



## An Improved Color Difference Formula

By Peter Hauser

French researchers in the 1930s determined how people with normal color vision would match colors across the visual spectrum with red, green, and blue colored lights. Their data set became what is referred to as the Standard Observer.

In the early 1940s, instruments capable of measuring the reflectance of light at different wavelengths were developed and used to generate reflectance curves of colored surfaces, including dyed fabrics. Color scientists combined the Standard Observer data with reflectance curves to calculate what are called tristimulus values. These are three numbers (X, Y, and Z) that uniquely define a color. If any two items have the same X, Y, Z values, they have the same color. Tristimulus values are very useful in defining colors; however, they are not applicable for color matching since it is not clear how to adjust a dyed fabric with an observed XYZ to the XYZ of a color standard.

Also, in the 1940s, opponent color theory was recognized as the way color vision is understood. Light—dark, red—green, and yellow—blue are the three components of color vision. These were calculated from XYZ values as *L* (light—dark), *a* (red—green), and *b* (yellow—blue). Using *Lab* values to define colors allows for easier color matching. In 1976, improved calculations for *Lab* were introduced as  $L^*a^*b^*$ , then formalized as CIELAB. These are the current standard for color measurements.

The color difference between two dyed fabrics can be expressed with CIELAB as

$$\Delta E^* = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$$

By setting a maximum value for  $\Delta E^*$ , acceptable color matches can be made.

However, it was found that acceptable  $\Delta E^*$ s for bright shades did not give acceptable color matches for duller shades. McDonald, in this paper, explains the reason for this discrepancy and provides equations that allow consistent values for  $\Delta E^*$  for all colors. These equations, referred to as  $\Delta E_{CMC}^*$ , are the basis for AATCC Test Method 173 CMC: Calculation of Small Color Differences for Acceptability, and are accepted internationally as the best approach to date for determining color differences.

McDonald, Roderick, *Textile Chemist & Colorist*, June 1988, Vol.20, No.6, pp 31-37.

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