Ink-jet printing of nylon fabric using reactive dyestuff

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Abstract

Conventional nylon fabric is dyeing with acid dyestuff, because this method that nylon fabric only form the ionic bond with acid dyestuff, so in order to achieve better wet fastness, must still after dyeing then make aftertreatment with fix agent. We know using fix agent make aftertreatment is temporary in nature and loses its effectiveness after a few washes .

This research is to study ink-jet printing nylon fabric with reactive dyestuff, because reactive dyestuff can be form steady covalent bond with nylon fabric, do not need to use aftertreatment and achieve good wet fastness. The result show that the concentration of GUM NP is 8.0% and used coating method to pretreatment, pattern can achieve better sharpness and lower spreading. Maximum colour yield was achieved at 102℃×30 minutes with saturated steam, and adjust pH value at 5.5 with citric acid, maximum amount of ink can reach 240%. The ink-jet prints displayed excellent wet fastness to repeated wash testing, this study used four reactive dyestuff with colours of cyan, magenta, yellow and black, all colours wash fastness and crock fastness can reach grade 4.

Keywords: Ink jet printing, Pretreatment, Colour yield, Nylon, Reactive dyestuff

1.Introduction

Ink-jet printing is flourishing development that already the revolutionary change has arisen to the traditional textile industry, some printed fabrics, such as poster, clothing, decoration, etc, it had replaced with ink-jet printing fabrics. Ink-jet printing except have more available for short-run produced, no need to produce screens, easier to modify patterns, fewer amount of waste water, faster production speed, and finally, it can partially replace traditional printing, because the pattern are exquisite, it is very difficult to imitate and have a specialize , relatively improve the products value and increase its competitiveness〔1〕.

In so many man-made fiber materials, nylon fabric is applied to the fabrics most extensively, but because all nylon fabrics were used acid dyestuff to dyeing or printing traditionally, so in order to achieve better wash fastness, must through a serious fixing system make aftertreatment with tanning agent. Fixing agent is temporary in nature, so it is unable to maintain certain wash fastness after washing many times〔2,3〕.

This article mainly tries to ink-jet printing of nylon fabric with reactive dyestuffs, study for the best condition which formed the steady covalent bond about amino of nylon with reactive dyestuffs, and that needn't through a serious fixing system again, then can achieve good wash fastness〔4,5〕. Though some articles 〔4,6,8〕 mention to dyeing or printing nylon fabric with reactive dyestuff too, but they only selected some special reactive dyestuffs or colours for dyeing or printing with traditional method, not yet used ink-jet printing of nylon with reactive ink. This study used four commercial reactive ink cyan, magenta, yellow and black while ink-jet printing nylon fabric . We modified some condition for the pretreatment agent, steaming times , acid agents and pH value, then can achieve a target which ink-jet printing of nylon fabric can use reactive dyestuff.

2.Experimental

2.1 Fabric

Pretreated 100% nylon fabric(scoured, bleached and heat-setting) with plain weave structure , 148 ends/inch× 68picks/inch, 70D× 160 D, was obtained from Great Bell Printing and Dyeing Company, Taiwan.

2.2 Pretreated of pretreatment paste

Pretreatment paste were used the following recipe: Gum NP 80g/l; urea 30g/l ; penetrant 2g/l and add water to 1000ml, then were all incorporated in the pretreatment paste. The pH of the print paste was using citric acid , tartaric acid and sodium bicarbonate to adjust the value at 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0 and 7.5.

2.3 Fabric pretreatment

Fabric pretreatment was coated onto the nylon fabric using a semi-automatic flat printing machine (OSAKA/JAPAN), screen of mesh 100×100 threads, control size loading of 80% was achieved, all pretreatment fabrics were dried in an oven at 80 ℃.

2.4 Ink-jet printing processes

Printing was carried out on a Mutoh FalconandⅡ ink-jet printer device with a piezo-electric drop-on-demand and print head and pass number of 2 and resolution 720 dpi. A pattern of square with size 10 ×10 cm2,which was printed for each single sample color. Four commercially available reactive inks cyan, magenta, yellow and black were used. The cyan, magenta and yellow inks contained monochlorotriazine reactive dyestuff, while black ink contained vinyl sulphone reactive dyestuff.

2.5 Fabric post-treatment

All prints were heat air dried and then steamed at 102℃

of saturated steam. The steaming time was 15min, 20min, 25min, 30min and 35min.The steamed samples were washed-off in a fresh bath, employing a liquor ratio of 20:1, 2g/l MRT and 2g/l Na_2CO_3 at 60℃ of hot washing until all unreacted dyes and chemicals were remove from the fabric surface. The washed samples were dried in an oven at 80℃

2.6 Color yield measurement

The printing sample were determined using Datacolor SF-600 PLUS C-T spectrophotometer. The measurement was set under specular excluded with large aperture. The sample was folded twice to ensure opacity and measured three times, the measured results were then averaged.

The color yield (K/S value) was calculated for wavelengths of 400-700 nm at 20 nm intervals within the visible spectrum. The K/S values were calculated according to Equation 1:

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

Where , K is the absorption coefficient(depending on the concentration of colorant), S is the scattering coefficient (caused by the dyed substrate) and R is the reflectance of the colored sample at λ_{max}. The higher the K/S value is, the greater the color yield.

2.7 Color fastness measurement

Color fastness to washing was tested by AATCC Test Method 61.2A-2003, color fastness to crocking by AATCC Crockmeter Method 8-2001 and light fastness by AATCC Test Method 16.3-2003.

2.8 Ink limit estimation

The ink ejected amount of the printed fabrics was assessed by ErgoSoft Texprint Inklimit Test method, the determination interval of inks amount were from 150% to 400% at 10 % intervals.

3.Result and discussion

3.1 Effect of pH with colour yield

Nylon fabric is dyeing with reactive dyestuffs, the pH value acts a quite important role, so it is very important to control pH value in a suitable range, these were effect colour yield. We used sodium bicarbonate and citric acid to adjust pH value from 4.0 to 7.5 at 0.5 intervals, and measure the change of colouration. Figure 1 shows the effect of pH value with colour yield, the colour yield of all colors were increases with pH value raised, but reach highest when pH value is at 5.5, then the colour yield decrease with pH value continuous raised, particularly the colour yield of cyan was seriously down.

In general, the functional of reactive dyestuff mainly reacts with amino group of nylon fibre, and form the covalent bond , amino group is in pH value at 5.5 will produce high degree protonation, so can achieve higher color yield, but when pH value increases again, nylon fabric will absence of amino group protonation and lead the color yield to reduce〔6〕. On the other hand, the colour yield of color will be reduced while the pH value down , because the concentration of neucleophilic amino groups in the substrates were unable to react with reactive dye, so the colour yield of nylon fabric were to reduce. Therefore ink-jet printing of nylon fabrics used reactive dyesyuffs , the pH value of pretreatment paste must adjust at 5.5 which can achieve highest colour yield.

3.2 Effect of different acid agents with colour yield

In general , it must be under the alkali condition , the reactive dyestuff will form the covalent bond with the fibres, but printing nylon with reactive dyestuffs, we need to adjust the paste for neutral or weak acid , so the reactive dyestuffs can combine with nylon then form the covalent bond〔7,8〕. This article we selected two different non-volatile organic acid, citric acid and tartaric acid that take as pH adjust agents, probe into the same pH value (pH at 5.5) and different kind acid agent. Figure 2 show that the effect of different acid with K/S value, we can find that adopt citric acid to make pH value adjust agent , except yellow K/S value is almost same with tartaric acid, other colours cyan, magenta and black were all higher than tartaric acid. For this reason we recommended the citric acid for use while printing to nylon fabric with reactive dyestuff.

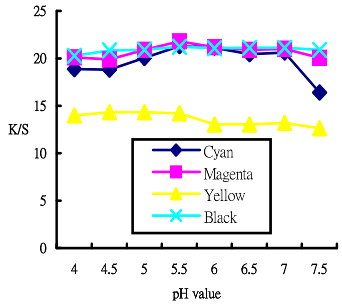

Fig. 1. Effect of pH value with K/S value

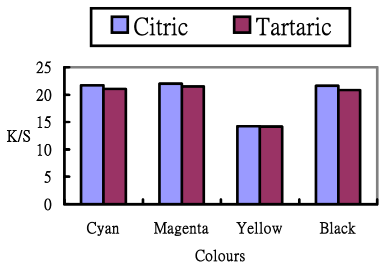

Fig. 2 .Effect of different acid agent with K/S value

3.3 Effect of fixation steaming condition with colour yield

Steam fixation is to make the dyestuff permeate into fibre and form covalent bond, the setting of steaming fixation conditions is very important, while saturated steam achieve better colour yield than overheating steam and heat curing〔4〕. In this research, 102 ℃ of saturated steam and changes the time of steaming in order to discuss about color yield.

Figure 3 show that color yield of yellow was slightly rising when we increased steaming time exceed 30min, color yield was not affected by steaming time. On the other hand, cyan, magenta and black could reach the maximum while steaming time at 30 min, but steaming time increase again, the K/S value has a downward trend . To sum up, the optimum condition analysis result of colour yield on the above various colors, the best performance of colour yield would be under 102℃×30 min of steaming fixation.

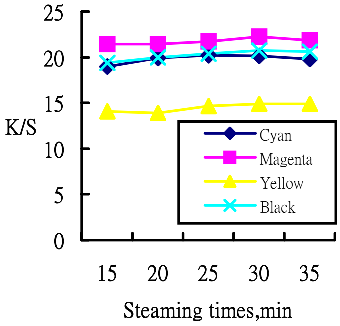

Fig. 3. Effect of steaming times with K/S value

3.4 Analysis of ink amount limit

Even after sizing treatment, every fabrics still contains its maximum absorbability. When the amount of ink exceeds the fabrics absorbed limit, the pattern will spread. Nylon fabric have lower absorbability than cotton, pattern is very easy to migration after ink-jet printing. So in order to achieve best quality, it is better to confirm the ink limit before printing. In Figure 4 we find that the fabric in this experiment (100% nylon, 148 ends/inch × 68picks/inch, 70D × 160D) still achieve good pattern sharpness, while the amount of ink reached 240%

3.5 Color fastness of printed fabric

Ink-jet printing of nylon fabric used reactive dyestuff to replace acid dyestuff , because reactive

Fig.4.Ink limit measure result

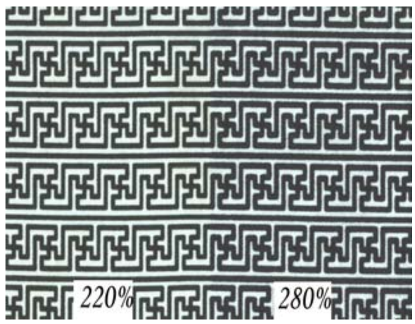

Fig. 5 .The pattern of different ink amount

3.5 Color fastness of printed fabric

Ink-jet printing of nylon fabric used reactive dyestuff to replace acid dyestuff , because reactive dyestuff can be form covalent bond with nylon fabric, theoretically, so do not need to use aftertreatment and can achieve good wet fastness. Table 1 show the color fastness result of printed nylon fabrics to light, washing and crocking, we can find four kind of reactive ink , wash fastness and crocking fastness reached grade 4, and light fastness reached more than grade 3-4.

4.Conclusion

Nylon fabric is mainly method of ink jet printing were used acid dyestuffs, but because it has bad wash fastness, must through a serious fixing system make aftertreatment with fix agent, this method could prolong the procedure of operation too.

This article we find the best colour yield ,while the pH value of pretreatment paste at 5.5, the pH value adjust agent used citric acid better than tartaric acid, the condition of steam fixation was 102℃×30min. To sum up above data, we can believe that ink-jet printing of nylon fabric can use reactive inks.

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Table 1. Color fastness result of printed cotton fabrics to light, washing and crocking

	Wash fastness		Crock fastness		Light fastness
	Color change	Staining of cotton	Dry	Wet	20AFU
Cyan	4	4	4	4	3-4
Magenta	4	4	4	4	4
Yellow	4	4	4	4	4
Black	4	4	4	4	4