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Engineering Design 2 Layer Woven Fabric Structures for UV Indexable Textiles

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Abstract

The negative effects of sunlight has been known associated with the development of skin cancer, skin aging, immune suppression, and eye diseases. The UV Index is an important parameter to alert people about the need to adopt protective measures. This paper reports a design concept and techniques developed in engineering UV indexable two-layer narrow woven fabrics. The fabrics were made using a type of photochromic yarn and three reference yarns with static colours indicating the level of UV intensity based on the measurement of colour change of the photochromic yarn under different level of UV intensities.

Keywords: UV indexable textile; UV index measurement;Photochromic yarn;Two layer woven fabric

Introduction

Photochromic pigments were developed for colour changing lenses for sunglasses initially. Their application have been expended in innovative textile and fashion design and many other applicable areas. There are irreversible photochromic pigments made for some specific applications. Other photochromic pigments are reversible that are important type for textile and fashion design. According to the photochromism, the photochromic process may be categorised into several groups including triplet [1], heterolytic cleavage [2,3], homolytic cleavage [4,5], trans-cis isomeration [6,7], photochromism based on tautomerism [4,5], and photodimerisation [8]. An example of working principle of photochromic pigments is shown in (Figure 1).

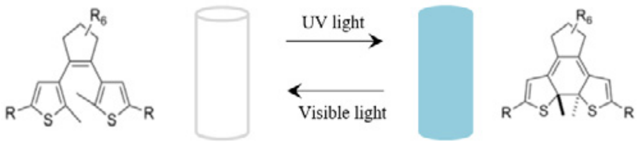

Figure 1: Working principle of photochromism.

Despite the beneficial effects of both solar and artificial UV radiation have been used in the phototherapy to cure or mitigate skin diseases such as psoriasis, neurodermatitis, scleroderma, lupus, erythematosus, urticarial pigmentosa, vitiligo and acne vulgaris [9-11] solar radiation of certain range of wavelength has negative effects on human health. UV index has been used as a general term for public awareness to identify the risk of high UV doses [12]. Detrimental effects to humans such as erythema and skin cancer can be triggered by high values of effective irradiance or high UV dose [13].

UV index is calculated from a direct measurement of the UV spectral power at a given location. It requires the measurement of the intensity of UV radiation as UV Index (UVI) [14]. A UV Index reading of 3 to 5 means moderate risk of harm from unprotected sun exposure. There is no such photochromic yarn or ink that is able to indicate or respond to different UV intensities, however the depth of colour will depend on the strength of UV, e.g. colour depth increases with stronger sunlight. The UV index can be calculated from a direst measurement of the UV spectral power at a given location. It requires the measurement of the intensity of UV radiation.

UV protective textiles have been reported by applying ZnO by different techniques and approaches, onto different types of textiles, cellulosic fibres [15,16], protein fibres [17], and synthetic fibres [18].

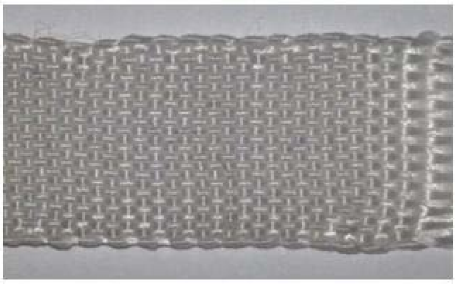

Figure 2: Fabric made of chromic yarn taken indoor.

UV protection is very important; however UV warning is another element needs to be considered alarming people about the need to use sun protection. This research reports engineering design fabric structures and UV indexable fabrics using colour reversible photochromic yarn and normal yarns with pre-identified reference colours.

Design Principle, Materials and Testing

Colour reference

The aim of the project is to engineering design textile-based accessories for indoor and outdoor wear, in this case smart watchbands will be designed and engineered. In the watchband a section of patterned photochromic yarn will be designed and its colour under UV light can be compared to other sections of the watchband made of yarns with static reference colours.

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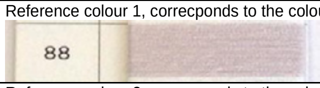
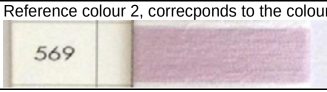
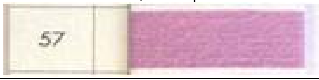
900 denier Photochromic PP yarn	Indoor  outdoor at low UV index 
Nylon yarn with 'static colour 1'	Reference colour 1, correcponds to the colour of photochromic yarn under low level UV light 
Nylon yarn with 'static colour 2'	Reference colour 2, correcponds to the colour of photochromic yarn under moderte level UV light 
Nylon yarn with 'static colour 3'	Reference colour 3, correcponds to the colour of photochromic yarn under high level UV light 

Table 1: Photochromic yarn and three reference yarns.
Note: The photochromic yarn was made by Guangzhou Lanjing Chemical Fibre Co. Ltd. The yarns with the three reference colours 1, 2 & 3 were supplied by J.H. Ashworth & son Ltd.

Figure 3: UV index checker.

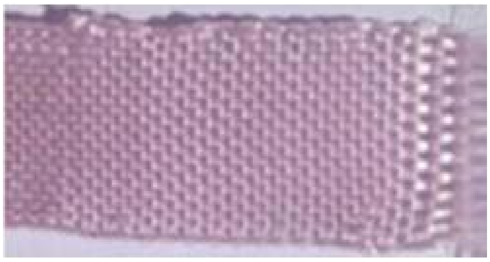


Figure 4: Comparison between the woven sample and the shade card.

Materials

The yarns used for construction the watchband are listed in (Table 1).

Testing of UV index

A piece of fabric was constructed using the photochromic yarn shown in (Figure 2), which was taken in door.

A smart UV checker shown in (Figure 3)was used to measure the UV index value in different weather conditions and UV intensities. The UV checker has a semiconductor Sensor that connects to your Smartphone to measure, collect and analyze UV light.

Under all weather conditions tested and UV index values, the developed photochromic fabric (Figure 4) was tested and the corresponding colours were recorded by using a digital camera as reference colour for watchband design. In the end, three reference colours were identified corresponding to three different UV levels - low, moderate and high.

Results and Discussion

Colour change of the photochromic fabric under different UV intensities

The fabric sample (Figure 4) was taken to the sunlight in different UV intensity conditions, the change of colour was recorded under different exposure time. The colour of the woven cloth was then compared to the colours of a shade card by doing so to obtain the reference colours corresponding to different UV intensities. The shade card is the Sabac polyester core spun thread shade card from AMANN.The comparison of the colours was conducted. The following images show the colour comparison observed. In the end three reference colours were identified corresponding to low, moderate and high UVI values.

In order to use the colour change of the photochromic yarn to indicate different UV intensities, the observation time was set at 20 second in which there is an obvious difference between the colour shade in corresponding to low and moderate UV exposure. According to literature, it is possible to use photochromic material to identify UV exposure because the intensity of the colour has a linear relationship with UV irradiation [4]. Higher UV radiation triggers higher intensity of the colour. Also, the colour change time is affected by the UV radiation. The two have a negative linear relationship, shorter change time corresponds to higher UV radiation.

Fabric design and development

Three types of weave structures - plain, twill and satin were selected for the watchband cloth development. For all the three weave structures, two layer cloth is required in order for the face of the fabric has photochromic and reference yarns appear in different sections of the fabric indicated in (Figure 5).

In this research two layer narrow fabrics (20mm wide) were planned to be used for watchband.The total number of ends of the cloth is 56, warp and weft yarn linear density are 28 and 24 in total

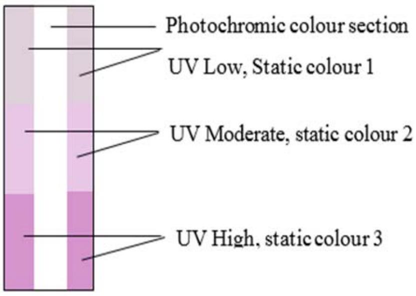


Figure 5: Colour design with different sections in double layer watchband narrow cloth.

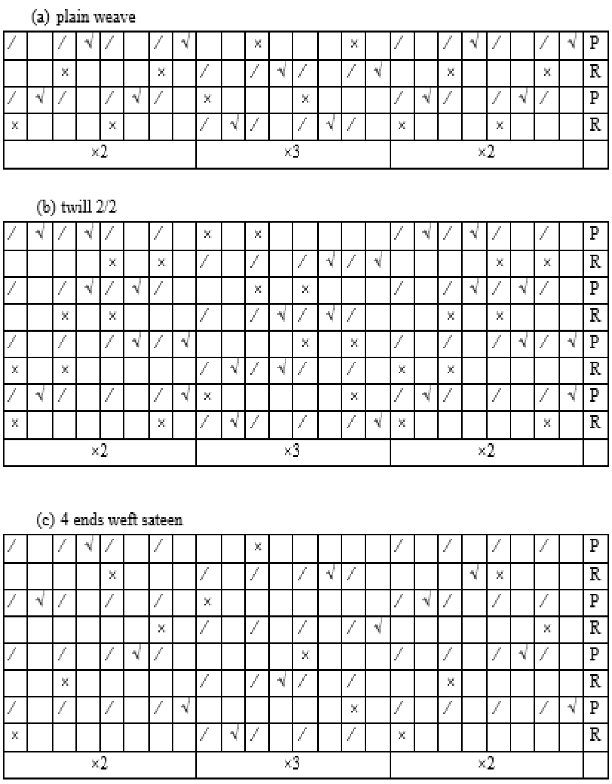


Figure 6: Weave plan of plain, 2/2 twill and 4 ends weft sateen, where: '×', '√' and '/'indicate the face weave, back weave, and a separating lifter (face end lifts over back pick), respectively. 'R' and 'P' represent the Reference/ indicator Yarn and the Photochromic Yarn respectively.

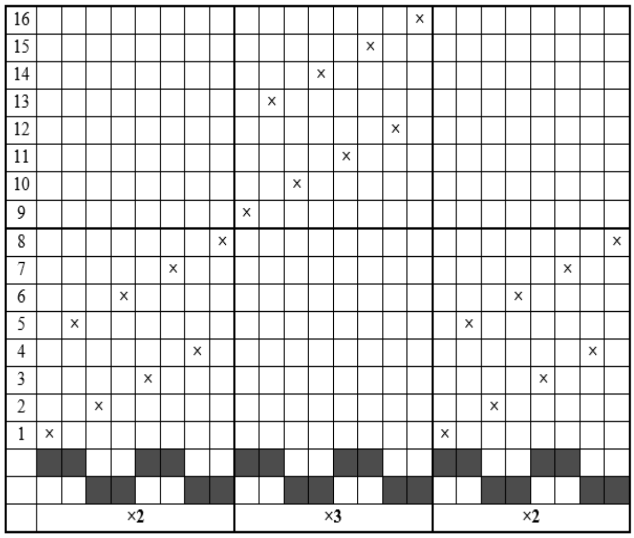


Figure 7: Draft Plan of plain and twill 2/2 weave, total number of ends is 56.

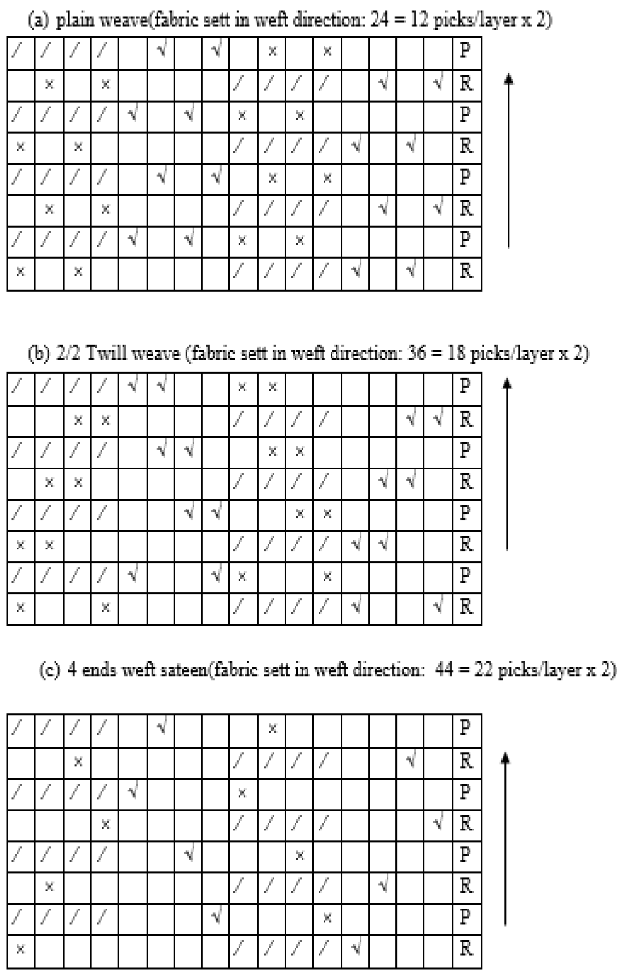


Figure 8: Peg plan of the three woven fabrics plain, twill and sateen.

which are14 and 12 ends (orpicks)/cm. layer respecvitely. The detailed weave design, draft and peg plan of the double cloth are shown in (Figure 6-8).

The above three design plans were practised on a Texel manual floor loom, as shown in (Figure 9).

Three prototypes of the photochromic watchband were made using the three types of two layer woven fabrics. (Figure 10) presents watchband made of two-layer plain weave structure. All designs have different appearance between indoor and outdoor due to the colour change of the photochromic yarn in the watchband. The middle section of the watchband appears creamy and white coloured indoor, and changes to light pink – dark outdoor exposed to a low (Figure 10) and medium level of UV intensities. The light pink colour is close to the low UV index reference colour. Therefore, the photochromic

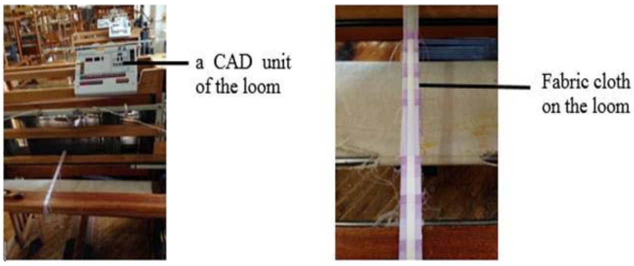


Figure 9: Weave loom, photochromic cloth on the loom.

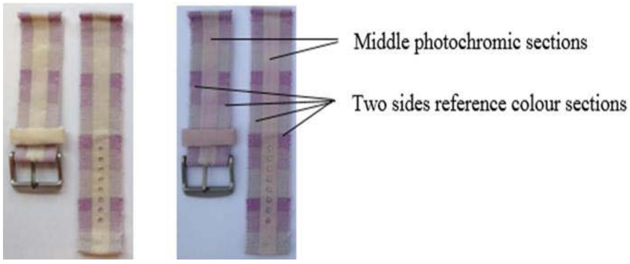


Figure 10: Photochromic watchband made of plain weave cloth, indoor and outdoor UVI: (left) indoor and (right) outdoor with UVI 0.06.

watch band can be used to indicate the real time UV index level to alarm the wearer.

Conclusion

The principle and techniques of engineering design two layer woven fabrics for UV warning textile applications have been studied and the following conclusions have been made.

- The colour effect of a type of photochromic fabric in different strength of sunlight corresponding to different UVI levels. Based on the colour obtained three yarns with three static colours were identified to be used as reference colours for comparison to the colour when the chromic yarn exposed in the sunlight.

- Three two-layer narrow woven fabrics were developed for UV indexable watchbands using the photochromic yarn and the three reference yarns based on the pre-determined colour effects in different sections of the fabrics (watch bands) available for users to know the UVI level by comparing the colour of the chromic section and the reference colours. The developed techniques could be used for developing fabrics for other textile products and applications.

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