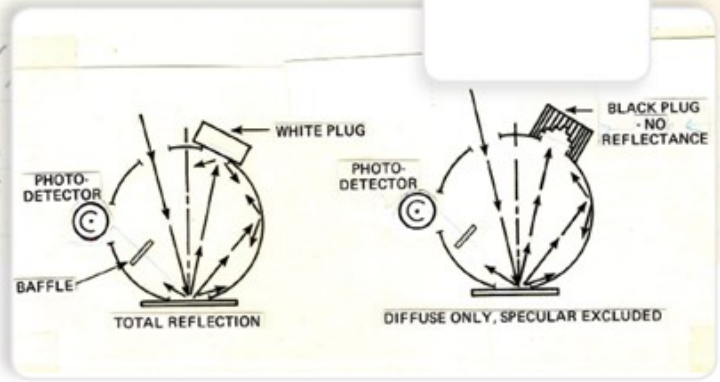
Applications Note

AN 1010



Measuring Metamerism and Inconstancy in Samples

Metameric samples usually contain different pigments or dyes, and under two different illuminants will never match perfectly.

Abstract

Metamerism in color measurement is the application where two materials match when viewed under one light source but do not match under another illuminant. This can be a serious problem for manufacturers who make products that can be placed in a wide variety of lighting conditions. Metamerism occurs when materials are combined from different dye lots or chemical processes.

This application note considers the phenomenon of metamerism and methods for detecting metamerism in samples.

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HunterLab

Challenge: To measure metamerism using a repeatable method.

What is Metamerism?

The light in which an object is viewed can definitely affect its appearance. We have all experienced some level of metamerism as consumers. Does the fluorescent lighting in a department store dressing room really show you how an outfit looks on you, or do you have to wait until you get outside to judge the color? Does a car look the same under bright sunlight as it does under a dim streetlight at night? A customer expects all the parts of a car that are the same color to match whether it is a sunny or cloudy day. A clothes shopper expects that parts of a coordinated outfit (i.e. a jacket and slacks) match in daylight as well as under the fluorescent lights of the department store.

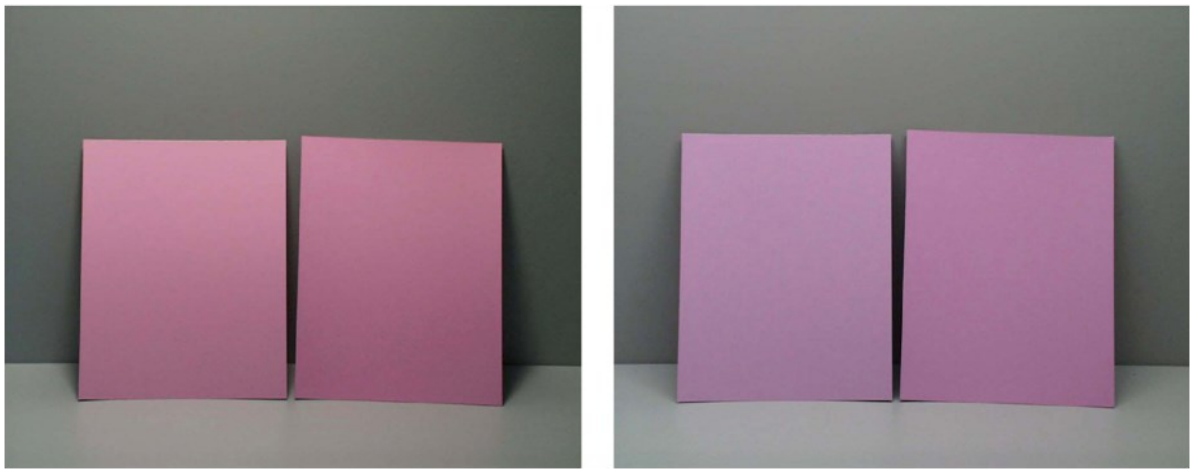
Metamerism is the phenomenon by which a pair of spectrally different specimens match under one illuminant, but not under other illuminants. Textile dyers, for example, measure metamerism to ensure that the fabric used for shirt sleeves matches that used for shirt bodies under indoor fluorescent and incandescent lighting, as well as outdoor natural daylight. Metameric fabrics would not achieve this match under all lighting conditions. Because metamerism involves the spectral reflectances of samples, a spectrophotometer (rather than a colorimeter) is required to evaluate it.

Textile dyers for example, measure metamerism as part of their quality control to ensure that shirt sleeves match shirt bodies under fluorescent, incandescent and natural daylight. Fabrics displaying metamerism would not achieve this match under all lighting conditions.

The quality control procedures for metamerism involves the analysis of spectral data. Therefore spectrophotometer rather than a colorimeter is required.

Metamerism Index

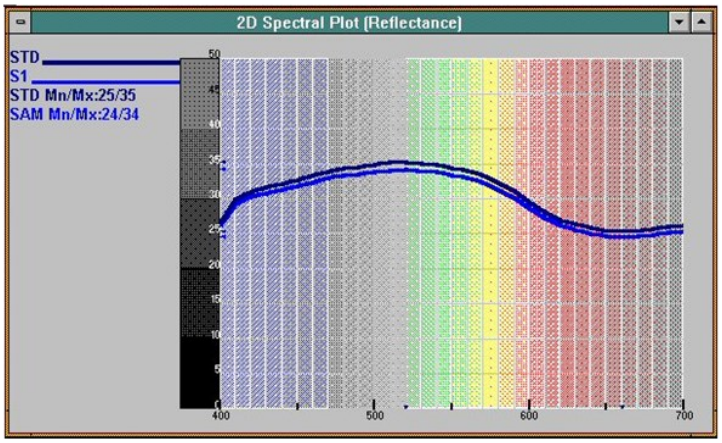
Metamerism index is a single-number value used to indicate the closeness of two materials measured under two illuminant conditions. The larger the Index, the bigger the color difference under the two illuminants of interest.



Incandescent light versus Fluorescent light

For metamerism index to be meaningful, the materials should be a good match under the reference illuminant. Using HunterLab instruments, any two illuminants may be chosen for calculating metamerism index. The metamerism index calculation is based on Hunter L, a, b values.

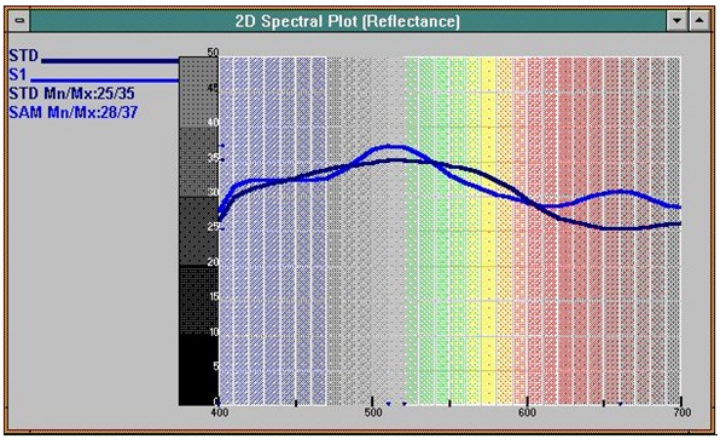
To begin, each spectral data is read for each sample. If the spectral curves cross more than once, then the samples are thought to be metameric. Top figure shows the spectral curves of two closely matching specimens. These specimens could theoretically be made to match perfectly as their differences are most likely related to dye strength or concentration.



Closely matched standard and sample.

The next figure shows the spectral curves of two metameric samples. Note the multiple crossing lines in the spectral curves. This characteristic indicates metamerism. Since Metameric samples usually contain different pigments or dyes, they will never match perfectly. In some cases, the difference can be ignored if the metamerism index is low.

Once the spectral data has been obtained, then the Metamerism Index can be calculated.



A Standard and Sample showing the crossing characteristic of metamerism.

Table 1. Closely Matching Spectral Data: Standard and Sample

Illuminant/	Std/Sample	L	a	b	Metamerism
D65/10°	Standard	57.44	-5.96	0.23	0.05
D65/10°	Sample	56.55	-5.77	0.03	
CWF/10°	Standard	57.24	-4.62	0.13	
CWF/10°	Sample	56.34	-4.47	-0.04	

Table 2. Data on A Metameric Pair: Sample & Standard					
Illuminant/ Observer	Standard/ Sample	L	a	b	Metamerism Index
D65/10°	Standard	57.44	-5.96	0.23	0.79
D65/10°	Sample	57.35	-5.76	0.16	
CWF/10°	Standard	57.24	-4.62	0.13	
CWF/10°	Sample	56.66	-4.29	-0.56	

The Metamerism Index Formula

Metamerism Index is used to assign a numeric value to the degree of metamerism. It is calculated with respect to two different illuminants using the Hunter L,a,b scale. Typically, one of these illuminants is a fluorescent source since. With HunterLab software, you choose the illuminants for which metamerism will be calculated.

$$MI = \sqrt{\left(\Delta L_{n1} - \Delta L_{n2}\right)^2 + \left(\Delta a_{n1} - \Delta a_{n2}\right)^2 - \left(\Delta b_{n1} - \Delta b_{n2}\right)^2}$$

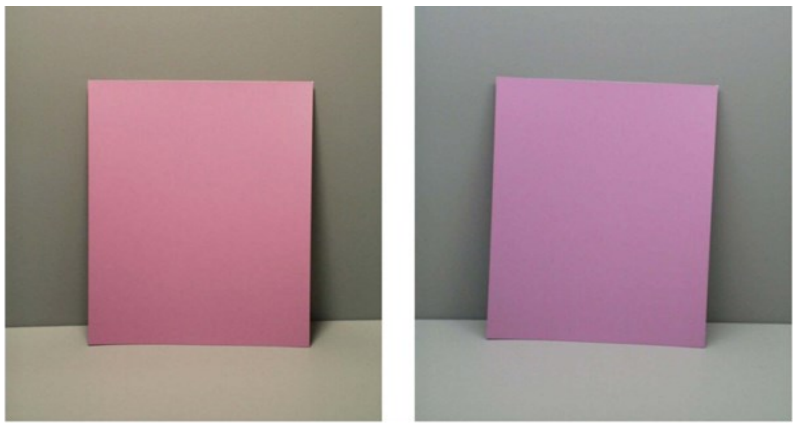
Where, n1 is the first illuminant,
n2 is the second illuminant, and
Δ = Value $_{sample}$ - Value $_{standard}$.

A metamerism index less than 0.5, is one where there is a low degree of metamerism and thereby an acceptable match (Table 1) . An index greater than 0.5 but less than 1 is indicating metamerism (Table 2). An index of greater than 1 is highly metameric and requires reformulation.

Note: Fluorescent illuminants are always the most difficult for matching. You may wish to allow some leeway in your specification when dealing with a fluorescent illuminant.

Relationship between Metamerism and Inconstancy

Metamerism Index is calculated to show the difference between two items under two different lighting conditions, and color inconstancy index is determined for *one single item.* Color inconstancy (sometimes called flare) indicates the degree to which the appearance of a sample's color changes when the light source illuminant is changed. Like Metamerism Index, color inconstancy is determined by measuring the sample under one illuminant to predict the corresponding color under a second illuminant. If the color values are different, then the total color difference (ΔE) between them is used as a measure of the color inconstancy.



Color Inconstancy showing Incandescent on the left and fluorescent on the right.

References

Hunter, Richard S., and Harold, Richard W; The Measurement of Appearance, 2nd ed., John Wiley and Sons, Inc. New York, NY USA 1987.

About HunterLab

HunterLab is the technology leader in color measurement solutions, providing instruments, software, knowledge and service to a wide variety of industries. With over 5 decades of experience in more than 65 countries, HunterLab applies our leading edge technology to your products helping you measure and communicate color simply and effectively.

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