9
Colour fastness testing

9.1 Introduction

Poor colour fastness in textile products is a major source of customer complaint. The fastness of a colour can vary with the type of dye, the particular shade used, the depth of shade and how well the dyeing process has been carried out. Dyes can also behave differently when in contact with different agents, for instance dyes which may be fast to dry-cleaning may not be fast to washing in water. It is therefore important to test any dyed or printed product for the fastness of the colours that have been used in its decoration. There are a number of agencies that the coloured item may encounter during its lifetime which can cause the colour either to fade or to bleed onto an adjacent uncoloured or light coloured item. These factors vary with the end use for which the product is intended. For instance carpets and upholstery are cleaned in a different way from bed linen and clothing and therefore come into contact with different materials. The agencies that affect coloured materials include light, washing, dry-cleaning, water, perspiration and ironing. There are a large number of colour fastness tests in existence which deal with these agencies and a full list will be found in the British Standard [1]. A further group of tests is connected to processes in manufacturing that the coloured material may undergo after dyeing but before completion of the fabric, processes such as decatising or milling. Despite the fact that the list of colour fastness tests is very long, most of them are conducted along similar lines so that the main differences among the tests are in the agents to which the material is exposed.

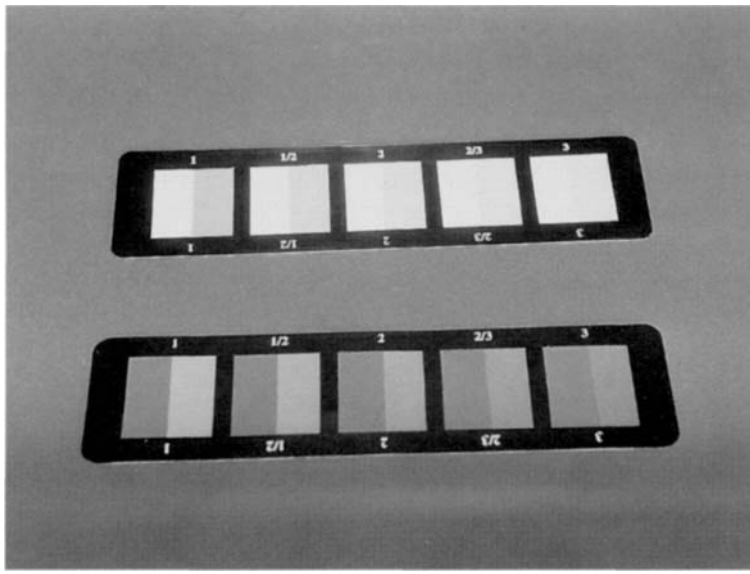
Colour fastness is usually assessed separately with respect to:

1 changes in the colour of the specimen being tested, that is colour fading;
2 staining of undyed material which is in contact with the specimen during the test, that is bleeding of colour.

In order to give a more objective result a numerical assessment of each of these effects is made by comparing the changes with two sets of standard grey scales, one for colour change and the other for staining.

1 **Colour change grey scales.** These scales consist of five pairs of grey coloured material numbered from 1 to 5. Number 5 has two identical greys, number 1 grey scale shows the greatest contrast, and numbers 2, 3 and 4 have intermediate contrasts. After appropriate treatment the specimen is compared with the original untreated material and any loss in colour is graded with reference to the grey scale. When there is no change in the colour of a test specimen it would be classified as '5'; if there is a change it is then classified with the number of the scale that shows the same contrast as that between the treated and untreated specimens.

2 **Degree of staining grey scales.** A different set of grey scales is used for measuring staining. Fastness rating 5 is shown by two identical white samples (that is no staining) and rating 1 shows a white and a grey sample. The other numbers show geometrical steps of contrast between white and a series of greys. A piece of untreated, unstained, undyed cloth is compared with the treated sample that has been in contact with the test specimen during the staining test and a numerical assessment of staining is given. A rating of 5 means that there is no difference between the treated and untreated material. If the result is in between any two of the contrasts on the scale, a rating of, for example, 3–4 is given. Sets of grey scales, examples of which are shown in Fig. 9.1, can be supplied by the British Standards Institution.



9.1 Grey scales.

Table 9.1 Multifibre strip

Multifibre DW	Multifibre TV
Secondary acetate	Triacetate
Bleached cotton	Bleached cotton
Polyamide	Polyamide
Polyester	Polyester
Acrylic	Acrylic
Wool	Viscose

9.1.1 Sample preparation

Fabric

Fabric is usually tested in the form of a composite specimen (at least 10 cm × 4 cm), made up of the test specimen placed in contact with undyed fabric, usually in the form of multifibre strip, of the same size. Two specific undyed fabrics may be used instead of the multifibre strip; one of these is usually of the same type as the fabric under test and the other is given in the standard. The purpose of the undyed fabric is to measure the staining effect of any dye that has been lost from the test fabric.

There are two types of multifibre adjacent fabric, one with wool which is type DW and one without wool which is type TV. The specification of each is given in Table 9.1.

Fibres

Loose fibres may be tested by compressing them into a pad and sewing it between multifibre strip or undyed cloth.

Yarns

Yarns may be knitted into fabric before testing or sewed between multifibre strip or undyed cloth as above.

9.2 Outline of colour fastness tests

For full experimental procedures see BS EN 20105 [1].

9.2.1 Colour fastness to light

This test measures the resistance to fading of dyed textiles when exposed to daylight. The test is of importance to the dyestuff manufacturer, the dyer

and the retailer. Certain end products require a high resistance to fading because of their exposure to light during use, for example: curtains, upholstery, carpets, awnings and coatings. However, many items of apparel also require a degree of light fastness because they are exposed to light when on display, particularly in a shop window.

Light sources

The British Standard allows either daylight or xenon arc light to be used for the test.

Daylight B01

To test the resistance of a material to fading in daylight a sample of it is exposed facing due south (in the northern hemisphere), sloping at an angle from the horizontal which is approximately equal to the test site latitude. The sample is covered with glass and provision is made for it to be ventilated. Together with the specimen under test eight 'standard blue wool dyeings' are exposed. This method gives a true indication of the light fastness of a dyed material but it is slow.

Xenon arc B02

The xenon arc is a much more intense source of light which has a very similar spectral content to that of daylight so that the test is speeded up considerably. Because of the large amount of heat generated by the lamp an efficient heat filter has to be placed between the lamp and specimen and the temperature monitored. This is in addition to a glass filter as above to remove ultra-violet radiation.

Mercury–tungsten fluorescent lamp (MBTF)

This is a source found in certain commercial light fastness testers. It provides a less intense light source than the xenon arc but will still give a faster test result than using daylight. One advantage of it is that the bulbs are cheaper and last longer than do xenon ones. It is claimed to give similar results to daylight [2].

Reference standards

The essence of the test is to expose the sample under test to the light source together with eight blue wool reference standards. The sample and blue standards are partly covered so that some of the material fades and some

is left unfaded. A rating is given to the sample which is the number of the reference standard which shows a similar visual contrast between the exposed and unexposed portions as the specimen. This means that the specimen will be given a grade between *one* (poor light fastness) and *eight* (highly resistant to fading). If the result is in between two blue dyeings it is given as 3–4, for example.

There are two sets of blue wool reference standards in use. Those used in Europe are identified by the numerical designation 1 to 8. They range from 1 (very low light fastness) to 8 (very high light fastness) so that each higher numbered reference is approximately twice as fast as the preceding one. The blue wool references used in America are identified by the letter L followed by the numerical designation 2 to 9. The two sets of references are not interchangeable.

Recommended procedure

The sample under test and a set of blue wool reference standards are arranged on a suitable backing as shown in Fig. 9.2. The middle third of the strips is covered with opaque card (A). The assembly is then exposed to light until the specimen just shows a change in shade (4–5 on the grey scale). The number of the standard showing a similar change is noted.

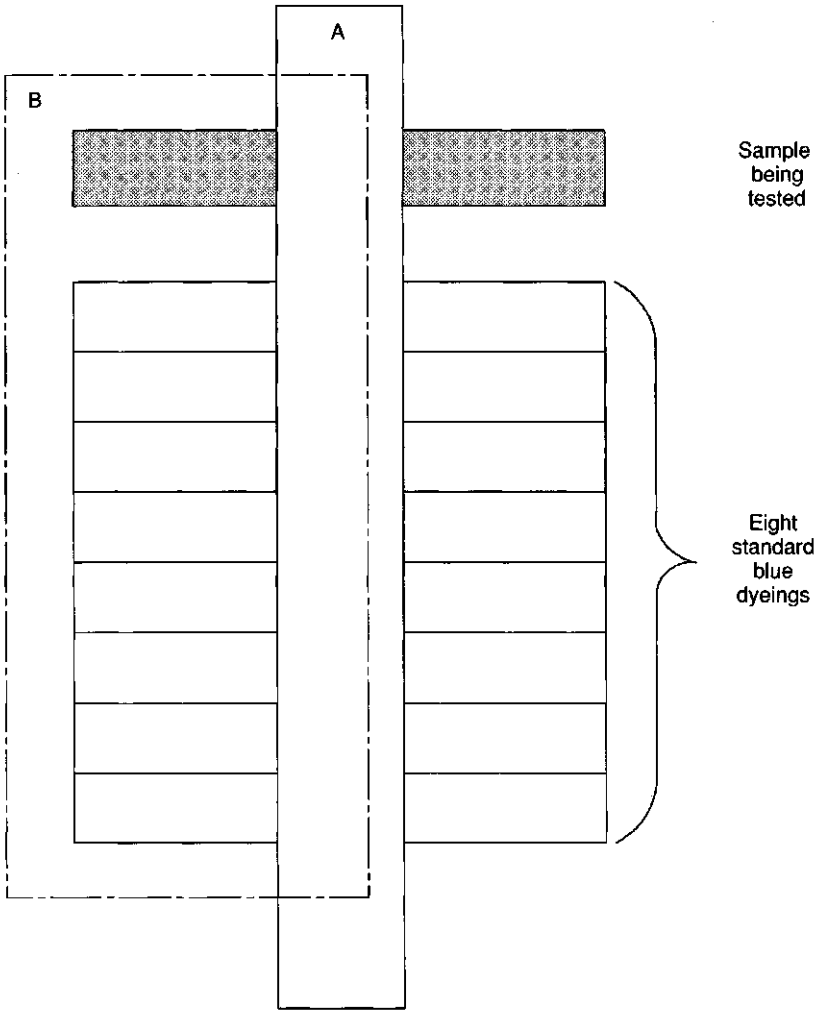
The exposure is continued until the contrast in the specimen is equal to grey scale 4, at which point a second segment of the specimen and standards is covered with another piece of opaque card (B). The exposure is again continued until the contrast between the exposed and unexposed parts of the specimen is equal to grey scale 3, at which point the exposure is terminated.

When the cards are removed the specimen and standards will show two areas that have been exposed for different lengths of time together with an unexposed area. The specimen is given the rating of the standard which shows similar changes. If the exposed areas have different ratings then the overall rating is the mean of the two ratings.

If the grade given to the specimen is 4 or higher then the initial assessment at a contrast 4–5 on the grey scale becomes significant as some colours can fade at a faster rate on initial exposure to light. If this initial grade is different from the main grade it is included after the main grade in brackets, for example 6(3).

Photochromism

Some dyes change colour rapidly on exposure to a strong light but on being put in the dark the original colour returns to a greater or less extent. This



9.2 Sample for light fastness test.

is known as photochromism. To avoid any error due to this effect samples should be conditioned for 24 h in the dark before assessment.

Change in hue

Certain dyed materials change hue on prolonged exposure to light, for instance a yellow may become brown or a purple may become blue. The rating for colour fastness concerns only change in contrast of the dyed mate-

Table 9.2 Wash test conditions

Test	Liquor	Temp. (°C)	Time (min)	Reproduces action of
C01	0.5% soap	40	30	Hand washing
C02	0.5% soap	50	45	Repeated hand washing
C03	0.5% soap 0.2% soda ash	60	30	Medium cellulosic wash Severe wool wash
C04	0.5% soap 0.2% soda ash	95	30	Severe cellulosic wash
C05	0.5% soap 0.2% soda ash	95	240	Very severe cellulosic Wash
C06	4g/l reference detergent + perborate	Various	Various	Domestic laundering

rial which in such cases may not have altered. In such cases the change in hue is included as part of the rating depending on the blue dyeing which has changed at the same time. A rating of '5 bluer' would be used for a sample which changed from green to blue at the same rate as the reference sample 5.

Effect of humidity

The fastness of dyes is affected by both temperature and humidity. Increases in temperature and humidity both increase the rate of fading of dyes. The effect of humidity is much greater than that of temperature. However the humidity that affects colour fastness is the humidity at the surface of the specimen which can be modified by the surface temperature of the specimen. The specimen temperature is raised by the absorption of radiation and this has the effect of lowering the relative humidity in the immediate region of the specimen. In order to monitor the effective humidity a standard fabric of red azoic dyed cotton can be used, exposed at the same time as the test specimen. The light fastness at different relative humidities of this fabric is known.

9.2.2 Colour fastness to other agents

Fastness to washing C01–C06

A composite specimen is agitated in a wash-wheel using one of the sets of conditions shown in Table 9.2. The sample is then dried and assessed for colour loss and the adjacent fabric is assessed for staining.

A wash-wheel consists of a number of closed stainless steel containers rotating in a water bath at 40 revolutions per minute. The sample and appro-

priate liquor are sealed inside the container and the water bath is heated to the desired temperature.

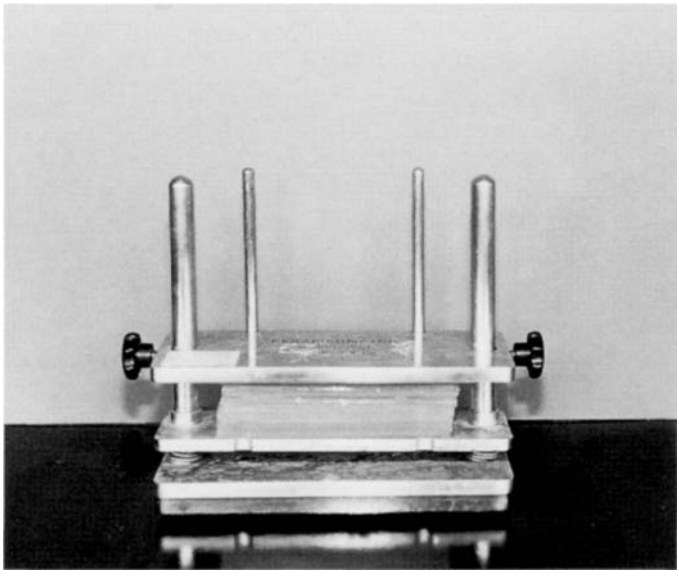
Dry-cleaning D01

The sample to be tested is enclosed in an undyed cotton bag with 12 steel discs. The bag is then agitated in a wash-wheel for 30 min in perchloroethylene at 30 °C. The specimen is then removed, dried and then assessed for colour change. The colour of the remaining solvent is also compared with that of unused solvent to detect any staining.

Colour fastness to water E01

In this test composite specimens are wetted out in distilled water at room temperature. They are then placed in a perspirometer in an oven at 37 °C for 4 h, removed and dried. They are then assessed for colour change of the test fabric and staining of the adjacent fabric.

A perspirometer, an example of which is shown in Fig. 9.3, consists of a stainless steel frame constructed to hold a number of glass or acrylic plates each measuring 60 mm × 115 mm. The samples of size 40 mm × 100 mm are each placed separately between a pair of these plates in order to keep them moist. A mass of 5 kg is then placed on top of the apparatus so as to apply a pressure of 12.5 kPa to each specimen. The perspirometer



9.3 Perspirometer.

is so constructed that when the mass is removed the specimens remain under pressure.

Seawater E02

The composite specimen is wetted out in sodium chloride solution (30 g/l) and placed in a perspirometer in an oven for 4 h at 37 °C. It is then separated, dried and assessed for colour change of the test fabric and staining of the adjacent fabric.

Chlorinated water (swimming-pool water) E03

The specimen is agitated in a wash-wheel for 1 h at 27 °C in a weak solution of sodium hypochlorite (either 20 mg/l active chlorine for towels or 100 mg/l for swimwear), dried and assessed for colour change.

Colour fastness to perspiration E04

This method is intended for the determination of the resistance of the colour of textiles of all kinds and in all forms to perspiration.

Composite specimens are treated in solutions containing histidine, drained and placed in a Perspirometer or equivalent apparatus. The specimen and the undyed cloths are dried separately. The change in colour of the specimens and the staining of the undyed cloths are assessed with standard grey scales.

Solutions

1 Alkaline solution, *freshly prepared*, containing 0.5 g histidine monohydrochloride monohydrate, 5 g sodium chloride and 2.5 g disodium hydrogen orthophosphate ($Na_2HPO_4 \cdot 2H_2O$) *per litre*, brought to pH 8 with 0.1 N sodium hydroxide.
2 Acid solution, *freshly prepared*, containing 0.5 g histidine monohydrochloride monohydrate, 5 g sodium chloride and 2.2 g sodium dihydrogen orthophosphate ($NaH_2PO_4 \cdot 2H_2O$) *per litre*, brought to pH 5.5 with 0.1 N sodium hydroxide.

Procedure

Thoroughly wet one composite specimen in the solution at pH 8 (solution 1 above) at a liquor ratio of 50:1 and allow it to remain in the solution for 30 min at room temperature. Wipe excess liquid off the specimen between two glass rods and place the specimen between two plates of the per-

spirometer under a pressure of 12.5 kPa. Repeat with the other composite specimen in the acid solution using a separate perspirometer.

Place the perspirometers in an oven at 37 °C for 4 h.
Remove specimens, open out and allow to dry.

Both specimens are then assessed for colour change of the test fabric and staining of the adjacent fabric.

Fastness to acid spotting E05

The specimen is spotted with either acetic, sulphuric or tartaric acid which is rubbed into the fabric with a glass rod to form a 20 mm diameter spot. The specimen is then dried and compared with the grey scale for colour change.

Alkali spotting E06

This is carried out as the above test for acid spotting but using a 10% sodium carbonate solution.

Potting E09

The composite specimen is rolled around a glass rod, tied with thread, boiled for 1 h in water; the dyed specimen is then separated from the undyed cloth, dried and assessed for colour change of the test fabric and staining of the adjacent fabric.

Decatising E10

The specimen is wrapped around a perforated steam cylinder for 15 min (mild or severe treatment as required) together with a test control specimen. The control specimen is one that has been dyed to a given formula and that should change colour to a known degree if the procedure has been carried out correctly. The specimen is then dried and assessed for colour change.

Steaming E11

This test is carried out to determine the effect that the steaming stage in printing has on the colours. In the test steam is passed at atmospheric pressure through the composite specimen for 30 min, the adjacent fabric is then assessed for staining.

Colour fastness to nitrogen oxides G01

This method determines the resistance to fading of dyed fabrics by gases produced during the combustion of gas, coal, oil, etc. In the test the sample is exposed to nitric oxide inside a special test chamber. At the same time a control sample is exposed and the test is allowed to proceed until this fades to a given extent. The sample is then assessed for fading.

Colour fastness to burnt gas fumes G02

This method determines the resistance to fading of dyed fabrics to the nitrogen oxides produced during the combustion of butane. In the test the sample and control fabrics are exposed to the fumes of a butane burner in a test chamber. The test is continued until the control fabric has faded to a given extent. The sample is then assessed for fading.

Bleaching with sodium hypochlorite N01

In this test the sample is wetted out and placed in sodium hypochlorite solution of a standard strength (2.0 g/l available chlorine pH 11) and liquor ratio for 1 h; it is rinsed, immersed in hydrogen peroxide solution (30%) for 10 min, rinsed again, dried and assessed for change in colour.

Bleaching with peroxide N02

A composite specimen is placed in a test-tube with standard bleaching solution (composition, temperature and time vary for different fibres, e.g. wool in hydrogen peroxide solution for 2 h). It is then removed, rinsed, squeezed out, opened out, dried, and then assessed for colour change of the test fabric and staining of the adjacent fabric.

Milling E12

The composite specimen is treated in a wash-wheel with additional agitation (ball bearings) using a soap solution for alkaline milling. The treatment is carried out for a fixed time, the specimen is then rinsed, separated and dried, and assessed for colour change of the test fabric and staining of the adjacent fabric.

Carbonising X02

The composite specimen is immersed in sulphuric acid solution (50 g/l) for 15 min at room temperature; removed, squeezed, dried, and then baked for 15 min at 105 °C. The colour change is then assessed. A control specimen is

treated at the same time to ensure that the test has been correctly performed. This is a fabric that has been dyed to a given formula and that should change colour to a known degree if the procedure has been carried out correctly.

Cross-dyeing (wool) X07

In this test composite specimens are treated in different dye baths containing all the chemicals except the dye (e.g. sodium sulphate and acetic acid for wool), rinsed and dried. The composite specimens are then separated and assessed for colour change of the test fabric and staining of the adjacent fabric.

Pressing X11

Fastness to pressing can be carried out under three different conditions, dry, damp or wet:

1 Dry – the specimen is placed on dry undyed cotton adjacent fabric and pressed for 15 s with a heated press (a domestic iron may be used, cotton 200 ± 2 °C; wool 150 ± 2 °C). It is then assessed immediately and after a 4 h interval for colour change and the adjacent fabric for staining.
2 Damp – the dry specimen is placed on dry cotton adjacent fabric, covered with wet cotton adjacent fabric and pressed for 15 s. It is then assessed as before.
3 Wet – the specimen is wetted and placed on dry cotton adjacent fabric and then covered with wet cotton adjacent fabric and pressed for 15 s. It is then assessed as before.

Rubbing X12

In this test the dyed specimens are rubbed 10 times using a Crockmeter which has a weighted finger covered with piece of undyed cotton cloth 5 cm × 5 cm. For wet rubbing the cotton cloth is wetted out before being rubbed on the dyed sample. The cotton rubbing cloth is then examined for dye which may have been removed and assessed using the grey scales for staining.

References

1. BS EN 20105 Textiles. Tests for colour fastness.
2. Hindson W R and Southwell G, 'The mercury–tungsten fluorescent lamp for the fading assessment of textiles', *Tex Inst Ind*, 1974 **12** 42–45.