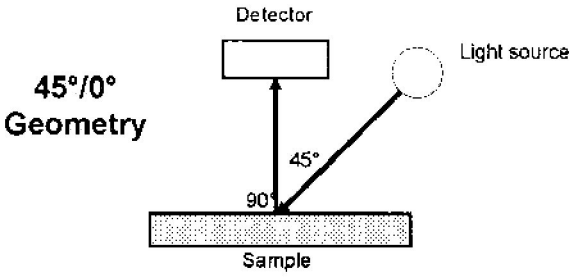
Applications Note

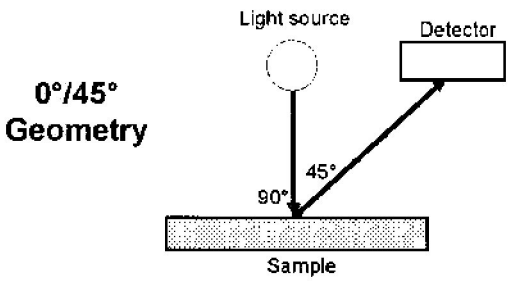
Insight on Color **Vol. 6, No. 7**

Instrument Geometries and Color Measurements
Part I: 45°/0° and 0°/45°

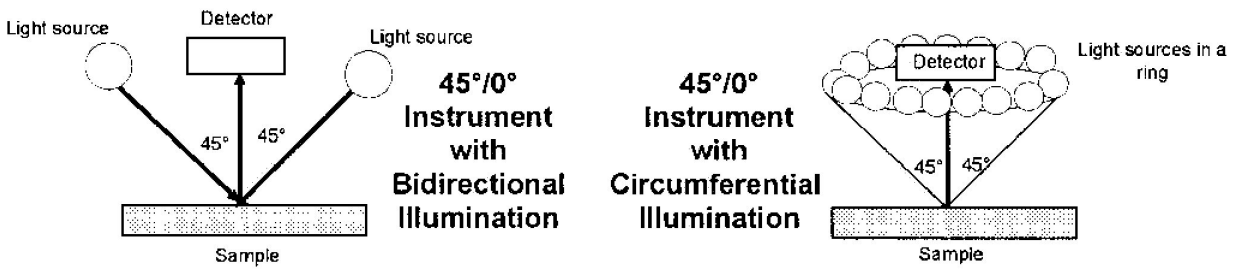
Description

In a description of instrument geometry, the first number is the angle or method of illumination and the second number is the angle or method of viewing. These are both relative to the perpendicular to the surface of the sample being measured. In an instrument with a 45°/0° geometry, the illumination (light source) shines on the sample at an angle 45° from the perpendicular to the sample surface. The viewer (detector) receives the reflected light at a location 0° from (in line with) the perpendicular to the sample. 45°/0° and 0°/45° are reciprocal geometries and yield equivalent measurements. See the drawings below. The following instruments are built using this geometry: ColorFlex 45/0, ColorQuest 45/0 LAV, D25A/L/M, D25LT, MiniScan XE Plus 45/0, and LabScan XE.





These instruments can have either bidirectional or circumferential illumination. Bidirectional 45°/0° instruments illuminate the sample with two light sources on opposite sides of the sample, each 45° from the sample plane. Circumferential instruments illuminate the sample using many lights in a ring around the sample, 45° from it. See the diagrams below. Measurements using the two types of instruments are slightly different, since circumferential illumination reduces the effects of sample directionality (by providing even lighting across the sample surface), and bidirectional illumination does not. HunterLab D25A instruments use bidirectional illumination. HunterLab ColorFlex 45/0, ColorQuest 45/0 LAV, D25L/M, D25LT, and MiniScan XE Plus 45/0 instruments use circumferential illumination. The LabScan XE 0°/45° has circumferential *viewing*.



45°/0° and 0°/45° instruments measure in reflectance-specular excluded mode only. They optimally measure *appearance* of samples, which includes a color component and a geometric component (gloss and texture). For instance, when a shiny specimen is viewed, it may appear darker and more saturated in color than a matte sample, even if the samples are equally pigmented. A 45°/0° or 0°/45° instrument yields values indicating that the shiny sample *is* darker and more saturated.

Applications

- These instruments "see" color in the same way the eye does and are preferable for applications where this feature is important.
- Measurements for which reflectance-specular excluded mode is preferred.
- For measuring differences in *appearance* of samples, including the effects of color, gloss, and texture.
- 45°/0° and 0°/45° instruments are generally preferred for measuring fluorescent samples and translucent samples by reflection.
- Opaque specimens.
- Color formulation. You should perform color formulation using samples and standards on the same substrate.
- Quality assurance/quality control.

How the Numbers Look

In order to demonstrate that 45°/0° and 0°/45° instruments measure how specimens appear, including the contributions of color and geometry, readings of shiny (silky) and matte cloth of the same color were made. On visual assessment, the shiny fabric looked darker and more saturated than the matte fabric. Two measurements of each fabric were made using a ColorQuest 45/0.

Fabric ID	L (D65/10°)	a (D65/10°)	b (D65/10°)
Shiny 1	83.92	10.63	10.98
Shiny 2	84.25	10.45	10.98
Matte 1	85.32	8.74	9.79
Matte 2	85.28	8.86	9.99
Range	1.40	1.89	1.19

These numbers agree with the visual assessment. The shiny samples appear darker and have lower (closer to black) L values. Both a and b are larger (more saturated) for the shiny fabric.

In order to demonstrate the difference between bidirectional and circumferential instruments, readings of blue and white striped check paper were made. Two readings were taken with the strips parallel to the length of the instrument, and two were made with the sample turned 90°, with the stripes parallel to the width of the instrument.

Bidirectional (D25A) ID	**X (C/2°)**	**Y (C/2°)**	**Z (C/2°)**	**Circumferential (ColorQuest 45/0) ID**	**X (C/2°)**	**Y (C/2°)**	**Z (C/2°)**
Length 1	63.33	67.89	81.43	Length 1	65.29	69.69	82.53
Length 2	63.32	67.86	81.41	Length 2	65.82	70.39	83.01
Width 1	66.08	70.45	84.71	Width 1	65.93	70.52	83.25
Width 2	66.05	70.40	84.69	Width 2	65.93	70.50	83.22
Average	64.70	69.15	83.06	Average	65.74	70.28	83.00
Range	2.76	2.59	3.30	Range	0.64	0.83	0.72

As you can see, the measurements using circumferential illumination are much closer together. If a bidirectionally-illuminated instrument is used, averaging two readings with 90° rotation between readings is recommended.

References

Billmeyer, Fred W., Jr. and Saltzmann, Max, *Principles of Color Technology*, New York: John Wiley & Sons, Inc., 1981.

Hunter, Richard S. and Harold, Richard W., *The Measurement of Appearance*, New York: John Wiley & Sons, Inc., 1987.

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