11

Quality assurance management for coloured goods

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11.1 Reproduction of colour

11.1.1 Traditional identification of colour attributes and recipe/reproduction forecasting

The reproduction of a specific shade or colour is a fundamental part of textile manufacture. Commercially successful products and designs require the concept of colour to be recreated in the closest manner possible so that the holistic effect of the cut, shape, pattern and texture are carried into the retail product.

Because of the way in which inspirational colours are found or accumulated by designers, from articles as varied as feathers, minerals, ceramics or other surfaces, the task of interpreting these into a dyed textile has fallen to the dyer working in collaboration with the designer. The dyer uses expert knowledge of practical dyestuff combinations and effects to predict or create the closest match to the vision of the designer. Sometimes a close approximation is not possible due to the technical limitations of process or materials – but usually a compromise can be found if the communication is good between the parties.

Some apparel producers try to reduce the difficulties of recreating a designer's colour choice by insisting that only textile materials are put forward for development – this means that there is a greater likelihood of being able to match the colour closely and that instrumental techniques may also be employed.

As with any evaluation or assessment of colour, it is vitally important that the viewing conditions, i.e. the illumination and environment, are defined and standardised. Unfortunately, this is still not widely understood by non-colourists but failure to establish these basic rules can needlessly invalidate much effort and work. Ideally, one or more internationally recognised illuminants (such as D65, TL84, A (Tungsten), etc.) should be specified for viewing.

Samples should always be viewed in a neutral environment, such as in one of the commercially available colour assessment cabinets[1] – remembering to shield the cabinet from exterior light pollution and ensuring that the clothing of the observer is not reflecting colour back into the cabinet!

The physical condition of the samples also affects the perceived colour so the samples should preferably be at a constant temperature and humidity if at all possible. For textiles this is recommended to be 65% ± 2% relative humidity and 20° ± 2°C – the normal standard atmosphere found in physical testing laboratories. Where these conditions cannot be met in the working area, environmental cabinets,[2] that maintain the correct temperature and humidity conditions and expose the samples to a consistent level of light prior to measurement can be used to condition the samples immediately prior to assessment.

Once it is certain that the colour is being observed correctly, other factors essential to the design or product need to be clarified prior to production.

- What is the material (or substrate) to be coloured?
- Will it need to be after-treated?
- How will it be cleaned?
- Will it be exposed to high levels of light (e.g. summer wear) or only be worn in the dark, or in nightclubs?
- Will the light sources change during normal wear (indoors/outdoors)?
- Are other coloured materials to be used in combination?

The answers to these questions help the producer to select the most appropriate materials and processes to meet the specification.

Historical or experience-based forecasting

The most common way of developing a recipe for a new colour has been to review the results of previous recipes – the historical shade library. All dyers retain records and samples of previous dyeings and these have the advantage of being 'known' properties. They are 'known' to have produced a given shade under the local conditions found in the dyehouse. If they are deemed to have been 'successful' recipes, they will be reliable, reproducible and efficient means of obtaining given colours with the available dyestuffs, chemicals, water, equipment and substrates. In absolute terms, they may not be the cheapest or best – but they will work predictably.

By finding colours similar to the required one and adjusting the relative ratios of elements in the recipes, it is usually possible to find a reliable recipe fairly quickly – and the behaviour of the recipe can be predicted reasonably well so that unforeseen production problems do not occur.

With an experienced dyer, this method can be a reliable and quite a speedy way of recipe generation; unless a new colour happens to be completely outside the gamut (colour range) of previous experience or if the substrate is new with unknown behavioural characteristics. In these cases it is necessary to go back to basics in the laboratory and develop a recipe empirically.

Empirical recipe development

Because of the number of variables affecting the colouration of materials, it is essential to establish a valid experimentation method that will allow predictions to achieve a reasonable probability of success. In the case of application of dyes to textile materials, the methods need to assess the colouration or yield effects of a particular dyestuff in isolation and in combination with others, on typical or actual substrates (in the state or form that they will be finally processed), using the same water and chemicals as the industrial process.

Whilst this preliminary work on the 'raw materials' can be accurately and consistently performed in the laboratory, to find the 'working recipe', the scaling-up of the recipe to 'bulk' often requires changes in order to achieve the same result.

These changes are necessitated by:

- the different fluid dynamics inside large-scale machines compared to laboratory-scale equipment;
- the physical state or positioning of material in the dye liquor and the degree of control existing in the system and plant – slight temperature variations, pump rates and pressures, liquor ratios, etc.;
- the small but inherent variations in water quality, chemical compositions and dosing.

The difficulties of the move from the 'lab-dip' to 'bulk production' can often be underestimated by those not involved in production and may lead to some unrealistic expectations. However, most successful dyers understand and can predict the differences in their own circumstances and therefore ensure that the laboratory work takes this into consideration or that the bulk recipes are suitably modified.

To undertake empirical recipe development is an important but expensive and time-consuming exercise. Some organisations choose to limit this work – and avoid the errors or mistakes that can happen with inexperienced staff – by 'subcontracting' this work to professional laboratories or by using the services of dyestuff companies.

Third-party or subcontracted recipe development

Most, if not all, dyestuff manufacturers offer customers their services in the form of recipe development or advice using their products. The advantages of such a service are that the recipes are usually 'optimised' for reliability and performance and the quality of the result with regard to colour fastness and durability is usually indicated. If the service provider uses water from the same source and all the same chemicals, the results will be very reliable. It will just be the time and scaling elements that will need to be considered.

Dyestuff suppliers offer development services for major clients with a rapid turnaround (i.e. days rather than weeks). Smaller clients may have to wait significantly longer.

11.2 Instrumental or computer recipe prediction

One of the advantages of computer-based systems is the ability to retain a total history of empirical, practical and imported data for purposes of predicting likely colour outcomes of specific colourants, methods of application and substrate combinations. These databases are generally site specific and peculiar to the local factors in play (local water, actual equipment design, stocked dyestuffs, available chemicals, regular substrates). Importantly, they are also normally an average or consensual value of the work of technicians and colourists and therefore more reliable, being less prone to bias or one-off situations.

11.2.1 Target measurement

As with all instrumental methods, the care taken in measuring the target will repay itself by requiring fewer iterations and corrections to achieve the desired end result. In other words, if the target is not measured properly, it is rather pointless trying to use the data for predicting anything.

The importance of technique has been well documented elsewhere but it is always worth remembering that more errors are made due to inconsistent or poor measurement technique than probably all other instrumental calibration or correlation factors combined.

Firstly – can the target actually be measured accurately?

Is the sample large enough to be able to present an opaque, representative area to a spectrophotometer?[3] Representative in this case means large enough (folded if necessary) to be able to use an aperture sampling size that is consistent with the material texture and form so that repeated measurements are comparable (typically a difference between readings $\leq 0.3\ \Delta E$ CMC 2:1).

Note that although the choice of a colour difference formula to be used by instrumental colour measuring systems is not discussed here, it is essential that the same formula is applied by all parties sharing or using the same colour data and systems to make comparisons or judgements.

With most commercial spectrophotometers it is possible to change aperture size to suit the available samples. However, it must be remembered that readings from different aperture sizes are not generally comparable due to the differing amounts of light falling on, and reflected from, the samples during measurement.

Sometimes the structure or shape of a desired target may make meaningful measurement impossible – for example, a feather cannot be easily measured with a spectrophotometer. However, recent developments in the use of digital cameras, standardised viewing conditions and software to create reflectance data, mean that in future many more items – previously thought to be impossible to measure – may be able to be viewed and used to target colour predictions and matches.[4]

Secondly – has it been conditioned?

Much work has been published regarding the change of perceived or measured colour due to the effects of heat and moisture. It is therefore important to ensure that measurements are only performed on materials that are in equilibrium with a standardised atmosphere (as referred to in Section 11.1.1 above).

Similarly, light will affect the behaviour and appearance of certain colourants so measurements should only be made on samples that have been exposed to normal or standard levels of light radiation so that they are in a stable condition. Because of this sensitivity to light with some materials, repeated measurements with a spectrophotometer xenon flash may also change the colour being measured, so care must be taken when deciding how many readings (flashes) to take to obtain a specific reflectance value.

Thirdly – does the target have any common physical or material features with the predicted substrate?

Widely differing surface characteristics, coating chemistry and pigment types may make any prediction non-viable due to the lack of similarity in such critical factors as appearance, colour component combinations and surface measurement geometry with the proposed manufactured product.

11.2.2 Predictive systems

Predictive systems have been available for many years from various providers of colour applications.[5] Essentially, they all provide the same function and allow a recipe to be created and then modified, based on measurement of the actual results. Some systems have been enhanced to 'learn' or become 'expert' in the results achieved and to modify the first 'pass' or prediction thus increasing the likelihood of a first-time success and reducing the need for further iterations.

Any predictive system depends on accurate base data for the generation of suitable recipes. As with empirical recipe development, the use of representative data is fundamental to the accuracy and usefulness of the system. However, with a digital system using only one data set for all calculations, the accuracy of this data set is crucial.

Recently, there have been web-based prediction systems established on the Internet[6] and these can be used to locate and identify ranges and mixtures of dyes that offer the promise of a close match with identifiable and comparable matching under different illuminants.

These tools can be used to help dyestuff manufacturers offer a rapid 'virtual' sampling service to existing or would-be clients – prior to them investing in the laboratory time and cost to create a working recipe from the most suitable dyes. The tools can also be used to share accumulated knowledge and methodology across multi-site operations, avoiding the duplication of effort (and eliminating the cost and errors of that effort).

11.2.3 Primary data creation or sourcing

Textile dyes exhibit different performance and yield attributes depending on their concentration in the application medium, the quantity actually taken up by the substrate and the combination of different quantities and types of dyes used to achieve a given shade. Advice on these characteristics should be obtained from the dyestuff manufacturers so that needless work, and fundamental errors, can be avoided.

For a prediction system to generate reliable results, it is important that the colour yield attributes are accurately known over the full range of commercial application rates, i.e. the quantities of dye known to provide acceptable levels of fastness or stability on the substrate.

This primary data is generated by completing a series of monochromatic dyeings using the 'standard' substrate, water, chemicals, liquor ratio and dyeing method to be found in the laboratory or production unit, with an evenly spaced range of dyestuff concentrations between the recommended minimum and maximum application rates.

The ultimate accuracy of this data is always going to be determined by the number of correct and representative dyeings performed and measured into the system. Smooth and accurate prediction curves are unlikely to be achieved with fewer than 12 gradations – although as few as six can be seen in practice.

The work required to achieve the required level of accuracy should not be underestimated, and high levels of personnel training and care are essential if the database is to be reliable, and therefore usable.

Automated dispensing systems[7] can certainly help to eliminate some of the work and errors. Although these can be relatively expensive for small- to medium-sized producers, they do save much time and cost. However, they do depend on the same high level of operator care to load and maintain the standard solutions of dyestuffs used in the dispenser.

Alternatively, the work can be subcontracted to professional laboratories who have been supplied with all the information and materials (water, dyes, chemicals and substrates) to permit the generation of data specific to site condition.

Whilst these data will be consistent and accurate, it is essential that the currency of these data is ensured and maintained by constant updating whenever material changes are made to dyes, chemicals, process conditions, equipment or substrates.

11.3 Colour variation evaluation and monitoring

Commercial reproduction of coloured materials is only possible if the quality and repeatability of a colour can be assured. Systems to enable this control are essential elements of any manufacturing process.

11.3.1 Establishment of colour standards

Practical colour standards need to be created in order for any colouration process to be controlled effectively. This means creating colour standards that are relevant and consistent with the products and processes being used, essentially by using the same colourants and substrates as the production items.

Colour standards are often produced 'in-house' as laboratory dyeings or special small-scale production lots, depending on the requirements and use of the standards. For internal use, these can be stored as fibre tufts, yarn windings or fabric swatches, and are usually measured into a colour library database for routine usage in controlling production, the 'original' physical standard being filed, purely as a reference.

However, colour standards are often created commercially for specifiers or buyers and distributed (or sold) to the various producers in the supply chain. These so-called 'engineered standards' are actually small production runs on standard substrates – or special substrates to order.[8]

These engineered standards are often supplied with the recipe (or at least the dyestuff concentrations) used to create the colour, as well as the standard reflectance value – which is effectively the mean of all the values of a standard measured on a reference quality spectrophotometer under prescribed conditions.

The coloured materials are checked for consistency prior to sale or shipment and are warranted to be within a certain colour matching tolerance to the master reflectance value reading (typical examples may be $\leq \pm 0.5\ \Delta E$ CMC 2:1 from the mean value).

Whilst these engineered standards are invaluable for enabling buyers and agents to specify and evaluate the purchased materials, they may constitute merely a guide, albeit a very detailed and accurate guide, to the production unit. Most production units have a different source of raw materials to those used for the engineered standard and will therefore create a local production standard, based on the engineered standard, but using local substrates and dyestuffs normally sourced by that unit.

11.3.2 Ensuring continuity and constancy

Once a colour standard has been established, every production lot or batch must be compared to this and be within an agreed commercial tolerance before it is approved for release.

If the colour standard is a local one, matched to a client's engineered standard, both standards should be used when assessing the acceptability of a particular lot. A good rule of thumb is that the colour of any lot should always lie between the two standards. This eliminates any tendency to drift away from the colour expected by the client.

The maintenance of continuity records for every production lot is essential in order to achieve this level of control. Modern computer-based systems simplify this process by providing measurement and reporting features able to display current and historical data simultaneously.

With larger, multi-unit groups or buyers requiring production from more than one manufacturer, it is essential that common data is shared and used to ensure colour consistency across the supply chain. Effectively, this means maintaining a single colour standard for any given product – no matter how many production units are involved – and for each and every dye lot to be matched against this standard *and every other dye lot produced to the same colour*! The result is a single, multi-unit continuity record, where all units are linked in real time over the Internet so that no drift or pass/fail disagreement can occur.[9]

All measurement data must be typical of the material being produced and steps must be taken to ensure that production batches are coloured consistently and evenly throughout. For continuous dyeing and finishing ranges, on-line systems are available and are being developed using the latest remote and no-contact sensor technology with high-speed sampling.[10]

As with all colour measurement, it is vitally important to ensure that the substrate condition (i.e. temperature and humidity) is regulated or known during measurement if the results are to be meaningful and comparable.

11.3.3 Practical re-standardisation

Sometimes it is necessary to change a local standard for production – even if the master or engineered standard has not been changed. This can be caused by the temporary or permanent unavailability of one or more of the original raw materials, such as the withdrawal or lack of colourants, or perhaps a change in substrate composition, e.g. new cotton crops, synthetic merge changes, etc., or even a forced change in production conditions: water supply problems, plant breakdown or closure, etc.

Whatever the cause, the result is a practical and technical inability to reproduce the exact colour conditions previously established. A new local or production standard must be created to control subsequent production but the impact of this change needs to be carefully evaluated and considered.

Sometimes the change may be so small as to be within expected normal process variation. This is not usually an issue. At other times, the result may be a significant move from the original standard under one or more illuminants. In these instances, it is essential to advise the client, and probably the rest of the supply chain, so that the impact can be assessed and measures taken before unexpected costs and problems are incurred. Even if the adjustment is accepted in principle by the client, a sudden arrival of off-standard goods, which may need to be re-matched by other processors and trim suppliers, can cause serious problems and delays to product manufacture.

11.3.4 Instrumental systems and methods

Colour standard and continuity maintenance are best achieved by the use of instrumental measuring systems and digital record keeping. These are the only means of ensuring consistent application of objective decision criteria and the preservation of colour records in a state free from degradation due to handling or poor storage.

Spectrophotometric measurements of materials prepared and presented in standard forms create highly consistent and reliable data for use as standards and in continuity assessment.

Any data used for colour assessment need to contain all the important parameters of the measurement conditions so that any differences can be noted and the comparability, or not, of the results taken into consideration.

Ideally, these data should show:

- the type and model of the measuring instrument;
- the calibration data condition;
- the choice of measuring aperture;
- the use of any UV or other filtering in the sample illumination;
- the percentage reflected light at given specified intervals across the 'visible' spectrum.

Because of the different designs, ages and condition of spectrophotometers in use throughout the industry, some extra method (other than normal calibration) of assessing comparability of results had long been felt to be desirable.

Internet applications are now available to check the performance of instruments against a virtual standard and to correct the output, correcting any drift or degradation in performance.[11]

Whilst it is important that instruments are correctly maintained and calibrated, it must be remembered that the biggest influence on the accuracy of spectral data is the human operator! Web-based applications that can correlate and compare the actual results of the same samples measured by different users[12] should also be considered as another essential part of a quality assurance scheme to ensure the reliability of data.

Once accurate digital information is available, these data can be used to generate consistently uniform images on calibrated CRT monitors, allowing identically coloured images to be viewed simultaneously at any location. Such techniques are excellent aids to describing colour relationships and variations. Photorealistic images can also be incorporated into these systems allowing 'texture' to be seen and taken into account when colours are modified or changed.[13]

The use of digital camera technology allows 'real' images to be presented rather than facsimile masks but one limitation of all these systems lies in the inability to show a complete gamut or range of colours. High quality monitors can provide stable, consistent and reproducible colours but the actual appearance of a coloured image on a glowing monitor may not look like the original fabric in a light assessment cabinet. For quality assessment and control purposes this may not matter as the comparing images will only be seen 'on screen' as relative colours and the 'real' information for control is digital.

Many other factors affect the accuracy and reliability of spectral data and codes of practice, or other measuring conditions, should also be specified in the data or taken into account. Colour record files are available in many formats from different manufacturers or different equipment and systems and contain varying amounts of information. There has been some rationalisation in the types used, usually driven by retailers wanting commonality in their systems, but the creation of a single file format and colour difference formula for use by everyone has yet to be achieved.

At the time of writing, work was in hand by the Society of Dyers and Colourists and by the American Association of Textile Chemists and Colorists to create an international form of data record that would include all the relevant factors.

In addition to spectrophotometric measurement of colour, the use of digital cameras to capture coloured images in standardised conditions, which can then be processed to create real or synthetic, i.e. software derived, reflectance curves for use in comparison with 'traditional' spectral data is also available.

Data storage and communication is also being developed rapidly away from so-called stand-alone systems, where colour data was created by local measurement only, to open Internet connected systems where colour data can be stored, shared, searched and exchanged in the same way as financial data. It is this paradigm change in communications that now enables instrumental systems to be used creatively in the global manufacturing industry for control and standardisation.

11.4 Colour performance

The management of colour must include the delivery or assurance of colour performance in addition to the colour reproduction. Coloured materials are expected to retain their colour properties for the service life of the product. For example, a disposable napkin will have a colour quality requirement that is totally different to an Atlantic trawlerman's waterproofs but they both have to deliver user satisfaction.

11.4.1 The quality factor – fitness for purpose

The quality of any item is judged by fitness for purpose, and this is no different for colour properties. Fitness for purpose in colour terms usually means a retention of appearance in keeping with expectation, and this varies enormously in apparel. For example, indigo-dyed jeans are expected to 'wash down', but a black formal shirt or sweater will be expected to stay black after washing. The quality of materials used and the expertise required to apply the colourants is probably no different between the two, but both need to be applied consistently and reliably so that the product will behave as expected by the consumer. How to ensure this performance at a known cost is the question to be addressed when considering fit for purpose quality.

Contributing factors

Many things contribute to the colour quality of an item but the main areas usually considered in textile apparel centre around the choice of materials, the methods of process and the abuse or otherwise of the finished product during its service life.

Raw materials

The choice of the correct raw materials is fundamental to any manufacturing process. Whilst it is not normally possible to 'make a silk purse out of a sow's ear', neither is it guaranteed to make the best product from the most expensive materials available. Raw materials need to be selected, based on the required final performance and acceptable cost.

Processes used in colouration invariably have a negative effect on raw materials due to the chemical, physical and thermal treatments involved. Raw materials also need to be selected so that they will withstand these processes in an acceptable fashion.

Fibres, yarns and fabrics should be of an acceptable form, strength and constitution that will withstand the mechanical stresses imposed when wet and/or hot. They should be consistent or homogeneous in composition so that colourants are absorbed and retained regularly and in a predictable manner.

Process materials similarly should be of consistent quality; this includes everything from water, which should be adequately filtered and treated, through the chemicals and additives that must be of consistent purity and strength, to the colourants used to achieve the desired shade. Colourant types and chemistry are substrate dependent, but the consistency and quality of these products with regard to their purity and physical form and preparation (powders, grains or liquids) is of paramount importance.

High quality materials can be compromised by poor storage and housekeeping, which will reduce the reliability and quality of colour obtained. Apart from cleanliness and cross-contamination concerns, environmental factors are tremendously important to dry dyestuffs as they may be hygroscopic (thus affecting the colour yield per unit of mass). In textile dyehouses, which can be hot and humid, the colourant storage areas should be climate controlled to reduce the chance of moisture absorption, which would affect the dosage and may even react with the materials, reducing their efficacy still further.

Liquid dispersions and solutions should be carefully controlled to ensure homogeneity and freshness, so that results remain predictable.

Application techniques

The accurate application of colourants is a science and technology of extreme breadth and depth. For consistent quality, these techniques must be followed to the letter. The vast number of variables involved in the colouration process demands that every possible attempt is made to standardise and control as many factors as possible. The design and automation of colouration equipment has improved this area immeasurably but care still needs to be exercised.

This not only means controlling the mass of substrate, the concentrations of colourants and the time/temperature profiles, but also the standardisation in design of the equipment and the consistency of the material packages, beams or pieces.

Ideally, repeat colours should always be dyed in the same machine as this will reduce the risk of other variables coming into play, which may result in a re-process or re-dye, which will add cost and time to the process as well as reducing the quality of the end product!

The results of poor or inconsistent application techniques are often evidenced by; uneven and inconsistent dyeing, poor colourfastness and damaged fibres – in addition to extra costs and delays to market.

After-treatment and finishing

Product colour quality is often 'made or broken' by post-dyeing treatments. For some dyeing processes, an after-treatment may be used purely to remove unabsorbed or unreacted colour from the surface of the fibres, providing a 'clean' surface that will not contaminate or stain adjacent materials. This process may also ensure that the 'pure' colour is observed. Other after-treatments may add chemicals, which combine or react with the colourants to make them more resistant and long lasting.

More frequently, after-treatments are applied to change or modify the fabric properties and handle. These finishes can affect both the appearance and durability of the colour and so need to be carefully considered before use.

Fabric finishing may involve the use of heat, moisture and pressure to achieve a particular effect. Care must be taken that the colourants used are suitable for these processes and able to resist induced changes due to these factors. For example, colourants that have a low sublimation fastness should not be used in fabrics that will be treated at high temperatures in curing or pressing.

Aftercare and 'wear and tear'

The selection of colourants must take into consideration the final destination of the product, and how the purchaser will expect to be able to treat the product.

Normally, textile materials are washed to clean them, and the quality of colour must be sufficient to allow this process to take place. International conventions on the labelling of materials exist so that suitable washing and cleaning processes can be recommended for various types of textile materials and construction.[14] Rapid colour loss and staining in normal washing cycles are evidence of poor colour quality and inferior processing.

Certain luxury fibre types and colourants are more susceptible to damage by incorrect cleaning but these should be clearly marked by the correct labelling. The application of labels stating that 'this garment should not be cleaned' has been evidenced but is really an indication of poor design and inconsideration by the manufacturer, unless the garment is a design statement or work of art only to be used for display.

All products will suffer colour degradation due to 'wear and tear' but the relative rate of change can be designed into the product by the choice of materials and methods of manufacture. This effect should be consciously built into garments and assessed by wearer trials so that the product can be adequately labelled and marketed.

Colour durability

Assuming that colour has been applied consistently and at the required quality level, the retention of the colour is subject to several factors, which are outside the control of the manufacturer.

Abrasion and wear

Textile materials are flexed and abraded in use and this mechanical action gradually ruptures and removes the surface of the fibres and the fibres themselves. The type of fibre and method of colouration will affect the change of appearance and loss of colour due to this process. Certain fibres and yarns may be coloured consistently through the material so that erosion or abrasion does not remove colour; whereas other fibres and yarns may be surface dyed and relatively little abrasion may eliminate the coloured effect.[15]

Typically, colour loss effects are welcomed in fabrics such as denim but are usually to be totally avoided in dark woollen garments, for example.

Washing and cleaning

As mentioned previously, washing and cleaning can have a drastic effect on colours that are not well bonded to substrates;[16] but colour loss can be attributed to other factors as well.

Many commercial detergents include enzymes and fluorescent brightening agents (FBAs) in their composition. Enzymes will erode certain fibres (particularly protein fibres such as wool and silk) under given conditions and this may cause a change in colour (as well as a structural weakening of the fabric!). FBAs are added to some detergents to brighten whites and colours. However, if these products are applied to dark colours, they effectively 'fade' the colours by masking the shade with a lightening effect. These effects are cumulative and proportional to the amount of exposure during wash and wear cycles.

Modern detergents are usually labelled as to their suitability and alternative products without enzymes or FBAs are marketed for all fibre types, but consumer education in this matter is still wanting, so colours are still at risk!

Light and environment

Electromagnetic radiation in the form of visible and ultraviolet light can have a marked effect on colour retention and on the catalytic degradation of fibres.

When designing coloured materials for environments with high exposure to light, it is essential that the correct fibre/colourant combinations are employed and suitably tested.[17] The environment existing during light exposure is also critical as this may accelerate or modify the effects. For example, the effects of sunlight in the desert will be totally different from the same intensity at the coast.

11.4.2 Testing methodology

The evaluation of colour quality or durability is traditionally performed by trained observers using standard test methods. Usually, these tests entail various processing of test fabrics (normally a multi-fibre strip, composed of bands of common textile fibres) in contact with a dyed sample of known dimension or mass. The two components are then assessed for colour loss and/or transfer (staining). However, the subjective nature of this method has long been recognised as a concern and more objective means are desirable.

Traditional (subjective) assessment systems

For the assessment of colour loss or staining, special scales of grey coloured tiles or chips are used in standard methods. One set (grey to grey) is used for colour change or loss and another set (white to grey) is used for assessing the staining of adjacent fabric. The results are quoted in half steps from 1 (maximum staining or loss of colour) to 5 (little or no change or staining).

The grey tiles are grouped in pairs of increasing contrast. The skilled observer uses these scales to assess a similar degree of contrast between a sample 'before and after' test. The method of illuminating and viewing the samples and the scales is defined by the test methods but the results on a given pair of samples can be slightly different from observer to observer due to differences between the observers! This is especially so in the middle ranges, and this is where the most of the problems lie! There is usually no disagreement about little or no staining or colour loss; nor for severe staining or colour loss. The difficulties arise in the 3 to 4 grade regions where a buyer's grading may be lower than a seller's and the commercial implications are serious! A more consistent method would be preferable.

Instrumental (objective) assessment systems

Digital camera-based systems that are able to assess staining and colour change are now available and have been proved to be far more consistent than human assessment across a range of samples and laboratories. One of the pioneers in this area is the DigiGrade system.[18]

The DigiGrade equipment consists of a standardised sample mounting and illumination system, which is scanned by an accurate digital colour camera. The images are then processed by sophisticated software and the results shown on a calibrated monitor together with their fastness rating. Being digital, these data and images can be copied or shared via computer systems to other DigiGrade installations, allowing all parties to see the actual results.

11.5 Future trends

As production areas become ever more dispersed from the final consumer market and design centres, the importance of fast, reliable communication increases. Even within the manufacturing supply chain there can be multiple levels of fabrication and processing that are separated geographically and culturally and need common technology and data formats to enable processes to be managed.

The Internet increasingly will provide the means to bring all the disparate elements into a cohesive structure.

This impact of web communication will be seen at all levels of endeavour from the remote monitoring and control of production machinery, garment assembly and identification to the tracking and delivery of goods to the final consumer.

The use of linked web services allows simply tasked systems to use queries and searches in extremely complex and powerful ways at a fraction of the resource and cost required for individual stand-alone systems.

Design software will use the same source colour data shared with production, quality assurance and logistics systems; there will be no need to duplicate or copy data, merely to access and share it.

Once a colour has been measured and approved, it can be eternally linked to the product containing that coloured material. This means that true and reliable colour becomes a product attribute that can be managed and specified, just as fabric weight, yarn titre and garment sizes are used in product codes.

The agreed establishment of standardised colour evaluation systems (colour difference formulae and means of recording reflectance data) will be necessary to provide truly global communication but the technology is already capable of delivering the data; it is just the development of the human interface that will impede or hasten these moves.

11.6 Notes and references

The list of contacts given below is representative and not exhaustive.

1. Suppliers of colour assessment cabinets:
   www.datacolor.com
   www.gain.com.tw
   www.gretagmacbeth.com
   www.verivide.com
2. Suppliers of environmental cabinets:
   www.vindon.co.uk
3. Suppliers of spectrophotometers:
   www.datacolor.com
   www.gretagmacbeth.com
   www.hunterlab.com
   www.konicaminolta.com
   www.xrite.com
4. Suppliers of digital camera-based colour measurement:
   www.color-aixperts.de
   www.digieyeplc.com
5. Suppliers of recipe prediction systems:
   www.datacolor.com
   www.ewarna.com
   www.gretagmacbeth.com
6. Suppliers of web-based recipe prediction systems:
   www.ewarna.com
7. Suppliers of laboratory dispensing systems:
   www.datacolor.com
   www.gain.com.tw
8. Suppliers of engineered standards:
   www.archroma.com
   www.dystar.com

9. Suppliers of web-based colour QC software:
www.ewarna.com
10. Suppliers of non contact measuring systems:
www.hunterlab.com
www.xrite.com
11. Suppliers of spectrophotometer correlation software:
www.datacolor.com
www.gretagmacbeth.com
12. Suppliers of web-based user correlation application:
www.ewarna.com
13. Suppliers of textured imaging software and systems:
www.datacolor.com
14. 'Caring for Your Clothes' guide.
www.asbci.co.uk
15. Test method for abrasion (example):
BS EN ISO 12945-2:2000
16. Test methods for fastness to washing and dry cleaning:
BS EN ISO C06:1997
BS EN ISO D01:1995
17. Test for fastness to light:
BS EN ISO 105 B02:1999
18. Supplier of instrumental colour fastness rating equipment:
www.digieye.com

11.7 Sources of further information

Society of Dyers and Colourists
www.sdc.org.uk

American Association of Textile Chemists and Colorists
www.aatcc.org