Cork Tech TalkNews

Manufacturers of Waterbase, UV+EB Curable Coatings, Varnishes and Adhesives

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TAKING THE MEASUREMENT OF COLOR

Color, you might question, why is it that a coating manufacturer, that is known for it's clear coatings, be writing about color? The answer is that we are involved with color all of the time. While not all of our coatings are applied over color, the majority are. These overprints, as they are aptly named, are applied over printing, printing that is quality controlled for color accuracy. Additionally, there are times when we are asked to supply a color coating, or a water white/blue clear, and it is essential to define that color precisely.

How is color measured? Spectrophotometry is the best method to collect spectral infor-mation which can be used to calculate density and colorimetry data. Colorimetry defines color in the following three dimensions:

- *lightness or darkness*
- *hue (a particular shade or tint)*
- *vividness, dullness or saturation, chroma*

Color results from the interaction between light, an object viewed and the viewer (observer). Light reflected by an object is the color that we perceive. We see color because the human eye contains photoreceptors some of which are sensitive to red, some to green and some to blue. The eye sees colors in the range of 400nm (violet) to 700nm (red). CIE, the International Commission on Illumination has developed international standards and a numerical system that is correlated with color that we perceive. Three numbers (XYZ values) are used to reference red, green and blue. These are used to establish a three dimensional location for that color, also described as a color space. Some offer the comparison that this is like we describe a location on earth by longitude, latitude and altitude. A plot of % reflectance vs. wave-length (data that can only be collected from a spectrophotometer) produces a color curve. The number of points measured to plot a color curve vary by spectrophotometer with more points being better.

CIE L*a*b* is an interpretation of CIE XYZ color values. L*, a*, and b* (as defined below) is a rectangular coordinate system.

CIE L*C*h∞ is a modification of L*a*b* and is a polar coordinate system (x, distance from zero, and angle from zero).

A section of L*a*b* color space is a cube and a section of L*C*h∞ color space is like a piece of a cylinder. L*C*h∞ matches human color perception more closely than L*a*b* because L*C*h∞ coordinates cause a color to rotate based on its color space location.

A color space defined using these systems gives identity to a color that we perceive such that it might be identified as one having a light-ness of 43, a hue of 302, and a chroma of 51.

Putting precise numerical values to a color allows everyone involved to be speaking the same language. L*a*b* or L*C*h∞ values can be established for everything from proofing materials to substrates to ink proofs allowing better control of variation.

Tolerances and their establishment is key to meeting and agreeing with ones customers requirements. Color tolerance is expressed as the difference or Delta value and is by defini-tion the acceptable difference from a standard, L*a*b* or L*C*h∞ values. Color difference is ex-pressed for each axis, DL*, Da*, Db*, DC* and D*h∞, and the total distance from the standard, DE. DE is the square root of the sum of the squares of the differences in L*a*b* values.

Variations in hue are readily noticeable visually and differences are objectional sooner than variations in lightness or saturation (chroma). This becomes a problem considering that hue is expressed in space differently for each color (see definitions).

A person perceives color in an elliptical shape around a standard. The size of the ellipse varies according to the hue (shade) of the color. Both L*a*b* and L*C*h∞ are angular areas, but an L*C*h∞ tolerance is closer to an ellipse shape and therefore is better. Nevertheless both will sometimes produce erroneous results. Consequently other tolerance methods have been developed. These involve the use of three dimensional ellipses or ovals. They offer an improved correlation to visual color perception compared to L*C*h∞ tolerencing. Two tolerencing methods CMC and CEI94, both based on L*a*b* color space are accepted as being more accurate than L*a*b* or L*C*h∞.

CMC offers advantages in that it mimics the human eye representing a range of accept-ability in the shape of an ellipse and the area of acceptability is varied in size depending on the location of the standard in color space. Because the eye notices a small change in yellow sooner than a small change in blue, this is notable. The shape of the ellipse is determined by the ratio of lightness (L) to the chroma (C). One Delta E CMC represents the same amount of visible color difference for any color. This means that one DE CMC toler-

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ance unit will indicate the same amount of color difference in both yellow and blue, unlike one L*a*b* tolerance unit where a noticeable color difference in yellow might be unacceptable, while a color difference in blue might not be noticeable and therefore be judged acceptable.

Observer and illumination reference the type of light illuminating the object and the angle of viewing. L*a*b* and L*C*h∞ values change depending upon observer and illuminant. Observers are always either 2∞ or 10∞. Typical illuminants are D50 (northern daylight), D65 (daylight), CWF (cool white fluorescent) or A (incandescent). Some colors will appear different when viewed in different light (metamerism). Color space coordinates will change depending on the observer/illuminant. When comparing color be sure that the same color space, instrument geometry/illuminate-/observer combination and tolerance language is being used.

Some defining color terms:

Visible light: The wavelengths or colors of light observable by the human eye between the wavelengths of 400nm and 700nm.

Spectrophotometry: Science of using an analyzer to measure the light absorbing and light reflecting properties of colors. Light reflected from an object is the color of the object seen by an observer.

Analyzer: The section of a spectrophotometer that separates light reflected from an illuminated object into it's component colors and measures the amount of reflectance at specific wavelengths.

% reflectance: The amount of light reflected to the analyzer from an illuminated object.

Color curve: A spectral or reflectance curve that is a plot of % reflectance at specific wavelengths.

Illuminant: A standardized light source.

Observer: A standardized angle of view.

*** :** Refers to CIE color space rather than Hunters.

L*: Lightness value on a scale of zero to 100 with zero being pure black and 100 pure white.

a*: Redness (+ value) versus greenness (- value) hue axis with zero value being neutral.

b*: Yellowness (+ value) versus blueness (- value) hue axis with zero value being neutral.

C*: Chroma as the difference from gray (less saturated) to the pure hue of color (more saturated).

h∞: Hue angle from zero with zero∞ red, 90∞ yellow, 180∞ green and 270∞ blue.

DL*, Da*, Db*, DC*, Dh∞: Distance and direction difference between a standard and a sample or between any two colors on the proper axis.

L*a*b* DE: Absolute distance between a standard and a sample or between any two colors without defining direction of difference.

DE CMC: Relative color difference between a standard and a sample or between any two colors without defining direction of difference.

Tolerance: Defined limits of acceptance applied to each color space axis and/or distance from a standard forming a 3-D area around a standard defining color acceptance.

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