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The Dyeing of Lyocell Fabric with Direct Dyes

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ABSTRACT

Lyocell, cotton and viscose fabrics were dyed using four direct dyes. With the exception of the bordeaux dye used, dyeings on Lyocell were of slightly different colour to comparative dyeings on cotton and viscose; the colour strength (K/S) of the dyeings on Lyocell was lower than on cotton and viscose and the four dyes exhibited lower build-up character on Lyocell than on the other two fibres. The wash fastness of 1/1 standard depth dyeings on Lyocell was comparable to that of identical depth dyeings on cotton and viscose. The results suggest that the dyeability of Lyocell with the four direct dyes used more closely resembles that of cotton than regular viscose.

INTRODUCTION

In previous papers, which compared the dyeability of Tencel, regular viscose and cotton with reactive dyes[1] and also CI Solubilised Sulphur dyes,[2] it was found that, in general, there was relatively little difference in colour between the dyeings of the three different types of reactive dye[1] as well as between the four CI Solubilised Sulphur dyes[2] used on each of the three types of fibre. It was observed that Tencel more closely resembled regular viscose than cotton in terms of its dyeability with reactive dyes,[1] whilst Tencel exhibited more similar dyeability to cotton in the case of CI Solubilised Sulphur dyes.[2] This paper examines the dyeability of Lyocell with direct dyes and compares the dyeing behaviour of the fibre to that of both cotton and regular viscose.

EXPERIMENTAL

Materials

Fabric
Scoured and bleached woven Lyocell (123·5 g m^{-2}), cotton (186·5 g m^{-2}) and regular viscose (187·5 g m^{-2}) were generously supplied by Courtaulds Research.

Dyes
The four commercial direct dyes used, namely Solophenyl Blue FGL (CI Direct Blue 85), Solophenyl Bordeaux 3BL (CI Direct Red 83), Solophenyl Scarlet BNL (CI Direct Red 89) and Solophenyl Yellow ARL (CI Direct Yellow 106), which were not purified prior to use, were generously provided by Ciba–Geigy. Ciba–Geigy divide their Solophenyl dyes into groups **I** and **II**;[3] the four dyes used were selected, arbitrarily, from group **I**.

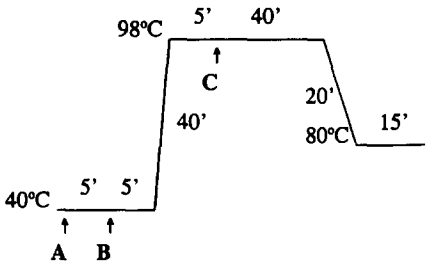
Auxiliaries
A sample of Solfix E, which was used to aftertreat the dyeings, was kindly provided by Ciba–Geigy.

All other reagents were of general purpose grade.

Procedures

Dyeing
All dyeings were carried out using fabric which had been wetted out in cold tap water in partially sealed glass dyepots of 200 cm^3 capacity housed in a Zeltex Vistacolor laboratory-scale dyeing machine using a 30 : 1 liquor ratio; the dyeing method employed is shown in Fig. 1. For each of the four dyes, samples (2·00 g) of each of the three types of fibre were dyed separately at 1, 2 and 4% omf depths; in addition, samples (2·00 g) of Lyocell, cotton and viscose were dyed competitively using 2% omf of each of the four dyes. At the end of dyeing, the dyed sample was removed, rinsed in cold tap water for 10 min and allowed to dry in the open air.

1/1 standard depth dyeings
These were produced, by visual comparison with the SDC Standard Depths, using the dyeing method shown in Fig. 1, for each of the four dyes on each of the three types of fibre.



A Dye
Fabric
B 20% of electrolyte addition
C 80% of electrolyte addition

Electrolyte (NaCl) addition:
1% omf dye, 15 gl^{-1};
2% omf dye, 20 gl^{-1};
4% omf dye, 25 gl^{-1}.

Fig. 1. Dyeing method.

Aftertreatment of dyeings

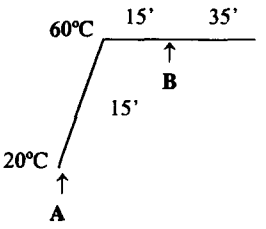
This was carried out on each of the 1/1 standard depth dyeings. At the end of dyeing, the dyed sample was removed from the dyebath and rinsed for 10 min in tap water. The rinsed sample was then aftertreated with Solfix E using the method shown in Fig. 2(a) in the case of cotton or Fig. 2(b) in the cases of Lyocell and viscose. At the end of aftertreatment, the samples were removed from the treatment bath and, as Fig. 2(a) and (b) shows, neutralised using dilute aqueous acetic acid for 5 min, rinsed for 10 min in tap water and then allowed to dry in the open air.

Colour measurement

The reflectance values of the undyed samples of Lyocell, cotton and viscose, as well as those of each of the dry dyeings on Lyocell, cotton and viscose, were measured using a Macbeth MS2020 spectrophotometer interfaced to a Digital PC100 personal computer, under illuminant D_{65} using a 10° standard observer with specular component excluded and UV component included, from which the corresponding K/S values and CIE L^*, a^*, b^*, C^* and $h°$ coordinates were calculated at the appropriate λ_{max} of each dye. Each fabric sample was folded twice so as to realise a total of four thicknesses of fabric.

Determination of wash fastness

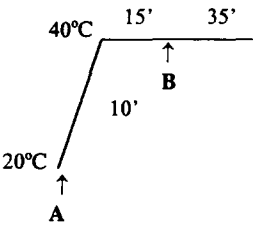
The fastness of the 1/1 standard depth dyeings to the ISOC06/C2 wash test was determined using the standard method.[4]



A Solfix E (0.5 + [3 x % omf dye]) % omf
B 2 cm^3 l^{-1} 36°Bé NaOH

Neutralisation: 40°C
Rinse: 20°C

(a)



A Solfix E (0.5 + [3 x % omf dye]) % omf
B 4 cm^3 l^{-1} 36°Bé NaOH

Neutralisation: 60°C
Rinse: 60°C

(b)

Fig. 2. Aftertreatment method for (a) cotton and (b) viscose and Lyocell.

RESULTS AND DISCUSSION

Table 1 shows the colorimetric parameters obtained for the three types of undyed fabric;[1] the colorimetric data obtained for the 1, 2 and 4% omf dyeings of the four direct dyes used on cotton, viscose and Lyocell are shown in Table 2. In the case of lightness, Table 1 shows that L^* values of the three undyed fabrics decreased in the order cotton > viscose > Lyocell; Table 2 clearly demonstrates that although this particular order of decreasing lightness was achieved for the 1, 2 and 4% omf dyeings of CI Direct Yellow 106 and the 1 and 2% omf dyeings of CI Direct Red 89, for the remaining two dyes, the order of the L^* values of the dyeings differed to that obtained for the lightness of the undyed fabrics. Furthermore, in terms of chroma, Table 1 shows that the C^* values of the three undyed fabrics increased in the order Lyocell < cotton < viscose, whilst

TABLE 1
Colorimetric Data for Undyed Fabrics

Fabric	*L**	*a**	*b**	*C**	*h°*	*K/S*
Lyocell	91·35	−0·32	1·72	1·75	100·5	0·04
Cotton	93·89	−0·29	3·07	3·08	95·4	0·03
Viscose	92·48	−0·39	4·75	4·77	94·7	0·05

TABLE 2
Colorimetric Data for Dyeings

Dye	*Fibre*	*% omf*	*L**	*a**	*b**	*C**	*h°*	*K/S*
	viscose	1	44·5	−0·6	−21·6	21·6	268·4	4·1
	Lyocell	1	37·7	−0·06	−18·7	18·9	269·8	5·9
	cotton	1	38·7	−1·5	−22·7	22·8	266·3	6·4
	viscose	2	35·4	1·5	−21·3	21·3	273·9	7·3
CI Direct Blue 85	Lyocell	2	31·0	2·5	−17·6	17·8	278·0	8·8
	cotton	2	30·2	0·8	−21·6	21·6	272·3	11·0
	viscose	4	22·1	5·7	−20·4	21·2	287·3	18·9
	Lyocell	4	25·7	3·4	−15·8	16·2	282·0	12·7
	cotton	4	23·2	3·2	−18·4	18·6	279·8	16·8
	viscose	1	36·7	39·7	−7·6	40·4	349·2	12·1
	Lyocell	1	38·2	34·8	−5·9	35·3	350·5	8·8
	cotton	1	37·3	39·8	−6·9	40·4	350·1	11·2
	viscose	2	28·9	36·3	−5·2	36·7	351·7	20·4
CI Direct Red 83	Lyocell	2	31·2	31·9	−4·2	32·3	352·6	13·8
	cotton	2	30·2	35·8	−4·6	36·1	352·6	16·9
	viscose	4	22·3	30·6	−4·1	30·9	352·4	29·3
	Lyocell	4	25·9	28·4	−3·0	28·5	353·9	19·7
	cotton	4	24·4	29·6	−2·8	29·8	354·7	22·6
	viscose	1	52·1	49·1	20·1	53·1	22·2	6·1
	Lyocell	1	51·9	46·1	20·7	50·6	24·2	5·5
	cotton	1	52·8	49·6	21·2	53·9	23·2	5·9
	viscose	2	45·4	50·1	24·3	55·6	25·8	11·1
CI Direct Red 89	Lyocell	2	45·4	47·1	23·8	52·8	26·8	9·4
	cotton	2	46·8	50·5	25·1	56·3	26·4	9·9
	viscose	4	38·9	49·3	27·3	56·3	28·9	19·1
	Lyocell	4	39·9	45·9	25·4	52·5	29·0	14·1
	cotton	4	40·5	50·3	28·4	57·8	29·4	16·4
	viscose	1	75·1	23·7	78·6	82·1	73·2	10·1
	Lyocell	1	73·1	24·9	69·0	73·4	70·2	7·3
	cotton	1	75·7	24·7	75·9	79·9	72·1	8·5
	viscose	2	69·6	33·1	80·4	86·8	67·6	16·1
CI Direct Yellow 106	Lyocell	2	67·8	31·9	76·9	76·9	65·5	10·3
	cotton	2	71·5	32·4	79·4	85·7	67·8	12·8
	viscose	4	65·4	38·1	81·1	89·5	64·8	23·1
	Lyocell	4	63·5	38·5	68·8	78·8	60·8	14·8
	cotton	4	66·2	37·8	77·6	86·3	64·1	17·4

TABLE 3
Difference in Colour Strength ($\Delta K/S$) Between Dyeings

Dye	*Fibres*	*Dye applied (% omf)*		
		1	*2*	*4*
CI Direct Blue 85	V–L	−1·8	−1·5	6·2
	C–L	0·5	2·2	4·1
	V–C	−2·3	−3·7	2·1
CI Direct Red 83	V–L	3·3	6·6	9·6
	C–L	2·4	3·1	2·9
	V–C	0·9	3·5	6·7
CI Direct Red 89	V–L	0·6	1·7	5·0
	C–L	0·4	0·5	2·3
	V–C	0·2	1·2	2·7
CI Direct Yellow 106	V–L	2·8	5·8	8·3
	C–L	1·2	2·5	2·6
	V–C	1·6	3·3	5·7

C: cotton; V: viscose; L: Lyocell.

Table 2 demonstrates that the C^* values of the dyeings obtained for the four dyes on the three substrates did not follow this order. However, for each dye and at each concentration used, it is evident from Table 2 that the Lyocell dyeings were duller than their cotton and viscose counterparts; this particular finding reflects the lower chroma of the undyed Lyocell (Table 1). In terms of chromaticity (a^*, b^* and $h°$ values), the orders of these three colorimetric parameters obtained for the dyeings (Table 2), with some exceptions, did not follow the orders secured for the undyed fabrics (Table 1). Thus, in general, the colour of the dyeings obtained using the four direct dyes on the three types of fabric did not reflect the inherent colour of the undyed fabrics. Furthermore, the results displayed in Table 2 show that on Lyocell, the dyeings obtained using the blue dye were slightly redder, those secured using the red dye were yellower and those of the yellow dye were redder than the respective dyeings on cotton and viscose, whilst the bordeaux dyeings on Lyocell were of a similar hue to those of the dyeings obtained on the other two fabric types.

The K/S values in Table 2 demonstrate that, with the exception of the 1 and 2% omf dyeings of CI Direct Blue 85, the colour strengths of the dyeings on Lyocell were lower than those on cotton and viscose and, also, that the dyeings on viscose were of greater colour strength than those on cotton. These findings are further illustrated by the results in Table 3,

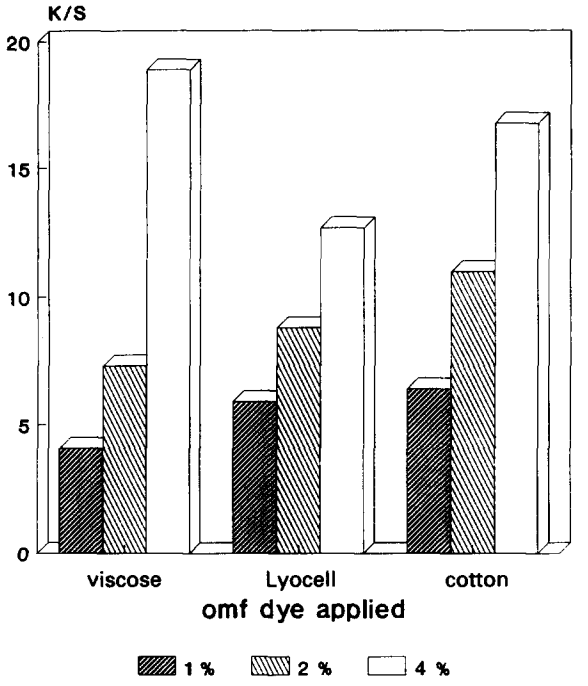


Fig. 3. Colour yield obtained for CI Direct Blue 85.

which also show that for each dye, the difference in colour strength ($\Delta K/S$) between dyeings on the pairs of different types of fibre increased with increasing concentration of dye applied. The findings shown in Table 3 imply that in terms of colour strength, Lyocell resembles cotton rather than viscose. The difference in colour strength obtained for the same dye on the different fibres is also demonstrated by the build-up profiles displayed in Figs. 3–6 which, in addition, show that the four dyes used exhibited slightly lower build-up character on Lyocell than on the other two substrates. Hence, in terms of colour strength (K/S), Lyocell exhibited lower dyeability than either cotton or viscose; this is clearly reflected in the results obtained for the competitive dyeings (Fig. 7), insofar as the colour strength of the dyeings on Lyocell was lower than that of the dyeings on the other two fibre types.

Table 4 shows the fastness to washing of 1/1 standard depth dyeings of the four dyes on each of the three types of fibre. In the cases of both the untreated and aftertreated dyeings, the wash fastness of the dyeings on Lyocell was comparable to that of identical depth dyeings on cotton and viscose. Table 4 also shows the marked improvement in wash fastness secured by aftertreatment with Solfix E, the extent of staining of adjacent fabrics having been reduced by between 1 and 3 points.

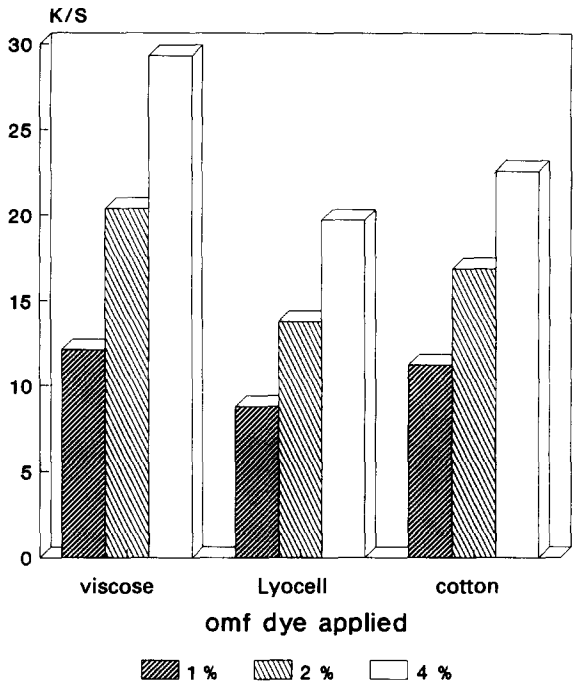


Fig. 4. Colour yield obtained for CI Direct Red 83.

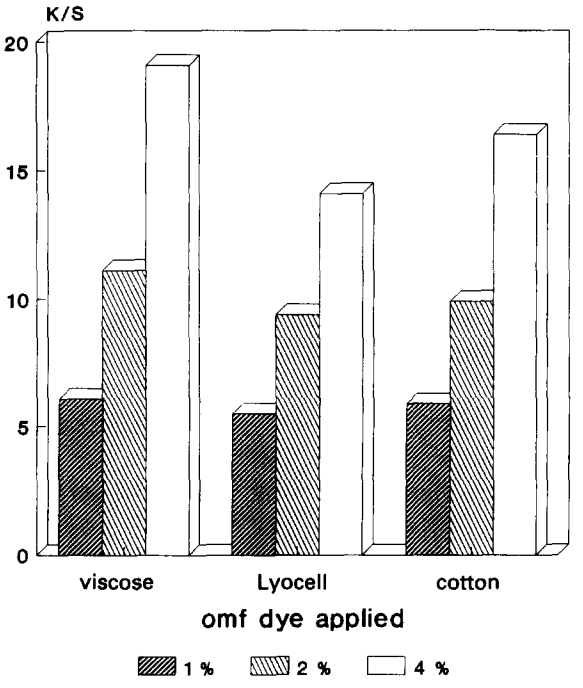


Fig. 5. Colour yield obtained for CI Direct Red 89.

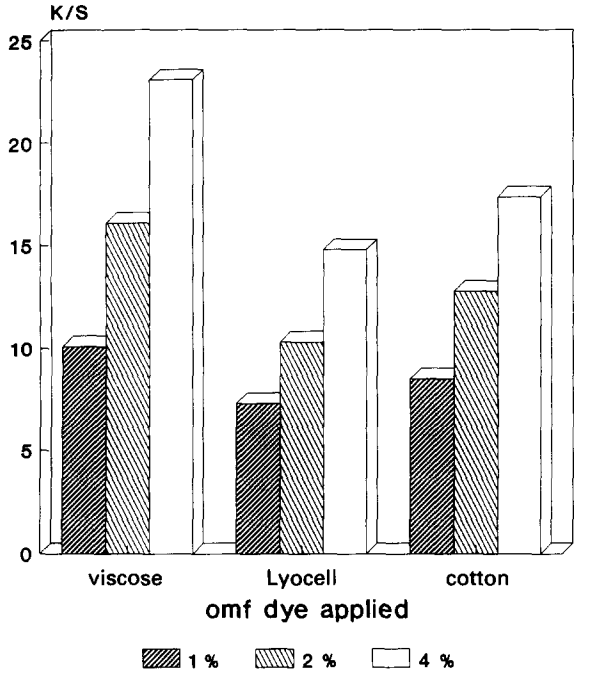


Fig. 6. Colour yield obtained for CI Direct Yellow 106.

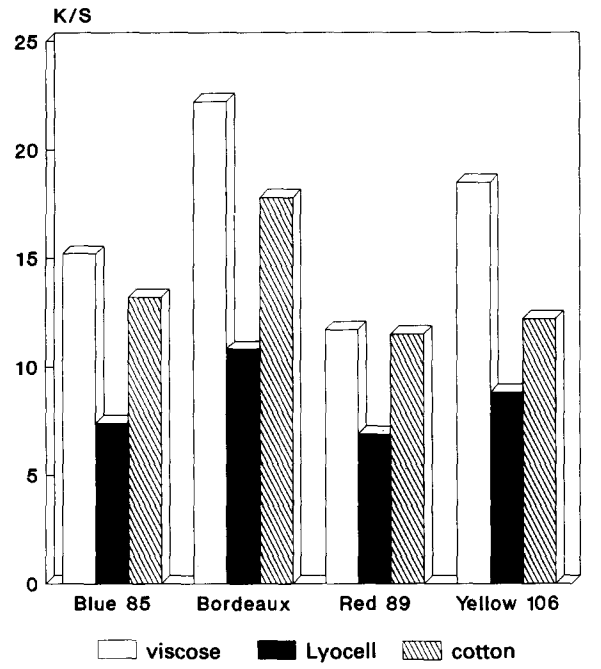


Fig. 7. Colour yield obtained for 2% omf competitive dyeings.

TABLE 4
Fastness of 1/1 Standard Depth Dyeings to the ISOC06/C2 Wash Test

Dye	*Fibre*	*Untreated*				*Aftertreated*			
		Ch	*C*	*V*	*L*	*Ch*	*C*	*V*	*L*
	viscose	4–5	1–2	2	—	4–5	4–5	4–5	—
CI Direct Blue 85	Lyocell	4–5	2	—	3	4–5	4	—	4–5
	cotton	4–5	2	—	—	4–5	3–4	4–5	—
	viscose	4–5	2	3–4	—	4–5	4–5	5	—
CI Direct Red 83	Lyocell	4–5	2	—	2–3	4–5	4–5	—	4–5
	cotton	4–5	2	3	—	4–5	4–5	5	—
	viscose	4–5	2	2–3	—	5	4–5	5	—
CI Direct Red 89	Lyocell	4–5	2	—	2–3	5	4–5	—	5
	cotton	4–5	2	3	—	5	4–5	5	—
	viscose	4–5	3	4	—	5	5	5	—
CI Direct Yellow 106	Lyocell	4–5	3	—	4	5	5	—	5
	cotton	4–5	3	4	—	5	5	5	—

Ch: change in shade of original sample; *C:* staining of cotton adjacent; *V:* staining of viscose adjacent; *L:* staining of Lyocell adjacent.

CONCLUSIONS

The colorimetric parameters of the dyeings of the four dyes employed on the three types of fibre did not generally reflect those of the undyed substrates; with the exception of the bordeaux dye used, dyeings on Lyocell were of slightly different colour than comparative dyeings on cotton and viscose. The colour strength of the dyeings on Lyocell was lower than on cotton and viscose, this being manifest in the four dyes exhibiting lower build-up character on Lyocell than on the other two fibres. The wash fastness of 1/1 standard depth dyeings on Lyocell was comparable to that of identical depth dyeings on cotton and viscose. The results obtained suggest that the dyeability of Lyocell with the four direct dyes more closely resembles that of cotton than regular viscose.

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