Applications
Note

# Strength Calculations

Colorant strength is defined as a pigment or dye's ability to change the color of an otherwise colorless material. Often, this value is determined by comparing it with a standard for which the amount of colorant is known. When this is the case, care must be taken that the sample and standard are prepared in exactly the same way, such as by mixing a dye into solution or disbursing pigment onto a card. The spectral curves of the sample and standard must also be similar. There are several different types of strength, which are described below.

Color value, used in calculating colorant strength, is a single numerical value related to the amount of light-absorbing material (colorant) contained in a sample and is usually based on spectral data. Color value may be calculated by any one of three acceptable methods. The color value which results from one method may not agree with any other method. The choice of method is usually dependent on the nature of the sample and the need to obtain a color value. The Spectrophotometric methods for obtaining color value are described below.

Since most of these formulas have their basis in K/S, you may also want to refer to the *Applications Note* entitled "The Kubelka-Monk Theory and K/S."

## Color Value SUM

Color Value SUM is an index available in EasyMatch QC versions 3.70 and higher, and is calculated as the sum of the K/S values for the sample read across the spectrum for reflectance measurements, and from the sum of the absorbances for the sample read across the spectrum for transmittance measurements.

$$\text{Color Value SUM} = \frac{\sum_{\lambda=1}^{\#\,points} \frac{K}{S\lambda}}{\#\,points} \qquad \text{for reflectance}$$

$$\text{Color Value SUM} = \frac{\sum_{\lambda=1}^{\#\,points} \text{Absorbance}_\lambda}{\#\,points} \qquad \text{for transmittance.}$$

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## Color Value SWL

Color Value SWL, an index available in EasyMatch QC versions 3.70 and higher, is the K/S measured at the wavelength of maximum absorption (minimum reflection) for reflectance measurements or the absorbance at the wavelength of maximum absorption (minimum transmittance) for transmittance measurements.

## Color Value WSUM

Color Value WSUM, an index available in EasyMatch QC versions 3.70 and higher and an index difference available as "ST" in the ColorFlex and MiniScan XE Plus firmware, is calculated using the sum of K/S weighted by illuminant and observer for the sample read across the spectrum for reflectance measurements, and using the sum of absorbances weighted by illuminant and observer for the sample read across the spectrum for transmittance measurements.

$$\text{Color Value WSUM} = \frac{\sum_{\lambda=1}^{\# points} \frac{K}{S_\lambda} * E_\lambda * S_\lambda}{\# points} \qquad \text{for reflectance}$$

$$\text{Color Value WSUM} = \frac{\sum_{\lambda=1}^{\# points} Absorbance_\lambda * E_\lambda * S_\lambda}{\# points} \qquad \text{for transmittance}$$

where  E = Energy distribution of light source

   S = Observer function.

## Average Strength

Average Strength (called % Strength SUM in EasyMatch QC versions 3.70 and higher) is a difference scale available for display in the Color Data Tables in EasyMatch QC, EasyMatch OL, and Universal Software.  Relative average strength is calculated from the Color Value SUMs of the sample and standard.

$$\% \text{Strength SUM} = \frac{\text{Color Value SUM}_{SAM}}{\text{Color Value SUM}_{STD}} \times 100.0 \ .$$

## Weighted Strength

Weighted Strength (called % Strength WSUM in EasyMatch QC versions 3.70 and higher) is a difference scale available for display in the Color Data Tables in EasyMatch QC, EasyMatch OL, and Universal Software.  Relative weighted strength is calculated using the Color Value WSUMs for the sample and standard.

$$\% \text{Strength WSUM} = \frac{\text{Color Value WSUM}_{SAM}}{\text{Color Value WSUM}_{STD}} \times 100.0 \ .$$

## % Strength - SWL

Single-wavelength, or SWL, strength is a difference scale available for display in the Color Data Table in EasyMatch QC (versions 3.70 and higher) and an index difference called "SM" in the ColorFlex and MiniScan XE Plus firmware.

% Strength SWL is the % Strength measured at the wavelength of maximum absorbance.  This is the same % Strength described below, but at the appropriate single wavelength.

## % Strength

Selecting % Strength as a difference data type for display in the Spectral Data Table of EasyMatch QC versions 3.70 and higher results in the display of % Strength values for samples as compared to a standard.  % Strength is calculated separately for each wavelength displayed, as follows:

$$\% \, \text{Strength} = \frac{\text{K/S}_{\text{sample}}}{\text{K/S}_{\text{standard}}} * 100 \qquad \text{for reflectance}$$

$$\% \, \text{Strength} = \frac{\text{Absorbance}_{\text{sample}}}{\text{Absorbance}_{\text{standard}}} * 100 \, \text{for transmittance.}$$

It is also available in the Spectral Data view of Universal Software, and called "Relative Colorant Strength."

## References

AATCC Evaluation Procedure 6, "Instrumental Color Measurement," American Association of Textile Chemists and Colorists, Research Triangle Park, www.aatcc.org.

Berns, Roy S., *Billmeyer and Saltzman's Principles of Color Technolog*y, 3rd edition, New York: John Wiley & Sons, 2000.

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