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Influence of Fluorescence Whitening Treatment on the UV Blocking Property of 100% Cotton Knitted Fabric

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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. Author YLL managed the literature searches and analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

This paper was concerned with the effect of fluorescence whitening treatment on the UV blocking effect of 100% cotton knitted structure. UV measurement was carried out using a spectrophotometer and UVA transmission and UPF were obtained. The results revealed that fluorescence whitening process did affect much the UV blocking effect.

Keywords: Fluorescence whitening; UV blocking; cotton; knit.

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1. INTRODUCTION

Singh and Pant showed that cellulosic cotton fabrics transmit ultraviolet A (UVA) and ultraviolet B (UVB) with the transmittance ratio 0.9 equally [1]. When the fabrics are dyed with reactive dyes, the ultraviolet protection factor (UPF) value can increase from 4.7 to 5.0 -14 depending on the concentration of dyestuffs being used. However, this is not sufficient to satisfy the minimum requirement of sun protection to the wearer. Some dyestuffs possess UV absorption characteristics that especially increase with the concentration. It can reduce UVA transmission from 24.6% to 10-20% and UVB transmission from 27.8% to 8-22%. Therefore, UPF can be increased significantly. There are various whitening methods named as "fluorescent bleaching', 'optical bleaching', 'optical brightening agents' (OBAs) or 'fluorescent whitening'. Fluorescent whitening agents (FWAs) are commonly used to enhance the whiteness of fabric by UV excitation and visible blue emission, due to the transition of electrons from either conjugated or aromatic compounds. Although FWAs are colorless or slightly colored, they act as fluorescent dyestuffs. Based on Levene and Lewin's study [2], FWA can absorb light in the ultra-violet region of spectrum about 400 nm, and re-emit the light, as fluorescence, in violet-blue visible region. Moreover, according to Grancarić and Pušić et al. [3], fabrics being optical bleached can absorb the UV lights and remit them as the blueness, redness and greenness lights resulting in the textile that appears whiter. FWAs on textile, therefore, can influence UPF values in the wide range of FWAs concentration. In this paper, the effect of fluorescence whitening process on the UV blocking property of 100% cotton knitted fabrics will be studied.

2. METHODOLOGY

2.1 Material Preparation

Six 100% cotton in fabric form were used (obtained from a fabric manufacturer in China). The fabrics were named as A to F and their specifications are listed in Table 1.

The fabrics were dyed with reactive dyes using recipe below in a jet-dyeing under industrial conditions and the fabrics were dyed at 60°C for 15 minutes. After dyeing, the fabrics were neturalised with acidic buffer (Acetic acid (98%): 1.6 g/l; Sodium acetate: 0.8 g/l) to acquire a nearly neutral pH at 7.0, finally washed by hot water at 97°C for three minutes and then washed by cold water for three minutes. Then the fabrics were dried completely and conditioned for 24 hours before fluorescence whitening treatment.

Material liquor ratio	20:1
Sumifix Yellow 3RS	0.0014%
Sumifix Red EF	0.0167%
Sumifix Blue BRF	0.0044%
Sodium sulphate (99%)	10 g/l
Sodium carbonate (99%)	5.6 g/l

Table 1. Fabric specifications

Sample	Fabric structure	†Yarn count (Ne)
A	Single Jersey	30
B	Single Jersey	32
C	One-by-one Rib	30
D	One-by-one Rib	32
E	One-by-one Rib	40
F	Interlock	40

†Thickness of yarn in the English Cotton Count

2.2 Fluorescence Whitening Treatment

Fluorescence whitening agent (FWA), Uvitex BHT (a fluorescent dye based on diaminostilbene disulphonic acid which is characterised by a planar molecule and a conjugated ring system), was added by an all-in one process. Fabrics were treated at 60°C with a material liquor ratio of 20:1 for 15 minutes with the following recipe:

Acetic acid (98%)	0.1 g/l
Uvitex BHT	0.5%

2.3 UV Measurement

After fluorescence whitening treatment, all the fabrics were then stored in conditioning room with the temperature at 20±1°C and relative humidity at 65±2% for four hours before UV measurement. Three swatches with size at 3 inches x 3 inches were randomly cut from each treated fabric. UV measurement was carried out using Cary model 50 UV/VIS Spectrophotometer for getting the UVA transmission and UPF values according to AS/NZS 4399:1996 standard.

3. RESULTS AND DISCUSSION

Fig. 1 and Table 2 show the UVA transmission (UVA) and UV protection factor (UPF) of the control and fluorescence whitening treated 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 fluorescence whitening treatment. According to Fig. 1 and Table 2, all the fluorescence whitening treated fabrics had the better UV protection results than untreated control. All the fabrics had better blocking property on UVA transmission and UPF rating. Fabrics C to F have "excellent protection" after FWA treatment. This may be because of the fluorescence whitening agent which could absorb the UV radiation effectively as well as UVA. This absorption of UV radiation could decrease the transmission of UVA and provide fabrics of higher UPF rating [1,3]. Therefore, fabrics treated with FWA not only improved the whiteness, but also the UV protection. With regard to Samples, Fabric A and Fabric B, they were classified as "good protection"; In Fabric C to Fabric F, all were classified as "excellent protection". 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 Table 2. 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 [4] because of the high fabric thickness, weight, density and tightness [5]. In addition, if the fabric parameter such as yarn count was taken into consideration, it does not have any significant effect under the effect of fluorescence whitening treatment.

Table 2. UPF rating of fabrics

Sample	Control	Fluorescence whitening treated
A	15	20
B	15	20
C	40	50+
D	40	50+
E	20	50+
F	50	50+

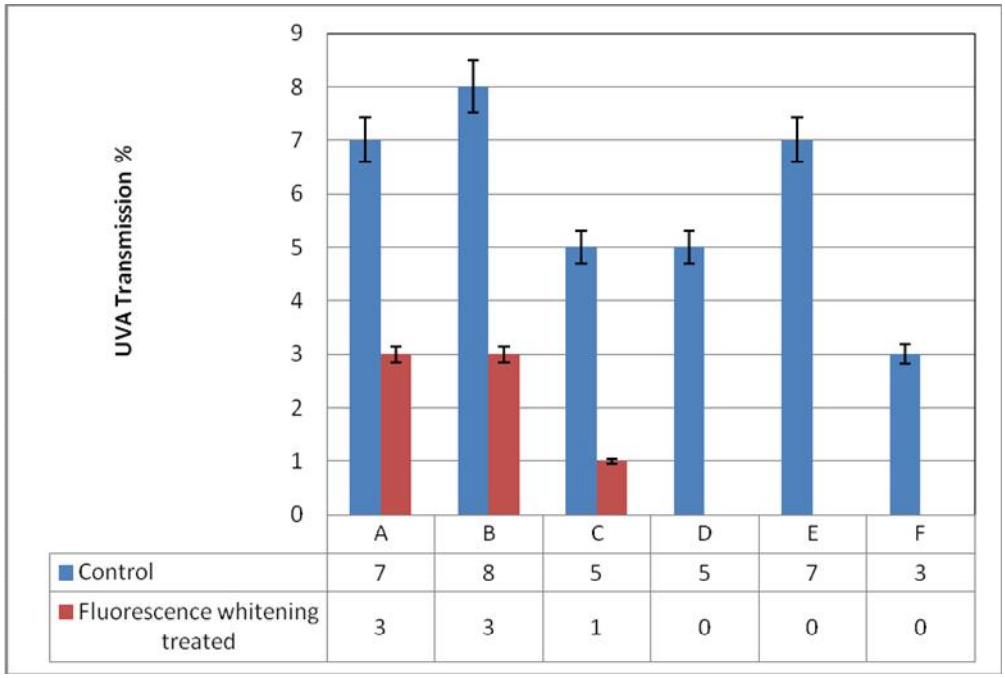

Fig. 1. UV transmission of fabrics

4. CONCLUSION

UV blocking property was measured for different fluorescence whitening treated 100% cotton knitted fabrics. Experimental results revealed that fluorescence whitening treatment greatly enhanced the UV blocking effect. In addition, when the fabric structure was compared, double knitted structure would have better UPF than single knitted structure.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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