IMPROVEMENT OF DYEABILITY OF COTTON TEXTILE MATERIALS AFTER FUNCTIONALISATION OF THEIR SURFACE

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Abstract
The study of surface textile treatment by various methods for the improvement of the dyeing or finishing of textile is very interesting for a few years. The low-temperature plasma at the atmospheric pressure uses for the increase of hydrophility of textile surface, which would be to provide the finishing treatment of these materials on the higher qualitative and quantitative level. In this paper the effect of the various conditions of plasma activation of cotton on the classical exhaustion dyeing from bath will be presented.
Key words: cotton textile, surface treatment, low-temperature plasma, classical exhaustion dyeing

1. Introduction

The surface textile treatment by low temperature plasma technologies is more and more popular as a surface modification technique [1, 2]. It offers numerous advantages over the conventional chemical processes. The use of water and chemicals does not require at the plasma surface modification what is good for more economical and ecological process. The enormous advantage of plasma processes concerns the drastic reduction in pollutants and a corresponding cost reduction for effluent treatment, so it can be considered as an environmentally benign technology [1, 3]. The low temperature plasma is a partially ionized gas with electron temperatures much higher than ion temperatures. The high-energy electrons and low-energy molecular species can initiate reactions in the plasma volume without excessive heat causing substrate degradation. Low temperature plasma is able to apply to textile processing because most textile materials are heat sensitive polymers. At this method, a large variety of chemically active functional groups can be incorporated into the textile surface. The results of this activity can be the improvement wettability, adhesion of coatings, printability, induced hydro- and/or oleophobic properties, changing physical and/or electrical properties, cleaning or disinfection of fibre surfaces etc.

Plasma can also be used to modification of the fibre surface such as: increase the failure stress and strain of carbon fibre [4, 5] and to improve shrink resistance of wool fabric [4, 6, 7]. It has been reported that exposure of cotton yarn to the plasma of an electrical glow discharge resulted in an increase in breaking strength of the yarn [4, 8]. Plasma treated wool top offers a number of processing benefits at different stages of the wool pipeline including significant improvements in spinning performance and dyeing properties [4, 9]. The production of woven fabrics from plasma treated tops offers considerable potential for the production of machine washable products minimising the conventional wet oxidation techniques. With the reference to previous research [4, 10], exposure natural fabrics to a plasma environment can produce more reactive surfaces.

In this paper the effect of the various conditions of low temperature plasma activation of cotton textile materials will be presented. There will determine the dyeability as color difference and wear resistance of untreated and treated cotton textile materials.

2. Experimental part

2.1 Materials used

The woven textile fabrics from the bleached and unbleached cotton were used as a substrate for treatment of low temperature plasma.

2.2 Methods used

The samples of unbleached and bleached cotton textile were activated by low temperature plasma generated discharge at the atmospheric pressure for 3 seconds. Next, the samples were dyed by classical exhaustion dyeing from bath from various time of plasma activation.

The equipment AHIBA ↑↓ AG CH 4127 Bisfelden (Switzerland), type G6 RTC (4,4 kW) was used for the dyeing of cotton materials by classical exhaustion method from bath. The dyed conditions were follows: dyes - Bezaktiv Rot and Bezaktiv Blau, concentration of dye - 2% o.w.f., concentration of auxiliary agents - 20 g/l Na_2CO_3 and 75 g/l NaCl, dyeing time 60 minutes, temperature - 60°C. After the dyeing the samples were cleaned in the water for 10 minutes and dried.

The color difference ΔE was evaluated for the all dyed untreated and treated cotton materials using spectrophotometer. Wear resistance to dry and water of these samples were also evaluated.

3. Results and Discussion

The obtained results from the evaluation of the color difference of various treated cotton samples are in tables 1 and 2.

Table 1. Color difference ΔE of unbleached and bleached cotton before and after cleaning dyed from various time of plasma activation (dye Bezaktiv Rot)

Unbleached				Bleached			
Before cleaning		After cleaning		Before cleaning		After cleaning	
t, min	ΔE	t, min	ΔE	t, min	ΔE	t, min	ΔE
7	1,67	7	2,83	7	5,83	7	7,43
10	1,83	10	2,17	10	7,70	10	11,63
15	1,22	15	3,57	15	7,09	15	6,90
20	2,28	20	5,13	20	6,00	20	8,27
30	2,38	30	6,03	30	5,57	30	9,12
60	1,89	60	2,33	60	0,85	60	0,64
1440	0,89	1440	2,96	1440	1,46	1440	0,91

The color difference of dyed (unbleached and bleached) cotton increases till 15-30 min after plasma activation. The dyeing after longer time from plasma activation decreases of color difference. It means the worse dyeability of cotton by classical exhaustion from bath.
The effect of various times from the plasma activation on the dyeability after cleaning of unbleached and bleached cotton was not observed. The higher color differences at the dyeing were obtained for the bleached cotton like the unbleached cotton.

Table 2. Color difference ΔE of unbleached and bleached cotton before and after cleaning dyed from various time of plasma activation (dye Bezaktiv Blau)

Unbleached				Bleached			
Before cleaning		After cleaning		Before cleaning		After cleaning	
t, min	ΔE	t, min	ΔE	t, min	ΔE	t, min	ΔE
7	1,16	7	1,66	7	3,44	7	9,33
10	1,59	10	1,51	10	3,82	10	10,39
15	1,44	15	4,51	15	6,04	15	7,46
20	1,18	20	3,81	20	2,99	20	9,45
30	1,82	30	4,88	30	2,71	30	11,08
60	2,22	60	4,11	60	0,92	60	1,91
1440	4,28	1440	4,24	1440	0,32	1440	2,04

The wear resistances to dry and to water of unbleached and bleached cotton before and after cleaning dyed from various time of plasma activation by two dyes are in the tables 3-6.

Table 3. Wear resistance to dry of unbleached and bleached cotton before and after cleaning dyed from various time of plasma activation (dye Bezaktiv Rot)

t [min]	Unbleached		Bleached	
	Before cleaning	After cleaning	Before cleaning	After cleaning
0	4	4	4-5	4-5
7	5	5	5	5
10	5	5	5	5
15	5	5	5	5
20	5	5	5	5
30	5	5	5	5
60	5	5	5	5
24	4	5	5	5

Table 4. Wear resistance to water of unbleached and bleached cotton before and after cleaning dyed from various time of plasma activation (dye Bezaktiv Rot)

t [min]	Unbleached		Bleached	
	Before cleaning	After cleaning	Before cleaning	After cleaning
0	2	3	3	4
7	2	3-4	3-4	4-5
10	2-3	4	3-4	4-5
15	2-3	4	3-4	4-5
20	2-3	4	2	4-5
30	3	4	2	4-5
60	2	3-4	3-4	4
24	2-3	3-4	3	4

From obtained results it follows that the wear resistance to dry at the unbleached and bleached cotton dyed by both dyes are higher like the wear resistance to water and satisfy to standard specification at all samples.

Table 5. Wear resistance to dry of unbleached and bleached cotton before and after cleaning dyed from various time of plasma activation (dye Bezaktiv Blau)

t [min]	Unbleached		Bleached	
	Before cleaning	After cleaning	Before cleaning	After cleaning
0	4	4	4-5	4-5
7	4	4-5	5	5
10	5	5	5	5
15	5	5	5	5
20	5	5	5	5
30	5	4-5	5	5
60	4	4-5	5	5
24	4-5	4-5	5	5

The wear resistance to water is very low mainly evaluated for the samples of unbleached cotton before cleaning. After cleaning the wear resistances to water are higher. It is induced by the diffusion of unbound dyed molecules from cotton to cleaning bath.

Table 6. Wear resistance to water of unbleached and bleached cotton before and after cleaning dyed from various time of plasma activation (dye Bezaktiv Blau)

t [min]	Unbleached		Bleached	
	Before cleaning	After cleaning	Before cleaning	After cleaning
0	1-2	2-3	2-3	4
7	2	3-4	2-3	4-5
10	2	3-4	2-3	4-5
15	2	3-4	3	4-5
20	2-3	3-4	2-3	4-5
30	2	4	2-3	4-5
60	1-2	3	2	4-5
24	1-2	2-3	2-3	4-5

4. Conclusion

The color difference of unbleached and bleached cotton dyed both reactive dyes increases to 15-30 min after the plasma activation.
The better dyeability was obtained for the bleached cotton materials.
The wear resistance to dry of dyed cotton materials is higher like the wear resistance to water for the all cotton samples.
The cleaning of dyed cotton samples increases the wear resistance to water.

5. References

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