A STUDY ON THE MODIFICATION AND HEAVY SHADE OF RAMIE TREATED BY LOW TEMPERATURE PLASMA

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ABSTRACT: The modification and heavy shade ability of ramie treated by low temperature plasma were studied in three ways, including plasma surface treatment, grafting polymerization of acrylamide initiated by plasma, as well as combination treatment by resin or soft finish and plasma after dyeing. The correlation between weight loss, hydroscopicity, as well as heavy shade ability after treatment and treating conditions was investigated systematically. The result shows that the ramie's physical properties and chemical composition are changed, and heavy shade can be obtained.

I. INTRODUCTION

Ramie fabric is ventilative, pleasantly cool and comfortable to wear, and it is a kind of favourite fabric. Because its orientation is much higher than that of cotton and the diffusion rate of dye is much lower than in cotton, it is difficult to dye ramie in heavy or bright shade. Therefore there is an urgent need to improve the heavy shade ability of ramie. It has been reported that the dyeing ability of ramie can be improved to some extent by modification with cationic agent[1] or by treatment with alkli[2]. But they produce pollution and do damage to fabric, and the cost is high.

Recently some researchers have used low temperature plasma to improve the dyeing properties of fabrics, but little has been done to ramie because of the difficulty in dyeing it. Low temperature plasma has many advantages shuh as doing no damage to fibre, reducing the consumption of water and energy, and producing no pollution. So it has a bright prospect. In the study, ramie was treated by low temperature oxygen plasma. The result shows that after treatment many microcraters were formed on the fibre surface, the hydroscopicity and heavy shade ability were increased, and the fastness was improved.

II. TREATMENT AND DYEING

Ramie samples were scoured and dried before treatment. After that they were

treated and dyed in three different ways, treated by plasma then dyed, treated by grafting polymerization of acrylamide initiated by plasma and dyed, dyed first and then treated by resin or soft finish and plasma respectively.

Dyeing was carried out at the initial temperature of 40 ℃ in direct black T at the concentration of 1.5% owf and the liquor ratio of 50:1. Then the temperature was raised to 90 ℃. After that the samples were dyed for 30 minutes at 90 ℃.

III. TEST METHODS

Determine the weight W_0 of a sample before treatment by plasma and the weight W_i after treatment respectively. Then the lost weght was obtained according to $(w_0-w_i)/w_0 \times 100\%$.

Hydroscopicity was determined by measuring the vertical height to which water climbed in 30 minutes.

The absorptivity of dye liquor was measured on a 722 spectrophotometer before and after dyeing respectively. Then the dye-uptake of a sample was determined according to the absorptivity, and the dye-uptake C_i of every sample after treatment by plasma was determined. After that the percent increase of dye-uptake ΔC_f was calculated according to the equation

$$\Delta C_f=(C_i-C_0)/C_0 \times 100\% \qquad (1)$$

in which C_0 was the dye-uptake of an untreated sample.

Heavy shade ability DE was determined[3] according to CIE L a b , in which the untreated sample was refered to as a standard. If DE is positive, it indicates the dye-uptake is increased by treatment, and *vice versa*.

The tests of wash-fastness and rub-fastness were carried out according to ISO 105/C03-1985 and ISO 105/X12-1987 respectively.

IV. RESULT AND DISCUSSION

First, the effects of treating time by plasma on weight loss, dye-uptake and heavy shade ability are illustrated in Fig. 1. It can be seen from Fig. 1(a) that the weight loss increases with the increase of treating time. The reason is that microcraters are formed on the surface of the treated sample, and the longer it is treated, the more microcraters. This will influence the dye-uptake and heavy shade ability. It also can be seen from Fig. 1(a) that the hydroscopicity is increased greatly by treatment in a short time. When the sample is treated for 30s, the capility reaches the highest value. From Fig. 1(b) and (c) it can be seen that the dye-uptake and heavy shade ability vary in the similar way. The dye-uptake and heavy shade ability reach the highest values when the sample is treated for 30s. After that they decrease with the increase of treating

time. After 60s they keep constant. The reason is that many factors such as the electrical properties and the degree of erosion on the ramie surface, the hydroscopicity and microstructures of ramie have effects on dyeing and plasma treatment can influence the factors. So the optimal treating time is 30s.

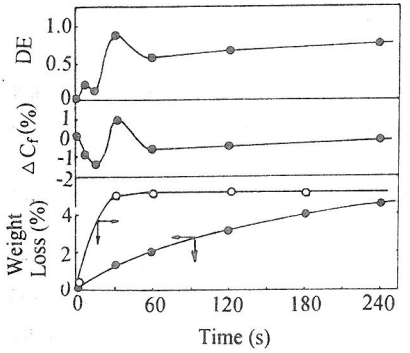

Fig. 1 Dye-uptake, heavy shade ability, weight loss and capilarity against treating time

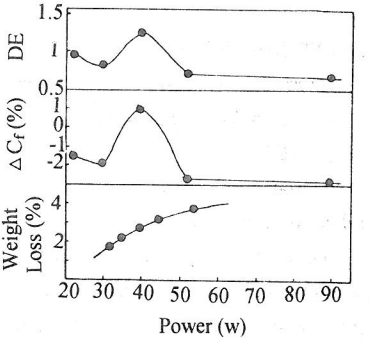

Fig. 2 Dye-uptake, heavy shade ability and weight loss against treating power

The effects of treating power are shown in Fig. 2. It can be seen from Fig. 2 that the weight loss increases with the increase of treating power. The reason is that the greater the treating power, the greater the energy of the particles colliding with the surface of ramie, the stronger the interaction between the particles and the surface, and the greater the weight loss. The dye-uptake and heavy shade ability change almost in the same way. they reach the highest values when the treating power is 40w. After that they decrease with the increase of treating power. When treating power is over 50w, they will almost keep constant. So the optimal treating power is 40w.

The effects of treating vacuum degree are shown in Fig. 3. It can be seen from Fig. 3 that when treating vacuum degree is less than 30Pa, the weight loss increases with the increase of vacuum degree. But when vacuum degree is over 30Pa, the weight loss will decrease. The reason is that the average energy of the particles colliding with the surface of ramie and the eroding ability decrease when vacuum degree is too high. There is also an optimal vacuum degree, when the dye-uptake and heavy shade ability reach the highest values.

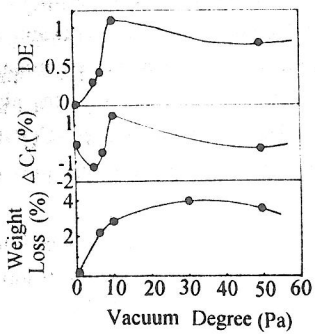

Fig. 3 Heavy shade ability, dye-uptake and weight loss against treating vacuum degree

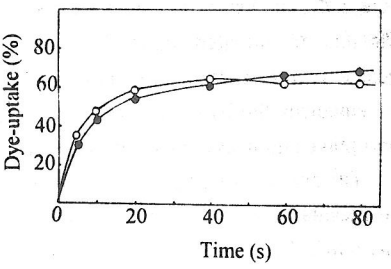

Fig. 4 Dyeing rate curve at 90 ℃ ○:untreated ramie, ●: treated ramie

From above, when ramie fabric is treated by low temperature oxygen plasma, its surface is eroded, its hydroscopicity is increased, the electrical property of its surface and its crystallinity are changed. Thus its heavy shade ability is increased, but its dye-uptake only changes a little. The optimal treating condition is 30s, 40w and 10Pa.

In order to investigate the dyeing property of ramie treated by plasma further, the dyeing rate of ramie treated by plasma at the optimal condition was determined. The result is shown in Fig. 4, in which the dyeing rate of untreated ramie is also given as reference. From Fig. 4 it can be seen that though the strike rate of the treated ramie is lower than that of the untreated, the equilibrium dye-uptake of the former is higher than that of the latter.

Second, after having obtained the optimal treating condition by plasma, we studyed the effect of grafting polymerization on dyeing. The dye-uptake and heavy shade ability of the treated ramie by grafting polymerization of acrylamide initiated by plasma and only by acrylamide are shown in Table 1.

Table 1 The Effect of Grafting Polymerization on Dye-uptake and Heavy Shade Ability

Treating Condition	Untreating	Acrylamide	Grafting Polymerization of Acrylamide Initiated by Plasma
Dye-uptake	67.7	67.4	74.7
DE	0.00	-0.31	1.61

Form Table 1 it can be seen that the dye-uptake and heavy shade ability of the ramie treated by grafting polymerization of acrylamide initiated by plasma are increased, but that of the ramie treated by acrylamide do not change, as compared with that of untreated ramie. The reason is that grafting polymerizaton takes place because of the reactive free radicals produced by plasma and it produces -$CONH_2$, and enhances the hydrogen bond force between the fibre and the dye, and thus the dye-uptake and heavy shade ability are increased.

Thirdly, we invastigated the effect of the united treatment by resin or soft finish and plasma respectively on the heavy shade ability of dyed ramie and the result is shown in Table 2, in which the treating condition by plasma is 10Pa and 20s.

Table 2 The Heavy shade ability of Ramie Treated by Resin or Soft Finish and Plasma

Treating Condition	by Plasma for 30s	by Plasma for 180s	2D Resin Finish	by Plasma for 30s after Resin Finish	Softener SHF Finish	by plasma for 30s after Soft Finish
DE	1.41	1.63	0.92	2.23	1.50	2.35

From Fig. 2 it can be seen that the heavy shade ability of dyed Ramie is increased by plasma, and the effect is more evident with the increase of treating time. It can also be seen that the increase in the heavy shade ability of the dyed ramie when treated by resin or soft finish and plasma respectively is greater than that when treated only by resin or soft finish. The reason is that the surface reflection is decreased more evidently under the former circumstance than the latter one, and therefore there is a more obvious increase in heavy shade ability under the former circumstance.

Lastly, the dye fastness of the dyed ramie treated in various conditions was investigated. It can be concluded that the rub-fastness and wash-fastness of the ramie treated by plasma are improved, the effect of treatment after dyeing is better than before dyeing, and the effect of the united treatment by resin finish and plasma is the best.

V. CONCLUSION

When ramie is treated by plasma, many microcraters are formed on the surface, and the hydroscopicity, equilibrium dye-uptake, heavy shade ability and fastness are increased. The treatments by plasm-initiated grafting polymerization of acrylamide

and by resin finish and plasma are more effective than only by plasma, in which the effect of the united treatment by resin finish and plasma is even better than plasm-initiated grafting polymerization of acrylamide.

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