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REUSE OF DECOLORIZED DYEING EFFLUENTS IN REPEATED DYEINGS

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Abstract: *In this experimental work, the effluents of the reactive and disperse dyeings were reused in the next dyeing after the decolourization by ozone gas. Accordingly, the polyester woven samples were dyed with C.I. Disperse Yellow 160, C.I. Disperse Red 77 and C.I. Disperse Blue 79:1, and the cotton woven samples were dyed with C.I. Reactive Yellow 176, C.I. Reactive Red 239 and C.I. Reactive Blue 221. The effluents of the dyeings with these dyes and also with their mixtures were decolorized by ozone gas. The colours of the samples dyed with the decolorized effluents were compared with the original dyeings (standards) and the colour differences were calculated. Under the experimental conditions of this investigation, the many of the dyeing effluents were decolorized successfully, except the effluent of C.I. Disperse Red 77. In the case that this red disperse dye present in the dyebath, the decolorized effluent had a slight reddish colour. The colour differences between the original dyeing (standard) and the samples dyed with the decolorized effluent are mostly below the tolerance (DE<1) or slightly above the tolerance. The solid colours and uniform dyeings were achieved in the dyeings. The method seems promising in decreasing the amount of water used in textile dyeings.*

Key words: *ozone treatment, reuse of dyebaths, decolourization, disperse dyes, reactive dyes*

1. INTRODUCTION

The textile dyeing and finishing processes consume large amount of energy and produce large amount of effluent. The process effluents are usually characterized by high chemical oxygen demand, dissolved solids, large amount of organic chemicals, low biodegradability, strong colour and salinity. In the last two decades, new technologies have been utilized in order to minimize the processing time, energy consumption, water consumption and the amount of effluent [1-6]. The Best Available Techniques (BAT) for water reuse in textile SMEs were summarized elsewhere [7]. “Green production” is a preventive business strategy in textile dyeing and finishing industry and may include the following emerging technologies:

- use of ultrasonic energy in textile dyeing and finishing,
- use of microwave energy in textile dyeing, drying, and dye fixing,
- use of plasma technology in dyeing and finishing,
- use of supercritical fluids in dyeing,
- use of ozone in bleaching of textiles and also in the treatment of effluents,
- use of combined enzymatic processes in the pre-treatment of textiles,
- use of the direct dyebath reuse technology to minimize the amount of water to be

used, and

- reuse of decolorized effluent in dyeing and finishing.

The aim of this work was to reuse the decolorized dyebath effluents in dyeings. Accordingly, the ozone gas treated dyeing effluents of disperse and reactive dyes were reused in the repeated dyeings. The coloristic properties of the repeated dyeings were compared with the results of the dyeings which were carried out conventionally.

2. EXPERIMENTAL

2.1 Fabrics

In this work, 100% cotton (125 g/m^2) and 100% polyester (138 g/m^2) woven fabrics were used in dyeings. The fabrics were already pretreated and ready for dyeing [2].

2.2 Dyes and Chemicals

The dyes and the chemicals used in this experimental work are given in Table 1 and Table 2, respectively.

Table 1: *Disperse and reactive dyes used in the experimental work.*

Trade Name	Producer	Colour Index No.	Constitution
Dianix Yellow S.G.	Dystar	C.I. Disperse Yellow 160	Quinoline
Dianix Red S.G.	Dystar	C.I. Disperse Red 77	-
Dianix Navy S.G. (%200)	Dystar	C.I. Disperse Blue 79:1	Monoazo
Remazol Yellow 3RS	Dystar	C.I. Reactive Yellow 176	Azo
Remazol Brilliant Red 3BS	Dystar	C.I. Reactive Red 239	Monoazo
Sumifix Blue BRF	Sumitomo Chemicals	C.I. Reactive Blue 221	Formazan

Table 2: *The chemicals used in the experimental work.*

Chemical	Trade Name	Producer
Sodium hydroxide	-	Merck
Sodium dithionite	-	Merck
Dispersing agent	Dispersege PTR	Clariant
Sodium sulphate	-	Merck
Sodium carbonate	-	Merck
Nonionic washing agent	Perlavin OSV	Dr. Petry
Acetic acid	-	Merck

2.3 Equipment

The main equipment used is given in Table 3. Decolourization treatment is carried out in a gas washing bottle which was connected to 3 g/h ozone gas generator.

Table 3: *The equipment used in the experimental work.*

Equipment	Producer
Roaches HT Sample Dyeing Machine	Roaches Eng. LTD.
Reflectance Spectrophometer (SF600+)	Datacolor
Ozone Generator [BNP OZ-3G,Ozone (3g/h)]	BNP Ozone Technology Co. Ltd.

2.4 Dyeing of Polyester

1 g samples of polyester fabric were dyed at the concentrations of 1%,1.5%, and 2% o.w.f. in a HT dyeing machine with a bath containing deionized water, 0.25 g/L dispersing agents, pH 4.5-5, L:R 40:1 at 130°C for 80 minutes. After each dyeing, the reductive clearing process was carried

out with a bath containing 2 g/L sodium dithionite, 2 g/L NaOH, 2 g/L dispersing agent, 1 g/L detergent at 75°C for 20 minutes. The Liquor Ratio was 40:1.

2.5 Dyeing of Cotton

1 g samples of cotton fabric were dyed at the concentrations of 1%,1.5%, and 2% o.w.f. in a HT dyeing machine with a bath containing deionized water, 65 g/L sodium sulphate, 5 g/L sodium carbonate, L:R 40:1 at 60°C for 150 minutes. The dyed samples were later given 2 rinses at 70°C for 10 minutes, neutralized and soaped with 1 g/L Perlavin OSV at the boil. Two more rinses were later given at 70°C and 50°C for 10 minutes with fresh water.

2.6 Decolourization of Dyeing Effluents

The disperse dyeing effluents were decolorized by ozone gas at pH 10.5-11, at 25°C for 1 hour in a gas washing bottle which was connected to a 3 g/h ozone gas generator. A very clear, decolorized water was achieved with the yellow and blue disperse dyes, but a complete decolourization was not possible with the red disperse dye. The decolourization of the reactive dyeing effluents for three dyes were successful at pH 7-8.5, at 25°C for 30 minutes.

2.7 Dyeing with Decolorized Effluents

The reactive and disperse dyeings with decolorized effluents were carried out as described above and if necessary, small amounts of fresh water were added to the dyebaths in the preparation of the dyebaths for the next dyeing. The samples were coded in respect to the origin of the decolorized effluent and the dyes used for the next dyeing. The decolorized effluents and the dyeings were coded as shown below:

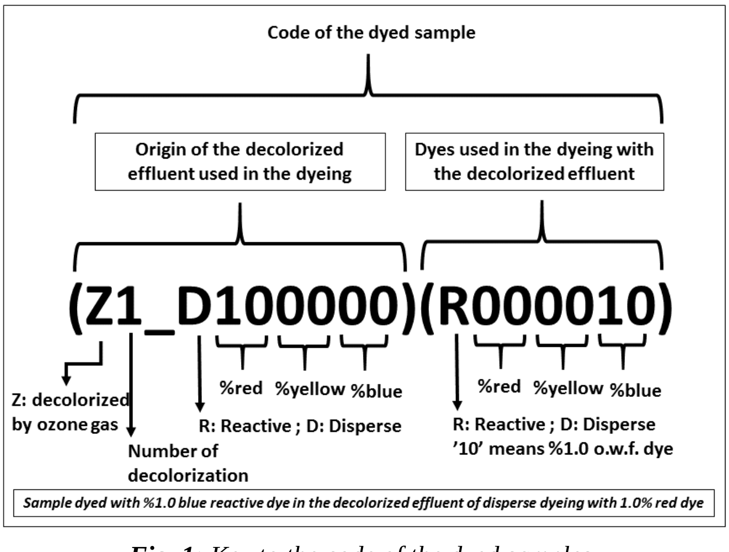

Fig. 1: *Key to the code of the dyed samples.*

As an another example, the sample coded as **(Z1_D001000) (D050505)** is the sample dyed with a mixture of 0.5% o.w.f. red, 0.5% o.w.f. yellow and 0.5% o.w.f. blue disperse dyes in the decolorized effluent of disperse dyeing with 1.0% o.w.f. yellow dye. "**K**" is used to describe the conventionally dyed sample (standard). For example, **(K_D050505)** is the sample dyed with 0.5% o.w.f. disperse red, 0.5% o.w.f. disperse yellow and 0.5% o.w.f. disperse blue conventionally.

3. RESULTS AND DISCUSSIONS

The decolourization process for many of the dyes except the red disperse dye (C.I. Disperse Red 77) was successful, and the clear decolorized water was achieved for the reuse in the next dyeing. Because of the failure of the decolourization process for the red disperse dye under the test conditions of this investigation, the colour differences were higher than the tolerance between the original dyed samples and the samples dyed with the decolorized effluents including red disperse dye. The best results of the reuse of the decolorized effluents in dyeings were summarized in Table 6 and Table 7. The CIELab values of the conventionally dyed samples (standards) and the samples dyed in the decolorized effluents are given in Table 4 and Table 5, respectively. The colour differences are mostly below the tolerance (DE < 1); however, in some dyeings, DE is slightly higher than the tolerance.

Table 4: *CIELab and tristimulus values of the conventional dyeings.*

Dye	Code of Dyeing	CIELab and Tristimulus Values							
		L^*	a^*	b^*	C^*	h°	X	Y	Z
Disperse Dyes	(K_D100000)	40.85	56.03	18.49	59.00	18.26	20.70	11.77	6.75
	(K_D200000)	36.34	52.56	21.31	56.71	22.07	16.32	9.19	4.39
	(K_D001000)	84.94	-4.88	84.61	84.76	93.30	60.39	65.89	9.59
	(K_D002000)	83.96	-4.73	87.23	87.36	93.11	58.68	63.98	8.27
	(K_D000010)	30.03	0.40	-29.30	29.30	270.77	5.96	6.25	17.21
	(K_D000020)	23.40	3.42	-21.66	21.93	278.98	3.94	3.92	9.65
	(K_D050505)	25.88	8.90	-2.21	9.17	346.09	5.15	4.70	5.53
	(K_D101010)	21.40	4.74	-1.82	5.07	339.03	3.47	3.35	3.91
Reactive Dyes	(K_R000010)	46.74	-2.89	-28.72	28.87	264.26	14.53	15.82	34.42
	(K_R200000)	55.43	52.26	-9.98	53.49	349.25	35.52	23.35	31.65
	(K_R002000)	71.56	26.84	72.81	77.60	69.76	50.11	43.01	6.40
	(K_R000020)	35.52	-0.12	-30.18	30.81	269.78	8.29	8.76	22.97
	(K_R050505)	43.32	-2.85	1.69	3.32	149.32	12.26	13.37	13.65

*Key to the codes: "**K**" is used to describe the conventionally dyed sample.*

Table 5: *CIELab and tristimulus values of the samples dyed with decolorized effluents.*

Code of Dyeing	CIELab and Tristimulus Values							
	L^*	a^*	b^*	C^*	h°	X	Y	Z
(Z1_R050505) (D100000)	40.56	56.45	19.33	59.66	18.91	20.53	11.59	6.41
(Z1_R050505) (D000010)	28.19	0.77	-28.74	28.75	271.54	5.31	5.23	15.30
(Z1_R050505) (D000020)	23.14	2.78	-19.87	20.07	277.96	3.82	3.84	8.94
(Z1_R000010) (D000020)	23.03	3.83	-22.17	22.50	279.81	3.86	3.81	9.61
(Z1_R001000) (D000020)	21.76	3.94	-21.54	21.90	280.15	3.51	3.45	8.73
(Z1_R100000) (D000020)	22.61	3.87	-21.63	21.98	280.15	3.74	3.69	9.20
(Z2_R000010) (D050505)	24.60	9.16	-3.25	9.72	340.48	4.74	4.29	5.27
(Z1_D001000) (D000020)	22.28	3.19	-21.36	21.60	278.48	3.75	3.74	9.21
(Z1_D000010) (D200000)	35.95	51.85	20.66	55.81	21.73	15.91	8.98	4.39
(Z1_D000010) (D000020)	23.33	3.92	-21.86	22.21	280.16	3.96	3.90	9.67

(Z1_D001000) (D050505)	25.39	9.41	-2.23	9.67	346.68	5.03	4.54	5.35
(Z1_D000010) (D050505)	26.64	8.51	-2.57	8.89	343.20	5.39	4.97	5.91
(Z2_D050505) (R000010)	46.04	-3.05	-28.48	28.64	263.89	14.02	15.30	33.34
(Z1_D001000) (R200000)	54.94	51.37	-9.31	52.20	349.72	34.55	22.87	30.59
(Z1_D001000) (R002000)	71.17	26.90	72.45	77.28	69.63	49.50	42.43	6.33
(Z1_D001000) (R000020)	35.48	0.02	-30.25	30.25	270.04	8.29	8.74	22.62
(Z1_D001000) (R050505)	44.43	-2.40	1.96	3.10	140.86	13.04	14.14	14.34
(Z1_D000010) (R200000)	55.15	53.44	-9.50	54.28	349.92	35.42	23.07	30.97
(Z1_D000010) (R002000)	73.32	27.25	74.00	78.86	69.78	53.14	45.65	6.87
(Z1_D000010) (R000020)	36.96	0.15	-31.84	31.84	270.27	9.04	9.52	25.06
(Z1_D000010) (R050505)	43.24	-1.20	2.27	2.57	117.96	12.45	13.32	13.27
(Z1_D050505) (D050505)	26.73	9.17	-1.21	9.25	352.48	5.48	5.00	5.63

Table 6: *Colour Differences between the original dyeings and the dyeings in the decolorized bath.*

Colour Differences	(Z1_R050505) (D100000) Standard: (K_D100000)	(Z1_R050505) (D000010) Standard: (K_D000010)	(Z1_D000010) (D200000) Standard: (K_D200000)	Z2 (D050505) (R000010) Standard: (K_R000010)	(Z1_D001000) (R000020) Standard: K (R000020)	(Z1_D000010) (R000020) Standard: (K_R000020)	(Z1_D001000) (R200000) Standard: (K_R200000)	(Z1_D000010) (R200000) Standard: (K_R200000)	(Z1_D001000) (R002000) Standard: (K_R002000)	(Z1_D000010) (R002000) Standard: (K_R002000)	(Z1_D050505) (D050505) Standard: (K_D050505)
$\Delta E_{CMC(2:1)}$	0.981	1.957	1.038	0.757	0.576	1.793	1.447	1.040	0.534	2.164	2.061
ΔL^*	-0.289	-1.897	-0.386	-0.699	-0.038	1.442	-0.494	-0.283	-0.393	1.758	1.035
ΔC^*	0.661	-0.556	-0.902	-0.229	-0.557	1.031	-1.289	0.783	-0.314	1.262	-0.146
ΔH^*	0.664	0.390	-0.339	-0.182	0.139	0.271	0.434	0.624	-0.179	0.030	1.473

Table 7: *Colour Differences between the original dyeings and the dyeings in the decolorized bath.*

Colour Differences	(Z1_D001000) (D000020) Standard: (K_D000020)	(Z1_D000010) (D000020) Standard: (K_D000020)	(Z1_R000010) (D000020) Standard: (K_D000020)	(Z1_R001000) (D000020) Standard: (K_D000020)	(Z1_R100000) (D000020) Standard: (K_D000020)	(Z1_R050505) (D000020) Standard: (K_D000020)	(Z1_D001000) (R050505) Standard: (K_R050505)	(Z1_D000010) (R050505) Standard: (K_R050505)	(Z2_R000010) (D050505) Standard: (K_D050505)	(Z1_D000010) (D050505) Standard: (K_D050505)	(Z1_D001000) (D050505) Standard: (K_D050505)
$\Delta E_{CMC(2:1)}$	0.731	0.536	0.750	1.722	0.915	1.919	1.231	1.748	1.671	0.931	0.702

ΔL^*	-0.624	-0.068	-0.369	-1.639	-0.795	-0.265	1.115	-0.075	-1.281	0.760	-0.485
ΔC^*	-0.330	0.279	0.568	-0.032	-1.864	-1.864	-0.218	-0.750	0.545	-0.285	0.498
ΔH^*	-0.188	0.453	0.321	0.527	-0.372	-0.372	-0.473	-1.577	-0.923	-0.455	0.097

The decolorized effluents of the reactive dyeings were used in the dyeing of disperse dyeings, and vice versa. Overall, the results are quite promising. DE values in many dyeings are below the tolerance (DE < 1). DH^* values are also quite small in many of the dyeings, which mean that there are no dramatic hue changes.

4. CONCLUSIONS

Under the experimental conditions of this investigation, many of the dyeing effluents were decolorized successfully, except the effluent of C.I. Disperse Red 77. In the case that this red disperse dye present in the dyebath, the decolorized effluent had a slight reddish colour. The colour differences between the original dyeing (standard) and the samples dyed with the decolorized effluent are mostly below the tolerance (DE<1) or slightly above the tolerance. The solid colours and uniform dyeings were achieved in the dyeings. The method seems promising in decreasing the amount of water used in textile dyeings and the further investigations are required. Much better results can be achieved by carefully control of the decolourization process and the dyebath conditions.

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