieve glossy finishes with improved distinctness of image, oversized particles have to be minimized. The haze-gloss is an objective tool to measure matte to high-gloss surfaces by offering three gloss geometries (20°, 60°, 85°) as well as reflectance haze measurement in one unit. However, to measure gloss and haze the TiO_2 has to be incorporated in the coatings system and a drawdown has to be made.

Gloss and Haze dependent on dispersing time



During the dispersion process, the pigments are dispersed into small particles: the smaller the particles, the smoother the surface. The graph above shows the influence of degree of dispersion on gloss and haze. Pigment particles that are smaller than 10 µm show a tremendous reduction in haze and a slight increase in gloss, resulting in a glossy finish with improved imaging forming qualities.

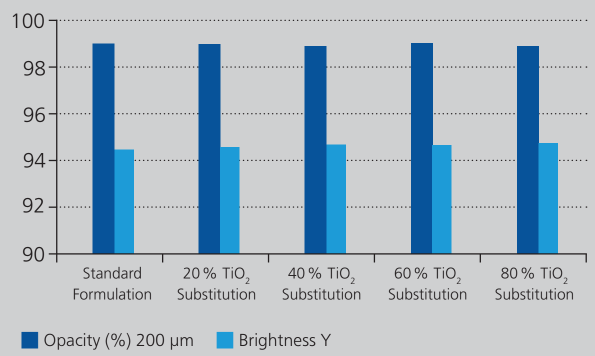
Absorption pigments

Organic and inorganic absorption pigments selectively absorb and scatter the incident light. Besides the color itself, tinting strength is one of the most important properties that need to be controlled. Tinting strength is directly influenced by the pigment type and concentration used in the coating system (see page 28 "Industrial Coatings").

Fillers

Fillers are solid particles, which are virtually insoluble in the vehicle. They serve to increase the volume of the paint and to improve mechanical and optical properties. They are usually less expensive than other pigments and reduce the overall costs of a paint formulation. Among all, calcium carbonate fillers are quantitatively the most important class. They exhibit a neutral tone and a high brightness ($L^* \geq 95$) and can therefore be used to substitute TiO_2. As their mean particle size is larger and their refractive index is lower, care has to be taken to achieve the required hiding power. New synthetically produced calcium carbonate types are available which consider the aforementioned. In a medium class interior paint formulation with 12.5 % TiO_2 and a PVC (pigment volume concentration) of 76 % the amount of TiO_2 was substituted 1:1 by the new calcium carbonate type. The graph below shows the results: Opacity as well as brightness compared to the standard formulation did not change up to a TiO_2 substitution of 60 %.[1)]

Substitution of TiO_2



In this experiment only an increase in 85° gloss from 4 to 7 gloss units was monitored.

[1)] Dr. Petra Fritzen; Solvay Chemicals GmbH: Ein gut gefülltes Paket; Farbe und Lack (June 2015); page 58 – 62

Automatic Film Applicator
byko-drive

Drawdown Test Charts
byko-charts

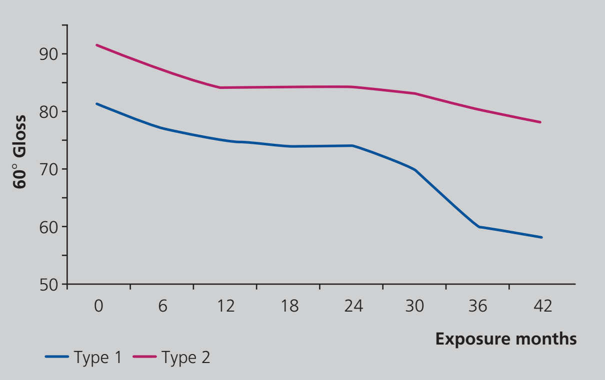
Applicators
Bar applicatos

Binder
The binder or resin combines all solid components of the coating and acts as the film former. It imparts mechanical properties such as hardness, flexibility and adhesion. The binder itself is clear and glossy.

Resin systems are subject to degradation by thermal and photo induced oxidation. Therefore, resistance against weathering and UV radiation needs to be ensured. This is highly important for corrosion coatings that protect objects like bridges, storage tanks or steel structures against environmental influences. Tests are either done by using accelerating weathering chambers or under real-world conditions. The most popular weathering areas are located in Arizona and South Florida.

In the example below, two different types of silicone-epoxy resins were exposed. As displayed in the graph, type 2 started at a higher initial 60° gloss and even after 42 months of Florida exposure continues to maintain a much higher gloss level than type 1.

Outdoor weathering

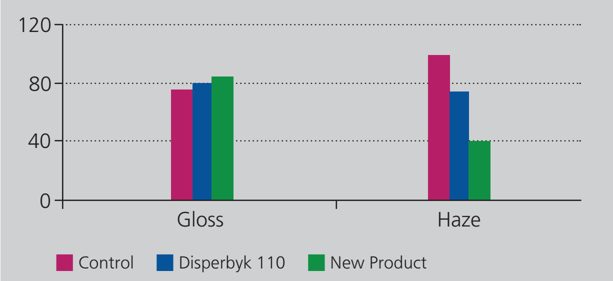


Color retention was excellent for both systems. After 42 months of outside exposure they exhibit a ΔE* of less than 1 compared to the control.

Additives
Additives are substances that are added to a coating in very small amounts to improve properties such as wetting and dispersing, flow and leveling, defoaming or can act as matting agent.

Wetting and Dispersing Additives
One of the most important steps in the production of pigmented coatings is the homogeneous distribution and stabilization of pigments and fillers within the liquid binder solution. If this step is not optimized, a variety of defects can occur: e.g. flocculation, gloss reduction, color shift and settling. Wetting and dispersing additives are surface-active substances that improve the wetting of solids and prevent the flocculation of the particles.

Influence of wetting/dispersing additive



The diagram above shows the influence of wetting/ dispersing additives on the dispersion quality. Two different additives used in a solvent-free coating system are compared with the same system without additive (= control). The new product perfectly stabilizes the pigments resulting in an increased 20° gloss value and a significant reduction in haze.

Flow and Leveling Additives
The chapter "Industrial coatings" discusses an application how the orange peel of powder coatings can be optimized by using the flow & levelling additive BYK-3902 P. Measurements were taken using the wave-scan instrument (see page 30).

BYK-Gardner Solution

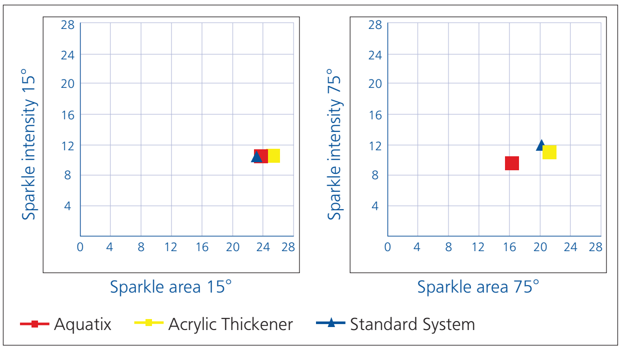
Solid Color & Gloss
spectro2guide

Gloss
micro-gloss

Gloss & Haze
haze-gloss

Rheology Additives

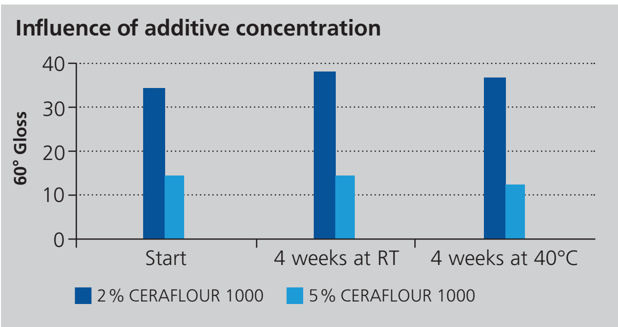
Rheology additives are used to adjust the flow behavior of the coating. For example waxes are utilized to improve the orientation of effect pigments. In the following example a waterborne system was evaluated using three different rheology additives: a standard system, an acrylic thickener and the wax additive AQUATIX®. Visually, the three panels look the same under direct illumination at a steep angle. When comparing at a lower grazing angle, the system using the wax additive shows less sparkling.



BYK-mac i measurement data correlate with a visual judgment. The sparkle area for the system with wax additive at 75° is smaller than for the two other systems. As Sparkle 75° evaluates flakes which are non-parallel oriented, this clearly shows that by using the wax additive AQUATIX® the orientation of the aluminum flakes is improved.

Matting Agents

Dependent on their particle size, wax additives can have an influence on the surface gloss. Usually, particle sizes larger than 1 µm produce a matting effect. CERAFLOUR 1000 is a micronized polymer with wax-like properties to improve surface protection and haptics (soft feel effect). It has a matting effect, especially in radiation curable systems. The graph below shows the influence of additive concentration on the gloss level of a 1-K AC-PU Copolymer Dispersion. Even after 4 week storage at 40°C the matting effect isn`t hardly reduced.



Orange Peel & DOI
wave-scan

Multi-angle Color & Effect
BYK-mac i