ELSEVIER

Dyes and Pigments 40 (1998) 59–71

DYES AND PIGMENT

Dyeing of cotton-polyester blends with anthraquinonoid vat dyes

Y.C. Chao [a,*], Y.L. Chung [a], C.C. Lai [a], S.K. Liao [b], J.C. Chin [c]

[a] *Department of Textiles, National Taipei University of Technology, Taiwan*
[b] *Department of Textile Engineering, Feng Chia University, Taiwan*
[c] *Department of Textile Engineering, Nan-Ya Institute of Technology, Taiwan*

Received 10 March 1998; accepted 10 April 1998

Abstract

The synthesis of several series of anthraquinone vat dyes is described. The dyes were dyed on polyester, cotton a cotton–polyester blend fabrics and their dyeing and fastness properties evaluated. The levelling and fastness propert of all dyed samples meet commercial requirements. © 1998 Elsevier Science Ltd. All rights reserved.

Keywords: Single-dye system; Polyester–cotton blends; Anthraquinonoid vat dyes

1. Introduction

Polyester–cotton blends have developed into one of the most important textile fabrics. Achieving a satisfactory union dyeing on polyester–cotton blend fabrics while at the same time reducing the use of expensive machinery, consumption of water, dyes, chemicals, and energy is an attractive idea to the modern dyer. Various possibilities exist for dyeing the blends. Vat, sulphur, reactive, or direct dyes may be used for the cotton component after fixation of the disperse dye on the polyester component. Vat dyes have some significant advantages over other dyes: viz., colour value, reproducibility of colour, and fastness properties are usually better, and the dyeing is easier to wash-off, as no reductive clearing of the polyester is necessary [1]. The use of mixed dyes, i.e. ranges from carefully select disperse and vat dyes, has gained considerab importance in continuous dyeing, since disper dyes do not colour the polyester fibres satisfact rily in the presence of a typical vat dye reduci agent. The application of mixtures of disper dyes and vat dyes must therefore be carried o in two stages. Some problems associated wi this two-stage method have also been describe viz., (a) a large proportion of the dyes us goes onto the wrong fibre and there is also t possibility of staining of white fabric; (b) t colour gamut available from the mixtures restricted, particularly with respect to brig reds and turquoises; (c) it is hardly possible obtain solid shades on blend fabrics [2].

The method of processing the blends with single-dye system would have a great advanta over mixed-dyes systems. Du Pont and BAS have introduced some selected disperse dyes wi very low solubility in water as in the Dybln rang

* Corresponding author. Fax: +886-22-751-8845.

PII: S0143-7208(98)00033-3

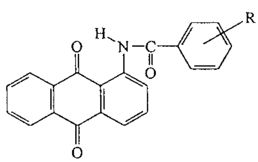
and Cellestren ranges respectively. Both these ranges of dyes can give the same colour and good build-up properties on both fibres of the blend fabrics by the thermosol process in the presence of specified solvents, e.g. polyethylene glycols within a certain range of molecular weight (Dybln) and derivatives of a polyalkylene oxide (Cellestren) [3]. The amount of solvent depends mainly on the dye concentration, and also on the proportion of cotton in the blend, and on the liquor pick-up. The other major disadvantages are that the colours are somewhat dull and the fixation conditions are much more severe than conventional disperse dyes [4].

The observation that polyester fibres can be dyed by leuco vat dyes when the pH of the liquor is lowered opens up the possibility, with the fabrics, of allowing the dye to be taken up by both component fibres by adjusting the pH of the leuco dye liquors [5]. The synthesis of several series of anthraquinonoid vat dyes obtained from 1-amin anthraquinone (I), 1,4-diaminoanthraquinone (and III), 4,8-diamino-anthrarufin (IV), 4-amino nitro-anthrarufin (V and VI) and 1,4-diamino-2, dicyanoanthraquinone (VII) is reported here. A evaluation of the dyeing properties of the dyes o polyester, cotton and polyester–cotton blend fa rics is also presented.

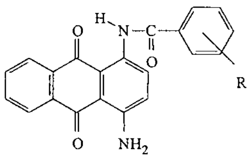
2. Experimental

2.1. *1-Aroylaminoanthraquinones [6]*

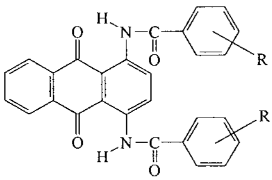
1-Aminoanthraquinone (1 g, 0.0045 mol) a benzoyl chloride (0.83 g, 0.0059 mol) were stirr in nitrobenzene (30 ml) at 130°C for 3 h.T liquor was cooled to room temperature, dilut with toluene (60 ml), and then left to stand ove night. The crystalline material which separat



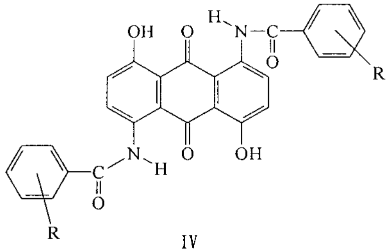
I



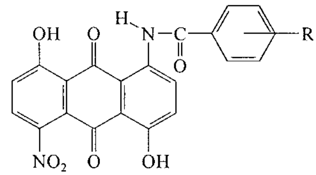
II



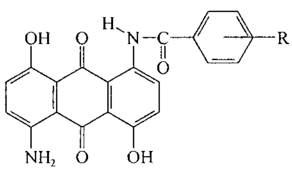
III



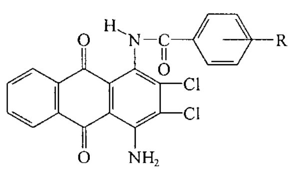
IV



V



VI



VII

was filtered and washed with *n*-hexane until the washings were colourless. Recrystallization from ethanol afforded 1.26 g (86%) of 1-benzoylamino-anthraquinone (dye I.1) as bright yellow needles, m.p. 235°C–236°C.

Dyes I.2–I.9 were synthesized by similar procedures, as detailed in Table 1.

2.2. 1-Aroylamino-4-aminoanthraquinones (II)

1,4-Diaminoanthraquinone (1 g, 0.0042 mol) and sodium acetate (0.4 g) were stirred in nitrobenzene (30 ml) at 90°C for 0.5 h; a mixture of benzoyl chloride (0.65 g, 0.0046 mol) and nitrobenzene (10 ml) was added portionwise and stirring was continued for 7 h. The reaction mixture was cooled to room temperature, poured into toluene (50 ml) and then left to stand overnight. The crystalline material which separated was filtered and washed with *n*-hexane until the washings were colourless. Recrystallization from ethanol gave 1.18 g (yield 82%) of 1-benzoylamino-4-amino-anthraquinone (dye II.1) as dark purple crystals, m.p. 275–276°C.

Dyes II.2–II.8 were synthesized by similar procedures, as detailed in Table 1.

2.3. 1,4-Bis(aroylamino)-anthraquinones (III)

A mixture of 1,4-diaminoanthraquinone (1 g, 0.0042 mol), benzoyl chloride (1.41 g, 0.01 mol), potassium iodide (0.40 g) and nitrobenzene (30 ml) was stirred at 150°C for 8 h. The reaction liquor was cooled to room temperature and the product isolated as in Section 2.1 to give, after recrystallization from ethanol, 1.63 g (yield 87%) of 1,4-bis-(benzoylamino)anthraquinone (dye III. 1) as dark red needles, m.p. 262–263°C.

Dyes III.2–III.9 were synthesized by similar procedures, as detailed in Table 1.

2.4. 1,5-Bis(aroylamino)-4,8-dihydroxyanthraquinones (IV)

The above procedures (Section 2.1) were repeated, except that 1-aminoanthraquinone was replaced by 4,8-diaminoanthrarufln. Relevant data on yield and m.p. are given in Table 1.

2.5. 1-Aroylamino-5-nitro-4,8-dihydroxyanthraquinones (V)

4,8-Dinitroanthrarufin (14 g, 0.042 mol), d odium hydrogen phosphate (26 g) and wat (100 ml) were stirred at 90°C for 1 h. The reactio mixture was cooled to room temperature, and *D*-glucose (28 g) was added. After stirring for 0.5 at 90°C, a mixture of sodium hydroxide (4 g) an water (30 ml) was added dropwise, and stirrin was continued for 12 h. The liquor was cooled room temperature and left to stand overnight. Th precipitate was filtered and washed with wat until the washings were neutral and colourless; th product was dried in vacuum at 50°C for 8 h give 11.71 g (92%) of 4-amino-8-nitro-anthraruf [7], m.p. 294–297°C. The mass spectrum con firmed the structure by the base peak (*m*/*e* 30 and other principal peaks (*m*/*e* 270 and 22 which corresponded to fragmentation by loss NO and NO_2 and CO from the molecular io respectively.

Dyes V.1–V.4 were synthesized by the sam methods to those in Section 2.1, except that amino-anthraquinone was replaced by 4-amino- nitroanthrarufin (2.00 g, 0.0067 mol). Releva data on yield and m.p. are given in Table 1.

2.6. 1-Aroylamino-5-amino-4,8-dihydroxyanthraquinones (VI) [8]

A mixture of dye V.1 (1 g) and hydrated sodiu sulphide (2 g) was refluxed in ethanol (50 ml) f 2 h. The liquor was cooled, diluted with wat (50 ml) and filtered to give 1-benzoylamino- amino-4,8-dihydroxyanthraquinone (dye VI. (0.7 g, yield 75%) as dark purple crystals, m. 332–333°C.

By using a similar procedure, dyes VI.2–VI (Table 1) were obtained.

2.7. 1 -Aroylamino-4-amino-2,3-dicyanoanthra quinones (VII)

1.4-Diamino-2,3-dicyanoanthraquinone (1 0.0033 mol) and potassium carbonate (2.4 g) we stirred in *o*-dichlorobenzene (30 ml) at 120°C f 1 h; a mixture of benzoyl chloride (2.88

Table 1
Synthesis and characterisation data of dyes

Dye	R	m.p. (°C)	Reagents (g.mol)	Reaction time (h) (temperature, °C)	Weight (%yield) (g)	Appearance o precipitate
I.2	4-Cl	222–223	4-Chlorobenzoyl chloride (1.03, 0.0059)	2.5 (110)	1.38 (85)	Yellow
I.3	2-Cl	216–217	2-Chlorobenzoyl chloride (1.03, 0.0059)	3.0 (110)	1.32 (81)	Bright yellow
I.4	4-OCH_3	256–258	4-Methoxybenzoyl chloride (1.01, 0.0059)	2.0 (130)	1.36 (85)	Golden
I.5	2-OCH_3	174–177	2-Methoxybenzoyl chloride (1.01, 0.0059)	2.0 (130)	1.12 (70)	Yellow
I.6	4-NO_2	278–280	4-Nitrobenzoyl chloride (1.09, 0.0059)	2.5 (130)	1.44 (86)	Bright yellow
I.7	3-NO_2	202–205	3-Nitrobenzoyl chloride (1.09, 0.0059)	2.0 (110)	1.41 (84)	Yellow
I.8	2-C1, 4-Cl	262–265	2,4-Dichlorobenzoyl chloride (1.24, 0.0059)	3.0 (130)	0.89 (50)	Orange
I.9	3-C1, 4-Cl	235–237	3,4-Dichlorobenzoyl chloride (1.24, 0, 0059)	2.5 (130)	1.57 (88)	Dark yellow
II.2	4-Cl	228–230	4-Chlorobenzoyl chloride (0.84, 0.0048)	11 (30)	1.34 (85)	Rubine
II.3	2-Cl	250–252	2-Chlorobenzoyl chloride (0.81, 0.0046)	16 (30)	1.50 (95)	Purple
II.4	4-OCH_3	238–239	4-Methoxybenzoyl chloride (0.78, 0.0046)	6 (90)	1.09 (70)	Dark purple
II.5	2-OCH_3	182–185	2-Methoxybenzoyl chloride (0.78, 0.0046)	6 (90)	1.31 (84)	Reddish purp
II.6	4-NO_2	280–282	4-Nitrobenzoyl chloride (0.85, 0.0046)	20 (30)	0.82 (50)	Dark red
II.7	3-NO_2	280–283	3-Nitrobenzoyl chloride (0.85, 0.0046)	20 (30)	0.56 (34)	Brownish red
II.8	2-C1, 4-Cl	262–264	2,4-Dichlorobenzoyl chloride (0.96, 0.0046)	14 (30)	1.35 (78)	Reddish purp
III.2	4-Cl	308–310	4-Chlorobenzoyl chloride (1.75, 0.01)	12 (130)	1.81 (84)	Red
III.3	2-Cl	309–311	2-Chlorobenzoyl chloride (1.75, 0.01)	10 (130)	1.78 (82)	Rubine
III.4	4-OCH_3	264–265	4-Methoxybenzoyl chloride (1.71, 0.01)	10 (150)	1.37 (64)	Rubine
III.5	2-OCH_3	221–223	2-Methoxybenzoyl chloride (1.71, 0.01)	8 (150)	0.96 (45)	Brownish red
III.6	4-NO_2	381–382	4-Nitrobenzoyl chloride (1.86, 0.01)	3.5 (130)	1.79 (80)	Bright red
III.7	3-NO_2	310–312	3-Nitrobenzoyl chloride (1.86, 0.01)	5 (130)	1.97 (88)	Red
III.8	2-C1, 4-Cl	360–363	2,4-Dichlorobenzoyl chloride (2.10, 0.01)	20 (110)	1.42 (58)	Scarlet
III.9	3-C1, 4-Cl	368–371	3,4-Dichlorobenzoyl chloride (2.10, 0.01)	18 (110)	2.06 (84)	Bright red
IV.1	H	282–284	Benzoyl chloride (1.13, 0.008)	7 (130)	0.98 (62)	Brown
IV.2	4-Cl	338–339	4-Chlorobenzoyl chloride (1.40, 0.008)	6 (130)	1.03 (57)	Dark blue
IV.3	2-Cl	343–346	2-Chlorobenzoyl chloride (1.40, 0.008)	5 (130)	1.62 (90)	Violet
IV.4	4-OCH_3	359–361	4-Methoxybenzoyl chloride (1.37, 0.008)	10 (130)	1.65 (93)	Brownish blac
IV.5	2-OCH_3	306–308	2-Methoxybenzoyl chloride (1.36, 0.008)	7 (130)	1.39 (78)	Brownish blac
IV.6	4-NO_2	431–433	4-Nitrobenzoyl chloride (1.49, 0.008)	3 (130)	1.60 (90)	Dark violet
IV.7	3-NO_2	410–413	3-Nitrobenzoyl chloride (1.49, 0.008)	3.5 (130)	1.38 (77)	Purple
IV.8	2-C1, 4-Cl	336–339	3,4-Dichlorobenzoyl chloride (1.68, 0.008)	12 (110)	1.82 (90)	Purple
V.1	H	352–353	Benzoyl chloride (0.98, 0.007)	4 (130)	1.46 (54)	Brownish blac
V.2	4-Cl	242–245	4-Chlorobenzoyl chloride (1.23, 0.007)	22 (110)	2.44 (83)	Dark purple
V.3	2-Cl	249–252	2-Chlorobenzoyl chloride (1.23, 0.007)	20 (110)	2.52 (86)	Rubine
V.4	4-OCH_3	234–236	4-Methoxybenzoyl chloride (1.19, 0.007)	3 (130)	2.46 (85)	Rubine
V.5	2-OCH_3	250–251	2-Methoxybenzoyl chloride (1.19, 0.007)	2 (130)	1.90 (65)	Brownish red
VI.2	4-Cl	240–242	Sodium sulphide (2 g)	2 (reflux)	0.82 (87)	Rubine
VI.3	2-Cl	243–246	Sodium sulphide (2 g)	2 (reflux)	0.85 (90)	Rubine
VI.4	4-OCH_3	319–322	Sodium sulphide (2 g)	2 (reflux)	0.82 (88)	Dark purple
VI.5	2-OCH_3	282–285	Sodium sulphide (2 g)	2 (reflux)	0.78 (84)	Dark purple
VII.2	2-Cl	213–216	2-Chlorobenzoyl chloride (3.50, 0.02)	15 (120)	1.39 (95)	Rubine
VII.3	3-Cl	219–221	3-Chlorobenzoyl chloride (3.50, 0.02)	15 (120)	1.33 (90)	Scarlet
VII.4	4-Cl	180–183	4-Chlorobenzoyl chloride (3.50, 0.02)	12 (120)	1.32 (90)	Rubine
VII.5	3-C1, 4-Cl	233–235	3,4-Dichlorobenzoyl chloride (4.19, 0.02)	14 (120)	1.38 (87)	Orange
VII.6	2-C1, 4-Cl	232–234	2,4-Dichlorobenzoyl chloride (4.19, 0.02)	10 (120)	1.33 (84)	Red
VII.7	3-Br	227–230	3-Bromobenzoyl chloride (2.86, 0.013)	14 (80)	1.55 (96)	Dark brown
VII.8	3-NO_2	232–235	3-Nitrobenzoyl chloride (2.45, 0.013)	10 (120)	1.46 (97)	Orange
VII.9	4-CH_3	221–223	4-Methylbenzoyl chloride (2.73, 0.016)	4 (120)	1.21 (86)	Rubine
VII.10	4-OCH_3	243–244	4-Methoxybenzoyl chloride (3.33, 0.020)	6 (150)	1.21 (83)	Rubine

0.02 mol) and *o*-dichlorobenzene (10 ml) was added dropwise and stirring was continued for 4 h. The reaction mixture was cooled to room temperature, and the product isolated as in Section 2.2 to give 1.27 g (94%) of 1-benzoylamino-4-amino-2,3-dicyanoanthraquinone (dye VII.1) as dark brown crystals (m.p. 241–244°C).

Dyes VII.2–VII.10 were synthesized by similar procedures, as detailed in Table 1.

2.8. General

All dyes were purified by TLC on Kieselgel 60 (Merck). Electronic spectra were recorded on a Shimadzu UV 240 from dye solutions in *N*,*N*-dimethylformamide (DMF) (Table 3). Structure and purity were confirmed by mass(Hitachi M-52), infrared (Hitachi 260-50) and elemental analysis (Perkin–Elmer 24OC) (Table 2).

Dyeing of cotton was carried out using an aqueous solution of $Na_2S_2O_4$ (20 g litre^{-1}) , NaOH (15 g litre^{-1}) and Na_2SO_4 (20 g litre^{-1}) at room temperature (liquor ratio 25:1) for 30 min; the samples were oxidized with a mixture of 0.5 g litre^{-1} 35% H_2O_2 and 1.5 g litre^{-1} glacial acetic acid at 60°C for 10 min, and then washed with an aqueous solution of detergent (2 g litre^{-1}) at 40°C for 10 min. Dyeing of polyester was carried out in a liquor ratio of 25:1 at 130°C at pH 5.0–5.5 for 40 min; the samples were then cooled to room temperature and washed with an aqueous solution of 10 ml litre^{-1} 32.5% Na_2CO_3 and 5 g litre^{-1} $Na_2S_2O_4$ at 70°C for 20 min. Dyeing of cotton–polyester blends (35/65) was carried out in a liquor ratio of 25:1 by a one bath—two stage process. Polyester component of the blends was dyed at 130°C (pH 5.0–5.5) for 40 min, and then cotton component was dyed in an aqueous solution of $Na_2S_2O_4$ (20 g litre^{-1}), NaOH (15 g litre^{-1}) and $Na_2S_2O_4$ (20 g litre^{-1}) at room temperature for 30 min; the samples were oxidized with a mixture of 0.5 g litre^{-1} 35% H_2O_2 and 1.5 g litre^{-1} glacial acetic acid at 60°C for 10 min, and then washed with an aqueous solution of detergent (2 g litre^{-1}) at 40°C for 10 min. The dye uptake was evaluated by extracting the dye from a known weight of dyed material by DMF (polyester) and DMF/glacial acetic acid (9/1) (cotton and cotton–polyester blend fabrics) and determining the absorbance the solution using a Shimadzu UV240. Dye uptal was calculated from the calibration curve absorbance vs concentration of dye.

The wash fastness was tested. according to CN 1494-A3, similar to AATCC 61-1989-1A, exce that the test conditions were replaced by 100 r liquor (5 g litre^{-1} detergent and 2 g litre^{-1} anh drous Na_2CO_3) at 60°C ± 2°C for 30 min. Su limation and light fastness assessments were carri out as for a previous investigation [8].

3. Results and discussion

3.1. Electronic spectra

Electronic spectra data of the dyes are shown Table 3. Comparison of λ_{max} values of dyes I–V shows the dyes to be bathochromic in the ord VI > IV > II > V > III > VII > I, differences being 3 95, 29–36, 2–23, 37–59, 2–27 and 58–71 nm, respe tively. On comparing λ_{max} values of 1-acetamidoa thraquinone (400 nm) with 1-aminoanthraquino (475 nm) and 1,4-bisacetamidoanthra-quino (474 nm) with 1,4-diaminoanthraquinone (550 nr produces a pronounced hypsochromic shift by 75 n [8].

This may be due to the weaker intramolecul hydrogen bonding (with carbonyl group anthraquinone nucleus) and electron-donati properties of α-amido group, compared with amino group. Comparison of λ_{max} values of dyes IV and V with the corresponding arylamino anal gues gives a similar general order (85–90 nr I→VIII; 98–107 nm, IV→IX; 80–87 nm, V→X).

Comparing λ_{max} values of dyes VI with IV ar of dyes II with III indicates that electron-donati amino group at α-position of anthraquino nucleus, which formed intramolecular hydrog bond with carbonyl group, gives pronounc bathochromic shifts of 37–59 nm (IV→VI) ar 39–79 nm (III→II). It can be seen from Table that electron-withdrawing groups, e.g. NO_2 ar C1, on the anthraquinone nucleus, produce larg hypsochromic shifts of 10–35 nm (IV→V) and 6 67 nm (II→VII). Introducing electron-withdrawi groups and bulky groups ortho to the amic

Table 2
Spectroscopic Data of Dyes

Dye	*R*	Mass (m/e)	IR[a] (cm^{-1}, KBr)	Elemental analysis %: found (calculated)
I.1	H	327 (M^+), 310 (M^+–OH), 105 $(C_6H_5CO)^+$	1680, 1640 (C=O); 1670, 1530 (amide); 1510 (phenyl); 1340 (Car–N)	C:76.10 (77.06), H:3.82 (3.98), N:4.03 (4.28)
I.2	4-Cl	361/363 (M^+), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(C_6H_4Cl)^+$	1690, 1630 (C=O); 1665, 1310 (amide); 1590 (phenyl); 1340 (Car–N)	C:70.80 (69.71), H:3.00 (3.32), N:4.05 (3.87)
I.3	2-Cl	361/363 (M^+), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(C_6H_4Cl)^+$	1690, 1625 (C=O); 1660, 1320 (amide); 1590 (pheny1); 1330 (Car–N)	C:70.95 (69.71), H:2.95 (3.32), N:4.38 (3.87)
I.4	4-OCH_3	357 (M^+), 178.5 ($M^{+}2$), 135 $(OCH_3C_6H_4CO)^+$, 107 $(OCH_3C_6H_4)^+$	1680, 1610 (C=O); 1640, 1310 (amide); 1580 (pheny1); 1330 (Car–N); 1260 (Ar.ether)	C:73.02 (73.95), H:3.78 (4.20), N:3.03 (3.92)
I.5	2-OCH_3	357 (M^+), 178.5 ($M^{+}2$), 135 $(OCH_3C_6H_4CO)^+$	1680, 1615 (C=O); 1660 (amide); 1590 (pheny1); 1340 (Car–N); 1265 (Ar. ether)	C:73.72 (73.95), H:3.52 (4.20), N:3.42 (3.92)
I.6	4-NO_2	372 (M^+), 150 $(NO_2C_6H_4CO)^+$, 104 $(C_6H_4CO)^+$	1680, 1640 (C=O); 1665 (amide); 1580 (phenyl); 1340 (Car–N)	C:67.00 (67.74), H:2.51 (3.23), N:6.58 (7.53)
I.7	3-NO_2	372 (M^+), 150 $(NO_2C_6H_4CO)^+$, 104 $(C_6H_4CO)^+$	1680, 1640 (C=O); 1660 (amide); 1580, 1400 (phenyl); 1340 (Car–N)	C:68.08 (67.74), H:3.67 (3.23), N:6.63 (7.53)
I.8	2-Cl, 4-Cl	395/397/399 (M^+), 173/175/177 $(Cl_2C_6H_3CO)^+$, 145/147/149 $(Cl_2C_6H_3)^+$	1680, 1640 (C=O); 1665 (amide); 1580, 1400 (phenyl); 1340 (Car–N)	C:65.00 (63.64), H:2.02 (2.78), N:4.08 (3.54)
I.9	3-Cl, 4-Cl	395/397/399 (M^+), 173/175/177 $(Ci_2C_6H_3CO)^+$, 145/147/149 $(Cl_2C_6H_3)^+$	1680, 1630 (C=O); l 670 (amide); 1580 1400 (phenyl); 1360 (Car–N)	C:63.02 (63.64), H:3.0 (2.78), N:3.95 (3.54)
II.1	H	342 (M^+), 327 (M^+-C_6H_5CO), 105 $(C_6H_5CO)^+$	3300 (b, NH_2); 1675, 1625 (C=O); 1660, 1540 (amide); 1340 (Car–N)	C:73.15 (73.68), H:4.68 (4.09), N:7.69 (8.19)
II.2	4-Cl	376/378 (M^+), 237/239 (M^+-ClC_6H_4CO), 139/141 $(C1C_6H_4CO)^+$, 111/113 $(C_6H_4Cl)^+$	3350(b, NH_2); 1675, 1610 (C=O); 1660 (amide); 1350 (Car–N)	C:66.15 (66.93), H:4.12 (3.45), N:7.02 (7.44)
II.3	2-Cl	376/378 (M^+), 237/239 (M^+-ClC_6H_4CO), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(ClC_6H_4)^+$	3400 (b, NH_2); 1670, 1630 (C=O); 1655, 1550 (amide); 1345 (Car–N)	C:66.28 (66.93), H:4.35 (3.45), N:7.58 (7.44)
II.4	4-OCH_3)	372 (M^+), 135 $(OCH_3C_6H_4CO)^+$, 107 $(OCH_3C_6H_4)^+$	3350 (b, NH_2); 1670, 1610 (C=O); 1640, 1550 (amide); 1350 (Car–N); 1245 (Ar. ether)	C:71.45 (70.97), H:4.08 (4.30), N:7.12 (7.53)
II.5	2-OCH_3	372 (M^+), 135 $(OCH_3C_6H_4CO)^+$ 107 $(OCH_3C_6H_4)^+$	3340 (b, NH_2); 1665, 1610 (C=O); 1635 (amide); 1590 (phenyl); 1360 (Car–N); 1260 (Ar. ether)	C:70.38 (70.97), H:4.72 (4.30), N:7.75 (7.53)
II.6	4-NO_2	387 (M^+), 237 (M^+-$NO_2C_6H_4CO$) 150 $(NO_2C_6H_4CO)^+$, 104 $(C_6H_4CO)^+$	3060 (b, NH_2); 1690, 1610 (C=O); 1630, 1550 (amide); 1350 (NO_2); 1320 (Car–N)	C:65.83 (65.12), H:3.13 (3.36), N:10.35 (10.85)
II.7	3-NO_2	387 (M^+), 237 (M^+-$NO_2C_6H_4CO$) 150 $(NO_2C_6H_4CO)^+$, 104 $(C_6H_4CO)^+$	3100 (b, NH_2); 1690, 1610 (C=O); 1640 (amide); 1585 (phenyl); 1360 (NO_2);	C:64.87 (65.12), H:3.58 (3.36), N:11.20 (10.85)
II.8	2-Cl, 4-Cl	410/412/414 (M^+), 237 (M^+–$Cl_2C_6H_3CO$), 173/175/177 $(Cl_2C_6H_3CO)^+$, 145/147/149 $(Cl_2C_6H_3)^+$	3100 (b, NH_2); 1685, 1610 (C=O); 1635 (amide); 1590 (phenyl); 1370 (NO_2); 1340 (Car–N)	C:60.54 (61.31), H:3.72 (2.92), N:7.53 (6.81)
III.1	H	446 (M^+), 105 $(C_6H_5CO)^+$, 77 $(C_6H_5)^+$	1675 (C=O); 1620 (amide); 1510, 1490 (phenyl); 1350 (Car–N)	C:76.02 (75.34), H:3.74 (4.04), N:5.89 (6.28)
III.2	4-Cl	514/516/518 (M^+), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(ClC_6H_4)^+$	1680 (C=O); 1610; 1300 (amide); 1590 (phenyl); 1350 (Car–N)	C:65.89 (65.24), H:3.87 (3.11), N:4.78 (5.44)
III.3	2-Cl	514/516/518 (M^+), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(ClC_6H_4)^+$	1690 (C=O); 1620; 1305 (amide); 1580 (phenyl); 1350 (Car–N)	C:64.88 (65.24), H:3.62 (3.11), N:5.89 (5.44)

(continue

Table 2—*contd.*

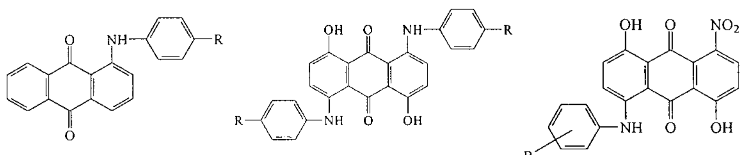
III.4	4-OCH_3	506 (M^+), 135 $(OCH_3C_6H_4CO)^+$ 107$(OCH_3C_6H_4)^+$	1670 (C=O); 1630; 1550 (amide); 1600, 1595, 1395 (phenyl); 1350 (Car–N); 1250 (Ar. ether)	C:71.68 (71.15), H:4.02 (4.35), N:6.07 (5.53)
III.5	2-OCH_3	506 (M^+), 135 $(OCH_3C_6H_4CO)^+$	1660 (C=O); 1620 (amide); 1590 (phenyl); 1340 (Car–N); 1260 (Ar. ether)	C:70.67 (71.15), H:5.03 (4.35), N:5.25 (5.53)
III.6	4-NO_2	536 (M^+), 150 $(NO_2C_6H_4CO)^+$ 104 $(C_6H_4CO)^+$	1695 (C=O); 1630 (amide); 1590, 1400 (phenyl); 1350 (NO_2)	C:63.05 (62.69), H:2.68 (2.99), N:10.21 (10.45)
III.7	3-NO_2	536 (M^+), 150 $(NO_2C_6H_4CO)^+$ 104 $(C_6H_4CO)^+$	1690 (C=O); 1620 (amide); 1585, 1400 (phenyl); 1350 (NO_2)	C:62.24 (62.69), H:3.38 (2.99), N:10.62 (10.45)
III.8	2-Cl, 4-Cl	582/584/586/588/590 (M^+), 173/175/177 $(Cl_2C_6H_3CO)^+$, 145/147/149 $(Cl_2C_6H_3)^+$	1680 (C=O); 1660 (amide); 1580 (phenyl); 1340 (Car–N	C:57.00 (57.53), H:2.70 (2.40), N:5.03 (4.79)
III.9	3-Cl, 4-Cl	582/584/586/588/590 (M^+), 173/175/177 $(Cl_2C_6H_3CO)^+$, 145/147/149 $(Cl_2C_6H_3)^+$	1680 (C=O); 1630 (amide); 1585, 1400 (phenyl); 1340 (Car–N)	C:58.07 (57.53), H:2.22 (2.40), N:4.58 (4.79)
IV.1	H	478 (M^+), 105 $(C_6H_4CO)^+$	1670 (C=O); 1620, 1305 (amide); 1585 1380 (phenyl); 1340 (Car–N)	C:70.85 (70.29), H:3.62 (3.77), N:5.67 (5.86)
IV.2	4-Cl	546/548/550 (M^+), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(ClC_6H_4)^+$	1690 (C=O); 1610, 1300 (amide); 1580 (phenyl); 1340 (Car–N)	C:61.27 (61.43), H:3.98 (2.93), N:4.98 (5.12)
IV.3	2-Cl	546/548/550 (M^+), 139/141 $(ClC_6H_4CO)^+$ 111/113 $(ClC_6H_4)^+$	1680 (C=O); 1620, 1550 (amide); 1380 (pheny1); 1350 (Car–N)	C:61.98 (61.43), H:2.78 (2.93), N:4.86 (5.12)
IV.4	4-OCH_3	538 (M^+), 135 $(OCH_3C_6H_4CO)^+$	1680 (C=O); 1610, 1300 (amide); 1580, 1380 (phenyl); 1340 (Car–N); 1250 (Ar. ether)	C:66.28 (66.91), H:3.82 (4.09), N:4.82 (5.20)
IV.5	2-OCH_3	538 (M^+), 135 $(OCH_3C_6H_4CO)^+$	1660 (C=O); 1605, 1300 (amide); 1400, 1380 (phenyl); 1260 (Ar. ether)	C:66.78 (66.91), H:3.67 (4.09), N:5.48 (5.20)
IV.6	4-NO_2	568 (M^+), 150 $(NO_2C_6H_4CO)^+$, 104 $(C_6H_4CO)^+$	1680 (C=O); 1610 (amide); 1580, 1400 (phenyl); 1375 (NO_2)	C:62.54 (62.22), H:2.87 (2.96), N:4.98 (5.19)
IV.7	3-NO_2	568 (M^+), 418 (M^+-$NO_2C_6H_4CO$), 150 $(NO_2C_6H_4CO)^+$, 104 $(C_6H_4CO)^+$	1680 (C=O); 1610 (amide); 1590, 1400 (phenyl); 1350 (NO_2)	C:61.87 (62.22), H:3.18 (2.96), N:5.35 (5.19)
IV.8	3-Cl, 4-Cl	614/616/618/620/622 (M^+), 173/175/179 $(Cl_2C_6H_3CO)^+$, 145/147/149 $(Cl_2C_6H_3)^+$	1640 (C=O); 1610 (amide); 1590, 1395 (phenyl); 1360 (NO_2)	C:54.03 (54.55), H:2.65 (2.27), N:4.68 (4.55)
V.1	H	404 (M^+), 327 (M^+–C_6H_5), 105 $(C_6H_4CO)^+$	1670 (C=O); 1605, 1550 (amide); 1580 (phenyl); 1350 (Car–N)	C:62.01 (62.38), H:3.15 (2.97), N:7.27 (6.93)
V.2	4-Cl	438/440 (M^+), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(ClC_6H_4)^+$	1680 (C=O); 1605, 1560 (amide); 1390, 1380 (phenyl); 1340 (Car–N)	C:57.98 (57.47), H:3.03 (2.51), N:6.87 (6.39)
V.3	2-Cl	438/440 (M^+), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(ClC_6H_4)^+$	1680 (C=O); 1640, 1550 (amide); 1370 (NO_2); 1340 (Car–N)	C:57.02 (57.47), H:2.38 (2.51), N:6.92 (6.39)
V.4	4-OCH_3	434 (M^+), 135 $(OCH_3C_6H_4CO)^+$	1670 (C=O); 1610, 1560 (amide); 1580, 1390 (phenyl); 1370 (NO_2); 1320 (Car–N); 1245 (Ar. ether)	C:60.57 (60.83), H:2.96 (3.23), N:6.87 (6.45)
V.5	2-OCH_3	434 (M^+), 135 $(OCH_3C_6H_4CO)^+$ 105 $(C_6H_5CO)^+$	1660 (C=O); 1605 (amide); 1380 (phenyl); 1360 (NO_2); 1260 (Ar. ether)	C:60.45 (60.83), H:2.87 (3.23), N:6.75 (6.45)
VI.1	H	374 (M^+), 105 $(C_6H_5CO)^+$	3300 (b, NH_2); 1670 (C=O); 1640, 1560 (amide); 1340 (Car–N)	C:67.00 (67.38), H:4.15 (3.74), N:7.72 (7.49)
VI.2	4-Cl	408/410 (M^+), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(ClC_6H_4)^+$	3400 (b, NH_2); 1660 (C=O); 1610, 1560 (amide); 1340 (Car–N)	C:61.50 (61.69), H:3.67 (3.18), N:7.03 (6.85)
VI.3	2-Cl	408/410 (M^+), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(ClC_6H_4)^+$	3380 (b, NH_2); 1660 (C=O); 1605, 1520 (amide); 1340 (Car–N)	C:62.03 (61.69), H:2.85 (3.18), N:6.78 (6.85)
VI.4	4-OCH_3	404 (M^+), 135 $(OCH_3C_6H_4CO)^+$, 107 $(OCH_3C_6H_4)^+$	3450 (b, NH_2); 1680 (C=O); 1605 (amide) 1580, 1380, (phenyl); 1260 (Ar. ether)	C:65.02 (65.35), H:4.17 (3.96), N:7.08 (6.93)

(continued)

Table 2—*contd.*

Dye	*R*	Mass (m/e)	IR[a] (cm^{-1}, KBr)	Elemental analysis %: found (calculated)
VI.5	2-OCH_3	404 (M^+), 135 $(OCH_3C_6H_4CO)^+$, 105 $(C_6H_5CO)^+$	3400 (b, NH_2); 1650 (C=O); 1605 (amide); 1585, 1380 (phenyl); 1350 (Car–N); 1260 (Ar. ether)	C:65.92 (65.35), H:3.68 (3.96), N:6.72 (6.93)
VII.1	H	410/412/414 (M^+), 375/377 (M^+–Cl), 105$(C_6H_4CO)^+$	3300 (b, NH_2); 1680, 1605 (C=O); 1640 (amide); 1590, 1460, 1400, 1380 (phenyl); 1340 (Car–N)	C:61.03 (61.31), H:3.07 (2.92), N:7.05 (6.81)
VII.2	2-Cl	444/446/448/450 (M^+), 411/413/415 (M^+–Cl), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(ClC_6H_4)^+$	3300 (b, NH_2); 1680, 1605 (C=O); 1640 (amide), 1590, 1460, 1400(phenyl); 1360 (Car–N)	C:56.98 (56.57), H:2.04 (2.47), N:6.12 (6.29)
VII.3	3-Cl	444/446/448/450(M^+), 411/413/415 (M^+–Cl), 139/141 $(ClC_6H_4CO)^+$, 111/113 $(ClC_6H_4)^+$	3250(b, NH_2); 1680, 1605(C=O); 1630 (amide), 1590, 1500(phenyl); 1360 (Car–N)	C:56.32 (56.57), H:2.58 (2.47), N:6.48 (6.29)
VII.4	4-Cl	444/446/448/450 (M^+), 411/413/415 (M^+–Cl), 139/141$(ClC_6H_4CO)^+$, 111/113 $(ClC_6H_4)^+$	3390 (b, NH_2); 1680, 1605 (C=O); 1640 (amide), 1590, 1400, 1380 (phenyl); 1340 (Car–N)	C:57.03(56.57), H:2.12 (2.47), N:6.01 (6 .29)
VII.5	3-Cl, 4-Cl	478/480/482/484/486 (M^+), 443/445/447/449 (M^+–Cl), 189/191/193 $(Cl_2C_6H_3CONH_2)^+$, 173/175/177 $(Cl_2C_6H_3CO)^+$, 145/147/149 $(Cl_2C_6H_3)^+$	3300 (b, NH_2); 1670, 1605 (C=O); 1630, 1300 (amide); 1340 (Car–N)	C:52.03 (52.50), H:2.38 (2.08), N:6.12(5.83)
VII.6	2-Cl, 4-Cl	478/480/482/484/486 (M^+), 443/445/447/449(M^+-Cl), 173/175/177 $(Cl_2C_6H_3CO)^+$,	3350 (b, NH_2); 1680, 1605 (C=O); 1640, 1550 (amide); 1590, 1500, 1380 (phenyl) 1335 (Car–N)	C:52.98 (52.50), H:1.87 (2.08), N:5.65 (5.83)
VII.7	3-Br	488/490/492/494 (M^+), 452/454/456 (M^+-Cl), 200/202 $(BrC_6H_4CONH_2)^+$, 183/185 $(BrC_6H_4CO)^+$	3400 (b, NH_2); 1680, 1605 (C=O); 1640, 1550 (amide); 1590, 1400, 1380 (phenyl); 1340 (Car–N)	C:51.87 (51.43), H:2.01 (2.24), N:5.62 (5.71)
VII.8	3-NO_2	455/457/459 (M^+), 420/422 (M^+–Cl), 150 $(NO_2C_6H_4CO)^+$, 122 $(NO_2C_6H_4)^+$	3350 (b, NH_2); 1680, 1605 (C=O); 1640 (amide); 1580, 1460, 1400 (phenyl); 1380 (NO_2)	C:54.93 (55.26), H:2.52 (2.41), N:9.38(9.21)
VII.9	4-CH_3	424/426/428 (M^+), 389/391 (M^+–Cl), 119 $(CH_3C_6H_4CO)^+$	3350 (b, NH_2); 1680, 1605(C=O); 1640 (amide); 1590, 1460, 1400, 1380 (phenyl); 1340 (Car–N)	C:62.48 (62.12), H:3.01 (3.29), N:6.48 (6.59)
VII.10	4-OCH_3	440/442/444 (M^+), 405/407 (M^+–Cl), 135 $(OCH_3C_6H_4CO)^+$,	3350 (b, NH_2); 1650, 1605 (C=O); 1620 (amide); 1590, 1460, 1400, 1380 (phenyl); 1340 (Car–N); 1220 (Ar. ether)	C:59.67 (59.86), H:3.28 (3.17), N:6.58 (6.35)

[a] Ar and ar, aromatic; b, broad.



VIII[8] IX[9] X[10]

R = H, NO_2; H, OCH_3; H, 4-OCH_3, 2- OCH_3

λ^{nm}_{max} 500, 487; 642&677, 640&678; 620, 622, 620

Table 3
Colour and TLC data

Dye	R	$Rf^{a}(TLC)$	λ_{max}^{nm} [b] (log ϵ) in DMF
I.1	H	0.690	410 (3.826)
I.2	4-Cl	0.836	409 (3.972)
I.3	2-Cl	0.795	400 (4.102)
I.4	4-OCH_3	0.789	420 (3.783)
I.5	2-OCH_3	0.752	408 (3.849)
I.6	4-NO_2	0.862	402 (3.947)
I.7	3-NO_2	0.789	405 (3.992)
I.8	2-Cl, 4-Cl	0.842	400 (4.165)
I.9	3-Cl, 4-Cl	0.887	404 (3.638)
II.1	H	0.602	540 (4.028)
II.2	4-Cl	0.857	538 (4.038)
II.3	2-Cl	0.628	535 (4.161)
II.4	4-OCH_3	0.618	544 (4.223), 570s (4.141)
II.5	2-OCH_3	0.637	535 (3.968), 555s (3.515)
II.6	4-NO_2	0.622	534 (3.878), 565s (3.718)
II.7	3-NO_2	0.652	537 (3.726), 563s (3.712)
II.8	2-Cl, 4-Cl	0.642	534 (4.084)
III.1	H	0.750	500 (3.905)
III.2	4-Cl	0.882	480 (3.864)
III.3	2-Cl	0.763	475 (3.894)
III.4	4-OCH_3	0.684	505 (3.818)
III.5	2-OCH_3	0.671	474 (3.805)
III.6	4-NO_2	0.881	486 (4.021)
III.7	3-NO_2	0.801	476 (4.051)
III.8	2-Cl, 4-Cl	0.869	475 (3.997)
III.9	3-Cl, 4-Cl	0.868	474 (3.636)
IV.1	H	0.781	548 (3.816), 570 (3.688)
IV.2	4-Cl	0.775	545 (3.688), 568 (4.070)
IV.3	2-Cl	0.789	540 (4.118), 565 (4.227)
IV.4	4-OCH_3	0.768	580 (3.517), 551 (3.809)
IV.5	2-OCH_3	0.778	565 (3.613), 542 (4.010)
IV.6	4-NO_2	0.690	565 (3.922), 535 (3.914)
IV.7	3-NO_2	0.826	567 (3.631), 545 (3.624)
IV.8	3-Cl, 4-Cl	0.769	563 (3.874), 541 (3.851)
V.1	H	0.705	538 (4.028)
V.2	4-Cl	0.840	518 (4.132)
V.3	2-Cl	0.815	512 (4.233)
V.4	4-OCH_3	0.773	542 (3.943)
V.5	2-OCH_3	0.809	533 (3.898)
VI.1	H	0.560	645 (3.788), 590s (3.716)
VI.2	4-Cl	0.691	605 (4.297), 578 (4.450)
VI.3	2-Cl	0.678	603 (4.383), 572 (4.514)
VI.4	4-OCH_3	0.605	675 (4.018), 628 (4.026)
VI.5	2-OCH_3	0.618	610 (3.656), 560 (3.689)
VII.1	H	0.610	475 (3.687)
VII.2	2-Cl	0.690	471 (3.408)
VII.3	3-Cl	0.660	473 (3.410)
VII.4	4-Cl	0.745	471 (3.418)
VII.5	3-Cl, 4-Cl	0.630	472 (3.407)
VII.6	2-Cl, 4-Cl	0.816	471 (3.403)
VII.7	3-Br	0.745	473 (3.420)
VII.8	3-NO_2	0.712	471 (3.434)
VII.9	4-CH_3	0.650	477 (3.578)
VII.10	4-OCH_3	0.737	478 (3.697)

(continued)

Table 3—*contd.*

[a] Eluent: toluene/ethyl acetate/glacial acetic acid = 8/2/1 (
volume).
[b] s: shoulder.

group into the aroylamino ring of dyes in ea
series gave a hypsochromic shift (Table 3). This
consistent with previous results [8,10].

3.2. Dyeing and fastness properties

All dyes in the seven series gave level colour tion on polyester, cotton and polyester–cott blend fabrics. Comparison of the dye uptake dyes I–VII on cotton fabrics, IV > III > VI > II VII > I, indicates that dyes with higher molecul weight and which form more intermolecul hydrogen bond with fibres have a higher su stantivity than those of others [11] (Table 4). Dy with an *o*-substituted group, e.g. dyes I.3, I.5, I. II.3, II.5, II.8, III.3, III.5, III.8, IV.3, IV.5, V. V.5, VI.3, VI.5, VII.2 and VII.6, have lower dy uptake on cotton fabrics than dyes with *m*- and substituted groups (Table 4). This might be due the steric hindrance hindered the coplanar co formation of dye molecules and the formation intermolecular hydrogen bond between amido grou of dyes and cotton fibres [11]. From Table 4 it apparent that the dye-uptake of the four shades dyes I–VII on polyester fabrics is in the order V > II > VI > IV > III > I > VII. The increase in su stantivity can be interpreted in terms of relati coplanarity, intermolecular hydrogen bonding a dispersion forces factors (with polyester) and t presence of more hydrophobic groups (e.g. nitr viz. (a) dyes V: greater coplanarity and inte molecular hydrogen bonds, and more hydrophob groups; (b) dyes II, VI and IV: greater coplanari and intermolecular hydrogen bonds; (c) dyes I greater coplanarity; (d) dyes VII lowered coplana ity [12]. It can be seen from Table 4 that dyes with electron-donating group on the aroylamino rin e.g. dyes I.4, I.5, II.4, II.5, III.4, III.5, IV.4, IV V.4, V.5, VI.4, VI.5, VII.9 and VII.10, have high substantivity on polyester fabrics than other dye

Table 4
Uptake [a] of dyes on cotton, polyester and cotton–polyester blend Fabrics

o.w.f.	Cotton				Polyester				Cotton–polyester blends			
Dye	0.1%	0.5%	1.0%	2.5%	0.1%	0.5%	1.0%	2.5%	0.1%	0.5%	1.0%	2.5%
I.1	0.46	0.96	1.46	2.85	0.68	3.22	5.86	11.54	0.61	2.61	4.13	8.08
I.2	0.50	1.03	1.59	3.13	0.62	2.81	5.46	11.07	0.60	2.75	4.45	8.57
I.3	0.33	0.70	0.98	1.97	0.57	2.70	5.12	10.61	0.50	1.91	3.50	7.05
I.4	0.48	0.99	1.51	3.03	0.73	3.54	6.29	12.25	0.69	3.01	4.95	9.06
I.5	0.41	0.87	1.26	2.41	0.78	3.77	6.90	12.88	0.57	2.39	3.91	7.80
I.6	0.44	0.91	1.36	2.61	0.55	2.67	4.98	9.24	0.53	2.16	3.78	7.45
I.7	0.36	0.78	1.08	2.17	0.52	2.47	4.62	8.62	0.47	1.87	3.30	6.72
I.8	0.29	0.59	0.80	1.76	0.46	2.34	4.17	8.08	0.43	1.78	3.18	6.28
I.9	0.31	0.64	0.90	1.84	0.44	2.28	3.98	7.53	0.41	1.75	3.05	6.13
II.1	0.53	2.55	3.51	7.27	0.80	3.85	7.31	14.28	0.70	3.22	6.03	11.29
II.2	0.62	2.85	3.95	8.21	0.76	3.63	7.06	13.21	0.74	3.46	6.44	12.01
II.3	0.48	2.37	3.18	6.82	0.70	3.40	6.51	12.90	0.62	2.92	5.43	10.21
II.4	0.59	2.75	3.78	7.47	0.87	4.21	8.01	16.58	0.80	3.68	7.11	12.81
II.5	0.50	2.45	3.34	6.99	0.89	4.39	8.59	17.32	0.68	3.17	5.89	10.98
II.6	0.51	2.50	3.41	7.09	0.67	3.27	6.33	12.21	0.65	3.02	5.63	10.58
II.7	0.49	2.40	3.22	6.89	0.65	3.17	6.07	11.87	0.56	2.59	5.02	9.39
II.8	0.43	2.19	2.87	6.46	0.63	3.11	5.93	11.64	0.50	2.38	4.08	7.48
III.1	0.80	3.98	7.62	13.92	0.71	3.40	6.21	12.16	0.74	3.47	6.47	12.22
III.2	0.92	4.51	8.15	16.31	0.63	2.95	5.59	11.53	0.76	3.52	6.57	12.45
III.3	0.51	2.50	4.88	10.23	0.61	2.84	5.41	11.00	0.59	2.76	5.02	10.42
III.4	0.85	4.20	7.90	15.32	0.75	3.60	6.32	12.80	0.80	3.61	6.77	12.86
III.5	0.57	2.78	5.38	12.52	0.80	3.80	7.14	14.14	0.69	3.35	6.23	12.58
III.6	0.71	3.49	6.87	13.18	0.58	2.74	5.33	10.04	0.62	2.96	5.48	10.81
III.7	0.53	2.61	5.03	11.33	0.55	2.65	5.15	9.62	0.54	2.64	5.10	10.07
III.8	0.48	2.30	4.43	9.86	0.50	2.40	4.72	9.20	0.49	2.36	4.60	9.28
III.9	0.46	2.21	4.06	8.56	0.48	2.35	4.60	8.89	0.47	2.30	4.45	8.79
IV.1	0.86	4.28	8.27	19.82	0.72	3.45	6.40	13.22	0.80	3.96	7.31	16.54
IV.2	0.92	4.54	8.87	21.51	0.68	3.08	5.94	12.08	0.82	4.02	7.39	16.68
IV.3	0.68	3.18	6.08	13.80	0.63	2.94	5.83	11.41	0.67	3.02	5.92	12.93
IV.4	0.90	4.48	8.65	20.54	0.78	3.75	7.05	14.00	0.84	4.08	7.51	16.90
IV.5	0.79	3.81	7.25	15.74	0.80	3.80	7.44	14.30	0.79	3.81	7.30	15.68
IV.6	0.83	4.08	7.79	16.73	0.60	2.85	5.60	10.60	0.74	3.64	6.84	14.35
IV.7	0.75	3.64	7.03	15.01	0.59	2.83	5.55	10.36	0.63	2.94	5.76	12.53
IV.8	0.60	2.86	5.41	13.08	0.56	2.75	5.00	9.80	0.58	2.80	5.30	12.05
V.1	0.68	3.31	5.11	9.36	0.82	3.98	7.59	14.54	0.72	3.60	6.07	10.24
V.2	0.73	3.50	5.62	10.07	0.78	3.73	7.21	13.80	0.77	3.70	7.07	12.20
V.3	0.64	3.11	4.73	9.00	0.74	3.59	6.80	13.22	0.67	3.34	5.31	9.72
V.4	0.70	3.44	5.32	9.61	0.88	4.36	8.53	16.87	0.85	4.25	8.38	13.21
V.5	0.66	3.21	5.01	9.25	0.90	4.46	8.81	17.53	0.71	3.52	5.72	10.09
VI.1	0.74	3.51	6.02	12.51	0.75	3.50	6.44	13.35	0.75	3.51	6.38	12.45
VI.2	0.83	4.00	6.62	13.37	0.71	3.24	6.02	12.28	0.78	3.78	6.59	12.85
VI.3	0.68	3.20	5.27	9.80	0.65	2.98	5.52	11.43	0.67	3.18	5.42	10.70
VI.4	0.78	3.71	6.33	12.92	0.83	3.97	7.18	14.32	0.81	3.88	6.98	13.92
VI.5	0.72	3.47	5.71	12.20	0.85	4.15	7.83	14.78	0.73	3.47	6.09	12.25
VII.1	0.49	1.64	3.08	6.07	0.66	3.15	5.61	8.94	0.54	2.52	4.73	7.58
VII.2	0.44	1.48	2.71	5.69	0.55	2.65	5.05	8.01	0.46	2.03	3.60	5.78
VII.3	0.52	1.74	3.23	6.48	0.58	2.70	5.24	8.34	0.56	2.60	4.87	7.84
VII.4	0.54	1.77	3.31	6.62	0.60	2.77	5.40	8.62	0.58	2.65	5.05	8.02
VII.5	0.42	1.42	2.61	5.52	0.43	2.18	3.95	6.32	0.43	1.96	3.40	5.69
VII.6	0.37	1.27	2.34	4.89	0.45	2.31	4.05	6.62	0.40	1.82	3.08	5.03
VII.7	0.48	1.59	3.02	6.01	0.39	2.11	3.76	5.92	0.47	2.08	3.70	5.90
VII.8	0.47	1.57	2.95	5.96	0.50	2.43	4.52	7.34	0.50	2.38	4.62	7.26
VII.9	0.46	1.52	2.79	5.89	0.72	3.73	6.12	9.54	0.63	2.98	5.15	8.42
VII.10	0.50	1.67	3.14	6.14	0.71	3.35	5.85	9.21	0.67	3.27	5.35	8.86

[a] g Dyes kg^{-1} fibres.

Table 5
Fastness on polyester fabrics

o.w.f.	Sublimation fastness (S.P./S.C./C.C.)[a]				Sublimation Temperature (°C)[b]	Wet fastness (S.P./S.C./C.C.)[a]				Light fastness			
Dye	0.1%	0.5%	1.0%	2.5%		0.1%	0.5%	1.0%	2.5%	0.1%	0.5%	1.0%	2.5%
I.1	5/5/5	4–5/4–5/5	4/4/4–5	3/3–4/4	160	5/5/5	5/5/5	5/4–5/5	5/4/4–5	4	4	4–5	4–5
I.2	5/5/5	5/5/5	5/5/5	5/4–5/4–5	160	5/5/5	5/5/5	5/5/5	5/5/5	5	5	5–6	5–6
I.3	5/5/5	5/5/5	5/5/5	5/5/5	170	5/5/5	5/5/5	5/5/5	5/5/5	5	5	5–6	5–6
I.4	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	160	5/5/5	5/5/5	5/5/5	5/5/4–5	4–5	4–5	5	5
I.5	5/5/5	5/5/5	4–5/5/4–5	4/4–5/4	160	5/5/5	5/5/5	5/5/5	5/5/4–5	5	5	5	5–6
I.6	5/5/5	5/5/5	4–5/5/5	4/4–5/5	170	5/5/5	5/5/5	5/5/5	5/5/5	5	5	5–6	5–6
I.7	5/5/5	5/5/5	4–5/5/5	4/4–5/5	160	5/5/5	5/5/5	5/5/4–5	5/5/4	4	4	4	4
I.8	5/5/5	4–5/5/4–5	4/4–5/4	3–4/4/3–4	160	5/5/5	5/5/5	5/5/5	5/5/4–5	4	4	4–5	5
I.9	5/5/5	4–5/5/5	4/4–5/5	3–4/4/4–5	170	5/5/5	5/5/5	5/5/5	5/5/4–5	5	5	5	5–6
II.1	5/5/5	4/4–5/5	3–4/4/5	3/3–4/4–5	150	5/5/5	5/5/5	5/4–5/5	5/4/4–5	4	4	4	4–5
II.2	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	160	5/5/5	5/5/5	5/5/5	5/5/5	5	5	5	5–6
II.3	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	170	5/5/5	5/5/5	5/5/5	5/5/5	5	5	5	5–6
II.4	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	160	5/5/5	5/5/5	5/5/5	5/5/4–5	4	4	4–5	4–5
II.5	5/5/5	5/5/5	4–5/5/4–5	4/4–5/4	160	5/5/5	5/5/5	5/5/5	5/5/4–5	4	4	4–5	4–5
II.6	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	160	5/5/5	5/5/5	5/5/5	5/4–5/4–5	4	4–5	5	5–6
II.7	5/5/5	4/4/4–5	3–4/3–4/4	3/3/3–4	150	5/5/5	5/5/5	5/4–5/5	5/4/4–5	4	4	4–5	4–5
II.8	5/5/5	4–5/4–5/4–5	4/4/4	3/3–4/3	150	5/5/5	5/5/5	5/5/5	5/5/5	4–5	4–5	5	5–6
III.1	5/5/5	5/5/5	5/5/5	4–5/5/4–5	170	5/5/5	5/5/5	5/5/5	5/5/4–5	6	6	7	7–8
III.2	5/5/5	5/5/5	5/5/5	4–5/5/4–5	210	5/5/5	5/5/5	5/5/5	5/5/5	6	6–7	6–7	7–8
III.3	5/5/5	5/5/5	5/5/5	4–5/5/4–5	200	5/5/5	5/5/5	5/5/5	5/5/5	6	6–7	6–7	7
III.4	5/5/5	5/5/5	5/5/5	5/5/5	210	5/5/5	5/5/5	5/5/5	5/5/5	6	6	6–7	6–7
III.5	5/5/5	5/5/5	5/5/5	4–5/5/4–5	200	5/5/5	5/5/5	5/5/5	5/5/4–5	6	6	6–7	6–7
III.6	5/5/5	5/5/5	5/5/5	5/5/5	180	5/5/5	5/5/5	5/5/5	5/5/4–5	5	5	5–6	5–6
III.7	5/5/5	5/5/5	5/5/5	4–5/5/4–5	180	5/5/5	5/5/5	5/5/5	5/5/4–5	5	5	5	5–6
III.8	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	180	5/5/5	5/5/5	5/5/5	5/5/5	7	7	7–8	7–8
III.9	5/5/5	5/5/5	5/5/5	5/5/4–5	190	5/5/5	5/5/5	5/5/5	5/5/5	5	5	5–6	5–6
IV.1	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	190	5/5/5	5/5/5	5/5/4–5	5/5/4	5–6	6	6–7	7
IV.2	5/5/5	5/5/5	5/5/5	4–5/5/4–5	190	5/5/5	5/5/5	5/5/5	5/5/5	6	6–7	6–7	7
IV.3	5/5/5	5/5/5	5/5/5	4–5/5/4–5	190	5/5/5	5/5/5	5/5/5	5/5/5	6–7	6–7	7	7–8
IV.4	5/5/5	5/5/5	5/5/5	5/5/5	210	5/5/5	5/5/5	5/4–5/4–5	4–5/4/4	7	7	7	7
IV.5	5/5/5	5/5/5	5/5/5	4–5/5/4–5	200	5/5/5	5/5/5	5/4–5/4–5	4–5/4/4	7	7	7	7–8
IV.6	5/5/5	5/5/5	5/5/5	5/5/5	200	5/5/5	5/5/5	5/4–5/5	5/4/4–5	6	6–7	6–7	6–7
IV.7	5/5/5	5/5/5	5/5/4–5	4–5/4–5/4	190	5/5/5	5/5/5	5/5/4–5	5/5/4	4	4–5	5	5–6
IV.8	5/5/5	5/5/5	5/5/4–5	4–5/5/4	180	5/5/5	5/5/5	5/5/5	5/5/5	5	5–6	5–6	6
V.1	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	170	5/5/5	5/5/5	5/5/4–5	5/4–5/4	5	5	5–6	5–6
V.2	5/5/5	5/5/5	5/5/5	4–5/5/4–5	170	5/5/5	5/5/5	5/5/5	5/5/5	5	5	5–6	5–6
V.3	5/5/5	5/5/5	5/5/5	4–5/5/4–5	170	5/5/5	5/5/5	5/5/5	5/5/5	5–6	5–6	5–6	6
V.4	5/5/5	5/5/5	4–5/5/5	4/5/5	190	5/5/5	5/5/5	5/4–5/5	5/4/4–5	5–6	5–6	6	6–7
V.5	5/5/5	5/5/5	4–5/5/5	4/5/5	190	5/5/5	5/5/5	5/4–5/4–5	5/4/4	6	6	6–7	6–7
VI.1	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	180	5/5/5	5/5/5	5/4–5/5	5/4/4–5	4	4–5	5	5–6
VI.2	5/5/5	5/5/5	5/5/4–5	4–5/4–5/4	170	5/5/5	5/5/5	5/5/5	5/5/5	5	5	5–6	5–6
VI.3	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	170	5/5/5	5/5/5	5/5/5	5/5/5	5–6	5–6	5–6	6
VI.4	5/5/5	5/5/5	4–5/5/5	4/5/5	200	5/5/5	5/5/5	5/4–5/5	5/4/5	5–6	6	6	6–7
VI.5	5/5/5	5/5/5	5/5/5	4–5/5/5	200	5/5/5	5/5/5	5/4–5/5	5/4/4–5	5–6	6	6–7	6–7
VII.1	5/5/5	5/5/5	5/5/5	4–5/4–5/5	190	5/5/5	5/5/5	5/5/5	5/5/5	5	5–6	6	6–7
VII.2	5/5/5	5/5/5	5/5/5	4–5/4–5/5	200	5/5/5	5/5/5	5/5/5	5/5/5	5	5–6	5–6	6
VII.3	5/5/5	4–5/5/5	4–5/5/5	4/4–5/4–5	170	5/5/5	5/5/5	5/5/5	5/5/5	5–6	5–6	6	6
VII.4	5/5/5	5/5/5	5/5/5	4–5/4–5/5	210	5/5/5	5/5/5	5/5/5	5/5/5	5–6	5–6	5–6	6
VII.5	5/5/5	5/5/5	5/5/5	5/5/5	210	5/5/5	5/5/5	5/5/5	5/5/4–5	6	6	6–7	7
VII.6	5/5/5	5/5/5	5/5/5	5/5/5	220	5/5/5	5/5/5	5/5/5	5/5/4–5	5	5–6	6–7	7
VII.7	5/5/5	5/5/5	5/5/5	4–5/5/5	210	5/5/5	5/5/5	5/5/5	5/5/4–5	5	5–6	6	6–7
VII.8	5/5/5	5/5/5	5/5/5	5/5/5	220	5/5/5	5/5/5	5/5/5	5/5/4–5	5–6	5–6	6	6–7
VII.9	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	190	5/5/5	5/5/5	5/5/5	5/5/5	6	6–7	7	7–8
VII.10	5/5/5	5/5/5	5/5/5	5/5/5	210	5/5/5	5/5/5	5/5/5	5/5/5	6	6–7	7	7–8

[a] S.P., staining on polyester; S.C., staining on cotton; C.C., colour change.
[b] Initial temperature/°C of mark–off (2.5% o.w.f.).

Table 6
Fastness on cotton fabrics

o.w.f.	Sublimation fastness (S.P./S.C./C.C.)[a]				Wet fastness (S.P./S.C./C.C.)[a]				Light fastness			
Dye	0.1%	0.5%	1.0%	2.5%	0.1%	0.5%	1.0%	2.5%	0.1%	0.5%	1.0%	2.5%
I.1	5/5/5	5/5/5	4–5/5/4–5	4/4–5/4	5/5/5	5/5/5	5/4–5/5	5/4/4–5	5	5	5	5
I.2	5/5/5	5/5/4–5	5/5/4	4–5/4–5/3–4	5/5/5	5/5/5	5/5/5	5/4–5/4–5	4–5	4–5	4–5	4–5
I.3	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	4	4–5	4–5	4–5
I.4	5/5/5	5/5/5	4–5/5/5	4/5/4–5	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	4	4–5	4–5	4–5
I.5	5/5/5	4–5/5/5	4/5/5	3–4/4–5/4–5	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	4	4–5	4–5	4–5
I.6	5/5/5	5/5/5	4–5/5/5	4/4–5/5	5/5/5	5/5/5	5/5/5	5/4–5/5	6–7	6–7	6–7	7
I.7	5/5/5	5/5/5	4–5/5/5	4/4–5/5	5/5/5	5/5/5	5/4–5/4–5	5/4/4	3–4	3–4	3–4	3–4
I.8	5/5/5	5/5/5	4–5/4–5/5	4/4/4–5	5/5/5	5/5/5	5/5/5	5/4–5/4–5	4	4	4–5	4–5
I.9	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	5/5/5	5/5/5	5/5/5	5/5/4–5	5	5	5	5
II.1	5/5/5	4–5/4–5/5	4/4/4–5	3–4/3–4/4	5/5/5	5/5/5	5/4–5/5	5/4/4–5	4	4	4	4–5
II.2	5/5/5	5/5/5	5/5/4–5	4–5/4–5/4	5/5/5	5/5/5	5/5/4–5	5/4–5/4	4	4	4	4
II.3	5/5/5	5/5/5	5/5/4–5	4–5/4–5/4	5/5/5	5/5/5	5/5/5	5/4–5/4–5	4	4–5	4–5	4–5
II.4	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	5/5/5	5/4–5/5	5/4/4–5	4–5/3–4/4	4	4–5	4–5	4–5
II.5	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	5/5/5	5/4–5/5	5/4/4–5	5/3–4/4–5	4	4–5	4–5	4–5
II.6	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/4–5/4–5	5/4/4	4	4	5	5–6
II.7	5/5/5	5/5/5	4–5/4–5/4–5	4/4/4	5/5/5	5/5/5	5/4–5/4–5	5/4/4	3–4	3–4	4	4–5
II.8	5/5/5	4–5/4–5/5	4/4/4–5	3–4/3–4/4	5/5/5	5/5/5	5/5/5	5/4–5/4–5	6	6–7	7	7
III.1	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	5/5/5	5/5/5	5/4–5/4–5	5/4/4–5	6	6–7	7	7–8
III.2	5/5/5	5/5/5	5/5/5	4–5/5/4–5	5/5/5	5/5/5	5/5/5	5/5/5	7	7–8	7–8	7–8
III.3	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	6	6	6–7	6–7
III.4	5/5/5	5/5/5	4–5/5/5	4/5/4–5	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	6	6	6–7	6–7
III.5	5/5/5	5/5/5	5/5/5	4–5/5/4–5	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	6	6	6–7	6–7
III.6	5/5/5	5/5/5	5/5/5	4–5/5/5	5/5/5	5/5/5	5/4–5/5	5/4–5/4–5	5	5–6	6	6–7
III.7	5/5/5	5/5/5	4–5/4–5/5	4/4/4–5	5/5/5	5/5/5	5/4–5/4–5	5/4/4–5	4–5	5	5–6	6
III.8	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	5/5/5	5/5/5	5/5/5	5/5/5	7–8	7–8	7–8	7–8
III.9	5/5/5	5/5/5	5/5/5	4–5/5/4–5	5/5/5	5/5/5	5/5/5	5/5/5	5	5	5–6	5–6
IV.1	5/5/5	5/5/5	4–5/5/4–5	4/4–5/4	5/5/5	5/5/5	5/4–5/5	5/4/4–5	5–6	6	6–7	7
IV.2	5/5/5	5/5/5	4–5/5/4–5	4/5/4	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	5–6	5–6	6	6–7
IV.3	5/5/5	5/5/5	5/5/5	4–5/5/4–5	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	5–6	5–6	6	6–7
IV.4	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/4–5	5/4–5/4	4–5/4/4	7	7	7–8	7–8
IV.5	5/5/5	5/5/5	5/5/5	4–5/5/4–5	5/5/5	5/5/5	5/4–5/4–5	4–5/4/4	7	7	7–8	7–8
IV.6	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/4–5/5	5/4/4–5	6–7	6–7	7	7
IV.7	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/4–5/4–5	5/4/4	4	4–5	5	5–6
IV.8	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	6–7	6–7	7	7–8
V.1	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	4–5/4–5/5	4–5/4/4–5	5	5	5–6	5–6
V.2	5/5/5	5/5/5	4–5/5/4–5	4/5/4	5/5/5	5/5/5	5/5/5	4–5/4–5/4–5	5	5	5–6	5–6
V.3	5/5/5	5/5/5	5/5/4–5	4–5/5/4	5/5/5	5/5/5	4–5/4–5/5	4–5/4–5/4–5	5	5–6	6	6
V.4	5/5/5	5/5/5	4–5/4–5/5	4/4/4–5	5/5/5	5/5/5	5/4–5/5	4–5/4/4–5	6	6	6	6–7
V.5	5/5/5	5/5/5	4–5/4–5/5	4/4/4–5	5/5/5	5/5/5	4–5/4–5/4–5	4/4/4	6	6	6–7	6–7
VI.1	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/4–5/5	5/4/4–5	5/3–4/4–5	4	4–5	5	5–6
VI.2	5/5/5	5/5/5	4–5/4–5/4–5	4/4/4	5/5/5	5/5/5	4–5/4–5/4–5	4/4/4	4	4	4–5	4–5
VI.3	5/5/5	5/5/5	4–5/5/4–5	4/4–5/4	5/5/5	4–5/5/5	4–5/4–5/4–5	4/4/4	4	4	4–5	4–5
VI.4	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	4–5/5/5	4/4–5/4–5	3–4/4/4–5	5–6	5–6	6	6–7
VI.5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	4–5/4–5/5	4/4–5/4–5	3–4/4/4–5	5–6	6	6–7	6–7
VII.1	5/5/5	5/5/5	4–5/5/5	4–5/4–5/4	5/5/5	5/5/5	5/4–5/4–5	4–5/4–5/4	4	4	4–5	4–5
VII.2	5/5/5	5/5/5	5/5/5	4–5/4–5/5	5/5/5	5/5/5	5/4–5/4–5	5/4–5/4	4	4–5	4–5	4–5
VII.3	5/5/5	4–5/5/5	4–5/5/4–5	4/4–5/4	5/5/5	5/5/5	5/5/4–5	5/4–5/4	3–4	4	4–5	4–5
VII.4	5/5/5	5/5/5	4–5/5/5	4–5/4–5/5	5/5/5	5/5/5	5/5/4–5	5/4–5/4	3–4	4	4	4
VII.5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/4–5/4–5	4–5	4–5	4–5	5
VII.6	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/4–5	5	5	5–6	5–6
VII.7	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/4–5	5/5/4–5	3–4	3–4	3–4	4
VII.8	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/4–5	5/4–5/4–5	3–4	3–4	3–4	3–4
VII.9	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/4–5/5	6	6	6–7	6–7
VII.10	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/5/5	5/4–5/5	5–6	6	6–7	6–7

[a] S.P., staining on polyester; S.C., staining on cotton; C.C., colour change.

It can also be seen from Table 4 that dyes III and VI, dye polyester and cotton fabrics to almost the same depth, especially dyes III.3, III.8, III.9, IV.5, VI.1, VI.2 and VII.7. Tables 5 and 6 show that the sublimation, wet and light fastness of all the dyes on polyester and cotton fabrics are of an acceptable order to meet commercial requirements.

It can be concluded that dyes III.3, IV.5, VI.1 and VI.2 dye polyester and cotton fabrics to approximately the same depth with good build-up and fastness properties.

Acknowledgement

The financial support for this project by National Science Council of Taiwan is gratefully acknowledged.

References

[1] Baumgarte U. Rev Prog Coloration 1974;5:17.
[2] Glover B. Rev Prog Coloration 1977;8:36.
[3] Miksovsky F. Journal Soc Dyers and Colouri 1980;96:347.
[4] Jenkinson K. Journal Soc Dyers and Colouri 1979;95:384.
[5] Baumgarte U. Re Prog Coloration 1987;17:29.
[6] Fierz-David HE, Blangey L. Fundamental processes dye chemistry. New York: Interscience Publishers, 19 p. 322.
[7] Sandoz US Patent 3,060,200, 1962.
[8] Gordon PF, Gregory P. Organic chemistry in colo Berlin: Springer–Verlag, 1983, p. 176, 179–81.
[9] Chao YC, Yu CT. Dyes and pigments 1992;19:249.
[10] Peters AT, Chao YC. J Soc Dyers and Colouri 1988;104:435.
[11] Vickerstaff T. The physical chemistry of dyeing, 2nd London: Oliver and Boyd, 1954, pp. 306–9.
[12] Shore J. Colourants and auxiliaries, vol. 1. Bradford, U Society of Dyers and Colourists, 1990. p. 105.