The Effect of Binders on The Fastness Properties of Thermochromic dyes

M Gobalakrishnan[#1], V Thanabal[#2], S Rajesh Kumar[#3]& A Ashok kumar[#4]
Assistant Professor, Department of Textile Technology, Bannari Amman Institute of Technology, Sathyamangalam -638401, Erode, Tamil Nadu, India.

Abstract *- People like fashion and thermochromic dyed materials give colour when it is activated. Thermochromic colourants were activated by the stimuli temperature and the colour changes from colourless to colour and wise versa. Thermochromic materials are used in wide applications including T-Shirts, caps, thermometers, buildings, urban structures, medical thermography, food packaging, toys etc. The fastness properties of thermochromic dyes are very poor due to its particle size. In this work, the binder is used along with thermochromic dyes with different concentrations to improve the fastness properties. The other parameters like tearing strength, colour strength and thickness are also analyzed.*

Key words: *Thermochromic dyes, Fastness, Binder, Cotton fabric, Perspiration, Tear strength*

I. INTRODUCTION

In the 19th century the phenomenon of thermochromism has been identified and so far it is not exploited properly. Thermochromic colorants show reversible color change from colourless to colour and colour to colourless when it is activated with temperature (sunlight). Colour changes when it reacts to environmental conditions and stimuli. The stimuli may be anelectricity (electrochromic), light (photochromic), pressure (piezochromic), heat (thermochromic), electron beam (carsolchromic) or liquid (solvate chromic)[1].

There is two principal class of thermochromic systems for textiles[2]. The first one is a multicomponent system relying on a color former (such as Crystal Violet lactone). The effect of thermochromic is usually a reversible interchange from one color to another, or from colourless to colour, at a given temperature accompanied by a pH-dependent chemical change[3]. The second class the thermochromic effect is different from the farmer one and it is a continuous spectrum of colors is possible over a range of temperatures using liquid crystals, known as 'color play' [4].

Advance in materials of nanoscience have added intelligence to textile and created smart textile apparel which can sense and react to the environmental conditions or stimuli like sunlight, heat, temperature,pressure,electricitysources. The advance of smart textile makes it possible to bring the traditional textile sector to a level of the high technology industry. Such textiles find uses in numerous applications ranging from military, leather industry and fashion field[5].

In textile fields like optics, sensors, fibres, and photo storage systems, the organic thermochromic systems were used and the colour change is very sharp and the control of temperature is easy[6]. Different colours were exhibited at different temperature for a selective light reflection. Liquid crystals behave like crystals and liquids. So it is also termed as the fourth state of matter. The variation in colour was produced by altering the crystal structure with temperature. [7].

The commercially available thermochromism are in encapsulated liquid crystal suspension in the form of water-based inks and paints. But these inks and paints are not fast to washing when we apply on textile materials[8]. In this project, the thermochromic dyes were applied along with binders and the fastness properties were analyzed.

II. MATERIALS AND METHODS

A. Materials

100 % bleached cotton fabric is procured in erode district with the following fabric parameters shown in Table 1. The procured bleached cotton was washed with soap to remove the surface finishes and used in this research. The Thermochromic dyes and the binders were purchased in and around Tirupur District.

B. Application of Dyes

The cotton fabric was dyed with thermochromic dyes with different concentration of dyes and different concentration of binders as per the Table 2. In padding mangle with 80% expression. The dyed fabric was dried below 80^{O}C in an oven and cured at 150^{O}C in a curing chamber for 5 minutes. The cured sample was subjected to various fastness testing and tear strength testing.

Table 1
THE CONCENTRATION OF DYE AND BINDER

Sample No.	Concentration of dye in (%)	Concentration of binderin (%)
1	100	0
2	95	5
3	90	10

4	85	15
5	80	20
6	75	25

As per the ASTM D1424 test method, the fabric tear strength was analyzed in Elmendorf tear tester. The fabric was prepared as the template and tested in Elmendorf tester. The rubbing fastness of the sample was tested in crock meter. The sample was prepared with the dimension of 25*10 centimeter for colour fabric and 5*5 centimeter for the white bleached sample. After 10cycles of rub, the change in colour was analyzed on the dyed sample and staining was analyzed on the white sample using a grey scale.The ISO 105 test method was followed to analyze the colour fastness to washing. The laundro meter was used for this purpose.

III. RESULTS AND DISCUSSIONS

A. Rubbing Fastness

Table 2& 3displays the dry rubbing fastness and wet rubbing fastness of the sample dyed with thermochromic dyes on cotton respectively. The sample dyed without binder shows less fastness to rubbing than compare with the sample dyed with a binder. When the binder concentration increases the fastness properties also increases for both in wet and dry rubbing fastness and the same trend is followed for color fastness to staining.

Table 2
DRY RUBBING FASTNESS OF THE SAMPLE

Sample No.	Change in colour	Staining
1	3/4	4
2	4	4
3	4/5	4/5
4	4/5	5
5	5	5
6	5	5

Table 3
WET RUBBING FASTNESS OF THE SAMPLE

Sample No.	Change in Colour	Staining
1	3	3
2	4	4
3	4	4
4	4/5	4/5
5	5	5
6	5	5

B. Wash Fastness

Table 4 display the wash fastness of the sample dyed with thermochromic dyes on cotton. The sample dyed without binder shows less fastness to wash than compared with the sample dyed with an increase in the concentration of binders. When the binder concentration increases the fastness properties also increases.

Table 4
WASH FASTNESS OF THE SAMPLE

Sample No.	Change in Color	Staining
1	3	4-5
2	4	5
3	4	5
4	4/5	5
5	5	5
6	5	5

C. Light Fastness

Table 5 display the light fastness of the sample dyed with thermochromic dyes on cotton. The grey scale rating of the light fastness of thermochromic dyed fabric, was very poor (1-2) without the addition of binder whereas, when increasing the concentration of binder, the fastness properties also increases gradually till 15% of binder concentration then it starts decreasing.

Table 5
LIGHT FASTNESS

Sample No.	Light Fastness
1	1/2
2	2
3	2
4	5
5	4/5
6	3/5

D. Perspiration Fastness

Table 6 displays the perspiration of the sample dyed with thermochromic dyes on cotton. The perspiration fastness is excellent for all thermochromic dyed fabric for both with and without the addition of the binder.

Table 6
PERSPIRATION FASTNESS

Sample No.	Acidic	Alkaline
1	5	5
2	5	5
3	5	5
4	5	5
5	5	5
6	5	5

E. Tear Strength

Table 7 displays the tear strength of the sample dyed with thermochromic dyes on cotton. From the results, it is concluded that the tear strength of the fabric remains the same in all cases before dyeing. But after dyeing, the strength was decreasing with the increase in binder concentration. The increase in binder concentration will reduce the strength of the cotton fabric[9].

Table 7
TEAR STRENGTH OF THE SAMPLE

Sample No.	Tear Strength in Kgf	
	Before dyeing	After dyeing
1	50	79
2	50	75
3	50	72
4	50	69
5	50	49
6	50	40

IV. CONCLUSION

The sample dyed with 100% thermochromic dyes show poor fastness to washing, light, rubbing and perspiration whereas, the sample dyed with binder the fastness properties increases. The wash and rubbing fastness properties increase with an increase in the concentration of binder. The light fastness of thermochromic dyed fabric increases with increasing the concentration of binder till 15% thereafter the light fastness decreases. The perspiration fastness is excellent for all thermochromic dyed fabric with and without binder. The tear strength of the sample decreases with increase in the concentration of binder. It is concluded that 10-15% of binder concentration is optimum for all-round fastness properties without much losing its tear strength.

REFERENCE

[1] J. M. Abdulkarim, A. K. Khsara, H. N. Al-kalany, and R. A. Alresly, "Impact of Properties of Thermochromic Pigments on Knitted Fabrics," Int. J. Sci. Eng. Res., vol. 7, no. 4, pp. 1693–1705, 2016.

[2] R. M. Christie and I. D. Bryant, "An evaluation of thermochromic prints based on microencapsulated liquid crystals using variable temperature colour measurement," Color. Technol., vol. 121, no. 4, pp. 187–192, 2005.

[3] S. M. Burkinshaw, J. Griffiths, and A. D. Towns, "Reversibly thermochromic systems based on pH-sensitive spirolactone-derived functional dyes," J. Mater. Chem., vol. 8, no. 12, pp. 2677–2683, 1998.

[4] D. Demus, "Peter J. Collings. Liquid Crystals, Nature's Delicate Phase of Matter. Adam Hilger, Bristol 1990, 222 Seiten, 117 Abbildungen und 16 Farbfotos, Paperback £ 9.95, ISBN 0-7503-0055-8," Cryst. Res. Technol., vol. 27, no. 1, pp. 40–40, 1992.

[5] R. M. Christie, S. Robertson, and S. Taylor, "Design Concepts for a Temperature-sensitive Environment Using Thermochromic Colour Change," Colour Des. Creat., vol. 1, no. 1, pp. 1–11, 2007.

[6] M. a Chowdhury, M. Joshi, and B. S. Butola, "Photochromic and Thermochromic Colorants in Textile Applications," J. Eng. Fibres Fabr., vol. 9, no. 1, pp. 107–123, 2014.

[7] J. P. Singh, "Intelligent textiles," Asian Text. J., vol. 20, no. 8, pp. 67–71, 2011.

[8] T. Karlessi, M. Santamouris, A. Synnefa, D. Assimakopoulos, P. Didaskalopoulos, and K. Apostolakis, "Development and testing of PCM doped cool colored coatings to mitigate urban heat island and cool buildings," Build. Environ., vol. 46, no. 3, pp. 570–576, 2011.

[9] M. Gobalakrishnan and D. Saravanan, "Antimicrobial Activity of Coleus Ambonicus Herbal Finish on Cotton Fabric," Fibres Text. East. Eur., vol. 25, no. 0, pp. 106–109, 2017.