PERSONAL CARE INDUSTRY COLOR CONTROL
SKIN COLOR MEASUREMENT AND ANALYSIS

In dermatologic practice and clinical research, visual cues such as color are of primary importance for the accurate diagnosis and grading of skin lesions. Quantification of erythema and pigmentation is important for in vivo assessment of skin reactions to external stimuli such as ultraviolet radiation. Measurement of lesion color is also useful for quantitative evaluation of the efficacy of therapies for skin lesions.

However, visual inspection is a matter of perception and subjective interpretation and hardly quantifiable. This is because there is such a wide variety of ways to express a color which make describing a color or color difference extremely difficult and vague. In spite of the ability of human eyes to recognise up to millions of colors, we are unable to precisely quantify our color perception without instrumental means. Therefore, there is a need for objective, science based and non-invasive quantification of skin color or the extent of erythema and pigmentation.

Quantification of Color

Optical properties of opaque object in general are based on reflectance and scatter of light by the object. The ratio of light reflected from a surface patch to the light falling onto that patch is often referred to as the reflectance and it is a function of incoming and outgoing light direction. The light reflected from an object and which we recognise as color is (with the exception of man-made monochromatic light) a mixture of light at various wavelengths within the visible light spectrum from approximately 380 to 780nm.

We can see the lights from wavelengths in the visible light region; however, light is not a color itself. As the definition specifies “the radiant energy which can stimulate the retina in the eye to produce a sense of sight”, the concept of color is formed when light enters the eye and stimulates the retina, and the brain reacts to it.

Chroma Meter CR-400

Spectrophotometer CM-700d

Among the colors of the spectrum, three colors of red, green, and blue are generally described as the three primary colors of light. It is believed that we can perceive colors because the eye has three types of cones (color sensors), which are sensitive to these three primary colors. Figure 1 shows the spectral response curves corresponding to the human eye, according to CIE definition of the 1931 Standard observer. These are referred to as the color-matching functions. $\bar{x}$ (λ) has a high response in the red wavelength region, $\bar{y}$ (λ) has a high response in the green wavelength region, and $\bar{z}$ (λ) has a high response in the blue wavelength region. The colors that we see are the result of different $\bar{x}$ (λ), $\bar{y}$ (λ), and $\bar{z}$ (λ) proportions (stimuli) in the light received from an object.

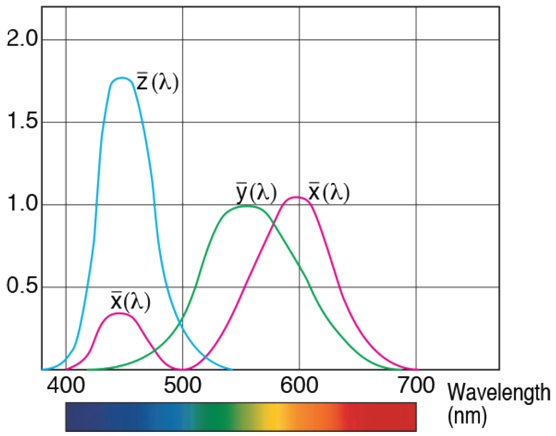


Figure (1) - Spectral response corresponding to the human eye

The XYZ tristimulus values are calculated using these three standard observers color matching functions. XYZ tristimulus values and the associated Yxy color space form the foundation of the present CIE color space.

The L*a*b* color space (also referred to as CIELAB) is presently one of the most popular color spaces for measuring object color and is widely used in virtually all fields. It is one of the uniform color spaces defined by CIE in 1976 in order to reduce one of the major problems of the original Yxy color space: that equal distances on the x, y chromaticity diagram did not correspond to equal perceived color differences. In this color space, L* indicates lightness and a* and b* are the chromaticity coordinates. Figure 2 is a representation of the color solid for the L*a*b* color space.

KONICA MINOLTA SENSING SINGAPORE PTE LTD
10 TEBAN GARDENS CRESCENT SINGAPORE 608923
sensing.konicaminolta.asia

PERSONAL CARE INDUSTRY COLOR CONTROL
SKIN COLOR MEASUREMENT AND ANALYSIS

In this diagram, the a* and b* indicate color directions: +a* is the red direction, -a* is the green direction, +b* is the yellow direction, and -b* is the blue direction. The centre is achromatic; as the a* and b* values increase and the point moves out from the centre, the saturation of the color increases.

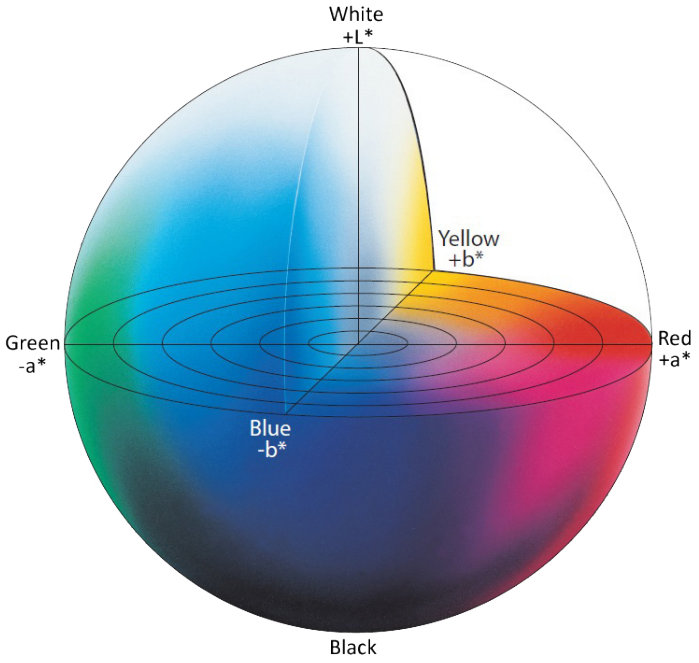


Figure 2 – Representation of color solid for L*a* b* color space

Measuring Skin Color in the L*a*b* system

Konica Minolta chroma meters or spectrophotometers are usually used for the observation of skin color. To quantify the changes in skin color, the CIE L*a*b* color system is most often used. The L*a*b* parameters provide a measure of the perception of skin color and can therefore emulate how the dermatologist or the average person perceive skin. The L*, b* values are often used to evaluate the amount of epidermal melanin, while the a* value is used to evaluate the amount of erythema in the superficial plexus. In an attempt to quantitate skin pigmentation, the 'Individual Typology Angle (ITA)' or 'Alpha Characteristic Angle' has been proposed, defined as the vector direction in the L*–b* plane:

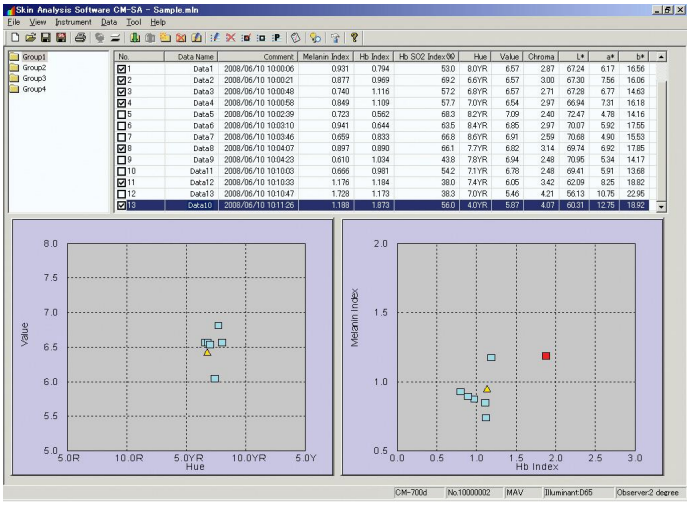
$$ITA^{o} = [\tan^{-1}((L^{*}-50) / b^{*})] \times (180/\pi)$$

Where ITA is given in degrees. It should be noted that ITA values are inversely related to skin pigmentation, e.g. UV induced pigmentation decreases the measured ITA values.

Indices Based On Reflectance Spectrophotometry

Erythema, also referred to as haemoglobin, and melanin indices are the indicators that quantify the intensity of erythema and pigmentation, respectively. These indices are derived from reflectance data of the skin at selected spectral bands. Unlike color coordinates, these indices are designed to show quantities that correlate linearly with the amounts of haemoglobin and melanin in the skin. Therefore, they can be handled as genuine physical quantities.

Previously when full spectrum reflectance spectrophotometers were expensive and cumbersome, portable opto-electronic instruments with selected narrowband wavelength detectors (2 to 3 bands) have been designed and become widely used for measuring the absorption of melanin as well as the absorption of hemoglobin and calculated as a relative index. As technology improved, affordable and portable full visible spectrum reflectance spectrophotometers become available. Utilising spectral methods to analyse the reflected light by its spectral components and then quantify erythema and melanin from the calculated concentrations of haemoglobin and melanin become popular.



Shiseido Co Ltd has developed a method for calculating the concentration of melanin and haemoglobin by spectrum resolution (SR) method. In brief, the spectrum absorbance of skin is expressed as a linear summation of the absorbance of

PERSONAL CARE INDUSTRY COLOR CONTROL
SKIN COLOR MEASUREMENT AND ANALYSIS

melanin in the epidermis, of haemoglobin in vessel blood, and of the dermis. Spectrum absorbance of the skin was calculated from the spectrum reflectance of the skin (in the range of 500-700 nm) measured by a spectrophotometer. Konica Minolta Skin Analysis Software CM-SA is developed based on this research by Shiseido Co Ltd.

The advantage of using Konica Minolta Spectrophotometer with Skin Analysis Software CM-SA over the narrow-band simple reflectance meters is its capability to provide both colorimetric data, as well as, the melanin and haemoglobin indices.

Konica Minolta offers a wide range of colorimeters and spectrophotometers for non-invasive skin color measurement. For more information on display measuring instruments, please visit Konica Minolta website at https://sensing.konicaminolta.asia/color-measurement/

You can visit this website at https://www.konicaminolta.net/instruments/registration_index/ to download our education handbook, Precise Color Communication, which describes the basic theory of color and object color measurement. It includes information on the differences between spectrophotometers and tristimulus colorimeters, as well as an overview of the various color spaces and color-difference notations commonly used.

Alternatively, you can email to us at ssg@gcp.konicaminolta.com or call us at 65 6895 8685 to find out more from our color team on the product capabilities or to have a no-obligation discussion with our application advisors to help you select the appropriate models for your specific application.