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An Investigation on the Effect of Azeotropic Solvent Mixture Pretreatment of 67:33 PET/CO Blended Fabric and Yarn- Part II

[1,2]B. Muralidharan, [1,2]S. Laya and [3]S. Vigneswari
[1]Birla Institute of Technology and Science-Pilani, Dubai Campus, International Academic City, Dubai, United Arab Emirates
[2]Department of Industrial Chemistry, Alagappa University, Karaikudi, Tamilnadu, India
[3]Department of Chemistry, Raja Duraisingam Govt. Arts College, Sivaganga, Tamilnadu, India

Corresponding Author: B. Muralidharan, Department of Chemistry, Birla Institute of Technology and Science-Pilani, Dubai Campus, International Academic City, P.B. No. 345055, Dubai, UAE

ABSTRACT

Commercially polyester/cotton blended fabrics are dyed by two-bath or one-bath-two step dyeing method employing suitable dyes and chemicals for each fiber. The two bath dyeing methods are relatively long and complicated and the one bath-two step dyeing procedure is shorter as compared to two bath method but the dyeability is poor. To address this issue, the present investigation focused to formulate a new method in which the polyester/cotton blends can be dyed at lower temperature with an improved dye uptake and fastness properties using disperse and reactive dyes. Polyester/cotton blended fabric and yarns were subjected to pre-treatment using two different azeotropic solvent mixtures and then dyed using disperse and reactive dyes. The dyeability of the pre-treated samples was found to increase tremendously while the fastness properties get slightly improved.

Key words: Irreversible swelling, segmental motion, oligomer, dyeability, amorphous region, crystallites

INTRODUCTION

Many apparel articles and other textile products consist of blend yarns composed of polyester and cotton which are widely used because of their advantageous properties. To dye these blends, the polyester portion is generally dyed with a disperse dye, while there is a choice of several classes of dyes for the cotton portion. More particularly, vat dyes, sulfur dyes as well as reactive dyes can be used, as required (Swiderski, 2000). A number of dyeing processes are available for dyeing polyester/cotton blends with disperse and reactive dyes, and they are extensively described in the literature (Beech, 1970; Derbyshire, 1974). Owing to the very different dye and fiber specific requirements of the dyeing conditions, the disperse and reactive dyes are frequently applied separately in two steps with or without a reduction clearing process being carried out in between the steps for fastness improvement (Lee *et al.*, 2003). This procedure is extraordinarily cost-intensive and requires large amounts of chemicals, water and energy. Owing to these disadvantages, an economically optimized one-bath processing procedure has been reported in the past (Youssef *et al.*, 2008). Disadvantages of this one-bath method are the possible interactions with the auxiliaries used, poor colour reproducibility and poor fastnesses.

Many reports are available on improving the dyeing behaviour and fastness properties of the dyed textile fibres through chemical pre-treatments (Muralidharan *et al.*, 2004; Shahidullah *et al.*, 2007; Islam *et al.*, 2006; Kamal Uddin *et al.*, 2002). To enhance the dyeability of polyester and its blends, lot of proposals has been put forward by many researchers in terms of modifying the fibre and experimenting new class of dyes. Many researchers have studied and shown that the fiber structure of polyester has been modified with the pretreatment of polyester yarns with strong interacting solvents (Muralidharan and Laya, 2011; Jameel *et al.*, 1981). Chidambaram *et al.* (2003) have reported that solvent pre-treatment and heat settings are the important processes that produce extensive structural modification in PET fabrics and yarns. Both of these processes induce crystallization in the polymer, alter the glass-transition temperature and enhance the segmental mobility of polymer chains. A very recent research work reported by Najafi *et al.* (2008) discusses the process of dyeing PET/cotton fabrics using disperse/reactive dyestuff in one bath dyeing process.

Many attempts were done by researchers to dye polyester/cotton blends using reactive disperse dyes by modifying the dye structure as well as by pre-treating the fibre (Koh and Park, 2008; Chavan and Subramanian, 1982). Dystar Textilfarben, GMBH and Co. (2009) has patented dyeing of polyester-cotton blends fabrics with disperse and reactive dyes in a one bath process in alkaline medium using disperse dyes which are stable in alkaline medium. Blus *et al.* (2005) have investigated the possibility of dyeing cellulose fibres with selected reactive dyes containing triazine system in combination with disperse dyes for polyester component in a blend of polyester and cotton at 130°C at a pH ranging from 6-8 in a single-bath and single stage method. The present investigation, in continuation with the previous work which was presented in part I (Muralidharan *et al.*, 2011c), provides a process for low temperature dyeing of a polyester-cotton blended fabric and yarn with a mixture of disperse and reactive dyes after treating with non-aqueous azeotropic ternary solvent mixture. The dyeing behaviour of the azeotropic solvent treated polyester/cotton blended fabric and yarn with four different dyes and the fastnesses of the dyed materials were studied. The physico-chemical behaviors of the samples were investigated and were reported in part-I of this paper.

MATERIALS AND METHODS

Materials

67:33 Polyester/cotton blended Fabric (67:33 PCF): Commercial fabric which is partially texturized and with following specifications from Universal Textile Mills, Mumbai, India was used for the study.

- Wt/sq. meter: 79.8 g cm^{-2}
- Type of end: Filament
- Type of pick: Filament
- Ends/inch: 121
- Picks/inch: 74
- Crimp of weft yarn: 9.2 cm
- Crimp of warp yarn: 8.7 cm

67:33 Polyester/cotton blended Yarn (67:33 PCY): Fine filament yarns of 50^s supplied by Karpaka Vinayaka Mills, Karaikudi, Tamil Nadu; India was used in this study.

Dyes: The following Disperse dyes collected from Parishi Chemicals, Surat, India were used without further purification to dye the polyester component of 67:33 PCY and PCF.

- Disperse Brilliant Red G (C.I. Red 277)
- Disperse Orange 73 (C.I. Orange 73)
- Disperse Brilliant Blue - SR (C.I.Blue-354)
- Disperse Yellow 232 (C.I. Disperse Yellow 232)

The following reactive dyes (Ridhi Sidhi Trading Co., Mumbai, India) were used without further purification to dye the cotton component of the 67:33 PCY and PCF.

- Drimarene Brilliant Red K-BL (C.I. Reactive Red 124)
- Drimarene Brilliant Orange (C.I. Reactive Orange 64)
- Drimarene Turquoise K-2B (C.I. Reactive Blue 116)
- Drimarene Brilliant Yellow X 4GL (C.I. Reactive Yellow 58)

Methods

Solvent Pre-treatment of the samples: The samples were pre-treated with azeotropic mixture of solvents prepared based on the composition stated in Table 1 at room temperature for various time intervals, viz. 2, 4, 6, 8, 10, 20 and 30 min. The pre-treated samples were then squeezed using a padding mangle and then air dried. Since, the pretreated solvent mixture is reused, the amount of solvent let in to the environment is very negligible compared to the volume of processed material thereby air pollution due to solvent treatment is very much minimized.

Studies of dyeing and fastness behaviour: Dyeing of pre-treated and untreated polyester/cotton yarns and fabrics was performed using the rota dyer bath (Rota dyer 18×100-N machine, R.B. Electronic and Engineering Pvt. Ltd., Mumbai-53). The dye bath was prepared with the following recipe and dyeing conditions:

- Disperse Dye-2%
- Reactive Dye-2%
- Glauber's salt-5 gpl
- Soda ash-3 gpl
- Borax-5 gpl
- Temperature-80, 95 and 110°C

Table 1: Details of Azeotropic solvent mixtures

Solvent System	Weight (%)	Volume (%)	Solubility parameter	Solubility parameter of the mixture	Polarity index	B.P.(°C)
Acetone	24.3	30.6	10.0	11.73	14.5	63.2
Ethyl alcohol	10.4	13.2	12.7			
Chloroform (Ac-EA-Cf)	65.3	44.0	9.3			
Acetone	51.1	64.3	10.0	13.22	9.5	49.7
Methyl acetate	5.6	6.0	9.8			
n-Hexane (Ac-MAc-nH)	43.3	66.1	7.3			

- Dyeing Duration-30, 45 and 60 min
- pH of the dye bath-10 to 11
- Material to Liquor Ratio (MLR)-1:50

The dyed and washed yarns were reduction cleared by using commercially available reduction clearing agent, Ladipur MCL (Clariant Chemicals, India) then it was washed with water and dried in a hot air oven.

The amount of dye uptake of the samples during dyeing were measured spectrophotometrically using UV-VIS Spectrophotometer (Labomed- model spectro 23 RS, USA).

The untreated and solvent pre-treated samples after dyeing were tested for their wash fastness, light fastness and rubbing fastness using AATCC test methods (AATCC, 2000 technical manual). The washing fastness was evaluated by AATCC method 61(2A) using an Atlas-Launder Ometer. Fastness to light was evaluated by AATCC method 16E using an Atlas CI 3000+Xenon Weatherometer. The fastness for rubbing was also evaluated as per AATCC 116-1995 standards using crock meter.

RESULTS AND DISCUSSION

Dyeability characteristics: The effect of non-aqueous azeotropic solvent mixture pre-treatment on the dyeing behaviour of 67:33 PCY and PCF were studied by dyeing the pre-treated and untreated samples under different conditions using four different pairs of disperse and reactive dyes. The dye uptake results are presented in Fig. 1-16. Ac-EA-Cf pre-treated yarns treated for 8 min showed a maximum dye uptake percentage of 88 using Disperse Red 60 and Reactive Red124 at 110°C dyed for 60 min. The corresponding dye uptake percentage of untreated sample was found to be 53.5, indicating an increase of about 64.5%. A similar trend was observed in the case of fabric samples also. The dye uptake of the samples got increased for all dyeing durations and dyeing temperatures for a pre-treatment duration up to 8 min. and then the improvement in dye uptake was found to get decreased for higher pre-treatment durations. Ac-EA-Cf pre-treated yarns treated for 30 min showed an improvement of only about 7.5% using Disperse Red 60 and Reactive Red 124 at 110°C dyed for 60 min. A similar trend was observed for the Ac-MAc-nH pre-treated samples dyed with other pairs of dyes for different dyeing duration and dyeing temperature. So, it

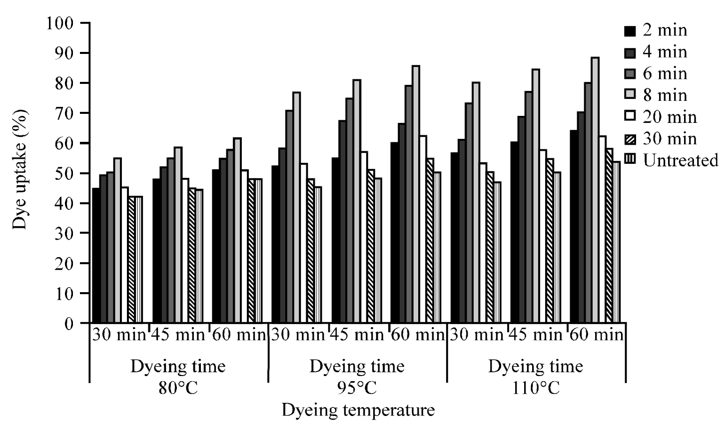

Fig. 1: Dye uptake of 67:33 PCY treated with Ac-EA-Cf (Disperse Red 60 and Reactive Red124)

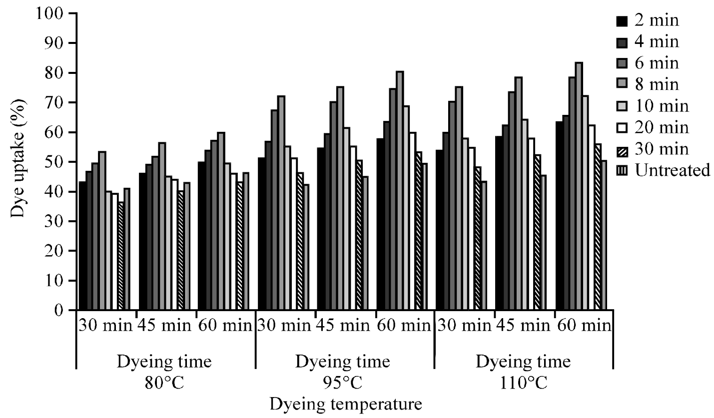

Fig. 2: Dye uptake of 67:33 PCY treated with Ac-EA-Cf (Disperse Orange 96 and Reactive Orange 64)

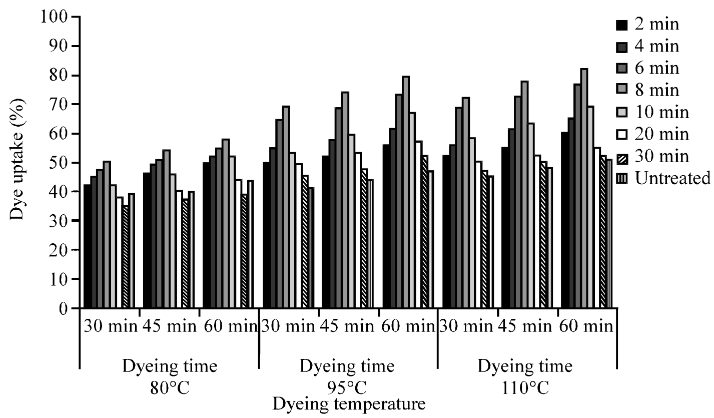

Fig. 3: Dye uptake of 67:33 PCY treated with Ac-EA-Cf (Disperse Blue 183 and Reactive Blue 116)

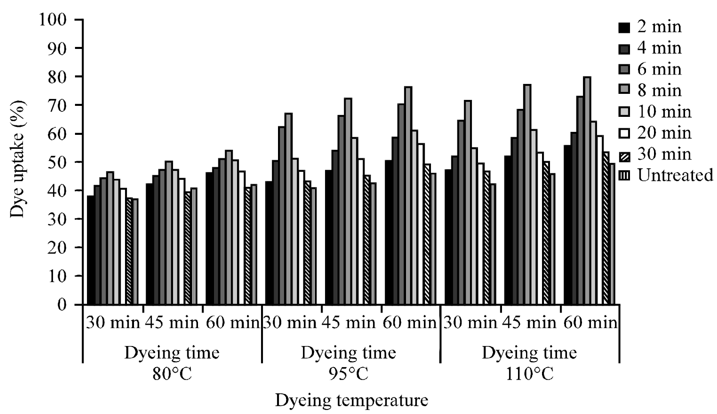

Fig. 4: Dye uptake of 67:33 PCY treated with Ac-EA-Cf (Disperse Yellow 49 and Reactive Yellow 14)

is observed that solvent pretreatments gave a maximum dye uptake for 8 min treatment duration and the improvement got decreased as the pretreatment duration increased. The decrease in

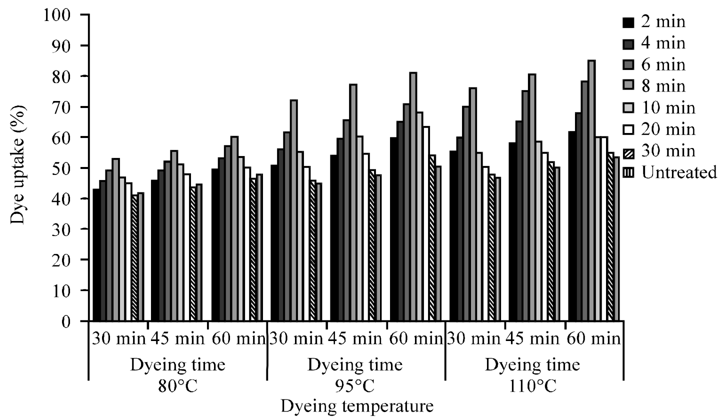

Fig. 5: Dye uptake of 67:33 PCY treated with Ac-MAc-nH (Disperse Red 60 and Reactive Red124)

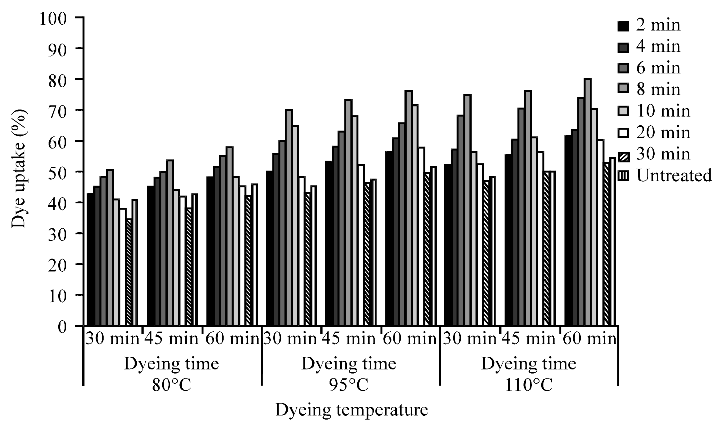

Fig. 6: Dye uptake of 67:33 PCY treated with Ac-MAc-nH (Disperse Orange 96 and Reactive Orange 64)

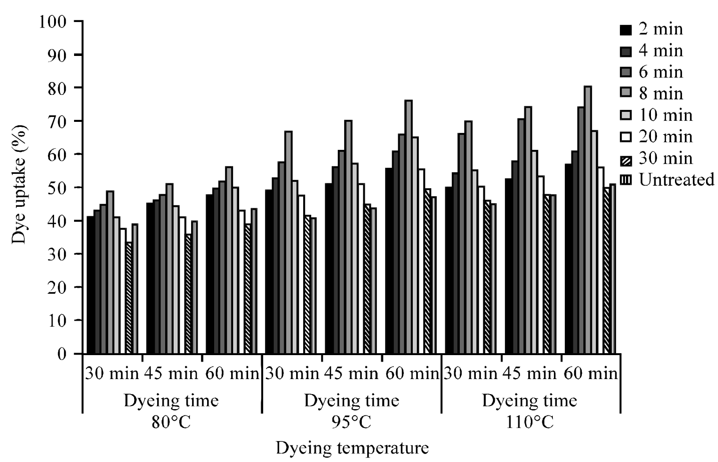

Fig. 7: Dye uptake of 67:33 PCY treated with Ac-MAc-nH (Disperse Blue 183 and Reactive Blue 116)

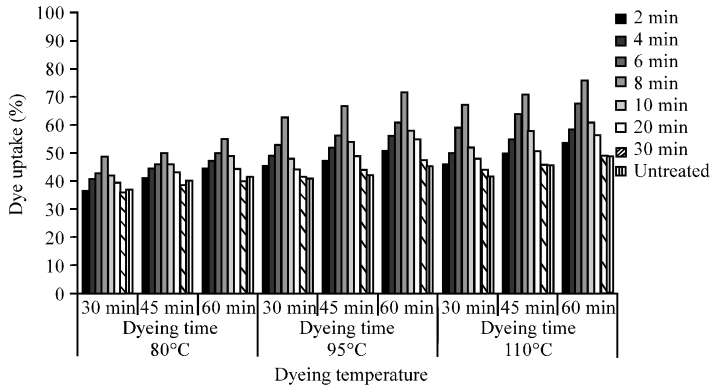

Fig. 8: Dye uptake of 67:33 PCY treated with Ac-MAc-nH (Disperse Yellow 49 and Reactive Yellow 14)

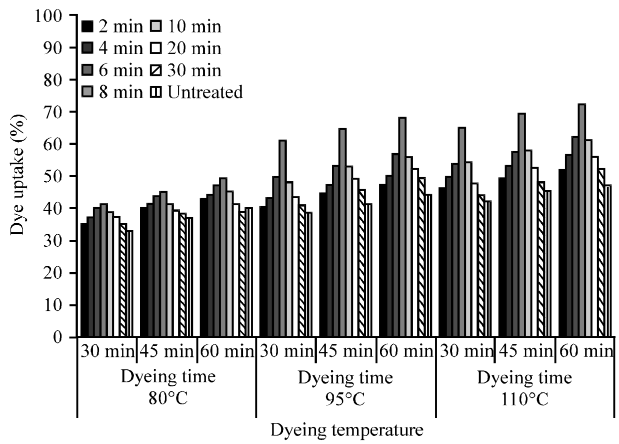

Fig. 9: Dye uptake of 67:33 PCF treated with Ac-EA-Cf (Disperse Red 60 and Reactive Red124)

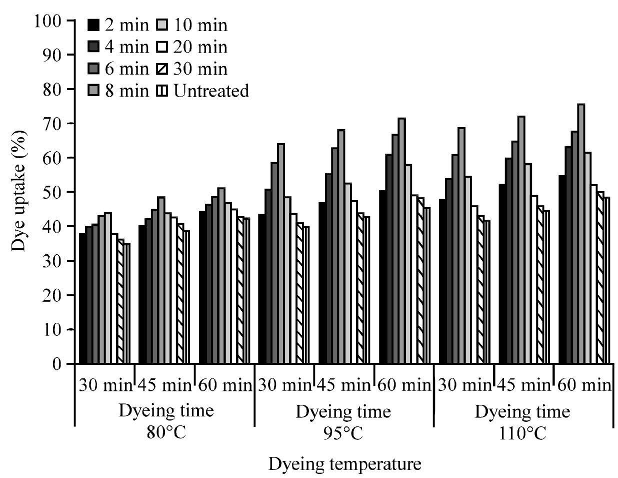

Fig. 10: Dye uptake of 67:33 PCF treated with Ac-EA-Cf (Disperse Orange 96 and Reactive Orange 64)

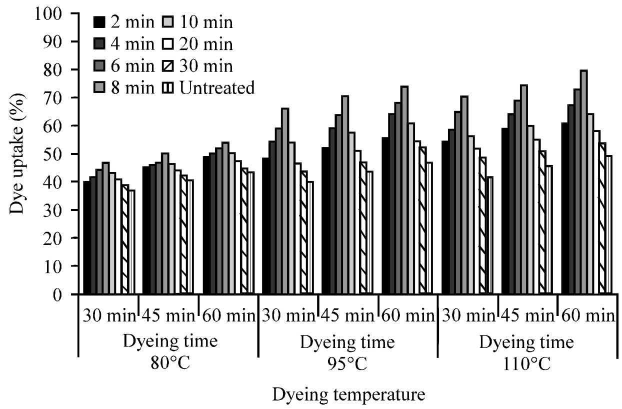

Fig. 11: Dye uptake of 67:33 PCF treated with Ac-EA-Cf (Disperse Blue 183 and Reactive Blue 116)

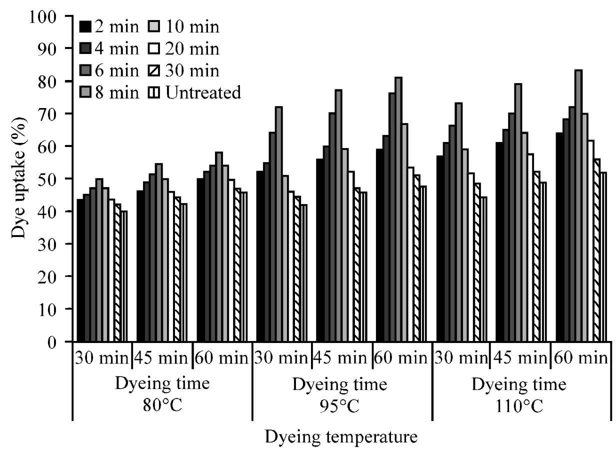

Fig. 12: Dye uptake of 67:33 PCF treated with Ac-EA-Cf (Disperse Yellow 49 and Reactive Yellow 14

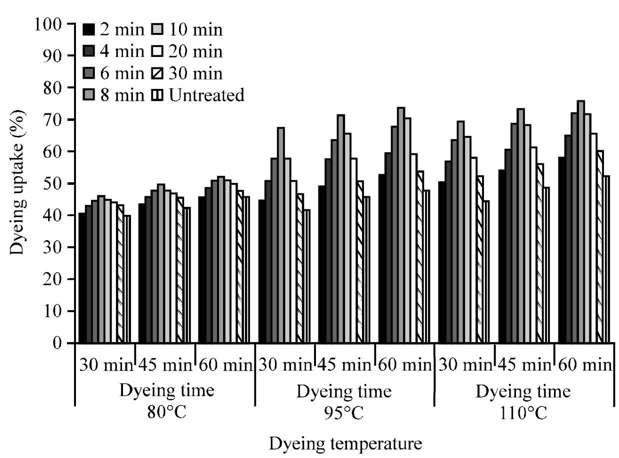

Fig. 13: Dye uptake of 67:33 PCF treated with Ac-MAc-nH (Disperse Red 60 and Reactive Red 124)

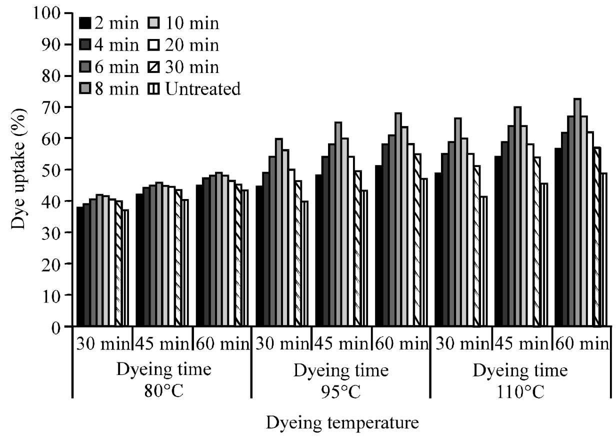

Fig. 14: Dye uptake of 67:33 PCF treated with Ac-MAc-nH (Disperse Orange 96 and Reactive Orange 64)

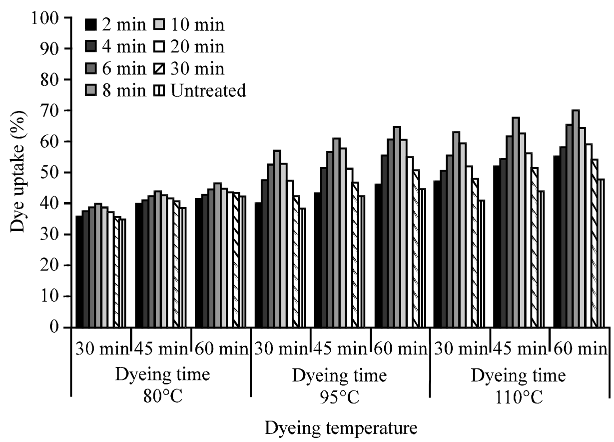

Fig. 15: Dye uptake of 67:33 PCF treated with Ac-MAc-nH (Disperse Blue 183 and Reactive Blue 116)

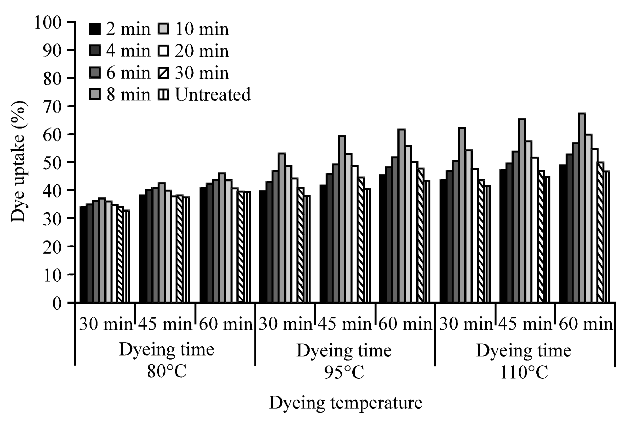

Fig. 16: Dye uptake of 67:33 PCF treated with Ac-MAc-nH (Disperse Yellow 49 and Reactive Yellow 14

improvement with increase in pretreatment duration may be due to the fact that prolonged solvent pre-treatment led to increase in crystallanity of the fibre and made dye penetration difficult. The improved dye uptake in the case of samples pre-treated up to 8 min may be attributed to the fact that the pretreatment might have modified the fibre structure by creating voids, making the fibre structure more open and thus, promoting not only the increased rate of dye transport but also enhancing the dye uptake. These solvents can dissolve out oligomers present, homogenize the fine structural differences and provide increased internal surface by more opening up of the structured assembly permitting increased deposition of dyestuffs. All these observations are supported by the experimental results that were obtained using Scanning Electron Microscopic, FTIR and Differential Scanning Calorimetric studies which were presented in the part-1 of this paper. The improvement in the dye uptake results suggest that polyester/cotton blends can be dyed with the combination of disperse and reactive dyes in one-bath method by pre-treating the fibre for a duration up to 8 min using azeotropic solvent mixture with better dye uptake than conventional two bath/ one bath two step methods. The observed results are in conformity with the results reported earlier in the literature (Muralidharan *et al*., 2011a, b; Sivakkumar, 2007a,b).

On comparison it was found that the extent of the dye pick up is more in the case of 67:33 PCY than 67:33 PCF pretreated and dyed under identical conditions. This is attributed to the fact that the yarn samples are free from strain and dye uptake would be more. From the dyeing results it is evident that the solvent pre-treatment has made an effect on dyeing of polyester component in the polyester/cotton blended samples. The two components viz. cotton and polyester, present in the blend possess different characteristics individually. Cotton fibre comprises of cellulose network in an ordered arrangement results to crystallites. The pore sizes between the crystallites of the cotton component are big enough for the penetration of dye molecule. This along with the presence of reactive group in cotton makes the dyeing of cotton part possible. Whereas for polyester, the pore size is minimum and are less than the size of the dye molecule. The solvent treatment creates more voids and pits in the polyester component and enhances the dye molecules to penetrate into the fibre matrix. As the solvent treatment duration increases the pore sizes in the polyester part increases leading to the irreversible swelling and dye molecules get diffused out of the polymer structure. The decrease in dye uptake observed for the longer treatment durations substantiates this point.

Fastness properties: Table 2-7 show the wash, light and rubbing fastness properties of the treated and untreated samples. The pretreatment process could improve the fastness properties of the dyed samples. The results indicated that the samples pretreated for 6-8 min duration shown better fastness properties in the case of Ac-EA-Cf and Ac-MAc-nH solvent mixtures and for both fabric and yarn. Wash fastness properties were found to be 4 and 5, respectively for untreated and 6-8 min Ac-EA-Cf pre-treated fabrics and yarns dyed with all the four set of dyes. Light fastness properties were found to be 6-7 and 7-8, respectively for untreated and 6-8 min Ac-EA-Cf pre-treated fabrics and yarns dyed with all the four set of dyes. Rubbing fastness properties were found to be 4 and 5, respectively for untreated and 4-8 min Ac-EA-Cf pre-treated fabrics and yarns dyed with all the four set of dyes. A very similar trend was observed for Ac-MAc-nH treated fabrics and yarns. This can be attributed to improvement in the dye pick up due to better build up inside the fibre matrix as a consequence of the solvent pre-treatment of the fibre material. These observed results were in conformity with the earlier observations (Muralidharan and Laya, 2011).

Table 2: Wash Fastness Properties of Treated and Untreated 67:33 PCY

				Grading pretreatment time (min.)						
Solvent system	Dye	Dyeing temp. (°C)	Untreated	2	4	6	8	10	20	30
Ac-EA-Cf	A	80	3	3-4	4	4-5	4-5	4	4	4
		95	4	4	4-5	5	5	4	4	4
		110	4-5	4	4-5	5	5	4-5	4	4
	B	80	3	3-4	4	4-5	4-5	4	4	4
		95	4-5	4	4-5	5	5	4	4	4
		110	4	4	4-5	5	5	4	4	4
	C	80	3	3-4	4	4-5	4-5	4	4	4
		95	3-4	4	4-5	5	5	4	4	4
		110	4	4	4-5	5	5	4	4	4
	D	80	3	3-4	4	4-5	4-5	4	4	4
		95	3-4	4	4-5	5	5	4	4	4
		110	4	4	4-5	5	5	4	4	4
Ac-MAc-nH	A	80	3	3	4	4-5	4-5	4	4	4
		95	3-4	4	4-5	5	5	4-5	4	4
		110	4	4	4-5	5	5	4-5	4	4
	B	80	3	3-4	4	4-5	4-5	4	4	4
		95	3-4	4	4-5	5	5	4-5	4	4
		110	4	4	4-5	5	5	4-5	4	4
	C	80	3	3-4	4	4-5	4-5	4	4	4
		95	3-4	4	4-5	5	5	4-5	4	4
		110	4	4	4-5	5	5	4-5	4	4
	D	80	3	3-4	4	4-5	4-5	4	4	4
		95	3-4	4	4-5	5	5	4-5	4	4
		110	4	4	4-5	5	5	4-5	4-5	4

A = Disperse Red 60 and Reactive Red 124, B = Disperse Orange 96 and Reactive Orange 64, C = Disperse Blue 183 and Reactive Blue 116, D = Disperse Yellow 49 and Reactive Yellow 14

Table 3: Wash Fastness Properties of Treated and Untreated 67:33 PCF

				Grading pretreatment time (min.)						
Solvent system	Dye	Dyeing temp. (°C)	Untreated	2	4	6	8	10	20	30
Ac-EA-Cf	A	80	3	3	3-4	4	4-5	4	4	4
		95	3	3-4	4	4-5	4-5	4	4	4
		110	4	4	4-5	5	5	4-5	4	4
	B	80	3	3	3-4	4	4-5	4	4	4
		95	3	3-4	4	4-5	4-5	4	4	4
		110	4	4	4-5	5	5	4-5	4	4
	C	80	3	3	3-4	4	4-5	4	4	4
		95	3	3	4	4-5	4-5	4-5	4	4
		110	4	4	4-5	5	5	4-5	4	4
	D	80	3	3	3-4	4	4-5	4	4	4
		95	3	3-4	4	4-5	4-5	4	4	4
		110	4	4	4	5	5	4-5	4	4
Ac-MAc-nH	A	80	3	3-4	4	4	4-5	4	4	4
		95	3-4	4	4-5	4-5	5	4-5	4	4
		110	4	4	4-5	5	5	4-5	4-5	4

Table 3: Continued

Solvent system	Dye	Dyeing temp. (°C)	Untreated	Grading pretreatment time (min.)						
				2	4	6	8	10	20	30
	B	80	3	3-4	4	4	4-5	4	4	4
		95	3	4	4-5	4-5	5	4-5	4	4
		115	4	4	4-5	5	5	4-5	4	4
	C	80	3	3-4	4	4	4-5	4	4	4
		95	3	4	4	4-5	4-5	4	4	4
		110	4	4	4	5	5	4	4	4
	D	80	3	3-4	4	4	4-5	4	4	4
		95	3	4	4	4-5	4-5	4	4	4
		110	4	4	4	4-5	5	4-5	4	4

A = Disperse Red 60 and Reactive Red 124, B = Disperse Orange 96 and Reactive Orange 64, C = Disperse Blue 183 and Reactive Blue 116, D = Disperse Yellow 49 and Reactive Yellow 14

Table 4: Light Fastness Properties of Treated and Untreated 67:33 PCY

Solvent system	Dye	Dyeing temp. (°C)	Untreated	Grading pretreatment time (min.)						
				2	4	6	8	10	20	30
Ac-EA-Cf	A	80	5	5	6	6-7	6-7	6	6	6
		95	5	5	6	7	7	6-7	6	6
		115	6-7	6-7	6	7-8	7-8	6-7	6	6
	B	80	5	5	5-6	6-7	6-7	6	6	6
		95	5	5	6	7	7	6-7	6	6
		110	6-7	6-7	7	7-8	7-8	7	6-7	6
	C	80	5	5	5-6	6	6-7	6	6	6
		95	5	5	6	7	7	6-7	6	6
		110	6	6	6-7	7	7	6-7	6	6
	D	80	5	5	5-6	6	6-7	6	6	6
		95	5	5	5-6	7	7	6-7	6	6
		110	6	6	6-7	7	7	6-7	6	6
Ac-MAc-nH	A	80	5	5	6	6-7	6-7	6-7	6	6
		95	5	5	6-7	7	7	6-7	6	6
		110	6-7	6-7	6-7	7	7-8	7	6	6
	B	80	5	5	6	6-7	6-7	6	6	6
		95	5	5	5-6	7	7	6-7	6	6
		110	6-7	6-7	6-7	7	7	6-7	6	6
	C	80	5	5	6	6-7	6-7	6	6	6
		95	5	5	6	7	7	6-7	6	6
		110	6	6	6-7	7	7	6-7	6	6
	D	80	5	5	6	6-7	6-7	6-7	6	6
		95	5	5	6	7	7	7	6	6
		110	6	6	6-7	7	7	7	6	6

A = Disperse Red 60 and Reactive Red 124, B = Disperse Orange 96 and Reactive Orange 64, C = Disperse Blue 183 and Reactive Blue 116, D = Disperse Yellow 49 and Reactive Yellow 14

Power saving in dyeing process: Trials dyeings were carried out at laboratory scale using 1 kg of the 67:33 PCF and 67:33 PCY each for all durations of dyeing by both pretreatment and

Table 5: Light Fastness Properties of Treated and Untreated 67:33 PCF

				Grading pretreatment time (min.)						
Solvent system	Dye	Dyeing temp. (°C)	Untreated	2	4	6	8	10	20	30
Ac-EA-Cf	A	80	5	5	5-6	6	6-7	6	6	5-6
		95	5	5	5-6	6-7	6-7	6-7	6	6
		110	6-7	6-7	6-7	7	7-8	7	6-7	6
	B	80	5	5	5-6	6	6-7	6	6	6
		95	5	5	6	7	7	6-7	6	6
		110	6-7	6-7	6-7	7	7-8	7	6-7	6
	C	80	5	5	5-6	6	6-7	6	6	6
		95	5	5	6	6-7	7	6-7	6	6
		110	6	6	6-7	7	7	6	6	6
	D	80	5	5	6	6-7	6-7	6	6	5-6
		95	5	5	6	6-7	7	6	6	6
		110	6	6	6-7	7	7	6	6	6
Ac-MAc-nH	A	80	5	5	5-6	6	6	6	6	5-6
		95	6	6	6	6-7	6-7	6	6	5-6
		110	6	6-7	6-7	7	7	6-7	6	5-6
	B	80	5	5	5-6	6	6	6	6	5-6
		95	5	5	5-6	6-7	6-7	6	6	5-6
		110	6	6	6-7	7	7	6-7	6	5-6
	C	80	5	5	5-6	6	6	6	5-6	5-6
		95	5	5	5-6	6-7	6-7	6	6	5-6
		110	6	6	6-7	7	7	6	6	5-6
	D	80	5	5	5-6	6	6	6	5-6	5-6
		95	5	5	5-6	6-7	6-7	6	6	5-6
		110	6	6	6-7	7	7	6-7	6	5-6

A = Disperse Red 60 and Reactive Red 124, B = Disperse Orange 96 and Reactive Orange 64, C = Disperse Blue 183 and Reactive Blue 116, D = Disperse Yellow 49 and Reactive Yellow 14

Table 6: Rubbing Fastness Properties of Treated and Untreated 67:33 PCY

				Grading pretreatment time (min.)						
Solvent system	Dye	Dyeing temp. (°C)	Untreated	2	4	6	8	10	20	30
Ac-EA-Cf	A	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4-5	4-5	5	5	4-5	4-5
		110	4	4	4-5	5	5	5	4-5	4-5
	B	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4-5	4-5	5	5	4-5	4-5
		110	4	4	4-5	5	5	5	4-5	4-5
	C	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4-5	4-5	5	5	4-5	4-5
		110	4	4	4-5	5	5	5	4-5	4-5
	D	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4-5	4-5	5	5	4-5	4-5
		110	4	4	4-5	5	5	5	4-5	4-5
Ac-MAc-nH	A	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4-5	4-5	5	5	4-5	4-5
		110	4	4	4-5	5	5	5	4-5	4-5

Table 6: Continued

Solvent system	Dye	Dyeing temp. (°C)	Untreated	Grading pretreatment time (min.) 2	4	6	8	10	20	30
	B	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4-5	4-5	5	5	4-5	4-5
		110	4	4	4-5	5	5	5	4-5	4-5
	C	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4-5	4-5	5	5	4-5	4-5
		110	4	4	4-5	5	5	5	4-5	4-5
	D	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4-5	4-5	5	5	4-5	4-5
		110	4	4	4-5	5	5	5	4-5	4-5

A = Disperse Red 60 and Reactive Red 124, B = Disperse Orange 96 and Reactive Orange 64, C = Disperse Blue 183 and Reactive Blue 116, D = Disperse Yellow 49 and Reactive Yellow 14

Table 7: Rubbing Fastness Properties of Treated and Untreated 67:33 PCF

Solvent system	Dye	Dyeing temp. (°C)	Untreated	Grading pretreatment time (min.) 2	4	6	8	10	20	30
Ac-EA-Cf	A	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4	4-5	5	5	4-5	4-5
		110	3-4	4	4-5	5	5	5	4-5	4-5
	B	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4	4-5	5	5	4-5	4-5
		110	3-4	4	4-5	5	5	5	4-5	4-5
	C	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4	4-5	5	5	4-5	4-5
		110	3-4	4	4-5	5	5	5	4-5	4-5
	D	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4	4-5	5	5	4-5	4-5
		110	3-4	4	4-5	5	5	5	4-5	4-5
Ac-MAc-nH	A	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4	4-5	5	5	4-5	4-5
		110	3-4	4	4-5	5	5	5	4-5	4-5
	B	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4	4-5	5	5	4-5	4-5
		110	3-4	4	4-5	5	5	5	4-5	4-5
	C	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4	4-5	5	5	4-5	4-5
		110	3-4	4	4-5	5	5	5	4-5	4-5
	D	80	2-3	3	3	4	4	4	4	4
		95	3-4	4	4	4-5	5	5	4-5	4-5
		110	3-4	4	4-5	5	5	5	4-5	4-5

A = Disperse Red 60 and Reactive Red 124, B = Disperse Orange 96 and Reactive Orange 64, C = Disperse Blue 183 and Reactive Blue 116, D = Disperse Yellow 49 and Reactive Yellow 14

conventional method to compare the energy consumption in dyeing. It was observed that the method suggested in this work saves the power consumption and hence the cost of dyeing to a range of 40-45%. The observations are presented in Table 8.

Table 8: Power saving comparison of pretreatment and conventional dyeing methods

Dyeing method	Dyeing duration (min.)	Power consumption (KWH)	Percentage of power saving
Pretreatment method	30	1.82	44.6
	45	2.40	41.1
	60	2.61	40.9
Conventional high temperature method	30	3.29	-
	45	4.08	-
	60	4.42	-

CONCLUSIONS

From the present investigation it can be concluded that polyester/cotton blended yarn can be dyed by one-bath dyeing method using disperse and reactive dyes at a much lower temperature of 80°C compared to conventional dyeing method leading to a cost effective dyeing method with energy conservation. The power and hence the cost of dyeing is saved to a range of 40-45% with improved dyeing quality. The extent of improvement in the dye uptake depends on the nature of the solvent mixture and duration of pre-treatment. As the pre-treatment duration increased beyond 8 minutes, the extent of improvement in dye uptake got decreased. Measurement of fastness properties showed improvement indicating no detrimental effect on fastness properties due to solvent pre-treatments.

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