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Dyes and Pigments 48 (2001) 57–69

DYES and PIGMENTS

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The aftertreatment of acid dyes on nylon 6,6 fibres Part 1. 1:2 pre-metallised acid dyes

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Received 2 July 2000; accepted 11 August 2000

Abstract

Nylon 6,6 knitted fabric was dyed using a total of eight, commercial, 1:2 pre-metallised acid dyes and the dyed samples were aftertreated using three different commercial systems, namely a *syntan*, a *syntan/cation* process and a newly developed *full backtan*. When all dyeings were subjected to five consecutive ISO C061C2 wash tests, it was found that while all three aftertreatments imparted improved wash fastness, the newly developed backtanning system bestowed greatest wash fastness improvement towards repeated wash testing. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Nylon 6,6; Pre-metallised acid dyes; Repeated washing

1. Introduction

It is well known that the wash fastness of acid dyes on nylon 6,6 leaves much to be desired and that 1:2 pre-metallised acid dyes generally display higher levels of wash fastness than their non-metallised counterparts on the substrate. However, despite the good levels of wash fastness and the typically high fastness to light displayed by 1:2 pre-metallised acid dyes on nylon 6,6, an aftertreatment with either a synthetic or a natural tanning is commonly used [1] to secure highest levels of wash fastness, especially in moderate to deep depths of shade.

Three types of 1:2 pre-metallised acid dye are commercially available, namely unsulfonated, monosulfonated and disulfonated. The three types of dye differ in terms of their wash fastness behaviour on nylon 6,6 insofar as the extent of shade change that occurs during washing generally increases with increasing degree of sulfonation of the dyes [2,3] whereas the extent of staining of adjacent nylon and also wool materials during washing decreases with increasing sulfonation of the dyes. This difference in washing behaviour is attributable to the difference in the aqueous solubility of the three types of dye [2,3]. The disulfonated types of dye are most readily removed during washing because they are the most water-soluble but the removed dye displays little tendency to stain

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0143-7208/01/$ - see front matter
PII: S0143-7208(00)00077-2

adjacent materials because of its high water-solubility. In contrast, their low water-soluble, non-sulfonated counterparts are more resistant to removal during washing but, owing to its higher hydrophobicity, the removed dye has a greater propensity to redeposit on adjacent material. Thus, in the aftertreatment of nylon 6,6 which has been dyed with 1:2 pre-metallised acid dyes, the aftertreatment is required to contend with variations in the extent of the shade change as well as the staining propensity of each of the three types of dye.

In the case of the natural tanning agent (full backtan) aftertreatment, it is believed that the high M_r gallotannin component (tannic acid) behaves as a high M_r acid which binds to the protonated amino end groups in the nylon fibre and, that subsequent treatment with potassium antimony tartrate (tartar emetic) results in the formation of a surface skin [1]. However, the use of the full backtan has, in recent years been superceded by that of synthetic tanning agents (syntans) owing to several disadvantages inherent in the two-stage, backtanning process [1]:

- potassium antimony tartrate is poisonous;
- treatment can impart a harsh handle to and reduce the light fastness of dyeings;
- the treatment can impart a shade change to the dyeing and also can discolour during repeated washing owing to oxidation of the high M_r gallotannin component.

While syntans have the advantage of being applied in a single process compared with the common, two-bath, backtanning process and do not suffer from the disadvantages displayed by their natural counterpart, an aftertreatment with a syntan is not as effective as an aftertreatment with the full backtan [1]. However, it has been demonstrated that the effectiveness of a commercial syntan in improving the wash fastness of various pre-metallised acid dyes [2,3] and also non-metallised acid dyes [4,5] on nylon 6,6 can be enhanced by the subsequent application of a selected, polymeric cationic agent to the syntanned, dyed material. It is proposed [1,4] that this two-stage aftertreatment process, as exemplified by the first such commercial *syntan/cation* system, the Fixogene AC (Uniqema) aftertreatment process, results in the formation of a large molecular size, low aqueous solubiity, complex between the anionic syntan and the cationic compound within the dyed fibre.

In recent times, the fastness of dyeings towards repeated washing has become increasingly important for many dye/fibre systems, including acid dyes/nylon 6,6 in response to increased consumer and retailer demands. In the context of dyed nylon 6,6, the Fixogene AC process was shown to be highly effective in improving the fastness of 1:2 pre-metallised acid dyes on both conventional decitex and microfibre nylon 6,6 to repeated wash tests [3]. However, while this particular syntan/cation system was more effective than a syntan aftertreatment alone in improving the fastness over 10 washes, the extent of dye loss and staining of adjacent fibres during washing was not insubstantial.

This paper comprises an investigation of a newly developed full backtan aftertreatment process for dyed nylon 6,6 that does not use tartar emetic. This part of the paper examines the effectiveness of the new full backtan, when compared to a commercial syntan and a commercial syntan/cation system, in improving the fastness to repeated washing of pre-metallised acid dyes. Subsequent papers will consider the ability of the new backtan treatment to improve the repeated wash fastness of nonmetallised acid dyeings on nylon 6,6 as well as the development of a modified syntan aftertreatment system.

2. Experimental

2.1. Materials

Knitted, nylon 6,6 (78F68) fabric, supplied by Du Pont Nylon (UK), was scoured in a solution comprising 2 g l^{-1} Na_2CO_3 and 5 g l^{-1} of the non-ionic surfactant Lanapex R (Uniqema) for 30 min at 60°C. The scoured fabric was rinsed thoroughly in tap water and allowed to dry in the open air.

Commercial samples of the dyes listed in Table 1 were generously supplied by Crompton & Knowles. Commercial samples of the syntan Fixogene AXF

Table 1
Dyes used

Commercial name	C.I. generic name	
Neutrilan Black K-BL	C.I. Acid Black 107	Unsulfonated
Neutrilan Bordeaux K-RL	C.I. Acid Red 182	
Neutrilan Yellow K-3R	C.I. Acid Yellow 137	
Neutrilan Orange S-R	C.I. Acid Orange 144	Monosulfonated
Neutrilan Rubine S-2R	None ascribed	
Neutrilan Bordeaux M-B	C.I. Acid Violet 90	Disulfonated
Neutrilan Navy M-BR	C.I. Acid Blue 193	
Neutrilan Yellow M-3R	C.I. Acid Yellow 384	

and the cationic agent Fixogene CXF were kindly supplied by Uniqema. Commercial samples of Floctan 1 (high M_r gallotannin) and Gallofix were generously provided by Omnichem-Ajinmoto.

2.2. Dyeing

Nylon 6,6 fabric was dyed in sealed, stainless steel dye pots of 200 cm^3 capacity, housed in a Zeltex Polycolor PC 1000 laboratory-scale dyeing machine using a liquor ratio of 20:1. The dyeing method used is shown in Fig. 1.

The pH was adjusted using McIlvaine buffer [6] comprising 63.2 cm^3 of 0.2 M aqueous Na_2HPO_4 solution and 36.8 cm^3 0.1 M aqueous citric acid solution per 100 cm^3. At the end of dyeing, the dyed sample was removed, rinsed thoroughly in tap water and allowed to air dry.

2.3. Aftertreatment

Dyeings were aftertreated using three different systems, namely the syntan Fixogene AXF, the syntan/cation system Fixogene AXF/Fixogene CXF and a newly developed full backtan process. Each of the three aftertreatments was carried out on the same machine as that for dyeing using a liquor ratio of 20:1.

2.3.1. Syntan

The method used for aftertreatment with the commercial syntan is shown in Fig. 2. At the end of treatment, the syntanned samples were removed, rinsed thoroughly in tap water and allowed to air dry.

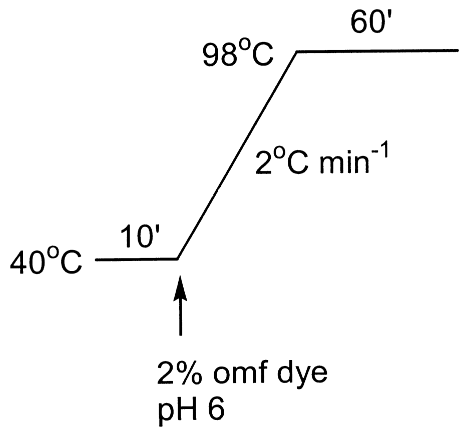

Fig. 1. Dyeing method.

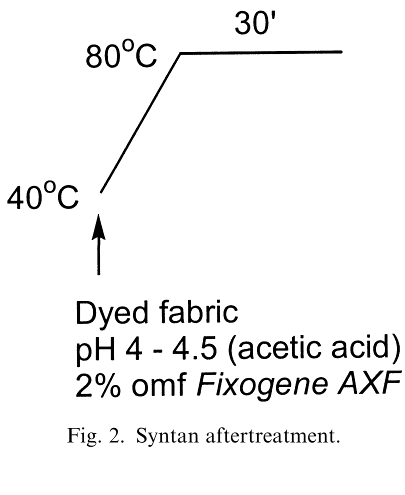

Fig. 2. Syntan aftertreatment.

2.3.2. Syntan/cation

The syntanned, dyed nylon 6,6 samples were aftertreated using the cationic polymer using the method depicted in Fig. 3. At the end of treatment, the samples were removed, rinsed thoroughly in tap water and allowed to air dry.

2.3.3. *Full backtan*

The aftertreatment method is given in Fig. 4; the aftertreated samples were removed, rinsed thoroughly in tap water and allowed to air dry.

2.4. *Colour measurement*

All measurements were carried out using an X-rite spectrophotometer interfaced to a PC using D_{65} illumination, 10° standard observer with specular component excluded and UV component included. Each fabric was folded once to give two thickness and an average of four readings was taken each time.

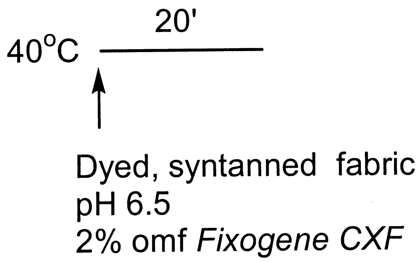

Fig. 3. Cationic aftertreatment.

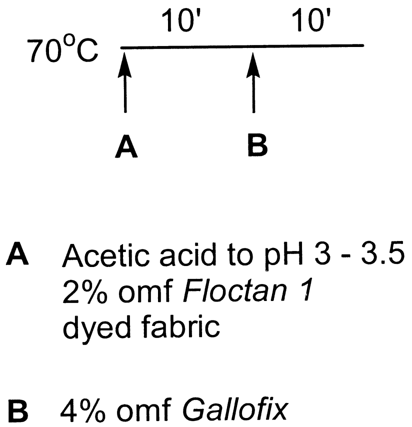

Fig. 4. Full backtan aftertreatment.

2.5. *Wash fastness*

The ISO 105:C06/C2 wash test method [7] using SDC multifibre strip fabric as adjacent material was used. The samples were sequentially washed five times. The reduction in depth of shade that occurred as a result of washing was calculated using Eq. (1) where fk_u and fk_w are the weighted K/S functions of the unwashed and washed samples, respectively.

$$\text{Reduction in colour strength} = \left(\frac{fk_u - fk_w}{fk_u}\right) \times 100 \quad (1)$$

2.6. *Light fastness*

The ISO 105 test method [7] was employed.

3. Results and discussion

Commonly, the traditional full backtan aftertreatment that uses high M_r gallotannin and potassium antimony tartrate, is a two-stage, usually two-bath process in which the high M_r gallotannin is firstly applied to the dyed nylon fibre and the tartar emetic is subsequently applied from a fresh bath. Typically, these stages each take some 20–30 min at a temperature of between 70 and 90°C [1]. The particular backtan aftertreatment method used in this work does not employ potassium antimony tartrate and is a two-stage, single-bath process which takes just 20 min at 70°C. In essence, the application profile of the new backtan process closely resembles that of a typical commercial syntan and therefore offers the opportunity of time- and cost-savings over the traditional full backtan aftertreatment.

3.1. *Unsulfonated dyes*

Fig. 5. shows the reduction in colour strength that occurred for dyeings of the unsulfonated 1:2 pre-metallised acid dye, C.I. Acid Black 107, as a result of the five consecutive ISO Co6/C2 wash

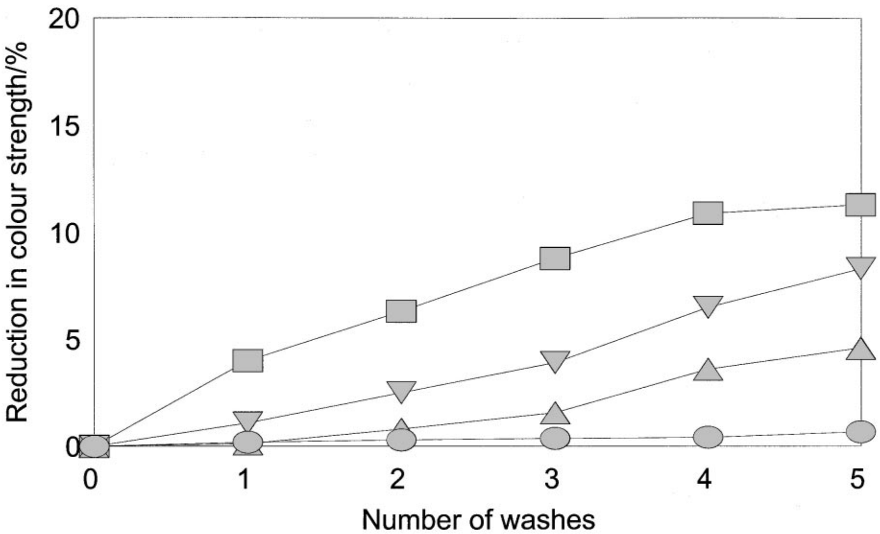

Fig. 5. Effect of repeated wash testing on colour strength of dyeings: C.I. Acid Black 107. ■ Nil aftertreatment; ▼ syntan; ▲ syntan/cation; ● full backtan.

tests. It is apparent that the reduction in colour strength achieved for the non-aftertreated dyeing increased with increasing number of washes thus showing that dye loss occurred in progressive manner. Clearly, each of the three aftertreatments reduced the extent of dye loss that occurred during repeated washing; the effectiveness of the three aftertreatments in reducing dye loss followed the order: syntan < syntan/cation < full backtan. The corresponding assessments of the extent of staining of adjacent multifibre strip achieved for the dyeings after one and five washes (Table 2) support the findings displayed in Fig. 5 insofar as aftertreatment lowered the extent of staining of the adjacent nylon and the effectiveness of the three aftertreatments in reducing staining followed the order: syntan < syntan/cation < full backtan.

Figs. 6 and 7 show the reduction in colour strength that occurred as a result of the repeated washing of dyeings of the two remaining unsulfonated 1:2 pre-metallised acid dyes, C.I. Acid Red 182 and C.I. Acid Yellow 137, respectively. The corresponding staining results are displayed in Table 2. The results for the two dyes are similar to those obtained for C.I. Acid Black 107 in that the three aftertreatments not only reduced both the extent of dye loss and the degree of staining of adjacents during repeated washing but also the effectiveness of the three aftertreatments in improving wash fastness followed the order: syntan < syntan/cation < full backtan.

The same scale was used for the ordinate in Figs. 5–7 for two reasons:

- to show that the three unsulfonated dyes varied in terms of the extent of dye loss that occurred during repeated washing.
- to demonstrate that the newly developed full backtan was equally effective towards each of the three dyes used.

3.2. Monosulfonated dyes

The reduction in colour strength that occurred for the two monosulfonated 1:2 pre-metallised acid dyes, C.I. Acid Orange 144 and Neutrilan Rubine S-2R, as a result of the five, consecutive wash tests is shown in Figs. 8 and 9. Again, the colour strength of the non-aftertreated dyeings decreased as the number of washes increased and each of the three aftertreatments reduced the extent of dye loss that occurred during repeated washing; the effectiveness of after treatment followed the order: syntan < syntan/cation < full backtan. The corresponding assessments of the extent of

Table 2
Staining of adjacent multifibre strip[a]

Aftertreatment	Dye	1 wash						5 washes					
		Ac	C	N	P	A	W	Ac	C	N	P	A	W
Nil	C.I. Acid Black 107	5	5	2/3	5	5	5	5	5	1/2	5	5	3/4
Syntan		5	5	4	5	5	5	5	5	2/3	5	5	4/5
Syntan/cation		5	5	4/5	5	5	5	5	5	2/3	5	5	4/5
Full backtan		5	5	5	5	5	5	5	5	4/5	5	5	5
Nil	C.I. Acid Red 182	5	5	2	5	5	4/5	5	5	1/2	5	5	2/3
Syntan		5	5	2/3	5	5	4/5	5	5	2	5	5	3
Syntan/cation		5	5	3	5	5	4/5	5	5	2/3	5	5	3/4
Full backtan		5	5	4/5	5	5	5	5	5	3/4	5	5	4
Nil	C.I. Acid Yellow 137	5	5	2/3	5	5	4/5	5	5	2	5	5	2/3
Syntan		5	5	3/4	5	5	4/5	5	5	2/3	5	5	3
Syntan/cation		5	5	4	5	5	4/5	5	5	2/3	5	5	4
Full backtan		5	5	4/5	5	5	5	5	5	4	5	5	4/5
Nil	C.I. Acid Orange 144	5	5	3	5	5	4/5	5	5	2/3	5	5	3
Syntan		5	5	4/5	5	5	4/5	5	5	3/4	5	5	4
Syntan/cation		5	5	4/5	5	5	5	5	5	4	5	5	4/5
Full backtan		5	5	5	5	5	5	5	5	4/5	5	5	5
Nil	Neutrilan Rubine S-2R	5	5	2/3	5	5	5	5	5	2	5	5	3
Syntan		5	5	4	5	5	5	5	5	3	5	5	4
Syntan/cation		5	5	4	5	5	5	5	5	3/4	5	5	4
Full backtan		5	5	5	5	5	5	5	5	4/5	5	5	5
Nil	C.I. Acid Violet 90	5	5	4	5	5	5	5	5	3/4	5	5	4/5
Syntan		5	5	5	5	5	5	5	5	4	5	5	4/5
Syntan/cation		5	5	5	5	5	5	5	5	4/5	5	5	5
Full backtan		5	5	5	5	5	5	5	5	5	5	5	5
Nil	C.I. Acid Blue 193	5	5	3/4	5	5	5	5	5	3/4	5	5	4/5
Syntan		5	5	4	5	5	5	5	5	4	5	5	4/5
Syntan/cation		5	5	4/5	5	5	5	5	5	4/5	5	5	5
Full backtan		5	5	5	5	5	5	5	5	4/5	5	5	5
Nil	C.I. Acid Yellow 384	5	5	3	5	5	5	5	5	2/3	5	5	3/4
Syntan		5	5	4/5	5	5	5	5	5	3/4	5	5	4
Syntan/cation		5	5	5	5	5	5	5	5	3/4	5	5	4/5
Full backtan		5	5	5	5	5	5	5	5	5	5	5	5

[a] Ac, acetate; C, cotton; N, nylon; P, polyester; A, acrylic; W, wool.

staining of adjacent multifibre strip achieved for the dyeings after one and five washes (Table 2) support the findings displayed in Figs. 8 and 9 in as much as aftertreatment reduced the extent of staining and the effectiveness of the after-treatments in reducing staining generally followed the order: syntan < syntan/cation < full backtan.

As the same scale was used for the *y*-axis in Figs. 8 and 9, it is once more evident that the two dyes varied in terms of the dye loss that occurred during repeated washing and that the full backtan was effective for both dyes used.

3.3. Disulfonated dyes

In the cases of C.I. Acid Violet 90, C.I. Acid Blue 193 and C.I. Acid Yellow 384 (Figs. 10–12), the progressive loss of dye obtained for the non-aftertreated dyeings was markedly reduced by each of the three aftertreatments. The effectiveness

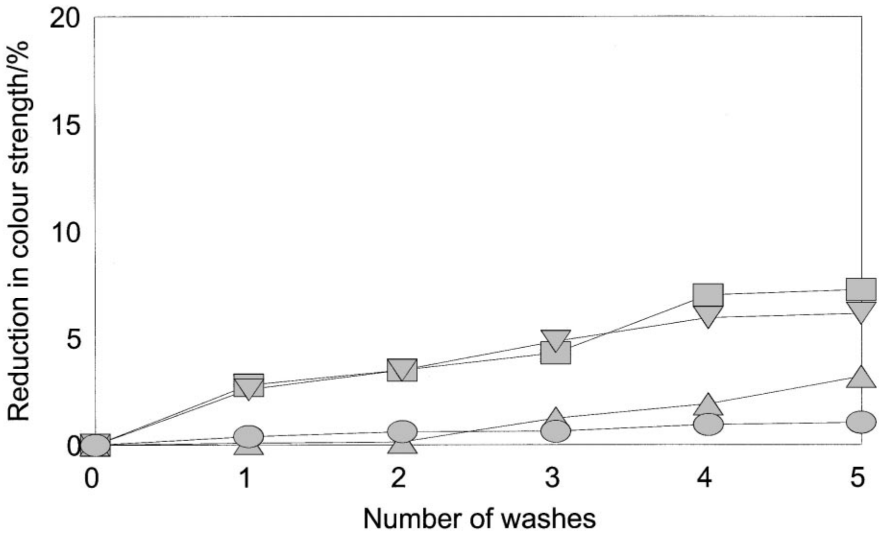

Fig. 6. Effect of repeated wash testing on colour strength of dyeings: C.I. Acid Red 182. ■ Nil aftertreatment; ▼ syntan; ▲ syntan/cation; ● full backtan.

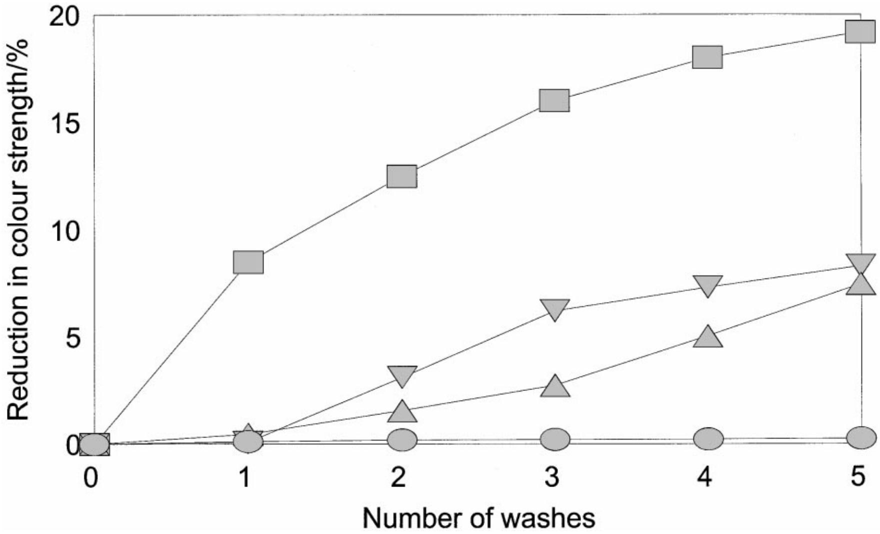

Fig. 7. Effect of repeated wash testing on colour strength of dyeings: C.I. Acid Yellow 137. ■ Nil aftertreatment; ▼ syntan; ▲ syntan/cation; ● full backtan.

of the three aftertreatments in reducing dye loss once more followed the order: syntan < syntan/cation < full backtan. The extent of staining of adjacent fibres (Table 2) was also improved by aftertreatment, with the full backtan being generally the most effective of the aftertreatments used.

Figs. 10–12 show that despite the difference in the amount of each dye that was removed as a result of repeated washing, the newly developed

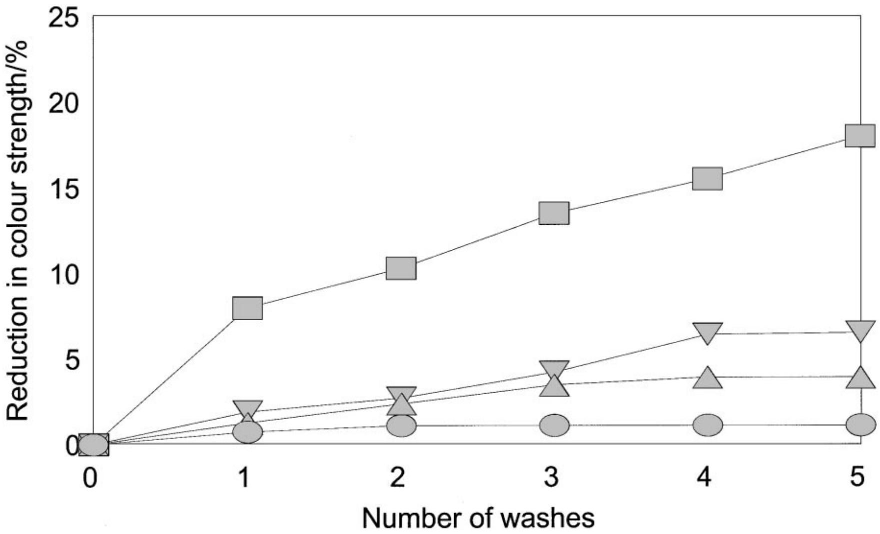

Fig. 8. Effect of repeated wash testing on colour strength of dyeings: C.I. Acid Orange 144. ■ Nil aftertreatment; ▼ syntan; ▲ syntan/cation; ● full backtan.

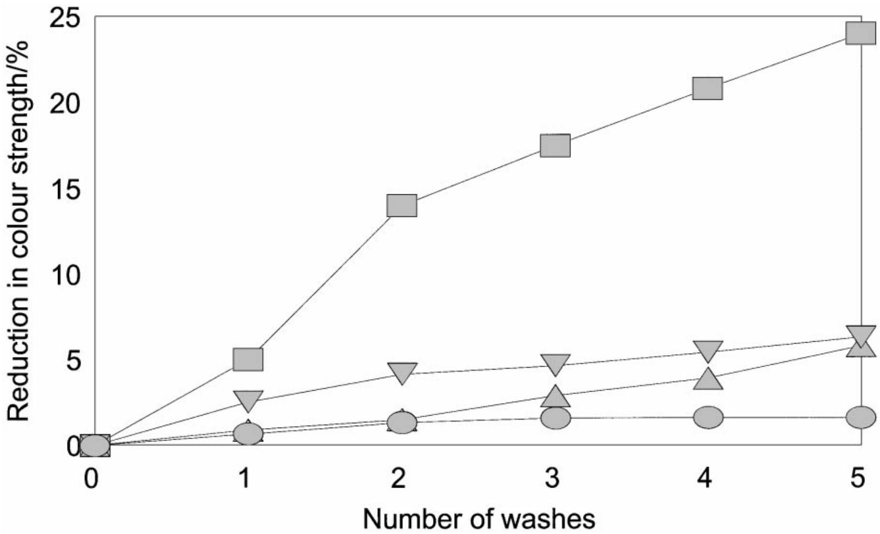

Fig. 9. Effect of repeated wash testing on colour strength of dyeings: Neutrilan Rubine S-2R. ■ Nil aftertreatment; ▼ syntan; ▲ syntan/cation; ● full backtan.

full backtan process was effective for each dye used.

3.4. General comments

The data presented in Table 2 and Figs. 5–12 illustrate the difference between the three types of 1:2 pre-metallised acid dyes in terms of their wash fastness behaviour on nylon 6,6. Figs. 5–12 show that the extent of shade change that occurred during repeated washing generally increased with increasing degree of sulfonation of the dyes (Figs. 5–7, unsulfonated dyes; Figs. 8 and 9, monosulfonated dyes; Figs. 10–12, disulfonated dyes).

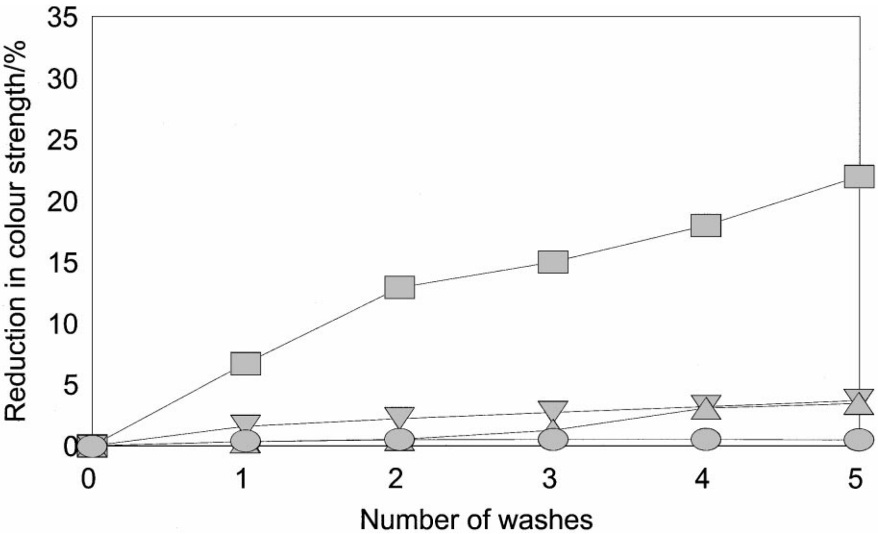

Fig. 10. Effect of repeated wash testing on colour strength of dyeings: C.I. Acid Violet 90. ■ Nil aftertreatment; ▼ syntan; ▲ syntan/cation; ● full backtan.

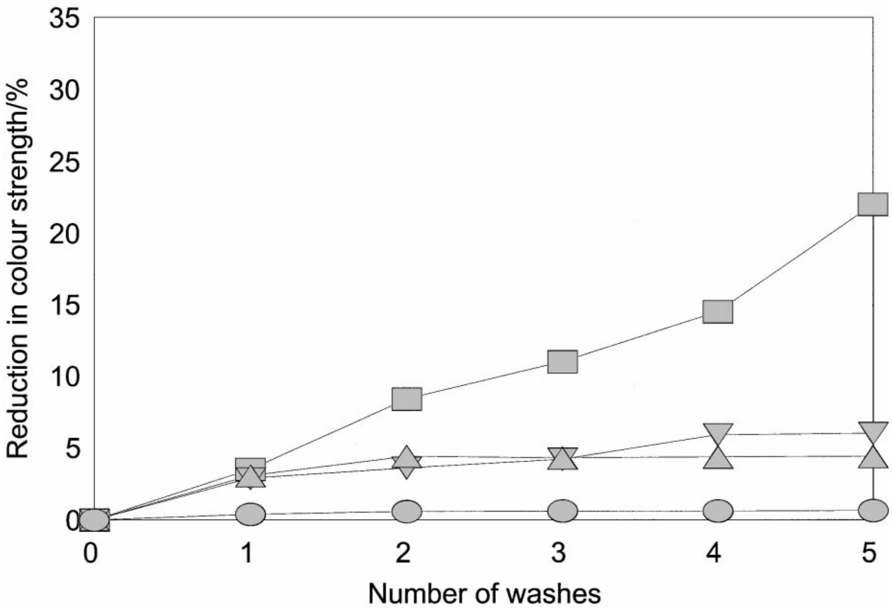

Fig. 11. Effect of repeated wash testing on colour strength of dyeings: C.I. Acid Blue 193. ■ Nil aftertreatment; ▼ syntan; ▲ syntan/cation; ● full backtan.

In contrast, Table 2 shows that the extent of staining of adjacent nylon and also wool materials during washing decreased with increasing sulfonation of the dyes. The results obtained in this work demonstrate that despite the difference in wash fastness behaviour of the three types of pre-metallised acid dye, the new full back tan aftertreatment was able to impart significant improvement to the wash fastness of all of the dyes used. Thus, the new aftertreatment seems able to contend with variations in both the extent of the shade change and the staining propensity of each of the three types of dye.

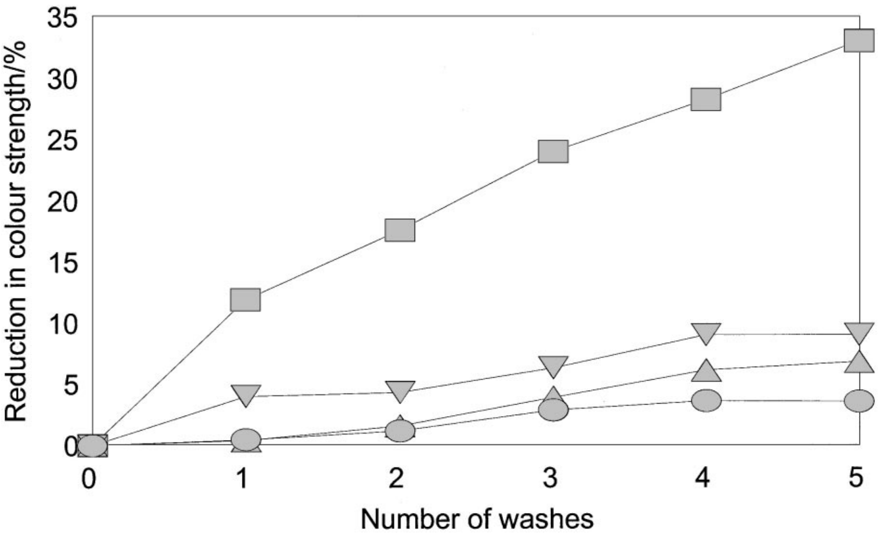

Fig. 12. Effect of repeated wash testing on colour strength of dyeings: C.I. Acid Yellow 384. ■ Nil aftertreatment; ▼ syntan; ▲ syntan/cation; ● full backtan.

Table 3
Colorimetric data for unsulfonated dyes[a]

Aftertreatment	No. of washes	C.I. Acid Yellow 137					C.I. Acid Red 182					C.I. Acid Black 107				
		*L**	*a**	*b**	*C*	*h*°	*L**	*a**	*b**	*C*	*h*°	*L**	*a**	*b**	*C*	*h*°
Nil	0	54.3	28.7	52.8	60.1	61.5	28.0	35.2	0.1	35.2	0.2	20.3	−1.2	−3.0	3.3	247.6
	1	55.4	28.2	52.9	60.0	61.9	28.2	34.9	−0.2	34.9	359.7	20.8	−1.4	−3.0	3.3	243.9
	2	55.5	27.4	51.9	58.7	62.2	28.2	34.9	−0.3	34.9	359.4	20.8	−1.3	−3.0	3.3	246.9
	3	56.0	27.4	51.8	58.6	62.1	28.5	35.3	−0.3	35.3	359.5	21.3	−1.3	−3.1	3.3	246.4
	4	56.4	27.5	52.2	59.0	62.2	28.7	35.2	−0.9	35.2	358.5	21.6	−1.4	−3.1	3.4	246.5
	5	56.3	27.6	51.7	58.6	61.9	28.8	35.0	−0.5	35.0	359.2	21.6	−1.4	−3.1	3.4	246.0
Syntan	0	55.3	28.5	52.9	60.1	61.7	29.3	35.1	−0.6	35.1	359.0	20.0	−1.3	−3.1	3.3	246.7
	1	55.2	28.5	52.7	59.9	61.6	29.2	34.9	−0.8	34.9	358.8	20.1	−1.3	−3.0	3.3	247.3
	2	55.5	28.4	52.5	59.7	61.6	28.9	34.6	−0.9	34.6	358.6	20.3	−1.4	−2.9	3.2	243.6
	3	56.0	28.2	52.9	59.9	61.9	29.4	35.1	−0.9	35.1	358.5	20.6	−1.3	−3.0	3.3	246.5
	4	56.0	28.1	52.4	59.5	61.9	29.4	34.9	−1.3	34.9	357.9	21.0	−1.4	−3.0	3.3	245.2
	5	56.1	28.1	52.4	59.4	61.8	29.6	34.9	−0.3	34.9	358.6	21.0	−1.3	−3.0	3.3	246.0
Syntan/cation	0	55.4	28.6	53.6	60.7	61.9	28.1	35.4	0.1	35.4	0.1	20.2	−1.3	−3.1	3.4	247.5
	1	55.0	28.5	53.0	60.2	61.7	28.5	35.0	−0.2	35.0	359.7	20.1	−1.3	−2.9	3.2	245.9
	2	55.2	28.6	52.8	60.0	61.5	28.3	34.8	−0.6	34.8	359.0	20.1	−1.3	−3.0	3.2	247.0
	3	55.2	28.3	52.6	59.7	61.7	28.6	35.0	−0.6	35.0	359.0	20.4	−1.3	−2.9	3.2	245.9
	4	56.0	28.3	52.9	60.0	61.9	28.7	35.0	−1.0	35.0	358.3	20.7	−1.3	−3.0	3.3	246.5
	5	56.1	28.2	53.1	60.1	62.0	28.6	34.9	−0.7	34.9	358.8	20.6	−1.3	−2.9	3.2	245.7
Full backtan	0	55.5	28.2	53.0	60.0	62.0	29.0	35.3	−0.3	35.3	359.5	20.8	−1.3	−3.6	3.8	249.5
	1	55.2	28.2	52.5	59.6	61.8	28.9	34.8	−0.3	34.8	359.4	20.8	−1.4	−3.1	3.4	246.2
	2	54.3	27.7	50.8	57.9	61.4	28.8	34.3	−0.8	34.3	358.7	20.8	−1.4	−3.1	3.4	246.0
	3	54.3	27.6	50.8	57.8	61.5	28.7	34.7	−0.4	34.7	359.3	20.8	−1.4	−3.0	3.3	245.8
	4	54.3	27.9	50.9	58.0	61.3	28.6	34.2	−0.7	34.2	358.8	20.6	−1.2	−3.3	3.5	250.6
	5	54.8	27.7	51.9	58.8	61.9	28.7	34.2	0.0	34.2	360.0	20.7	−1.4	−3.0	3.3	245.6

[a] *L**, vertical axis (lightness); *a**, axis in plane normal to *L** (redness–greenness quality of the colour); *b**, axis normal to both *L** and *a** (yellowness–blueness quality of the colour); *C*, chroma; *h*°, line angle.

3.5. Shade change

As previously mentioned, the use of the traditional full backtan which used potassium antimony tartrate to complex the high M_r gallotannin, has, in recent years been superceded by that of syntans because of several reasons, including the facts that the treatment can impart a shade change to the dyeing and also can discolour during repeated washing owing to oxidation of the high M_r gallotannin. The colorimetric data displayed in Tables 3–5 reveal that the new backtan imparted very little change of shade to the dyeings and, furthermore, that the extent of this shade change was virtually identical to that conveyed by the other two aftertreatments. The data also shows that the shade of the dyeings which had been aftertreated using the full backtan changed very little after repeated washing and, again, that the magnitude of this shade change was no different to that suffered by the other two aftertreatments.

3.6. Handle

The handle of the backtanned fabrics was judged to be no harsher than that of the dyeings which had been aftertreated with the syntan/cation system; the syntanned fabrics were judged to have slightly less harsh handle than both the backtanned and the syntan/cation aftertreated samples.

3.7. Light fastness

Table 6 shows that the light fastness of the dyeings was very little altered by the full backtan and, indeed, that the aftertreated dyeings displayed very good light fastness.

Table 4
Colorimetric data for monosulfonated dyes[a]

Aftertreatment	No. of washes	C.I. Acid Orange 144					Neutrilan Rubine S-2R				
		L^*	a^*	b^*	C	$h°$	L^*	a^*	b^*	C	$h°$
Nil	0	47.7	45.6	47.0	65.5	45.9	30.1	44.1	9.2	45.1	11.7
	1	48.6	45.5	46.1	64.8	45.4	30.5	44.1	9.1	45.0	11.6
	2	48.8	45.1	46.9	65.0	46.1	31.4	43.6	7.9	44.3	10.3
	3	49.2	44.8	46.8	64.8	46.2	31.8	43.9	8.0	44.6	10.3
	4	49.5	44.8	46.9	64.9	46.3	32.1	44.1	7.9	44.8	10.1
	5	49.5	44.8	46.2	64.4	45.9	32.6	44.0	7.3	44.6	9.4
Syntan	0	47.6	45.4	46.7	65.1	45.8	30.2	44.0	9.1	44.9	11.7
	1	48.0	45.2	47.0	65.2	46.1	30.2	44.0	9.1	44.9	11.7
	2	48.0	54.4	47.3	65.6	46.2	30.1	43.5	8.8	44.4	11.4
	3	48.3	45.2	47.3	65.5	46.3	30.5	44.0	8.9	44.9	11.5
	4	48.4	45.4	46.7	65.1	45.8	30.4	43.8	8.1	44.6	10.5
	5	48.5	45.2	47.3	65.5	46.3	30.7	43.9	8.6	44.7	11.1
Syntan/cation	0	47.8	45.4	47.3	65.5	46.2	30.1	44.3	9.7	45.3	12.3
	1	48.1	45.3	47.3	65.5	46.5	30.4	44.1	9.4	45.1	12.0
	2	48.0	45.5	47.2	65.5	46.1	30.2	43.7	8.8	44.6	11.4
	3	48.1	45.3	47.1	65.4	46.1	30.4	44.0	9.0	45.0	11.6
	4	48.2	45.2	47.1	65.3	46.2	30.5	44.1	8.9	44.9	11.4
	5	48.0	45.1	46.9	65.0	46.1	30.6	43.9	9.0	44.8	11.6
Full backtan	0	47.9	45.0	46.6	64.6	46.0	30.2	43.6	8.7	44.4	11.3
	1	47.7	44.6	46.0	64.1	45.9	30.2	43.1	8.5	44.0	11.2
	2	47.3	44.3	45.7	63.6	45.9	29.8	42.2	7.8	42.9	10.4
	3	47.1	43.9	45.4	63.1	46.0	29.9	42.3	8.0	43.1	10.7
	4	47.2	44.0	45.8	63.3	46.0	29.7	42.4	7.9	43.1	10.6
	5	47.2	44.1	45.7	63.5	46.0	30.0	42.7	8.6	43.6	11.4

[a] L^*, a^*, b^*, C and L^o as in Table 3.

Table 5
Colorimetric data for disulfonated dyes[a]

Aftertreatment	No. of washes	C.I. Acid Violet 90					C.I. Acid Blue 193					C.I. Acid Yellow 384				
		L^*	a^*	b^*	C	h°	L^*	a^*	b^*	C	h°	L^*	a^*	b^*	C	h°
Nil	0	28.4	41.2	−0.9	41.2	358.8	24.8	1.0	−16.4	16.4	273.5	59.4	24.9	68.9	73.3	70.1
	1	29.0	40.8	−1.3	40.9	358.2	25.3	0.8	−16.4	16.5	272.9	60.6	24.1	68.3	72.4	70.5
	2	29.7	41.0	−1.7	41.0	357.6	25.9	0.9	−16.5	16.6	273.0	59.7	21.6	65.6	69.1	71.8
	3	30.1	41.3	−1.5	41.3	357.9	26.3	0.9	−16.6	16.6	273.0	60.7	22.1	65.7	69.3	71.4
	4	30.3	41.4	−1.7	41.4	357.7	26.3	0.8	−16.6	16.6	272.8	61.5	22.3	65.8	69.5	71.3
	5	30.6	41.5	−1.7	41.5	357.7	26.8	0.9	−16.8	16.8	278.1	61.9	22.4	65.5	69.2	71.1
Syntan	0	28.7	41.0	−1.1	41.0	358.5	25.1	0.9	−16.4	16.4	273.2	58.8	25.0	68.1	72.5	69.9
	1	28.9	41.1	−1.0	41.1	358.6	25.5	0.9	16.5	16.5	273.0	59.3	24.7	67.9	72.3	70.0
	2	28.9	41.1	−1.1	41.1	358.5	25.3	0.9	−16.5	16.5	273.1	58.9	24.0	67.5	71.6	70.5
	3	29.1	41.2	−0.9	41.2	358.8	25.7	0.9	−16.5	16.5	273.1	58.9	24.2	67.2	71.5	70.2
	4	29.0	41.4	−2.1	41.5	357.1	25.9	1.0	−16.8	16.8	273.5	59.4	24.4	67.2	71.5	70.0
	5	29.1	41.1	−1.1	41.1	358.5	25.7	0.9	−16.6	16.7	273.3	59.3	24.3	67.1	71.3	70.1
Syntan/cation	0	28.9	41.4	−0.7	41.4	359.0	24.8	0.9	−16.3	16.3	273.1	58.6	25.0	68.1	72.5	69.9
	1	28.9	41.2	−0.9	41.2	358.8	25.3	0.9	−16.3	13.3	273.0	58.5	24.8	67.9	72.3	69.9
	2	28.8	40.9	−1.1	40.9	358.5	25.3	0.9	−16.4	16.4	273.1	58.6	24.5	67.7	72.0	70.1
	3	29.0	41.1	−0.9	41.1	358.8	25.4	0.9	−16.4	16.4	273.1	58.7	24.6	67.4	71.7	70.0
	4	29.1	41.2	−1.1	41.2	358.5	25.3	1.0	−16.6	16.6	273.4	58.7	24.9	65.8	70.3	69.3
	5	29.2	41.2	−0.9	41.3	358.8	25.5	0.9	−16.5	16.5	273.1	58.8	24.7	67.4	71.8	69.9
Full backtan	0	28.8	41.3	−2.0	41.3	357.3	25.5	0.9	−16.7	16.7	273.0	56.4	27.8	63.1	69.0	66.3
	1	28.3	40.9	−1.0	40.9	358.5	25.5	0.8	−16.4	16.4	272.9	55.6	27.4	61.8	67.6	66.1
	2	28.8	40.4	−1.4	40.5	358.0	25.3	0.9	−16.4	16.4	273.1	55.6	27.2	61.3	67.1	66.1
	3	28.8	40.4	−1.1	40.4	358.5	25.4	0.8	−16.2	16.3	272.7	55.4	27.2	60.7	66.6	65.9
	4	28.8	40.6	−1.0	40.6	358.5	25.2	0.8	−16.2	16.2	272.7	55.9	27.0	61.6	67.2	66.3
	5	28.8	40.5	−1.0	40.5	358.6	25.5	0.8	−16.2	16.2	272.7	55.6	27.0	61.1	66.8	66.2

[a] L^*, a^*, b^*, C and L° as in Table 3.

Table 6
Light fastness

Dye	Non-aftertreated	Full backtan aftertreated
C.I. Acid Black 107	6	7
C.I. Acid Red 182	7	7
C.I. Acid Yellow 137	7	7
C.I. Acid Orange 144	7	7
Neutrilan Rubine S	7	7
C.I. Acid Violet 90	6	7
C.I. Acid Blue 193	6	7
C.I. Acid Yellow 384	7	7

4. Conclusions

The newly developed, one-bath, two-stage, full backtan aftertreatment, which does not use potassium antimony tartrate, improved the fastness of each of the eight 1:2 pre-metallised acid dyes. The extent of the fastness improvement secured, in terms of both reduction in colour strength and staining of adjacent multifibre, was considerably greater than that furnished using both the syntan and the syntan/cation aftertreatments. Backtanning imparted little shade change to the dyeings and the extent of this shade change was very similar to that bestowed by the other two aftertreatments. In addition, the shade of the dyeings which had been aftertreated using the full backtan changed little after repeated washing and in a manner that was no different to that observed for the two other two aftertreatments. The handle of the backtanned fabrics, while harsher than that of the syntanned fabrics, was similar to that of dyeings which had been aftertreated with the syntan/cation system. The light fastness of the dyeings was little changed as a result of the backtanning process.

Acknowledgement

The authors thank Dr. R.A. Mussche of Omnichem-Ajinmoto, Belgium for helpful discussions.

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