5 A practical guide to visual evaluation of textile samples

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5.1 Introduction

By most definitions, colour is a sensation produced by certain effects of light interactions with an object, either emitted or reflected. In the commercial sense, this sensation of colour is capable of imparting significant aesthetic value to otherwise non-coloured materials and objects. For the vast majority of consumers, colour plays a very important role in their decision-making process when purchasing goods such as clothes, home furnishings, cars and many others. The art and science of the colouration industry is to add sufficient value to the item through colour such that it will be more desirable to the consumer as something newer, more stylish, complementary and more attractive than an otherwise similar product.

Since colour is a sensation in the mind of an individual, it follows that the most straightforward method of assessing the quality of one colour vs. another is simply to look at it. While one cannot ignore the validity of colour measurement instruments, one must also be reminded that instruments do not measure colour but rather factors directly relating to colour. In cases where visual and instrumental results are in disagreement, the visual assessment is the final arbiter of acceptability of a sample. We draw two conclusions from this – firstly, that as there will always be a need for visual colour assessment, when visual processes are used for colour development and quality control purposes, they must be standardised as much as possible so as to minimise the subjectivity that exists in individuals, and secondly, that when utilised, it should be the goal of instrumental analysis to emulate the visual process as closely as possible.

In order for visual colour evaluation to be an effective tool in the colour development and colour quality control processes, certain parameters must be well understood and controlled. This chapter will focus, therefore, on the various aspects of the visual colour evaluation process and will provide practical guidelines for ensuring consistency among observers.

5.2 The components of colour perception

The physiology of human vision is a very complex process and as such lies beyond the scope of this discussion. To understand how colour is visually assessed we must, however, first realise that colour perception is a function of both the optical and neurological systems in the observer and that, by working together, they produce the sensation in the brain we call, for example, the colour pale purple. In other words, two observers who have perfectly matched optical systems, or eyes, and who see the exact same object will not necessarily have the same sensation of colour. The visual input is processed or analysed by the brain and it is in this area that the sensation of colour is realised. In Josef Albers' famous work *The Interaction of Color* he writes 'In visual perception a color is almost never seen as it really is – as it physically is. In order to use color effectively it is necessary to recognize that color deceives continually' (Albers, 1975). The sources of this deception can be categorised into the effects of the source of light, the object itself and the observer of the sensation of colour, each of which must be properly controlled in order to ensure effective and repeatable visual assessment of colour.

5.2.1 The illuminant, or light source

The first component required for the sensation of colour is a source of light. Two terms are often used interchangeably when discussing the source of light for colour evaluation, and those terms are illuminant and light source. A 'standard illuminant' is defined by the American Society for Testing and Materials (ASTM International) in method E284 – 'Standard Terminology of Appearance' as 'a luminous flux, speci–fied by its spectral distribution, meeting specifications adopted by a standardizing organization' (ASTM International, 2002). In simpler terms, a standard illuminant is light energy quantified and listed in a table as a set of spectral power distribution values, though it may not be exactly represented by a light bulb that produces light. A light source is defined in the same ASTM method as 'an object that produces light or other radiant flux, or the spectral power distribution of that light' (ASTM International, 2002). A source may therefore be defined as a physical light bulb, manufactured with the goal of producing light energy corresponding to a particular set of standard illuminant spectral power distribution data. Based on these definitions, visual colour evaluation will focus on the effects of a light source on the colour evaluation process, while illuminant data has application in calculation of numerical colour values and colour differences.

Light source selection

A variety of light sources are available to the retail and clothes market, and a number of reasons are identified for selection of a particular light source or sources that will be used in the retail store environment. The reasons include, but are not limited to, the design and layout of the store, the mood generated by the light sources and their arrangement, the energy requirements of the light sources when they are used in large quantities, the availability of external lighting through skylights or windows and doors, the costs associated with equipping a large number of stores and so on. It is unfortunate, however, that little thought may be given to the effect of the selected light source on the consumer's perception of the colour of the goods being marketed. It is not uncommon for the colour design and development process to be performed in one light source while the end-product is displayed in a different light source or combination of light sources. The net effect in this scenario is that the colour perceived by the consumer is not the colour intended by the developer.

A number of standard illuminants have been defined by ASTM International in method E308 – 'Practice for Computing the Colors of Objects by Using the CIE System', and the goal of light source manufacturers is to produce bulbs that closely simulate the spectral power distribution curves of these standard illuminants. For the textile industry, the most commonly used light sources include daylight – designated as standard illuminant D65 and rendered in light source form as 'D65'; fluorescent – designated as a number of standard illuminants including F2, F7, F11, and others, and rendered in light source form as CWF, TL83, TL84, and others; incandescent – designated as standard illuminant A and rendered in light source form as 'A'; and a number of others. Additional light sources are available for which the manufacturer provides spectral power distribution data, and include light sources such as Horizon and Sylvania FO35.

The goal of the colour developer should be to select the light source or light sources for use in initial colour development and on-going colour quality control that most closely duplicate the light sources used in the retail store. By doing so, there will be some degree of assurance that the colour that is developed will be rendered as intended on the showroom floor. The light source that is selected is then communicated as the primary light source throughout the supply chain.

In addition to the primary light source, a secondary light source is also specified. Specification of a secondary light source will allow for the evaluation of the colour characteristics of flare and metamerism, which are qualitative assessments of the degree of colour change that is observed when one or more samples are visually evaluated in multiple light sources. Flare is a term used to describe a condition in which a single sample exhibits an observable colour change when it is visually evaluated in multiple light sources. Metamerism is a term used to describe a condition in which the direction or magnitude of colour difference exhibited between a pair of samples visually evaluated in one light source changes in either magnitude or direction when the pair of samples is viewed in a secondary light source. Given that elimination of either of these effects is virtually impossible, clear communication of the expected limits of flare and metamerism is essential.

Light source evaluation and quality

The suitability of a particular light source for visual colour evaluation is determined not only by how closely the light source matches the light source used in the retail environment, but also by the ability of the light source to reliably simulate the intended standard illuminant. Manufacturers of light cabinets and similar lighting units evaluate the spectral power distributions of the installed light sources against the spectral power distributions of the standard illuminants as well as determine the colour rendering indexes of the light sources. CIE ratings are also calculated to assess the quality of daylight simulators. These assessments give an indication of the suitability of the light sources for a particular application and should be considered when comparing and purchasing a light cabinet or lighting device.

Manufacturing techniques in combination with light cabinet design and filtering serve to increase the correlation between the light sources and the standard illuminants. It must be noted, however, that design and manufacturing methods vary between light cabinet manufacturers, which introduces the potential for variability in the perceived colour when light cabinets of various manufacturers are used. This same variability may exist even in light cabinets supplied by the same manufacturer and is related to cabinet design, light source specification, cabinet maintenance and cabinet condition. Light cabinets must be regularly maintained in order to ensure long-term repeatability of visual colour evaluation results as well as reproducibility of results among multiple cabinets.

Replacement of bulbs according to manufacturer specifications is a key element of light cabinet maintenance. Use of non-conforming light sources, whether in a commercial light cabinet or in a light fixture, for the purpose of visual colour evaluation will result in inconsistencies in visual colour difference evaluation when compared to evaluations performed using approved bulbs.

5.2.2 The object

The second component required for the sensation of colour is the object being observed. While this may be considered understood, the nature of the object plays an important role in determining the colour perceived in the mind of the observer and it cannot be overlooked. Visual evaluation of textile samples can most accurately be described as an evaluation of the appearance of the sample rather than an evaluation of the colour of the sample. The appearance of an object may be defined as the observer's response to the combination of both the colour and the physical characteristics of the sample.

Physical aspects of textile samples and the effect on visual evaluation

The processes of weaving, knitting, preparation, dyeing and finishing, among others, impart physical characteristics to a textile sample as well as colour. Common examples of physical characteristics include non-uniform fabric construction in the form of twill and corduroy or a glossy surface finish that results from a mechanical calendering process. These physical characteristics contribute to the perceived appearance of a sample by altering the way in which the sample interacts with the light that is incident upon the sample, which in turn affects the reflected light that interacts with the observer. In most cases the contribution of physical characteristics to overall appearance can only be quantified by visual evaluation and not by instrumental evaluation.

Consistency in form and function

Visual sample evaluation requires that a sample of the desired colour be available to each party involved in the colour development and quality control processes. In most cases an original concept sample is selected and then duplicated for distribution to others involved in colour creation. This is typically accomplished by development of small quantities of standard material by organisations specialising in this service. These working standards are then distributed for visual as well as for instrumental colour analysis. The physical characteristics of these working standards will be almost identical, but care must be taken to ensure that the colour variability among these working standards is practically non-existent. The previously defined characteristics of flare and metamerism must also be controlled for the working standards as they may be referenced for colour development for a variety of materials and dye classes. The integrity of the standard must be controlled as, over time, its perceived colour may change due to handling, storage and fading.

Specific guidelines should be either referenced or developed with regard to the placement and positioning of samples in a light cabinet for visual evaluation so as to minimise inconsistencies in visual evaluation that are due solely to the orientation of the samples.

An often overlooked factor that must be considered when performing visual colour evaluation is the temperature and moisture level of the sample. Depending upon fabric construction and dye class, the temperature and relative humidity to which the sample has been conditioned may significantly affect the interaction of the sample with incident light, resulting in noticeable colour differences. Specific guidelines for textile sample conditioning are given in ASTM International method D1776 – 'Standard Practice for Conditioning and Testing Textiles'. This method specifies that samples should be conditioned to 21 ± 1°C and relative humidity of 65 ± 2% prior to sample testing.

5.2.3 The observer

The third component required for the sensation of colour is an observer. By nature, the observer is the most difficult component of the colour sensation process to characterise, and the most subjective. While substantial research has resulted in the creation of 'standard observers' for use in numerical colorimetric calculations, the average observer may or may not fit the model of the 'standard observer'. Observers are affected by a number of internal and external factors, each of which can contribute to inconsistencies in observations among observers as well as inconsistency in the repeatability of the observer's own visual evaluation results.

Colour vision testing

As evidenced by the process used to develop the standard observer, it is clear that the inherent capacity to visualise colour varies among observers. It is also documented that 'about 8% of the male and 0.5% of the female population have color-defective vision' (Berns, 2000). For these reasons it is vital that everyone involved in the visual evaluation of colour undergoes certain tests to determine if a colour vision deficiency exists or if there are issues with discrimination of small differences between similar colours. Poor results in either type of test may indicate that the individual is not suited for visual colour evaluation. Note that, as an observer's colour vision may change over time, tests of this nature should be periodically repeated.

Two well-known tests for colour deficiencies are the Isihara *Tests for Color Blindness* and the Dvorine *Pseudo-Isochromatic Plates*. Both tests will identify the presence of a colour deficiency on the part of the observer. Tests for colour discrimination – the ability to recognise and distinguish between samples with small colour differences – include the *Farnsworth–Munsell 100 Hue Test* and the *HVC Color Vision Skill Test*. Specific guidelines for evaluation of observers are defined in ASTM International method E1499 – 'Standard Guide for Selection, Evaluation, and Training of Observers'.

Factors affecting colour perception

In addition to the genetic characteristics of the observer's optic system that result in the previously mentioned rates of colour deficiencies, a number of other physical and psychological factors influence their ability to discern and discriminate among colours. Internal factors affecting colour vision include fatigue, desensitisation due to prolonged exposure to certain colours, emotional state and the influence of chemical substances that affect the mental and physical condition of the individual. Personal bias may also exist in an individual based on their past experience, cultural influences and personal preferences with regard to style and colour.

External factors affecting colour vision include both positive and negative influences. Experience and training can improve the observer's ability to discern and describe small colour differences between similar samples. Failure to adhere to proper methods for visual evaluation, such as improper sample positioning, failure to control the surrounding area or extraneous materials in the viewing space and external lighting influences, will result in inconsistencies in visual colour evaluation. The physical characteristics of the sample being evaluated contribute significantly to the final acceptability of a sample. These effects are either consciously or subconsciously included in the overall evaluation of the sample.

5.2.4 Sample viewing environment

The source of light, the object and the observer are joined together to produce a sample viewing environment. It is not enough just to define and understand the contribution of these three components to the visual colour evaluation process because it is only when they are combined together in the viewing environment that evaluation of colour is possible. As such, the interaction of these three components and the environment in which they are placed must also be defined. Guidelines for specifying and controlling the sample viewing environment as documented in various industry methods and procedures will be examined in more detail in a later chapter.

The light source environment

As previously mentioned, suitable primary and secondary light sources should be selected for evaluation of sample colour, and these light sources should be incorporated into an acceptable lighting cabinet or lighting device. The surrounding environment including the colour of the walls, the presence of extraneous material or other coloured samples, the clothing being worn by the observer, ambient light, etc., will determine whether or not the desired level and quality of spectral energy emitted by the light source is actually incident upon the sample. Specific guidelines must be followed with respect to the colour of the surrounding area, the intensity of the light at the level of the sample and control of external influences, including ambient or direct light from other sources such as windows and lamps. Visual colour evaluations performed using uncontrolled light sources such as light through an office window, a desk lamp, standard overhead lighting or natural outdoor light cannot be considered reliable.

The object environment

In addition to the criteria previously mentioned for the objects being evaluated, the preparation and positioning of the objects must be addressed. To ensure consistency and repeatability in sample evaluation, samples must be prepared and positioned in the same way each time the samples are evaluated.

Sample preparation will include any mechanical or manual cleaning of the surface, pile orientation for applicable fabrics and sample conditioning as previously described. Sample positioning will include specification of the number of layers of material to use, the type and colour of any background that might be present, the relative positioning of the samples to each other, the orientation of the fabric construction, the orientation of individual yarns or fibres for materials being evaluated in yarn or fibre form and designation of the minimum sample size required for evaluation.

The observer environment

After confirming that all observers are qualified to perform visual colour evaluations as described previously, the observers must follow specific guidelines during the visual evaluation process. A number of standard methods exist for the purpose of defining the criteria to be followed by the observer when visually evaluating samples and are addressed in other chapters. Of primary importance are the positioning of the observer relative to the sample and proper techniques for changing light sources for sample evaluation.

5.3 Industrial guidelines for visual colour assessment

A number of professional organisations including the American Association of Textile Chemists and Colorists (AATCC) and ASTM International have developed methods to assist the colour industry with the visual evaluation process. These tests include but are not limited to:

- AATCC Evaluation Procedure 9: Visual Assessment of Color Difference of Textiles
- ASTM D1729: Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminate Opaque Materials
- ASTM D4086: Practice for Visual Evaluation of Metamerism
- ASTM E308: Practice for Computing the Colors of Objects by Using the CIE System
- ASTM E1499: Guide for Selection, Evaluation, and Training of Observers

Additional methods have been developed for specific application of visual techniques for the assessment of sample characteristics such as colour change, staining and gloss and include:

- AATCC Evaluation Procedure 1: Gray Scale for Color Change
- AATCC Evaluation Procedure 2: Gray Scale for Staining
- AATCC Evaluation Procedure 3: AATCC 5-Step Chromatic Transference Scale
- ASTM D2616: Test Method for Evaluation of Visual Color Difference With a Gray Scale
- ASTM D3134: Practice for Establishing Color and Gloss Tolerances

These and other methods are published yearly as the *Technical Manual of the American Association of Textile Chemists and Colorists* (AATCC, 2004) and the *Annual Book of ASTM Standards* (ASTM International, 2002) and are available from the applicable organisation. The observer should reference each of these test methods in order to become familiar with the specific details of each method. Adherence to these methods will greatly increase the repeatability and reproducibility of visual colour evaluations.

5.3.1 AATCC Evaluation Procedure 9: Visual Assessment of Color Difference of Textiles

The purpose of this evaluation procedure is to provide the user with guidelines to be used for developing a repeatable technique for visual assessment of colour and colour difference. The primary focus is on lighting conditions, sample preparation and determination of visual colour difference.

Lighting conditions

AATCC Evaluation Procedure 9 (AATCC EP9) provides the user with specific information regarding acceptable illuminants and their colour temperature, which may be measured with a colour temperature meter or photometer, and the illumination level at the sample plane. Illumination level may vary from one lighting environment to another, which may affect the perceived colour, depending upon the degree of variation, and may be measured using a spectroradiometer. Also described are the recommended neutral gray specifications for the surrounding area, the arrangement of the light source relative to the sample and the observer – better known as viewing geometry, and the manner in which the viewing area should be maintained.

Sample preparation

AATCC EP9 provides the user with guidelines for preparing samples for visual evaluation, including sample conditioning and sample size as appropriate for the type of material being evaluated, such as woven and knitted cloths, narrow cloths, loose fibre, threads and yarns. As with any recommendation for sample presentation, the user may find that their particular presentation method may require some alteration of the method presented in this procedure if deemed necessary for accurate sample evaluation. The presentation method selected must be clearly communicated to all observers who will be evaluating the material in question in order to avoid misinterpretation.

Determination of visual colour difference

Visual colour differences between samples are determined by the observer, and AATCC EP9 defines several descriptive terms that can be used to verbalise the visual evaluation. The primary descriptors used should communicate a direction of colour difference and a magnitude of colour difference between the sample designated as the standard and another sample designated as the test specimen. As previously stated, the results of the visual evaluation will be dependent upon a number of internal and external factors that influence the observer. The goal is that all parties involved in visual evaluation of a particular sample pair will perceive approximately the same colour difference direction and magnitude.

5.3.2 ASTM D1729: Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminate Opaque Materials

ASTM D1729 was developed to assist the observer in defining the equipment and procedures required to produce repeatable visual evaluation results. ASTM D1729 addresses the same requirements of sample illumination and geometry, sample preparation and evaluation of colour difference as previously defined in AATCC EP9.

5.3.3 ASTM D4086: Practice for Visual Evaluation of Metamerism

ASTM D4086 offers a method for detecting the presence of both illuminant metamerism and observer metamerism. Illuminant metamerism has been previously defined, and observer metamerism may be defined as the circumstance in which a pair of samples are a visual match to one observer in one set of conditions but are not a visual match to another observer in the same conditions. Note that calculations for metamerism are not included in this method, though they are available in computer programs that calculate colorimetric differences. Instead, ASTM D4086 provides the user with recommendations regarding use of a grey scale to determine the degree of metamerism.

5.3.4 ASTM E308: Practice for Computing the Colors of Objects by Using the CIE System

ASTM E308 provides details for calculation of colour coordinates based on the CIE system. Also included in this method are spectral tristimulus values for CIE 1931 Standard (2°) Observer and CIE 1964 Supplementary Standard (10°) Observer, relative spectral power distribution data for a range of CIE standard illuminants and tristimulus weighting factors for the same range of CIE standard illuminants. These data tables are incorporated into computer programs that calculate colorimetric coordinates and colour differences.

5.3.5 ASTM E1499: Guide for Selection, Evaluation, and Training of Observers

ASTM E1499 details the criteria and tests that should be used for determining the suitability of an individual for visual evaluation of colour and colour difference. Also included in this method are techniques for training observers in order to improve their colour discrimination abilities. Colour vision tests and training tools such as the *Dvorine Pseudo-Isochromatic Plates* and the *Farnsworth–Munsell 100 Hue Test* are described in detail.

5.4 Practical application of visual colour assessment methods

After gaining a thorough understanding of the factors affecting visual colour evaluation, the observer must actively apply this understanding to every observing situation. While each situation and circumstance may be different, the fundamental principles for visual colour evaluation remain the same. By clearly communicating the parameters within which samples are being visually evaluated, the observers are free to focus on the primary goals of the evaluation process, which may vary.

5.4.1 Colour vs. appearance

As previously defined, colour is only one of the characteristics of a sample that may be evaluated. The overall visual effect produced by the colour of a sample and its physical characteristics is defined as the sample's appearance. For the average observer, separation of 'colour' from 'appearance' may be an impossible task. With experience, the observer may learn techniques of sample positioning and illumination that allow for some degree of isolation of the colour characteristic from the overall appearance of a sample. It is left to the observer then to determine which of these aspects are of primary importance, either the sample's colour or its overall appearance.

5.4.2 Initial colour development

The initial colour development phase begins with selection of a standard. As previously discussed, the availability of a sufficient quantity of standard material in the desired colour for use by each observer in the colour development process can be a significant challenge. Assuming that an acceptable physical sample is available for each observer, it is then necessary for the person or organisation with final responsibility for approving the developed colours to specify the viewing parameters. These parameters are:

- primary and secondary light sources
- viewing geometry
- physical form of the test sample (woven, knit, yarn, etc.)
- size of the test sample
- conditioning (temperature and humidity) requirements
- orientation of pile or other physical modifications
- number of layers for each sample or backing material
- orientation of the standard and test sample relative to each other.

In addition to the above items, clear guidelines must be communicated regarding the expectations for the quality of the colour match. Because of the nature of visual colour evaluation, this is a very subjective aspect of initial colour development, as it relies upon the experience of the colour developer – the 'dyer' or 'supplier' in the case of textile colour development – and their familiarity with the expectations of the 'customer'. Specification of colorimetric tolerances generated using a spectrophotometer and appropriate computer software is an invaluable aid in this process as it gives the colour developer specific numerical data to use in their evaluation of the quality of the sample that has been produced.

Consideration must also be given to the type of material on which the new colour is being developed and how it compares with the material used to prepare the target standard. Differences in the fibre type, construction, or dye chemistry may result in differences in total appearance in one or both of the primary or secondary light sources. For example, the supplier may not be able to match the brightness of a glossy paint chip while developing the colour on cotton yarn. In this scenario the customer must recognise the limitations of colour development on the selected material and adjust expectations accordingly. This is especially true when a colour is being developed on a variety of dissimilar materials, in which case coordination and harmony among the final materials is more important than an absolute match to the original standard.

5.4.3 Production quality control

The primary concerns in production quality control are deviation from the approved target standard and consistency within and between production lots. The target standard for visual evaluation in the production environment will be either the original standard used for initial colour development, the sample approved by the customer, or the first production lot produced by the supplier. There must be agreement between customer and supplier as to which standard is used in order to eliminate any misunderstanding regarding colour quality. This is especially true when production lots from multiple sources will be combined into the same garment or when they will be displayed together in the retail store.

A key to visual colour evaluation in the production environment is understanding the difference between perceptible colour difference and acceptable colour difference. The goal of the initial colour development phase is to produce a colour on the specified material that is identical in colour to the original standard. While this is theoretically possible – giving consideration to the points previously mentioned regarding dissimilar materials – it is typically impractical and requires an excessive amount of time and expense. Both parties agree then on a level of colour difference that still meets the needs of the customer and, while the test sample may be almost identical in colour, there is still a perceptible colour difference. Perceptibility, therefore, is defined as a level of colour difference that is almost non-existent. This level of colour difference is not practical in the production environment, so the customer and supplier must agree on a level of colour difference that, while potentially too excessive for initial colour development, is acceptable for bulk production. Note that the end-use of the product should be considered when specifying the degree of colour difference accepted in production.

A final consideration for production quality control is shade sorting and sequencing. While production material may be acceptable to the target standard, there may be excessive variability when comparing individual production units to each other. The degree of visible variance can be minimised by organising production units – lots, rolls, batches, etc. – in such a way as to minimise the visible colour change between the individual units. Shade sorting and sequencing (or tapering) involves the visual arrangement of production units such that, even though there may be considerable variation between the colorimetric extremes in the set of production units, the sorted and sequenced group will appear uniform. The manufacture of garments from production units delivered in their sorted and sequenced order will minimise the possibility of noticeable colour variation within the set of manufactured garments or within the individual garments.

5.4.4 Sample testing

Product characteristics related to appearance such as washfastness and lightfastness are evaluated based on visual assessment methods. Specific guidelines have been developed for testing of these characteristics and are detailed in AATCC and ASTM International methods, as previously mentioned, as well as in test methods developed by the International Organization for Standardization (ISO). A number of other visual characteristics may be of importance, such as gloss, metamerism, resistance to abrasion, resistance to colour change from abrasion, etc., and appropriate test methods should be used if available.

5.4.5 Application to various textile materials

Visual evaluation methods for textiles will vary depending upon the physical characteristics of the material. For those samples with significant physical variability it is critical that the visual evaluation methods be well defined and clearly communicated. The following guidelines regarding sample positioning and preparation should be considered when evaluating various textile materials. For all materials, the accuracy and repeatability of the visual evaluation will diminish as the size of the sample decreases. All materials should be clean and free of visible contamination before they are evaluated.

Flat wovens and knits

These types of materials are often the least difficult to evaluate as they are uniform in construction. The material should be orientated with the face of the fabric up and the horizontal/vertical position aligned according to the manufactured direction of the fabric. Twill and knit patterns should be observed if present and the sample orientated accordingly. Sample opacity should be considered, and either a suitable number of layers to achieve opacity be specified or a common backing material be used.

Pile goods such as velour, corduroy and carpet

Of primary concern for pile goods is the orientation of raised fibres and yarns. Most pile goods have a natural pile direction, and through handling the pile may no longer be uniformly orientated. These types of materials should be brushed with an appropriate device prior to visual evaluation to re-orientate the pile into its natural pile direction. Also of interest when evaluating pile goods is the positioning of the sample during evaluation. When the pile direction faces the observer, the observer's evaluation is influenced by the colour of the ends of the pile, while if the pile direction faces away from the observer, the observer's evaluation is influenced by the colour of the sides of the pile yarns. Clear communication regarding sample positioning will eliminate any misunderstandings when evaluating these types of materials.

Yarns and threads

The preferred method for evaluation of yarns and threads is first to wind the sample skein on to a card in order to align the individual yarns. Care must be taken in this process to ensure that a sufficient quantity of material is used so as to completely obscure the card from view. Tension during winding must also be controlled to prevent bowing of the card and to prevent changes in appearance that are related to the application of excessive tension. Winding of wet yarn typically leads to excessive yarn tension or bowing of the sample card as the yarn dries.

Loose fibre

Loose fibre cannot be accurately evaluated in its natural loose form. As such, the fibre must be processed into a pad for evaluation. Loose fibre may also be compacted into a compression cell under uniform pressure, especially when the sample is to be evaluated instrumentally.

5.5 Future trends

Visual colour assessment by a skilled observer will always be a part of the colour development and quality control processes. This visual evaluation process has traditionally required transfer of large numbers of physical samples between the organisations involved in colour development. This transfer of physical samples adds a significant amount of time to the development process as samples are shipped around the world, which ultimately translates into lengthy colour development cycles. In order to have finished goods available to consumers at the proper time, colour development must often begin months in advance of delivery deadlines.

To shorten the development cycle, the transfer of physical samples must be eliminated. The question that must then be answered is how are samples to be evaluated if physical samples are not available? This problem is addressed by proper application of instrumental analysis followed by digital data communication and display of the sample colour on a calibrated monitor. Technologies currently exist to address each of these steps in digital colour development.

Just as very specific guidelines must be followed to ensure proper visual assessment of textile samples, specific guidelines must also be followed to ensure accurate and repeatable instrumental analysis of textile samples. A successful programme of instrumental assessment of textile samples requires guidelines for sample size, sample orientation, the number of measurements performed on a single sample, sample conditioning and so forth. A key requirement for instrumental analysis is that the results are not only repeatable, but that they correlate well with visual colour evaluations. Extensive information on the subject of instrumental sample analysis has been presented at colour symposia developed by organisations such as AATCC and the Society of Dyers and Colourists (SDC). Test methods for successful implementation of instrumental analysis have also been developed by AATCC.

Digital communication of instrumental data in the form of spectral reflectance values is facilitated by any of a number of commercially available computer software programs. These programs allow for instantaneous communication of colorimetric information between organisations anywhere around the world. Once received, the digital data can be evaluated numerically against established colorimetric tolerances, and decisions regarding acceptability can be made. Additional value in digital data is realised when the spectral reflectance values can be displayed on a calibrated monitor. Software for this purpose provides tools for characterisation of the monitor's colour output followed by accurate representation of spectral reflectance data on images of the actual textile material. Accurate display of colour on a calibrated monitor in this way allows the observer to evaluate the quality of a sample using digital data rather than a physical sample, thereby eliminating the time required to deliver the sample and ultimately reducing the time required for colour development. These technologies have been successfully implemented by a number of retail and clothing companies and their suppliers. Though they may never replace the need for visual evaluation of the final product, they are invaluable tools for increasing the efficiency of the colour development process.

5.6 Sources of further information

A number of organisations offer extensive information on textile visual analysis, instrumental sample analysis, testing, and industry trends in textile colour development. The following organisations should be considered as sources for reference information, as well as for symposia offerings:

The American Association of Textile Chemists and Colorists (AATCC)
PO Box 12215
Research Triangle Park, NC 27709, USA
www.aatcc.org
AATCC Review (published by AATCC)

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959, USA
www.astm.org

The International Commission on Illumination (CIE)
Kegelgasse 27
A-1030 Wien, Austria
www.cie.co.at/cie/

International Organization for Standardization (ISO)
1, rue de Varembé, Caisse postale 56
CH-1211 Geneva 20, Switzerland
www.iso.org

The Inter-Society Color Council (ISCC)
www.iscc.org

The Society of Dyers and Colourists (SDC)
PO Box 244, Perkin House,
82 Grattan Road, Bradford
BD1 2JB, UK
www.sdc.org.uk

5.7 References

Albers, J. (1975). *Interaction of Color*, New Haven, CT: Yale University Press.
Berns, R. (2000). *Principles of Color Technology*, 3rd Edition, New York, NY: John Wiley & Sons, Inc.

2004 Technical Manual of the American Association of Textile Chemists and Colorists, Research Triangle Park, NC: AATCC.
2002 Annual Book of ASTM Standards Section Six, West Conshohocken, PA: ASTM International.

Part II

Managing colour