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Effect of Mordant on the Flammability of Fabrics

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Due to the sensitiveness of textile for flaming and the rate of flame transfusion of fiber, some experiments with natural dyes (*e.g.* reseda, madder, kermes and pomegranate peel) have been done on cotton, wool and polyester fabric. In these experiments, fabrics were dyeing with natural dyes by bottom chrome method. Considering the standard flame test of material, those cotton fabrics which are dyed by reseda and alum mordant, when the fire is died out, the kind of mordant is an effective parameter. Actually, by increasing the molecular weight of the mordant (*e.g.* alum mordant) the after glow (A.G.) is decreased. The results indicated that between samples there is a significant difference which can be depend on the kind of mordant and dyes.

Key Words: Natural dye, Flammability, Flame retardant, Flaming parameter.

INTRODUCTION

The demand for the safety products is increasing in the world and textile products are not excluded from this rule. Because the thermo physical properties of fibers and fabrics as well as their related factors affect on flaming, propagation of flame and time of flaming, so the information about the above mentioned properties is very important[1]. Many empirical theories have been developed to explain how a cellulosic substrate is made flame-retardant[2,3]. In this context, cotton fabrics are extremely important. The subject of flame-retardant of cotton warrants more serious consideration in depth than it has received in the past. Many effective durable flame-retardant finishes for cotton fabrics have been proposed[4]. Cyanamid in combination with phosphoric acid as a flame retardant for cellulosic fabrics has been known for a number of years and many patents[5,6].

Benisek[7,8] applied phosphorus based flame retardant to wool and blended inherently flame-retardant fibers with wool to produce flame-retardant fabrics. Wool and cotton/wool blends have been successfully treated with an oligomeric vinyl phosphonate finish[9,10]. Change in thermo physical properties of fiber are dependent

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to factors for example, thermal conductance, specific heat of fabric, density, ignition and melt temperature, heat of burning, kind of dye and methods of dyeing, humidity, rate of increase of temperature, compaction of fabric and designed, *etc.*[1]. When surface temperature of fabric and fiber have enough arrived to the critical of temperature in this time flaming were happened that in this condition had exploration effective parameter on propagation of flam and time of flaming that kind of design of garment and dress; size of garment occurrence of thermoplastic fiber in garment and fabric and arrangement of layers in fabric and garment were effective, but in time of flaming are parameters for example; weight of fabric; distance to source of heat; pores of fabric that were effective[1,11].

The property of textile can improve with decrease of temperature of burn with wetting material, for example mineral salt, coated fabric with an incombustible material, product incombustible residual, product incombustible gas from burn, change chemical demand of fiber with heat, product less heat of gas in burn, remove oxygen from fire, product dehydration of fiber for example cellulose and polypropylene fibers done by this method and reported[11,12]. In additional, the effect of different concentrations of flame retardant reagent on physical properties and absorption characteristic of activated carbon fiber absorbents (ACFA) were examined to derive the optimal conditions for manufacturing and activated carbon fiber absorbents. There are two kind of cellulose pyrolysis reaction. One kind of reaction is depolymerization with higher activation energy and the other one is depolymerization with lower activation energy[13].

EXPERIMENTAL

The weaving fabrics used in this research were three groups of material as follow: cotton (100 %), wool (100 %) and polyester (100 %). Plane woven fabrics were produced by using same yarn as weft and warp with count 30 Ne. The warp and weft density of these fabrics are 25 picks/cm. The fabrics were dyed with reseda, madder, kermes, pomegranate peel by general method. Then flame test done with method B.S.3119 (*e.g.* standard of flame test for S.D.L. machine flame tester) with Shirley machine and ignition parameters were compared with witness sample of each group. All flammability tests were conducted under ambient temperature and relative humidity existing in the laboratory. The average temperature ranged between 23 and 27 °C and the average relative humidity ranged between 60 and 70 %. The samples were prepared with the bath make from 3 g/L detergent, 1 g/L soda ash and liquor ratio 40:1 for 20 min at 70 °C. The samples were washed finally rinsed and hydro extraction. The condition of mordant of samples is shown in Table-1. After mordant of samples, it is dyeing with natural dyes at pH 5-5.5 as follows: reseda, madder, kermes, pomegranate peel according to Table-2.

The residual dyes and three groups of samples were separated with the bath contain 3 g/L detergent with liquor ratio 50:1 for 20 min at 70°C. Test samples measuring 28 cm in the warp direction and 10 cm in the fill were placed in a metal

holder and mounted in the test cabinet at a 45° angle. The burner was set to provide a burner-tip-to-fabric distance of 30 mm and the height of flame was adjusted to 45 mm. Ignition time for the fabrics (cotton, wool and polyester) was set at 5 s. Fabrics were ignited at the lower edge. Finally, time of travel and burning rates were calculated from the measurements with eight measuring points of holding frame by used digital camera (*e.g.* S7000 Fuji digital camera) that was recorded on the file with continuous shooting frames (*e.g.* 3.3 frame/s and making file with JEPG format at high resolution picture (*e.g.* 6 Mega pixel)). The experimental results of flame tests for all samples were analyzed at 95 % level significant by using ANOVA and Duncan test[14]. To recognize the difference among means, the Duncan test for obtained results has been used.

TABLE-1
CONDITION OF MORDANT OF SAMPLES

Condition \ Mordant	$Fe_2(SO_4)_3$	Alum	$Na_2Cr_2O_7$
Mordant (%)	3.0	3.0	3.0
Acetic acid (%)	1.5	1.5	1.5
Temperature (ºC)	70	70	70
L:R*	50:1	50:1	50:1
Time (min)	45	45	45

*: Liquor ratio.

TABLE-2
CONDITION OF DYEING

Condition	Natural dye (%)	Acid acetic (%)	L:R*	Temperature (ºC)	Time (min)
Value	10	1.5	30/1	80	80

*: Liquor ratio.

RESULTS AND DISCUSSION

The samples of fabric, dye and mordant were coded in Table-3. Therefore, for the better comparison of these results (Table-3) the first character of code is kind of material of fabric, second character is kind of natural dye and the third character is condition of mordant. For example "CR2" the first character "C" is cotton fabric, the second character "R" is Reseda dye and the third character "2" it means that the mordant process done by alum 3 % another example "PK1" show that the first character "P" is polyester fabric, the second character "K" is kermes dye and the third character "1" is condition of mordant process done by sodium dichromate 3 %.

Flammability of samples dyes were tested by standard machine and its results were shown in the Table-4. These tests done by Shirley machine and all of fabrics samples placed on this machine with the obverse position and also it's after experimental tests these fabrics have many residual to turn into ashes. The results of samples of flame ret ardency tests were coded as in Table-4. For example flame

application time were coded "F.A.T.", after burn were coded "A.B." and also after glow were coded A.G. Fig. 1 showed that the time of cotton fabric after burn in spite of high oxidation of sodium dichromate effect on the samples which causes negative effect of "A.B" time, but because of having natural dyes effect on cotton fabric in compare to its witness of sample, we have a tangible increase in amount of A.B. time except sample CM1. Also in sample CR2 because of no negative effect of mordant and on the other hand positive effect of natural dyes cause high duration of "A.B." time in the all of cotton samples.

TABLE-3
CODE OF SAMPLES

Code of fabric		Code of dye		Code of mordant	
Sample	Code	Sample	Code	Sample	Code
Cotton	C	Reseda	R	$Na_2Cr_2O_7$ 3 %	1
Wool	W	Pomegranate peel	N	Alum 3 %	2
Polyester	P	Kermes	K	$Fe_2(SO_4)_3$ 3 %	3
		Madder	M		

TABLE-4
RESULTS OF FLAME TEST SAMPLES

Code	F.A.T.	A.B.	A.G.	Code	F.A.T.	A.B.	A.G.
C*	5	12.75	19.62	WK1	5	19.08	0
CR1	5	15.79	10.38	WK2	5	16.63	0
CR2	5	23.24	15.88	WK3	5	17.41	0
CR3	5	15.87	13.57	WM1	5	12.82	0
CN1	5	14.78	15.99	WM2	5	23.61	0
CN2	5	12.97	20.82	WM3	5	18.89	0
CN3	5	18.85	13.36	P*	5	3.9	0
CK1	5	17.65	17.04	PR1	5	3.45	0
CK2	5	17.43	14.51	PR2	5	1.75	0
CK3	5	16.26	14.18	PR3	5	2.47	0
CM1	5	11.7	16.56	PN1	5	3.25	0
CM2	5	16.8	14.73	PN2	5	1.7	0
CM3	5	15.32	15.44	PN3	5	1.83	0
W *	5	15.66	0	PK1	5	1.93	0
WR1	5	13.65	0	PK2	5	2.77	0
WR2	5	20.85	0	PK3	5	1.57	0
WR3	5	20.55	0	PM1	5	2.15	0
WN1	5	20.83	0	PM2	5	2.56	0
WN2	5	22.46	0	PM3	5	2.29	0
WN3	5	20.79	0				

*: Witness of sample of fabrics, Code: code of sample, F.A.T.: flame application time (second), A.B.: after burn time (second), A.G.: after glow time (second).

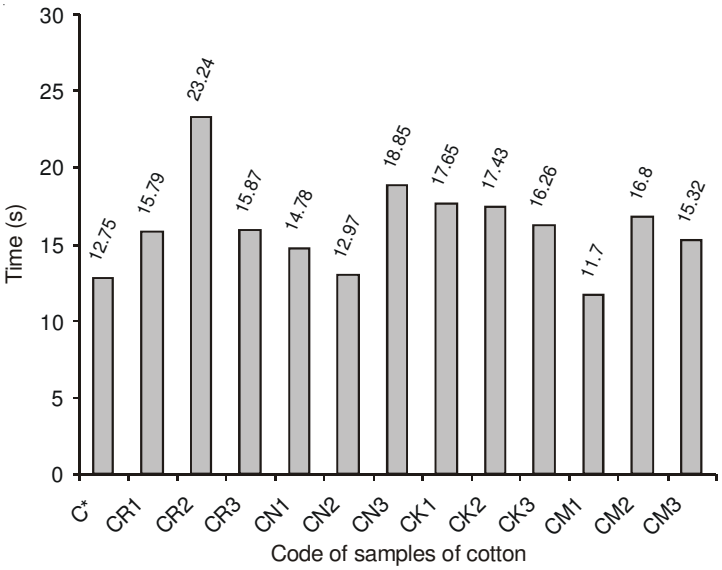

Fig. 1. Variation in cotton fabrics' behaviour after burn time

In cotton fabrics which are dyed by reseda and alum mordant, when the fire is died out, the kind of mordant is an effective parameter and by increasing the molecular weight of mordant, the A.G. time decreases (CR1). The wool fabric dyed by madder and the polyester fabric dyed by reseda (in order WM2 and PR1) have the greatest pyrolysis for ignition. It can be the cause of having a lot of mineral salts and also mineral mordant which are used in natural dyeing process. The above results are shown in Table-4 and illustrating this effect is shown in the graphs of Figs. 2 and 3.

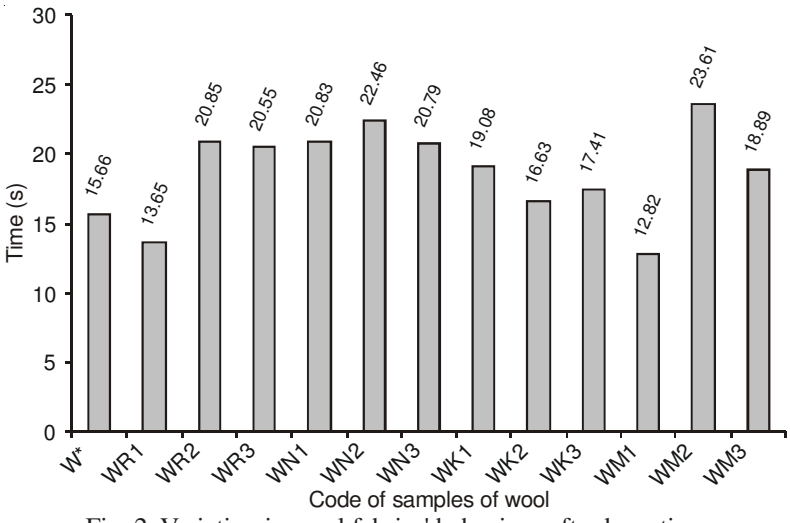

Fig. 2. Variation in wool fabrics' behaviour after burn time

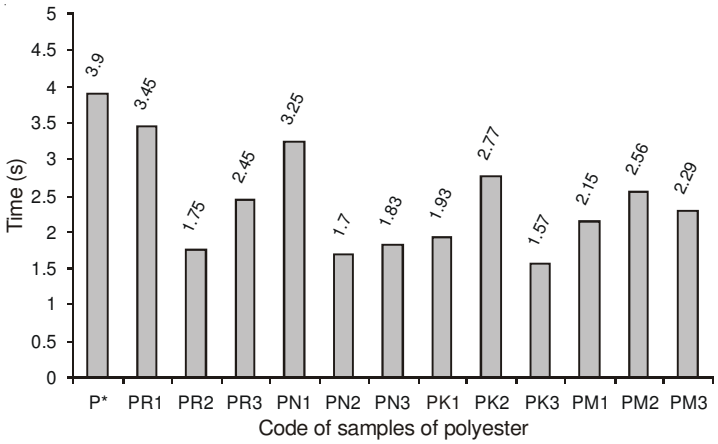

Fig. 3. Variation in polyester fabrics' behaviour after burn time

ANOVA and Duncan test on the experimental results of after burn (A.B.) on samples showed significant differences among the means (Tables 1 and 2). Trend to increase the molecular weight of mordant (alum mordant) on cotton and wool dyed fabrics cause increase in time of after burn (A.B.) and maximum values of samples are WM2 and CR2 (wool and cotton with alum mordant). But in polyester fabrics because of low diffusion of mordant and dye, amount of A.B. time have not positive effect and minimum amount of A.B. time concern of PK3 and PN2. In other words, by increasing the molecular weight of mordant of samples, the A.B. time in the wool and cotton fabrics increase in compare to witness of sample.

Conclusion

The obtained results in this studies indicated that the cotton fabrics have a maximum A.B. time in CR2 and less A.G. in CR1 by reseda dye with sodium dichromate. Therefore if the fire died out in this time, the kinds of mordant are effective parameters and whatever the mordant have more molecular weight after the fire died out in this time A.G. drop and decrease in the A.G. time happen. The wool fabric dyed with madder have the greatest pyrolysis for ignition, it could be because of different various mineral salts and also different mineral mordant use in dyeing on natural dyes. Therefore in the natural dye by increasing the molecular weight of mordant of samples, the time of after burn (A.B.) increases and molecular weight of mordant is effective parameter.

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