Technology Profile

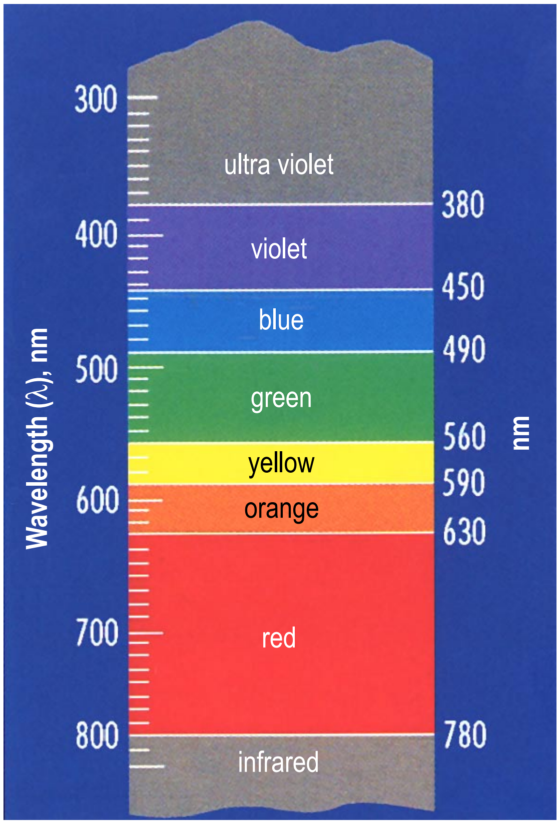
Value to Wood

TP–05–01E
February 2006

Application of Colorimetry[1] for Wood Appearance Products

Colour is a crucial factor in manufacturing hardwood appearance products, and uniformity of colour has a direct impact on the final value of a product[2]. Most wood component manufacturers classify colour using a subjective scale. Although reference samples are used, subjective classification is influenced by both environmental factors and individual perceptions.

In physiological terms, colour is a sensation that translates the impression received by the human eye in the form of electromagnetic energy in a wavelength range from 400 to 800 nanometres. The perception of colour by a human observer is a psychophysical phenomenon that cannot be measured with exactitude[3]. The eyes and the brain tend to automatically adjust to interpret colours correctly based on a given environment[4].



Source: Chrisment (1997)

Optical spectrum

Forintek Canada Corp.

Natural Resources Canada

Ressources naturelles Canada

www.valuetowood.ca

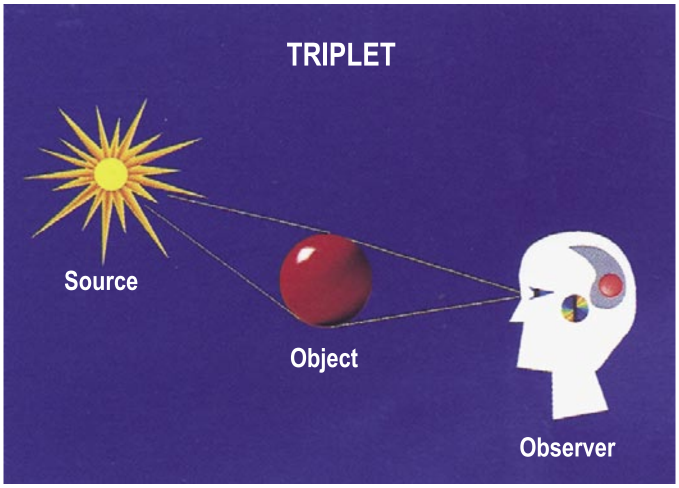
The complexity of colour interpretation, whether for the wood products industry or for other applications, has necessitated the development of an objective method of colour measurement. Colorimetry is the scientific foundation for colour measurement. The International Commission on Illumination (abbreviated as CIE), created in 1913, is the only internationally recognized authority on standards for illumination, colour and colorimetry.

Colorimetry provides a rigorous scientific definition of the perception of colour, and makes it possible to translate colour into numeric values. Colorimetry is a function of a given light source, the observer's trichromatic response, and the material characteristics of the object involved.

The ***light source*** must be perfectly defined and emit a constant energy across the entire visible spectrum (400 – 800 nm). The CIE defines a light source by the quantity of energy emitted at each wavelength.

The observer's ***trichromatic response*** is a reaction to colours, with the retina of the human eye containing three types of light-sensitive receptors, each of which responds to different colours. The CIE has conducted a number of tests to define the parameters of a standard observer's field of vision.

The ***material characteristics*** of an object influence its reflection of light, making the object the only variable to be determined in colorimetry.

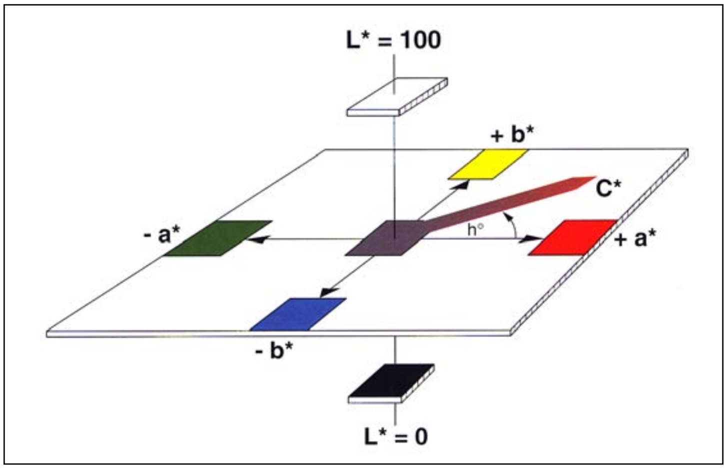


Source: Chrisment (1997)

Three elements : source – object – observer

Initial figures used in colorimetry were based on the wavelengths of primary colours. Subsequently, several versions of a colorimetric standard were developed by the CIE, with the goal of offering improved precision and simplified calculations. Today, the most commonly used standard system is **CIELab**, which refers to the presence of three sets of opponent chromatic signal types, which are converted during the transmission process between the eye and the optic nerve: white – black, red – green, and yellow – blue.

The **CIELab** system is dedicated to the study of surface and object colours using the parameters of L*, a* and b*. L* values represent lightness, and can range from 0 to 100, with 0 designating a perfect black, 50 a medium grey, and 100 a pure white. Lightness is the attribute of visual sensation according to which a body appears to transmit or reflect a greater or lesser portion of light. The red – green chromatic component, a*, ranges from –100 to 100, with –100 designating a perfect green and 100 designating a perfect red. The yellow – blue chromatic component, b*, ranges from –100 to 100, with –100 designating a perfect blue and 100 a perfect yellow.



Source: Chrisment (1997)

CIELab System

The **CIELab** system is well suited to a time-based or repetitive evaluation of variations in colour. The total colour difference, ΔE^*, integrates the difference of the three independent variables of the colorimetric system, as seen in the following equation:

$$\Delta E^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

Literature on the topic indicates that a total colour difference of less than 2 ΔE^* is imperceptible to the naked eye, while a total colour difference of approximatively 1.5 to 2 ΔE^* is just barely perceptible using appropriate equipment. However, industrial application proved that a colourist can see total colour difference of 0.5 ΔE^*.

The difference in chromaticity Δc^* can be used to evaluate the difference in chromatic variation:

$$\Delta c^* = \sqrt{\Delta a^{*2} + \Delta b^{*2}}$$

The total colour difference ΔE^*, the difference of chromaticity Δc^*, and chromatic differences ΔL^*, Δa^*, et Δb^*, are all useful for measuring variations in order to quantify differences and acceptable colour limits.

There are two main types of devices used for measuring colour: the colorimeter and the spectrocolorimeter. These devices are equipped with an international colour reference standard. The colorimeter is used primarily in quality control, to obtain numeric values and to verify comparability with defined levels of tolerance. The spectrocolorimeter executes a wavelength-by-wavelength analysis of the luminous energy reflected or transmitted, in order to determine the spectral curves of an object.

« The colorimeter makes it possible to eliminate subjectivity from the decision-making process, resulting in precise, coherent classification. »

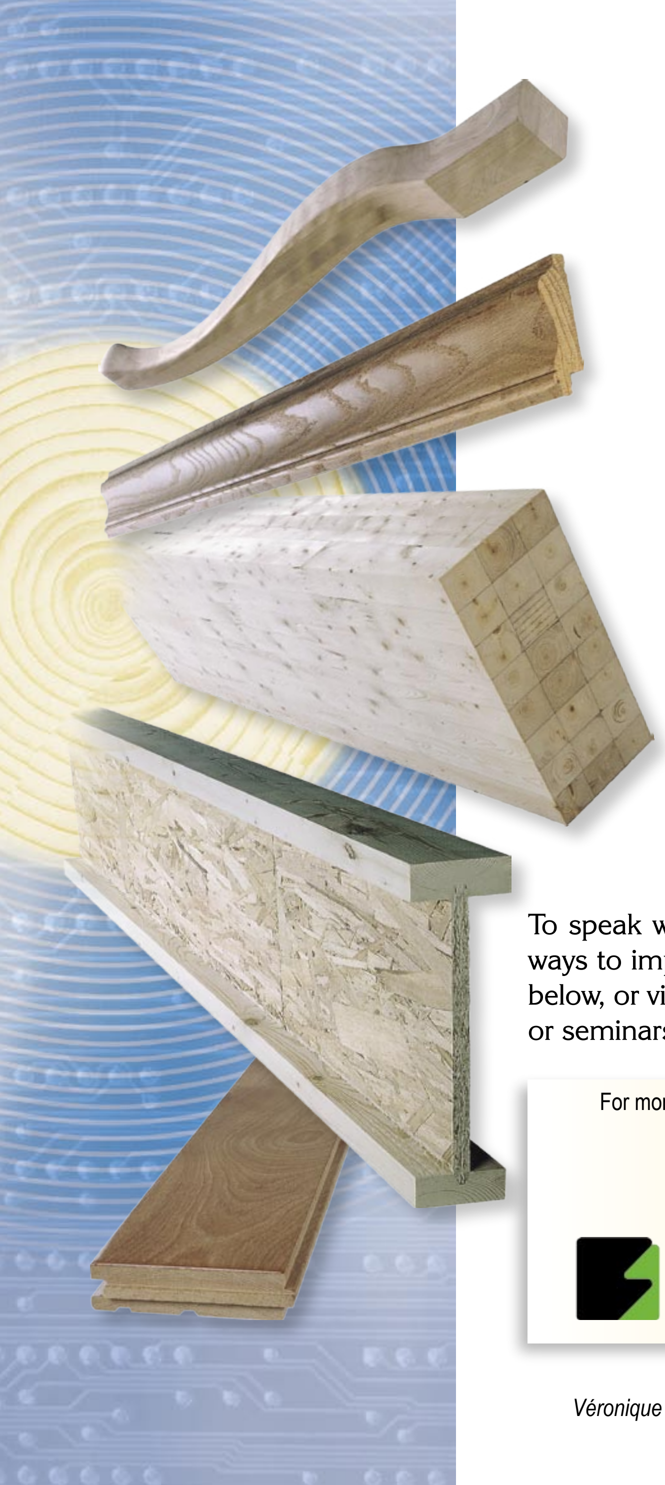
The Colour-Guide spectrophotometer is a portable colorimeter suited to taking readings from various types of wood (green, dry, light, dark, raw, planed, sanded, varnished, stained, painted, etc.), provided that the contact zone (40mm in diameter) is in stable equilibrium. This colorimeter complies with the following colour standards: DIN 5033, 5036, 6174; ISO 7724; and ASTM D2244, E308, E1164. Readings can be expressed in terms of **CIELab** system parameters, or using other parameters, depending on the intended application. The colorimeter can be used for quality control, sorting, definition of colour class limits, analysis of the product behaviour, or for any other related task where the subjectivity of colour perception is problematic.

Source: Folio Instruments inc.

Colour-guide spectrophotometer

An analysis of the behaviour of wood flooring finished with anti-yellowing varnish is one such example of an application. Readings of the parameters L*, a* and b*, pre-exposure and post-exposure to controlled UV rays, enables an analysis of variations in colour, in particular with regard to the efficacy of the anti-yellowing effect, as expressed in parameter b*. The colorimeter can also serve to establish the limits of a colour standard for a panel manufacturer, the numeric values for colour classification shared between a client and a supplier, or tolerances for the use of finishing products with different levels of opacity.

In conclusion, colour is a determining indicator of product acceptability. The consumer associates uniformity of colour with product quality. The classification of wood by colour is difficult because of the nature of the material and the environment in which it is typically processed. The colorimeter makes it possible to eliminate subjectivity from the decision-making process, resulting in precise, coherent classification.



References

1. The content of this Technology Profile is based upon the information found in: Chrisment A. 1997. *Couleur et colorimétrie*. Paris: Editions 3C Conseil. ISBN 2-9508797-4-8. 30 p.
2. Lu Q., Srikanteswara S., King W., Drayer T., Conners R., and Kline E. 1997. "Machine Vision System for Color Sorting Wood Edge-Glued Panel Parts". In: The Proceedings of IECON 1997; 23rd International Conference on Industrial Electronics, Control and Instrumentation, Volume 3 of 4, Emerging Technologies, Factory Automation, Robotics, Vision, and Sensors, pp. 1460-1464.
3. Stokke D.D., Pugel A.D., and Phelps J.E. 1995. "Variation in Lightness of White Oak Dimension Stock". In: *Forest Products Journal* 45 (10), pp. 51-56.
4. Brunner C.C., Shaw G.B., Butler D.A, and Funck J.W. 1990. "Using Color in Machine Vision Systems for Wood Processing". In: *Wood and Fiber Science*, 22 (4), pp. 413-428.

To speak with your nearest Forintek Industry Advisor about this article or other ways to improve the performance of your business, call Forintek at the numbers below, or visit us at **www.valuetowood.ca** to find out about upcoming workshops or seminars in your area.

For more information on the 2005-2006 ***Value to Wood*** research program, visit www.valuetowood.ca (Research and Development). The partners involved are:

Forintek Canada Corp. — Université Laval — UNB — University of Toronto — UBC

*This **Technology Profile** has been edited by*
Véronique Rancourt, Research Scientist, Value-Added Products, Eastern Division, Forintek Canada Corp.

*Ce **Profil technologique** est également disponible en français.*

Value to Wood

As part of the ***Value to Wood*** program, funded by Natural Resources Canada, Forintek's Industry Advisors are providing technical services to value-added wood product manufacturers in all regions of Canada. If you need information on any technical issue related to wood product manufacturing, you can:

- Send a request via *valuetowood.ca* (Help Desk).
- Contact a *Value to Wood* co-ordinator at one of the following locations:

Forintek Canada Corp.
Value to Wood Co-ordinator (East)
319, rue Franquet, Quebec, QC
Canada G1P 4R4

Tel: (418) 659-2647
Fax: (418) 659-2922

Forintek Canada Corp.
Value to Wood Co-ordinator (West)
2665 East Mall, Vancouver, BC
Canada V6T 1W5

Tel: (604) 224-3221
Fax: (604) 222-5690

info@valuetowood.ca