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Basic Principles of Colour Measurement and Colour Matching of Textiles and Apparels

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Abstract

This book chapter covers basic principles of quantitative measurement and analysis of surface colour parameters and surface appearance of undyed/dyed textile materials and finally matching of colours with standard samples of any textiles. Surface colour parameters of textile materials change with different chemical processing including bleaching, dyeing and finishing and need to measure it quantitatively for understanding the effect of different chemical processes/dyes and auxiliaries and finishes. So, CIE-1976 equations for measurement of Tristimulus values, surface colour strength, colour differences, Metamerism index, colour difference index as well as specific formulae for measuring Whiteness Index, Yellowness Index, Brightness Index and the theory of colour match prediction are discussed here. One Case study of colour match prediction for a specific case is also shown. Finally, the importance of single constant measurement of surface color parameters for coloured textiles and practical cares for database preparation and colour measurement and match prediction for textile and apparel products are deliberated. Apparel industry is very much dependent on colour psychology and colour preferences of customers in different seasons and occasions and hence, it is important to measure all surface colour parameters of textile materials to choose perfectly matched coloured textiles for making any garment.

Keywords: surface colour strength, Tristimulus values, Total colour differences, colour difference index, Metamerism, whiteness-yellowness and brightness indices. Computer aided colour matching

1. Introduction

Colour and aesthetics are as important as its various physical properties for textiles/garments, leather, moulded plastics, and products of various other fields. The ability to integrally colour (dyeing and Printing) textiles, leather, plastic moulded articles has an important edge over others non polymeric rigid hard materials like metals etc.

Matching of colours and imitate texture, especially in specific textiles of different fibres and blends is crucial in many of its apparel applications. The task becomes more difficult when colours need to be exactly matched with standard colour yield desired with endurable criteria for acceptable colour fastness to wash, rubbing, light

and perspiration etc. for different textiles/plastics and polymer products. So, understanding Theory of colour measurement, quantification, for well defined applications of different dyes/pigments on different textiles materials has become a must for the textile or leather dyers/printers and plastics injection moulder/wall paints etc.

Day by day, more and more concern of consumers on colour matching for consumers' textiles and live-style products of apparels and furnishings, bed linen and auto-mobile (car) Interiors, appliances and along with polymer/plastic assemblies, are pushing the dyed/printed coloured textile product manufacturer to develop their products with more precision colour matching with least meta-merism.

In order to understand the colour we have to know, how the colour is perceived. The perception of colours [1] involves the interaction of three elements. (i) source of light, (ii) an object and (iii) human eye.

2. Colour theory

Colour can be broadly defined as the physio-psychometric effect on the brain of an observer from reflected wavelength of an object, when that object is viewed in presence of a definite light source.

Colour theory meant a Standardised scientific method with specific mathematical/empirical formula with arrangement of incidence of light/standard illuminant for absorption and reflection of the colour on and from the object and then detecting followed by measurement of colour value specific reflectance or any other quantified values to record and communicate colour information for reproducibility and matching.

2.1 CIE definition 845-02-18 of perceived colour

As per CIE definition 845-02-18: (perceived) **colour** may be defined [2] or perceived as “ Attribute of a visual perception consisting of any combination of chromatic and achromatic content. This attribute can be described by chromatic color names such as yellow, orange, brown, red, pink, green, blue, purple, etc., or by achromatic color names such as white, gray, black, etc., and qualified by bright, dim, light, dark etc., or by combinations of such names [Unquote].

Human Perception of colour usually appear to describe a colour in terms of amount of RGB (Red, Green and Blue) sensation of human eye as an additive colour mixing system (as shown in **Figure 1**) distinguish among qualitative and geometric differences of colour perceptions by its predominating Hue (predominating Reflected wavelength observed), Value (Light or Dark i.e. White or Black

Figure 1. Schematic display of colour observed from RGB primary colour stimuli with standard illuminant by a standard observer /detector.

respectively) and chroma (Strength or Concentrations of Coloured mol.) [1] with/without associated brightness/dullness and uv absorption.

Thus, Colour of any object can be considered as an physio-psychological illusion of reflected radiation / visible light from a substance/object after incidence of light on it, which is to be detected in exact quantitative terms by amount of RGB in it (**Figure 1**), while, colorimetry is the measurement and evaluation technique of colour value in any quantifiable terms by which this physio-psychological sensation of our eyes can be converted to the actual physical measurement of colour values either in solution or in solids in some sensory values of primary colours.

If any one want to buy a skirt or a pair of slacks to match a jacket, one cannot match the colour by memory — he/she has to take the jacket with him/her to match it visually by judging colour by eye measurement in the store itself. it may happen that in some cases, the store light is insufficient and faulty matching by eyes results, So, one has to match it also under standard and sufficient incandescent light in the dressing room and and also in the outdoor sunlight too.

Three fundamental components of understanding or measuring or matching any colour:

- light sources /standard illuminant
- objects / samples illuminated by standard light
- observers /detector to record colours reflected from it

Most Important and commercially useable Two of the major Colour quantification systems are:

- Munsell Colour Theory -hue, value and chroma
- The CIE Theory of Colour -Tristimulus values (X, Y and Z) and CIE L^* , a^* and b^* values

The CIE Theory of Colour –1931 updated in 1976 [1.2] is in wide commercial use for textile's colour communication and hence it has significant importance in apparel sector and is described below.

2.2 CIE 1931 standard theory of colour

The Commission Internationale de l'Éclairage (CIE) has recommended $x(\lambda)$, $y(\lambda)$, $z(\lambda)$ for λ [360 nm, 830 nm] in 1 nm steps for distinguishing colour based on tristimulus values, which are well accepted/.

Over a wide range of conditions of observation, many colour stimuli can be matched in colour completely by additive mixtures of three fixed primary colour stimuli (RGB) combine linearly, symmetrically, and transitively and may be expressed as X (stimuli of Red Primary), Y (stimuli of Green primary), and Z (*Stimuli of Blue Primary) as three coordinates called Tristimulus values (X, Y and Z) or stimuli of any colour observed under standard illuminant under standard detector / observer, based on reflected contributions of R G B primaries from any object (**Figure 1**) having spectral sensitivity of RGB primary stimuli (as shown in **Figure 2a**) and actual Tristimulus values of any object (X, Y and Z values, as per formulation shown in **Figure 2b**).

Thus, a monochromatic colour stimulus (Q_λ) of wavelength λ , it can be represented /expressed as

Figure 2.
(a): Spectral sensitivity of human eyes of RGB primary Stimulli and (b): Resultant actual measurement of reflectance values and corresponding Tristimulus values of any object.

Figure 3.
a: CIE 1931 chromaticity diagram showing b: CIE 1931 chromaticity diagram all predominating visible hues at 380-700 nm (coloured) showing x and y coordinates.

$$Q_l = X_l R + Y_l G + R_l B,$$

where R_l , G_l , and B_l are the spectral tristimulus values of Q_l .

Consequently, the **CIE 1931 chromaticity diagram** [1–3] is **not** a perceptually uniform chromaticity space from which the perception of chromaticity can be derived, where (Figure 3a and b)

$$x = X/(X + Y + Z), \tag{1}$$

$$y = Y/(X + Y + Z), \tag{2}$$

$$z = Z/(X + Y + Z), \tag{3}$$

$$\text{and } x + y + z = 1 \tag{4}$$

and also $z = [1-x-y]$.

Hence there is no need to plot a three dimensional x,y and z diagram, rather the 2 dimensional chromaticity coordinate plot (**Figure 3a or b**) is sufficient to get x,y & z values from x vs. y plot of 2 dimensional CIE chromaticity diagram [1–3].

As per 1976 CIE $L^*a^*b^*$ colour space, L^* , a^* and b^* values for comparing colour differences in between two samples of same or similar textile fabrics n be represented by ΔL^* , Δa^* and Δb^* values [1–3].

CIE 1976 lightness/darkness is represented by, L^* ($L = 0$ black and $L=100$ white), more or less similar to lightness distribution to the Munsell Value scale and, CIE 1976 scale of redness (a^{*-ve}) /greenness (a^{+ve}) is represented by a^* and CIE 1976 scale of yellowness (b^{+ve}) /blueness (b^{-ve}) is represented by b^* , and 1976 CIE $L^*a^*b^*$ colour space diagram represent total colour differences value by ΔE or ΔE^* (as shown in Figures 4 and 5).

$$\text{Where, } L^* = 116(Y/Y_0)^{1/3}-16, \quad \Delta L^* = L^*_1-L^*_2 \tag{5}$$

$$a^* = 500 \left[(X/X_0)^{1/3}-(Y/Y_0)^{1/3} \right], \quad \Delta a^* = a^*_1-a^*_2 \tag{6}$$

$$b^* = 200 \left[(Y/Y_0)^{1/3}-(Z/Z_0)^{1/3} \right], \quad \Delta b^* = b^*_1-b^*_2 \tag{7}$$

Figure 4.
CIE- $L^*a^*b^*$ system of colour difference plot to determine ΔL^* , Δa^* and Δb^* values of a pair.

Figure 5.
Example of metameric match under two different illuminant (day light and Fluoroscent light conditions).

Chroma, (psychometric chroma) values in CIELAB colour space [1–3] was calculated as follows:

$$C_{(ab)}^* = (a^{*2} + b^{*2})^{1/2}, \quad \Delta C^* = C_{1(ab)}^* - C_{2(ab)}^* \quad (8)$$

Where, $C_{1(ab)}^*$ and $C_{2(ab)}^*$ are the chroma values for standard and produced sample.

CIE 1976 metric Hue-Difference (ΔH) for CIELAB system [1–3] was calculated as follows:

$$\Delta H_{ab} = \left[(\Delta E_{ab}^*)^2 - (\Delta L^*)^2 - (C_{ab}^*)^2 \right]^{1/2} \quad (9)$$

Total Colour Differences [1–3]:

$$\Delta E^* = \left[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2 \right]^{1/2} \quad (10)$$

As per Kubelka Munk Equation [1–3]. Surface colour Strength (K/S value) of Coloured flat surface is:

$$\begin{aligned} K/S &= \frac{\text{Co-efficient of absorption}}{\text{Co-efficient of scattering}} \\ &= \frac{(1 - R_{\lambda \max})^2}{2R_{\lambda \max}} = \alpha C_D \end{aligned} \quad (11)$$

Where K is the coefficient of absorption; S, the coefficient of scattering; and $R_{\lambda \max}$, is the Reflectance value at maximum absorbance wavelength ($\lambda_{\max}$) and C_D is the dye concentration and α is the constant.

For use mixture of colourants to obtain a compound shades on the surface of textiles or similar substrate, as K/S is additive in nature, it can be represented as follows:

$$\begin{aligned} (K/S)_{\text{MAX}} &= (K/S)_{\text{subs}} + (K/S)_1 + (K/S)_2 + (K/S)_3 + \dots \\ &= (K/S)_{\text{subs}} + \lambda_1 C_1 + \lambda_2 C_2 + \lambda_3 C_3 + \dots \end{aligned} \quad (12)$$

Moreover, plot of dye concentration Vs K/S value is linear in relation and is easier to predict for any unknown concentration of dyes, while plot of Reflectance vs. dye concentration is non linear in relation and is difficult to predict and hence K/S is an important surface colour measuring criteria of textiles, against application of increase or decrease in dye concentration on same or similar fabrics.

For coloured textile materials, it may be presumed that dye molecules are not contributing to change in scattering and therefore K integrated over visible wavelength is the total sum of absorption of dyestuff and textile substrate (so, if substrate is not changed, scattering is not changed). Therefore, surface colour strength i.e. K/S value is directly proportional with concentration of dye molecules and the scattering value of the dyed textile sample is not dependent on the concentration of dye stuff (but that is not true for the case of pigments in paint or binded over textile substrate with binder chemical and fixed on the surface of the materials). So, for textile substrate, it is single constant theory of Colour Matching applicable for all textile materials.

Hence, for any textile surface, for the particular dyed/coloured textile sample (Fibre, Yarn and Fabric construction and type and amount of surface deposited

(coated or impregnated) finish remains un-altered), and scattering values remains constant always, if textile fabric used is not changed.

Thus higher is the K/S value, meant higher is the absorption value, meant higher absorption value signifying or indicating higher surface dye uptake, governed by following formulae.

$$(K/S)_{\text{mix}} = C_1(K/S)_1 + C_2(K/S)_2 + C_3(K/S)_3 \quad (13)$$

$$(K/S)_{\text{dyed substrate}} = C_0(K/S)_{\text{un dyed substrate}} + C_1(K/S) d_1 + C_2(K/S) d_2 + C_3(K/S) d_3 \quad (14)$$

Finally, reflectance Vs. dye concentration is not linear & is difficult to interpolate or curve fitting.

While K/S Vs. dye concentration is linear can be interpolated thus can be used in computerised colour measurement and matching software.

2.3 Principles of colour matching of dyed textiles

A colour match between two sets of samples means:

Colour of produced sample = Colour of given standard sample i.e. (X_{SL}, Y_{SL}, Z_{SL}) values of produced sample = (X_{SD}, Y_{SD}, Z_{SD}) values of given standard sample while X, Y & Z are the tristimulus value of produced Sample (SL) and Standard (SD) sample Also match may be predicted or judged [1–3] by $(\text{Reflectance})_{SL}$ of produced sample integrated at 400 to 700 nm = $(\text{Reflectance})_{SD}$ of standard sample integrated at 400 to 700 nm or $(K/S)_{SL}$ values of produced sample = $(K/S)_{SD}$ value of standard sample, where $K/S = \alpha C_D$ and K/S values (as per kubelka munk Equation [1–3]) as stated above), is:

$$\begin{aligned} K/S &= \frac{\text{Co-efficient of absorption}}{\text{Co-efficient of scattering}} \\ &= \frac{(1 - R_{\lambda \text{ max}})^2}{2R_{\lambda \text{ max}}} = \alpha C_D \end{aligned} \quad (15)$$

For a ternary mixture of colourants/dyes to obtain any particular compound shade on textiles, three equations are to be solved as a function of dye concentrations of the colourants (1,2,3 or n) and have to determine tristimulus values or K/S Values obtained through reflectance measurement of samples to match. More over K/S value being additive and dye concentration vs. K/S being linear in nature, the resultant K/S value of a dyed sample (dyed with mixture of three different dyes $(d_1, d_2$ and $d_3)$ in respective concentrations $(c_1, c_2$ and $c_3)$ is represented by following matrix equations:

$$\begin{aligned} \begin{cases} f_x(c_1, c_2, c_3) = X \\ f_y(c_1, c_2, c_3) = Y \\ f_z(c_1, c_2, c_3) = Z \end{cases} & \text{ and } \begin{cases} (K/S)_{\text{mix}} = c_1(K/S)d_1 + c_2(K/S)d_2 + c_3(K/S)d_3 \\ (K/S)_{\text{dyed substrate}} = c_0(K/S)_{\text{un dyed substrate}} + c_1(K/S)d_1 \\ + c_2(K/S)d_2 + c_3(K/S)d_3 \end{cases} \end{aligned} \quad (16)$$

Where, X, Y and Z are the tri-colorimetric tristimulus values of samples produced i.e. to be matched finally and c_1, c_2, c_3 are the exact concentration of amount of dyes/colourants required.

In practical ceases, the reflectance values of given standard sample at 400 to 700 nm are determined from given standard coloured solid textile fabric surface

and the obtained results of reflectance values at different wave length in visible region are processed in computer aided colour matching software for matching **X, Y and Z** values of produced samples or simply by comparing the total integrated K/S values at 400–700 nm wavelength (visible range) for ultimate checking of colour matching of textiles in terms of allowable limits (tolerances) of colour difference values of ΔL^* , Δa^* and Δb^* values representing 1976 CIE $L^*a^*b^*$ colour space diagram and in terms of allowable limit of total colour differences value represented by $\Delta E / \Delta E^*$.

A textile match however should ideally be an isomeric match i.e. match under all illuminant. But in actual practice, when two coloured sample show a match of colour under one illuminant may not match under other illuminant and this difference of match under specific two conditions of different illuminant is termed as illuminant based metamerism. Besides variation of illuminant, there are other different types of metamerism for change of conditions of colour measurement, as follows, arise during colour matching under varying ambience of any one factor or others [1–3]:

Types of metamerism:

- **Illuminant metamerism:** example: daylight and D65 simulation fluorescent lamp
- **Object metamerism:** example: metamerism inks (see metamerism kit)
- **Observer or Sensor metamerism:** example: Instrumental scanner and human visual perception
- **Complex metamerism and Instrument metamerism:** example: two inks/ dyed clothes measured under two different instruments.

Colour matching is therefore based on to find a Least metamerism match where, General metamerism index [1–3] is as given below:

$$\text{General metamerism Index} = \frac{\sum (\Delta R\bar{x})^2}{X^2} + \frac{\sum (\Delta R\bar{y})^2}{Y^2} + \frac{\sum (\Delta R\bar{z})^2}{Z^2} \quad (17)$$

Where ΔR = Difference in reflectance between pair of metamer samples;
 $\bar{x}, \bar{y}, \bar{z}$ = CIE standard observer colour function X, Y, Z = CIE tristimulus value normally taken for illuminant C.

The Metamerism-Index (MI) shows the probability that two samples will show the same colour difference under two different illuminants (represented by the first and second illuminant) or under two different instruments or under any two different conditions of colour measurements. CIE LAB i.e. LABD metamerism index [1–3] is represented as:

$$MI_{(LABD)} = \left[(\Delta L_1^* - \Delta L_2^*)^2 + (\Delta a_1^* - \Delta a_2^*)^2 + (\Delta b_1^* - \Delta b_2^*)^2 \right]^{1/2} \quad (18)$$

ΔL_1^* , Δa_1^* , and Δb_1^* are the Delta CIE Lab* colour coordinates between Standard and Sample for the first illuminant and ΔL_2^* , Δa_2^* , and Δb_2^* are the Delta CIE Lab* colour coordinates between Standard and Sample for the second illuminant
 Interpretation:

When, MI (metamerism index) is low, the colour difference between the sample pair (standard vs. produced) is the more closer and similar, for different conditions of measurement even under different illuminants.

Reflectance Spectrophotometers are very effective instrument in measuring and recording colours of any solid substrate / textiles from its substrate. All measurements are done by CIE –1976 System [1–3], which is commonly used in textile and other colour related industry.

The accuracy of colour matching of textiles depend on the set of tolerance limits [1–3] for ΔL^* , Δa^* , Δb^* and $\Delta E / \Delta E^*$. **values under pre decided illuminant as standard illuminant, which** is another significant task. It is generally thumb rule from practical observations that DE values below or within 1.0 are acceptable match i.e. DE values above 1 is not a good match at all. Moreover, during dyeing in industry, all dyers and other relevant people likes to create more stringent tolerance values for colour matching of textile substrate preferably DE value are to be within 0.7 only. Setting of colour matching tolerences in terms of Colour differences values are discussed later in item 3.1 in details.

Thus these colour difference data has many benefits to the dyers entailing how much it is darker or light, how much it is redder or greener or how much it is bluer and yellower, when the shades of two nearly match samples are compared. Thus, Human eye estimated perception of colour differences between two or more objects against any standard shade, can be quantified to numerical values of colour differences in terms of total colour differences (DE values) and also in terms of DL(light and dark), Da (redness and greenness) and Db (blueness and yellowness). This has made easier to match/compare colours of textiles of a nearly matched two dyed textile samples(Standard shades given vs. Produced shade) by determining what are the colour differences between the two, leaving behind opportunity by batch correction either manually or instrumentally [1–3] to help different dyers to add or subtract particular colour to get better match.

2.3.1 Batch Correction in subsequent iteration to improve match precision

The reformulation of batch correction issue for computing the incremental value of concentration of dyes by each iteration at each stage may be represented by the following matrix as follows [4]:

$$\Delta C_1 = \frac{\partial C_1}{\partial X} \Delta X + \frac{\partial C_1}{\partial Y} \Delta Y + \frac{\partial C_1}{\partial Z} \Delta Z \quad (19)$$

$$\Delta C_2 = \frac{\partial C_2}{\partial X} \Delta X + \frac{\partial C_2}{\partial Y} \Delta Y + \frac{\partial C_2}{\partial Z} \Delta Z \quad (20)$$

$$\Delta C_3 = \frac{\partial C_3}{\partial X} \Delta X + \frac{\partial C_3}{\partial Y} \Delta Y + \frac{\partial C_3}{\partial Z} \Delta Z \quad (21)$$

2.4 Colour measuring instruments

Photometry is the most common analytical technique used in measurement of colour in solution/solid in the laboratory. It is designed to measure the intensity of transmitted /reflected beam of light through the coloured solution/solid. Different types of instruments with Photometric principles are applied to the different ways of analysis of coloured materials /substrate/solution by different techniques [5] as listed below:

a. Where absorbed or transmitted light is measured:

- Colorimeter
- UV–VIS Absorbance Spectrophotometer

- Atomic absorption spectrophotometer, and
 - Turbidometer
- b. Where emitted light is measured: Flame photometry
- c. Where reflected light is measured: UV VIS Reflectance Spectrophotometer

In analytical chemistry or in textile analytical chemistry laboratory, colorimetry based on UV VIS Spectrophotometer technique is used to determine the concentration of coloured compounds (analytes) in sample of a coloured solution or in solid coloured sample of textiles or leather or plastics or polymer film or any other chemical compounds” at visible spectrum of light (400–700 nm as VIBGYOR as described in **Figure 6**), is observed in the visible spectrum of electromagnetic radiation, emitted in the form of dominating wave lengths emitting VIBGYOR wavelengths ranging from 400 nm to 700 nm. Similarly UV Light /sunlight radiation usually is observed to have UV radiation of 180 to 380 /400 nm wave length, as UV-A, UB-B, and UV-C type.

Emitted/Reflected COLORS and Their Dominating WAVELENGTH (λ in nm)

The Ultra-violet range of wavelength lies between $<190-380/400\text{nm}$, while visible spectra of ordinary light (what is considered as visibly seen to be colored materials) have specific predominated hues as mentioned below against particular ranges of visible wavelength (nm) for particular hue/colour :

Violet : 380 – 435nm

Indigo/ Blue :436 – 480nm and Greenish-

Blue :481 – 490nm

Bluish-green : 491 – 500nm

Green : 501 – 560nm

Yellowish-green : 561 – 580nm and

Yellow : 581 – 595nm

Orange : 596 – 650nm

Red : 651 – 700 nm and beyond
sometimes up to 780 nm

while , Near Infrared is $> 780\text{ nm}$ and
far infrared are beyond up to 2500 nm

Figure 6.
Major wavelength from incident white light dominating at visible range.

UV VIS Spectrophotometer technique of colour measurement are done by following two principles:

- a. UV VIS Absorbance Spectrophotometry: (for determining UV–VIS wavelength scan pattern of a particular coloured compounds/dyes and to determine concentration of pure coloured compounds/dyes (analytes) in sample solution(dilute solution)
- b. UV VIS Reflectance Spectrophotometry: **(for determining UV or VIS wavelength scan results of a solid materials surface (dyed/printed coloured textiles, leather /paper, cosmetics etc) of any particular coloured materials /dyes etc and to determine concentration of surface colour strength of any of the said coloured materials' surface for a solid sample(non- destructive) [6].**

This chapter mainly covers the basic principles of analysis of surface colour parameters vis a vis other appearance properties of the surface of solid textile materials and associated colour difference parameters by using Reflectance Spectrophotometer in terms of specific 1931 CIE and 1976 CIE formulae [1–3] for determination of all specific Surface colour parameters of textile materials, changes with or without different chemical processing and computer aided colour match prediction theories and practices [7, 8].

2.5 Reflectance spectrophotometer

Reflectance Spectrophotometer is an human eye simulated UV–VIS double beam spectrophotometer instrument for measuring colour of solid textile surface under standard illuminant and standard observer with or without UV Absorption included and Excluded to measure reflectance, surface colour strength and to compare the colour differences of two sets of samples nearly to match or unmatched/matched coloured samples and also for storing and analysis of database of colour values of different textile dyes applicable to different textile substrate and its use for computer aided colour match prediction at finger tips with specific allowable limits of ΔL^* , Δa^* and Δb^* and ΔE^* values of colour differences as well as Studies on quality checking of Dyes, effect of dyebath additives, dyeing process variables and UV absorbance criteria of dyes / additives and effect of UV-absorbers/Optical brighteners on textile fabric under given treatment conditions and after care treatment/washability etc.

2.6 Diagram of Reflectance spectrophotometer and its working principles

In UV–VIS reflectance spectrophotometer based on measuring reflectance of the solid sample for measuring different colour parameters for quality control and colour matching purpose, there is tungsten light source, which acts as source of monochromatic incidence light and it falls on the opaque surface of the solid sample at a particular incident angle to reflect at the same angle for specular reflectance component and also reflects the incident light all around in diffused form at all angles for non-specular reflectance inside the integrating sphere. There are specular component in and out arrangement with UV component in and out arrangement for specific requirement of setting of the instrument. Led detector situated in the inside circumference of the integrating sphere detects the total reflectance values at all diffused angles as well as at specific specular reflectance angle and the amount of reflected light intensity is measured and shown as the reflectance values

Figure 7.
Schematic diagram of working of UV-Vis spectrophotometer.

of sample at different wave length. Finally from reflectance values obtained for any sample, it calculates other colour parameters as per CIE –1976 formulae [1–3] and other formulae as per software inserted/installed for it for the data processing in a suitable computer system for computer aided colour measuring and also for textile match prediction system using pre-fed data base of textile dyes.

Usually a double beam UV VIS reflectance spectrophotometer, the incident light beam is first split into two parts by a half mirror as two light beam called double beam. One light beam falls /passes on the sample mounted and the other light beam falls (for reflectance mode) /passes (for transmission mode) through a control sample panel. This system of double beam eliminates the problems of interference from control sample and normalises the variations in reflected /transmitted light intensity readings uncreasing accuracy of the instrument reading, as the final reflectance/ transmittance/absorbance values are taken as the differences between the readings of two reflected/transmitted beams of light intensity recorded. The semicircular LED Detector inside the integrating sphere measures both the two reflected/transmitted light intensity alternately and gets its processed in computerised processor to give final reading. However, in some UV-VIS spectrophotometer, a second detector is separately installed to measure the intensity of the two beams separately. Thus, the major instrumental parts of an UV-VIS Double Beam Reflectance Spectrophotometer are shown in **Figure 7** indicating the position of light source, diffraction grating, monochromator, sample cell/ integrating sphere, detector and integrator and computerised recorder. The instrument changes the light source from visible to UV light at about 350 nm by a mechanically moving mirror, as shown in **Figure 7**.

The diffused reflection shows total effect of incident light including specular reflection in integrating sphere diffraction, which may be excluded by opening a port at particular angle without detecting the specular reflections in UV-Vis reflectance spectrophotometer and different types of solid samples with varying surface and texture show variation in reflectance values, effecting surface colour strength, as shown in **Figure 8**.

Sphere Geometries of illumination and viewing in reflectance spectrophotometer [7, 8] is very important here. It is based on measurement of Reflectance of dyed samples of textiles. On a glossy surface there are mirror-like (specular) reflections and there are more reflections in the case of diffuse light sources. **Figure 9** shows the effect of transmission mode and total reflection mode of integrating sphere of in

Figure 8.
Schematic diagram of optical system of UV-Vis reflectance spectrophotometer.

Figure 9.
Schematic diagram of working of integrating sphere type optical system in UV-Vis reflectance spectrophotometer.

UV-Vis reflectance spectrophotometer, showing provision of specular component inclusion and exclusion by keeping specular port off and on (close or open).

Since the colour of the illuminant is white, specular reflections add white, with the effect of de-saturating the colour. Textiles or any non-metallic glossy surfaces look more saturated in directional than in diffuse illumination, while matte surfaces scatter the light diffusely — matte surfaces usually look less saturated than glossy surfaces.

Most of the textile surfaces are between glossy and matte and hence in reflectance spectrophotometer, diffuse illumination is provided by integrating spheres with provision of gloss traps /lid at regular reflection points to include or exclude specular/regular reflectance in instrumental set up. REflectance spectrophotometer Instruments with 45/0 and 0/45 geometry are less critical and give better results and accuracy. ASTM recommends [1–4] use the geometry that minimises surface effects (usually the one that gives lowest Y and highest excitation purity) for partly glossy samples. 45/0 geometry gives rise to polarisation problems [9].

2.6.1 Calibration and certification of the instrument 's accuracy

White calibration: Before Use always this instrument should be callibrated with standard white tiles equivalent to white surface of saturated dry layer of Magnesium sulphate, which adjusts computational parameters for any setting disturbances, so the calculated reflectance values match with calibrated value of white tiles being 100 and the accuracy of reflectance curve is the same as the absolute reflectance curve do it often.

Absolute certification: The instrument need better to be certified by NABL, which verifies that the measured colour of the standard white tile is 100 or specified values by manufacturer, within the tolerance (e.g. within $0.6 \Delta E^*$ units) from the absolute colour of the standard white tile, in perfect agreement between instrument and laboratories, when checked for certifiocation.

Relative certification: verifies if the measured colour of the standard white callibrated tile is within the tolerance (e.g. $0.3 \Delta E^*$ units) from the initial colour of the standard white tile in the same instrument, which is very very important for reproducibility and reliability of colour data produced.

2.6.2 Measurement of overall colour difference index

Colour Difference Index (CDI) [10] indicates the combined effects of different known individual colour difference parameters between any two samples when dyed with varying conditions of dyeing, indicating dispersion of colour value, to understand the combined effects of different dyeing variables by a single parameter. For application of same concentration of dye between two sets of dyeing under any varying conditions of dyeing like pH, taking only the magnitudes of the respective ΔE , ΔC , ΔH and MI values (irrespective of their sign and direction) may be considered to calculate CDI values using the following empirical relationship [10].

$$\text{Colour Difference Index (CDI)} = \frac{\Delta E \times \Delta H}{\Delta C \times \text{MI}} \quad (22)$$

Higher the CDI value dispersion of Colour values are more widely dispersed and that variable become critical for reproducibility for such dyeing. So, Lower CDI value below 5.0, is considered as good.

2.6.3 Use of Standrad Illuminats in reflectance spectrophotometer

The followings are the Standrad Illuminats [1–3] used in Reflectance Spectrophotometer, providing UV -Tungsten lamp for different illuminant with swift arrangement of Illuminnat -A to Illuminnat -D65.

- **Standrad Illuminant A (CIE):** CIE standard illuminant -A is defined as equivalent light source from a tungsten filament (as radiator) when heated at 2854°K (as correlated colour temperature)
- **Standard Illuminant D65 (CIE):** CIE standard illuminant -D65 is defined as a representation of natural daylight considering as equivalent light source from a tungsten filament (as radiator) when heated at 65040 K (as correlated colour temperature)

Figure 10.
 2° standard observer (small area of view) and 10° standard observer (large area of view).

- **Standard illuminants B and C:** CIE Standard illuminant -B and C are defined to represent as simulated direct sunlight, as equivalent light source from a tungsten filament (as radiator) when heated at 4874°K and 6774°K respectively (as respective correlated colour temperature). But, Standard illuminants B and C are not so much used and are being dropped because they are seriously too much deficient in the UV region (important for fluorescent materials)
- **Standard Observer:** There are two angular view areas considered as standard viewing areas called 2° standard observer (small area of view) and 10° standard observer (large area of view) as shown in **Figure 10** [1–3]. As recommended by CIE, in 1964, the larger area of view of solid samples mounted for colour measurement on sample port of UV VIs reflectance spectrophotometer is most widely used for evaluating colour values and for colour matching of various types of solid samples including textiles. Ordinary Colorimeters, on the other hand, typically use a 2° Standard Observer (as per CIE, 1931), which has a smaller area of view and is common for general colour measurement and colour quality control and evaluation purposes for comparative purposes and also for printed textiles.

2.7 Computer aided colour match prediction system

Computer aided Colour Match prediction system (CACMPS) [4, 9] is the combination of specific hardware and software for scientific use for measuring colour of solid textile surface for given sample as standard for predicting the dyeing recipe or formulation for the exact shade reproduction in a textile fabric sample to produce. Hence, this technique is known by names e.g-computer colourant formulation, computer recipe prediction, Instrumental colour matching system or Computer aided Colour Match prediction system (CACMPS) using reflectance spectrophotometer and associated computerised system for storing and analysis of data with specific software to predict colour matching of textile substrate. A colour matching computer system consists of the following three basic modules,:

1. Colour measuring instrument: A Reflectance Spectrophotometer with specific geometry of colour measurement, which expresses the colour in numerical form in terms of X,Y, Z or R or K/S values with L^* , a^* and b^* , ΔL^* , Δa^* and Δb^* and ΔE^* values.

2. Computer hardware: Usually latest PC or Laptop based Computing and data analysis and storing system for data storing, analysing and processing for converting and comparing etc.
3. Specific Computer aided colour match prediction software with desirable Logic system for computer aided colour measuring /storing and analysis of colour data to convert into relevant information in terms of calculating X,Y, Z, R, K/S values and L^* , a^* and b^* values or, ΔL^* , Δa^* and Δb^* and ΔE^* values for textile surface colour measuring and colour match prediction by the said / compatible specific Software to obtain desirable output required.

So, Suitable Software is crucial in recording, analysing for colour measurement and matching and for comparing a pair of nearly matched textile dyed/coloured samples. Samples should have the same type of fabric, same surface finish and same shape as far as possible, for accurate measurements.

The Reflectance Spectrophotometer has small view and large view sample mounting holders with small hole area or large area hole respectively to place sample to scan its surface for colour measuring and recording in the diode type detector to use for storing and analysis for comparison to obtain X,Y, Z or R or K/S values with L^* , a^* and b^* , ΔL^* , Δa^* and Δb^* and ΔE^* values for further use and processing for computer aided colour match prediction from stored colour data of dyes known as database (Fabric type wise, Dye class wise or Dye Company wise etc) as per requirement.

Standard Name		=		C51555ton		Mode		=		Spectro %	
				cotton						RFL	
3.28	3.50	3.83		4.77	5.94	8.27	9.61	11.71			
12.19	13.08	10.72		9.42	8.67	7.68	6.53	5.36			
File	name	=	Dir cot	—	3	dye combination					
ID# selected		=	2,	3,	4,	5,	6,	9,	11,		
Subst ID#		=	1 bleach cotton								
DED65'. 1.00	DEA.	=	1.00,	Amount	t	=	100				
Exhaustion factors are included, Operator											
ID# Colourant	Amount	Per cent				da*	db*	dL*	dE*	Rs	
						CIE					
Recipe Generated											
Formula#1											
3	OrangeSE	0.0408	0.0408		D	−0.0	−0.0	0.0	0.0	18.51	
5	Cry SE	0.4238	0.4238		A	−0.6	0.2	0.0	0.2	187.73	
9	Turquoise Blue	1.6111	1.6111		F	−0.5	0.3	0.3	0.7	285.44	
		2.0747	2.0747							491.68	
Formula # 2											
4	Scarlet	0.0362	0.0362		DS	−0.0	−0.0	0.0	0;0'	16.12	
5	Cry SE	0.5466	0.5466		A	−0.5	0.3	0.0	0.6	194.77	
9	Turquoise Blue	1.4834	1.4834		F	−0.4	0.2	0.1	0.5	224.04	
		2.0662	2.0662							434.93	

Table 1.
A case study of colour match prediction from the database of direct dye for cotton.

After that, the associated Computer aided colour match prediction software takes over the rest part of the work of calculations and comparison of colour data to show the measured values and calculated colour values using stored colour database of specific dyes for specific type of textile substrate. **Table 1** shows Computer aided colour match prediction system (CACMPS) generated dyeing recipe and its dye cost and estimated approximation of Colour difference values with least metameric ratio for cotton fabric sample to be dyed to match against given standard samples using direct dye data base stored.

The above shown formulae of colour match prediction generated against standard shade C5, has generated two possible recipes, and is difficult to decide which one we should accept and proceed for bulk dyeing. From the Point of least metamerism, formulation-1 and from the point of least cost Formula –2 are respectively found better after 4 trial run in Computer aided colour match prediction system (CACMPS) within DE limit to 1.00. Thus, computer predicted formulation –2 is least cost and formulation –1 is least metameric in nature, as shown in output result generated here.

3. Some practical consideration during measurement on CCMP system

The practical aspects of data base generating match generation using a data base, setting up proper DE or multiple colour tolerance & above all accurate spectrophotometer measurement depends on following factors.

3.1 Colour matching tolerance set-up and pass/fail system

It is also essential to develop mutually agreeable pass/fail system between buyer or seller or by company itself for their shade control to match produced samples lot with the colour values of standard shade given, which should be specified by set up specific tolerance values of these colour difference criteria for any par of near matched textiles. These may be more important while considering batch to batch variation during production of shades as per match of standard samples given. As all textile dyers and dyeing units or composite textile mills have procured this computer aided colour match prediction system, this become a regular job to check match accuracy from shift to shift or lot to lot variation always, to understand the colour differences from standard shade given. So that the colour differences from batch to batch variation at factory /dye house in company production department, the shade may be corrected by revised addition of dyes, to obtain more precision match, so that chance of rejection in export level on this ground may be eliminated and for this, specific sets of colour tolerances values are decided and pre -set.

In practice in textile industry/ dye houses, for dyed /coloured cotton textiles, if not otherwise mentioned/specified, the thumb rule for setting a symmetric colour tolerances values in terms of dL^* , da^* , db^* and dE^* for effective colour matching of cotton textiles are as follows:

Standard set of colour tolerance values: $dL^* = 0.7$ to 1.2 ; $da^* = 0.6$ to 1.0 $db^* = 0.6$ to 1.0 ; $dE^* = 1.0$ to 1.5 applicable for selected common shades and common dyes for cotton. However, these colour tolerance limits for colour matching of dyed textiles could be somewhat narrower in case of requirement of precession matching. The main dependant factors responsible for lot to lot or batch to batch dyeing production with variation of shade are: i) weighing / solubilisation/dilution error, ii) substrate and pre treatment variation, iii) pretreatment or heat setting variation, and iv) Variation in dyeing conditions by change of dyeing process variables or variation in additive concentrations and 5) dye selected and its purity.

3.2 Calibration dyeing for preparation of data base

The calibration dyeing for preparation of dyestuff data base for dyeing specific textile fabrics with selected type and class of dyes is an essential pre requisite. After selection of substrate and class of dyes and dye manufacturer/suppliers), to run a computer aided colour measuring and matching system, preparation of dyestuff data base to store using selective class and type of dyes, the control bleached cotton/ otherwise textile fabric sample are to be dyed with each selected dye at 5-8 different concentration levels of dyes (say, within 0.1 / 0.5 to 4%) and those samples dyed are to be subjected to measure their reflectance values at different wavelength and their individual values or their integrated sum of these Reflectance / tristimulus colour values are to be stored for future uses to form a Dye class wise/company wise data bank or data base of all different type of dyes for specific substrate / substance following a particular standard process of dyeing in a separate file of the computerised processor or computer to use at every re-call. Samanta et al. [9, 10] mentioned the cares necessary for accuracy in colour measurement of textiles including nos. of folding etc. and orientation of samples and measure of colour difference index values etc. Randall and Stutts [11] specifies how to prepare reliable samples of calibration dyeing for creating dyestuff data base in computer aided colour matching system as a most important step. For optimum efficacy in computer aided colour matching system, the laboratory dyeing machine and process must be highly controlled in terms of dyeing process variables and all these must be standardised before calibration dyeing be carried out accurately, which is to be assured by the lab dyers /colourist to store precision colour data/ dyestuff database separately for company wise /substrate wise for separate class of dyes.

3.3 Checking of linearity / non-linearity for plots of K/S vs. dye concentrations in dyestuff data base

The accuracy of computer aided colour matching system depends on the correct dyestuff data base preparation as discussed in calibration dyeing in item 3.1 above. The accuracy of dyestuff data base can be checked by checking linearity of K/S vs. Dye Concentrations curve pattern for each individual dye applied on same substrate under standardised control dyeing conditions. Sometimes, this linear relation does not exist and then the deviation from linearity is to be eliminated, before such dyestuff data base are stored for future use of colour matching functions. The deviation from linearity of plot between K/S vs. dye concentration are due to (i) inherent variation in dye uptake rate or variation in exhaustion rate of the dye for higher percentage of dyes (ii) unknown interference of dyes with given dye bath auxiliaries (iii) variation in dyeing conditions /stirring rate (iv) weighing/solubilisation/dilution error (v) impurities/agglomeration of few dyestuff itself, where these said reasons causes a variation of dyeing with increase in dye concentration [9] showing non linearity/deviation from linearity in observed. Dye uptake.

Therefore, this linearization is to be ultimately done by statistical best fit linearization process or elimination of one or two concentrations of dyes (where / from which point the said linearization is originated/deviated) for particular dye or by empirical modifications of the equation of K-M functions (K/S value). before storing dyestuff database to be used for colour match prediction of coloured textiles easily. For this type of special cases, the dye absorption co-efficient/diffusion coefficient of the dye is to be determined and to be checked at about five to eight level of dye concentrations to check the dyeing absorption/diffusion rate and then linearization can be made either eliminating few dye concentrations where dyeing rate

is much varying. Repeat colouration is to be done to avoid variation in dyeing process variables to get correct data. Only after linearization of plots of K/S vs. Dye concentrations, the individual dyestuff data base may be stored in the computerised storing and saving file as ready made database for use in predicting recipe for colour matching formulations for specific substrate for specific dye class within user choiced/ standard tolerances of colour differences in terms of DE, DL, Da, Db values under standard illuminants of D65 or otherwise. If dyestuff cost are entered and uploaded and updated regularly, the dye cost of predicted colour matching formulations are also available along with predicted metamerism values.

3.4 Effect of variability in measurement of colour value of textiles

Colour Matching of textiles is very much dependant on the Pigment /dye Data-base created –dye class based and type of fibre/fabric based and dye company based to be pre-up-loaded in spectro. To match full strength of colour, Light and dark i.e. white and black reduction are very important.

Pigments /dyes should be thoroughly dispersed and uniformly dyed, which is Very difficult with powder pigments, but much easier with Master batch mass pigmentation to produce coloured textiles.

There are so many variations in measuring surface colour of textiles. A measurement is never perfect. The effect of variability of colour measurement is reduced by using multiple measurements and taking avrages at 10 points atlesat. How many measurements should I make for averaging is a good question and Rule of thumb is 10 times atleast for each variability parameter of dyeing for standardising dyeing process variables. For any variable instrumental factors also, measure each spot of colour value for 10 times to take average of it. But for sample uniformity for data base storing data, one should repeat colour measurements at several locations — more than 10 to 100, depending CV % of K/S values or reflectance values of coloured textile surface. One can follow ASTM standard E 1345-90 to determine how many measurements are necessary in each case.

Some more Practical Aspects of variability in colour mesurement of textile surface [9] are:

- a. Level / Un level dyeing (Usually Less than 5% CV of K/S Value is taken as level dyeing for textiles).
- b. Back ground opaqueness of the sample (No. of Folds are to be kept Constant say usually 4 fold).
- c. Variation in warp wise or weft wise sample's vertical/horizantal orientation may differ K/S value)
- d. Variation in texture or surface roughness may vary K/S values for change in scattering (Any chemical/ physical intervention/Treatment before dyeing may change surface texture)
- e. Variation of colour and texture in two sides of the fabric sample (K/S -surface colour strength in one face of fabric may sometimes differ from other face due to the said effect).
- f. Any Fabric or Dyeing Defects/Stains in the fabric sample (Any defect of the fabric may cause colour variation).

- g. Dull shade / Fluorescent colour & bright shade etc. some times behave differently.
- h. Blended fabric may pose problem with change of Blend % of each component of fibres.

The reasons of variation of colours produced in textiles during data base preparations - are

- Improper weighing and mixing of colourants.
- Improper Cleanliness of dyeing machinery parts, like steam pipes and dye bath
- In-compatible colour mixing and variation of dyeing time and other process variables
- Interference from regrind/ slubilization of dyes having some chances of contamination.
- Shedding of fibres / Degradation of fibres or chemicals used during processing.
- Machine stoppages and inadequate steam purging in dye bath having in adequate temperature
- Improper selection of Colourant/ Master-batch.
- Interference with processing additives - chrome pigments containing lead will discolour if Tin stabilisers are present.

Moreover, different other cares are necessary, without which in-accurate measurement occur for measuring of colour values of textiles –e. g.

- Accent on cleanliness: Poor housekeeping results colour contamination and stain,
- Selecting correct Colourant and clear understanding of colour type and properties to specific textile fibre / polymer involved. Master-batch of colour supplier plays crucial role in this case.
- Use of pre-coloured standard materials and best checking by replicating same colour on a same or different textiles. Cost of instrument is usually more
- Inventory and logistics issues are there also for variation of colour and its measurement.

Use of Pigment colouring for small quantities where Master-batch development is easier.

3.5 Areas of application of computer colour measuring and matching system

1. Measurement of tristimulus values, reflectant at maximum absorbance wave length or K/S measurement of transmittants.

2. Calculation of colour difference by CIELAB equation of total colour difference i.e. $\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$ with plot of CIE colour difference space diagram. The shade sorting i.e. pass/fail mechanism of quality control of dyed shades from batch to batch or lot to lot represents colour difference values in terms of Darkness and lightness (ΔL^*) Redness & Greenness (Δa and Yellowness and Blueness (Δb^*).
3. Finger Tips solution of predicting newer computer aided d colour matching recipe /formulation with lowset cost & lowest metameric match recipe using pre- set stored speicific dyestuff data base.
4. Batch correction or auto correction of shades by manual or computerised corrections.
5. Extension of match Prediction by batch corrections and utilisation of dyeing waste liquor.
6. Purity/ Quality test of incoming newer batch of dyes with the help of this computer aided colour measuring system.
7. Determination of whiteness, yellowness and brightness indices of bleached textile substrate using different standard scales like CIE scale, Hunter Lab scale, ASTM-E-313 scale, Stansby scale etc.
8. Prediction of efficiency of OBA (optical brightening agents) utilising this system by change of with or without UV light setting.
9. More accurate and Quantitative understanding and grading of colour fastness grade for colour fading behaviour to wsah, crocking/rubbing. Exposure to UV light etc. replacing conventional grey scale rating.

4. Surface appearence measurement in terms of whiteness, yellowness and brightness indices

Whiteness is assesment of freedom from any colour and contamination/stain / soil and as such it is taken as an indicator of quality for a bleached textile fabric prepared for dyeing. Objective measurement and meaningful numerical expression whiteness index as per CIE and Hunter lab scale are widely used. It represents whiteness index (WI) in terms of colorimetric values for the specimen and the chromaticity coordinates of the illuminant:

$$WI(\text{CIE scale}) = Y + 800(x_n - x) = 1700(y_n - y) \quad (23)$$

$$WI(\text{Hunter Lab-Scale}) = L^* - 3b^* = 10\sqrt{Y} - [21(Y - Z\%)]/\sqrt{Y} \quad (24)$$

where x , y and Y are the colorimetric values for the sample under illuminant D_{65} , and x_n and y_n are the chromaticity coordinates of the light source/illuminant used. A value for WI of 100 represents a perfect reflecting white diffuser, equivalent to surface of saturated paste of Magnesium sulphate.

X , Y and Z are the CIE tri-stimulus values of the sample and L^* is the lightness/darkness indicator, b^* is the blueness/yellowness indicator.

Similarly, yellowness indices [12] as per ASTM-E313/1973 can be expressed as follows:

$$\text{Yellowness Index (YI)(ASTM-E313/1973)} = 100 [1 - (B/G)] = 100 \left[1 - \frac{0.8477}{Y} \right] \quad (25)$$

Where, X, Y and Z are the CIE tri-stimulus values of the sample, L^* is the lightness/darkness indicator, b^* is the blueness/yellowness indicator and $B = Z/1.181 = 0.847 Z$, $G = Y = L^2/100$.

Brightness Index (BI) as per ISO-2469/2470-1977 method [13] can be calculated by following formula:

Brightness index =

$$\frac{\text{Reflectance Value of the Sample at 457 nm}}{\text{Reflectance value of Standard white diffuser (white tiles) at 457 nm}} \times 100 \quad (26)$$

Treatment with fluorescent brightening agents can lead to reflectance values of up to 150. Although the pattern appears to become whiter, the change in appearance is due to a change in chroma towards blue, and this fact is expressed in quantitative form as the 'tint factor'. Allied to the appearance of the uncoloured fabric is the yellowness, which suggests yellowing by chemical treatment or by heat scorching or degradation by light or by gases. Thus along with colour parameter the said other surface appearance properties are also very very important too in defining the quality of the surface appearance of any textiles.

5. Importance of colour measurements and matching in garment industry

Colour is one of the important element of a design. Colour with aesthetics / texture of any textile fabrics / garments are as important as its physical and functional property criteria. Matching of colours, especially in specific textiles made from specific or different fibres and their blends is very very crucial in many applications. The task of communicating and measuring and matching of colour becomes more difficult when colours need to be exactly matched with a given standard supplied for different textiles. More and more precision colour matching is required in specialised textile products like defence dress materials, school uniform etc. and also for matching suits for consumer textiles and lifestyle products for matched furnishings, bed linen and auto Interiors etc.

This Computer aided reflectance spectrophotometer is an important tool/instrument for quality up gradation of textiles and garments by measuring surface colour strength and colour differences values as per CIE equations/ formulae. Some Other Application of computer aided colour measuring cum matching System used in textiles or apparel industry's Dye House:

1. For quality control of dyed textiles including pass/fail decision of batch to batch checking.
2. For Evaluation of Quality of dyes supplied.

3. Effect of dyeing additives by measuring colour yield.
4. Efficiency of optical brighteners by UV analysis.
5. Soil removal efficiency of surfactants by measuring Reflectance value.
6. Measurement of whiteness / yellowness / brightness index etc. of undyed and bleached samples besides dyed samples.

6. Concluding remarks

Computer Aided Colour Measuring and Match Prediction System (CACMPS), now a days, become an essential tools for each textile dye houses to match colours or shade as per panton shade nos. or as per given samples, to reduce export rejection for colours. Moreover, to judge colour fastness grading more accurately from measurement of colour difference values after corresponding fading by wash or light or rubbing etc., than subjective/comparative judging by grey scale rating purpose is more scientific and advantegios. Quality control activity and batch to batch pass / fail checking of shades developed from shift to shift needs to be implemented in all dye houses for quality assurance on colour matching which is an integral demand of today's apparel and fashion industry. Hence learning of colorimetric principles of UV VIS reflectance spectrophotometer and proper utilisation of this instrument carefully for deriving all round benefits out of it, for surface colour measuring and matching of textiles for customer satisfaction is also helps in brand building by quality assurance on colour matching of textiles.

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References

- [1] Shah HS, Gandhi RS. Instrumental Colour Measurements & ComputerAided Colour Matching for Textiles. Amhedabad, India: Mahajan Book Distributers; 1990. pp. 76–116
- [2] Gangakhedkar NS. Part II : Colour measurement and its applications. In: Gularajani ML, editor. Colour Measurement: Principles, Advances and Industrial Applications. Manchester, UK: Woodhead Publishing, India and Textile Institute, Series in Textiles; 2010. pp. 219–252
- [3] McLaren K. The Colour Science of Dyes and Pigments. 2nd ed. Bristol: Adam Hilger; 1986. pp. 50–87
- [4] Pubalina S. Fundamentals and applications of of Computer aided Colour Match Prediction (CCMP) System. Latest Trends in Textile and Fashion Design Journal. 2018;2(5):1-10
- [5] Ingamells W. Colour for Textiles- A user's handbook. Bradford, UK: Society of Dyers and Colourists; 1993. pp. 138–157
- [6] Samanta AK. On-line colour control (for textile dyeing). Indian Textile Journal. 1992;105:70
- [7] Samanta AK. Review on Colour Control and Matching. Indian Textile Journal. 1995;108:50
- [8] Samanta AK. A review and case study of computer application in jute or textile mills' dye house and computerized colour matching. Textile Trend. 1993;36:37
- [9] Samanta AK, Das D. Studies on Quantitative colour measurement of direct dyed Jute Fabric in relation to computerized colour matching. Journal of Institution of Engineers-Textile Engineering. 1992;73:53
- [10] Samanta AK, Agarwal P, Singhee D, Dutta S. Application of single and mixtures of red sandalwood and other natural dyes for dyeing of jute fabric: Studies on colour parameters / colour fastness and compatibility. Journal of the Textile Institute. 2009;100(7): 565-587
- [11] Randall D, Stutts T. Optimizing calibration dyeings for computer color matching. American Dyestuff Reporter. 1988;28:44-46
- [12] ASTM-E-313-67/E-313-73 (Re-approved-1979). Determination of yellowness. In: Annual Book of ASTM Standards E 12.02. Philadelphia, Pennsylvania, PA: American Society for Testing Materials; 1974. p. 1
- [13] ISO-2470-1977 (E) and ISO-2469. Determination of Brightness. Switzerland: International Organization for Standardization (ISO); 1977. pp. 1–3