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Simultaneous and Durable Design of Colourful Diversity and Protective Alarms against Ultraviolet on Child's Apparel

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Abstract

Sunlight has energetic radiations like ultraviolet that exposed to it for specific time limit causes making vitamin D and bone in body. On the other hand, prolonged exposure to ultraviolet energetic irradiations available in sunlight could lead to irremediable damages such as eye and skin diseases for human beings. In this research, it is tried to create durable design using photochromic dyes sensitive to light and printing conventional process in order to safety against ultraviolet utilizing coloured diversity. To do this, polyester fabrics were put under printing treatment and printed samples were exposed to different irradiations such as sunlight, fluorescent, and D65. Finally, coloured changes were measured and compared with each other by evaluating monochromatic compounds amounts (red, blue, and yellow) of each printed sample and under mentioned irradiations. One of the findings of research is durable and effective protective alarm against ultraviolet through created coloured diversity for child's garment that was successfully obtained by conducting this research.

Keywords: Garment; Photochromic Dyes; Protective Alarm; Ultraviolet Irradiation

1. Introduction

Ultraviolet irradiation effects on human body specially causing dangerous skin disease and also protective role of garment by their coverings are among central aims of research. Although sun irradiation is essential for all kinds of lives, but if it becomes prolonged it will be dangerous and its ultraviolet irradiations are harmful for human and textiles (De, 1998). Some of ultraviolet

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irradiations which reached earth surface are variant considering factors such as season, time, climate conditions, and geographical coordinates (Dawson, 2005). Yearly, in England, about 46000 new conditions resulted from skin diseases are reported which 40000 cases are related to skin diseases that are not cancerous and 6000 cases are cancerous skin disease that finally leads to death of 2000 cases (Pearson and Mullen, 2003). In South Africa, cancerous skin diseases were increased from 1 case from 1000 which was related to 40 years ago to more than 1 case among 75 individuals (Pearson and Mullen, 2003). Regarding the significance of protection against ultraviolet, it was attempted to deal with creating protection of different fabrics and garment against of ultraviolet using different methods and chemical agents like nano TiO2 (Alebeid and Zhao, 2014; Nazari, 2014; Nazari et al, 2013), zinc oxide (Merati et al, 2017), natural compounds (Alebeid et al., 2015), polymeric materials (Carnlibel et al., 2018), utilizing fabric structure and its statistical analysis (Azeem et al., 2017), and also length and twist of fiber (Wong et al., 2016).

Photochromic is technically referred to reversible colour change generated by special chemical compounds. Foresaid colour change is developed by different irradiations such as ultraviolet irradiation. In a way that, after ultraviolet omission, initial colour is appeared again (Barnfield, 2001). Colour changes resulted from photochromic phenomenon could be made because of different mechanisms (Pimienta et al., 1999; Bouas-Laurent and Durr, 2001). Photochromic phenomenon was firstly observed and reported by Fritzche in 1876 (Fritzche, 1867).

In this research, it is tried to attend child's garment durable design accompany with developing and enhancing protection and alarm announcement against ultraviolet available in sunlight using photochromic dyes. Therefore, conventional process of simple screen printing was applied and photochromic dyes were exploited in printing paste. In a way that target design was printed on fabric durably with capability of usage for several times. Afterwards, printed fabrics were exposed to different irradiations of sunlight, fluorescent, and D65 and unsuitable irradiation condition for the child worn that garment could be obtained by observing colour change and in fact simultaneous and durable design of coloured diversity and announcement of protective alarms against ultraviolet would be achieved.

2. Materials and Methods

2.1. Material

Photochromic dyes were prepared in three colours of red, blue, and yellow from HALI INDUSTRIAL CO., LTD.; in China. Dyes were appeared in the environment without sunlight irradiation as colourless (Fig 1-a) and under sunlight irradiation as colourful (Fig 1-b) and this change is reversible. Also binder and acraconz synthetic thickener were provided from Pervyj Ukrainskij Market Himicheskogo Syrya Company of china. Polyester fabric was prepared from Yazdbaf company related to Iran with technical specification of plain weave 100% polyester fabric with warp density 36 yarn/cm, 30/1 Ne, weft density 24 yarn/cm, 30/1 Ne, and fabric weight of 118 g/m2.

a. before exposure to sunlight b. after exposure to sunlight

Fig 1 Photochromic dyes prepared from china

2.2. Equipment

To spread and pull printing paste on screen netting, squeegee (Figure 2), and silk screen (Figure 3) were applied. Basic piece in silk printing is silky net which had different mesh numbers and one scientific table based on printed object but it is utilized to number 50 for printing fabric in simple method, 50 to 90 for ordinary functions, 90 to 150 for elegant designs, and 150 to 200 for very accurate performances such as printing electronic circuits. There are very small pores in net to pass colour paste that should be immediately cleaned during and after finishing of printing treatment by thinner to remove any effects of colour in pores.

Fig 2 Utilized squeegee

Fig 3 Utilized silk screen for printing

SX40 HS camera (Figure 4) was applied to xerography of printed polyester fabrics. SX40 HS camera exploited from CCD 14.1 megapixel image sensor. SX40 HS is equipped with 12.1 megapixel sensor but of backside illuminated CMOS type which presented higher quality and sensitivity former models sensor. Therefore, suffix of this kind of camera is HS that means High sensitivity. Full HD taking photography is a capability of SX40 HS.

Fig 4 SX40 HS camera

To conduct the research, light cabinet was used with different simulated irradiations of sunlight, fluorescent, and D65 that characteristics are presented in Table 1.

Table 1 Characteristics of irradiations available in light cabinet

Lamp type	Watt	Company name	Country
Fluorescent	**40**	**SIBALEC**	**Indonesia**
D65	**18-20**	**Pars**	**Iran**
Sunlight	**20**	**GE**	**America**

3. Discussion on Results

3.1. Photochromic Red Colour Component Measurement in Printed Polyester Fabrics

Printed polyester fabrics were set under printing treatment by utilizing acraconz thickener and red photochromic dye and through silk screen conventional method. In continue, printed samples were exposed to different irradiations of sunlight, fluorescent, and D65 and also exposed to any irradiation. Images are illustrated in Fig 5.

Also red photochromic dye was broken up to basic colours through CS6 software and numerical amounts of each of them were measured and revealed in Fig 6.

Polyester fabrics	No irradiation	D65	Fluorescent	Sunlight
Red				

Fig 5 Colourful images of red spectra in printed polyester fabrics with photochromic dyes and under different irradiations

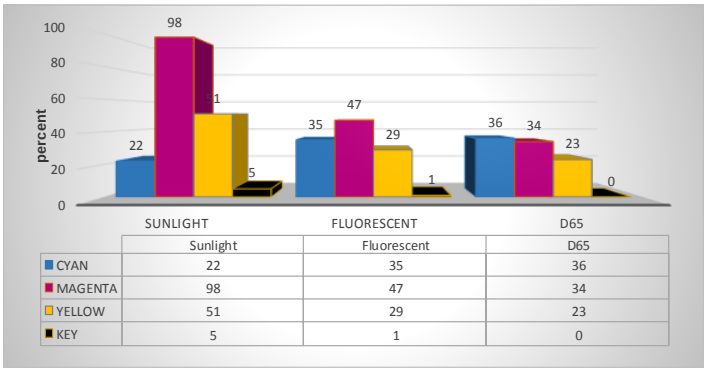


Fig 6 Amount of red colour component in printed polyester fabrics and under different irradiations

Also it is observed in Fig 6, highest amount of red colour (98) is occurred under sunlight irradiation and less amount of red colour (34) is occurred under D65 light source. Medium amount of red colour (47) is presented under fluorescent irradiation. Obtained results are in desirable accordance with shown images in Fig 5. In a way that part of sunlight involves ultraviolet irradiations and as long as printed polyester sample is exposed to it, red photochromic dye was more appeared and this could be appropriate warning for a child to prevent and hinder ultraviolet harmful irradiations.

3.2. Photochromic Blue Colour Component Measurement in Printed Polyester Fabrics

Polyester fabrics were put under printing treatment by using synthetic thickener and blue photochromic dye and in continue, printed samples were exposed to different irradiations of sunlight, fluorescent, and D65 and also exposed to any irradiation. Images are exhibited in Fig 7. Then blue photochromic dye was broken up to basic colour through CS6 software and numerical amounts of each of them were evaluated (Fig 8).

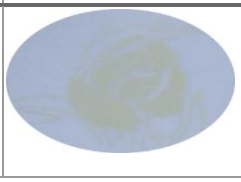
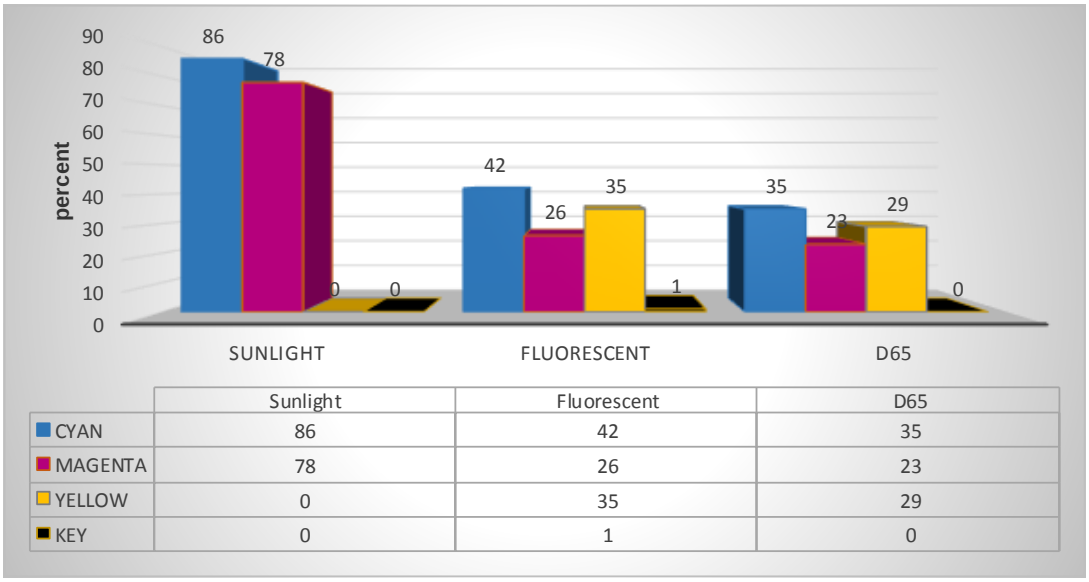
Polyester fabrics	No irradiation	D65	Fluorescent	Sunlight
Blue				

Fig 7 Colourful images of blue spectra in printed polyester fabrics with photochromic dyes and under different irradiations



	Sunlight	Fluorescent	D65
CYAN	86	42	35
MAGENTA	78	26	23
YELLOW	0	35	29
KEY	0	1	0

Fig 8 Amount of blue colour component in printed polyester fabrics and under different irradiations

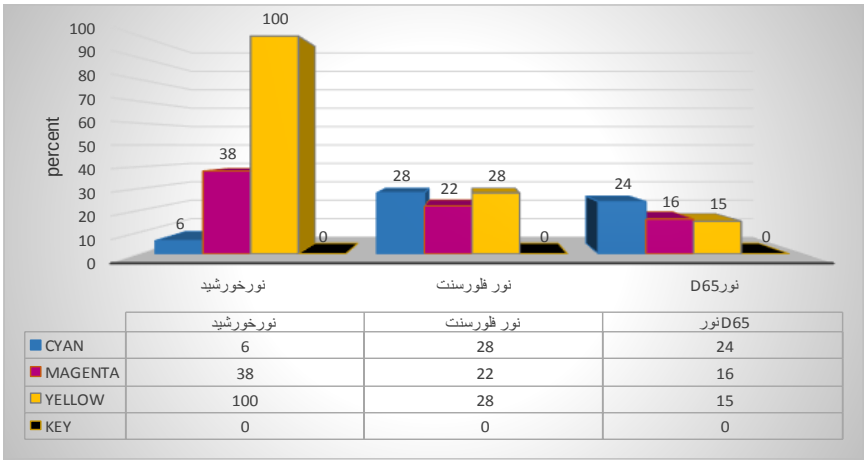
Also it is implied from Fig 8, highest amount of blue colour (86) is happened under sunlight irradiation and less amount of blue colour (35) is happened under D65 light source. Medium amount of blue colour (42) is emerged under fluorescent irradiation. Resulted findings are in suitable adaption with images illustrated in Fig 7. Some of sunlight includes ultraviolet irradiations and since printed sample is exposed to it, blue colour photochromic dyes are more appeared and this could be acceptable warning for hindering ultraviolet irradiation and also desirable colourful diversity is made because of different irradiations.

3.3. Photochromic Yellow Colour Component Measurement in Printed Polyester Fabrics

Polyester fabrics were printed with acraconz synthetic thickener and yellow colour photochromic dye, then were exposed to different irradiations of sunlight, fluorescent, and D65 and also exposed to any irradiation (Fig 9). After that, yellow colour photochromic dye was broken up to basic colour and numerical amounts of each of them were reported (Fig 10).

Polyester fabrics	No irradiation	D65	Fluorescent	Sunlight
Yellow				

Fig 9 Colourful images of yellow spectra in printed polyester fabrics with photochromic dyes and under different irradiations



	نورخورشید	نور فلورسنت	D65نور
CYAN	6	28	24
MAGENTA	38	22	16
YELLOW	100	28	15
KEY	0	0	0

Fig 10 Amount of yellow colour component in printed polyester fabrics and under different irradiations

Based on conclusions obtained from Figure 10, it is implied that highest amount of yellow colour (100) is presented under sunlight irradiation and less amount of yellow colour (16) is emerged under D65 light source, and medium amount of yellow colour (22) is appeared under fluorescent irradiation. Acquired results from illustrated images in Fig 9 confirm that ultraviolet irradiations available in sunlight could more effectively reveal yellow colour exists in photochromic dye than other applied irradiations and are further warning for a child that used aforementioned apparel.

3.4. Children's Apparel Design

After conducting experimental and investigative researches, it was identified that the photochromic dyes have dominant characteristics of colour change and sensitivity against ultraviolet irradiation which could be applied to achieve aims and progress in culture of clothes usage specially children's apparel. Injuries consequent from ultraviolet irradiations are serious threats for children. Therefore, providing stable garment for a child holding protective characteristics against ultraviolet with considering various designs are prominent necessities and impressive challenges that are attended in this research. In a way that prepared clothes resulted from this study could avoid skin damages and are well timed warning for a child and his/her parents to made child leave the place. Based on obtained conclusions, effective role of utilizing photochromic dyes could be announced in order to alarm and warn dangerous and energetic ultraviolet irradiation. Specifically since experimental equipment are not accessible to inform presence ultraviolet in environment, it is possible to use stable designed garment colourful with photochromic dyes. In design section of this research it is attempted to regards child's apparel with attractive and update design by applying photochromic dyes in printing process in parts of clothes such as upon of hat and back of clothes which do not place ahead of child's eye and exhibit a suitable display for others and specially parents to be a punctual alarm to change child's location. As a consequence, both matter of protective alarm announcement and developing colourful diversity are presented in designs of Fig 11-15, thus remarkable variety and creativity are provided for child's garment designs. Toy like printed designs were located on back of children parka (Fig 11) and also on the parka's hat (Fig 12). If the eyes of created designs were observed colourful (Fig 11-b and 12-b), it would be demonstrator and warner of child's exposure to ultraviolet energetic irradiations and it is required to change child's location. In fact, the conception of leave of unsuitable position is conveyed to other through made innovative and ingenious designs.

a. Far from b. Under sun ultraviolet irradiation

Fig 11 Design 1 printed and designed apparel for a child

a. Far from b. Under sun ultraviolet irradiation

Fig 12 Design 2 printed and designed apparel for a child

Printed designs on masculine shirt are illustrated in Fig 13 and 14 using photochromic dyes. Warning and clear changes are observed for a child (Fig 13-b) and other (Fig 14-b) when exposing to ultraviolet irradiation of sunlight that could be instantly hindered from damaging child's skin.

a. Far from b. Under sun ultraviolet irradiation

Fig 13 Design 3 printed and designed apparel for a child

a. Far from b. Under sun ultraviolet irradiation

Fig 14 Design 4 printed and designed apparel for a child

Spotted designs are devised for girly clothes in Fig 15. It is tried to use photochromic dyes on fabric to print each spot. Since a child is exposed to ultraviolet, white spots are turned into colourful spots (Fig 15-b). As it is perceived from created designs on child's clothes, simultaneous design of colourful diversity and warning announcement were clearly developed for the presence of ultraviolet dangerous irradiations. This means that attractive and creative designed garment for a child not only satisfy aestheticism desires in children but also, in upper level, play significant and cautionary role in protecting child against ultraviolet.

a. Far from b. Under sun ultraviolet irradiation

Fig 15 Design 5 printed and designed apparel for a child

4. Conclusion

In this research, simultaneous and stable design of colourful diversity and announcement of protective alarms on child's garment against ultraviolet utilizing photochromic dyes are considered. Hence, it could be possible to declare the concept of dangerous and energetic ultraviolet presence through printed attractive and creative designs applying silk screen current method on child's

apparel. To do this, photochromic monochromes of red, blue, and yellow were used during printing process, and then printed polyester fabrics were exposed to different irradiations. An effect of sunlight irradiation was further and more obvious than irradiations of fluorescent and D65 and develops more efficient and warning notifications through child's apparel. This is related to significant existence of ultraviolet irradiations in sun light. Results from research imply achievement of stable design for a child's apparel. Therefore, when printed clothes with photochromic dyes are exposed to ultraviolet, they became colourful and they loss their colours after removing ultraviolet irradiations. This characteristic could be emerged with high numbers of repetitions and several times of exposures to ultraviolet irradiations. The reason could be related to chemical structure of photochromic dyes and their reversible aspect to primitive chemical structure.

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