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Effect of Chitin Biopolymer on Dyeing Polyester/Cotton Fabrics with Disperse/Reactive Dyes

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Abstract: In this research into the process of dyeing polyester/cotton fabrics using disperse/reactive dyestuffs in one method dyeing processes. In order to improve the adhesion of chitin to the surface of polyester/cotton fibers, pre-treatment in NaOH solutions was performed. The colour and rubbing fastness properties of the chitin-deposited polyester/cotton fabrics were assessed. The colour difference between the dyed blank samples and samples dyed in after NaOH and/or different viscosity chitin treatment was estimated using spectrophotometer evaluation. The data obtained showed that it was possible to dye polyester/cotton fabrics finished by chitin with only one disperses/reactive dyestuff, which normally shows substantively to cellulose fibers. The dyed samples showed good rubbing and washing colour fastness properties within the range of colour change. The colour strength of the dyed samples increased with the increased deposition of chitin on the fabric.

Key words: Disperse/reactive dyestuff, one bath method, polyester/cotton fabric, chitin biopolymer, sulphatoethylsulphonyl

INTRODUCTION

Costumers generally will accept polyester/cotton textile fabrics. The selection of these fibres ensured sufficient comfort resulting mainly from the use of cotton fibres, as well as suitable mechanical properties such as the tensile strength characteristic of synthetic fibres. However, the presence of both components (polyester/ cotton) in textiles causes some difficulties in the dyeing process (Swiderski, 2000). Polyester fibres show a hydrophobic character and swell to a very small extent in the water bath. Hence, the access of the dyestuff molecules to the fibres inside is very difficult. This fact, together with an absence of active chemical groups in polyester's macromolecules makes it impossible to apply the majority of dyestuffs apart from disperse dyes (Perez *et al*., 2002; Neamtu *et al*., 2002; Erra *et al*., 1999). On the contrary, hydrophilic cellulose fibres may easily undergo swelling in water. Owing to this phenomenon, the dyestuff molecules first adsorbed on the fibre surface may diffuse into the fibre interior. Subsequently, the bonding interactions between the dyestuff and cellulose may be formed (Julia and Pascual, 2000).

In spite of their advantages, polyester fibres are difficult to dye. The often applied pressure method requires a suitable, intricate apparatus which causes great energy consumption. In order to obtain an intensive colour strength of polyester fibres, dispersing or carrier material agents are often added to the dye bath. These agents can often cause sensitization of the human skin. Moreover, the small amount of them left on the polyester fibres reduces colour fastness to light (Arslan, 2001; Bhattacharya, 1992).

It is possible to eliminate disperse dyestuffs and the detrimental auxiliary agents by the application of natural polymer such as chitin in the textile finishing processes (Shridhar *et al*., 1995; Legrini *et al*., 1993).

MATERIALS AND METHODS

Fabrics: Polyester/cotton fabric its 65/35 blends, enzymatic method with 2 g L^{-1} by Baylase AT (Bayer Co. Germany) at 70°C 40 min and then washing hot water with add 0.5 g L^{-1} nonionic soap, scoured and bleaching H_2O_2 35% 4 g L^{-1}, NaOH 30% 2 g L^{-1}, stabilizer 2 g L^{-1}, wetting agents 1 g L^{-1} in 90°C at 45 min and then washing hot water and cold water and air dried at room temperature when finishing in pretreatment dyeing with disperse/reactive sulphatoethylsulphonyl dyes.

Polyester/cotton fabric, PE/CO 65/35 (120 g m^{-2}), containing in warp and weft disperse/reactive ions PE/C0 65/35 yarns of linear density 10×2 tex. The samples were washed for 50 min in an aqueous solution containing 2 g L^{-1} of wetting agent Diadavin EWN (Product by Bayer Co. Germany) with a liquor ratio of 1:30 at 70°C and then rinsed in cold water and dried at 100°C. In order to

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Table 1: The chitin samples characteristics; the viscosity was determined for a 1-7% solution of chitin in a 1.5% solution of acetic acid at a temperature of 30°C, by means of a Brookfield Viscometer at 40 rpm

Property	Chitin 1	Chitin 2	Chitin 3
Dry mass (%)	96.50	88.90	89.40
Ash content (%)	1.29	0.28	1.10
Acetylating degree (%)	0.82	0.65	77.60
Viscosity (M.Pas)	19.70	0.1228	0.24

improve the adhesion of chitin to the smooth surface of polyester fibres, an alkaline pretreatment in water solution containing 0, 5, 10, and 15 g L^{-1} of NaOH for 25 min at 95°C with a liquor ratio of 1:30 was performed. Subsequently, the samples were rinsed twice in cold water and dried at 100°C. Three chitin samples of different viscosity and different deacetylation degree, produced by the Sails Chem. Co Iran were used. The properties of the samples are shown in Table 1.

The chitin flakes were dissolved in an aqueous 1.5% acetic acid. After adding a cross linking agent (glutar aldehyde, 4% w/w, calculated to the weight of pure chitin). The samples were immersed in the chitin solutions in the special laboratory padding squeezing machine, made by Atlas Co. This process was repeated several times to ensure the even deposition of chitin on the fabric surface. Then the samples were dried at 98°C for 35 sec and subjected to a thermo fixation process at 145°C for 20 sec.

The chitin amount deposition on the surface fabric was determined an according to the Eq. 1:

$$p = \frac{T.a}{d} \qquad (1)$$

Where:

p = The chitin amount deposited on the fabric (%) calculated in relation to the weight of fabrics
a = The chitin concentration in the padding solution (g L^{-1})
T = The chitin pick-up, in % (80% for Polyester/cotton blends)
d = The density of the chitin solutions, (Approximately 1 g L^{-1} for all chitin solutions)

A chitin solution of concentration 20 g L^{-1} was used for deposition. For Example, at T = 80%, a = 20 g L^{-1} and d = 1 g L^{-1}, the chitin amount p = 1.6%.

Dyeing of polyester/cotton fabric: For satisfactory dispersion in the dye bath, the dye were initially finished by mortar milling in the presence of a specially selected dispersing agent polyester/cotton fabric were dyed in Atlas Co. dyeing machine at a liquor ratio of 1:40 using distilled water. The dye bath were prepared with the dye concentration 2% of and with 1.5 g L^{-1} anionic Carrier

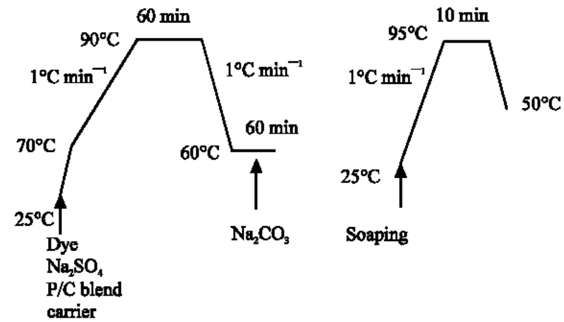

Fig. 1: One bath dyeing profile of PE/C0 blend with temporarily solubilized disperse/ reactive dyes

(Levegal PEW Bayer Co. Germany). The pH was then adjusted 6.5 and 0.2 mol sodium sulphate solution. Dyeing was started at 45°C for 15 min and then the dye bath temperature was raised at a rate of 1.5-2°C min to 70°C. Dyeing was commenced at 70°C and then the dye bath temperature was raised by 1°C min to 90°C, maintained at this temperature for 60 min and cooled to 60°C. After 30 min at 60°C, 20 g L^{-1} of alkali (Na_2CO_3) was added to effect fixation of the reactive dye on cotton and maintained at 60°C for further 30 min. The dyeing were rinsed and soaped at 95°C for 10 min with 1.5 g L^{-1} soaping agent and then dried at room temperature (Fig. 1).

After dyeing, the samples were fixed in an aqueous solution containing 3% Acrafix MF Bayer co Germany. (without formaldehyde) for 45 min at 50°C, then rinsed and dried at room temperature. The colour difference between the dyed blank samples and samples dyed after the alkaline and/or chitin treatment was monitored with a Macbeth Color Eye 3000 diffusion reflectance spectrophotometer, made in the USA, under illuminant D65 using a 10° observer. The colour and rubbing fastness properties were estimated according to Polish standards. The results were assessed in ratings from grade 1 (very poor) to grade 5 (excellent). The colour change was assessed according to the grey scale from grade 1 (much altered) to grade 5 (unaltered).

RESULTS AND DISCUSSION

The dyeing with disperse/reactive dyestuffs obtained on chitin deposited polyester/cotton fabric samples is even, independent of earlier alkaline pretreatment. The dyeing uniformity depends on the uniformity of chitin deposition. The dyed polyester/cotton samples are characterized by better dyeing uniformity and mélange effect, which decreases with an increased amount of chitin.

Table 2: Changes in dry-rubbing, wet-rubbing (PN-EN ISO 105-X12:1999) and washing fastness (PN-EN 20105-C01:1997) properties of polyester/cotton fabric samples dyed using disperse/reactive Blue after treatment with chitin(I), 0-without alkaline pretreatment and A_1-with alkaline pretreatment, NaOH 5 g L^{-1}

		Color fastness		
Pretreatment	Chitin deposition	Dry-rubbing	Wet-rubbing	Washing-fastness
0	0	4	3	4
	1	4	3	4
	2	4	3	4-5
	3	4	3	4-5
	4	4	3	4-5
	5	4-5	3	4-5
	6	4	3	4
	7	4-5	3-4	4-5
A1	0	4-5	3	4
	1	4-5	3	4
	2	4	3	4-5
	3	4	3	4-5
	4	4	3-4	4-5
	5	4	4	4-5
	6	4	3	4
	7	4	3	4-5

Table 3: Changes in dry-rubbing , wet-rubbing (PN-EN ISO 105-X12:1999) and washing fastness (PN-EN 20105-C01:1997) properties of polyester/cotton fabric samples dyed using disperse/reactive Blue after Treatment with chitin (II), 0-without alkaline pretreatment and A_1-with alkaline pretreatment, NaOH 5 g L^{-1}

		Color fastness		
Pretreatment	Chitin deposition	Dry-rubbing	Wet-rubbing	Washing-fastness
0	0	4	3	4-5
	1	4	3	4-5
	2	4	3	4-5
	3	4	3	4-5
	4	4	3	4-5
	5	4	3	4-5
	6	4-5	4	4-5
	7	4-5	4	4-5
A1	0	4	3	4-5
	1	4-5	4	4-5
	2	4-5	4	4-5
	3	4	3	4-5
	4	4	3	4-5
	5	4	3	4-5
	6	4	3	4-5
	7	4	3	4-5

The data obtained shows that after chitin treatment it is possible to dye polyester/cotton fabric with only one disperse/reactive dyestuff, which shows substantively only to cellulose fibres. The dyed textiles are characterized by good dry rubbing and fastness properties (3-4 to 4-5 grades), as well as good washing fastness properties in the range of the colour change (4 to 4-5 grades),apart from the polyester/cotton fabric samples dyed with the disperse/reactive red dyestuff, for which 3 to 3-4 grades were obtained (Table 2-6).

An alkaline pretreatment of fabric samples has practically no essential consequence for changes in colour fastness to rubbing and washing, but causes a slight increase in the depth of shade. In order to improve the adhesion of chitin to the surface of polyester fibres, the pretreatment in an alkaline solution containing 10 g L^{-1} of NaOH is permitted.

The colour strength increases with an increase in chitin deposition independent of the degree of acetylating. The colour difference between the dyed blank samples and the samples with chitin amount grows significantly and has a polyester/cotton fabric samples (Fig. 2-6).

The de acetylating degree of chitin does not essentially affect either the strength of colour of textiles or the colour fastness to rubbing and washing. The viscosity of chitin (which depends on the molecular weight) decides its application properties. The stiffness of the chitin deposited samples increases with an increase in the chitin deposition on textile. According to the data obtained, the polyester/cotton fabrics are best finished by means of disperse/reactive dyestuffs after an alkaline pretreatment in solution containing 10 g L^{-1} of NaOH and followed by impregnation with

Table 4: Changes in dry-rubbing, wet-rubbing (PN-EN ISO 105-X12:1999) and washing fastness (PN-EN 20105-C01:1997) properties of polyester/cotton fabric samples dyed using disperse/reactive Blue after treatment with chitin (III), 0-without alkaline pretreatment and A_1-with alkaline pretreatment, NaOH 5 g L^{-1}

		Color fastness		
Pretreatment	Chitin deposition	Dry-rubbing	Wet-rubbing	Washing-fastness
0	0	4-5	4	4
	1	4-5	4	4
	2	4-5	4-5	4
	3	4	4	4
	4	4	4	4
	5	4	4	4
	6	4-5	3-4	4-5
	7	4	4	4
A1	0	4	3-4	4-5
	1	4-5	3-4	4
	2	4	3-4	4
	3	4-5	3-4	4-5
	4	4-5	4	4
	5	4-5	4	4
	6	4-5	4	4
	7	4	4	4

Table 5: Changes in dry-rubbing, wet-rubbing (PN-EN ISO 105-X12:1999) and washing fastness (PN-EN ISO 20105 C01:1997) properties of polyester/cotton fabric samples dyed using disperse/reactive Red after treatment with chitin(I), 0-without alkaline pretreatment and A_1-with alkaline pretreatment, NaOH 5 g L^{-1}, A_2-with alkaline pretreatment, NaOH 10 g L^{-1} and A_3-with alkaline pretreatment, NaOH 15 g L^{-1}

		Color fastness		
Pretreatment	Chitin deposition	Dry-rubbing	Wet-rubbing	Washing-fastness
0	0	4-5	4	4
	1	4-5	3	4
	2	4-5	3-4	4
	3	4-5	3	4
	4	4-5	3	4
	5	4-5	3-4	4
	6	4-5	4	4-5
	7	4-5	3-4	4
A1	0	4-5	3	4-5
	1	4-5	3	4
	2	4-5	3	4
	3	4-5	3-4	4-5
	4	4-5	3-4	4
	5	4-5	4	4
	6	4-5	4	4
	7	4-5	3	4
A2	0	4-5	3	4-5
	1	4-5	3	4-5
	2	4-5	3	4-5
	3	4-5	3	4-5
	4	4-5	3-4	4
	5	4-5	3-4	4-5
	6	4-5	3	4-5
	7	4-5	3	4
A3	0	4-5	3	4
	1	4-5	3-4	4
	2	4-5	3-4	4-5
	3	4-5	3	4-5
	4	4-5	3	4-5
	5	4-5	3	4-5
	6	4-5	3-4	4-5
	7	4-5	3	4-5

chitin solution with concentration below 1-7% w/v, independent of the chitin characteristic.

The data obtained shows that it is possible to dye polyester/cotton fabrics finished by chitin with only one disperses/reactive dyestuff, which normally shows substantively to cellulose fibers. The dyed samples showed good rubbing and washing colour fastness properties within the range of colour change. The colour strength of the dyed samples increased with the increased deposition of chitin on the fabric. It is possible to

Table 6: Changes in dry-rubbing, wet-rubbing (PN-EN ISO 105-X12:1999) and washing fastness (PN-EN 20105-C01-1997) properties of polyester/cotton fabric samples dyed using disperse/reactive Blue after treatment with chitin(I), 0- without alkaline pretreatment and A_1-with alkaline pretreatment, NaOH 5g L^{-1}, A_2-with alkaline pretreatment, NaOH 10 g L^{-1} and A_3-with alkaline pretreatment, NaOH 15 g L^{-1}

		Color fastness		
Pretreatment	Chitin deposition	Dry-rubbing	Wet rubbing	Washing-fastness
0	0	3-4	3	4
	1	3-4	3	4
	2	3-4	3	4-5
	3	3-4	2-3	4-5
	4	3	3	4-5
	5	3	3	4-5
	6	3-4	3	4-5
	7	3-4	2-3	4-5
A1	0	4	3	4-5
	1	3	2-3	4
	2	3	2-3	4
	3	3	2-3	4-5
	4	3-4	3	4
	5	4	3	4
	6	4	3	4
	7	4	2-3	4
A2	0	3-4	2-3	4-5
	1	4	3	4
	2	4	3	4-5
	3	4	2-3	4-5
	4	3-4	3	4-5
	5	4	3	4-5
	6	4	3	4-5
	7	3-4	2-3	4-5
A3	0	4	3	4
	1	4	3	4
	2	4	3	4-5
	3	4	2-3	4-5
	4	4	3	4-5
	5	4	3	4-5
	6	4	3	4-5
	7	4	2-3	4-5

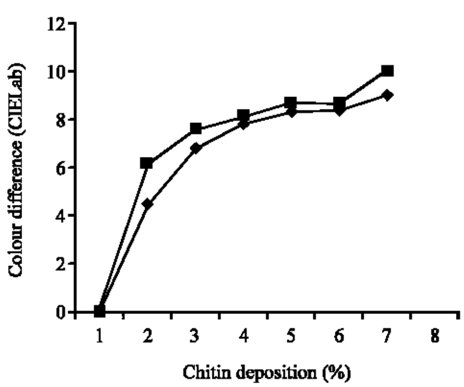

Fig. 2: Changes in colour difference of polyester/cotton fabric samples dyed using disperse/reactive Blue after chitin (I) NaOH concentrations (♦) 0 and (■) 5 g L^{-1}

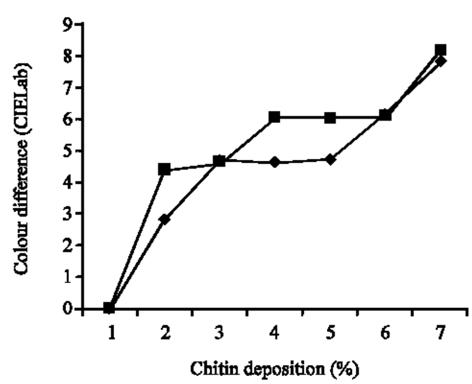

Fig. 3: Changes in colour difference of polyester/cotton fabric samples dyed using disperse/reactive Blue after chitin (II) NaOH concentrations (♦) 0 and (■) 5 g L^{-1}

polyester/cotton fabrics with disperse/reactive dyestuffs after chitin treatment and dyed textiles are characterized by good dry rubbing and washing fastness but medium wet-rubbing fastness properties.

The alkaline pretreatment affects the greater adhesion of chitin to the surface of polyester fibers which is manifested by the greater colour strength. Pretreatment in an alkaline solution containing 10 g L^{-1} NaOH is

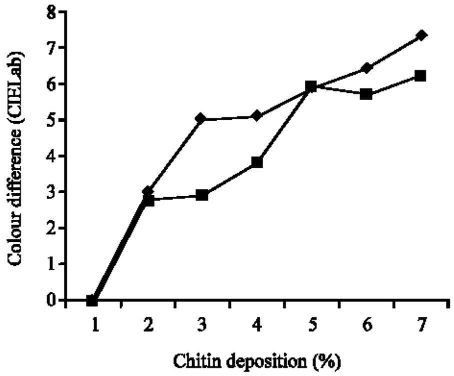

Fig. 4: Changes in colour difference of polyester/cotton fabric samples dyed using disperse/reactive Blue after chitin (III) NaOH concentrations (♦) 0 and (■) 5 g L^{-1}

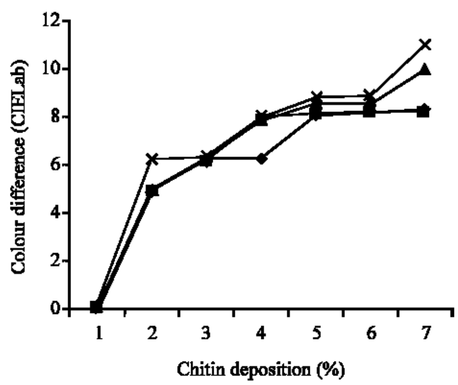

Fig. 5: Changes in colour difference of polyester/cotton fabric samples dyed using disperse/reactive Red after chitin (I) NaOH concentrations (♦) 0, (■) 5, (▲) 10 and (×) 15 g L^{-1}

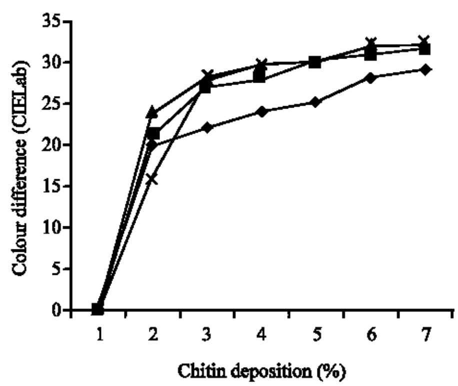

Fig. 6: Changes in colour difference of polyester/cotton fabric samples dyed using disperse/reactive Blue after chitin (I) NaOH concentrations (♦) 0, (■) 5, (▲) 10 and (×) 15 g L^{-1}

permitted. Finally, the achievement of good effects depends mainly on the amount of chitin deposited and its characteristic (e.g., de acetylating degree, molecular weight). The greater the molecular weight (viscosity) of chitin used, the worse effects in application are observed.

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