Journal of Textile Science & Engineering

Research Article Open Access

Effect of Different Mordanting Agents on the Fastness Properties of Cotton Knitted Fabric Dyed with Marigold Extracted Dyes

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Abstract

Natural dyes may be defined as the dyes which are extracted from the flower petals, leaves, barks, steams to ensure environmental friendly dyeing of the sample. Natural dyes are very popular for their different hues and environmental friendly nature but most of the natural dyes are non-substantive and must be applied on textiles with the help of mordants. In this study, natural dyes were extracted from marigold flower petals and applied on 100% cotton knitted fabric in exhaust method using six different metallic salts: $K_2Cr_2O_7$, $FeSO_4$, $NiSO_4$, $CuSO_4.5H_2O$, potash alum, and $SnCl_2$ during pre-mordanting prior to dyeing. The consequences of altering different types of mordanting agents during mordanting were evaluated by means of various fastness properties. From overall observation it has been found that the fastness properties of the dyed sample having mordanted with potash alum showed excellent result in case of all fastness properties.

Keywords: Color fastness; Marigold flower; Mordanting agents; Natural dyes

Introduction

A dye is a molecule which is responsible for absorption and reflection of light at a definite wavelength. Dyes flourish our life through textiles coloration [1]. Literary, the sources of dyes are divided into two categories: one is natural and another is man-made. Natural dyes directly come from nature: plants, minerals and animals. Man-made dyes are manufactured synthetically which gives the name of them as synthetic dyes [2]. Marigold flower is a common source of natural dyes which gives yellow to orange red shade due the presence of lutein and carotenoid pigments [3]. Again there are 500 dye-yielding plants has been found in our nature. Natural dyes are easily obtainable from those plants but in a less extent. That's why synthetic dyes manufacturing get more importance during industrial revolution [4,5]. But synthetic dyes have an adverse impact on environment. For this vital concern more interest has been shown in the use of natural dyes since 20th century again [6]. The main advantages of natural dyes compared to synthetic dyes are eco-friendly, non-allergic, and non-carcinogenic [7]. The efficiency of natural dyeing fully depends on proper extraction of dyes and mordanting process [8]. Aqueous extraction method is a traditional method for natural dyes extraction where distilled water or any other solvent are being used as media [9]. Another extraction method is supercritical fluid extraction where CO_2 is used as media and it gives high color yield but expensive rather than aqueous extraction method [10]. Mordanting of fabric is mandatory for natural dyeing whether it would be pre-mordanted or post mordanted, sometimes be simultaneous mordanted [11].

This study was designed to use traditional aqueous extraction method for extracting dyes from marigold flower. Then extracted dyes applied on pre-mordanted cotton knitted fabric that has been mordanted with six different metallic salts. Finally, various fastness properties have been evaluated to find out the performance of individual mordants in natural dyeing.

Materials and Methods

Materials

The fabric was supplied by Impress Newtex Composite Textiles Limited, Mirzapur, Tangail, Bangladesh. It was 100% cotton knitted single jersey fabric of 180 gsm (scoured and bleached). Marigold flowers were obtained from local market in Bangladesh. All chemicals ($K_2Cr_2O_7$, $FeSO_4$, $NiSO_4$, $CuSO_4.5H_2O$, $K_2Al_2(SO_4)_3.24H_2O$, $SnCl_2$ and NaCl) used were of laboratory grade.

Methods

Extraction of dyes: Firstly, the petals were separated and dried them on sunlight (8 hrs), then the dried petals were kept in normal atmosphere in a room. 50 g of dry flower was taken in a vessel with 1 liter of water without any chemical heated them at 80°C temperature, kept the heated flower for a while to cooling and again heated them up to 80°C temperature; it is successively repeated about 4 times. The extracted sap was filtered and again heated to make it concentrated.

Mordanting of fabric: The mordanting process was carried out in a sample dyeing machine with a liquor ratio of 1:20. The fabrics were mordanted at 100°C for 60 min with incorporation of different six mordant separately. Applied amount of mordants were of 5 g/l for each. After mordanting, the fabric was conditioned for overnight then squeezed the mordanted fabric and dried on normal hot air.

Dyeing of fabric: Finally, the dyeing process of mordanted fabric was carried out in same machine with same liquor and dyes dosing amount was 20 ml along with the addition of 5 g/l NaCl in every six dye bath. The dye bath was run for 60 min at 60°C. After dyeing, squeezed the dyed fabric and washed with cold water followed by dried on normal hot air.

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Received April 08, 2019; **Accepted** May 09, 2019; **Published** May 18, 2019

Citation: Karim R, Islam T, Mamun AA (2019) Effect of Different Mordanting Agents on the Fastness Properties of Cotton Knitted Fabric Dyed with Marigold Extracted Dyes. J Textile Sci Eng 9: 399.

Results and Discussions

Assessment of color fastness to wash

Color fastness to wash in this experiment was assessed to all the samples in the lab with multi-fiber fabric by obeying ISO 105C04 method. From Table 1, it is found that very good to excellent grading for color staining except $SnCl_2$. The effect of mordanting agents on the change in color of dyed samples are moderate for $K_2Cr_2O_7$, $NiSO_4$ and $SnCl_2$ and very good for $FeSO_4$ and $CuSO_4.5H_2O$. Very good to excellent grading is for potash alum with 4,5.

Assessment of color fastness to perspiration (Acid/Alkali)

Color fastness to perspiration (Acid/Alkali) in this experiment was assessed to all the samples in the lab with multi-fibre fabric by obeying ISO 105 E04 method.

For acidic perspiration Table 2 it is found that, grading for color staining are almost good to excellent. And for color change, samples are mordanted with $FeSO_4$ and potash alum is more resist to acidic perspiration.

For alkali perspiration, Table 3 it is noticed that grading for color staining are almost excellent for every mordanting agents except $K_2Cr_2O_7$ and $CuSO_4.5H_2O$ with a rating of 3-4 and 4 respectively. Alkaline perspiration fastness grades for color change shows very good to excellent grading for $FeSO_4$ and rest of them are almost very good with a rating of 4.

Assessment of color fastness to saliva

Evaluation of color fastness to perspiration was almost same as perspiration test, only main change in saliva preparation recipe. Saliva solution contains lactic acid-3 g/l, urea/carboamide-0.2 g/l, NaCl-4.5 g/l, KCl-0.3 g/l, NH_4Cl-0.4 g/l, Na_2SO_4-0.3 g/l, and distilled water-1 litre.

In case of saliva (Table 4) it is focused on samples mordanted with copper sulphate, potash alum are more resist to saliva. For color change, samples mordanted with copper sulphate, potash alum are more resistant to saliva.

Assessment of color fastness to water

Color fastness to water in this experiment was assessed to all the samples in the lab with multi-fibre fabric by obeying ISO 105 E01 method.

For color staining grade of water (Table 5) it is evaluated that $FeSO_4$, $CuSO_4.5H_2O$ and potash alum gives better result with a rating of 4-5 whereas $SnCl_2$ gives poor result with a rating of 3-4. Samples mordanted with $FeSO_4$, $CuSO_4.5H_2O$, and potash alum shows very good to excellent result for change in color to water while rest of mordants show the rating of 3-4.

Assessment of color fastness to rubbing

Color fastness to rubbing (wet/dry) in this experiment was assessed to all the samples in the lab with multi-fibre fabric by obeying ISO 105 × 12 methods.

Used Mordanting agent	Color change grade	Color staining grade to multi-fiber fabric					
		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
$K_2Cr_2O_7$	3-4	4-5	4	4-5	4-5	4-5	4-5
$FeSO_4$	4	4-5	4-5	4-5	4-5	4	4-5
$NiSO_4$	3-4	4-5	4	4-5	4-5	4-5	4-5
$CuSO_4.5H_2O$	4	4-5	4-5	4-5	4-5	4	4-5
Potash Alum	4-5	4-5	4-5	4-5	4-5	4-5	4-5
$SnCl_2$	3-4	3-4	4	3-4	2-3	3	3-4

Table 1: Effect of different mordanting agents on the color fastness to wash.

Used Mordanting agent	Color change grade	Color staining grade to multi-fiber fabric					
		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
$K_2Cr_2O_7$	4	4	4	4-5	4-5	4-5	4-5
$FeSO_4$	4-5	4-5	4-5	4-5	4-5	4-5	4-5
$NiSO_4$	4	4	4	4-5	4-5	4-5	4-5
$CuSO_4.5H_2O$	4	4-5	4	4-5	4-5	4-5	4-5
Potash Alum	4-5	4-5	4-5	4-5	4-5	4-5	4-5
$SnCl_2$	4	4-5	4	4-5	4-5	4-5	4-5

Table 2: Effect of different mordanting agents on the color fastness to acidic perspiration.

Used Mordanting agent	Color change grade	Color staining grade to multi-fiber fabric					
		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
$K_2Cr_2O_7$	4	4	3-4	4-5	4-5	4-5	4-5
$FeSO_4$	4-5	4-5	4-5	4-5	4-5	4-5	4-5
$NiSO_4$	4	4-5	4-5	4-5	4-5	4-5	4-5
$CuSO_4.5H_2O$	4	4-5	4	4-5	4-5	4-5	4-5
Potash Alum	4	4-5	4-5	4-5	4-5	4-5	4-5
$SnCl_2$	4	4-5	4-5	4-5	4-5	4-5	4-5

Table 3: Effect of different mordanting agents on the color fastness to alkaline perspiration.

It is observed that Table 6 dry rubbing fastness is excellent for all mordanting agents unless $FeSO_4$, $SnCl_2$. On the other hand, wet rubbing fastness showed very good to excellent results for $K_2Cr_2O_7$, $NiSO_4$, potash alum with a rating of 4-5 and rest of them are only very good results.

Assessment of color fastness to light

Color fastness to light in this experiment was assessed to all the samples in the lab with multi-fibre fabric by obeying ISO 105 B02 method.

In case of color fastness to light, Tables 7 and 8 shows that better result found for $CuSO_4.5H_2O$ and potash alum with a rating of 5 while rest of mordants show good light fastness results.

Sample dyed with marigold flower extract dyes has a great effect on the fastness properties due to the use of different mordants. Different mordants impart better fastness properties against various agencies, like samples mordanted with potash alum shows excellent color fastness to wash and samples mordanted with ferrous sulphate and potash alum are more resistant to perspiration. Mordents like copper sulphate and potash alum makes the sample more resistance to saliva and gives the sample higher fastness to light. Briefly it can be said that potash alum mordant gives better fastness properties in all aspects to the sample dyed with marigold extract dyes (Figure 1).

Used Mordanting agent	Color change grade	Color staining grade to multi-fiber fabric					
		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
$K_2Cr_2O_7$	4	4-5	4-5	4-5	4-5	4-5	4-5
$FeSO_4$	4	4-5	4	4-5	4-5	4-5	4-5
$NiSO_4$	4	4	4-5	4-5	4-5	4-5	4-5
$CuSO_4.5H_2O$	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Potash Alum	4-5	4-5	4-5	4-5	4-5	4-5	4-5
$SnCl_2$	4	4-5	4	4-5	4-5	4-5	4-5

Table 4: Effect of different mordanting agents on the color fastness to saliva.

Used Mordanting agent	Color change grade	Color staining grade to multi-fiber fabric					
		Acetate	Cotton	Nylon	Polyester	Acrylic	Wool
$K_2Cr_2O_7$	4	4-5	4	4-5	4-5	4-5	4-5
$FeSO_4$	4-5	4-5	4-5	4-5	4-5	4-5	4-5
$NiSO_4$	4	4	4	4-5	4-5	4-5	4-5
$CuSO_4.5H_2O$	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Potash Alum	4-5	4-5	4-5	4-5	4-5	4-5	4-5
$SnCl_2$	4	3-4	4	4-5	4-5	4-5	3-4

Table 5: Effect of different mordanting agents on the color fastness to water.

Used Mordanting agent	Dry Rubbing	Wet rubbing
$K_2Cr_2O_7$	5	4-5
$FeSO_4$	4-5	4
$NiSO_4$	5	4-5
$CuSO_4.5H_2O$	5	4
Potash Alum	5	4-5
$SnCl_2$	4-5	4

Table 6: Effect of different mordanting agents on the color fastness to dry and wet rubbing.

Used Mordanting agent	Rating
$K_2Cr_2O_7$	4
$FeSO_4$	4-5
$NiSO_4$	4
$CuSO_4.5H_2O$	5
Potash Alum	5
$SnCl_2$	4

Table 7: Effect of different mordanting agents on the color fastness to light.

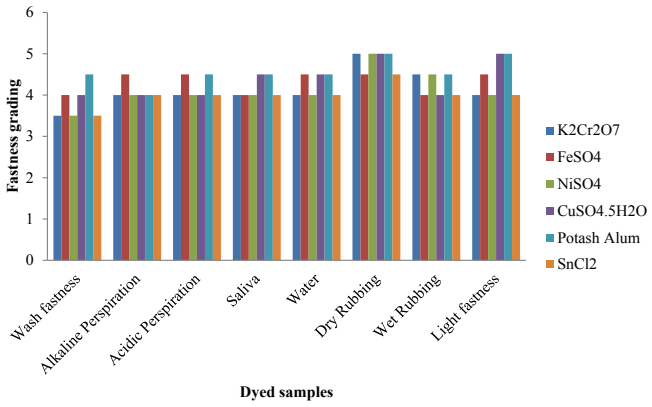

Figure 1: Effect of different mordanting agents on various fastness properties.

Mordanting Agent → / Color fastness ↓	$K_2Cr_2O_7$	$FeSO_4$	$NiSO_4$	$CuSO_4.5H_2O$	Potash Alum	$SnCl_2$
Wash fastness	3-4	4	3-4	4	4-5	3-4
Alkaline Perspiration	4	4-5	4	4	4	4
Acidic Perspiration	4	4-5	4	4	4-5	4
Saliva	4	4	4	4-5	4-5	4
Water	4	4-5	4	4-5	4-5	4
Dry Rubbing	5	4-5	5	5	5	4-5
Wet Rubbing	4-5	4	4-5	4	4-5	4
Light fastness	4	4-5	4	5	5	4

Table 8: Comparison among all fastness properties for different mordanting agents.

Conclusion

Marigold flowers seem to be one of the vital sources of natural dye for coloring the cotton fabric. Usually natural dyes do not exhibit substantively towards cotton fibres. Mordanting agent must be essential to enhance the substantively. Preferably mordanting agent is the metal salt or suitably co-ordinating complex forming agents. Mordanting agent can be applied on fabrics by three stages. One is known as pre-mordanting which is take place before dyeing process, another is known as simultaneous mordanting which is carried out during dyeing and last one is termed as post-mordanting which is occurred after dyeing. After mordanting, the metal salts make a coordinating complex which is responsible for natural dyeing chemistry. In this study aqueous extraction method is applied to extract the dyes and dyeing is introduced on pre-mordanted fabrics. Six chemical mordants are used in pre-mordanting process individually with the same volume. After dyeing, the results of different fastness properties show strong evidence that potash alum would be the right choice for mordanting process for this study.

Author's Contributions

MRK and TI planned and carried out the work. Moreover, they have also done the specimen fabrication, characterization, testing, data analysis, and presentation part. All authors read and approved the final manuscript.

Acknowledgements

Authors would like to highly acknowledge the Department of Textile Engineering Dyeing and Testing Lab, MBSTU for providing some excellent characterization facilities.

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