Pakistan Journal of Social Sciences

ISSN (E) 2708-4175 ISSN (P) 2074-2061
Volume 43: Issue 3 September 2023
Journal homepage: https://pjss.bzu.edu.pk

Exploring Color Fastness and Color Transition Effects of Thermochromic Pigments on Different Cotton Fabrics via Screen Printing

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ARTICLE DETAILS

History:
Accepted 01 September 2023
Available Online 30 September 2023

Keywords:
Thermochromic, Printing techniques, woven cotton

ABSTRACT

Purpose: The aim of this research is to analyze how thermochromic pigment interacts with different fabric types, including lawn, staple cotton, slub cotton, karandi, viscose, and cambric. The objective was to evaluate the effectiveness and durability of the pigment on each fabric type, taking into consideration factors such as color fastness to wash and spectrophotometer analysis. Researcher also examined and explored the artistic possibilities of textile design by developing two different seamless designs one is predicting colour transitions while other maintain complete look after vanishing of the color.

Design/Methodology: Quantitative Experimental method was used in this study. To assess the effectiveness of the thermochromic pigment on the different fabric types, the researcher applied the pigment onto swatches of each fabric by using screen printing technique then subjected the swatches to various tests.

Findings: The spectrophotometric analysis of printed samples revealed that Lawn, cambric and staple showed best result whereas all cotton samples showed good result to wash fastness.

Implications: This paper offered valuable insight and depth of understanding which will be needed for development of dynamic pattern. Moreover, the knowledge got from this research, open new doors of innovation in textile and fashion designing industry.

Recommended Citation: shafiasiddiqui26@gmail.com

Siddiqui, S., Saeed, A., & Abiodullah. M. (2023). Exploring Color Fastness and Color Transition Effects of Thermochromic Pigments on Different Cotton Fabrics via Screen Printing. *Pakistan Journal of Social Sciences*, 43(2), 381-388 DOI: 10.5281/zenodo.8424320

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1. Introduction

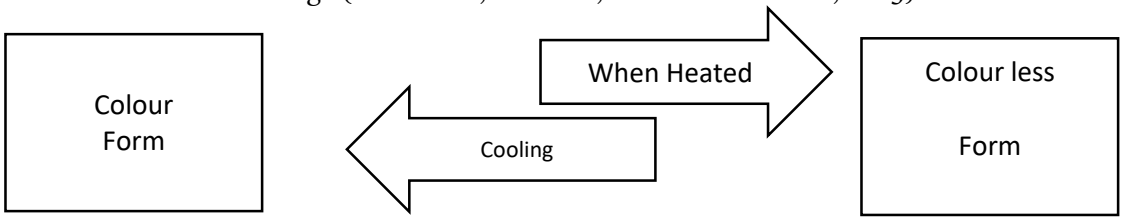
There is enormous use of textile material in our day to day life such as household furnishings and apparels. With the advancement of technology textile material is also used in multiple dimensions like geotextile, protective clothing and medical textile. Use of color on textile material has established new horizon of creativity. For many designers color is very important aesthetic concern. Introduction of synthetic dyes was great breakthrough for fashion industry wide range of commercial dyes or pigments help the designer to create their desired images. The

novel research on the color changing technology not only offers unique opportunities but also create more challenging atmosphere for today`s designers. Now- a- days smart textile or fabrics are in great demand. The Smart textiles are usually defined as garments that can sense and react to environmental conditions or external stimuli, such as light, pH, temperature, pressure, solvents of different polarities, mechanical or magnetic effects, chemicals, and electricity (Khattab, T. A., Rehan, M., & Hamouda, T. 2018).

Chromic colorant can be utilized to create versatile or adaptive products (Elmaaty, T. A., Ramadan, S. M., Eldin, S. M. N., & Elgamal, G. 2018). The word chromic is used for those colorants that change its physical properties due to external stimuli. Chromic colors have an extensive range of colorants where the physical as well as chemical properties are explored. There is a responsive effect of chromic textile that can be seen through a clear and visible change of color causing by an external stimulus. In last few decades chromic pigments have considerable commercial applications. Photochromic and thermochromic are more widely use in different areas like medical, ophthalmics, information recording materials, temperature indicators. The ratio of using photochromic & thermochroic dyes or ink in the field of "smart textile" is gradually getting its peak (Kert, M., & Gorjanc, M. 2017).

Thermochromic dyes

Thermography refers to a common reversible discoloration when it is exposed to heat or cold. Thermochromic materials can be classified into two categories. These include intrinsic materials, where heat is the direct cause of color changes, and indirect materials, where heat causes changes in an environment containing chromophores, which in turn cause a color change (A. Khattab, A. Allam, & S. Abdelrahman, 2019).



Type of thermochromic dyes

There are two types of thermochromic dyes i.e.

- Leuco dye
- Liquid crystal dye

Leuco dyes also known as molecular rearrangement which exhibit only single color change (Elmaaty, T. A., Ramadan, S. M., Eldin, S. ,M. N., & Elgamal G. 2018)

Liquid crystal dye: The molecular chain of the liquid crystal polymers has a helical structure which can be converted at different temperatures to display different colors. (Zhang.Y, Hu.Z, Xiang.H et al; 2019).

In this research, the examination of the impact of thermochromic pigment on the selection of textile design is an important aspect of the study. By applying the thermochromic pigment to the woven cotton fabric with different construction combinations, the researchers aim to investigate how this pigment influences the overall design choices in the textile industry.

The thermochromic pigment is known for its ability to change color in response to temperature variations. By incorporating this pigment into the fabric through screen printing, the researchers create a dynamic element within the textile design. This dynamic feature opens up new possibilities for creative and interactive designs that can capture the attention and interest of consumers.

Furthermore, the researchers analyze how the thermochromic pigment interacts with different fabric types, such as lawn, staple, slub cotton, karandi, viscose, and cambric. They evaluate the effectiveness and durability of the pigment on each fabric type, considering factors like color fastness to wash and spectrophotometer analysis.

Understanding the impact of the thermochromic pigment on textile design selection is crucial for textile manufacturers, designers, and marketers. It enables them to explore innovative and captivating design possibilities that cater to the evolving demands and preferences of consumers. Additionally, this knowledge can contribute to the development of new applications and products in the textile industry that incorporate thermochromic pigments effectively and aesthetically.

2. Material and Methods

a. Colorants

In this research yellow and blue thermochromic colorants had been used. Colors were taken from HK industrial Co., limited Hong Kong. Thermochromic color change itself at 31c on heating while photochromic change its color automatically with UV light. Regular colors non chromic pink, yellow and blue had also been used in research to give good artistic effect to the motif.

b. Screen printing techniques

Application of thermochromic colorants was done by screen printing technique. Two screens had been created for two different designs.
The screen size of first design was 10.37x 14 inches while the screen size of second design was 12x 16 inches.

c. Screen design

In order to examine and explore the artistic possibilities two bold textile design had been created. Seamless design had been considered as a more preferable approach for this research. Motifs were developed on computer software adobe illustrator.

i. Design 1

Floral inspiration was taken for the first design. Approach used in this design was that non chromic pink color is applied with yellow chromic color in such a manner that when yellow color was vanished or appeared it would still maintain the complete look to the motif.

ii. Design 2

The second design incorporated a flying bird motif, utilizing various tones of blue chromic color. The intention behind creating this particular motif was to investigate the intriguing transition effects that occur as the color vanishes and reappears. By utilizing different shades of blue, the researchers aimed to observe how the

thermochromic pigment interacted with the fabric, resulting in captivating visual transformations. This motif allowed for an exploration of the dynamic and visually appealing aspects of the thermochromic pigment, capturing the attention and curiosity of viewers.

d. Fabric

Fabric construction properties also impact the properties of the final printed fabric as well as the printing process itself. Woven are normally easier to print than knits. The main reason for this statement is because typically woven fabrics are much more dimensionally stable than knits. Therefore, 100% cotton woven fabric with different construction combination of warp and weft and thread count will be used. Four samples are natural and two are man-made.

Natural	Warp/Weft	Thread count	Man-made	Warp/Weft	Thread count
Cambric	79-78	52-52	Viscose	74-70	60-60
Lawn	90-88	80-80	Staple	72-66	40-40
Cotton Slub	72-30	301-10			
Karandi	92-48	84-16			

3. Test

i. Wash fastness

Color fastness to washing refers to the resistance of a material to changes in its color characteristics when it undergoes a washing process. It indicates how well the color of a material holds up and remains unchanged after being subjected to washing. (Rashid, M. A., Hossain, M. D., Nakib-Ul-Hasan, M., & Islam, M. A. 2013). In this research color fastness to wash was measured by the ISO 105 C03 method. Fabric sample size was 10 x 10 inches. The test was carried out by using regular washing detergent at the 40° c.

ii. Spectrophotometric evaluation

The spectrophotometric evaluation of samples was done by data color 850.

The spectrophotometer is a colorimetric instrument capable of measuring the entire range of light wavelengths between 360 and 700 nm. It is equipped with spectral power distributions of various illuminants, allowing it to detect color variations that may not be perceptible to the human eye under standard lighting conditions. Spectrophotometers offer a high level of precision and are capable of measuring colors with absolute accuracy. (Ly, B. C. K., Dyer, E. B., Feig, J. L., et al; 2020)

4. Results

4.1 Table :1 Spectrophotometric result of printed samples

Thermochromic test **Spectrophotometer analysis** **Data color 850** **Light source D-65**	Staple A1	Slub cotton B1	Karandi C1	Viscose D1	Lawn E1	Cambric F1
DL*	0.07	-1.19	-0.17	-0.20	-0.30	-0.27
Da*	-0.21	1.15	-0.20	-0.48	-0.03	0.22
Db*	-6.02	-5.73	-10.89	-9.88	-4.80	-5.03
DC*	-5.98	-5.54	-10.77	-9.72	-4.77	-5.00
DH*	0.76	-1.86	1.61	1.84	0.54	0.62
DE*	6.03	5.96	10.89	9.90	4.81	5.05
CMC DE*	2.65	3.30	4.34	4.10	2.15	2.36

Test with "*" superscript is/are under the scope of ISO/IEC 17025:2017, accredited by PNAC.
Table: 1 shows the spectrophotometric results of printed samples. The overall color difference CMC DE values indicate that sample E1 (LAWN) show best result with the value 2.15, sample F1 (CAMBRIC) and sample A1 (STAPLE) show come on second and third with the value 2.36 and 2.65 respectively.

4.2 Table: 2 Color Fastness to Wash

Color fastness to washing **ISO 105 C03**	Staple A1	Slub cotton B1	Karandi C1	Viscose D1	Lawn E1	Cambric F1
Shade change	4	4	4	4	4	4
Staining on Acetate	4-5	4-5	4-5	4-5	4-5	4-5
Staining on cotton	4-5	4-5	4-5	4-5	4-5	4-5
Staining on nylon	4-5	4-5	4-5	4-5	4-5	4-5
Staining on polyester	4-5	4-5	4-5	4-5	4-5	4-5
Staining on acrylic	4-5	4-5	4-5	4-5	4-5	4-5
Staining on wool	4-5	4-5	4-5	4-5	4-5	4-5

The ISO 105 C03 method was used to evaluate the wash fastness. All cotton fabric showed good result. The rating indicates that the color fastness is at a very good level. It means that the material's color has exhibited strong resistance to washing-induced color change or fading.

4.3 Motif Design Analysis

Design 1

Figure 1: Motif maintained its Complete Look After vanishing the color

Design 2

Transition of color

Figure2: before heating after heating

5. Discussion

In this research study, the application of thermochromic inks to various cotton fabrics was examined using screen printing. These 100% cotton fabrics were taken with different combinations of warp and weft threads, resulting in different textures and visual appearances. It was hypothesized that these varying fabric characteristics might influence the wash fastness performance of the thermochromic inks when applied to them. To assess this, the ISO 105 C03 method was employed to evaluate the wash fastness.

The obtained results from the wash fastness tests have provided compelling evidence of the excellent color fastness behavior of the printed fabrics. Notably, there was no evidence of fading or color bleeding observed in any of the tested samples. This in line with Tarek Abou Elmaaty et al., (2018) they conducted the application of thermochromic pigment printing and its antibacterial attributes on both 100% cotton and a 50/50 cotton-polyester blend fabrics. They utilized the screen printing method to apply the thermochromic ink to the fabric. The outcomes of their research revealed that the fabric exhibited outstanding color fastness when subjected to washing and rubbing. Furthermore, the fabric's surface roughness was reduced, and it displayed commendable antibacterial properties.

This research outcome is of utmost significance, particularly in the context of clothing production, where the preservation of the original color and appearance of garments after repeated wash cycles is paramount. This agree with K. R. Karpagam et.al,. (2016) have developed innovative chameleon-type color-changing prints on cotton fabrics, specifically designed for defense applications. They achieved this by incorporating thermochromic colorants into the fabric. Various color options, including light green, dark green, black, brown, and sandal, were created by blending blue and orange thermochromic colorants with natural dye turmeric and graphite. After subjecting the

fabric to five wash cycles, it was observed that the color fastness of the printed designs remained reasonably high for all tested colors. This demonstrated the effective fixation of colors to the fabric surface during the washing process.

These favorable results validate that different fabric textures resulting from diverse warp and weft combinations do not negatively impact the wash fastness of thermo chromic inks. Secondly, the ink, when applied using screen printing methods, is indeed capable of withstanding the rigors of washing, ensuring that the visual and aesthetic appeal of the fabric remains intact.

Figure 1: The researchers aim to examine how this pigment influences the overall design choices. In this design, a unique approach was employed, utilizing a non-chromatic pink color combined with a thermochromatic yellow color. The colors were strategically applied in a way that even when the yellow color disappeared or reappeared, the motif maintained its complete look.

Hence, by this experiment it is concluded that the color-changing properties of the pigment introduce an element of surprise and novelty to the textile design, making it more engaging and intriguing for potential customers.
Whereas **Figure 2:** Through this design, the researchers sought to showcase the potential of the thermochromic pigment in creating captivating and interactive textile designs that engage and fascinate consumers. Hence, by this experiment it is concluded that the varying tones in the motif contributed to the aesthetic appeal and added depth to the visual transitions occurring in the fabric Overall, this design choice aimed to demonstrate the creative possibilities and artistic applications of incorporating thermochromic pigments into textile design. These findings corroborate the experiments conducted by Kooroshnia in 2013. In Kooroshnia's study, a screen-printed pattern was generated by applying each temperature-sensitive color mixture next to one another. When the temperature was elevated, these temperature-sensitive color mixtures were activated, leading to a transition from violet-greyish hues to four distinct colors. This fascinating transformation in visual characteristics emerged as one of the most interesting outcomes, sparking the concept of crafting patterns that could undergo alterations through color changes. Furthermore, the intention of research was assisting designers in achieving more sophisticated textile surface patterns.

References

A.Khattab, T., A. Allam, A., & S. Abdelrahman, M. (2019). Development of Illuminant Glow- in-the-Dark Cotton Fabric Coated by Luminescent Composite with Antimicrobial Activity and Ultraviolet Protection. *Journal of Fluorescence*.

Elmaaty, T. A., Ramadan, S. M., Eldin, S. M. N., & Elgamal, G. (2018). One Step Thermochromic Pigment Printing and Ag NPs Antibacterial Functional Finishing of Cotton and Cotton/PET Fabrics. *Fibers and Polymers*, *19*(11), 2317-2323.

Karpagam, K. R., Saranya, K. S., Gopinathan, J., & Bhattacharyya, A. (2017). Development of smart clothing for military applications using thermochromic colorants. *The Journal of The Textile Institute*, *108*(7), 1122-1127.

Kert, M., & Gorjanc, M. (2017). The study of colour fastness of commercial microencapsulated photoresponsive dye applied on cotton, cotton/polyester and polyester fabric using a pad-dry-cure process. *Coloration Technology*, *133*(6), 491-497.

Kooroshnia, M. (2013). Leuco dye-based thermochromic inks: recipes as a guide for designing textile surfaces. In *13th AUTEX World Textile Conference, Dresden Germany*. AUTEX World Textile Conference.

Ly, B. C. K., Dyer, E. B., Feig, J. L., Chien, A. L., & Del Bino, S. (2020). Research techniques made simple: cutaneous colorimetry: a reliable technique for objective skin color measurement. *Journal of Investigative Dermatology*, *140*(1), 3-12.

Rashid, M. A., Hossain, M. D., Nakib-Ul-Hasan, M., & Islam, M. A. (2013). Evaluation of effective jute dyeing

process with basic dye and reactive dye. *International Journal of Advanced Scientific Engineering and Technological Research*, *2*(9), 525

Zhang, Y., Hu, Z., Xiang, H., Zhai, G., & Zhu, M. (2019). Fabrication of visual textile temperature indicators based on reversible thermochromic fibers. *Dyes and Pigments*, *162*, 705-711.

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