Journal of Scientific Research & Reports
5(1): 95-100, 2015; Article no.JSRR.2015.076
ISSN: 2320-0227

SCIENCEDOMAIN *international*
www.sciencedomain.org

UV Blocking Properties of Reactive Dyed Mercerized Fabric

C. W. Kan[1*] and Y. L. Lam[1]

[1]Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China.

Authors' contributions

This work was carried out in collaboration between all authors. Author CWK designed the study, arranged experiments in factory, and wrote the first draft of the manuscript. YLL managed the literature searches and analyses of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JSRR/2015/13313
Editor(s):
(1) Mohsen Miraftab, University of Bolton, Institute for Materials Research and Innovation Deane Road, Bolton BL3 5AB, UK.
(2) Mohamed Abd El-moneim Ramadan, Pretreatment & Finishing of Cellulosic Fibres Department, Textile Research Division, Egypt.
(3) Diana E. Marco, National University of Cordoba, Argentina and National Research Council (CONICET), Argentina.
Reviewers:
(1) Anonymous, National Research Centre, Cairo, Egypt.
(2) Salah A. Latief Mohammed, Dept. of Textile Engineering, College of Engineering, Sudan university of Science and Technology, Khartoum, Sudan.
(3) Anonymous, Maastricht University, The Netherlands.
(4) Anonymous, National Research Centre, Egypt.
(5) Anonymous, National Research Centre, Egypt.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=747&id=22&aid=7192

Short Research Article

Received 12th August 2014
Accepted 21st November 2014
Published 15th December 2014

ABSTRACT

This paper is concerned with the effect of mercerization on the ultraviolet (UV) blocking property of 100% cotton knitted fabrics with different structures. In this study, we proposed that the mercerization process may enhance UV blocking property of 100% cotton knitted fabrics. UV measurement is carried out using a spectrophotometer and the results revealed that mercerization process did not have significant improvement on the UV blocking properties but the fabric structure did.

Keywords: Mercerization; UV blocking; cotton; knit.

**Corresponding author: Email: tccwk@inet.polyu.edu.hk, kan.chi.wai@polyu.edu.hk;*

1. INTRODUCTION

Mercerization is a chemical process for cotton fibers, which was initially discovered by John Mercer in 1851. He discovered that immersing cotton fiber in a caustic soda bath would increase the fibers strength and allow them to uptake more dyestuff readily. Afterwards, in 1890, Horace Lowe modified the process by adding steps. He discovered that luster of cotton fibers increased when keeping the fibers under tension. With Lowe's popularization the process and the interested of British cotton industry in cotton products, nowadays, mercerized cotton becomes an essential chemical treatment, especially for high quality goods. Humphries citied that cotton fiber is not easy to care without special treatment because it readily wrinkles and swells in water [1]. Fabrics may shrink easily. Clothing made of mercerized long staple and combed cotton fibers that treated with mercerization are usually high quality and "top of the market".

Knitwear is a commonly used apparel in summer time which is a practical solution to avoid the contact of skin and ultraviolet (UV) radiation [2-6]. In summer times, there is a higher chance of UV radiation exposure in terms of intensity and duration while knitted garment is much more popular in that season. Previous study reveals that fabric structure and parameters such as weight and fabric density would affect the UV blocking effect of 100% cotton knitted fabrics [7,8]. However, little work has been done on the effect of mercerization on the UV blocking property of 100% cotton knitted fabrics. Since most of the knitwear may undergo the mercerization process to improve its luster, the aim of this paper was to study the effect of mercerization process on the UV blocking property of 100% cotton knitted fabric with different knitted structure.

2. EXPERIMENTAL DETAILS

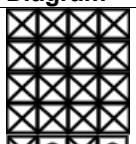
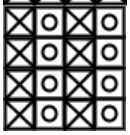
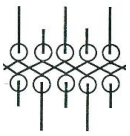
2.1 Material Preparation

Six weft knitted fabrics having different structure produced from 100% cotton yarns having different counts were used. Two were single jersey; three were one-by-one rib and one fabric was interlock. The six fabrics samples were categorized from A to F and their properties are given in Table 1.

2.2 Material Treatment

In general, there were three stages of processes: pre-treatment, piece dye and final mercerization. All the material treatment processes were conducted in factory under industrial setting.

Table 1. Properties of the selected fabric samples

Fabric	Structure	Yarn Count (Ne)*	Notation Diagram	Fabric weight (g/m^2)	Fabric thickness (mm)
A	Single Jersey	30		140	0.47
B	Single Jersey	32		145	0.44
C	One-by-one Rib	30		185	0.70
D	One-by-one Rib	32		180	0.77
E	One-by-one Rib	40		175	0.62
F	Interlock	40		190	0.77

**Yarn count - Thickness of yarn in the English Cotton Count System*

 *= knit stitch (technical face)*

 *= knit stitch (technical back)*

Greige cellulosic cotton fibres contain a lot of impurities: waxes, insects, oils, seed fragments, dusts, dirts and natural coloring matters. These impurities affect the dyeing performance and cause uneven dyeing and reactive dyestuff cannot from a strong bonding with cellulosic fibre. Scouring is an essential procedure to get rid of those dirts and impurities to produce a clean ground with higher wettability for later dyeing processing. The most common method is scouring by using strong alkali with detergent. This process was carried out in a jet-dyeing machine. The fabrics were inserted into a jet-dyeing machine, which was filled with scouring liquid with a liquid ratio of 20:1 at 105°C for 30 minutes. The constitution of the scouring liquid was as follow:

Sodium hydroxide (30% w/v)	3.5% on weight of fabric
Hydrogen peroxide	2.5% on weight of fabric
Fluowet UD	4.0% on weight of fabric

After scouring, the hydrogen peroxide was removed to avoid fabric from further damage. Liquor of scouring process was expelled and below recipe was used and poured into the bath with a liquid ratio of 20:1 at 85°C for eight minutes.

Sodium Sulphite (99% w/v) 2.5% on weight of fabric

Then the fabrics were dyed with reactive dyes with colours, yellow, red and blue, using a jet-dyeing machine. With refer to a completed dyeing process, the dyeing process has three steps: dyeing, neutralization and drying. After the process of removal of hydrogen peroxide, the liquor was drained and below recipe was used at a liquid ratio of 20:1. The fabrics were dyed at 60°C for 15 minutes.

Liquid ratio	1:20
Acetic acid (98% w/v)	0.1g/l (for adjust initial pH)
Sumifix Yellow 3RS	0.0014% on weight of fabric
Sumifix Red EF	0.0167% on weight of fabric
Sumifix Blue BRF	0.0044% on weight of fabric
Sodium sulphate (99% w/v)	10g/l
Sodium carbonate (99% w/v)	5.6g/l

In dyeing process, pH of fabric was relatively high and being alkali because of the usage of sodium sulphate and sodium carbonate; therefore, neutralization was followed by using acidic buffer to acquire a nearly neutral pH at 7.0. After the dyeing liquor was drained, below recipe was used, and with a liquid ratio of 20:1 and the fabrics were neutralized at room temperature for 4 minutes. After neutralization, the fabrics were washed by hot water at 97°C for three minutes and then washed by cold water for three minutes.

Acetic acid (98% w/v)	1.6g/l
Sodium acetate	0.8g/l

After the neutralization process, water on fabrics was removed by using centrifuge machine. It is a machine that speeds up the drying time of fabric by centrifuge liquor from fabrics by centrifugal force. The fabrics were dried using a stenter drying machine. Stenter consists of a liquid bath, a pair of padders stenter frame and eight heat chambers. When fabric passed through the liquid bath and the padders, liquor was padded on fabrics. The stenter frame can help to control the fabric width. Finally, fabrics passed into the eight heat chambers. Heat-setting temperature can be entered into the computer system of the stenter. Once entered, the computer can automatically control the speed of machine to achieve the heat-setting requirement for fabrics.

After dyeing, the fabrics were mercerized in mercerization machine by using a condition with machine speed at 20 meters per minute at 25°C. Mercerol QW-LF was used as a wetting agent, which was suitable for adding to a mercerizing liquor, in the process of mercerization. It was then followed by a hot water-washing process at 80°C for 15 minutes.

Mercerol QW-LF Liq	20g/l
Concentration of NaOH	25ºBé

2.3 UV Measurement

After mercerization, all the fabrics were then stored in conditioning room with the temperature at 20±1ºC and relative humidity at 65±2% for four hours. After conditioning, testing specimens were prepared in the conditioning room. Three swatches with size at three inches time three inches were randomly cut from each treated fabric and ready-for rearward testing. UV measurement was carried out using Cary model 50 UV/VIS Spectrophotometer. This spectrophotometer incorporated a Xenon flash

lamp and installed a Cary WinUV Beta software for measuring the UPF value by using AS/NZS 4399:1996 standard. It was placed in the conditioning room to ensure each specimen was stable and was measured consistently.

The UPF value of each fabric was determined in accordance with AS/NZS 4399:1996 (*in vitro* test) (*in vivo* test was not conducted in this study due to the involvement of human subjective). Each specimen was clipped by a pair of strong magnets on the transmittance port of the integrating sphere. Spectra and transmittance in percent of fabric samples were collected from the UV region of 280-400 nm. At 2nm intervals with a Cary 50 UV/VIS spectrophotometer fitted with an integrating sphere.

Before the measurement, stitch density of each fabric was measured by a densimeter to ensure its stitch density was as closed as its untreated control by elongating or compacting. This was because the difference in fabrication will affect the result significantly and in order to minimize the measurement error. UVR transmission was then taken by rotating each fabric at three directions: oriented, clockwise-oriented fabric at 45 degrees and 90 degrees. The mean of UPF, average percentage of UVA and UVB transmittance values were automatically calculated after each scan and were averaged by the software

3. RESULTS AND DISCUSSION

Figs. 1 to 3 show the UV transmission and UV protection factor (UPF) of the control and mercerized fabrics respectively. The UV transmission and UPF can be used for describing the UV blocking property of a material. The control fabrics refer to the dyed fabric without mercerization. According to Figs. 1 and 2, apart from Fabrics F, the UV blocking properties of mercerized fabrics were not significantly improved when compared with the untreated control. More UVA and UVB radiation was transmitted having higher UVA and UVB transmission percentage respectively. This may be because during mercerization, there was a chemical reaction between the cellulose and the caustic soda. A decline in the indices of crystallinity and degrees of polymerization of cellulose occurred as a result of the change from cellulose I into cellulose II [9]. The axial ratio was reduced and the light scattering, namely transparency) with the cotton fibres was increased. Also, the UPF rating as shown in Fig. 3 of mercerized single layer fabrics were declined into Ratings 10 to 15. However, in the result of Fabric F, which is a double layer, there was no change in the UV protection when compared with untreated that could have “excellent protection” as well.

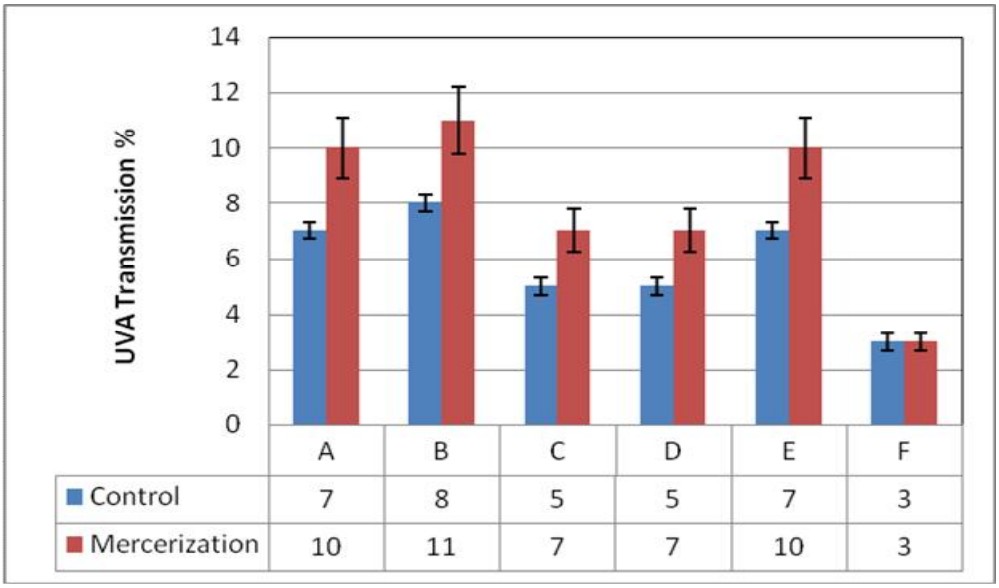


Fig. 1. UVA transmission of fabrics

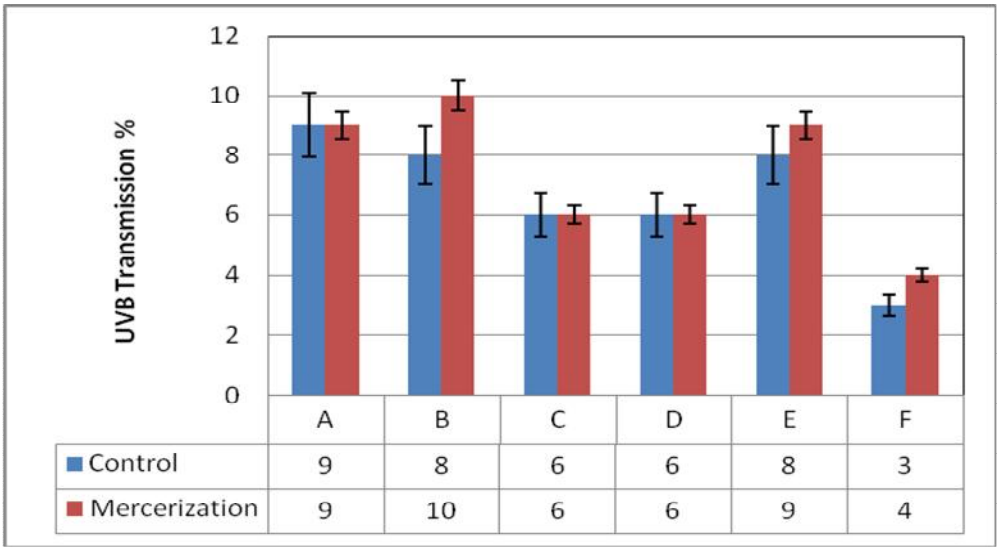


Fig. 2. UVB transmission of fabrics

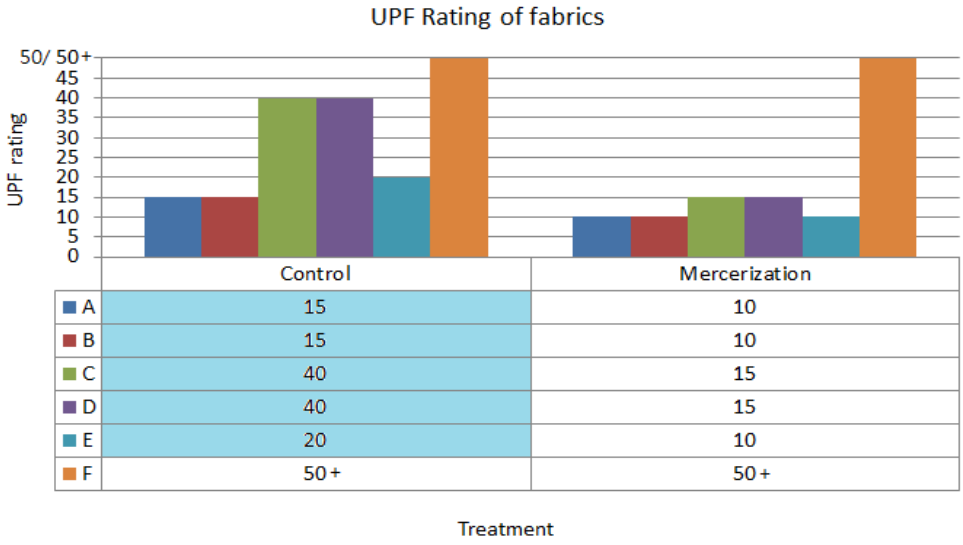


Fig. 3. UPF rating of fabrics

When the fabric structure was compared, three types of fabric structure were used, i.e. single jersey, rib and interlock. The single jersey structure generally gives the lowest UPF value while the rib and interlock structures give a better UPF value as shown in Fig. 3. The difference is that single jersey is a single knitted structure while the rib and interlock are double knitted structure. Generally speaking, double knitted structure would have better UPF than single knitted structure [7]. However, when rib and interlock structures are compared, interlock is able to provide excellent UV protection because of the high fabric thickness and weight as shown in Table 1 [8]. The characteristics of interlock structure are able to minimize the fabric openness and UV radiation transmittance. Hence, it results in high UPF in interlock structure.

4. CONCLUSION

UV blocking property was measured for different mercerized 100% cotton knitted fabric with different structures. Experimental results revealed that mercerization process did not affect much the UV blocking effect but the fabric structure did. When different structures were

compared, the interlock structure shows excellent UV protection because it has a high thickness and weight.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Humphries M. Fabric Reference; Pearson/Prentice Hall: Upper Saddle River, NJ; 2004.
2. Stanford DG, Georgouras KE, Pailthorpe MT. Rating clothing for sun protection: current status in Australia. Journal of the European Academy of Dermatology & Venereology. 1997;8(1):12–17.
3. Gies HP, Roy CR, Toomey S, McLennan A. Protection against solar ultraviolet radiation. Mutation Research. 1998;442(1):15-22.
4. Gies HP, Roy CR, Holmes G. Ultraviolet radiation protection by clothing: comparison of in vivo and vitro measurements. Radiation Protection Dosimetry. 2000;91(6):247-250.
5. Pailthorpe M. Textile and sun protection: the current situation. Australian Textiles. 1994;8(1):12-17.
6. Pailthrope M. Apparel textiles and sun protection: A marketing opportunity or a quality control nightmare? Mutation Research. 1998;442(1):175-183.
7. Kan CW. A study of ultraviolet protection of 100% cotton knitted fabric: effect of fabric parameters. The Scientific World Journal; 2014. Article ID 506049.
8. Chong HKS, Kan CW, Lam JKC, Ng SP, Hu H, Yuen CWM. Study on the relationship between UV protection and knitted fabric structure. Journal of Textile Engineering. 2013;59(4):71-74.
9. Rinaudo M. Polysaccharide characterization in relation with some original properties. Journal of Applied Polymer Science. 1993;52:11-17.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=747&id=22&aid=7192