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ANTIMICROBIAL EFFECT AND SOME COLOR PROPERTIES OF ANNATTO AS NATURAL DYE ON TREATED SILK FABRIC

REYHANEH AZARMI[1] AND ALI ASHJARAN[1*]

1: Young Researcher and Elite Club,Yadegar-e- Imam Khomeini (RAH) - Shahre-Rey Branch, Islamic Azad University, Tehran, Iran.

***Corresponding Author : E Mail: A.ashjaran@gmail.com**

ABSTRACT

In this work silk fabrics have been dyed employing extract of seed of annatto(Bixaorellena.L) in absence and presence of some mordants include aluminum sulfate, ferric sulfate, potassium dichromate and copper sulfate.Thecolor difference and color fastness to rubbing and washing of the dyed silk fabricswere evaluated. Also antibacterialproperties of dyed silk fabrics against two kinds of bacteria: *Staphylococcus aureus* and *Escherichia coli* were investigated. Ferric sulfate mordanted fabric has high adsorption and color difference,K/s,washing and rubbing fastness compared to other mordants. The treated silk fabrics were found to have antibacterial potential.Copper sulfate hashighantibacterial properties against both of bacteria compared to other ones.

Keyword: Silk, Antimicrobial, Annatto, Mordant

INTRODUCTION

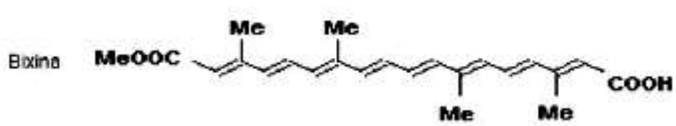
Silk fabric is well known for its water absorbency, dyeing affinity, thermaltolerances, insulation properties, and luster. Silk fiber can be used in many products such as precious fabrics, parachutes, tire lining materials, artificial blood vessels, and surgical sutures **[1-3]**.

There are manysynthetic and natural dyes that have antimicrobial properties **[4, 5]**. There is a growing demand for eco-friendly and non-toxic dyes that can be used to provide color to a wide variety of materials that one of these dyes is annatto **[6]**. Annatto (Bixaorellena) with antimicrobial effect is a small tree belonging to the family. **Figure 1** shows the picture of annatto tree and seed. The shrubby tree, reaching 25 to 30 feet in height, has tender, alternate leaves, heartshaped at the base and pointed at the apex, 3 to 8 long and 2 to 5M wide, palmately veined, and with slender, 2long petioles **[7]**. The major colorants are bixin and nor-bixin. Bixinis soluble in oil and nor bixin with the two carboxylic acid groups in its structure is soluble in water[8-**[10]**.The structure of bixin and nor bixin are given figure2.Annatto is commonly used as an edible color in butter,margarine,cheese,dairy products, biscuits and chocolates.The presents study was aimed at applying such colorant on silk fabrics and assessing some fundamental parameters related to dyeing of these fabrics using such colorant **[11, 15]**. However, natural dyes are less permanent and wash out easily so they need mordants to fix dye on fabric. Mordants can be divided into two groups: toxic metal salts such as aluminum potassium sulfate and stannous chloride and non-toxic mordants i.e. mud, blood, cream-of-tartar and tannic acid from leaves **[16-21]**. This paper focus on assessing of color and antimicrobial effect of annatto as natural dye on silk fabric in presence of various mordants.

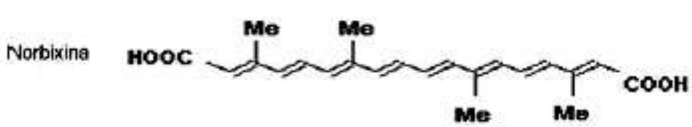
(a)

(b)

Figure 1: (a) Annatto tree (b) Annatto seeds



(**a)**



(b)

Figure 2: Color components of annatto [(a)bixin and (b)norbixin]

MATERIAL AND METHODS

Materials

Scoured silk fabric (100% silk, 30 denier, warp and weft respectively 71 and 67) was purchased from Simin Company. Annatto (Bixaorellana) seeds were selected as a natural dye source to color silk fabric.Annatto dye was purchased from YaseSepid Company. Aluminum sulfate (Al_2 (so_4).18 H_20), ferric sulfate (Fe so_4 .7 H_2o),potassium dichromate ($k_2cr_2o_7$) andcopper sulfate (Cu (So_4).5 H_2o) (from sigma company) were selected for mordanting.

Methods

Mordanting

Fabric was mordanted prior to dyeing by treating with aluminum sulfate, ferricsulfate, potassium dichromate and copper sulfatemordant at boil for 45 minutes. The liquor ratio is 1:40 and mordants concentration were 5% on weight of the fabric. After mordanting allfabrics were squeezed.

Dyeing

Mordanted and unmordanted fabrics were dyed with annatto dye. The silk fabrics were dyed, keeping material-to-liquor ratio at 1:40 while the pH was maintained at 4 by adding acetic acid gradually. The dye baths were prepared by adding dye (25 ml), to distilled water (15ml) at temperature 40° C. Wet fabricswere added to dye-baths and then temperature was raised to boiling temperature at 2.5°C /min, and dyeing was continued at boiling temperature for 15 minutes and then added acetic acid and again continued at boiling temperature for 15 minutes. At least the dyed fabrics were rinsed by cold water to remove the unfixed dye and dried at room temperature. The dyed fabrics are shown in **Table 1**.

Determination of Color Strength

Reflectance values of the treated and dyed fabrics were measured using reflectancespectrophotometer(X-rite, color Eye 1000 A,America) at their $\lambda_{max}$of reflectance, and color strength was calculated in terms of K/S values (calculated by Kubelka-Munk equation 1):

$$K/S= (1-R_{\lambda max})^2 /(2R_{\lambda max})\ldots\ldots \textbf{(1)}$$

Where K is the coefficient of absorption; S is the coefficient of scattering; R is the reflectance value of the fabric at λ_{max}. K/S values were calculated at 550 nm as the measured λ_{max}, and then color difference (ΔE)was calculated according to equation2.

$$\Delta E = \sqrt{(\Delta l)^2 + (\Delta a)^2 + (\Delta b)^2} \quad \ldots \textbf{(2)}$$

Where $\Delta L=L^*_{treated} - L^*_{treated}$;

$\Delta a=a^*_{treated} - a^*_{treated}$;

$\Delta b=b^*_{treated} - b^*_{treated}$;

'L*' refers to lightness–darkness values from 100 to 0 representing white to black; 'a*' represent redness if positive and greenness if negative and 'b*' describe yellowness if positive and blueness if negative.

Determination of Fastness Properties

Washing fastness

Dyed fabrics were washed as stated by the conditions mentioned in the test method ISO105:3001 to determine the change in color and staining of adjacent fabrics after washing. The rating scale of washing fastness for color change was from 1 (very poor), 2(poor), 3 (fair), 4 (good) to 5 (excellent).

Rubbingfastness

The treated and untreated samples were rubbed as stated by the conditions mentioned in the test method to determine the change in color and staining of adjacent fabrics after rubbed The rating scale of rubbing fastness for color change was from 1 (very poor), 2(poor), 3 (fair), 4 (good) to 5 (excellent).

Antimicrobial study

AATCC100 was used to analyze the antibacterial activity of the dyed silk fabrics.The organisms taken for this study were *Staphylococcus aureus (S.aureus)* and *Escherichia coli* (*E.coli*).

Reduction was calculated using the followingequation 3:

Percent reduction of bacteria (%) = ((A-B)/A)*100….. **(3)**

Where A is the number of bacteria on the un-treated silk yarns after 24 hours and B is the number of bacteria on the treated silk yarns with chitosan after 24 hours.

RESULT AND DISCUSSION

Color Strength

K/S values of dyed fabrics have close relationship to the amount of dye absorbed by the samples. The annatto color strength and K/S values of dyed silk samples are shown in **Table 2**, respectively.

It is observed (**Table 2**) clearly seen that ferric sulfate has highest colordifference. Potassium dichromate, Copper sulfate and Aluminum Sulfate have HighesttoLowest color difference.Also It is observed (**Table 2**) clearly seen that ferric sulfate has highest Strengthof color. potassiumdichromate, Copper sulfate and AluminumSulfate haveHighesttoLowest Strengthof color.

Fastness Properties

As the durability of the dye applied on the textile fabric is extremely important in these conditions, it has been assessed and is given in Table 3for annatto dyes.

It is observed (**Table 3**) seen that ferric sulfate and potassium dichromate have highest washing and rubbing fastness. Copper sulfate and aluminum sulfate were in the next level.

Antimicrobial Study

Antimicrobial assessments for dyed fabrics are shown in the **Table 4**. In general, for samples a higher reduction was observed for *E.coli* as compared to *S.aureus*. *S. aureus* is a Gram-positive bacterium and has a thicker cell wallhence is more resistant than *E.coli*. Highest reduction was observed for *E.coli* as compared toS.aureus. Also mordanted fabrics have more antimicrobial effect compared with unmordanted fabric. It is observed (**Table 3**) seen that copper sulfate have highest antibacterial effect. Ferric sulfate, potassium dichromate and aluminum sulfate were in the next level.

Table 1: Sample dyed with different mordants

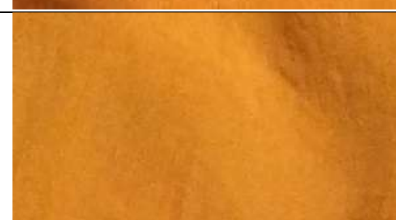
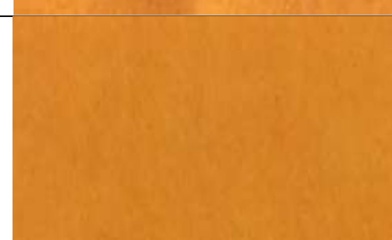
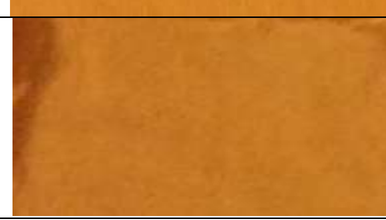
Samples	Color of dyed fabric
Unmordanted fabric	
Mordantedwith Al_2 SO_4	
Mordantedwith$CuSO_4$	
Mordantedwith K_2 cr_2 O_7	
Mordantedwith Fe SO_4	

Table 2: color strength and K/S values of dyed silkfabrics

Type of mordant	ΔE	K/s
Aluminum Sulfate	2.001	6.2
ferric sulfate	6.157	6.9
potassium dichromate	3.039	6.8
Copper sulfate	2.5046	6.5

Table 3: Fastness rating of annatto on fabrics

Type of mordant	Wet	Dry
Dyed sample	3	3-4
Aluminum Sulfate	3-4	4
ferric sulfate	5	5
potassium dichromate	4-5	5
Copper sulfate	4	4-5

Table 4: Bacteria reduction percentage in the Dyed fabric

Type of mordant	*E.coli*	*S.aureus*
Dyed sample	1%	0.5%
Aluminum Sulfate	4%	3.7%
ferric sulfate	10%	9%
potassium dichromate	5%	4%
Copper sulfate	15%	14%

CONCLUSION

Natural dyes require chemicals in the form of metal salts to produce an affinity between the fabric and the dye and these chemicals are known as mordants. Mordants facilitate the bonding of the dyestuff to the fiber. Although metallic salts work well to fix the dyes and provide an alternate palette, they are health hazard and produce toxic waste which requires special disposal.In this study,silk fabrics dyedwith annatto as a natural and antimicrobial dyein presence of some mordants such as Aluminum Sulfate, ferric sulfate, potassium dichromate, and Copper sulfate. Annat to can be successfully applied on silk fabric. Results show that ferric sulfate mordanted fabric has highest color difference. Also excellent washing and rubbing fastness belonged to ferric sulfate mordanted fabric. Antimicrobial test show that, Copper sulfate mordanted fabric has highest effect to compare others.

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