

Effectiveness of Various UV-absorbers on the Dyeing of Polyester with Disperse Dyes. Part IV.

E. G. Tsatsaroni,^{a*} A. H. Kehayoglou,^a I. C. Eleftheriadis^a
& L. E. Kyriazis^b

^aLaboratory of Organic Chemical Technology, Aristotle University of Thessaloniki, 540 06 Thessaloniki, Greece

^bViochrom S. A., 123 51 Aghia Varvara, Attiki, Greece

(Received 9 July 1997; accepted 15 August 1997)

ABSTRACT

The effect of benzotriazole type UV-absorbers Tinuvin P and Tinuvin 327 and 2,4-dihydroxy benzophenone in the dyeing of polyester fabrics with C.I. Disperse Yellow 86 and C.I. Disperse Red 86 at various depths of dyeing was studied. Various amounts and two application processes of the UV-absorber were used. The dye and UV-absorber uptake, and the light and sublimation fastness of the fabrics dyed and those treated with the UV-absorber were determined and the results compared with those obtained with the corresponding samples dyed in absence of a UV-absorber. © 1998 Elsevier Science Ltd. All rights reserved

Keywords: UV-absorber, dyeing of polyester, disperse dyes, light fastness.

INTRODUCTION

In our prior papers [1–3] the effect of applying various amounts of UV-absorbers in the dyeing of polyester (PET) fabrics with disperse dyes was examined and discussed. In this work a further study of the application of UV-absorbers in the dyeing of polyester fabrics was carried out, since these are widely used in automobile coloured upholstery, and their light fastness and improvement thereof is of high interest in the textile industry. Thus, the

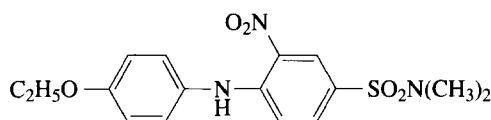
*Corresponding author.

previous [3] two benzotriazole type UV-absorbers Tinuvin P and Tinuvin 327 and 2,4-dihydroxy-benzophenone (DHB) were applied as aqueous dispersions in various amounts (0.5, 1.25 and 2% o.w.f.) by two different processes, viz., (a) direct addition of the dispersed UV-abs into the dye liquor and then reduction clearing of the dyed fabrics or (b) the dyed fabrics in the absence of a UV-abs were similarly cleared and aftertreated with the dispersed UV-absorber under the same dyeing liquor ratio and heating conditions, 135°C for 90 min. The dyes used in the dyeing of PET fabrics were of high light fastness, viz., C.I. Disperse Yellow 86 (1, Viospers Yellow 2RFS) and C.I. Disperse Red 86 (2, Viospers Brilliant Pink 2GLFS) in three depths of dyeing (0.5, 2.25, 4.0% o.w.f. of commercial dye (Viochrom S.A.) (Fig. 1).

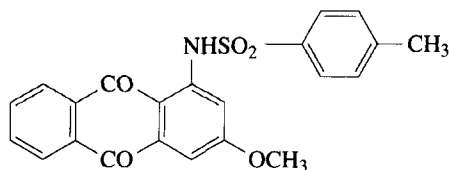
As previously [3], the effects of the application of the various UV-absorbers by the two processes on the final dye and UV-absorber uptake, their percentage adsorbed proportion on the final dyed fabrics and on the light and sublimation fastness of the dyed fabrics were compared with those of the corresponding reference dyeings carried out in the absence of a UV-absorber.

EXPERIMENTAL

Specimens (9×13 cm, approximately 3 g) of commercial polyester (PET) fabric were used. The dispersions of the three UV absorbers and the determination of their percentage content in UV-absorbers, as well as the determination of the dye concentration in the commercial dispersed dyes were carried out as previously described [3]. The commercial sample of the yellow dye 1 was found to contain 53.0%; and the red dye 36.5% (w/w) of pure dye (the balance being commercial diluents).



C.I. Disperse Yellow 86 (1)



C.I. Disperse Red 86 (2)

Fig. 1. Dyes used in the present study.

Dyeing

This was carried out as described previously [3] with the following modifications: A buffer solution of $pH = 4.5$ (instead of 5) was used and the dyeing was maintained at 135°C for 90 min (instead of 60 min). Reduction clearing [4], and the application of UV-abs. by aftertreatment were also carried out according to the previous paper [3].

Determination of dye and UV-abs uptake was effected spectrophotometrically as previously reported [3], measuring the absorbance for the yellow dye 1 at λ_{max} 419.5 nm and for the red dye 2 at λ_{max} 512.2 nm.

All determinations were made in duplicate and the results given are the mean values of the two measurements.

Light and sublimation fastness tests were carried out as in previous reports [3].

RESULTS AND DISCUSSION

The dyeing results obtained with yellow dye 1 in the absence of a UV-abs (reference samples) and by application (process A or B) of the three UV-abs Tinuvin P, Tinuvin 327 and DHB are given at Tables 1–3, respectively, and those with red dye 2 are given in Tables 4–6.

From the tables, it can be concluded that the percentage dye 1 uptake is especially high at a depth of dyeing of 0.5% o.w.f. of commercial dye, where the dye adsorption on the fibre is almost quantitative. In contrast, dye 2 uptake is medium to low for the three depths of dyeing, probably due to its bulky structural features, viz., an anthraquinone moiety with a tosylamido-substituent in an α -position (Table 1, Fig. 1). Both dyes are of high light fastness (7 grade) independent of the depth of dyeing. Sublimation fastness with respect to colour change (cc) did not depend on the depth of dyeing, while colour staining values were decreasing slightly with increasing depth of dyeing.

Application of the three UV-abs resulted in a decrease in dye uptake in most cases for both dyes 1 and 2. The UV-abs application process A seems to be more advantageous compared to B regarding the dye uptake for both dyes, probably due to a slight dye desorption during the aftertreatment, as also observed in previous studies [2]. No significant uniform effect of the UV-abs amount on the dye uptake for the same depth of dyeing can be concluded from Tables 1–6.

The percentage UV-abs uptake is not uniform for both dyes. Tinuvin P was adsorbed quantitatively in all yellow dyeings, its adsorption not being affected by depth of dyeing, amount of UV-abs or application process, while this is medium to low in all red dyeings.

TABLE 1
Dye and UV-abs Uptake and Light and Sublimation Fastness of Fabrics Dyed with 1 at Various Depths of Dyeing in Absence and/or Presence of Various Amounts of Tinuvin P (process A or B)

No.	Depth of dyeing % o.w.f. (d.o.d. in com. dye)	UV-abs % o.w.f. (UV-abs/dye mol mol ⁻¹)	UV-abs applic. proc.	g dye 100 g ⁻¹ dye fabric (% initial dye)	g UV-abs 100 g ⁻¹ dye fabric (% initial UV-abs)	UV-abs/dye (mol mol ⁻¹) on dyed fabric	Light fastness ^a	Sublimation		Fastness	
								cc	cs	cc	cs
1	0.26 (0.50)	—	—	0.26 ± 0.00 (99.8 ± 0.2)	—	—	7	5	4-5	5	4
2	0.26 (0.50)	0.50 (3.07)	A	0.25 ± 0.01 (96.1 ± 3.8)	0.49 ± 0.01 (98.0 ± 2.0)	3.19	7-8	5	4-5	5	4
3	0.26 (0.50)	0.50 (3.07)	B	0.24 ± 0.01 (92.3 ± 3.8)	0.50 ± 0.00 (100.0 ± 0.0)	3.32	7-8	5	4-5	5	4
4	0.26 (0.50)	1.25 (7.64)	A	0.24 ± 0.01 (92.3 ± 3.8)	1.25 ± 0.00 (100.0 ± 0.0)	8.32	7-8	5	4-5	5	4
5	0.26 (0.50)	1.25 (7.64)	B	0.26 ± 0.00 (100.0 ± 0.0)	1.24 ± 0.00 (99.2 ± 0.0)	7.73	7-8	5	4-5	5	4
6	0.26 (0.50)	2.00 (12.24)	A	0.25 ± 0.01 (96.1 ± 3.8)	1.99 ± 0.02 (99.5 ± 1.0)	12.96	7-8	5	4-5	5	4
7	0.26 (0.50)	2.00 (12.24)	B	0.26 ± 0.00 (100.0 ± 0.0)	2.00 ± 0.01 (100.0 ± 0.5)	12.24	7-8	5	4-5	5	4
8	1.19 (2.25)	—	—	0.96 ± 0.00 (80.7 ± 0.0)	—	—	7	5	4-5	5	3-4
9	1.19 (2.25)	0.50 (0.68)	A	0.92 ± 0.03 (77.3 ± 2.5)	0.50 ± 0.00 (100.0 ± 0.0)	0.89	7-8	5	4-5	5	3-4
10	1.19 (2.25)	0.50 (0.68)	B	0.89 ± 0.01 (74.8 ± 0.8)	0.50 ± 0.00 (100.0 ± 0.0)	0.90	7-8	5	4-5	5	3-4
11	1.19 (2.25)	1.25 (1.70)	A	0.91 ± 0.05 (76.5 ± 4.2)	1.24 ± 0.00 (99.2 ± 0.0)	3.05	7-8	5	4-5	5	3-4
12	1.19 (2.25)	1.25 (1.70)	B	0.93 ± 0.01 (78.1 ± 0.8)	1.25 ± 0.00 (100.0 ± 0.0)	2.17	7-8	5	4-5	5	3-4
13	1.19 (2.25)	2.00 (2.72)	A	0.97 ± 0.05 (81.5 ± 4.2)	2.00 ± 0.00 (100.0 ± 0.0)	3.32	7-8	5	4-5	5	3-4
14	1.19 (2.25)	2.00 (2.72)	B	0.91 ± 0.00 (76.4 ± 0.0)	1.99 ± 0.01 (99.5 ± 0.5)	3.49	7-8	5	4-5	5	3-4
15	2.12 (4.00)	—	—	1.58 ± 0.07 (74.5 ± 3.5)	—	—	7	5	4	4-5	2-3
16	2.12 (4.00)	0.50 (0.38)	A	1.48 ± 0.05 (69.8 ± 2.3)	0.50 ± 0.00 (100.0 ± 0.0)	0.55	7-8	5	4	4-5	2-3
17	2.12 (4.00)	0.50 (0.38)	B	1.42 ± 0.06 (67.0 ± 2.8)	0.49 ± 0.01 (98.2 ± 2.0)	0.55	7-8	5	4	4-5	2-3
18	2.12 (4.00)	1.25 (0.96)	A	1.59 ± 0.02 (75.0 ± 0.9)	1.24 ± 0.00 (99.2 ± 0.0)	1.26	7-8	5	4	4-5	2-3
19	2.12 (4.00)	1.25 (0.96)	B	1.61 ± 0.03 (75.9 ± 1.4)	0.24 ± 0.02 (99.2 ± 1.0)	1.24	7-8	5	4	4-5	2-3
20	2.12 (4.00)	2.00 (1.53)	A	1.45 ± 0.08 (68.4 ± 0.8)	2.00 ± 0.00 (100.0 ± 0.0)	2.24	7-8	5	4	4-5	2-3
21	2.12 (4.00)	2.00 (1.53)	B	1.59 ± 0.03 (75.0 ± 1.4)	2.00 ± 0.01 (100.0 ± 0.0)	2.04	7-8	5	4	4-5	2-3

^a Black panel temperature 50 ± 2°C.

TABLE 2
Dye and UV-abs Uptake and Light and Sublimation Fastness of Fabrics Dyed with 1 at Various Depths of Dyeing in Absence and/or Presence of Various Amounts of Tinuvin 327 (process A or B)

No.	Depth of dyeing % o.w.f. (d.o.d. in com. dye)	UV-abs % o.w.f. (UV-abs/dye mol mol ⁻¹)	UV-abs applic. proc.	g dye 100 g ⁻¹ dyed fabric (% initial dye)	g UV-abs 100 g ⁻¹ dyed fabric (% initial UV-abs)	UV-abs/dye (mol mol ⁻¹) on dyed fabric	Light fastness ^a	Sublimation		Fastness	
								cc	cs	cc	cs
1	0.26 (0.50)	—	—	0.26 ± 0.00 (99.8 ± 2)	—	—	7	5	4-5	5	4
2	0.26 (0.50)	0.50 (1.92)	A	0.25 ± 0.01 (96.0 ± 3.8)	0.45 ± 0.00 (90.0 ± 0.8)	1.81	7	5	4-5	5	4
3	0.26 (0.50)	0.50 (1.92)	B	0.26 ± 0.00 (100.0 ± 0.0)	0.49 ± 0.01 (98.0 ± 2.0)	1.88	7	5	4-5	5	3-4
4	0.26 (0.50)	1.25 (4.83)	A	0.26 ± 0.00 (100.0 ± 0.0)	0.48 ± 0.01 (38.4 ± 0.8)	2.06	7	5	4-5	5	4
5	0.26 (0.50)	1.25 (4.83)	B	0.24 ± 0.01 (92.0 ± 3.8)	0.94 ± 0.05 (75.2 ± 4.0)	3.70	7	5	4-5	5	4
6	0.26 (0.50)	2.00 (7.72)	A	0.26 ± 0.00 (100.0 ± 0.0)	0.53 ± 0.02 (26.5 ± 1.0)	2.09	7	5	4-5	5	4
7	0.26 (0.50)	2.00 (7.72)	B	0.26 ± 0.00 (100.0 ± 0.0)	1.00 ± 0.06 (50.0 ± 3.0)	3.94	7	5	4-5	5	4
8	1.19 (2.25)	—	—	0.96 ± 0.00 (80.7 ± 0.0)	—	—	7	5	4-5	5	3-4
9	1.19 (2.25)	0.50 (0.43)	A	0.92 ± 0.03 (77.3 ± 2.5)	0.49 ± 0.00 (98.0 ± 0.0)	0.55	7	5	4-5	5	3-4
10	1.19 (2.25)	0.50 (0.43)	B	0.85 ± 0.06 (71.3 ± 5.0)	0.50 ± 0.00 (100.0 ± 0.0)	0.60	7	5	4-5	5	3-4
11	1.19 (2.25)	1.25 (1.07)	A	0.97 ± 0.01 (81.5 ± 0.8)	0.59 ± 0.01 (43.2 ± 0.7)	0.62	7	5	4-5	5	3-4
12	1.19 (2.25)	1.25 (1.07)	B	0.87 ± 0.00 (73.1 ± 0.0)	1.03 ± 0.4 (82.4 ± 3.2)	1.21	7	5	4-5	5	3-4
13	1.19 (2.25)	2.00 (1.72)	A	0.90 ± 0.03 (75.6 ± 2.5)	0.60 ± 0.00 (30.0 ± 0.1)	0.68	7	5	4-5	5	3-4
14	1.19 (2.25)	2.00 (1.72)	B	0.90 ± 0.02 (75.6 ± 1.7)	1.36 ± 0.03 (68.0 ± 1.5)	1.55	7	5	4-5	5	3-4
15	2.12 (4.00)	—	—	1.58 ± 0.07 (74.5 ± 3.5)	—	—	7	5	4	4-5	2-3
16	2.12 (4.00)	0.50 (0.24)	A	1.48 ± 0.05 (69.8 ± 2.3)	0.50 ± 0.00 (100.0 ± 0.0)	0.34	7	5	4	4-5	2-3
17	2.12 (4.00)	0.50 (0.24)	B	1.44 ± 0.05 (67.9 ± 2.3)	0.50 ± 0.00 (100.0 ± 0.0)	0.36	7	5	4	4-5	2-3
18	2.12 (4.00)	1.25 (0.60)	A	1.59 ± 0.02 (75.0 ± 0.9)	0.71 ± 0.01 (56.8 ± 0.8)	0.45	7	5	4	4-5	2-3
19	2.12 (4.00)	1.25 (0.60)	B	1.37 ± 0.00 (64.6 ± 0.0)	0.90 ± 0.06 (72.0 ± 4.6)	0.66	7	5	4	4-5	2
20	2.12 (4.00)	2.00 (0.96)	A	1.44 ± 0.08 (68.2 ± 3.8)	0.74 ± 0.03 (37.0 ± 1.5)	0.53	7	5	4	4-5	2-3
21	2.12 (4.00)	2.00 (0.96)	B	1.44 ± 0.07 (67.9 ± 3.3)	0.95 ± 0.07 (47.5 ± 3.4)	0.68	7	5	4	4-5	2

^a Black panel temperature 50 ± 2°C.

TABLE 3

Dye and UV-abs Uptake and Light and Sublimation Fastness of Fabrics Dyed with 1 at Various Depths of Dyeing in Absence and/or Presence of Various Amounts of 2,4-Dihydroxybenzophenone DBH (process A or B)

No.	Depth of dyeing % o.w.f. (d.o.d. in com. dye)	UV-abs % o.w.f. (UV-abs/dye mol mol ⁻¹)	UV-abs applic. proc.	g dye 100 g ⁻¹ dye fabric (% initial dye)	g UV-abs 100 g ⁻¹ dye fabric (% initial UV-abs)	UV-abs/dye (mol mol ⁻¹) on dyed fabric	Light fastness ^a (180°C)	Sublimation Fastness (210°C)		
								cc	cs	cc
1	0.26 (0.50)	—	—	0.26 ± 0.00 (99.8 ± 0.2)	—	—	7	5	4-5	5 4
2	0.26 (0.50)	0.50 (3.21)	A	0.26 ± 0.00 (99.8 ± 0.2)	0.15 ± 0.00 (30.0 ± 0.0)	0.96	7	5	4-5	5 4
3	0.26 (0.50)	0.50 (3.21)	B	0.17 ± 0.00 (65.4 ± 0.0)	0.23 ± 0.00 (46.0 ± 0.0)	2.24	7	5	4-5	5 4-5
4	0.26 (0.50)	1.25 (8.04)	A	0.23 ± 0.01 (88.4 ± 3.8)	0.51 ± 0.10 (40.8 ± 8.0)	3.81	7	5	4-5	5 4
5	0.26 (0.50)	1.25 (8.04)	B	0.16 ± 0.00 (61.5 ± 0.0)	0.48 ± 0.00 (36.0 ± 0.0)	4.83	7	5	4-5	5 4-5
6	0.26 (0.50)	2.00 (1.87)	A	0.21 ± 0.00 (80.8 ± 0.0)	0.97 ± 0.01 (48.5 ± 0.5)	7.79	7	5	4-5	5 4
7	0.26 (0.50)	2.00 (1.87)	B	0.17 ± 0.01 (65.4 ± 3.8)	0.69 ± 0.04 (34.5 ± 2.0)	6.94	7	5	4-5	5 4-5
8	1.19 (2.25)	—	—	0.96 ± 0.00 (80.7 ± 0.0)	—	—	7	5	4-5	5 3-4
9	1.19 (2.25)	0.50 (0.72)	A	0.92 ± 0.00 (77.3 ± 0.0)	0.23 ± 0.00 (46.0 ± 0.0)	0.41	7	5	4-5	5 3-4
10	1.19 (2.25)	0.50 (0.72)	B	0.88 ± 0.00 (73.9 ± 0.0)	0.24 ± 0.00 (48.0 ± 0.0)	0.47	7	5	4-5	5 3-4
11	1.19 (2.25)	1.25 (1.79)	A	0.98 ± 0.05 (82.3 ± 4.2)	0.36 ± 0.00 (28.8 ± 0.0)	0.62	7	5	4-5	5 3-4
12	1.19 (2.25)	1.25 (1.79)	B	0.88 ± 0.00 (73.9 ± 0.0)	0.49 ± 0.00 (39.2 ± 0.0)	0.94	7	5	4-5	5 3-4
13	1.19 (2.25)	2.00 (2.85)	A	0.99 ± 0.05 (83.2 ± 4.2)	0.69 ± 0.00 (34.5 ± 0.0)	1.19	7	5	4-5	5 3-4
14	1.29 (2.25)	2.00 (2.85)	B	0.85 ± 0.01 (71.4 ± 0.8)	0.72 ± 0.01 (36.0 ± 0.5)	1.43	7	5	4-5	5 3-4
15	2.12 (4.00)	—	—	1.58 ± 0.07 (74.5 ± 3.5)	—	—	7	5	4	4-5 2-3
16	2.12 (4.00)	0.50 (0.40)	A	1.55 ± 0.16 (73.1 ± 7.5)	0.26 ± 0.02 (52.0 ± 4.0)	0.32	7-8	5	4	4-5 2-3
17	2.12 (4.00)	0.50 (0.40)	B	1.36 ± 0.06 (64.1 ± 2.8)	0.34 ± 0.02 (68.0 ± 4.0)	0.43	7-8	5	4	4-5 2-3
18	2.12 (4.00)	1.25 (1.00)	A	1.30 ± 0.16 (61.3 ± 7.5)	0.51 ± 0.10 (40.8 ± 8.0)	0.66	7-8	5	4	4-5 2-3
19	2.12 (4.00)	1.25 (1.00)	B	1.50 ± 0.02 (70.7 ± 0.9)	0.73 ± 0.10 (58.4 ± 8.0)	0.83	7-8	5	4	4-5 2
20	2.12 (4.00)	2.00 (1.60)	A	1.56 ± 0.01 (73.6 ± 0.47)	0.97 ± 0.01 (48.5 ± 0.5)	1.05	7-8	5	4	4-5 2-3
21	2.12 (4.00)	2.00 (1.60)	B	1.44 ± 0.06 (67.9 ± 2.8)	0.72 ± 0.11 (36.0 ± 5.5)	0.85	7-8	5	4	4-5 2

^a Black panel temperature 50 ± 2°C.

TABLE 4

Dye and UV-abs Uptake and Light and Sublimation Fastness of Fabrics Dyed with 2 at Various Depths of Dyeing in Absence and/or Presence of Various Amounts of Tinuvin P (process A or B)

No.	Depth of dyeing % o.w.f. (d.o.d. in com. dye)	UV-abs % o.w.f. (UV-abs/dye mol mol ⁻¹)	UV-abs applic. proc.	g dye 100 g ⁻¹ dye fabric (% initial dye)	g UV-abs 100 g ⁻¹ dye fabric (% initial UV-abs)	UV-abs/dye (mol mol ⁻¹) on dyed fabric	Light fastness ^a (210°C)	Sublimation		Fastness	
								cc	cs	cc	cs
1	0.18 (0.50)	—	—	0.06 ± 0.00 (36.0 ± 2.0)	—	—	7	5	5	5	4-5
2	0.18 (0.50)	0.50 (4.96)	A	0.05 ± 0.01 (27.8 ± 5.5)	0.10 ± 0.01 (20.0 ± 2.0)	3.53	7-8	5	5	5	4-5
3	0.18 (0.50)	0.50 (4.96)	B	0.04 ± 0.00 (22.2 ± 0.0)	0.19 ± 0.01 (38.0 ± 2.0)	8.55	7-8	5	5	5	4-5
4	0.18 (0.50)	1.25 (12.38)	A	0.05 ± 0.00 (27.8 ± 0.0)	0.24 ± 0.01 (19.2 ± 0.5)	9.15	7-8	5	5	5	4-5
5	0.18 (0.50)	1.25 (12.38)	B	0.05 ± 0.00 (27.8 ± 0.0)	0.44 ± 0.03 (35.2 ± 2.4)	14.52	7-8	5	5	5	4-5
6	0.18 (0.50)	2.00 (19.81)	A	0.04 ± 0.00 (22.2 ± 0.0)	0.34 ± 0.00 (17.0 ± 0.0)	14.03	7-8	5	5	5	4-5
7	0.18 (0.50)	2.00 (19.81)	B	0.05 ± 0.01 (27.8 ± 5.5)	0.72 ± 0.01 (36.0 ± 0.4)	23.78	7-8	5	5	5	4-5
8	0.82 (2.25)	—	—	0.28 ± 0.01 (34.7 ± 1.3)	—	—	7	5	4-5	5	3-4
9	0.82 (2.25)	0.50 (1.09)	A	0.30 ± 0.00 (36.6 ± 0.0)	0.10 ± 0.00 (20.0 ± 0.0)	0.57	7-8	5	4-5	5	3-4
10	0.82 (2.25)	0.50 (1.09)	B	0.27 ± 0.01 (32.9 ± 1.2)	0.23 ± 0.02 (46.0 ± 3.2)	1.51	7-8	5	4-5	5	3-4
11	0.82 (2.25)	1.25 (2.74)	A	0.27 ± 0.01 (32.9 ± 1.2)	0.20 ± 0.00 (16.0 ± 0.0)	1.31	7-8	5	4-5	5	3-4
12	0.82 (2.25)	1.25 (2.74)	B	0.25 ± 0.01 (30.5 ± 1.2)	0.47 ± 0.01 (37.6 ± 0.2)	3.37	7-8	5	4-5	5	3-4
13	0.82 (2.25)	2.00 (4.38)	A	0.27 ± 0.00 (32.9 ± 0.0)	0.31 ± 0.00 (15.5 ± 0.0)	2.11	7-8	5	4-5	5	3-4
14	0.82 (2.25)	2.00 (4.38)	B	0.29 ± 0.01 (35.4 ± 1.2)	0.83 ± 0.00 (41.5 ± 0.0)	5.20	7-8	5	4-5	5	3-4
15	1.46 (4.00)	—	—	0.50 ± 0.01 (34.2 ± 0.5)	—	—	7	5	4-5	5	3-4
16	1.46 (4.00)	0.50 (0.60)	A	0.38 ± 0.00 (26.0 ± 0.0)	0.16 ± 0.00 (32.0 ± 0.0)	0.74	7-8	5	4-5	5	3-4
17	1.46 (4.00)	0.50 (0.60)	B	0.36 ± 0.01 (24.6 ± 0.7)	0.20 ± 0.01 (40.0 ± 0.6)	0.98	7-8	5	4-5	5	3-4
18	1.46 (4.00)	1.25 (1.56)	A	0.45 ± 0.01 (30.8 ± 0.7)	0.31 ± 0.01 (24.8 ± 0.8)	1.23	7	5	4-5	5	3-4
19	1.46 (4.00)	1.25 (1.56)	B	0.36 ± 0.00 (24.6 ± 0.0)	0.44 ± 0.03 (35.2 ± 2.4)	2.16	7-8	5	4-5	5	3-4
20	1.46 (4.00)	2.00 (2.46)	A	0.39 ± 0.03 (26.7 ± 2.0)	0.44 ± 0.00 (22.0 ± 0.0)	2.03	7	5	4-5	5	3-4
21	1.46 (4.00)	2.00 (2.46)	B	0.36 ± 0.00 (24.6 ± 0.0)	0.83 ± 0.00 (41.5 ± 0.0)	4.11	7-8	5	4-5	5	3-4

^a Black panel temperature 50 ± 2°C.

TABLE 5

Dye and UV-abs Uptake and Light and Sublimation Fastness of Fabrics Dyed with 2 at Various Depths of Dyeing in Absence and/or Presence of Various Amounts of Tinuvin 327 (process A or B)

No.	Depth of dyeing % o.w.f. (d.o.d. in com. dye)	UV-abs % o.w.f. (UV-abs/dye mol mol ⁻¹)	UV-abs applic. proc.	g dye 100 g ⁻¹ dyed fabric (% initial dye)	g UV-abs 100 g ⁻¹ dyed fabric (% initial UV-abs)	UV-abs/dye (mol mol ⁻¹) on dyed fabric	Light fastness ^a	Sublimation		Fastness	
								cc	cs	cc	cs
1	0.18 (0.50)	—	—	0.06 ± 0.00 (33.3 ± 0.0)	—	—	7	5	5	5	4-5
2	0.18 (0.50)	0.50 (3.12)	A	0.06 ± 0.00 (33.3 ± 0.0)	0.50 ± 0.00 (100.0 ± 0.0)	9.20	7-8	5	5	5	4-5
3	0.18 (0.50)	0.50 (3.12)	B	0.04 ± 0.00 (22.2 ± 0.0)	0.38 ± 0.01 (76.0 ± 1.6)	10.82	7-8	5	5	5	4-5
4	0.18 (0.50)	1.25 (7.83)	A	0.09 ± 0.01 (50.0 ± 5.5)	1.20 ± 0.05 (96.0 ± 4.0)	22.11	7-8	5	5	5	4-5
5	0.18 (0.50)	1.25 (7.83)	B	0.06 ± 0.00 (33.3 ± 0.0)	0.54 ± 0.01 (43.2 ± 1.0)	14.08	7-8	5	5	5	4-5
6	0.18 (0.50)	2.00 (12.52)	A	0.06 ± 0.00 (33.3 ± 0.0)	1.90 ± 0.01 (95.0 ± 0.5)	33.04	7-8	5	5	5	4-5
7	0.18 (0.50)	2.00 (12.52)	B	0.04 ± 0.00 (22.2 ± 0.0)	0.57 ± 0.00 (28.5 ± 0.0)	16.22	7-8	5	5	5	4-5
8	0.82 (2.25)	—	—	0.28 ± 0.01 (34.7 ± 1.3)	—	—	7	5	5	5	3-4
9	0.82 (2.25)	0.50 (0.68)	A	0.29 ± 0.01 (35.4 ± 1.2)	0.48 ± 0.00 (96.0 ± 0.4)	1.86	7-8	5	5	5	3-4
10	0.82 (2.25)	0.50 (0.68)	B	0.27 ± 0.01 (32.9 ± 1.3)	0.41 ± 0.01 (82.0 ± 2.8)	1.73	7-8	5	5	5	3-4
11	0.82 (2.25)	1.25 (1.70)	A	0.30 ± 0.01 (36.6 ± 4.8)	0.58 ± 0.01 (46.4 ± 0.8)	2.22	7-8	5	5	5	3-4
12	0.82 (2.25)	1.25 (1.70)	B	0.27 ± 0.00 (32.9 ± 0.0)	0.54 ± 0.01 (43.2 ± 1.1)	2.25	7-8	5	5	5	3-4
13	0.82 (2.25)	2.00 (2.79)	A	0.28 ± 0.01 (34.1 ± 1.2)	0.60 ± 0.00 (30.0 ± 0.0)	2.46	7-8	5	5	5	3-4
14	0.82 (2.25)	2.00 (2.79)	B	0.26 ± 0.01 (31.7 ± 1.2)	0.59 ± 0.01 (29.5 ± 0.5)	2.55	7-8	5	5	5	3-4
15	1.46 (4.00)	—	—	0.50 ± 0.01 (34.2 ± 0.5)	—	—	7	5	5	5	3-4
16	1.46 (4.00)	0.50 (0.38)	A	0.39 ± 0.02 (26.7 ± 1.3)	0.49 ± 0.01 (98.0 ± 2.0)	1.42	7-8	5	5	5	3-4
17	1.46 (4.00)	0.50 (0.38)	B	0.34 ± 0.00 (23.3 ± 0.0)	0.49 ± 0.01 (98.0 ± 2.0)	1.64	7-8	5	5	5	3-4
18	1.46 (4.00)	1.25 (0.99)	A	0.38 ± 0.00 (26.0 ± 0.0)	0.64 ± 0.01 (51.2 ± 0.7)	1.92	7-8	5	5	5	3-4
19	1.46 (4.00)	1.25 (0.99)	B	0.33 ± 0.00 (22.6 ± 0.0)	0.62 ± 0.01 (40.0 ± 0.5)	2.16	7-8	5	5	5	3-4
20	1.46 (4.00)	2.00 (1.56)	A	0.47 ± 0.00 (32.2 ± 0.0)	0.80 ± 0.01 (40.0 ± 0.5)	1.92	7-8	5	5	5	3-4
21	1.46 (4.00)	2.00 (1.56)	B	0.34 ± 0.00 (23.3 ± 0.0)	0.74 ± 0.00 (37.0 ± 0.2)	2.49	7-8	5	5	5	3-4

^a Black panel temperature 50 ± 2°C.

TABLE 6
Dye and UV-abs Uptake and Light and Sublimation Fastness of Fabrics Dyed with **2** at Various Depths of Dyeing in Absence and/or Presence of Various Amounts of 2,4-Dihydroxybenzophenone DHB (process A or B)

No.	Depth of dyeing % o.w.f. (d.o.d.) in com. dye	UV-abs % o.w.f. (UV-abs/dye mol mol ⁻¹)	UV-abs applic. proc.	g dye 100 g ⁻¹ dye fabric (% initial dye)	g UV-abs 100 g ⁻¹ dye fabric (% initial UV-abs)	UV-abs/dye (mol mol ⁻¹) on dyed fabric	Light fastness ^a on dyed fabric	Sublimation Fastness (180°C)		Sublimation Fastness (210°C)	
								cc	cs	cc	cs
1	0.18 (0.50)	—	—	0.06 ± 0.00 (33.3 ± 0.0)	—	—	7	5	5	5	4-5
2	0.18 (0.50)	0.50 (5.20)	A	0.06 ± 0.00 (33.3 ± 0.0)	0.10 ± 0.00 (20.0 ± 0.0)	3.26	7	5	5	5	4-5
3	0.18 (0.50)	0.50 (5.20)	B	0.06 ± 0.00 (33.3 ± 0.0)	0.10 ± 0.00 (20.0 ± 0.0)	2.90	7	5	5	5	4-5
4	0.18 (0.50)	1.25 (13.04)	A	0.06 ± 0.00 (33.3 ± 0.0)	0.21 ± 0.01 (16.2 ± 0.8)	6.85	7	5	5	5	4-5
5	0.18 (0.50)	1.25 (13.04)	B	0.06 ± 0.00 (33.3 ± 0.0)	0.19 ± 0.01 (15.2 ± 0.8)	5.83	7	5	5	5	4-5
6	0.18 (0.50)	2.00 (20.88)	A	0.05 ± 0.00 (27.8 ± 0.0)	0.36 ± 0.00 (18.0 ± 0.0)	11.72	7	5	5	5	4-5
7	0.18 (0.50)	2.00 (20.88)	B	0.05 ± 0.00 (27.8 ± 0.0)	0.35 ± 0.00 (17.5 ± 0.0)	11.40	7	5	5	5	4-5
8	0.82 (2.25)	—	—	0.28 ± 0.01 (34.7 ± 1.3)	—	—	7	5	4-5	5	3-4
9	0.82 (2.25)	0.50 (1.15)	A	0.29 ± 0.02 (35.3 ± 2.4)	0.15 ± 0.01 (30.0 ± 2.0)	0.98	7-8	5	4-5	5	3-4
10	0.82 (2.25)	0.50 (1.15)	B	0.25 ± 0.01 (30.4 ± 1.2)	0.17 ± 0.00 (34.0 ± 0.0)	1.26	7-8	5	4-5	5	3-4
11	0.82 (2.25)	1.25 (2.90)	A	0.29 ± 0.01 (35.3 ± 1.2)	0.32 ± 0.01 (25.6 ± 2.4)	2.08	7	5	4-5	5	3-4
12	0.82 (2.25)	1.25 (2.90)	B	0.29 ± 0.00 (35.3 ± 0.0)	0.27 ± 0.05 (21.6 ± 0.4)	1.75	7-8	5	4-5	5	3-4
13	0.82 (2.25)	2.00 (4.63)	A	0.26 ± 0.03 (31.7 ± 3.6)	0.49 ± 0.00 (24.5 ± 0.2)	3.53	7	5	4-5	5	3-4
14	0.82 (2.25)	2.00 (4.63)	B	0.22 ± 0.01 (26.8 ± 1.2)	0.37 ± 0.00 (18.5 ± 0.1)	2.87	7-8	5	4-5	5	3-4
15	1.46 (4.00)	—	—	0.50 ± 0.01 (34.2 ± 0.5)	—	—	7	5	4-5	5	3-4
16	1.46 (4.00)	0.50 (0.66)	A	0.44 ± 0.01 (30.1 ± 0.7)	0.14 ± 0.00 (28.0 ± 0.2)	0.60	7-8	5	4-5	5	3-4
17	1.46 (4.00)	0.50 (0.66)	B	0.40 ± 0.07 (27.4 ± 4.8)	0.13 ± 0.01 (26.0 ± 2.0)	0.63	7-8	5	4-5	5	3-4
18	1.46 (4.00)	1.25 (1.62)	A	0.48 ± 0.02 (32.9 ± 1.4)	0.34 ± 0.01 (27.2 ± 0.4)	0.34	7	5	4-5	5	3-4
19	1.46 (4.00)	1.25 (1.62)	B	0.43 ± 0.00 (29.4 ± 0.0)	0.27 ± 0.00 (21.6 ± 0.0)	1.18	7	5	4-5	5	3-4
20	1.46 (4.00)	2.00 (2.60)	A	0.52 ± 0.01 (35.6 ± 0.7)	0.46 ± 0.01 (23.0 ± 0.3)	1.67	7	5	4-5	5	3-4
21	1.46 (4.00)	2.00 (2.60)	B	0.42 ± 0.00 (28.8 ± 0.0)	0.38 ± 0.01 (19.0 ± 0.5)	1.70	7	5	4-5	5	3-4

^a Black panel temperature 50 ± 2°C.

Percentage uptake of Tinuvin 327 is very high in the case of initial amount 0.5% o.w.f. in all depths of dyeing and for both dyes, while it remains in medium levels in all other cases.

Finally, DHB adsorption is medium to low especially on the red dyeings. Similar results were also obtained in previous studies [2, 3], where 2, 4-dihydroxybenzophenone showed significantly lower exhaustion values than the benzotriazole type UV-absorbers. This results in lower DHB/dye molar ratios on the dyed fabric than the initial ones in almost all cases (Tables 3 and 6), whereas such a regularity was not generally observed for Tinuvin P and 327 (Tables 1, 2, 4 and 5).

The low adsorption values of DHB could be attributed to the existence of 2-OH and 4-OH hydrophilic substituents in the benzophenone molecule, which reduce its affinity to the hydrophobic polyester fibre.

Except for the case of Tinuvin P application on yellow dyeings, where its adsorption is quantitative, and of DHB application on red dyeings, where the application process does not seem to affect the UV-abs content on the final dyed sample, aftertreatment of the dyed fabrics (process B) generally results in a higher UV-abs content on the dyed fabric compared to the corresponding ones of process A. This could be due to the fact that reduction clearing (by which part of the UV-abs adsorbed on the dyed fabric during process A is removed) takes place before the aftertreatment (process B) (Tables 2–5).

Light fastness values of the dyed fabrics were not uniformly influenced by the use of the three UV-abs. Application of Tinuvin P resulted in an improvement (0.5 units of the blue standard scale 1–8) in light fastness compared to the reference samples of both dyes in all cases (Tables 1–4), while that of Tinuvin 327 did not affect the light fastness of the yellow dyeings (Table 2), but only the red dyeings (improvement 0.5 units of the blue standard scale 1–8) (Table 5). Application of DHB did not affect the yellow dyeings, except for those with 4.0% depth of dyeing of the commercial dye, and red dyeings of 0.5% o.w.f. depth of dyeing (commercial dye) (Tables 3 and 4), while in all other cases a slight improvement in light fastness values (0.5 units) compared to the corresponding reference sample was observed, although its percentage adsorption values were lower than of Tinuvin P and 327, as previously noted.

The amount of UV-abs for the same depth of dyeing and UV-abs application process apparently do not influence the light fastness of the dyed fabric. Similar results were obtained previously [3]. Application of the three UV-abs in dyeing with both 1 and 2 showed no significant effect on the sublimation fastness of the dyed fabrics.

ACKNOWLEDGEMENTS

This work was supported by the General Secretariat of Research and Technology, Ministry of Industry Research and Technology and VIOCHROM S.A. (Greece). Thanks are also due to Ciba-Geigy Hellas S.A. for the supply of Tinuvin P and Tinuvin 327.

REFERENCES

1. Kehayoglou, A. H. and Tsatsaroni, E. G., *Dyes and Pigments*, 1993, **23**, 53.
2. Tsatsaroni, E. G. and Kehayoglou, A. H., *Dyes and Pigments*, 1995, **28**, 123.
3. Kehayoglou, A. H. and Tsatsaroni, E. G., Eleftheriadis, I. C., Loufakis K. C., and Kyriazis, L. E., *Dyes and Pigments*, 1997, **34**, 207.
4. Broadhurst, R., Dyeing of polyester fibres. In *The Dyeing of Synthetic—Polymer and Acetate Fibres*, ed. D. M. Nunn. The Society of Dyers and Colourists, Bradford, 1979, p. 175.