Applications Note

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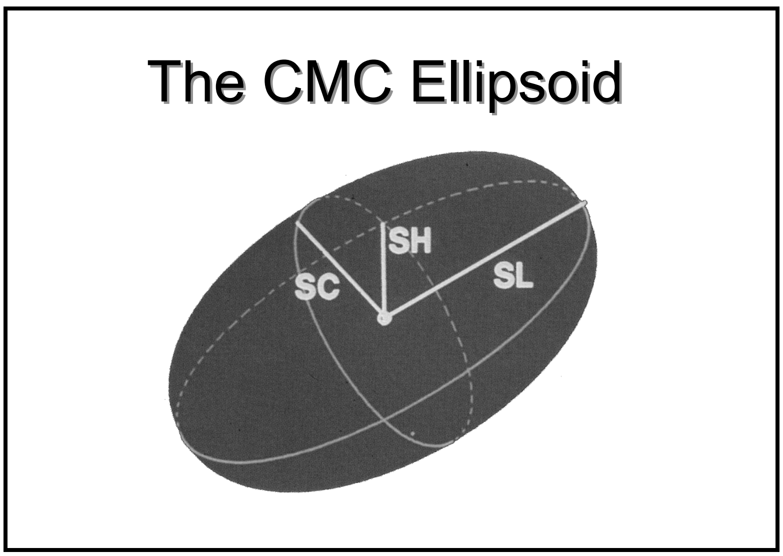
CMC

Background

CMC is a modification of CIELAB developed by the Color Measurement Committee of the Society of Dyers and Colorists. This modification is described in AATCC Test Method 173, "CMC: Calculation of Small Color Differences for Acceptability." Color differences calculated using the CMC method are believed to correlate better with visual assessment than color differences calculated using other instrumental systems. The CMC equations are based on an ellipsoidal space like that diagrammed below.



The semi-axis lengths determined by the color values of the standard set the shape of the ellipsoid. This is why the shape of the ellipsoid changes depending on where the standard is in color space. The CMC ratio *l*:c (lightness:chroma) influences the shape of the ellipsoid. The c (chroma) is usually smaller than the *l* (lightness) because humans perceive smaller shifts in chroma than in lightness. The *l*:c ratio is typically set at 2:1 for most applications. In most software packages only the *l* value may be adjusted. An h, hue, value could be added to this ratio, but h is always 1, so it is not included. The SL, SC, and SH are calculated based on the CIELCh values. They are used to set the base size and shape of the ellipsoid. The SL is multiplied by *l* and SC is multiplied by c to set the shape. A commercial factor may be set to change the size of the ellipsoid. If a commercial factor of 1 is used, the ellipsoid will be set at its base size. If another value is used for the commercial factor, the ellipsoid is changed based on that value. The *l*SL, cSC, SH are multiplied by the commercial factor to set the size of the ellipsoid. If the commercial factor is less than 1 the ellipsoid will be smaller than its base size. If the commercial factor is greater than 1, the ellipsoid will be larger than its base size. This tightens or loosens the tolerances set by the edges of the ellipsoid.

The ΔE_{cmc} is the total color difference value in this system. This number is useful as a single number indicator of the difference between a sample and a standard. Due to the method of calculation, the ΔE_{cmc} value allows the evaluation of the acceptability of a color match without regard to the color of the standard (e.g., two reds that have a ΔE_{cmc} of 0.5 have the same amount of visual color difference as two blues that have a ΔE_{cmc} of 0.5). As a result, a single ΔE_{cmc} limit value may be set to be used in evaluating the color matches of all the products a company produces.

The CMC method provides an easy method for calculating tolerances for ΔL*, ΔC*, and ΔH* that are suitable for the standard and take into account where it falls in color space. Standards falling into the dark blue region in color space will have tighter tolerances than those in the pastel yellow region in color space because humans can perceive and will reject smaller color differences in the dark blue region than in the pastel yellow region. The boundaries of the ellipsoid are the tolerances.

Tolerances for the CMC delta values equal the commercial factor if an absolute calculation is used.

Conditions for Measurement

Instrumental: Any HunterLab color measurement instrument

Illuminant: Any (although CMC was developed for use with D_{65})

Standard Observer Function: 2 or 10 degree (although CMC was developed for use with 10°)

Transmittance and/or Reflectance: Either.

Formulas

$$SL = \frac{0.040975L^*}{1 + 0.01765L^*} \qquad \text{for } L^* > 16$$

$$SL = 0.511 \qquad \text{for } L^* < 16$$

$$SC = \frac{0.0638C^*}{1 + 0.0131C^*} + 0.638$$

$$SH = (FT + 1 - F)\,SC$$

where

$$F = \sqrt{\frac{C^{*4}}{C^{*4} + 1900}}$$

$$T = 0.36 + |0.4 \cos(35 + h)| \qquad \text{for } h = 164° \text{ or } h > 345°$$

$$T = 0.56 + |0.2 \cos(168 + h)| \qquad \text{for } 164° < h < 345°$$

L* and C* are from CIE L*C*h.

Calculations by the absolute method:

$$\Delta L_{cmc} = \frac{\Delta L^*}{lSL}$$

$$\Delta C_{cmc} = \frac{\Delta C^*}{cSC}$$

$$\Delta H_{cmc} = \frac{\Delta H^*}{SH}$$

$$\Delta E_{cmc} = \sqrt{\left(\frac{\Delta L^*}{lSL}\right)^2 + \left(\frac{\Delta C^*}{cSC}\right)^2 + \left(\frac{\Delta H^*}{SH}\right)^2}$$

Tolerances:

$\Delta L^* = (cf)\ lSL$

$\Delta C^* = (cf)\ cSC$

$\Delta H^* = (cf)\ SH$

Absolute

$\Delta L_{cmc} = cf$

$\Delta C_{cmc} = cf$

$\Delta H_{cmc} = cf$

$\Delta E_{cmc} = cf$

Typical Applications

This method is being adopted in many industries as it provides a better correlation with visual evaluations than other instrumental color indices.

For Additional Information Contact:

Technical Services Department
Hunter Associates Laboratory, Inc.
11491 Sunset Hills Road
Reston, Virginia 20190
Telephone: 703-471-6870
FAX: 703-471-4237
www.hunterlab.com