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Dyeing of Polyester Microfibers in Acid and Alkaline Media

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In this study, the microfiber polyester fabric was dyed in three colour intensities with six commercial disperse dyestuffs under HT conditions, in acid (pH 5.5) and alkaline (pH 9.5) media at rates of 0.5, 1.0 and 2.0 %. The acid and alkaline methods were compared in terms of colour and fastness. In addition, the strength values of three disperse dyestuff dyeing processes were determined in each of the two methods. In the performed study, it has been observed that the fastness and strength results of acid and alkaline methods were either close or similar to each other, but that the colour measurements differed and that dyeing in alkaline medium provided lighter shades.

Key Words: Polyester microfiber, Alkaline dyeing, Colour values, Fastness values, Tensile strength.

INTRODUCTION

Microfiber technology allows the production of fiber thinner than all natural and synthetic fibers. As fibers made thinner, the softness, looseness and volume of the products increases. The thin filaments are placed in fabrics tightly as the microfiber diameter is small and because the pores between fibers and yarns are very small, the protection against wind and rain is ensured as well as the air and water vapour permeability of product is maintained[1]. In the literature, the problems such as differences between dyeing behaviours of standard polyester and polyester microfiber, decreasing of colour fastness, not obtaining the desired colour depth, the dyeing kinetics, strength measurements and colour depth, as well as pre-finishing, dyeing, chemical and mechanical finishing processes and thermo fixation processes were investigated[2-7]. Many chemicals and dyes manufacturers are developing methods with regard to dyeing polyester in alkaline media. The substances having stabilizing effect, the buffering effect and oligomer-solving effect and containing a mixture of organic and inorganic alkaline substances are used as dyeing auxiliaries in dyeing process of polyester in alkaline media. In this method, the selection of dyestuffs is also an important parameter. Because oligomers saponify in alkaline media many disperse dyestuffs start more or less saponification. As very low rates of oligomers remain on the surface of polyester material dyed in alkaline media, working in the next transactions will be easier. It is indicated that a brighter dyeing, better touch and lesser dusting during the air jet weaving machines operation after yarn dyeing in the alkaline dyeing. It is known that the dressings on microfiber fabrics cause imperfections in acid media dyeing as those cannot be removed completely. It is specified that the imperfection can be removed in alkaline media dyeing. The prerequisite necessary to obtain reproducible dyeing results is the use of the optimal concentrations of auxiliary substances. This issue has been proven in the laboratory scale. But implementing it in larger amounts is the important matter[8-13].

EXPERIMENTAL

Textile: Woven fabric obtained by using 100 % polyester microfiber having weft yarn of 111 dtex and warp yarn of 77 dtex with weft and warp yarns having denseness of 33 strings/cm and 40 strings/cm, respectively.

Dyestuff: Dyestuffs were sourced from Clariant Company and those were used without purification.

Foron Yellow brown SE-RL, Foron Red SE-RL, Foron Blue SE-RL, Foron Yellow RD-4GRL(C.I. Disperse Yellow 235), Foron Red RD-GL 200 %, Foron Blue RD- GLF

Other auxiliary substances: For acid media; Lyocol WPN: fatty acid derivatives, amphoteric (Clariant), dispersing agent. Albegal FFA: anionic, alkyl-aril polyglycolethersulphate (Ciba): De-foaming agent. Lyogen DFT: non-ionic alkaline polyglycolether (Clariant): Leveling agent. Sodium acetate: (Merck): pH Buffering agent.

For alkaline media: Lyocol BD: anionic, aromatic sulphonate (Clariant): Alkaline buffer/dispersing agent. Lyogen DFT: non-ionic alkaline polyglycolether (Clariant): Leveling agent. Imacol S: weak cationic, polyglycolether derivative (Clariant): Fracture prevention agent.

Used set-up: The dyeing processes were carried out in the Laboratory type Thermal HT dyeing machine. The colour measurements of dyed samples were carried out by Datacolor SF-600X colour measurement device with D_{65} illuminant using 10º standard observer. The strength tests of the fabrics were carried out by using the Instron 4011 strength apparatus.

Dyeing of test samples: Six disperse dyestuffs suitable for dyeing in alkaline media have been used. Prior to dyeing process, the samples were washed with 1 g/L foryl 100 (non-ionic substance-Henkel) at 60 ºC for 20 min. pH adjustment of liquor having all auxiliary materials was made, dyestuffs and materials have been added to the bath. The dyeing processes were carried out in the Laboratory type thermal HT dyeing machine. The arithmetic average of all the dyed samples was taken by performing 8 measurements. The dyeing process of fabric is conducted according to recipes shown in Table-1.

TABLE-1
DYEING RECIPE

Acid media			
Lyocol WPN	1 %	Material amount	5 g
Albegal FFA	0.5 g/L	Bath ratio	110 min
Lyogen DFT	0.5 %	Dyeing time	1:20
Sodium acetate	3 %	Disperse dyes	0.5, 1.0 and 2.0 % o.w.f.
pH	5.5 (acetic acid)		
Alkaline media			
Lyocol BD	2 g/L	Imacol S	1 mL/L
Lyogen DFT	0.5 %	pH	9.5

The temperature-time diagram for dyeing in acid and alkaline media in the study is shown in Fig. 1. At the end of the dyeing in acid and alkaline media all the washing was performed according to the conditions given in Table-2.

TABLE-2
WASHING PROCESSES APPLIED AFTER DYEING

Process	Conditions
1. Washing	10 min 70 ºC 1 L water
2. Washing	20 min 70 ºC
	4 mL solution of NaOH + 2 g $Na_2S_2O_4$

2. The material has been rinsed under running water after washing process.

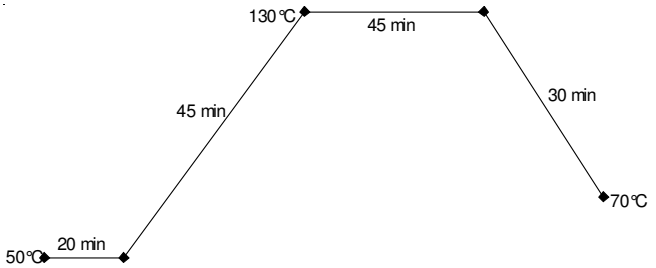


Fig. 1. Dyeing method in acid media and alkaline media

Colour measurements of test samples: The colour measurements of dyed samples were carried out with Datacolor Spectra Flash 600 plus reflectance spectrophotometer using the Datamaster computer program according to the CMC 2:1 CIELab and CIELch system. The colour measurements were carried out with D_{65} light source by using 10º observer and the samples dyed in an acid media has been adopted as a standard in the measurements.

Fastness tests: The water, light, perspiration, washing, organic solvent and friction fastnesses of test samples were tested according to relevant standards and those were evaluated with the help of gray and blue scales[14-19].

Strength tests: The strength tests of fabrics were carried out by using Instron 4011 strength apparatus. Five sample measurements were made in the warp and weft directions and the arithmetic average of the values were taken.

RESULTS AND DISCUSSION

Colour measurements (Table-3): In the dyeing processes with yellow brown SE-RL dyestuffs, the colour differences have been observed between the samples that were dyed in alkaline media and the samples which were dyed in acid media. But these differences have decreased with the increase in colour intensity. The colours of samples in dyeing process in alkaline media were usually lighter than the ones that were dyed in acid media.

In the dyeing processes with Red SE-RL dyestuffs, no colour differences have been observed between the samples that were dyed in alkaline media and the samples that were dyed in acid media. Here as well, the darkening of the colours

TABLE-3
COLOUR MEASUREMENT VALUES OF DYESTUFFS

	Colour intensity (%)	ΔE*	ΔL*	Δa*	Δb*	ΔC*	ΔH*
Yel. Brown SE-RL	0.5	2.881	0.803	2.567	1.033	2.239	-1.625
	1.0	1.168	0.829	0.669	0.478	0.775	-0.276
	2.0	0.684	-0.075	0.406	-0.545	-0.181	-0.655
Red SE-RL	0.5	1.920	1.864	-0.190	-0.422	-0.293	-0.359
	1.0	0.714	0.268	0.028	0.661	0.234	0.619
	2.0	1.151	-0.165	0.148	1.129	0.539	1.003
Blue SE-RL	0.5	4.370	1.434	-2.132	3.535	-3.044	-2.789
	1.0	6.300	3.259	-4.455	3.038	-2.636	-4.704
	2.0	7.082	0.856	-4.833	5.105	-5.303	-4.616
Yellow RD 4GRL	0.5	5.507	1.392	1.313	-5.163	-5.200	-1.158
	1.0	7.340	0.256	0.302	-7.329	-7.329	-0.302
	2.0	4.959	0.844	0.919	-4.799	-4.763	-1.092
Red RD-GL	0.5	1.050	1.000	-0.104	-0.305	-0.202	-0.251
	1.0	1.225	1.001	-0.192	-0.678	-0.438	-0.552
	2.0	0.278	0.095	0.211	0.155	0.257	0.051
Blue RD-GLF	0.5	5.412	2.538	-1.431	4.561	-4.302	-2.085
	1.0	9.433	8.332	-3.309	2.934	-2.692	-3.508
	2.0	4.822	3.461	-2.412	2.335	-2.439	-2.308

have improved the differences of colour nuances, but still the colours of samples in dyeing process in alkaline media were usually lighter than the ones that were dyed in acid media.

As a result of the dyeing processes with Red SE-RL dyestuffs, the colour differences between samples that were dyed in alkaline media and the samples that were dyed in acid media were not very large but also those were not satisfactory. The samples obtained as a result of the dyeing processes in alkaline media also had colours lighter than the ones that were dyed in acid media. In this dyestuff, again the increase in colour intensity also resulted in a reduction of colour difference as similar to the one with yellow brown SE-RL dyestuff.

When the colour differences of samples obtained as results of dyeing processes with blue SE-RL, yellow RD-4GRL and blue RD-GLF dyestuffs are examined, it was observed that the colours of samples dyed in alkaline media were too much lighter and in very different nuances compared to the ones that were dyed in acid media. It can be concluded that the dyeing processes in alkaline media with these dyestuffs could not reach to adequate shrinkage percentage values.

As a general assessment, the colours of samples obtained from dyeing processes in alkaline media are lighter than the colours of samples obtained from dyeing processes in acid media and different tons of colours are obtained. Most probably, these are because of dyestuffs could not reach adequate shrinkage percentage values and/or damaged in the alkaline media. According to the results of dyeing with different dyestuffs, it was determined that all the dyestuffs did not show the same behaviour in the dyeing processes in alkaline media.

Fastness tests: In Foron yellow brown, Foron yellow RD-4GRL, Foron Red RD-GL and Foron blue RD-GLF dyestuffs, the fastness values of samples dyed with alkaline method were similar to the fastness values of samples dyed with acid method. Alkaline method had no negative effects on fastness values of the dyeing processes (Tables 4-9).

Foron blue SE-RL: The light fastness values of the dyed samples in alkaline media are two degrees lower than the light fastness values of the dyed samples in acid media. Similarly, the perspiration fastness colour change values of the dyed samples in alkaline media are one degree lower (Tables 5 and 6).

TABLE-4
WATER FASTNESSES

	Yellow Brown SE-RL				Red SE-RL				Blue SE-RL			
	ab		bb		ab		bb		ab		bb	
Colour intensity (%)	r	l	r	l	r	l	r	l	r	l	r	l
0.5	5	5	5	5	5	5	5	5	5	5	5	5
1.0	5	5	5	5	5	5	5	5	5	5	5	5
2.0	5	5	5	5	5	5	5	5	5	5	5	5
	Yellow RD-4GRL				Red RD-GL				Blue RD-GLF			
0.5	5	5	5	5	5	5	5	5	5	5	5	5
1.0	5	5	5	5	5	5	5	5	5	5	5	5
2.0	5	5	5	5	5	5	5	5	5	5	5	5

ab: Acid media dyeing, r: colour fading, bb: alkaline media dyeing.

TABLE-5
LIGHT FASTNESSES

	Yellow Brown SE-RL		Red SE-RL		Blue SE-RL		Yellow RD 4GRL		Red RD-GL		Blue RD-GLF	
Colour Intensity (%)	ab	bb	ab	bb	ab	bb	ab	bb	ab	bb	ab	bb
0.5	7.0	7.0	6.0	6.0	3-4	3-4	8	8	6	6	3	3
1.0	7.0	7.0	6.0	6.0	3-4	3-4	8	8	6	6	3	3
2.0	7-8	7-8	6-7	6-7	4-5	3-4	8	8	6-7	6-7	3	3

ab: Acid media dyeing, r: colour fading, bb: alkaline media dyeing.

TABLE-6
PERSPIRATION FASTNESSES

Dye (%)	Yellow Brown SE-RL								Red SE-RL							
	Acid media dyeing				Alkaline media dyeing				Acid media dyeing				Alkaline media dyeing			
	ra	rb	la	lb	ra	rb	la	lb	ra	rb	la	lb	ra	rb	la	Lb
0.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
1.0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
2.0	5	5	5	5	5	5	5	5	5	5	5	5	4-5	4-5	5	5
	Blue SE-RL								Yellow RD 4GRL							
0.5	5	5	5	5	4-5	4-5	5	5	5	5	5	5	5	5	5	5
1.0	5	5	5	5	4-5	4-5	5	5	5	5	5	5	5	5	5	5
2.0	5	5	5	5	4-5	4-5	5	5	5	5	5	5	5	5	5	5
	Red RD-GL								Blue RD-GLF							
0.5	5	4-5	5	5	5	4-5	5	5	5	3-4	5	5	5	3-4	5	5
1.0	5	4-5	5	5	5	4-5	5	5	5	3-4	5	5	5	3-4	5	5
2.0	5	4-5	5	5	5	4-5	5	5	5	3-4	5	5	5	3-4	5	5

ra: Colour fading (acid media), la: staining (acid media), rb: colour fading (alkaline media), lb: staining (alkaline media).

TABLE-7
WASHING FASTNESSES

Dye (%)	Yellow Brown SE-RL				Red SE-RL				Blue SE-RL			
	ab		bb		ab		bb		ab		bb	
	r	l	r	l	r	l	r	l	r	l	r	l
0.5	5	5	5	5	5	5	5	5	5	5	5	5
1.0	5	5	5	5	5	5	5	5	5	5	5	5
2.0	5	5	5	5	5	5	5	5	5	5	5	5
	Yellow RD 4GRL				Red RD-GL				Blue RD-GLF			
0.5	5	5	5	5	5	5	5	5	5	5	5	5
1.0	5	5	5	5	5	5	5	5	5	5	5	5
2.0	5	5	5	5	5	5	5	5	5	5	5	5

ab: Acid media dyeing, r: colour fading, bb: alkaline media dyeing, l: staining.

TABLE-8
COLOUR FASTNESSES AGAINST ORGANIC SOLVENTS

Dye (%)	Yellow Brown SE-RL				Red SE-RL				Blue SE-RL			
	ab		bb		ab		bb		ab		bb	
	r	l	r	l	r	l	r	l	r	l	r	l
0.5	5	5	5	5	5	5	5	5	5	5	5	5
1.0	5	5	5	5	5	5	5	5	5	5	5	5
2.0	5	5	5	5	5	5	5	5	5	5	5	5
	Yellow RD 4GRL				Red RD-GL				Blue RD-GLF			
0.5	5	5	5	5	5	5	5	5	5	5	5	5
1.0	5	5	5	5	5	5	5	5	5	5	5	5
2.0	5	5	5	5	5	5	5	5	5	5	5	5

ab: Acid media dyeing, r: colour fading, bb: alkaline media dyeing, l: staining.

TABLE-9
FRICTION FASTNESSES

Dye (%)	Yellow Brown SE-RL				Red SE-RL				Blue SE-RL			
	ab		bb		ab		bb		ab		bb	
	y	k	y	k	y	k	y	k	y	k	y	k
0.5	5	5	5	5	5	5	5	5	5	5	5	5
1.0	5	5	5	5	5	5	5	5	5	5	5	5
2.0	5	5	5	5	5	5	5	5	5	5	5	5
	Yellow RD 4GRL				Red RD-GL				Blue RD-GLF			
0.5	5	5	5	5	5	5	5	5	5	5	5	5
1.0	5	5	5	5	5	5	5	5	5	5	5	5
2.0	5	5	5	5	5	5	5	5	5	5	5	5

ab: Acid media dyeing, y: wet, bb: alkaline media dyeing, k: dry.

Foron red SE-RL: It is understood that the perspiration fastness values of the dyed samples in alkaline media are one degree lower than the light fastness values of the dyed samples in acid media (Table-6). No differences are observed between the other fastness values (Tables 7-9).

Tensile strength measurement results: The tensile strength values of raw fabric are 42.22 kg in the weft direction and 48.37 kg in the warp direction. The shrinkage values of fabric are 3 % in the weft direction and 1.5 % in the warp direction. In Table-10 the values in parentheses were obtained by subtracting the strength values of raw fabrics from the strength values of dyed fabrics.

For Foron yellow brown SE-RL dyestuffs, when the strength values of the dyed samples in alkaline media and the strength values of the dyed samples in acid media are compared, the loss of strength values are higher by 5.58 % in the weft direction and 4.28 % in the warp direction in alkaline media. For Foron red SE-RL dyestuffs, when the strength values

TABLE-10
STRENGTH VALUES OF DYED SAMPLES

1 % dyestuff	Weft direction strength measurements (kg) pH: 5.5	Weft direction strength measurements (kg) pH: 9.5	Warp direction strength measurements (kg) pH: 5.5	Warp direction strength measurements (kg) pH: 9.5
Foron Yellow Brown SE-RL				
	50.20 (7.98)	47.40 (5.18)	48.55 (0.18)	46.47 (-1.90)
Foron Red SE-RL				
	47.35 (5.13)	46.38 (4.16)	47.50 (-0.87)	47.50 (-0.87)
Foron Blue SE-RL				
	47.02 (4.8)	46.42 (4.20)	47.80 (-0.57)	47.00 (-1.37)

of the dyed samples in alkaline media and the strength values of the dyed samples in acid media are compared, the loss of strength values are 2.05 % in the weft direction and similar in the warp direction in alkaline media. For Foron blue SE-RL dyestuffs, when the strength values of the dyed samples in alkaline media and the strength values of the dyed samples in acid media are compared, the loss of strength values are higher by 1.28 % in the weft direction and 1.67 % in the warp direction in alkaline media.

Conclusion

When the results of the six used dyestuffs are examined in general, it is observed that the colours of the dyed samples in alkaline media appeared to be much lighter than the colours of the dyed samples in acid media. This situation means that the amount of used dyestuff should be more when the materials dyed in alkaline media to obtain a colour achieved in acid media. Besides, it was determined that the fastness values were not affected by using dyeing process in alkaline media. Because the dyeing process in alkaline media saponify oligomers, as the reductive washing can be eliminated for medium and light tones by choosing dyestuffs with repeatability, this may be an alternative method in conventional polyester dyeing business.

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