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A comparison of the colour strength and fastness to repeated washing of acid dyes on standard and deep dyeable nylon 6,6

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Abstract

Five acid dyes were applied at 0.5%, 1%, 2% and 5% omf depths of shade to both standard (amino end group [AEG]: 45 meq kg^{-1}) and deep dyeable (AEG: 70 meq kg^{-1}) nylon 6,6 fibres. The colour strength (K/S) of the dyeings as well as their fastness to repeated washing at 60 °C was determined. The finding that the K/S of dyeings on the deep dyeing variant was higher than that on its standard dyeable counterpart supports the accepted mechanism of dyeing nylon 6,6 with anionic dyes, that dye–fibre substantivity occurs predominantly via ion–ion forces operating between anionic groups in the dye and the protonated amino end groups in the fibre. However, the small difference in colour strength observed between dyeings on the deep dyeable and the standard dyeable fibre types implies that forces of interaction (e.g. H-bonding, dispersion forces and polar van der Waals' forces) other than ion–ion contribute to dye–fibre substantivity. When subjected to repeated ISOC06/C2S (60 °C) wash fastness testing, the five dyes displayed similar behaviour insofar as at each of the four depths of shade used, the dyeings underwent a reduction in colour strength due to loss of dye during. The extent of this reduction in colour strength increased with increasing depth of shade and with increasing number of washes; the reduction in K/S that accompanied an increase in number of washes was similar for both the standard and deep dyeable nylon 6,6 variants. The corresponding colorimetric data revealed that the standard dyeable and deep dyeable fabrics were very similar in colour at each of the four depths of shade used, both before and after repeated wash testing, which can be attributed to the polymers that were used in the two fibre types being similar.

Keywords: Nylon 6,6; Deep dyeable; Dyeing; Acid dyes

1. Introduction

It is well known that the presence of amino end groups (AEG) in nylon fibres imparts substantivity towards various classes of anionic dye, namely *acid dyes*, *direct dyes*, *mordant dyes* and *reactive dyes*; of these dye classes, *acid dyes*, predominate commercially. It is widely held that the substantivity of such anionic dyes, under acidic conditions, towards nylon 6,6 is based mainly on electrostatic forces of interaction operating between anionic (typically sulfonate) groups in the dye and the protonated, terminal amino groups in the fibre; the adsorption of anionic dyes on nylon is thus considered to be site-specific [1]. The substantivity of anionic dyes towards nylon fibres can be modified by altering the concentration of amino end groups in the substrate. By increasing the AEG content, dye–fibre substantivity is enhanced; such anionic-dyeable variants are commonly referred to as *low, standard, deep* or *ultra-deep*, depending on AEG content [1].

Although attention has been focussed on the effects of AEG content on the thermodynamics and kinetics of

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the adsorption of acid dyes on nylon fibres, comparatively little research work has attended the effects of AEG content on the wet fastness of acid dyes on polyamide fibres [1]. The purpose of the present work was to compare the colour strength and wash fastness characteristics of several acid dyes on both standard dyeable and deep dyeable nylon 6,6 knitted fabrics.

2. Experimental

2.1. Materials

Scoured, knitted standard (AEG: 45 m eq kg^{-1}) and deep dyeable (AEG: 70 meq kg^{-1}) nylon 6,6 fabrics each of 78f68 (1.15 dtex per filament) were generously supplied by Du Pont (UK). The five acid dyes used in this work were kindly supplied by Crompton & Knowles (Table 1); the dyes were arbitrarily chosen and used without purification.

2.2. Dyeing

All dyeings were carried out in 200 cm^3 capacity, sealed stainless steel dyepots housed in a laboratory scale, Zeltex *Polycolor PC 1000* dyeing machine; the dyes were applied using the maker's recommendations.

2.3. Colour measurement

This was carried out using an X-Rite *Match-Rite* spectrophotometer coupled to a PC using illuminant D_{65}, 10° standard observer with the specular component excluded and the UV component included. Each fabric was folded once so as to give two thickness and an average of four readings was taken each time.

2.4. Wash fastness

Testing was carried out according to the ISO C06/C2 method [2].

Table 1
Dyes used

Commercial name	C.I. generic name	Dye type
Nylanthrene Blue B-2RF	C.I. Acid Blue 62	Non-metallised acid
Nylanthrene Yellow C-3RL	C.I. Acid Orange 67	
Neutrilan Red K-2G	C.I. Acid Red 278	Unsulfonated 1:2 pre-metallised acid
Neutrilan Rubine S-2R	None ascribed	Mono-sulfonated 1:2 pre-metallised acid
Neutrilan Black M-RX	C.I. Acid Black 194	Disulfonated 1:2 pre-metallised acid

3. Results and discussion

Fig. 1 shows the colour strength (K/S) obtained for the five acid dyes used on both standard dyeable and deep dyeable nylon 6,6 fabrics. It is apparent that for each of the four depths of shade applied, the colour strength of the dyeings on the deep dyeing substrate was greater than that on its standard dyeable counterpart. The finding that colour strength was higher on the deep dyeable (AEG: 70 meq kg^{-1}) 6,6 fabric than on the standard dyeable (AEG: 45 meq kg^{-1}) variant, supports the widely accepted mechanism of dyeing nylon 6,6 with anionic dyes, namely that dye–fibre substantivity occurs predominantly via ion–ion forces operating between anionic groups in the dye and the protonated terminal amino groups in the fibre. However, Fig. 1 also shows that, for each of the five dyes used, there was little difference in colour strength between the dyeings on the deep dyeable and the standard dyeable fibre types. Although the AEG contents of the deep dyeable and standard dyeable fabrics were 70 meq kg^{-1} and 45 meq kg^{-1}, respectively, this being a difference of some 55%, the observed difference in colour strength achieved for the 10 dyes on the two types of nylon 6,6 fabrics was, clearly, much lower than 55%.

The two types of fibres used in this work were specifically produced so as to be as similar as possible in terms of decitex, cross sectional form, delustrant content, knit construction, etc. but differed in amino end group content [3]. With this in mind, the similarity in colour strength observed for the deep and standard dyeable variants implies that the terminal amino groups were not solely responsible for the adsorption of the acid dyes and, therefore, that forces of interaction other than ion–ion contribute to dye–fibre substantivity. In this context, the observed similarity in colour strength obtained for the deep and standard dyeable fibre types could be attributed to the adsorption of dye via, for example, H-bonding, dispersion forces and polar van der Waals' forces. If this were to be the case then it is possible that for standard dyeable fibre, dye adsorption in excess of the AEG content of the fibre occurred and, therefore, the standard dyeable variant was 'overdyed' [1]. However, it is also possible that the extent of dye uptake onto the deep dyeable variant was lower than the AEG content of the fibre which implies that factors other than intermolecular forces of interaction contributed towards dye adsorption. For example, a *diffusional barrier* to dye adsorption may have developed within the deep dyeable nylon 6,6 fibre. It can be argued that ion–ion interaction operating between the anionic dye and the protonated terminal end groups in both types of fibres can be expected to result in the rapid, initial adsorption of the dye; such adsorption can be anticipated to be greater on to the deep dyeable substrate. If such rapid adsorption of the anionic dye was confined

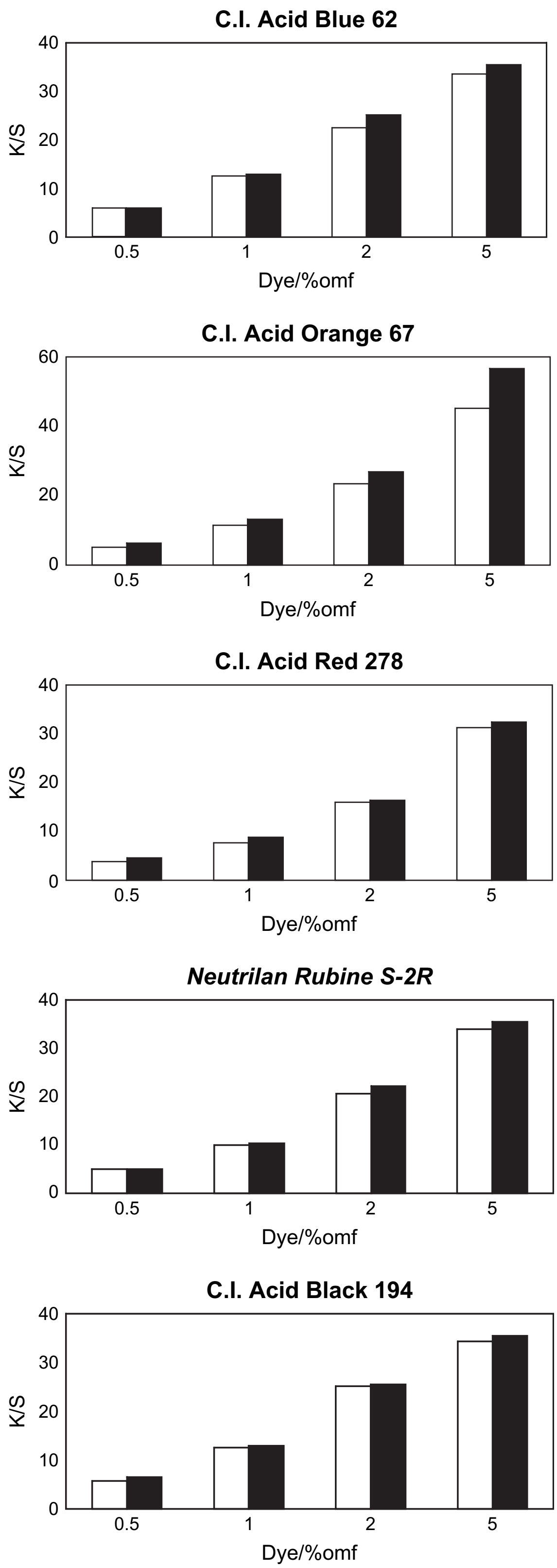

Fig. 1. Colour strength (K/S) obtained on standard □ and deep dyeable ■ fabrics.

mainly to the periphery of the fibre then a 'layer' of adsorbed dye molecules would be formed at the fibre surface which could then constitute a *diffusional barrier* to further dye adsorption. Thus, subsequent adsorption of the dye may not occur simply by virtue of ion–ion forces operating between the protonated amino end groups in the fibre and anionic groups in the dye but could also include H-bonding, dispersion forces, etc., thereby resulting in a difference in dye uptake onto deep dyeable and standard dyeable variants was not in accordance with the difference in the AEG content of the two fibres.

In order to determine the effects of AEG content on the wash fastness of dyeings, the ISOC06/C2S (60 °C) standard wash test [2] was used in this work but was modified, in that dyeings were subjected to five consecutive wash tests and at the end of each wash test, the washed sample was rinsed thoroughly in tap water (but was not dried) and a fresh sample of SDC multifibre strip was attached to the dyeing prior to the next wash test. Fig. 2 shows the colour strength obtained for 0.5%, 1%, 2% and 5% omf dyeings on both standard and deep dyeable nylon 6,6 variants before and after they had been subjected to five, repeated, ISO C06/C2 wash tests. It is evident that dyeings of C.I. Acid Blue 62 on both the standard and deep dyeable variants displayed moderate/poor fastness to repeated washing insofar as the dyeings underwent a reduction in colour strength (K/S) due to the loss of dye during washing. From the K/S values shown, it is also apparent that the reduction in colour strength increased as the depth of shade of the dyeings increased from 0.5% to 5% omf; in addition, the reduction in K/S increased with increasing number of washes. It is also clear that, at each of the four depths of shade used, the extent of the reduction in colour strength that accompanied an increase in number of washes was similar for both the standard and deep dyeable variants. The result of this was that the higher colour strength of the deep dyeable variants before wash testing was reflected in the correspondingly higher colour strength of the dyeings after repeated wash testing; the results in Fig. 2 suggest that the deep dyeable dyeings displayed neither better nor worse fastness to repeated washing than their standard dyeable counterparts. The corresponding colorimetric data obtained for C.I. Acid Blue 62 on both standard and deep dyeable nylon 6,6 variants before and after they had been subjected to five, repeated, ISO C06/C2 wash tests is shown in Table 2. The colorimetric data presented reveal that the shade changes observed for the dyeings on both types of nylon 6,6 fibre were attributable to a loss of dye from the dyeings rather than to changes in the colour of the dyeings. In the case of the dyeings both before and after repeated wash testing, it is apparent that the standard dyeable and deep dyeable fabrics were very similar in colour at each of the four depths of shade

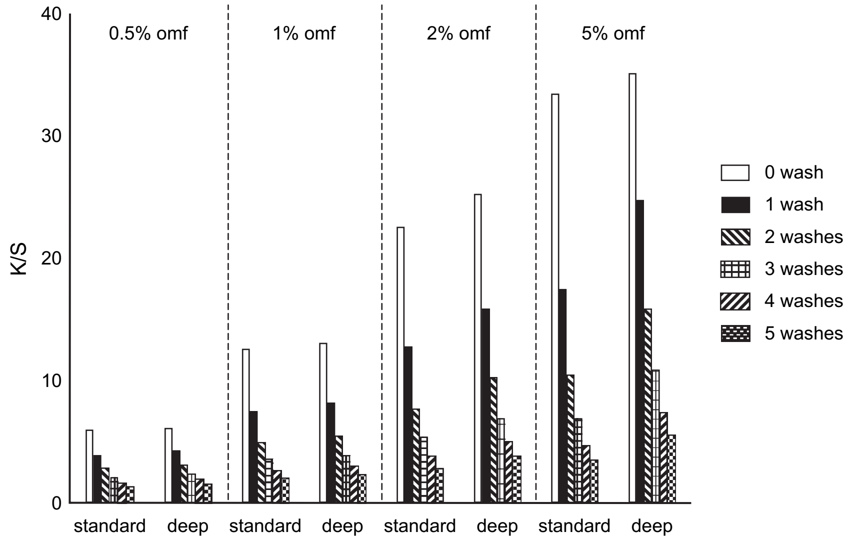

Fig. 2. C.I. Acid Blue 62.

used; this finding was not surprising as the polymers used in the two fibre types were themselves similar [3].

Fig. 3 shows the effects of repeated wash fastness testing on 0.5%, 1%, 2% and 5% omf dyeings of C.I. Acid Orange 67 on both standard and deep dyeable nylon 6,6 variants before and after they had been subjected to five, repeated, ISO C06/C2 wash tests. Dyeings on both the standard and deep dyeable variants displayed moderate/poor fastness to repeated washing, as exemplified by the reduction in K/S due to the loss of dye during washing; in addition, the reduction in colour strength increased as the depth of shade of the dyeings increased from 0.5% to 5% omf and, also, the reduction in K/S increased with increasing number of washes. Furthermore, at each of the four depths of shade used, the extent of the reduction in colour strength that accompanied an increase in number of washes was similar for both the standard and deep dyeable variants. The corresponding colorimetric data obtained (Table 3) reveal that the standard dyeable and deep dyeable fabrics were very similar in colour, at each of the four depths of shade used, both before and after repeated wash testing. Thus, the results obtained for the effects of repeated wash testing on dyeings of C.I. Acid Orange 67 were very similar to those secured for C.I. Acid Blue 62 (Fig. 2 and Table 2).

However, the colour strength results secured for 0.5%, 1%, 2% and 5% omf dyeings of C.I. Acid Red 278, *Neutrilan Rubine S-2R* and C.I. Acid Black 194 (Figs. 4, 5 and 6, respectively), differed to those of the two other dyes in that higher fastness to repeated washing was found in the cases of both the standard and deep dyeable variants, as evidenced by the very low reduction in colour strength that accompanied increases in depth of shade number of washes. Nevertheless, the results shown in Figs. 4–6 also reveal that, at each of the four depths of shade used, the extent of the reduction in colour strength observed for the three dyes was similar for both the standard and deep dyeable variants. The corresponding colorimetric data obtained (Tables 4–6) show that, for each of the three dyes under consideration, the standard dyeable and deep dyeable fabrics were very similar in colour, at each of the four depths of shade used, both before and after repeated wash testing. Thus, the results obtained for the effects of repeated wash testing on dyeings of C.I. Acid Red 278, *Neutrilan Rubine S-2R* and C.I. Acid Black 194 were, for the most part, very similar to those secured for C.I. Acid Blue 62 (Fig. 2 and Table 2) and C.I. Acid Orange 67 (Fig. 3 and Table 3).

4. Conclusions

The two types of fibres used in this work were specifically selected to be as similar as possible in terms of decitex, cross sectional form, delustrant content, knit construction, etc. but differed in amino end group content [2]. The finding that, for each of the five dyes used and at each of the four depths of shade applied, the colour strength of dyeings on the deep dyeing (70 meq kg^{-1}) nylon 6,6 variant was higher than that on its standard dyeable (45 meq kg^{-1}) counterpart supports the accepted mechanism of dyeing nylon 6,6 with anionic dyes, namely that dye–fibre substantivity occurs predominantly via ion–ion forces operating between anionic groups in the dye and the protonated amino end groups in the fibre. However, the small difference in colour strength between the dyeings obtained on the deep dyeable and the standard dyeable fibre types implies that the terminal amino groups may not be solely responsible for the adsorption of the acid dyes

Table 2
Colorimetric data for C.I. Acid Blue 62

No. of washes	L^*	a^*	b^*	C	$h°$
Standard dyeable nylon 6,6					
0.5% omf					
0	48.6	4.0	−46.8	46.9	274.9
1	53.8	1.8	−43.9	43.9	272.3
2	57.9	−0.5	−40.4	40.4	269.3
3	61.2	−1.6	−37.2	37.2	267.6
4	64.1	−2.6	−33.9	34.0	265.6
5	66.5	−3.3	−31.2	31.4	264.0
1% omf					
0	40.2	9.3	−51.2	52.0	280.3
1	45.9	5.8	−48.3	48.6	276.8
2	50.9	2.5	−44.9	44.9	273.2
3	54.3	1.0	−41.5	41.5	271.4
4	57.8	−0.6	−38.0	38.0	269.1
5	60.5	−1.5	−35.1	35.1	267.5
2% omf					
0	33.2	14.3	−52.8	54.7	285.2
1	39.4	9.3	−50.2	51.0	280.5
2	45.2	4.8	−46.4	46.7	276.0
3	48.9	2.9	−43.2	43.3	273.8
4	52.5	1.0	−39.7	39.7	271.5
5	55.9	−0.2	−36.4	36.4	269.7
5% omf					
0	27.0	18.1	−51.5	54.6	289.4
1	35.1	10.7	−49.4	50.5	282.2
2	40.9	5.8	−45.6	46.0	277.2
3	44.9	3.5	−42.1	42.2	274.7
4	48.9	1.6	−38.5	38.6	272.4
5	52.0	0.6	−35.3	35.3	270.9
Deep dyeable nylon 6,6					
0.5% omf					
0	48.0	2.1	−44.3	44.3	272.7
1	52.4	0.6	−42.4	42.4	270.8
2	56.4	−1.5	−39.3	39.4	267.9
3	59.4	−2.4	−36.5	36.6	266.3
4	62.1	−3.1	−34.0	34.1	264.9
5	64.7	−3.8	−31.1	31.3	263.1
1% omf					
0	39.6	8.0	−49.7	50.3	279.2
1	44.7	4.9	−47.4	47.4	275.9
2	49.4	1.9	−43.8	43.9	272.5
3	52.9	0.2	−40.5	40.5	270.3
4	56.0	−1.1	−37.7	37.7	268.4
5	59.3	−2.0	−34.7	34.8	266.7
2% omf					
0	31.7	14.7	−52.4	54.4	285.7
1	37.1	10.2	−50.5	51.5	281.4
2	42.0	6.1	−47.6	48.0	277.3
3	46.0	3.6	−44.5	44.7	274.6
4	49.4	2.0	−41.9	42.0	272.7
5	52.4	0.4	−38.8	38.8	270.5
5% omf					
0	25.3	19.5	−50.9	54.5	290.8
1	31.2	13.8	−50.5	52.3	285.3
2	36.4	8.7	−47.9	48.7	280.2
3	40.1	5.7	−44.9	45.2	277.2
4	44.1	3.3	−42.0	42.1	274.5
5	47.2	1.7	−39.1	39.1	272.5

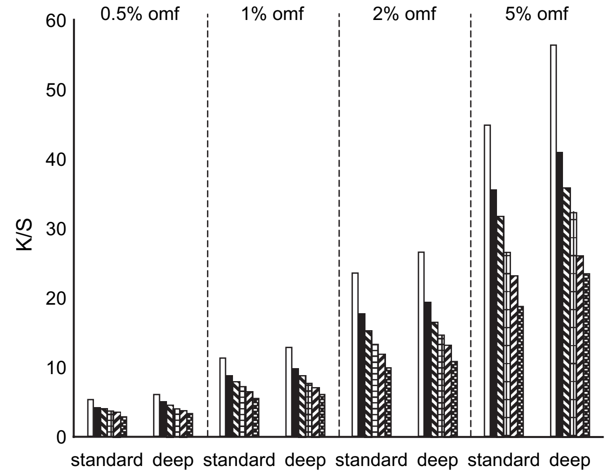

Fig. 3. C.I. Acid Orange 67 (keys as in Fig. 2).

and, therefore, that forces of interaction other than ion–ion contribute to dye–fibre substantivity. In this context, the observed similarity in colour strength obtained for the deep and standard dyeable fibre types, could be attributed to the adsorption of dye via, for example, H-bonding, dispersion forces and polar van der Waals' forces.

When 0.5%, 1%, 2% and 5% omf dyeings were subjected to repeated ISOC06/C2S (60 °C) wash fastness testing, the five dyes displayed similar behaviour insofar as at each of the four depths of shade used, the dyeings underwent a reduction in colour strength due to loss of dye during washing. For each of the five dyes used, the extent of this reduction in colour strength increased with increasing depth of shade and with increasing number of washes; the reduction in K/S that accompanied an increase in number of washes was similar for both the standard and deep dyeable nylon 6,6 variants. As the higher colour strength of the deep dyeable variants before wash testing was reflected in the correspondingly higher colour strength of the dyeings after repeated wash testing, the deep dyeable dyeings displayed neither better nor worse fastness to repeated washing than their standard dyeable counterparts. The corresponding colorimetric data reveal that the shade changes observed for the dyeings on both types of nylon 6,6 fibre were attributable to a loss of dye from the dyeings rather than to changes in the colour of the dyeings. The finding that the standard dyeable and deep dyeable fabrics were very similar in colour at each of the four depths of shade used, both before and after repeated wash testing, can be attributed to the polymers that were used in the two fibre types being similar.

Thus, although the presence of a higher number of amino end groups resulted in deeper dyeings being obtained on the deep dyeable nylon 6,6 fibre, the fastness of these dyeings to repeated wash fastness testing was neither better nor worse than that of (paler)

Table 3
Colorimetric data for C.I. Acid Orange 67

No. of washes	L^*	a^*	b^*	C	$h°$
Standard dyeable nylon 6,6					
0.5% omf					
0	72.9	25.3	62.9	67.7	68.1
1	74.4	22.7	60.3	64.4	69.4
2	75.0	22.1	59.3	63.7	69.7
3	75.4	21.5	58.3	62.1	69.8
4	75.9	20.7	57.3	60.9	70.2
5	77.0	19.1	55.3	58.5	70.9
1% omf					
0	68.8	31.2	71.9	78.4	66.5
1	70.3	29.5	69.8	75.8	67.1
2	71.4	28.1	68.5	74.1	67.7
3	71.7	27.5	67.1	72.5	67.7
4	72.4	26.2	65.6	70.6	68.2
5	73.3	25.3	64.5	69.3	68.6
2% omf					
0	64.7	36.6	77.6	85.8	64.8
1	66.4	35.4	76.7	84.5	65.3
2	67.6	34.2	75.4	82.8	65.6
3	68.2	33.1	74.0	81.0	65.9
4	68.9	31.8	72.6	79.2	66.3
5	69.6	30.9	71.3	77.7	66.6
5% omf					
0	60.6	44.2	80.3	91.6	61.2
1	62.1	42.1	80.4	90.7	62.4
2	63.4	40.6	80.1	89.8	63.1
3	64.3	39.2	79.1	88.3	63.7
4	64.9	37.9	78.0	86.7	64.1
5	65.9	36.5	77.3	85.5	64.7
Deep dyeable nylon 6,6					
0.5% omf					
0	73.3	25.6	66.1	70.9	68.9
1	73.9	24.8	63.4	67.8	69.0
2	74.9	22.7	61.9	66.0	69.9
3	75.3	22.1	60.4	64.3	69.9
4	75.8	21.1	58.8	62.5	70.3
5	76.2	20.4	57.4	60.9	70.4
1% omf					
0	68.6	31.2	73.5	79.8	66.9
1	69.7	29.4	71.2	76.9	67.6
2	70.6	28.4	69.4	75.0	67.8
3	71.2	27.4	67.8	73.1	68.0
4	71.8	26.3	66.5	71.5	68.4
5	72.4	25.5	65.1	69.9	68.6
2% omf					
0	64.7	36.6	77.6	85.6	64.8
1	64.8	34.8	75.8	83.4	65.3
2	66.2	33.6	75.0	82.2	65.8
3	66.9	32.7	73.5	80.4	66.0
4	67.5	31.7	72.1	78.8	66.3
5	68.2	30.8	70.8	77.2	66.5
5% omf					
0	58.3	44.1	78.3	89.9	64.9
1	60.4	42.6	79.3	90.0	61.8
2	61.7	41.3	79.3	89.4	62.5
3	62.4	39.9	78.8	88.4	63.1
4	63.4	38.6	77.8	86.8	63.6
5	64.0	37.6	77.2	85.8	64.0

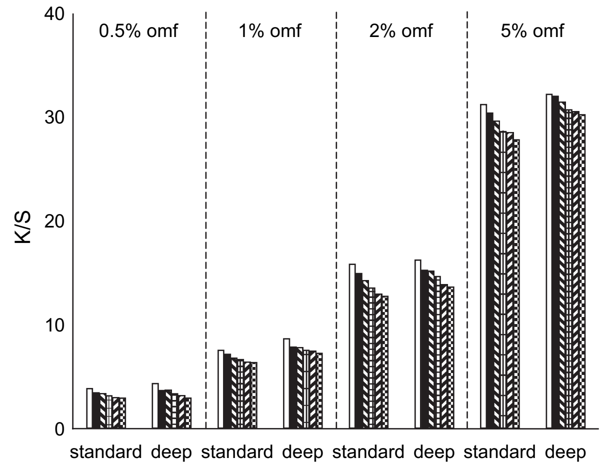

Fig. 4. C.I. Acid Red 278 (keys as in Fig. 2).

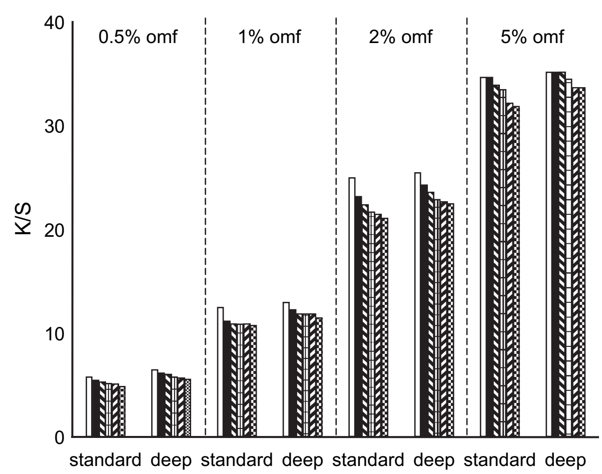

Fig. 5. *Neutrilan Rubine S-2R* (keys as in Fig. 2).

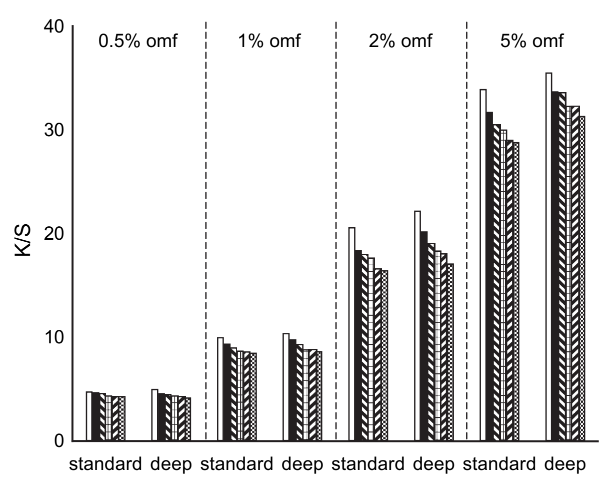

Fig. 6. C.I. Acid Black 194 (keys as in Fig. 2).

Table 4
Colorimetric data for C.I. Acid Red 278

No. of washes	L^*	a^*	b^*	C	$h°$
Standard dyeable nylon 6,6					
0.5% omf					
0	53.3	40.1	12.8	42.1	17.7
1	54.9	40.5	12.9	42.5	17.6
2	55.3	40.5	13.1	42.6	18.0
3	56.0	40.4	12.8	42.4	17.6
4	56.6	39.9	12.7	41.9	17.6
5	56.7	39.7	12.5	41.7	17.4
1% omf					
0	46.3	44.1	16.4	47.0	20.4
1	47.1	44.3	16.4	47.3	20.3
2	47.8	44.2	16.6	47.2	20.5
3	47.8	44.2	16.6	47.2	20.6
4	48.5	44.0	16.5	47.0	20.6
5	48.5	44.0	16.4	46.9	20.4
2% omf					
0	38.7	45.6	20.2	49.9	23.9
1	39.2	45.6	20.3	50.0	24.0
2	40.1	45.9	20.5	50.3	24.1
3	40.6	45.9	20.5	50.3	24.0
4	41.2	45.9	20.5	50.3	24.0
5	41.2	45.8	20.2	50.1	23.7
5% omf					
0	30.1	43.0	23.4	48.9	28.6
1	30.8	43.5	23.8	49.6	28.7
2	31.2	43.5	24.1	49.7	29.0
3	31.6	43.8	24.2	50.2	28.9
4	32.1	44.3	24.6	50.7	29.1
5	32.2	44.1	24.2	50.3	27.8
Deep dyeable nylon 6,6					
0.5% omf					
0	52.1	41.2	13.4	43.2	18.1
1	54.2	40.8	12.9	42.8	17.5
2	54.5	40.9	13.3	43.0	18.0
3	55.7	40.5	12.9	42.5	17.7
4	56.1	40.0	12.7	42.0	17.7
5	56.7	39.7	12.6	41.7	17.5
1% omf					
0	44.8	44.3	16.9	47.5	20.9
1	46.1	44.9	16.9	48.0	20.7
2	46.3	44.6	17.1	47.8	21.0
3	46.8	44.9	17.3	48.1	21.1
4	46.9	44.6	17.3	47.8	21.2
5	47.0	44.3	17.0	47.4	20.9
2% omf					
0	38.3	45.4	20.1	49.6	23.9
1	39.0	45.5	20.0	49.8	23.8
2	39.2	45.6	20.1	49.9	23.8
3	39.7	45.7	20.5	50.1	24.2
4	40.3	45.7	20.4	50.1	24.1
5	40.5	45.6	20.3	50.0	23.9
5% omf					
0	29.4	42.5	23.4	48.6	28.9
1	29.9	43.1	23.8	49.2	29.0
2	30.5	43.4	24.3	49.7	29.2
3	30.7	43.5	24.2	49.8	29.1
4	31.0	43.8	24.7	50.3	29.4
5	31.0	43.7	24.1	49.9	28.9

Table 5
Colorimetric data for *Neutrilan Rubine S-2R*

No. of washes	L^*	a^*	b^*	C	$h°$
Standard dyeable nylon 6,6					
0.5% omf					
0	47.1	40.7	2.8	40.8	4.1
1	47.5	40.9	2.9	41.0	4.1
2	47.8	40.9	3.1	41.0	4.3
3	48.5	40.6	3.2	40.7	4.5
4	48.4	40.3	2.9	40.4	4.1
5	48.4	40.3	3.0	40.4	4.2
1% omf					
0	38.8	43.9	55.5	44.3	7.2
1	39.6	43.9	5.3	44.2	6.9
2	39.9	43.8	5.5	44.2	7.1
3	40.5	43.9	5.6	44.2	7.3
4	40.7	43.6	5.3	43.9	6.9
5	40.7	43.5	5.3	43.8	6.9
2% omf					
0	31.3	44.5	8.9	45.4	11.2
1	32.5	44.7	8.6	45.5	10.9
2	32.8	44.7	8.5	45.5	10.7
3	33.2	44.8	8.8	45.7	11.1
4	33.6	44.6	8.3	45.4	10.5
5	33.7	44.5	8.1	45.2	10.3
5% omf					
0	24.2	40.0	13.0	42.0	18.0
1	25.4	41.1	12.6	43.0	17.0
2	26.1	41.6	12.3	43.4	16.5
3	26.6	42.2	12.5	44.0	16.5
4	26.6	42.2	12.0	43.8	15.9
Deep dyeable nylon 6,6					
0.5% omf					
0	46.2	40.9	2.8	41.0	3.9
1	47.8	40.6	2.6	40.7	3.6
2	47.9	40.6	2.8	40.7	3.9
3	48.1	40.6	3.1	40.8	4.3
4	48.6	40.3	2.7	40.4	3.9
5	48.9	40.1	2.6	40.1	3.7
1% omf					
0	38.3	43.8	5.3	44.1	6.9
1	39.0	43.6	5.1	43.9	6.6
2	39.6	43.7	5.1	44.0	6.7
3	40.3	43.7	5.4	44.0	6.9
4	40.2	43.3	5.0	43.6	6.6
5	40.8	43.0	4.9	43.7	6.5
2% omf					
0	30.4	44.3	9.2	45.2	11.8
1	31.4	44.3	8.8	45.2	11.2
2	32.0	44.4	8.7	45.3	11.0
3	32.6	44.6	8.7	45.5	11.1
4	32.7	44.4	8.4	45.2	10.7
5	33.1	44.4	8.1	45.1	10.4
5% omf					
0	23.2	38.6	13.1	40.8	18.7
1	24.1	39.6	12.7	41.5	17.8
2	24.4	39.9	12.6	41.9	17.6
3	25.2	40.8	12.8	42.7	17.4
4	25.3	40.8	12.1	42.6	16.5
5	25.6	40.9	12.1	42.7	16.5

Table 6
Colorimetric data for C.I. Acid Black 194

No. of washes	L^*	a^*	b^*	C	$h°$
Standard dyeable nylon 6,6					
0.5% omf					
0	36.3	−0.8	−3.8	3.9	257.1
1	37.0	−0.5	−3.7	3.7	261.9
2	37.5	−0.4	−3.7	3.7	263.2
3	37.7	−0.4	−3.6	3.6	263.3
4	38.0	−0.5	−3.7	3.7	262.9
5	38.5	−0.5	−3.6	3.6	262.2
1% omf					
0	26.3	−0.8	−3.6	3.7	257.6
1	27.6	−0.4	−3.7	3.8	263.5
2	27.9	−0.5	−3.6	3.7	262.9
3	27.8	−0.5	−3.5	3.5	262.6
4	27.9	−0.4	−3.7	3.7	263.5
5	28.0	−0.5	−3.6	3.6	262.5
2% omf					
0	17.6	−0.3	−2.6	2.7	262.3
1	18.7	−0.1	−3.1	3.1	268.0
2	19.1	−0.1	−3.2	3.2	268.3
3	19.4	−0.1	−3.0	3.0	267.3
4	19.5	−0.1	−3.2	3.2	268.5
5	19.7	−0.1	−3.1	3.1	267.3
5% omf					
0	13.1	0.4	−1.4	1.5	286.5
1	13.3	0.3	−1.6	1.7	279.7
2	13.6	0.3	−1.7	1.8	279.6
3	13.7	0.2	−1.6	1.6	276.8
4	14.2	0.3	−2.0	2.0	279.7
5	14.2	0.3	−1.9	1.9	277.4
Standard dyeable nylon 6,6					
0.5% omf					
0	34.6	−0.7	−3.6	3.7	258.9
1	35.4	−0.5	−3.7	3.8	261.9
2	35.7	−0.5	−3.7	3.7	261.8
3	36.1	−0.5	−3.6	3.7	262.8
4	36.4	−0.5	−3.7	3.7	262.5
5	36.5	−0.5	−3.7	3.7	262.0
1% omf					
0	25.5	−0.7	−3.3	3.4	257.7
1	26.3	−0.5	−3.6	3.6	262.6
2	26.8	−0.4	−3.5	3.5	262.9
3	26.7	−0.4	−3.4	3.4	262.9
4	26.7	−0.5	−3.5	3.5	262.7
5	27.0	−0.4	−3.5	3.6	263.3
2% omf					
0	17.3	−0.2	−2.8	2.8	266.0
1	18.0	−0.1	−2.9	2.9	267.7
2	18.3	−0.1	−2.8	2.8	267.1
3	18.6	−0.1	−2.8	2.8	267.3
4	19.8	−0.2	−2.8	2.9	266.5
5	18.9	−0.3	−2.8	2.8	265.0
5% omf					
0	12.6	0.4	−1.1	1.2	292.6
1	12.8	0.3	−1.3	1.3	285.0
2	12.9	0.3	−1.3	1.4	284.0
3	13.1	0.2	−1.2	1.2	281.3
4	13.3	0.3	−1.6	1.6	282.2
5	13.4	0.3	−1.6	1.7	281.7

dyeings on the standard dyeable fibre. Hence, whilst AEG content contributes towards dye–fibre substantivity and adsorption, it does not appear to make a contribution towards wash fastness.

References

[1] Burkinshaw SM. Chemical principles of synthetic fibre dyeing. Glasgow: Blackie Academic and Professional; 1995.
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