Applications Note

Insight on Color **Vol. 12, No. 6**

Evaluation of Appearance

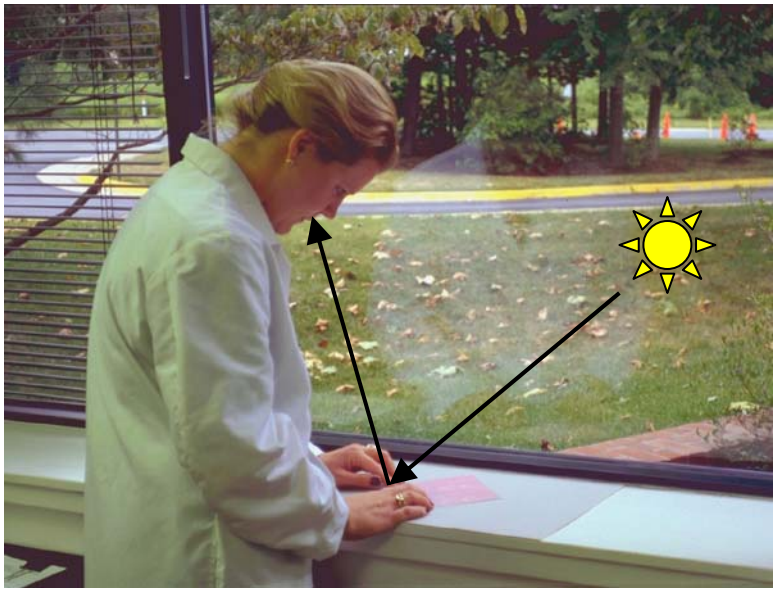
How Should Visual Evaluations of Appearance Be Performed?

As seen in earlier *Applications Notes*, conditions of illumination and viewing, as well as other factors, can greatly affect the perceived appearance of an object. In order to accurately and consistently compare appearance of objects, the viewing conditions should be standardized.

In general, you should make evaluations of *gloss* by viewing the object at an angle equal to but opposite the angle of incidence of the source light, since this is where the specular reflectance occurs. When evaluating *color*, the light should shine directly on the object from overhead and you should examine the specimen from a 45° angle (or vice versa, with the light source at a 45° angle and viewing from directly above). Further recommendations for color viewing conditions are provided in ASTM Method D1729 and are outlined below.

- **Light Source** - The light source may be daylight, incandescent, or cool white fluorescent, but the choice must be specified.
- **Photometric Conditions** - The intensity of the light should be 75-175 foot candles.
- **Geometric Conditions** - Light source overhead at 0° and viewing at 45° (or light source at 45° and viewing at 0°).
- **Background to samples being viewed** - Should be neutral gray and uncluttered.

The samples to be compared should be placed right next to each other (abutting), but should not overlap.



Visual evaluation of color with the light illuminating the sample from a 45° angle and the viewing from directly over the sample.

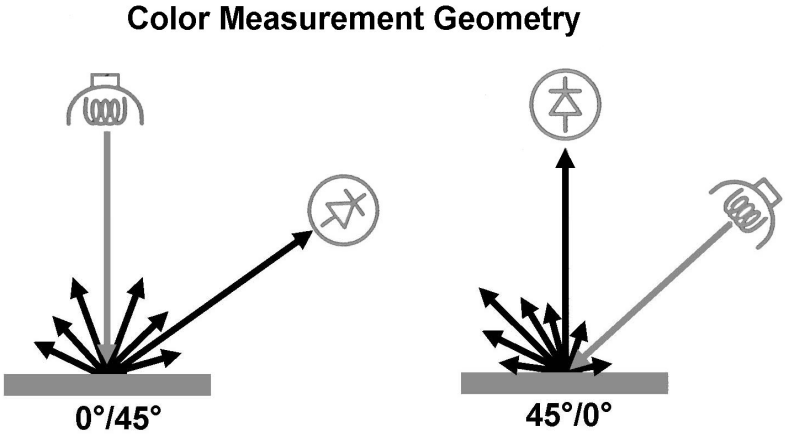
How is Appearance Evaluated Instrumentally?

Instruments used to measure color and appearance are based on the actual human observing situation that was described in the May 2000 *Applications Note*. They, too, have a light source (the light shining from the lamp onto the sample), an object (the sample being measured), and an observer (a detector). The configuration of these three elements can vary.

The factors affection instrumental measurements are listed in the sections below.

Instrument Geometry

The most important geometries of color-measuring instruments are discussed in the May 1995, June 1995, and July 1995 *Applications Notes*.



Example instrument configurations. Note that each has a light source (lamp), object (sample), and observer (detector), just like the visual observing situation.

Object Properties

Color, texture, and other properties of the object being measured are also factors affecting the numbers obtained via instrumental measurement. The four object types (initially described in the May 2000

Applications Note), opaque nonmetals, opaque metals, transparent samples, and translucent samples, should each be measured differently to take their object properties into account. These measurement procedures are outlined below.

Opaque Nonmetals

Opaque nonmetals should be measured in reflectance mode. The choice of instrument geometry depends on the information desired. When measurements that correspond to visual changes in the sample caused by surface texture or roughness are desired, a 45°/0° or 0°/45° instrument should be used. A diffuse/8° (sphere) instrument should be used for minimizing differences in measurements due to surface differences.

Metals

Since the color of a metal sample is contained in the specular reflection, smooth metal samples should be measured on a sphere instrument in the reflectance - specular included (RSIN) mode. If the surface of the metal is roughened, a 45°/0° instrument may be used.

Transparent Samples

Transparent samples should be measured in transmission mode using a sphere instrument. Diffuse, regular, or total transmission may be chosen. Transmission haze and APHA are also possible measurement parameters for transparent materials.

Translucent Samples

Translucent samples both reflect and transmit light. It is best to attempt to measure them in reflectance mode by:

- Fixing the thickness of the sample and adding enough layers to make it opaque or nearly opaque.
- Backing the sample material with a white background.
- Covering the sample with a black cover to minimize ambient lighting interference.
- Using small area illumination and large area viewing to minimize light trapping.

Instrument Types

There are two types of instruments for measuring color. These categories are separate from the geometrical instrument categories already discussed. Understanding the types of instruments available for measuring color is important when choosing the instrument to purchase or use for your application. The terms “colorimeter” and “spectrophotometer” cause some confusion, so their differences are outlined in the March 1995 A*pplications Note*.

Basis of Instrumental Calibration

The way the instrument was calibrated and to what primary standards from which standards agency readings are being compared is significant when measurements made on different instruments are being compared. Information on perfect reflecting diffuser standards is provided in the March 1996 *Applications Note*.

Sample Preparation Method

The ideal sample for instrumental color measurement would be completely opaque, uniform, flat, smooth, non-directional, homogeneous, and at least slightly larger than the instrument measurement port. It also should not be photochromic (its color changes with light) or thermochromic (its color changes with heat), and it should be representative of the entire lot from which the sample was obtained.

Most samples do not fall into this category, however, and must be prepared for measurement by making them as ideal as possible.

Samples for reflectance measurement that are not opaque can be layered or backed with a white tile for measurement. Non-opaque samples can also be measured in transmission mode. Samples that are not uniform, such as powders and granules, may be crushed or ground into a uniform powder. Solid samples that are not uniform, such as patterned fabrics, may be divided into similar sections which are measured individually, or the pattern may be measured as a whole and the color averaged over that sample area. Samples that are not completely flat can be flattened by pressure at the measurement port or pressed into a pellet or plaque (in the case of powders). Non-homogeneous samples may be stirred or several samples taken of the sample "with replacement" of the sample at the instrument port. If you require assistance in preparing an unusual sample for measurement, you may contact HunterLab Customer Support for assistance.

Sample Presentation Method

There are many different ways of presenting any given sample to the instrument. A powder, for example, may be poured into a sample cup and measured at the instrument port through the glass. It may also be pressed into a plaque and measured or dissolved in water and measured in the transmission compartment of a sphere instrument. Samples may be backed with a tile, covered with a light trap, rotated between measurements, or measured multiple times and averaged. Since there are so many different presentation procedures, the one used for a measurement must be specified. Information regarding orientation of the sensor and the size of the port plate used should also be indicated where various options are possible for the instrument.

The following is a list of general measurement guidelines applicable to most, if not all, samples.

- Where multiple steps are involved in preparing and measuring samples, it is a good idea to prepare a checklist of steps to be followed each time the measurement is performed.
- When multiple samples are to be measured and compared, be consistent with all parameters relating to preparation and presentation.
- Conduct measurements in a clean, air-conditioned room out of strong drafts and direct sunlight. Avoid fumes and dust which might leave deposits on instrumental components.
- Use the largest area of view possible for each sample.
- Take multiple measurements of each sample and average the readings.
- Avoid any noticeable surface imperfections on samples.
- Use an instrument with circumferential illumination or viewing or a sphere instrument when directionality of samples is obvious.

Reporting and Comparing Instrumental Measurements

We have already seen that many factors can affect perceptions and/or measurements of an object's color. They include the properties of the light source, the object itself, the observer, the color scale or index, and the type of instrument and its geometry. Since all of these factors play a role, it makes sense that when numbers describing color are reported, the conditions of the measuring situation must also be reported.

When reporting color measurements, the following information must be provided:

- The color scale or index being reported,

- The illuminant,
- The observer,
- The instrument type, geometry, and mode,
- The basis of the instrument calibration,
- The sample preparation method,
- The sample presentation method.

Comparison of instrumental measurements are meaningless unless all of these parameters are the same for the measurements being compared. Parameter differences are a major cause of disappointment when two plants or two operators try to compare their measurements and it proves unsatisfactory. If the differences still cannot be explained after confirming that the seven parameters are identical for the measurements, only then need product or instrumental problems be suspected.

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