Improvement of dyeability of cotton with natural cationic dye by plasma grafting

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ABSTRACT

Cotton fabric is usually dyed with anionic dyes such as direct and reactive dyes. Naturally, there is no affinity for basic dyes to cotton fiber. In this study, to improve the dyeability of cotton fiber with cationic dyes, the fabric was pretreated with air plasma and grafted with acrylic acid to create acidic groups on the surface of cotton fibers. The grafted samples were dyed with natural cationic dye extracted from roots of *berberis vulgaris*. The effect of plasma treatment and grafting of acrylic acid on the color strength of cotton fabric was studied.

INTRODUCTION

Natural dyes and pigments are found in some plants, animals, insects, bacteria, fungi and minerals. Recently, a new tendency to natural dyes has raised mainly due to their environmentally friendly characteristics [1,2].

Natural dyes can be used to dye protein fibers easily but there are several problems in using them on cotton fiber, mainly low affinity and fastness properties of natural dyes toward cotton fiber. To overcome this drawback, several studies have been carried out. P.S. Vankar *etal* have used mineral and biomordants and ultrasound energy to improve dyeability of cotton fiber with extract of *rubia cardifia* [2,3]. Also, chitosan, anionic active compounds, cross linking agents and enzymes have been used to improve the dyeability of cotton with natural dyes [4-6].

In this study, the roots of *Berberis Vulgaris*, has been used as a source of a natural colorant named Berberine. Because of low affinity of the cationic dye to cotton fiber, the fabric was pretreated with air plasma and grafted with acrylic acid to create acidic groups on the surface of cotton fibers. The grafted samples were dyed with natural cationic dye.

EXPERIMENTAL

Materials

In this work scoured and bleached cotton fabric (142 g/m2) was supplied from Mazandaran textile Company, Iran. Before being used, the fabric was treated with a solution containing 1 g/L non-ionic detergent and 1g/L sodium hydroxide at 95 °C for 30 minutes. Then the fabric was thoroughly washed with water and air dried at room temperature.

Berberis vulgaris roots were first washed and dried and then powdered. To prepare the original solution of the dye, each 100 gram of powder was added to 1 liter of distilled water and boiled for 2 hours and then filtered. All chemicals used were analytical grade reagents from Merck.

Methods

Plasma treatment: the cotton samples were treated in an atmospheric pressure plasma chamber composed of two parallel electrodes with 2 mm space having the power of 50 watts, voltage of 20 KV and frequency of 10 KHz at different time intervals. Air was used as the processing gas.

Grafting: The plasma-treated samples were grafted with different acrylic acid (AA) concentrations at different temperatures. Then the fabric sample was drained and soaked first in 1/1 methanol/water (60 min. at 85 °C), followed by two washings with distilled water for 15 min. to remove any non-reacted acrylic acid. The grafting yield is calculated according to equation 1:

$$G\% = [(W1-W2)/W1]*100 \quad (1)$$

Where, W1 and W2 are the weights of the dryed and conditioned cotton fabric before and after the grafting process, respectively.

Dyeing: 100 cc of original dye solution was mixed with 100 cc of distilled water for each 5 gram of cotton (L:G= 40:1). The dyeing was started at 40 °C and the temperature was raised to boil at the rate of 2 °C per minute. Then the samples remained in that condition for 45 minutes, and then rinsed and air dried.

Color measurements: the reflectance of dyed samples were measured on a Color-eye 7000A spectrophotometer using illuminant D65 and 10°standard observer. Color strengths (K/S) of dyed samples were calculated using equation 2:

$$K/S = (1-R)^2/2R \quad (2)$$

Where R is the reflectance, K is the absorption coefficient and S is the light scattering coefficient.

RESULTS AND DISCUSSION

Effect of plasma treatment on grafting efficiency

Cotton samples were plasma treated at different times and grafted with a 10% V/V of AA for 1 hour at 60 °C. Table 1 shows the effect of plasma treatment time of graft yield of AA on cotton. As we see the graft efficiency increases with the increase in plasma treatment time. The reason is the creation of more free radicals and active sites as the plasma treatment time increases. The grafting percent on the blank sample is approximately zero which approves the positive effect of plasma treatment on grafting yield.

Table 1. Effect of plasma treatment time on grafting

Plasma treatment time (min)	Grafting %
0 (blank)	0
1	0.41
2	0.64
3	0.96
4	1.54
5	2.37

Effect of AA concentration on grafting efficiency

Plasma treated cotton samples (1 min, 20 KV, 50 W, 10 KHz) were grafted using different concentrations of AA. Figure 1 shows that grafting percent increase as the AA concentration increased from 10% to 40% after which decreased with further increase in AA concentration. This decrease can be due to more chance of AA monomers to form homo-polymer instead of copolymer with cellulose at increased concentrations.

Effect of grafting time on graft yield

As we can see from figure 2, the grafting yield increases with the increase of grafting time from 20 minute to 60 minute, after which more increase in grafting time has no significant effect on grafting yield. it can be because of reduced amount of AA monomer in the solution and free radicals at the fibers surface after prolonged time.

Effect of graft yield on color strength of dyed cotton

As we see from figure 3 the K/S of samples increases as the graft yield increases. This is due to creation of more acidic sites after grafting of AA on cotton. Cellulose has no active site to react with cationic dye, Berberine. After grafting of AA on cotton, the acidic COOH groups will appear on cotton surface which will promote more absorption of cationic dye to it.

CONCLUSION

Plasma treatment of cotton fabric improves the graft yield of acrylic acid on the fiber. Grafting of AA on cotton fiber is affected by AA concentration and time of plasma treatment and grafting time. Grafting of acrylic acid onto cotton fiber improves the absorption of Berberine natural dye on it.

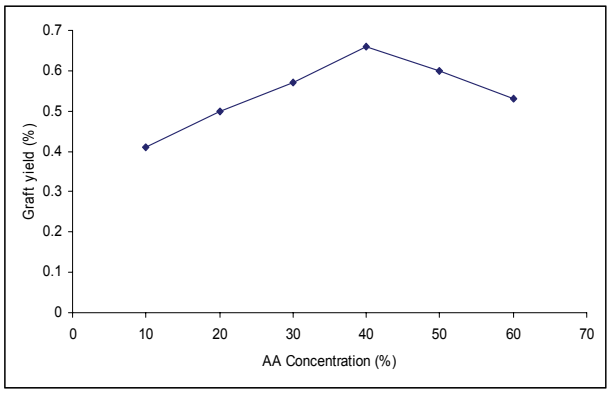

Fig. 1. The effect of AA conc. on Graft yield

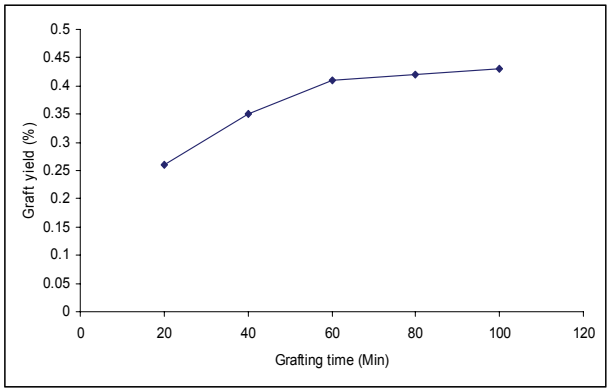

Fig. 2. Effect of grafting time on graft yield

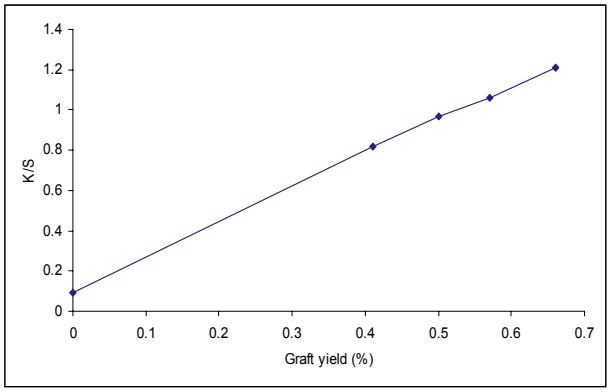

Fig. 3. Effect of graft yield on color strength

REFERENCES

1. A. Haji, Proceedings of the 10th Asian Textile Conference, ATC-10,G3-O-16, Japan, 2009
2. T. Kim and Y. Son, Dyes and Pigments, 64 , 85-89 (2005)
3. M. Kamel, R. M. El-Shishtawy, B.M. Youssef and H. Mashaly, Dyes and Pigments, 73, 279-284 (2007)
4. A. V. Popoola, Journal of applied polymer science, vol 77, 752-755 (2000)
5. S. Ali, T. Hussain and R. Nawaz, Journal of Cleaner Production, 17, 61–66 (2009)
6. A. K. Sarkar and C. M. Seal, Clothing and Textile Research Journal, 21, 162-166 (2003)