Cationic pretreatment for improving image quality of inkjet printing on polyester fabrics

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Abstract

The cationic pretreatment with gemini surface active agent was carried on the polyester fabric in order to improve the image quality of water-based pigment inkjet printing. The influence of pretreatment conditions such as concentration of cationic reagent, pH value of pretreatment bath, temperature and pretreatment time on the printing property of ink-jet printing was discussed in detail. Compared with untreated fabric, the K/S values increase nearly 36% of treated polyester fabric. The K/S values increase evidently with increasing of the pH of cationic pretreatment bath, especially when pH reached at 11. The K/S values appear saturation value when the concentration of cationic reagent is 15g/l. The K/S values increase when the treatment temperature changes from 10℃ to 30℃. However, The K/S values start to decrease when the treatment temperature continue to rise till 60℃. This may due to that temperature affect the adsorption property of cationic reagent on the surface of polyester fabric. When pretreatment carry on for 6 min, the K/S values reach balance. The video microscopy images show that the edge acuity and the brilliancy of ink-jet printing on polyester were improved largely after pretreatment with 15 g/l cationic pretreatment reagent at 30℃ and pH 11 for 6 min. The Atomic force microscopy (AFM) image shows that the surface morphology of polyester fabrics had changed after cationic pretreatments.

1. Introduction

The inkjet printing method has an advantage that it can satisfy desires of current consumers attaching importance to personality because factory automation is available through advancement of CAD/CAM using a computer system and it enables energy to be saved and further brings about no environmental problem because it causes no residual paste to take place. In this aspect, this inkjet printing method represents recent and rapid technical advancement in the printing textile industry[1-5].

The pretreatment process for inkjet printing is to treat a fabric material in advance to prevent the jetted ink from bleeding or flowing in the fabric material when conducting the actual inkjet printing work, and further enhance the color developing property and the fastness. If the pretreatment process is omitted, the quality of the printed fabric gets to be coarse so that it gets to lose a value as a product[6-11].

The sizing agent has a function to control the diffusion velocity of pigment in a fiber so that it may be uniform. It comprises mainly water soluble polymer and typical sizing agents include sodium alginate, carboxyl methyl cellulose, hydroxyl ethyl cellulose, xanthan gum, Arabic gum. However, they have to be washed away in post-treatment process. The anti-bleeding agent has a function to fix pigment to the fiber without bleeding when pigment is dropped onto the fiber, and also another function to enhance the color developing property. It may not be used because it may deteriorate the feel of the fabric material[12-19].

The inkjet printing method for polyester fabric is largely divided into two kinds, which are vapour phase transfer printing with disperse dye inks and direct printing with pigment ink. The disperse dye deposited on the waste transfer papers will increase the environment pollution. While pigment-based ink jet printing is very simplified: printing on the fabrics directly, followed by curing and no any environmental problem.

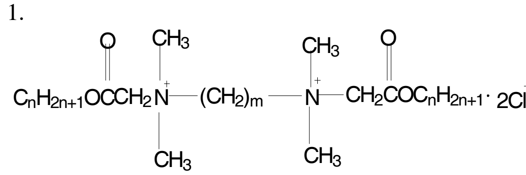
The bleeding phenomenon appears easily of ink-jet printing with pigment-based ink on polyester fabrics due to its hydrophobic performance. The gemini cationic surface active agent was chosen as the cationic pretreatment reagent to modify the surface of polyester fabric in order to improve the performance of ink-jet printing. The edge acuity, the color depth and the morphology on the surface of polyester were also investigated in detail.

2. Experimental

2.1 Materials

Polyester fabric (Poplin 80 g/m^2) offered by Wuxi Bleaching and Dyeing Plant, China. The fabric was purified in the laboratory by scouring at 90℃ for 30min using a solution containing sodium carbonate (2g/l). It was then washed with cold water and dried at ambient condition.

Sodium carbonate and sodium hydroxide were obtained from China Medical Group Shanghai Chemical Reagent Co. All the chemicals were analytical reagent grades. Pigment-based ink, including Pinks Y, Pinks M, Pinks LM, Pinks C, Pinks LC and Pinks K, were prepared in the laboratory. The cationic pretreatment reagent was available from Henan Daochun chemical engineering Ltd. Co. The schematic structure was representatively shown in Figure 1.



n=8,10,12,14,16; m=2,4,6,8

Figure 1. The schematic structure of the cationic reagent

2.2 Treatment of polyester fabrics

Aqueous solutions, containing the cationic pretreatment reagent and 10% of sodium hydroxide for pH adjustment by Mettler Toledo 320 pH machine (Mettler Toledo Co. Ltd. Shanghai) were employed for treating polyester fabrics in a HH-6 digital constant temperature water apparatus (Ronghua Co. Ltd. Jiangsu. China). The bath ratio was 1:30. The samples were dried at ambient condition and ironed for ink-jet printing. The treated fabrics were printed by Mimaki JV-180 ink-jet printing machine (Mimaki Co. Ltd. Japan), and cured in a curing oven at 150℃ for 3 min .

2.3 Printing image quality measurement

The print sharpness quality was evaluated by DZ3-video focus-exchanged microscope (Union Co. Ltd. Japan), the dates were collected by Pinnacle Studio Version 8.0 and analyzed via Imager-Proplus software.

2.4 Color measurements

X-Rite 8400 computer color measurement system (America X-Rite Co. Ltd) was used for color measurement. In this measurement system, K/S value represented the brilliancy and color depth of fabric after ink-jet printing. K/S value of the printed fabric was measured in the system of CIELab, D65 lamp-house, 10° visual angle.

2.5 Atomic force microscopy (AFM)

The morphological and topographical changes of polyester fabrics were investigated by CSMP 4000 Atomic force microscope (Beijing. China), employing a microfabricated V-shaped silicon cantilever with silicon conical tip. All AFM images were collected in air. The Image Processing and Data Analysis software of the quoted AFM was used for analyzing the surface roughness.

3. Results and discussion

3.1 Effect of the cationic reagent concentration on K/S value

The amounts of the cationic groups on the surface of the fabrics depend on the concentration of the cationic reagent in solution. The influence of concentration of the cationic reagent on the color intensity, K/S value was measured while the cationic reagent was carried out at different concentrations. The results were summarized in Figure 2.

It was clear that K/S value increased with increasing the concentration of the cationic reagent from 5 to 15 g/l. When the concentration of the cationic reagent reached 15 g/l, K/S value no longer increased remarkably in despite of increasing the concentration. It could be explained that at the start of the pretreating process, the amount of the cationic reagent adsorbed on the surface of the fabrics increased with increasing the concentration of the cationic reagent in the solution, while the amount of the pigments attracted by the cationic sites increased. The pigments in the ink were adsorbed on the surface of the fabrics, instead of moving into the clearance of the yarns. It is interesting to notice that concentrations of 15 g/l or bigger have only brought very little change to the K/S value of both fabrics.

In order to anchor the pigments, the anionic pigments were attracted to the cationic sites on the fabrics by ion-bond. The cationic reagent could obviously improve the brilliancy and color depth of the ink-jet printing.

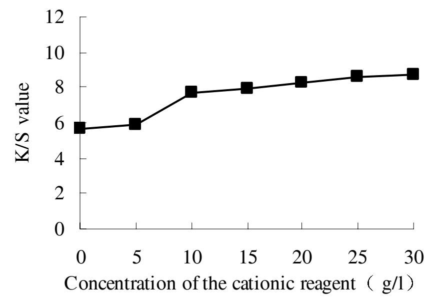


Figure 2. Effect of the cationic reagent concentration on K/S value of ink-jet printing[a].

a- The sample was treated at pH 7 and 30℃ for 6 min.

3.2 Effect of pH value on K/S value

The reagent is a quaternary ammonium salt of the functional groups, in the alkalic condition, the negative charges on the surface of the fabrics can adsorb the cationic sites easily. The pH value has an remarkable effect on the adsorption of the reagent on the fabrics and K/S value of the ink-jet printing. Figure.3 illustrated the effects of pH on K/S value.

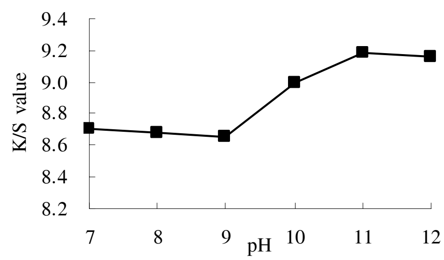


Figure 3. Effect of pH on K/S value of polyester fabric for ink-jet printing[b].

b- The sample was treated with 15 g/l cationic concentration at 30℃ for 6 min

The results in Figure 4 revealed that K/S value decreased with increasing pH from 7 to 9, while there was an increasing tendency in K/S value with pH increasing from 9 to 11. K/S value balance was obtained after pH value exceeding 11. It could be explained that in the strongly alkalic conditions, there were lots of negative charges adsorbed on the surface of the fabric, which could adsorb the cationic additive easily; In the weakly alkalic conditions, positive charges were adsorbed on the surface of the fabrics, which prevented the cationic additive being adsorbed; In the neutral conditions, there were many negative charges on the surface of the fabrics, which also adsorbed the cationic reagent, however, there were some differences between neutral condition and strongly alkalic condition.

3.3 Effect of treating temperature on K/S value

Temperature is an important factor affecting the adsorption of the cationic reagent on the fibers. The effects of different temperatures on K/S value of ink-jet printing on polyester fabrics were studied. The results were shown in Figure 4.

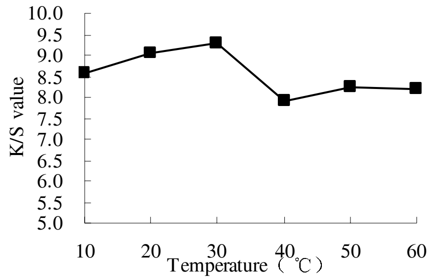


Figure 4. Effect of temperature on K/S value of ink-jet printing[c].

c- The sample was treated with 15 g/l cationic concentration at pH 11 for 6 min.

Figure 4 showed that K/S value of ink-jet printing was related to the treatment temperature. The highest K/S value was obtained employing temperature at 30℃. Indeed, at the start of the treating process, an increasing in K/S value was expected with increasing the temperature, as the adsorption of the cationic reagent on the surface of fabrics was improved with increasing the temperature. While a certain temperature was reached, the amount of the cationic reagent adsorbed on the surface decreased obviously. The suitable treating temperature was about 30℃.

3.4 Effect of treating time on K/S value

The relationship between treatment time and K/S value was discussed, the results were listed in Figure 5.

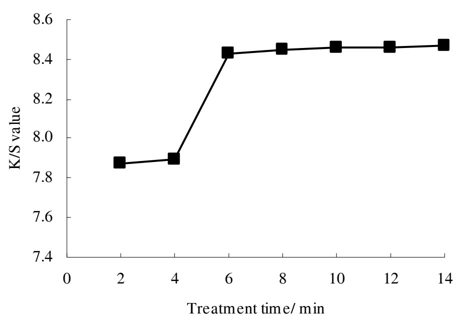


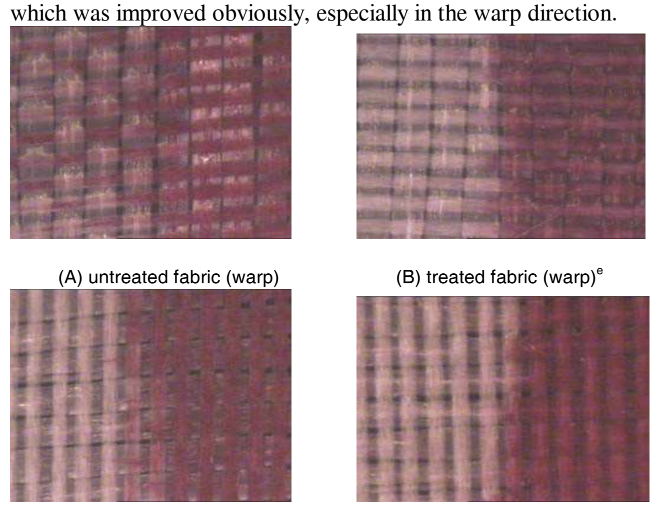
Figure 5. Effect of treatment time on K/S value of ink-jet printing[d].

d- The sample was treated with 15 g/l cationic concentration at 30℃ and pH 11.

It could be seen that K/S value of the ink-jet printed polyester fabrics increased with increasing treatment time to 6 min and then reached the equilibrium by treated with longer treatment time. The adsorption of the cationic reagent increased with increasing treatment time. It result that K/S value was improved and further the adsorption of the surface of the fabric reached the equilibrium.

3.5 Effect of cationic reagent on anti-bleeding performance

Detailed information on the edge acuity of ink-jet printing was obtained by video microscope. Figure 6 reported the bleeding of the untreated and treated fabrics. It was clear that the bleeding of the untreated fabric is remarkable in the warp direction. The fabrics treated with cationic reagent exhibited good edge acuity, which was improved obviously, especially in the warp direction.



(A) untreated fabric (warp) (B) treated fabric (warp)[e]

(C) untreated fabric (weft) (D)treated fabric (weft)[e].

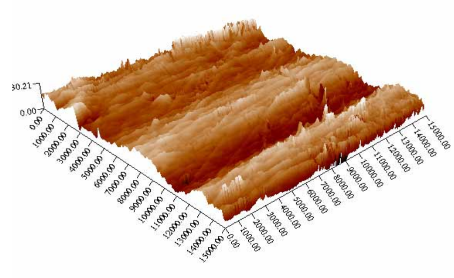
Figure 6. The video microscope images of ink-jet printing of polyester fabric

e- The sample was treated with 15 g/l cationic concentration at 30℃and pH 11 for 6 min

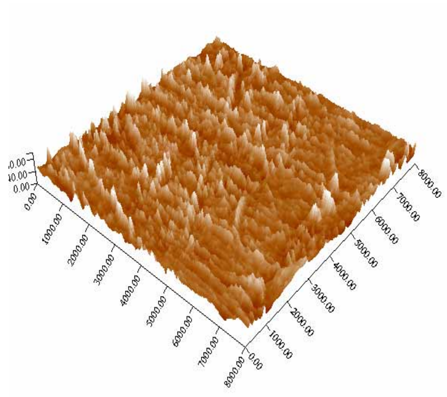
Due to the structure of the fabrics, intercrossing of the warps and wefts in the warp direction made the surface of the fabrics accidented. Compared with the untreated fabrics, the sharpness of ink-jet printing on the treated fabrics was improved. After ink-jet printing, the pigments moved along with the solvent of the ink and removed outside of the targeted area. In the weft direction, the bleeding performance was lightly, as there were clearance between warps and wefts. The clearance impeded the moving of the water and stopped the transporting of the pigments at the same time. Typically, the pigments in the ink contained carboxylic acid groups. These functional groups in the pigments made them dispersed in water, since these groups are ionized in the ink solution. After treating with the cationic reagent, these anionic ends were attracted to the cationic sites of the fabrics. The presence of cationic reagent on the surface of the polyester fabrics enhanced the resolution and the water fastness of the ink pigments through the immobilization of the pigment molecules. As a result, this immobilization impeded feathering and wicking as well as withstanding removal with water.

3.6 Surface characterization by AFM

AFM images of untreated and cationic treated polyester fabrics were shown in Figure 7 .



(A) untreated fabric



(B) treated fabric[e]

Figure 7. The 3-D views of non-contact mode AFM images

The surface of the untreated polyester fiber appeared flatter in comparison to the cationic treated sample; the surface of the cationic treated polyester fiber exhibited the topography of pits and craters, which were almost uniformly distributed on the surface of the fiber. It could be explained that the cationic reagent was adsorbed on the surface of the fabric and surface area of the treated specimens increased.

3.7 The images of untreated and treated fabrics

(A)untreated fabric (B) treated fabric[a]

***Figure 8.** The images of ink-jet printing on the polyester fabric*

Figure 8 showed the performance of ink-jet printing on untreated and treated polyester fabrics. Figure 8. (A) represented that the bleeding of the ink-jet printing on the untreated fabric was serious, and the brilliancy and the color depth of the ink-jet printing were weak; Figure 8. (B) showed the anti-bleeding performance of the ink-jet printing on the treated fabric was improved obviously, and the excellent edge acuity and brilliancy was obtained by treated with the cationic reagent. The vivid pattern presented the excellent image quality of pigment ink jet printing.

4 . Conclusion

This study has demonstrated the potential of using the cationic reagent as a functional pretreating agent for polyester fabrics in ink-jet printing. The application of this agent to the polyester fabric before ink-jet printing is a novel concept, which gives very less environmental pollution. The cationic reagent can adsorb the pigment by the ionic bonds after ink-jet printing. Fabrics pretreated with 15 g/l cationic pretreatment reagent at 30□ and pH 11 for 6 min exhibit a good performance of ink-jet printing. It gives a superior printing quality with little tendency to bleed by fixing the pigments ink. The treating method will have significant impact for textiles of ink-jet printing, which blazes a way in the characteristic and popular lives. In the future work, investigations will be conducted on the water fastness and the light fastness of the ink-jet printing as affected by the cationic reagent treatment.

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Chaoxia Wang received her BS in dyeing and finishing from Suzhou University (1995) and her PhD in textile chemical from in Donghua University Shanghai(2003). Since then she has worked in the Key Laboratory of Eco-Textiles of Ministry of Education, Jiangnan University. Her work has focused on the surface modification for improving properties of nano-scale pigment and ink jet printing and for imparting functionaln on fabric. She is on the Board of trend in Applied Science.