Silicone Softener for Stain Repellent Stain Release and Wrinkle Resistance Fabric Finishing

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ABSTRACT
In this paper a modified silicone softener was used on the finishing of stain repellent stain release and wrinkle resistance fabrics. The concentrations of silicone softener, durable press resin CTA-705 and process conditions on the properties of treated fabrics were investigated. In analyzing the results, the fabric's softness rating, smoothness and wrinkle recovery angle (WRA) increased with the increase of softener concentration. The use of softener has little effect on the fabrics soil release and oil repellency. Wrinkle recovery angle increased remarkably and softness rating decreased steadily with the increase of CTA-705 concentration. Soil release, oil repellency and softness rating of the treated fabrics increased steadily when the cured temperature was raised from 140°C to 170°C.

Keywords: Cotton, silicone softener, wrinkle resistance, stain repellent stain release

INTRODUCTION
Fabrics with both comfortable and “easy care” attract more and more attention. “Easy-care garments” mean that fabrics don’t wrinkle, repel or resistant stains and require only the most basic of laundering. Consequently, fabric and chemical manufacturers have worked on finishing technologies and chemicals that ease stain removal and prevent stain adsorption. One of the most useful finishing technology or agents is fluorochemicals. These kinds of finishes are very effective in preventing or releasing stains [1-2]. However, they generally create an uncomfortable handle and, in fact, can be quite harsh. Besides, cotton fabrics can be machine washed, but it will shrink and wrinkle. The use of wrinkle-free finishes is subject to this problem. These kinds ofchemicals are usually crosslinking agents; they can create permanent crosslinking with cellulose molecules [3], which will bring poor hand feeling, reduced abrasion resistance [4].

Recently, organic softeners have been used to remedy for this situation, especially silicones [5]. Amino-modified silicones have been recognized as premium fabric finishing agents. The amino groups in aminoalkyl terminated polymers can form electrostatic interaction with cotton surfaces, which will increase the adhesion of silicone polymer on cotton surfaces [6]. They not only provide unsurpassed softness but also improve many fabric physical properties. However, conventional aminofunctional silicones can significantly impair both the stain repellency and the stain release properties of most fluorochemical treated fabric substrates [7].

Fortunately, fabric and chemical manufacturers have realized these problems and continue to try to find solutions. For example, Fernando Vazquez developed a fluoropolymer branched silicone polyether composition; it was prepared by combining a fluoropolymer and a branched silicone polyether. The resulting compositions improved the hand or feel of the fabric without significantly diminishing oil repellency or the stain release properties associated with fluoropolymers [8-9]. Other specialty organo-modified silicones have also been investigated and used in this kind of textile finishing. These specialty silicones are generally silicone copolymers or terpolymers that have chemical structures hydrophilic groups, such as polyalkylene oxide polymers, are arranged in different ways along the siloxane backbone.

Textiles treated with these silicone based compounds have a feel or hand comparable to conventional hydrophobic silicones, but do not significantly impact negatively on the hydrophilicity of the textile [10-11].

This paper describes the development of a modified silicone softener that contains additional reactive organic groups, amines, amides, epoxides and carboxylic acid groups, which normally contribute to softness and durability. Then it was used in treatment of stain repellent stain release and wrinkle resistance fabric finishing.

EXPERIMENTAL

Materials

CTA-705 (Beijing CTA-tex Chemicals CO., Ltd.) was the durable press resin. X-Cape® DRC (OMNOVA Solutions Inc.) was the soil and water repellent agent. X-Cape®LK-30 (OMNOVA Solutions Inc.) was used as the crosslinker for water and oil repellent on 100% cotton fabrics. TG-9011 (Zhejiang Transfar CO., Ltd.) was the fluorocarbon soil release agent. Block modified, amino, polyether siloxane (BAPS, Made in laboratory) was a silicone block copolymer containing polyether-amide units. Its structure was shown as *Figure 1*.

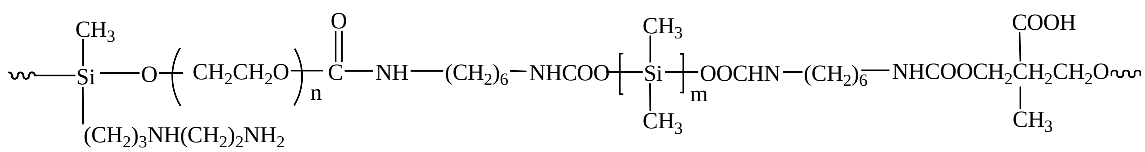

FIGURE 1. Structure of BAPS silicone softener.

The fabric treated was (Shandong ZhengYi Textile CO., Led.): a 100% cotton twill that was bleached and mercerized，style 75*80.

Fabric Treatment

The fabric was immersed in a finishing solution containing various finishing agents, and then passed through a laboratory padder. The concentrations (w/w) in the formulas were based on the weight of bath (o.w.b.) and were calculated based on the weight of the commercial products and not the active ingredients in those products. The wet pickup was ~78-82%. The impregnated fabric was first dried at 80℃ for 10min, and then cured at a specific temperature for 60 sec.

Testing

Fabrics were laundered three times prior to the various tests. Each washing cycle comprises washing the fabric using an aqueous solution containing 2g/L ionic detergent at 25℃ for 10min.Soil release was determined by AATCC Test Method 130-2000; the soils used were dirty motor oil and mineral oil. Softness ratings were determined on coded samples by a Hand panel with a minimum of 5 members. Fabrics were rated on a scale of 1-8 (8-very soft; 1-harsh). Oil repellency was determined by AATCC Test Method 118-2002. WRA of the fabric was determined according to AATCC Test Method 66-2003. Surface roughness was measured using the MDX-01 measuring instrument (Labthink Instruments Co., Ltd.).

RESULTS AND DISCUSSION

Effect of BAPS Concentration on the Properties of Treated Fabrics

Confined the concentration of durable press resin, soil and water repellent agent, crosslink agent and fluorocarbon soil release agent, treated the fabrics under the same conditions.

TABLE I. Fabrics treated with different concentration of BAPS[a].

Sample number	BAPS/ %	Soil release	Oil repellency	μ_d[b]	Softness rating	WRA	
						Warp	weft
[c]Control		1	2	0.684	2	63 º	67 º
1	2.5	5	5	0.578	5	99 º	99 º
2	3.5	5	5	0.569	6	103 º	104 º
3	4.5	4	6	0.558	7	109 º	112 º
4	5.5	4	6	0.551	7	112 º	112 º
5	6.5	4	6	0.547	8	123 º	125 º

Note:
[a] Finishing conditions: The concentration of CTA-705, X-Cape® DRC, X-Cape®LK-30 and TG-9011 were 10%, 2.5%, 0.15% and 0.6% respectively. Treated fabrics were dried at 80℃ for 10min, and then cured at 170℃for 60 sec.
[b] Kinetic friction coefficient: smoothness increase with μ_d decrease.
[c] Fabrics without any treatment.

The quantity of silicone softener used on the treated the fabrics was changed. The results were shown in *Table I*. It indicated that with the increase of BAPS, the fabrics became more and more soft, the μd decreased obviously. These were due to the brand silicone softener can form a uniform film on the surface of fabrics, which reduced the friction between fabrics when they were deformed and cause comfortable handle. The soil release decreased a little with an increase of BAPS concentration. It was caused by the film formed by BAPS on fabric surface that habited the penetration of detergent. The oil repellency had a little increase. In BAPS chains, the amide and amines can combine with the cotton fabrics; this made long polymer chains arranged along the fabrics. The alkyl groups attached on the chains directed to the air and decrease the fabric's surface tension. Results also showed that BAPS can increase wrinkle recovery angle in both the warp and weft directions. This probably resulted from the mobility increase in the treated fabric. When the fabric was formed, the yarn movement in response to the deformation force reduced the deformation magnitude, thus minimizing wrinkle formation. The use of BAPS in the finish increased the treated fabric wrinkle resistance by lubricating the yarns on the fabric and reducing the yarn friction coefficient. Otherwise, some literatures reported that the silicone softener can also reduce the strength loss of fabrics treated with wrinkle resistance finishing [3,12].

TABLE II. Fabrics treated with different concentration of CTA-705[a].

Sample number	CTA-705/ %	Soil release	Oil repellency	μ_d	Softness rating	WRA	
						warp	weft
1	6	4	6	0.519	8	85 º	87 º
2	8	4	6	0.538	7	99 º	99 º
3	10	4	6	0.558	7	109 º	112 º
4	12	4	6	0.569	7	117 º	119 º
5	14	4	5	0.594	6	125 º	127 º

[a] Finishing conditions: The concentration of BAPS, X-Cape® DRC, X-Cape®LK-30 and TG-9011 were 4.5%, 2.5%, 0.15% g/L and 0.6% respectively. Treated fabrics were dried at 80℃ for 10min, and then cured at 170℃for 60 sec.

Durable Press Resin Concentrations

Fabrics treated with different concentrations of durable press resin CTA-705 are shown in *Table II.* Results show that the concentration of CTA-705 has a significant influence on wrinkle recovery angle. WRA increased steadily from 85º to 125º on the warp directions and from 87º to 127º on the weft directions as CTA-705 concentration increased from 6% to 14%. Its change extent decreased when the concentration is above 10%. μ_d increased and softness rating decreased with an increase in CTA-705 concentration. This may be due to some small molecules compounds contained in the CTA-705 formed condensation polymer on the fabric surface.

TABLE III. Fabrics treated with different cured temperatures.

Sample number	Cured temperature/ °C	Soil release	Oil repellency	μ_d	Softness rating	WRA	
						warp	weft
1	140	3	5	0.528	5	93 º	93 º
2	160	3	6	0.521	6	103 º	104 º
3	170	4	6	0.558	7	109 º	112 º
4	180	4	5	0.582	5	110 º	114 º

[a] Finishing conditions: The concentration of BAPS,CTA-705, X-Cape® DRC, X-Cape®LK-30 and TG-9011 were 4.5%,10%,2.5%,0.15% and 0.6% respectively. Treated fabrics were dried at 80℃ for 10min, and then cured at different temperatures.

Process Conditions

The cotton fabrics were treated under confirmed concentration of finishing agents and then cured at different temperatures for 60 sec. Some properties of the treated fabrics were shown in *Table III*. Soil release, Oil repellency and softness rating of the treated fabrics increased steadily when the cured temperature was raised from 140°C to 170°C. This identified that the oil and water repellent agent, soil release agent and softener can form solid film on the surface of the yarn under higher temperature. But too high a temperature will result in more crosslinks, reducing the softness rating and comfortable handle of fabrics. WRA in both directions increased with an increase in the cure temperature as a result of increased crosslinking.

CONCLUSION

An intensive study has been carried out on the multifunctional finishing of cotton fabrics with self-made silicone softener, durable press resin, water and oil repellent and soil release agent. The results show that the silicon based softener overcomes common issues encountered when softeners are combined with soil release and anti-wrinkle agents. As BAPS concentration increases, fabric softness rating, smoothness and WRA increased, with little effect on soil release and oil repellency. With an increase of CTA-705 concentration, wrinkle recovery angle increased remarkably and softness rating decreased steadily. The cure temperature has an obvious effect on oil repellency and softness rating of the treated fabrics.

ACKNOWLEDGEMENT

This research was supported by the Beijing Key Laboratory of Clothing Materials R&D and Assessment and Beijing Municipal Commission of Education program (KYJH02110222).

This research was supported by National Natural Science Foundation of China (No.21304004).

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