WI 140804.02

T 562

DRAFT NO. 3 - SARG

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SUBJECT CATEGORY Optical Properties

RELATED METHODS See "Additional Information"

CAUTION:
This Test Method may include safety precautions which are believed to be appropriate at the time of publication of the method. The intent of these is to alert the user of the method to safety issues related to such use. The user is responsible for determining that the safety precautions are complete and are appropriate to their use of the method, and for ensuring that suitable safety practices have not changed since publication of the method. This method may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Material Safety Data Sheets which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this method, the user must determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, must follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

CIE whiteness and tint of paper and paperboard (45/0 geometry, *C*/2 illuminant/observer) (Five-year review of T 562 om-10)

(Changes from Draft 1 incorporated)

1. Scope

1.1 This method is used to determine the CIE whiteness and tint indicies *(1)* of white or near white specimens with or without optical brighteners. Whiteness differs fundamentally from paper brightness in that whiteness includes the entire visible spectrum in its assessment whereas brightness includes only the blue portion of the spectrum.

2. Summary

2.1 The conditions specified in this method determine the tristimulus values of the specimen and the CIE whiteness and tint values are then calculated. The ultraviolet (UV) content of different light sources affects the excitation of fluorescent brighteners to a greater or lesser degree and therefore it is necessary to provide a means of adjustment of the ultraviolet energy.

3. Significance

3.1 Paper is bought, sold and used primarily indoors. Therefore it is important to assess the "whiteness" of the paper under similar conditions. When "white" papers are ranked subjectively, it has been shown that people prefer bluish whites to grayish, yellowish, greenish, or pinkish whites. As a consequence, papermakers often add fluorescent whitening agents or optical brightening agents to enhance the appearance of their papers. The CIE whiteness and tint equations have a blue bias to better quantify what people prefer. CIE whiteness values correlate well with visual whiteness assessment when the UV level of the source approximates that of average indoor lighting *(2)*.

3.2 A positive tint value indicates a greenish sample; a negative value indicates a reddish sample. The further the tint value is from zero, the more colored the sample. The perfectly reflecting diffuser would have a whiteness value of 100 and a tint value of 0. Whiteness and tint values are not appropriate for strongly colored samples.

4. Definitions

4.1 *CIE whiteness index*: A measure of whiteness derived from measurements of the CIE tristimulus factors under the conditions specified in this method.

5. Apparatus

5.1 *Instrumental components*: a colorimeter or spectrophotometer consisting of a means for fixing the location of the surface of the specimen, a system for proper illumination of the specimen, suitable filters or monochromator for altering the spectral character of the rays reflected from the specimen, photosensitive receptors located to receive the rays reflected by the specimen and a means of transforming the receptor signals to tristimulus functions.

5.2 *Spectral characteristics.*

5.2.1 *Incident light*: The spectral power distribution of the light incident on the specimen is not critical so long as sufficient energy is provided at each wavelength between 400 and 700 nm to achieve the overall spectral

response referenced in 5.2.2 *(3)*. The incident UV light energy must be adjustable to allow calibration to the fluorescent standard.

5.2.2 *Spectral response*: If a colorimeter is used, the overall spectral response of the instrument, as determined by the combination of the spectral distribution of incident light on the specimen, the absorption characteristics of the filters and other light altering optics, and the photosensitive response of the receptors to light reflected from the specimen, shall simulate the CIE color-matching function weighted by the spectral energy distribution of the CIE Illuminant *C*/2° given in ASTM Standard E 308 *(4)*. If a spectrophotometer is used, mathematical integration shall be employed to achieve the tristimulus values.

5.2.3 *Geometric characteristics.* The angle of viewing is required to be separated from the angle of illumination in such a manner that only rays reflected diffusely from the test specimen enter the receptor, thereby excluding specular reflectance from the reading. The illuminating beam shall be centered about an axis of 45 ± 0.5° from the normal to the specimen surface. The direction of viewing shall be perpendicular ± 0.5° to the specimen surface. The angle between the axis and any ray of either the illuminating or viewing beam shall not exceed 22.5°.

Note 1: Geometric characteristics should be the same as TAPPI T452.

5.2.4 *Photometric characteristics*: The photometric system must be linear over the entire scale to within 0.3% of full scale. It must be sufficiently stable that the reflectance factor reading will not fluctuate by more than 0.1% of the full scale while the measurement is being made.

6. Standards

6.1 *Primary reflectance standard*: The primary reflectance standard (100%) is an ideal uniform diffuser with a perfectly reflecting and diffusing surface (the perfect reflecting diffuser).

6.2 *Reference standards*: Reference standards, used to adjust and check the instrumental scale on a regular basis, are available from calibration laboratories, instrument manufacturers and other sources. Reflectance values assigned to reference standards shall be traceable to an instrument calibrated in terms of the primary standard and having the appropriate geometric and spectral characteristics consistent with the instrument being used. A stable black standard and at least one stable non-fluorescent white standard must be employed. If measurements are to be made on optically brightened (fluorescent) specimens, the instrument must also be calibrated to a fluorescent white standard.

7. Calibration

7.1 Allow the instrument to warm up according to the manufacturer's instructions.

7.2 Using the reference standards described in 6.2, follow the manufacturer's instructions to achieve calibration.

8. Test specimen

8.1 From each test unit of the paper obtained in accordance with TAPPI T 400 “Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product,” cut the sample to be tested into pieces large enough to extend at least 1/4 inch beyond all edges of the instrument aperture. Assemble the pieces into a pad which is thick enough so that doubling the pad thickness does not change the test readings. (With creped or other bulky papers , take care to avoid pillowing of the pad into the instrument by too much pressure). Do not touch the test areas of the specimens with the fingers, and protect test area from contamination, excessive heat or intense light.

9. Procedure

9.1 Calibrate the instrument as described in Section 7.

9.2 Place the opaque pad of sample sheets with the side to be measured against the sample aperture and with the machine direction parallel to the light beam. Make a measurement. If the instrument automatically calculates CIE whiteness go on to 9.3, otherwise obtain the reflectance values R_X, R_Y and R_Z or tristimulus values, X, Y and Z.

9.3 Move the uppermost test piece to the bottom of the pad and obtain the reflectances of the newly exposed specimen. Repeat this process until five specimens have been measured.

Note 2: If necessary, recheck the instrument calibration and retest the sample if any of the calibration values have drifted by more than 0.1% of full scale.

10. Calculations

If the CIE whiteness and tint values are not calculated directly, perform the following calculations:

$$X = 0.78341\ R_X + 0.19732\ R_Z$$

$$Y = R_Y$$

$$Z = 1.18232\ R_Z$$

and then

$$x = X / (X + Y + Z)$$

$$y = Y / (X + Y + Z)$$

and finally (for C/2 illuminant/observer):

$$\text{CIE whiteness} = Y + 800\ (x_n - x) + 1700\ (y_n - y)$$

$$\text{CIE tint} = 1000\ (x_n - x) - 650\ (y_n - y)$$

Where x_n and y_n for *C*/2 illuminant/observer are:

$x_n = 0.3100605$

$y_n = 0.3161496$

As guidelines, the following limits are recommended:

$5Y - 280 > W > 40$

$-4 < T < 2$

where

W = CIE Whiteness

T = CIE Tint

11. Report

11.1 Report the average values and standard deviations for the whiteness and tint values rounded to the nearest tenth (0.1).

11.2 Report the use of 45/0 geometry and *C*/2 illuminant/observer.

11.3 Identify the sample type and side (or sides) tested.

11.4 Identify the instrument used by geometry, manufacturer's name and model number.

11.5 Report any deviations from this method.

12. Precision

12.1 Repeatability (within a laboratory) = 0.7%.

12.2 Reproducibility (between laboratories) = 10.5%.

Repeatability and reproducibility are estimates of the maximum difference (at 95% confidence) that should be expected when comparing test results for materials similar to those described below under similar test conditions. These estimates may not be valid for different materials and testing conditions.

12.3 The precision estimates of repeatability and reproducibility are based on data from 4 different printing papers with 5 specimens per sample. One measurement specimen, repeated 3 times, for a total of 15 determinations. Five laboratories were included in these calculations.

12.4 Calibration was conducted by participants prior to testing. Calibration standards of quality IR Level 3 (IR3) or IR Level 2 (IR2) were recommended.

Sample	Grand Mean	r TAPPI Repeatability	%r Repeatability	R TAPPI Reproducibility	%R TAPPI Reproducibility
14 pt. non FWA food board	71.50	1.394	1.95%	4.361	6.10%
60# offset	107.51	0.327	0.30%	9.692	9.02%
100 Brightness 28# bond	115.00	0.430	0.37%	17.761	15.44%
CIE 169 28# bond	132.95	0.259	0.19%	15.192	11.43%

13. Keywords

Color, Whiteness, Brightness, Tinting

14. Additional information

14.1 Effective date of issue: to be assigned.

14.2. This method is similar to TAPPI T 560. This method uses 45/0 geometry, whereas, T 560 uses *d*/0 geometry.

14.3 Related methods are: ISO 11475 “Determination of CIE Whiteness, D65/10 (Outdoor Daylight)”; ISO 11476 “Determination of CIE Whiteness, *C*/2 (Indoor Illumination);” ASTM E313 “Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates;” ASTM E308 “Standard Practice for Computing the Colors of Objects by using the CIE System;” TAPPI T 452 “Brightness of Pulp, Paper, and Paperboard (Directional Reflectance of 457 nm)”; ASTM E313 “Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates.”

14.4 Changes made to this document in 2017 include a reference to TAPPI T452 after Section 5.2.3, a change to the tolerance from 0.2% to 0.3% in Section 5.2.4, Section 9.4 was converted to Note 2, The tint tolerance was changed to -4<T<3 in Section 10, A reference to ASTM E313 was added to section 14.3.

Literature cited

1. Colorimetry, Second Edition, Publication CIE No. 15.2 (1986), Central Bureau of the CIE, A-1033 Vienna, P.O. Box 169 - Austria, pp. 36-38. CIE Journal 1.
2. Jordan, B. D. and O'Neill, M. A., "The Whiteness of Paper - Colormetry and Visual Ranking," *Tappi Journal,* **74**(5): (1991).
3. Malthouse, D. D., and Popson, S. J., "A new Way of Measuring the Effect of Fluorescent Whitening Agents," *APPITA Journal*, **48**(1): 95 (1995).
4. ASTM Standard Practice E308, standard practice for "Computing the Colors of Objects by Using the CIE. Systems," American Society for Testing and Materials, West Conshohocken, PA.

References

1. Brockes, A., "The Evaluation of Whiteness."
2. Ganz, E., "Whiteness Formulas: A Selection" *Applied Optics,* **18**(7): (April 1979).
3. Bristow, J. A., "What is ISO-Brightness? We Must Avoid Ambiguity!" *Tappi Journal*, **77**(5): (1994).
4. Gartner, F. and Griesser, R., "A Device for Measuring Fluorescent White Samples with Constant UV Excitation," *Die Farbe,* **24**(1/6): (1975).
5. Griesser, R., "Instrumental Measurement of Fluorescence and Determination of Whiteness: Review and Advances," *Review of Progress in Coloration,* Ciba-Geigy Ltd., Basle, Switzerland, **11**: 25 (1981).

Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Standards Department. ■