

Pretreatment of cotton to enhance its dyeability; Part 2. Direct dyes

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Abstract

Three commercial cationic fixing agents, namely Matexil FC-PN (ICI), Matexil FC-ER (ICI) and Solfix E (Ciba), originally marketed as aftertreating agents for direct dyes, were used as pretreatments for cotton modification. Pretreated cotton was dyed with four direct dyes and the effect of pretreatment on the colour strength as well as the wash and the light fastness of the dyeings were investigated. The dyeings were also aftertreated with the same agents used for the pretreatment, and their wash fastness properties were compared with those of the aftertreated standard dyeings. Pretreatment was found to increase the colour strength of the dyeings when dyeing had been carried out without electrolyte. However, when electrolyte was used, the pretreated samples exhibited generally lower colour strength than the standard dyeings. The wash fastness of the dyeings was almost unaffected by pretreatment while light fastness was slightly lowered. © 1999 Elsevier Science Ltd. All rights reserved.

Keywords: Cotton; Direct dyes; Pretreatment; Enhanced dyeability; Low salt dyeing

1. Introduction

The pretreatment of cotton with cationic agents to enhance its dyeability with anionic dyes, such as direct [1], reactive [2–8] and C.I. Solubilised Sulphur dyes [9] has attracted interest from many workers, especially in recent times. The reason behind such pretreatment is that the increased cationicity imparted to the cellulosic substrate reduces the inherent ion–ion repulsion that operates between the anionic dye and negatively charged groups (e.g. COO[−]) in the fibre, thus resulting in enhanced dye uptake. In addition, the enhanced cationicity of the pretreated substrate

can enable dyeing to be achieved using reduced amounts of electrolyte [1,8] or in the complete absence of electrolyte [3–7].

In the previous part of this paper [9], which examined the dyeability of cotton pretreated with cationic agents using C.I. Solubilised Sulphur dyes, it was found that pretreatment substantially increased the colour strength and also improved the wash fastness of the dyeings. This led to an examination of the dyeability of pretreated cotton with direct dyes, as they are one of the most popular of all dye classes used on cellulosic fibres [10,11], even though they possess generally poor wash fastness, because of their ease of application and low cost [12]. The present study was mainly directed at achieving high exhaustion of direct dyes on cotton in order to minimise some of the

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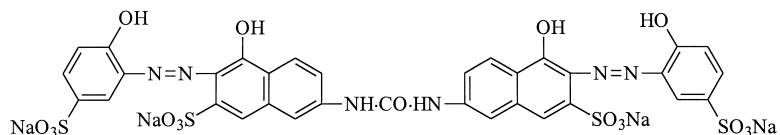
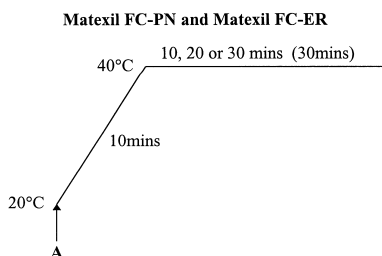
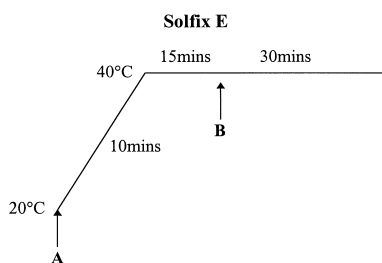


Fig. 1. Structure of CI Direct Red 83.



A 0.5, 1, 2 or 5% omf (4% omf) Matexil FC-PN or Matexil FC-ER



A 0.5, 1, 2 or 5% omf (6% omf) Solfix E
 B $2\text{cm}^3\text{ l}^{-1}$ 36°Be NaOH

Fig. 2. Application methods for cationic fixing agents. (Numbers in parenthesis refers to aftertreatment condition.)

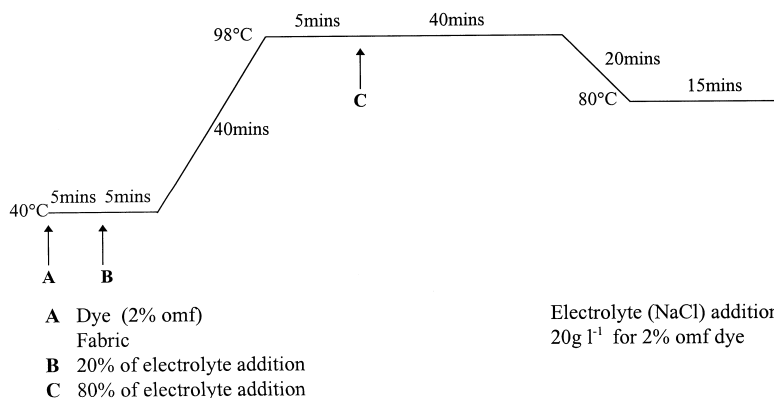


Fig. 3. Dyeing method.

environmental problems that the dyes pose during their application. Dyeing with the addition of a reduced amount of electrolyte or 'ideally' with no electrolyte was desired.

2. Experimental

2.1. Materials

2.1.1. Fabric

Scoured and bleached, fluorescent brightener-free woven cotton (156.5 g m^{-2}) was used.

2.1.2. Dyes

Four commercial direct dyes, namely Solophenyl Blue FGL (C.I. Direct Blue 85), Solophenyl Bordeaux 3BL (C.I. Direct Red 83), Solophenyl Scarlet BNL (C.I. Direct Red 89) and Solophenyl Yellow ARL (C.I. Direct Yellow 106), were used. They were generously provided by Ciba-Geigy and were not purified prior to use; only one of the dyes' structure is disclosed in the Colour Index (Fig. 1) [13]. Ciba divide their Solophenyl range of dyes into groups I

and II [14]; the four dyes were selected, arbitrarily, from group I.

2.1.3. Cationic fixing agents

Commercial samples of Matexil FC-PN and Matexil FC-ER were kindly supplied by ICI Surfactants; Solfix E was kindly provided by Ciba-Geigy.

All other reagents were of general purpose grade.

2.2. Procedures

2.2.1. Pretreatment

All pretreatment, using fabric samples (2.00 g) which had been wetted out in cold tap water, was

Table 1
Colorimetric data for dyeings pretreated using Matexil FC-PN (C.I. Direct Blue 85)

Pretreatment conditions (% omf)	K/S	L^*	a^*	b^*	C^*	h°
<i>Dyeing without salt</i>						
Untreated sample	3.28	49.13	-4.92	-21.38	21.94	257.04
FC-PN 0.5% 10 min	3.94	46.00	-3.63	-21.89	22.19	260.58
FC-PN 1.0% 10 min	4.24	44.65	-3.28	-21.51	21.76	261.33
FC-PN 2.0% 10 min	4.82	42.56	-2.70	-21.59	21.76	262.87
FC-PN 5.0% 10 min	5.07	41.52	-2.38	-21.15	21.28	263.58
FC-PN 0.5% 20 min	3.88	46.16	-3.70	-21.65	21.96	260.30
FC-PN 1.0% 20 min	4.23	44.62	-3.03	-21.72	21.93	262.06
FC-PN 2.0% 20 min	4.63	43.13	-2.75	-21.53	21.70	262.72
FC-PN 5.0% 20 min	5.32	40.83	-2.29	-21.18	21.30	263.83
FC-PN 0.5% 30 min	3.87	46.28	-3.82	-21.74	22.07	260.03
FC-PN 1.0% 30 min	4.43	43.97	-3.05	-21.72	21.93	262.01
FC-PN 2.0% 30 min	4.87	42.39	-2.70	-21.59	21.76	262.87
FC-PN 5.0% 30 min	5.21	41.17	-2.39	-21.18	21.31	263.56
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	17.88	23.41	0.26	-18.06	18.06	270.82
FC-PN 0.5% 10 min	16.26	24.57	0.10	-18.24	18.24	270.31
FC-PN 1.0% 10 min	16.04	24.46	0.37	-17.88	17.88	271.19
FC-PN 2.0% 10 min	16.24	24.21	0.68	-18.06	18.07	272.16
FC-PN 5.0% 10 min	15.12	25.31	0.41	-18.49	18.49	271.27
FC-PN 0.5% 20 min	16.33	24.22	0.50	-17.97	17.98	271.59
FC-PN 1.0% 20 min	16.53	23.94	0.73	-17.85	17.86	272.34
FC-PN 2.0% 20 min	16.02	24.45	0.50	-18.08	18.09	271.58
FC-PN 5.0% 20 min	15.42	24.88	0.48	-18.05	18.06	271.52
FC-PN 0.5% 30 min	16.86	24.06	0.10	-17.89	17.89	270.32
FC-PN 1.0% 30 min	16.29	24.17	0.64	-17.92	17.93	272.05
FC-PN 2.0% 30 min	16.35	24.32	2.78	-20.41	20.60	277.76
FC-PN 5.0% 30 min	16.59	24.09	0.45	-18.01	18.02	271.43
FC-PN 0.5% 10 min (5 g/litre salt)	14.00	26.96	2.05	-21.94	22.04	275.34
FC-PN 0.5% 10 min (10 g/litre salt)	15.33	25.64	2.28	-21.46	21.58	276.06
FC-PN 5.0% 30 min (5 g/litre salt)	14.19	26.57	1.66	-20.84	20.91	274.55
FC-PN 5.0% 30 min (10 g/litre salt)	15.28	25.32	2.69	-20.99	21.16	277.30

carried out in sealed, stainless steel dyeing tubes of 300 cm³ capacity housed in a Zeltex Polycolor laboratory-scale dyeing machine, using a 20:1 liquor ratio. The pretreatment methods employed to apply the cationic agents are shown in Fig. 2. At the end of pretreatment, the samples were removed from the treatment bath, rinsed in tap water and allowed to dry in the open air.

2.2.2. Dyeing

All dyeings were carried out, using fabric which had been wetted out in cold distilled water, in the same dyeing machine that was used for the pretreatment, using a 30:1 liquor ratio. The dyeing method employed is shown in Fig. 3. At the end of dyeing, the dyed sample was removed, rinsed thoroughly in cold tap water and allowed to dry in the open air.

Table 2

Colorimetric data for dyeings pretreated using Matexil FC-PN (C.I. Direct Red 83)

Pretreatment conditions (% omf)	K/S	L*	a*	b*	C*	h°
<i>Dyeing without salt</i>						
Untreated sample	4.81	48.30	37.50	-8.42	38.43	347.35
FC-PN 0.5% 10 minutes	5.15	46.67	36.63	-8.98	37.71	346.23
FC-PN 1.0% 10 min	5.39	46.50	37.53	-8.84	38.56	346.75
FC-PN 2.0% 10 min	5.53	45.29	36.03	-9.45	37.25	345.30
FC-PN 5.0% 10 min	5.56	44.57	34.75	-9.61	36.05	344.54
FC-PN 0.5% 20 min	5.10	47.20	37.30	-8.95	38.36	346.51
FC-PN 1.0% 20 min	5.48	45.82	36.83	-9.16	37.95	346.03
FC-PN 2.0% 20 min	5.71	44.68	35.76	-9.45	36.99	345.20
FC-PN 5.0% 20 min	5.87	43.75	34.73	-9.58	36.03	344.58
FC-PN 0.5% 30 min	5.40	46.43	37.45	-8.82	38.47	346.75
FC-PN 1.0% 30 min	5.52	45.69	36.82	-9.14	37.94	346.06
FC-PN 2.0% 30 min	6.03	44.07	36.24	-9.29	37.41	345.62
FC-PN 5.0% 30 minutes	5.95	43.55	34.75	-9.48	36.02	344.74
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	16.11	30.58	34.30	-3.23	34.45	354.62
FC-PN 0.5% 10 min	15.34	31.03	34.14	-4.24	34.40	352.92
FC-PN 1.0% 10 min	15.09	31.03	33.80	-4.39	34.08	352.60
FC-PN 2.0% 10 min	15.11	30.94	33.65	-4.58	33.96	352.25
FC-PN 5.0% 10 min	14.24	31.64	33.76	-4.96	34.12	351.64
FC-PN 0.5% 20 min	15.29	31.21	34.42	-4.23	34.68	352.99
FC-PN 1.0% 20 min	15.07	31.25	34.22	-4.39	34.50	352.69
FC-PN 2.0% 20 min	15.21	30.92	33.86	-4.51	34.16	352.41
FC-PN 5.0% 20 min	14.71	31.39	33.90	-4.93	34.26	351.73
FC-PN 0.5% 30 min	15.16	31.33	34.42	-4.24	34.68	352.98
FC-PN 1.0% 30 min	15.39	30.94	34.13	-4.22	34.39	352.95
FC-PN 2.0% 30 min	15.21	30.81	33.62	-4.15	33.88	352.96
FC-PN 5.0% 30 min	14.27	31.58	33.68	-4.91	34.04	351.71
FC-PN 0.5% 10 min (5 g/litre salt)	12.88	34.20	37.51	-7.72	38.30	348.37
FC-PN 0.5% 10 min (10 g/litre salt)	13.88	32.85	36.64	-7.23	37.35	348.84
FC-PN 5.0% 30 min (5 g/litre salt)	11.65	34.80	36.14	-8.78	37.19	346.34
FC-PN 5.0% 30 min (10 g/litre salt)	13.11	33.05	35.66	-7.89	36.52	347.52

2.2.3. Aftertreatment

Matexil FC-PN and Matexil FC-ER were applied at 4% omf for 30 min using the same method employed for the pretreatment, while Solfix E was applied at 6% omf using the respective method employed for the pretreatment (Fig. 2).

2.2.4. Colour measurement

The reflectance values of the dry, dyed samples were measured using a Colorgen reflectance spectrophotometer interfaced to a personal computer, under illuminant D₆₅ using 10° standard observer with specular component excluded and UV component included, from which the corresponding *K/S*

Table 3
Colorimetric data for dyeings pretreated using Matexil FC-PN (C.I. Direct Red 89)

Pretreatment conditions (% omf)	<i>K/S</i>	<i>L</i> [*]	<i>a</i> [*]	<i>b</i> [*]	<i>C</i> [*]	<i>h</i> [°]
<i>Dyeing without salt</i>						
Untreated sample	3.54	56.97	45.49	14.49	47.74	17.67
FC-PN 0.5% 10 min	4.76	53.23	45.82	16.91	48.84	20.26
FC-PN 1.0% 10 min	5.18	51.19	43.59	15.96	46.42	20.11
FC-PN 2.0% 10 min	5.47	50.76	44.92	17.02	48.04	20.75
FC-PN 5.0% 10 min	5.93	49.47	44.69	17.57	48.02	21.46
FC-PN 0.5% 20 min	4.80	53.15	45.71	17.02	48.78	20.42
FC-PN 1.0% 20 min	5.33	51.66	45.98	17.62	49.24	20.97
FC-PN 2.0% 20 min	5.73	50.34	45.55	17.88	48.93	21.43
FC-PN 5.0% 20 min	5.93	49.48	44.69	17.72	48.07	21.63
FC-PN 0.5% 30 min	4.83	53.15	45.82	16.84	48.82	20.18
FC-PN 1.0% 30 min	5.14	51.94	45.54	17.26	48.70	20.76
FC-PN 2.0% 30 min	5.65	50.39	45.08	17.71	48.43	21.45
FC-PN 5.0% 30 min	6.26	48.99	45.12	18.09	48.61	21.85
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	15.76	40.23	49.61	25.33	55.70	27.05
FC-PN 0.5% 10 min	14.40	40.52	47.70	23.97	53.38	26.68
FC-PN 1.0% 10 min	14.36	39.38	44.98	22.20	50.16	26.27
FC-PN 2.0% 10 min	14.45	40.20	47.25	23.69	52.86	26.63
FC-PN 5.0% 10 min	13.73	40.93	47.78	23.89	53.42	26.57
FC-PN 0.5% 20 min	14.03	40.87	47.98	23.91	53.61	26.49
FC-PN 1.0% 20 min	14.14	40.79	48.33	24.21	54.05	26.61
FC-PN 2.0% 20 min	14.10	40.81	48.26	24.29	54.03	26.72
FC-PN 5.0% 20 min	14.01	40.50	47.53	23.75	53.13	26.55
FC-PN 0.5% 30 min	14.70	40.25	47.45	24.03	53.19	26.86
FC-PN 1.0% 30 min	14.26	40.62	48.00	24.15	53.73	26.71
FC-PN 2.0% 30 min	14.33	40.46	47.81	24.13	53.55	26.78
FC-PN 5.0% 30 min	14.07	40.59	47.63	23.81	53.25	26.56
FC-PN 0.5% 10 min (5 g/litre salt)	12.00	43.16	50.32	20.46	54.32	22.13
FC-PN 0.5% 10 min (10 g/litre salt)	14.17	41.34	50.39	21.67	54.85	23.27
FC-PN 5.0% 30 min (5 g/litre salt)	12.50	41.93	49.06	20.00	52.98	22.18
FC-PN 5.0% 30 min (10 g/litre salt)	13.53	41.06	49.06	20.25	53.07	22.43

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 to realise a total of four thicknesses of fabric.

2.2.5. Determination of wash fastness

The fastness of the dry, dyed samples to the ISO CO6/C2 wash test was determined using the standard method [15].

3. Results and discussion

3.1. Pretreatment with Matexil FC-PN

Table 1 shows the colour strength values and colorimetric parameters of dyeings which had been pretreated with Matexil FC-PN and dyed using C.I. Direct Blue 85, together with the corresponding values recorded for the untreated fabric. It is

Table 4
Colorimetric data for dyeings pretreated using Matexil FC-PN (C.I. Direct Yellow 106)

Pretreatment conditions (% omf)	K/S	L^*	a^*	b^*	C^*	h°
<i>Dyeing without salt</i>						
Untreated sample	2.25	82.42	11.09	55.93	57.02	78.78
FC-PN 0.5% 10 min	3.23	79.47	11.56	59.63	60.74	79.03
FC-PN 1.0% 10 min	3.84	80.22	16.29	65.07	67.08	75.95
FC-PN 2.0% 10 minutes	4.32	78.59	18.28	65.18	67.69	74.33
FC-PN 5.0% 10 min	4.65	78.07	19.55	65.73	68.58	73.44
FC-PN 0.5% 20 min	3.13	80.95	14.87	61.43	63.20	76.39
FC-PN 1.0% 20 min	3.90	80.14	16.63	65.35	67.43	75.72
FC-PN 2.0% 20 min	4.34	78.57	18.37	65.33	67.86	74.29
FC-PN 5.0% 20 min	4.79	77.76	19.28	66.06	68.82	73.73
FC-PN 0.5% 30 min	3.32	79.92	16.55	61.14	63.34	74.85
FC-PN 1.0% 30 min	3.96	79.90	16.73	65.26	67.37	75.62
FC-PN 2.0% 30 min	4.43	79.06	18.53	66.47	69.00	74.42
FC-PN 5.0% 30 min	5.08	77.82	20.05	67.36	70.28	73.42
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	14.26	69.34	35.74	79.15	86.85	65.70
FC-PN 0.5% 10 min	14.04	67.87	30.44	76.15	82.01	68.21
FC-PN 1.0% 10 min	14.54	69.53	35.45	79.72	87.25	66.03
FC-PN 2.0% 10 min	14.74	69.05	35.49	79.15	86.74	65.85
FC-PN 5.0% 10 min	14.54	69.69	35.15	79.94	87.33	66.26
FC-PN 0.5% 20 min	13.91	69.45	35.39	78.74	86.33	65.80
FC-PN 1.0% 20 min	14.41	69.82	35.26	80.02	87.44	66.22
FC-PN 2.0% 20 min	14.39	69.82	35.51	80.00	87.53	66.06
FC-PN 5.0% 20 min	14.18	69.70	34.78	79.42	86.70	66.35
FC-PN 0.5% 30 min	14.09	69.18	35.27	78.49	86.05	65.80
FC-PN 1.0% 30 min	14.44	69.48	35.02	79.42	86.80	66.21
FC-PN 2.0% 30 min	13.88	70.25	34.14	79.84	86.83	66.85
FC-PN 5.0% 30 min	14.59	69.34	35.10	79.47	86.88	66.17
FC-PN 0.5% 10 min (5 g/litre salt)	10.92	73.21	29.22	75.50	80.96	68.84
FC-PN 0.5% 10 min (10 g/litre salt)	12.95	71.67	32.81	76.51	83.25	66.79
FC-PN 5.0% 30 min (5 g/litre salt)	11.64	71.36	29.55	73.53	79.25	68.11
FC-PN 5.0% 30 min (10 g/litre salt)	12.55	71.69	31.44	74.83	81.17	67.21

evident that the colour strength of the pretreated samples was enhanced when dyeing had been carried out in the absence of electrolyte and, also, it is apparent that the higher the concentration of the cationic agent used, the larger was this enhancement. However, the colour strength of pretreated samples which had been dyed in the presence of

electrolyte was lower than that of the corresponding untreated sample; the pretreatment with 5% omf Matexil FC-PN imparted the largest reduction in colour strength. The observed reduction in K/S probably arose because the cationic agent formed a layer around the fibre which restrained dye adsorption. The results in Table 1 also imply

Table 5
Colorimetric data for dyeings pretreated using Matexil FC-ER (C.I. Direct Blue 85)

Pretreatment conditions (% omf)	K/S	L^*	a^*	b^*	C^*	h°
<i>Dyeing without salt</i>						
Untreated sample	3.28	49.13	-4.92	-21.38	21.94	257.04
FC-ER 0.5% 10 min	11.05	28.30	4.73	-20.22	20.77	283.17
FC-ER 1.0% 10 min	11.44	27.70	4.82	-19.22	19.82	284.08
FC-ER 2.0% 10 min	11.00	28.22	4.42	-19.08	19.59	283.04
FC-ER 5.0% 10 min	10.41	29.23	3.85	-19.36	19.74	281.25
FC-ER 0.5% 20 min	11.03	28.47	4.71	-20.64	21.17	282.85
FC-ER 1.0% 20 min	11.10	28.08	4.51	-19.08	19.61	283.30
FC-ER 2.0% 20 min	10.56	28.96	3.97	-19.34	19.74	281.60
FC-ER 5.0% 20 min	10.49	29.24	3.61	-19.54	19.87	280.47
FC-ER 0.5% 30 min	11.06	28.32	4.81	-20.45	21.01	283.24
FC-ER 1.0% 30 min	10.88	28.27	4.48	-18.91	19.43	283.33
FC-ER 2.0% 30 min	10.60	28.79	4.01	-19.10	19.52	281.86
FC-ER 5.0% 30 min	10.46	29.16	3.77	-19.21	19.58	281.10
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	17.88	23.41	0.26	-18.06	18.06	270.82
FC-ER 0.5% 10 min	17.02	21.32	4.92	-13.85	14.70	289.56
FC-ER 1.0% 10 min	16.54	21.84	4.96	-14.55	15.37	288.82
FC-ER 2.0% 10 min	15.59	22.77	4.86	-15.44	16.19	287.47
FC-ER 5.0% 10 min	14.70	23.83	4.78	-16.66	17.33	286.01
FC-ER 0.5% 20 min	17.05	21.24	5.03	-13.62	14.52	290.27
FC-ER 1.0% 20 min	15.45	22.75	5.09	-15.13	15.96	288.59
FC-ER 2.0% 20 min	14.61	23.73	4.74	-16.70	17.36	285.85
FC-ER 5.0% 20 min	14.44	23.99	4.69	-16.49	17.14	285.88
FC-ER 0.5% 30 min	16.64	21.59	4.91	-14.00	14.84	289.33
FC-ER 1.0% 30 min	15.85	22.43	5.20	-14.93	15.81	289.20
FC-ER 2.0% 30 min	15.12	23.32	4.96	-16.12	16.87	287.10
FC-ER 5.0% 30 min	15.41	23.16	4.98	-16.26	17.01	287.03
FC-ER 1.0% 10 min (5 g/litre salt)	15.63	22.96	4.81	-16.18	16.88	286.56
FC-ER 1.0% 10 min (10 g/litre salt)	16.27	22.20	4.91	-15.20	15.97	287.90
FC-ER 1.0% 10 min (15 g/litre salt)	16.30	22.26	6.52	-16.87	18.09	291.13

that the duration of the pretreatment had very little effect on the results. It is evident that the pretreated samples were of similar colour to that of the corresponding untreated dyeings.

The K/S values and colorimetric parameters of the dyeings which had been pretreated with Matexil FC-PN and dyed using C.I. Direct Red 83, C.I. Direct Red 89 and C.I. Direct Yellow 106

Table 6
Colorimetric data for dyeings pretreated using Matexil FC-ER (C.I. Direct Red 83)

Pretreatment conditions (% omf)	K/S	L^*	a^*	b^*	C^*	h°
<i>Dyeing without salt</i>						
Untreated sample	4.81	48.30	37.50	-8.42	38.43	347.35
FC-ER 0.5% 10 min	10.73	35.50	34.92	-6.08	35.45	350.12
FC-ER 1.0% 10 min	10.45	35.33	33.60	-7.14	34.35	348.00
FC-ER 2.0% 10 min	9.98	35.56	32.68	-7.22	33.47	347.54
FC-ER 5.0% 10 min	9.79	35.73	32.39	-7.52	33.25	346.93
FC-ER 0.5% 20 min	10.75	35.27	34.50	-6.14	35.04	349.91
FC-ER 1.0% 20 min	10.59	34.86	33.02	-6.86	33.73	348.26
FC-ER 2.0% 20 min	10.10	35.13	23.05	-7.18	24.14	342.70
FC-ER 5.0% 20 min	10.70	34.45	32.09	-7.42	32.94	346.98
FC-ER 0.5% 30 min	10.85	35.13	34.43	-6.33	35.01	349.58
FC-ER 1.0% 30 min	10.64	34.75	32.90	-6.90	33.62	348.16
FC-ER 2.0% 30 min	10.51	34.78	32.45	-7.30	33.26	347.32
FC-ER 5.0% 30 min	10.63	34.52	32.18	-7.29	33.00	347.24
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	16.11	30.58	34.30	-3.23	34.45	354.62
FC-ER 0.5% 10 min	16.74	28.99	31.77	-1.48	31.80	357.33
FC-ER 1.0% 10 min	15.53	29.99	32.25	-2.40	32.34	355.74
FC-ER 2.0% 10 min	14.75	30.66	32.52	-2.98	32.66	354.76
FC-ER 5.0% 10 min	14.68	30.68	32.47	-3.26	32.63	354.27
FC-ER 0.5% 2 min	16.27	29.45	32.16	-1.71	32.21	356.96
FC-ER 1.0% 20 min	15.21	30.35	32.57	-2.74	32.69	355.19
FC-ER 2.0% 20 min	14.63	30.74	32.43	-3.22	32.59	354.33
FC-ER 5.0% 20 min	14.53	30.70	32.17	-3.27	32.34	354.20
FC-ER 0.5% 30 min	16.82	29.06	32.00	-1.57	32.04	357.19
FC-ER 1.0% 30 min	15.64	29.82	31.90	-2.20	31.98	356.05
FC-ER 2.0% 30 min	14.41	30.91	32.48	-3.14	32.63	354.48
FC-ER 5.0% 30 min	14.53	30.69	32.29	-3.25	32.45	354.25
FC-ER 0.5% 10 min (5 g/litre salt)	16.18	29.82	33.60	-3.55	33.79	353.97
FC-ER 0.5% 10 min (10 g/litre salt)	16.20	29.92	33.78	-3.21	33.93	354.57
FC-ER 0.5% 20 min (5 g/litre salt)	15.63	30.22	32.99	-2.25	33.07	356.10
FC-ER 0.5% 20 min (10 g/litre salt)	16.38	29.66	33.47	-3.06	33.61	354.78
FC-ER 0.5% 30 min (5 g/litre salt)	15.79	30.09	32.92	-2.10	32.99	356.35
FC-ER 0.5% 30 min (10 g/litre salt)	16.53	29.51	33.31	-2.90	33.44	355.02

are displayed in Tables 2–4, respectively. The results obtained followed the same pattern as those obtained for C.I. Direct Blue 85 (Table 1) and also show that pretreatment imparted no change in hue of dyeings obtained using C.I. Direct Red 83, whereas the pretreated dyeings of C.I. Direct Red 89 were slightly yellower and

those of the C.I. Direct Yellow 106 were slightly redder than the respective untreated dyeings.

3.2. Pretreatment with Matexil FC-ER

The colour strength and colorimetric parameters of dyeings which had been pretreated using

Table 7
Colorimetric data for dyeings pretreated using Matexil FC-ER (C.I. Direct Red 89)

Pretreatment conditions (% omf)	K/S	L^*	a^*	b^*	C^*	h°
<i>Dyeing without salt</i>						
Untreated sample	3.54	56.97	45.49	14.49	47.74	17.67
FC-ER 0.5% 10 min	7.60	47.43	46.99	20.53	51.28	23.60
FC-ER 1.0% 10 min	7.60	47.19	46.40	20.48	50.72	23.82
FC-ER 2.0% 10 min	7.75	46.47	45.67	19.86	49.80	23.50
FC-ER 5.0% 10 min	7.13	47.18	44.91	19.32	48.89	23.28
FC-ER 0.5% 20 min	7.68	47.21	46.71	20.82	51.14	24.02
FC-ER 1.0% 20 min	7.53	46.89	45.67	20.07	49.89	23.72
FC-ER 2.0% 20 min	7.16	47.21	45.10	19.41	49.10	23.29
FC-ER 5.0% 20 min	7.32	47.01	45.20	19.52	49.23	23.36
FC-ER 0.5% 30 min	7.60	47.44	46.97	20.84	51.39	23.93
FC-ER 1.0% 30 min	7.60	46.66	45.55	19.75	49.65	23.44
FC-ER 2.0% 30 min	7.25	47.10	45.15	19.43	49.15	23.28
FC-ER 5.0% 30 min	7.31	47.01	45.29	19.45	49.29	23.24
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	15.76	40.23	49.61	25.33	55.70	27.05
FC-ER 0.5% 10 min	15.17	40.26	48.76	25.84	55.18	27.92
FC-ER 1.0% 10 min	13.59	41.18	48.22	24.35	54.02	26.79
FC-ER 2.0% 10 min	13.53	41.12	48.00	24.26	53.78	26.81
FC-ER 5.0% 10 min	13.85	40.99	48.24	24.31	54.02	26.75
FC-ER 0.5% 20 min	14.70	40.72	49.09	25.62	55.37	27.56
FC-ER 1.0% 20 min	13.86	40.89	47.97	24.41	53.82	26.97
FC-ER 2.0% 20 min	13.73	41.11	48.28	24.42	54.10	26.83
FC-ER 5.0% 20 min	13.48	41.09	47.98	24.12	53.70	26.69
FC-ER 0.5% 30 min	14.76	40.41	48.25	25.57	54.61	27.92
FC-ER 1.0% 30 min	14.01	40.70	47.96	24.55	53.88	27.11
FC-ER 2.0% 30 min	13.26	41.26	47.87	24.10	53.59	26.72
FC-ER 5.0% 30 min	14.13	40.71	48.07	24.76	54.07	27.25
FC-ER 0.5% 20 min (5 g/litre salt)	13.66	41.45	48.99	24.98	54.99	27.02
FC-ER 0.5% 20 min (10 g/litre salt)	14.48	40.46	48.35	22.99	53.54	25.43
FC-ER 2.0% 10 min (5 g/litre salt)	12.67	41.89	48.21	23.76	53.75	26.24
FC-ER 2.0% 10 min (10 g/litre salt)	13.49	41.13	48.25	22.37	53.18	24.87

Matexil FC-ER and dyed using C.I. Direct Blue 85, C.I. Direct Red 83, C.I. Direct Red 89 and C.I. Direct Yellow 106, are shown in Tables 5–8, respectively.

The results in Table 5 demonstrate that pretreatment enhanced considerably the colour strength of the dyeings secured in the absence of electrolyte. Pretreatment time was not an important factor and

the optimum concentration for the application of Matexil FC-ER in terms of enhanced colour strength was between 0.5 and 1% omf. However, when electrolyte was used in dyeing the *K/S* values of the pretreated samples were lower than that of the corresponding untreated sample; and, also, the highest concentration at which the cationic agent was used gave the lowest colour strength. The

Table 8
Colorimetric data for dyeings pretreated using Matexil FC-ER (C.I. Direct Yellow 106)

Pretreatment conditions (% omf)	<i>K/S</i>	<i>L</i> *	<i>a</i> *	<i>b</i> *	<i>C</i> *	<i>h</i> °
<i>Dyeing without salt</i>						
Untreated sample	2.25	82.42	11.09	55.93	57.02	78.78
FC-ER 0.5% 10 min	6.00	75.41	22.43	68.05	71.65	71.76
FC-ER 1.0% 10 min	5.96	74.49	23.44	66.42	70.43	70.56
FC-ER 2.0% 10 min	5.68	74.29	23.40	64.95	69.04	70.19
FC-ER 5.0% 10 min	5.69	74.45	23.14	65.19	69.18	70.46
FC-ER 0.5% 20 min	5.80	74.98	22.91	66.51	70.35	70.99
FC-ER 1.0% 20 min	5.89	73.79	23.56	65.04	69.18	70.09
FC-ER 2.0% 20 min	5.76	74.68	23.85	65.92	70.10	70.11
FC-ER 5.0% 20 min	5.68	73.71	22.58	63.88	67.75	70.53
FC-ER 0.5% 30 min	5.92	73.73	22.64	64.94	68.77	70.78
FC-ER 1.0% 30 min	6.00	74.37	24.24	66.45	70.73	69.96
FC-ER 2.0% 30 min	5.62	74.91	23.43	65.68	69.73	70.37
FC-ER 5.0% 30 min	6.06	73.76	22.93	65.43	69.33	70.69
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	14.26	69.34	35.74	79.15	86.85	65.70
FC-ER 0.5% 10 min	16.27	68.21	34.37	79.38	86.50	66.59
FC-ER 1.0% 10 min	15.84	68.43	34.13	79.19	86.23	66.68
FC-ER 2.0% 10 min	14.54	68.69	33.59	77.98	84.91	66.70
FC-ER 5.0% 10 min	14.38	68.68	33.50	77.76	84.67	66.69
FC-ER 0.5% 20 min	15.29	68.29	33.44	78.29	85.13	66.87
FC-ER 1.0% 20 min	14.58	68.13	32.16	77.05	83.49	67.34
FC-ER 2.0% 20 min	14.73	69.13	33.88	78.88	85.85	66.76
FC-ER 5.0% 20 min	15.17	67.98	32.20	77.55	83.97	67.45
FC-ER 0.5% 30 min	16.42	66.60	32.54	76.86	83.46	67.05
FC-ER 1.0% 30 min	15.26	68.47	33.86	78.56	85.55	66.68
FC-ER 2.0% 30 min	14.73	69.10	33.98	78.81	85.82	66.68
FC-ER 5.0% 30 min	15.58	68.23	33.73	78.46	85.40	66.74
FC-ER 0.5% 10 min (5 g/litre salt)	12.82	70.87	33.23	78.76	85.48	67.12
FC-ER 0.5% 10 min (10 g/litre salt)	14.40	69.78	35.46	77.26	85.01	65.35
FC-ER 5.0% 30 min (5 g/litre salt)	13.01	68.09	34.69	74.40	82.09	65.00
FC-ER 5.0% 30 min (10 g/litre salt)	14.78	68.14	32.79	74.93	81.79	66.37

Table 9
Colorimetric data for dyeings pretreated using Solfix E (C.I. Direct Blue 85)

Pretreatment conditions (% omf)	K/S	L^*	a^*	b^*	C^*	h°
<i>Dyeing without salt</i>						
Untreated sample	3.28	49.13	−4.92	−21.38	21.94	257.04
SOLFIX E 0.5%	6.07	39.47	−1.28	−23.29	23.33	266.85
SOLFIX E 1.0%	7.39	36.06	−0.23	−22.48	22.48	269.41
SOLFIX E 2.0%	9.98	31.02	1.69	−21.59	21.66	274.48
SOLFIX E 5.0%	11.89	27.97	3.30	−20.50	20.76	279.14
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	17.88	23.41	0.26	−18.06	18.06	270.82
SOLFIX E 0.5%	16.85	23.48	3.79	−20.02	20.38	280.72
SOLFIX E 1.0%	16.30	23.89	3.70	−20.04	20.38	280.46
SOLFIX E 2.0%	16.82	23.18	4.33	−19.55	20.02	282.49
SOLFIX E 5.0%	16.56	23.22	4.63	−19.23	19.78	283.54
SOLFIX E 0.5% (5 g/litre salt)	14.11	26.68	2.42	−21.90	22.03	276.31
SOLFIX E 0.5% (10 g/litre salt)	15.36	25.09	3.14	−21.04	21.27	278.49
SOLFIX E 5.0% (5 g/litre salt)	15.02	25.62	2.84	−21.45	21.64	277.54
SOLFIX E 5.0% (10 g/litre salt)	15.73	24.46	3.60	−20.30	20.62	280.06

Table 10
Colorimetric data for dyeings pretreated using Solfix E (C.I. Direct Red 83)

Pretreatment conditions (% omf)	K/S	L^*	a^*	b^*	C^*	h°
<i>Dyeing without salt</i>						
Untreated sample	4.81	48.30	37.50	−8.42	38.43	347.35
SOLFIX E 0.5%	7.53	41.95	38.77	−9.23	39.85	346.61
SOLFIX E 1.0%	8.50	39.81	37.92	−9.16	39.01	346.42
SOLFIX E 2.0%	9.33	38.06	36.89	−9.20	38.02	346.00
SOLFIX E 5.0%	10.52	35.98	35.82	−8.88	36.90	346.08
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	16.11	30.58	34.30	−3.23	34.45	354.62
SOLFIX E 0.5%	15.67	31.11	35.99	−6.05	36.49	350.46
SOLFIX E 1.0%	15.67	31.23	36.17	−6.33	36.72	350.07
SOLFIX E 2.0%	15.12	31.42	35.84	−6.55	36.43	349.64
SOLFIX E 5.0%	14.48	31.99	35.84	−6.82	36.48	349.23
SOLFIX E 0.5% (5 g/litre salt)	14.35	32.12	35.84	−7.40	36.60	348.33
SOLFIX E 0.5% (10 g/litre salt)	14.99	31.66	36.01	−7.17	36.72	348.74
SOLFIX E 5.0% (5 g/litre salt)	14.14	32.41	36.20	−7.26	36.92	348.66
SOLFIX E 5.0% (10 g/litre salt)	14.08	32.23	35.68	−7.41	36.44	348.27

Table 11
Colorimetric data for dyeings pretreated using Solfix E (C.I. Direct Red 89)

Pretreatment conditions (% omf)	K/S	L^*	a^*	b^*	C^*	h°
<i>Dyeing without salt</i>						
Untreated sample	3.54	56.97	45.49	14.49	47.74	17.67
SOLFIX E 0.5%	6.41	50.25	48.03	17.81	51.23	20.35
SOLFIX E 1.0%	7.25	48.56	48.10	17.96	51.34	20.48
SOLFIX E 2.0%	9.43	44.97	47.09	19.67	51.03	22.67
SOLFIX E 5.0%	10.50	43.34	46.18	19.79	50.24	23.20
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	15.76	40.23	49.61	25.33	55.70	27.05
SOLFIX E 0.5%	14.90	40.71	49.76	21.94	54.38	23.79
SOLFIX E 1.0%	4.89	40.51	49.38	21.68	53.93	23.70
SOLFIX E 2.0%	14.74	40.26	48.47	21.72	53.11	24.14
SOLFIX E 5.0%	11.93	42.25	47.04	20.47	51.30	23.52
SOLFIX E 0.5% (5 g/litre salt)	12.93	42.54	50.18	21.58	54.62	23.27
SOLFIX E 0.5% (10 g/litre salt)	14.24	41.25	49.94	21.89	54.53	23.67
SOLFIX E 5.0% (5 g/litre salt)	13.71	41.98	50.41	22.33	55.13	23.89
SOLFIX E 5.0% (10 g/litre salt)	13.62	40.66	47.60	20.20	51.71	22.99

Table 12
Colorimetric data for dyeings pretreated using Solfix E (C.I. Direct Yellow 106)

Pretreatment conditions (% omf)	K/S	L^*	a^*	b^*	C^*	h°
<i>Dyeing without salt</i>						
Untreated sample	2.25	82.42	11.09	55.93	57.02	78.78
SOLFIX E 0.5%	4.68	79.02	18.29	64.98	67.50	74.28
SOLFIX E 1.0%	5.82	77.40	21.26	67.02	70.31	72.40
SOLFIX E 2.0%	7.24	75.31	24.45	67.91	72.18	70.20
SOLFIX E 5.0%	8.82	73.69	27.14	69.05	74.19	68.54
<i>Dyeing with salt (20 g/litre)</i>						
Untreated sample	14.26	69.34	35.74	79.15	86.85	65.70
SOLFIX E 0.5%	14.79	70.05	35.06	76.36	84.02	65.34
SOLFIX E 1.0%	15.86	69.66	35.38	76.67	84.44	65.23
SOLFIX E 2.0%	16.54	69.05	35.82	76.09	84.10	64.79
SOLFIX E 5.0%	16.34	69.34	35.55	76.10	83.99	64.96
SOLFIX E 0.5% (5 g/litre salt)	12.65	72.62	31.35	76.90	83.04	67.82
SOLFIX E 0.5% (10 g/litre salt)	13.92	71.32	32.92	76.99	83.73	66.85
SOLFIX E 5.0% (5 g/litre salt)	15.37	69.65	33.26	79.56	86.23	67.31
SOLFIX E 5.0% (10 g/litre salt)	15.98	69.82	34.34	80.69	87.69	66.95

Table 13
Wash fastness results (ISO CO6/C2) for C.I. Direct Blue 85

Pretreatment conditions (% omf)	Without aftertreatment				Without aftertreatment		
	K/S	Ch ^a	C ^b	V ^c	Ch	C	V
<i>Matexil FC-PN</i>							
Untreated (with salt)	17.88	2–3	1	1–2	3	2	2
FC-PN 5% 10 min	5.07	2–3	1–2	2	3–4	2	2–3
FC-PN 5% 20 min	5.32	2–3	2	2–3	3–4	2–3	3
FC-PN 5% 30 min	5.21	2–3	1–2	2–3	3–4	2	2–3
<i>Matexil FC-ER</i>							
Untreated (with salt)	17.88	2–3	1	1–2	3–4	2	3–4
FC-ER 0.5% 10 min	11.05	2–3	1–2	2–3	3	2–3	3–4
FC-ER 0.5% 20 min	11.03	2–3	1–2	2–3	3	2–3	3–4
FC-ER 0.5% 30 min	11.06	2–3	1–2	2–3	2–3	2–3	3–4
<i>Solfix E</i>							
Untreated (with salt)	17.88	2–3	1	1–2	4	4–5	5
SOLFIX E 0.5%	6.07	2	1–2	2	4–5	5	5
SOLFIX E 1.0%	7.39	2–3	1	1–2	4–5	5	5
SOLFIX E 2.0%	9.98	3	1	1–2	5	5	5
SOLFIX E 5.0%	11.89	3–4	1	1–2	5	5	5

^a Ch, change in shade of original sample.

^b C, staining of cotton adjacent.

^c V, staining of viscose adjacent.

pretreated samples were much redder than the corresponding untreated samples.

Table 6 clearly demonstrates the effectiveness of pretreatment using Matexil FC-ER as far as dyeing using C.I. Direct Red 83 without electrolyte is concerned. However, in this case the colour strength of the untreated dyeing carried out in the presence of electrolyte could be achieved with only 5 g/l NaCl following pretreatment with 0.5% Matexil FC-ER. Moreover, the pretreated samples did not show any change in hue.

Table 7 shows that pretreatment enhanced the colour strength of the dyeings that had been carried out without electrolyte using C.I. Direct Red 89 and that the dyed samples were slightly yellower than the corresponding untreated ones. Furthermore, it is evident that pretreatment was not effective in the case of dyeing in the presence of electrolyte.

Table 8 reveals the effectiveness of Matexil FC-ER pretreatment in the case of C.I. Direct Yellow 106; colour strength was increased when dyeing was carried out in the absence of electrolyte and the pretreated samples appeared slightly redder than the corresponding untreated sample. When dyeing was carried out in the presence of NaCl the colour strength of the untreated sample could be achieved using only half the amount of electrolyte normally used.

3.3. Pretreatment with Solfix E

The results displayed in Tables 9–12 show the colorimetric data obtained for dyeings which had been carried out both with and without pretreatment with Solfix E using each of the four direct dyes. The pretreated samples exhibited enhanced

Table 14
Wash fastness results (ISO CO6/C2) for C.I. Direct Red 83

Pretreatment conditions (% omf)	Without aftertreatment			Without aftertreatment			
	K/S	Ch ^a	C ^b	V ^c	Ch	C	V
<i>Matexil FC-PN</i>							
Untreated (with salt)	16.11	2–3	1–2	2–3	3–4	3	4
FC-PN 5% 10 min	5.56	3	2	2–3	3–4	3	4
FC-PN 5% 20 min	5.87	2	1–2	2–3	3–4	3–4	4
FC-PN 5% 30 min	5.95	2	1–2	2–3	3–4	3–4	4
<i>Matexil FC-ER</i>							
Untreated (with salt)	16.11	2–3	1–2	2–3	3–4	2–3	3–4
FC-ER 0.5% 10 min	10.73	2	1–2	2	2–3	2	2–3
FC-ER 0.5% 20 min	10.75	2	1–2	2	2–3	2–3	3
FC-ER 0.5% 30 min	10.85	2–3	1–2	2	2–3	2–3	3
FC-ER 0.5% 10 min 20 g/litre salt	16.74	2	1–2	2–3	2–3	2	3
FC-ER 0.5% 20 min 20 g/litre salt	16.27	2–3	1–2	2–3	2–3	2	2–3
FC-ER 0.5% 30 min 20 g/litre salt	16.82	3	1–2	2–3	3	2	3
FC-ER 0.5% 10 min 5 g/litre salt	16.18	2–3	2	3	3	2–3	3
FC-ER 0.5% 10 min 10 g/litre salt	16.20	2–3	2	2–3	3	2	2–3
FC-ER 0.5% 20 min 5 g/litre salt	15.63	3	2	2–3	3–4	2–3	3–4
FC-ER 0.5% 20 min 10 g/litre salt	16.38	3–4	2	2–3	3–4	2	2–3
FC-ER 0.5% 30 min 5 g/litre salt	15.79	2–3	2–3	3	3	2–3	3
FC-ER 0.5% 30 min 10 g/litre salt	16.53	3	2	3	3–4	2	3
<i>Solfix E</i>							
Untreated (with salt)	16.11	2–3	1–2	2–3	4–5	4	4–5
SOLFIX E 0.5%	7.53	2–3	1–2	2	5	5	5
SOLFIX E 1.0%	8.50	3	1–2	2	4–5	4	4–5
SOLFIX E 2.0%	9.33	3	1–2	2	4–5	4	4–5
SOLFIX E 5.0%	10.52	3–4	1–2	1–2	4–5	3–4	4

^a Ch, change in shade of original sample.

^b C, staining of cotton adjacent.

^c V, staining of viscose adjacent.

colour strength compared to their untreated counterparts; this enhancement increased with increasing amount of Solfix E used. However, when dyeing had been carried out in the presence of electrolyte, the pretreated samples generally exhibited lower colour strength than their untreated counterparts with the exception of samples dyed with C.I. Direct Yellow 106. The results displayed

in Tables 9–12 show that pretreated dyeings obtained using C.I. Direct Blue 85 were redder, those secured using C.I. Direct Red 89 were slightly yellower, and those furnished using C.I. Direct Yellow 106 were redder than the respective untreated dyeing, whilst the dyeings of C.I. Direct Red 83 were of a similar hue to the corresponding untreated one.

Table 15
Wash fastness results (ISO CO6/C2) for C.I. Direct Red 89

Pretreatment conditions (% omf)	Without aftertreatment			Without aftertreatment			
	K/S	Ch ^a	C ^b	V ^c	Ch	C	V
<i>Matexil FC-PN</i>							
Untreated (with salt)	15.76	3	1–2	2	3–4	2–3	3
FC-PN 5% 10 min	5.93	3–4	2	2–3	3–4	2–3	3
FC-PN 5% 20 min	5.93	3–4	2	2–3	3–4	2–3	3
FC-PN 5% 30 min	6.26	3–4	2	2–3	3–4	2–3	3
<i>Matexil FC-ER</i>							
Untreated (with salt)	15.76	3	1–2	2	3–4	2	2–3
FC-ER 0.5% 10 min	7.60	3	1–2	2	3	2	2–3
FC-ER 0.5% 20 min	7.68	2–3	1–2	2	2–3	2	2–3
FC-ER 0.5% 30 min	7.60	2–3	1–2	2	2–3	2	2–3
<i>Solfix E</i>							
Untreated (with salt)	15.76	3	1–2	2	4	4	4–5
SOLFIX E 0.5%	6.41	3–4	2	2–3	4–5	4–5	5
SOLFIX E 1.0%	7.25	3	2	2–3	3–4	4	4–5
SOLFIX E 2.0%	9.43	2–3	1–2	2	4	4	4–5
SOLFIX E 5.0%	10.50	3	1–2	2	4	3–4	4

^a Ch, change in shade of original sample.

^b C, staining of cotton adjacent.

^c V, staining of viscose adjacent.

A comparison of Tables 1–4, 5–8 and 9–12 shows that pretreatment with Matexil FC-ER and Solfix E imparted a greater enhancement in the colour strength of the dyeings than pretreatment with Matexil FC-PN. However, a higher concentration of Solfix E was required in order to achieve the same level of enhanced colour strength that was secured using a given concentration of Matexil FC-ER.

4. Wash fastness results

The wash fastness of both the pretreated and untreated dyeings was examined. As previously mentioned, aftertreatment was carried out using

the same cationic fixing agent used in the pretreatment. Wash fastness evaluation was carried out on samples that had the highest K/S values when dyeing had been carried out in the absence of electrolyte and those that had K/S values that were higher than that of the standard dyeing (20 g/litre salt), when dyed using a reduced amount of electrolyte. The wash fastness of the standard dyeing with electrolyte, as well as of the standard dyeing aftertreated with each of the three cationic dye-fixing agents used in the experiment, were also examined. However, the fastness results presented in Tables 13–16 are not comparable, in that although the same amount of each dye (2% omf) had been used, the colour strength of the dyeings differed owing to the pretreatments employed.

Table 16
Wash fastness results (ISO CO6/C2) for C.I. Direct Yellow 106

Pretreatment conditions (% omf)	Without aftertreatment				Without aftertreatment		
	K/S	Ch ^a	C ^b	V ^c	Ch	C	V
<i>Matexil FC-PN</i>							
Untreated (with salt)	14.26	2	1	1–2	3–4	2–3	3
FC-PN 5% 10 min	4.65	3	2	2–3	3	2–3	3
FC-PN 5% 20 min	4.79	2–3	2	2–3	3–4	2	3
FC-PN 5% 30 min	5.08	3	2	2–3	3–4	2–3	3
<i>Matexil FC-ER</i>							
Untreated (with salt)	14.26	2	1	1–2	3–4	2	3
FC-ER 0.5% 10 min	6.00	2–3	2	2–3	3–4	3	3–4
FC-ER 0.5% 20 min	5.80	2–3	2	2–3	3–4	2–3	3–4
FC-ER 0.5% 30 min	5.92	3	2	2–3	4	3	3–4
FC-ER 0.5% 10 min 5 g/litre salt	12.82	3–4	1–2	2	3–4	2	2–3
FC-ER 0.5% 10 min 10 g/litre salt	14.40	2–3	1	1–2	3	1–2	2–3
FC-ER 5.0% 30 min 5 g/litre salt	13.01	3	1–2	2	3–4	1–2	2–3
FC-ER 5.0% 30 min 10 g/litre salt	14.78	2–3	1	1–2	3	1–2	2–3
<i>Solfix E</i>							
Untreated (with salt)	14.26	2	1	1–2	5	4–5	5
SOLFIX E 0.5%	4.68	3	2–3	3	4–5	5	5
SOLFIX E 1.0%	5.82	2–3	2	2–3	4–5	5	5
SOLFIX E 2.0%	7.24	3–4	2	2–3	4–5	4–5	5
SOLFIX E 5.0%	8.82	3	2	2–3	4–5	4–5	4–5
SOLFIX E 0.5% 5 g/litre salt	12.65	2	1–2	2	4–5	5	5
SOLFIX E 0.5% 10 g/litre salt	13.92	2–3	1–2	2	4–5	4–5	5
SOLFIX E 5.0% 5 g/litre salt	15.37	3	2	2–3	4	4	4–5
SOLFIX E 5.0% 10 g/litre salt	15.98	3	2	2–3	4	4	4–5

^a Ch, change in shade of original sample.

^b C, staining of cotton adjacent.

^c V, staining of viscose adjacent.

5. Conclusions

The results demonstrate that the modification of cotton with cationic dye fixing agents, originally marketed as aftertreating agents for direct dyes, generally enhanced colour strength.

The *K/S* of the pretreated samples was always higher than that of the corresponding untreated dyes when dyeing had been carried out in the

absence of electrolyte. Matexil FC-PN and Solfix E displayed very similar behaviour, in that the higher their application level the greater was the enhancement in colour strength; however, Solfix E was by far the more effective. The effectiveness of Matexil FC-ER was mid-way between Solfix E and Matexil FC-PN.

Unfortunately, the colour strengths of pretreated samples which had been dyed in the presence of

electrolyte were lower than that of the standard dyeing with only a few exceptions. It is important to mention that pretreatment did not cause any unlevelness.

The wash fastness of the direct dyeings was almost unaffected by pretreatment. The effect of the cationic pretreatment on the light fastness of the dyed samples was impossible to be investigated precisely owing to the difference in the K/S values of dyed samples. It was, however, found that pretreatment slightly decreased the light fastness of the dyeings.

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