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Optical measurements terminology (related to appearance evaluation of paper)

1. Scope

1.1 This glossary defines terms used in the pulp and paper industry relating to both visual and instrumental evaluations of appearance. This technical terminology includes such optical assessments such as brightness, whiteness, color, gloss, opacity, scattering, absorption, etc.

2. Significance

2.1 This glossary of terms and definitions has been assembled by the TAPPI Optical Properties Committee. The committee has consulted definitions published by the American Society for Testing and Materials, Illuminating Engineering Society, International Commission on Illumination, Inter-Society Color Council, and the Optical Society of America. Many of the terms in this glossary are applicable to both radiometric and photometric quantities, but each term can be restricted to the intended quantity by adding the adjective “radiant” or “luminous,” respectively.

3. Safety precautions

There are no safety precautions required for this Standard Glossary.

4. Definitions

Abridged spectrophotometer - see *Spectrophotometer, abridged*.

Absolute brightness - the reflectance of blue light corresponding to a centroid wavelength of 457 nm in terms of the perfect reflecting diffuser. See TAPPI T 534 “Brightness of Clay and Other Mineral Pigments (Diffuse Blue Reflectance)” and TAPPI T 525 “Diffuse Brightness of Pulp.” Also, see *Perfect reflecting diffuser*.

Absolute reflectance factor - the ratio, which may also be expressed as a percentage, of the radiation reflected by a body to that reflected by the perfect reflecting diffuser under the same conditions of illumination and viewing.

Approved by the Standard Specific Interest Group for this Standard Glossary



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Absorbance - the negative logarithm to the base 10 of the internal transmittance for a transparent material.

Absorptance - the ratio of absorbed flux to incident radiant flux.

Absorption - the process by which light or other electromagnetic radiation is converted into another form of energy such as heat when incident on or passing through material.

Absorption, coefficient of (K) - for a thin layer within an isotropic absorbing and scattering material over a black backing, the limit as the layer thickness approaches zero of the fraction of the incident radiation absorbed by the layer, divided by its thickness. Dimensions are reciprocal grammage (usually m²/kg in this case).

Absorptivity - see *Absorption, coefficient of*.

Adams coordinates - see *Opponent color scales (L,a,b)*.

Additive color mixture - see *Color mixture additive*.

Angle of incidence - the angle between the axis of an impinging light beam and the normal to the specimen surface.

Angle of view - angle between the axis of observation and the normal to the specimen surface.

Angstrom - see *Wavelength units*.

Beer's law - transmittance of a stable solution is the exponential function of the product of concentration (*c*), absorptivity (*k_l*), and length of path (*x*) in solution.

$$T = E^{ck_l x}$$

Black - color name applied to opaque objects that are highly absorbing throughout the visible spectrum.

Bleached specimen - specimen whose absorptance has been decreased by chemical or radiant means.

Blue - hue name applied to light of wavelengths from 455 to 485 nm and to visually similar stimuli.

Brightener: optical - see *Fluorescent whitening agent*.

Brightness (of paper) - reflectance of an infinitely thick stack of material (reflectivity) measured for blue light with centroid wavelength of 457 nm under specified spectral and geometric conditions of measurement [see TAPPI T 452 "Brightness of Pulp, Paper and Paperboard (Directional Reflectance at 457 nm)"].

Brightness, absolute - see *Absolute brightness*.

Brightness reversion - see *Reversion, brightness*.

Bronzy color (or bronzing) - a metallic-like color observed by viewing a surface in the general direction of specular reflection. (Hue observed in the direction of specular reflection is usually quite different from the hue observed for other directions.)

Brown - color name for perception of dark yellow or dark orange.

Candela - the SI unit of luminous intensity; luminous intensity, in the perpendicular direction, of a surface of 1/600,000 m² of a blackbody (full radiator) at the temperature of freezing platinum under a pressure of 101,325 Pa.

Centroid (wavelength) (effective wavelength) - wavelength of center of gravity of area under curve of spectral function.

Chromatic - perceived as having a hue; not white gray, or black.

Chroma, Munsell - see *Munsell chroma*.

Chromaticity - dimensions of color stimulus excluding luminous magnitude, often designated by coordinates of point in rectangular or polar coordinate system.

Chromaticity coordinates - the ratios of each tristimulus value of a color to the sum of the tristimulus values. (Chromaticity coordinates in the CIE system of color specification are designated *x*, *y*, and *z*.)

Chromaticity diagram - plane diagram formed by plotting one of the three chromaticity coordinates against another.

Chromaticity diagram, CIE - formed by plotting two CIE chromaticity coordinates, usually *x* and *y*.

CIE - abbreviation for International Commission on Illumination, which in french is commission Internationale de l'Eclairage.

CIE coordinates - see *Chromaticity coordinates*.

CIE $L^*a^*b^*$ (CIELAB) - see *Opponent color scales*.

CIE observer - see *Observer, standard, CIE 1931 and Observer, supplementary, CIE 1964*.

CIE illuminant A - colorimetric illuminant, representing the full radiator at 2856K, defined by the CIE in terms of a relative spectral power distribution.

CIE illuminant C - colorimetric illuminant, representing daylight with a correlated color temperature of approximately 6800K, defined by the CIE in terms of a relative spectral power distribution.

CIE illuminant D 65 - colorimetric illuminant, representing daylight with a correlated color temperature of approximately 6500K, defined by the CIE in terms of a relative spectral power distribution.

Clarity - the characteristic of a material permitting distinct images to be observed through it (see *Transparency*).

Color, perceived - attribute of visual perception that can be described by color names, such as *white*, *gray*, *black*, *yellow*, *brown*, *vivid red*, *deep reddish purple*, or by combinations of such names.

NOTE 1: Spectrally different color stimuli can under certain conditions produce identical perceived colors; their colorimetric specifications are then also identical (see *Metameric objects*).

NOTE 2: When the meaning is clear from the context, the term *color* may be used alone.

Color, psychophysical - characteristics of a color stimulus (i.e., light producing a sensation of color) denoted by three values such as three tristimulus values.

NOTE 3: The appearance of a color depends not only on its tristimulus values but also on the conditions under which it is viewed, including the nature of the surround; however, colors having the same tristimulus values appear the same if viewed under the illuminant for which the tristimulus values were determined.

NOTE 4: Spectrally different color stimuli can have the same absolute tristimulus values.

NOTE 5: When the meaning is clear from the context, the term *color* may be used alone.

Color difference -

1. *Color difference (perceived)* - the magnitude and character of the difference between two colors, described by such terms as redder, bluer, lighter, darker, grayer, or more saturated.

2. *Color difference (computed)* - the magnitude of color difference and its components computed from tristimulus values, or chromaticity coordinates and luminance factor, by means of a specified set of color difference equations.

Color difference units - determined by weighting factors of particular color difference equations. For identification of various color-difference scales, see TAPPI T 1215 "The Determination of Instrumental Color Differences."

Color match - one color indistinguishable from another under specified illuminating and viewing conditions.

Color matching - procedure of selecting and adjusting a color mixture until all visually apparent differences are minimized between mixture and standard.

Color measurement - the process of deriving, for a given color, numbers which serve to identify it. Since color is tridimensional, a minimum of three numbers is required for a complete specification. Most widely used for color measurement are the various forms of tristimulus color specification, each of which is traceable to a visually matching mixture of three primary lights.

Color mixture, additive - superposition or other non-destructive combination of lights of different chromaticities.

Color mixture, subtractive - mixture of absorbing media or superposition of filters so that spectral composition of light passing through combination is determined by simultaneous or successive absorption.

Color notation - the systematic use of symbols or numbers to designate color.

Color of an object - the aspect of object appearance distinct from form, shape, size, position, or gloss that depends upon spectral composition of incident light, spectral reflectance or transmittance of the object, and spectral response of the observer as well as the illuminating and viewing geometry.

Color perception - subjective impressions of color, as modified by conditions of observation and by mental interpretation of stimulus object.

Color scale - series of stimuli perceived as having differences of some attribute of color sensation.

Color solid - same as *color space*.

Color space - A three-dimensional arrangement representing all possible colors with respect to their primary attributes of hue, brightness or lightness, and saturation.

Color specification - tristimulus values, chromaticity coordinates and luminance value, or other color-scale values, used to designate a color numerically in a specified color system. (Practical color specifications should include tolerances as well as target color designations.)

Color staining - discoloration of a material by unintended transfer of ingredients from contact with another material.

Color standard - objects used for making a visual or photo-electric evaluation of the color of a test material. The standard may represent physical example of numerical color specification.

Color tolerance - the permissible color difference between a sample and a specified standard color.

Colorant - substance added to an object to change the color of light reflected from, or transmitted by, an object.

Colorimeter - an instrument designed for direct measurement of color.

Colorimetric purity - see *Purity, colorimetric*.

Colorimetric specification - see *Color specification*.

Colorimetry - science of color measurement.

Complementary color - the color that when combined additively with another color produces mixture that matches the agreed-upon achromatic color.

Contrast ratio - ratio of the luminous reflectance of a specimen backed with a black material of specified reflectance to the reflectance of the same specimen backed with white material of a specified reflectance. *Contrast gloss* (see *Luster*).

Daylight, artificial - a light source whose spectral distribution of radiant flux is similar to that from natural daylight (combined light from sun and sky).

Densitometer - instrument designed for measuring optical density of a photographic negative or positive or a printed image.

Density, optical - negative logarithm to base 10 of transmittance for transparent material or the reflectance for an opaque material.

Diffuser, perfect - ideal, completely reflecting or transmitting uniform diffuser.

Diffuser, uniform - ideal surface that reflects or transmits in accordance with Lambert's Law.

Diffusion - scattering of the incident radiant flux.

Directional reflectance - see *Reflectance factor*.

Directional transmittance - see *Transmittance factor*.

Dominant wavelength - see *Wavelength, dominant*.

Energy, radiant - energy emitted, transferred, or received as radiation.

Entrance window - see *Stop, field*.

Equal-energy illuminant - see *Illuminant, equal energy*.

Excitation purity - see *Purity excitation*.

Exit window - see *Stop, field*.

Fluorescence - process by which electromagnetic radiation in one spectral region is absorbed and re-emitted at other wavelengths, usually longer.

Fluorescent whitening agent (FWA) - fluorescent dye or pigment that absorbs ultraviolet radiation and re-emits blue light, thereby effecting whiter appearance when added to yellow-white material. Same as *Optical Brightening Agent (OBA)*.