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ScienceDirect
Dyes and Pigments 77 (2008) 86–91
DYES and PIGMENTS
www.elsevier.com/locate/dyepig

A polyvinyl alcohol aftertreatment for nylon 6,6. Part 2: Complex formation

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Received 16 July 2006; accepted 3 April 2007
Available online 1 May 2007

Abstract

The effectiveness of a PVA aftertreatment in improving the fastness of acid dyes to repeated washing at 40, 50 and 60 °C was enhanced by the sequential application of an organic titanate, $MgSO_4$ and a protease enzyme. This was attributed to the formation of a large molecular size, low water-solubility complex situated at the surface of the dyed substrate which physically resists diffusion of dye from the dyed fabric during washing. Although aftertreatment with each of four PVA-based aftertreatments reduced the lightness and chroma of the red and, in particular, the yellow dyeings, it had little effect on the colour of black dyeings.

Keywords: Nylon 6,6; Acid dyes; Aftertreatment; PVA; Tannic acid

1. Introduction

Although tannic acid, used either alone [1] or in conjunction with potassium antimony tartrate [2], metal salts [3,4], or protease enzymes [5–7], is very effective in improving the wash fastness of acid dyes on nylon 6,6, as tannic acid imparts a yellowish brown hue to dyeings [2], it was decided to determine if the high M_r gallotannin could be replaced by polyvinyl alcohol (PVA). The first part of this paper [8] showed that the fastness, to repeated washing at 50 °C, of three acid dyes on nylon 6,6 was improved by an aftertreatment with polyvinyl alcohol. Whilst aftertreatment reduced the lightness and chroma of red and, in particular, yellow dyeings, it had little effect on the colour of black dyeings; the extent of this shade change did not increase significantly with increasing amounts of PVA used. Although PVA imparted a yellow colouration to undyed fabric, the extent of this shade change was much lower than that imparted by the same concentration of tannic acid.

Having obtained promising results using PVA as an aftertreatment [8], it was decided to determine the effectiveness of the polymer when used in conjunction with metal salts and protease enzymes, using a repeated wash testing protocol at three temperatures (40, 50 and 60 °C), in recognition of the wide range of washing temperatures commonly used in Northern Europe.

2. Experimental

2.1. Materials

The scoured, knitted nylon 6,6 fabric described earlier [8], which was kindly supplied by Dupont (UK), was used; the three commercial acid dyes (Table 1) that had been previously used [8] were again employed. A sample of the enzyme *Savinase* was kindly provided by Novazyme; *Celvol 540* (87–89% hydrolysed PVA) was obtained from Celanese chemicals, *Tyzor TE* (triethanolamine titanate; **1**) was generously supplied by DuPont (US) and magnesium sulphate was obtained from Aldrich. All other chemicals were laboratory grade reagents.

2.2. Dyeing

The dyes were applied using the equipment and methods described earlier [8]; the pH was adjusted using McIlvaine

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doi:10.1016/j.dyepig.2007.04.001

Table 1
Dyes used

Commercial name	Type	C.I generic name
Nylanthrene Black C-DPL	Non-metallised acid	None ascribed
Neutrilan Red K-2G	Unsulfonated 1:2 pre-metallised	None ascribed
Nylanthrene Yellow C-3RL	Non-metallised acid	Acid Orange 67

Table 2
Colorimetric data for untreated dyeings

Dye	Wash temp/°C	No. of washes	L^*	a^*	b^*	C^*	h^0	$f(k)$
Red K-2G	–	0	39.8	47.5	20.2	51.6	23.0	96.4
	40	5	40.7	48.6	21.5	53.2	23.8	94.7
	50	5	40.4	47.7	20.6	51.9	23.4	93.2
	60	5	41.0	47.5	21	51.9	23.8	89.3
Yellow C-3RL	–	0	67.4	32.9	78.1	84.7	67.1	80.6
	40	5	68.2	31.0	76.0	82.1	67.7	68.9
	50	5	69.6	28.9	73.7	79.2	68.5	55.3
	60	5	72.3	24.6	68.3	72.6	70.1	35.7
Black C-DPL	–	0	20.9	0.2	−4.5	4.5	273.6	188.4
	40	5	21.2	0.1	−4.7	4.7	271.6	183.8
	50	5	22.1	0.1	−4.8	4.8	271.9	170.3
	60	5	23.4	0.1	−5.2	5.2	271.9	151.8

buffer. The dyeings were rinsed thoroughly in tap water and allowed to dry in the open air.

2.3. PVA aftertreatment

The aftertreatment method is given in Fig. 1; the equipment described earlier [1] was used, the application pH (pH 3) being adjusted using McIlvaine buffer. The aftertreated samples were removed, rinsed thoroughly in tap water and allowed to air dry.

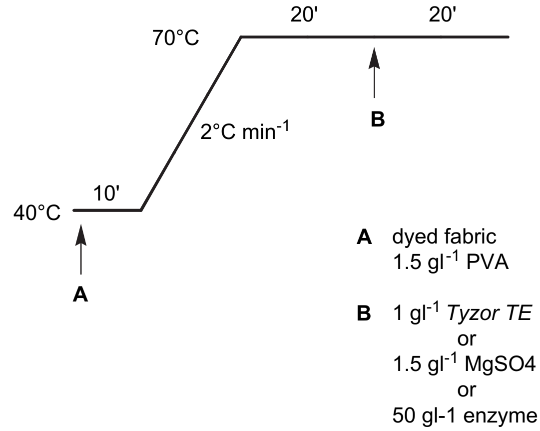

Fig. 1. Two-stage aftertreatment method.

2.4. Colour measurement

All measurements were carried out using the equipment and procedures described earlier [8].

2.5. Wash fastness

Three ISO wash tests, namely ISO CO6/A2S (40 °C), ISO CO6/B2S (50 °C) and ISO CO6/C2S (60 °C) [9] were used but were modified in that dyeings were subjected to five consecutive wash tests and, at the end of each wash test, the washed sample was rinsed thoroughly in tap water (but was not dried) and a fresh sample of SDC multifibre strip was used to assess the extent of staining for each of the five wash tests.

3. Results and discussions

The moderate fastness to washing of the three dyes on nylon 6,6 is clearly evident from the reduction in colour strength $f(k)$ (Table 2) which the dyeings underwent as a consequence of their submission to five repeated wash tests. It is also apparent that the reduction in colour strength increased with increasing temperature of wash testing due to the corresponding increase in removal of dye from the dyed samples during wash testing. The colorimetric data presented in Table 2 show that the changes observed for the three dyes can be attributed to loss of dye from the dyeings rather than to changes in the colour of the dyeings; the effect of increasing washing temperature on the extent of dye loss is clear, especially in the case of the yellow dye at 60 °C. Table 3 shows the change in shade of the dyeings that occurred as a result of the five repeated wash tests; all three dyes displayed poor fastness, especially the yellow dye. The increase in shade change that accompanied an increase in wash temperature is attributable to an increase in the amount of dye removed from the dyeings. The extent of staining of adjacent multifibre strip by vagrant dye, as a result of the five, consecutive wash tests is also shown in Table 3.

Table 3
Shade change and staining of adjacent multifibre strip achieved for untreated dyeings

Dye	No. of washes	Change in shade	Wool	Acrylic	Polyester	Nylon 6,6	Cotton	2° Acetate
Red K-2G	1	**3** 2/3* (1/2)	**5** 5* (5)	**5** 5* (5)	**5** 5* (5)	**2/3** 1* (1)	**5** 5* (5)	**5** 5* (5)
	5	**1** 1* (1)	**5** 5* (5)	**5** 5* (5)	**5** 5* (5)	**3** 2* (2)	**5** 5* (5)	**5** 5* (5)
Yellow C-3RL	1	**2** 2* (2)	**5** 2* (2)	**5** 5* (4)	**5** 4* (3)	**2** 1/2* (1)	**5** 4* (4)	**2** 1/2* (1)
	5	**1** 1/2* (1)	**5** 4* (2/3)	**5** 5* (5)	**5** 4/5* (4)	**3** 2/3* (2)	**5** 4/5* (4/5)	**3** 2/3* (2)
Black C-DPL	1	**2** 1/2* (1)	**5** 4/5* (3)	**3** 2/3* (2/3)	**5** 4/5* (4/5)	**2** 1/2* (1)	**5** 5* (4/5)	**5** 5* (5)
	5	**1/2** 1* (1)	**5** 5* (4)	**4** 3/4* (4)	**5** 5* (5)	**2/3** 2* (2)	**5** 5* (5)	**5** 5* (5)

Bold = 40 °C; * = 50 °C; () = 60 °C.