A Study on Dyeing Properties of *Swietenia macrophylla* King (Mahogany) Bark on Lining Cloths

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Abstract

Dyeing is a process of applying coloring matter directly on fiber, yarn or fabric without any additives. Natural dyes were used only for coloring of textile from ancient times till the nineteenth century. The natural dyes are derived from natural resources of coloring materials which is obtained from plant, animal, mineral and microbial origins. Natural dyes were used for coloration of various textile materials. Today, natural dye is the most scientific and advanced level of dyeing processes in the world. Natural and man-made colour was also used for dyeing processes. In this research, the natural dyes are extracted from Mahogany barks with water extraction and dyeing processes is studied by applying dye on 100% pure Lining cloths. At first stage, sample was collected from WYU Campus, Htantabin Township, Yangon Region. The sample was washed with water and air dried. Dried sample is ground with grinder. The powder sample (20g) was extracted with water to obtain (3g) of brown dye sample. The dye solution was prepared with the weight by volume ratio of 1:100, dye:water at 60˚C.The mordant used in dyeing process are alum, aloe vera, copper(II) sulphate, ferrous sulphate, potassium dichromate with the weight by volume ratio of 1:100, mordant:water at 60˚C.The dyeing processes were studied by pre mordanting, simultaneous mordanting and post mordanting. This dye sample was characterized by FT-IR method. In dyeing processes, colour density is measured by colour densitometer. The dyed fabric tested for washing fastness and light fastness will be studied.

Keywords: natural dye, mordant, colour fastness, dyeing processes, mahogany bark

Introduction

Natural dyes

Natural dyes are those obtained from plants, animals and minerals. The majority of natural dyes are acid dyes (anionic) and are attached to the cationic site in keratin (the alpha-protein in wool), mediated by a metal mordant. They are non-allergic, non-toxic and eco-friendly on human skin. Natural dyes have become significant importance due to the increased environmental awareness in order to avoid some hazardous synthetic dyes (Sarkar *et al.*, 2006). Natural dyes are considered to be eco-friendly as these are obtained from renewable natural resources. Most of the natural dyes have not substantively dyeing for fiber and mordant must be used (Samanta *et al.*,2011).

Mahogany *(Swietenia macrophylla* King)

Swietenia is a species of plant in the Meliaceae family. It is one of three species that yields genuine mahogany timber, the other being Swietenia mahogany and Swietenia humilis. It is native to south America and Mexico, but cultivated in plantations and wind-breaks elsewhere. Mahogany trees can grow in a range of soil types. Bark of *Swietenia macrophylla* (Mahogany) is a valuable natural dye source for textile. It grows best in areas where annual daytime temperatures are within the range 20-30 ºC (Amoros *et al*., 1959).

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Materials and Methods

All chemicals used in this research were procured from British Drug House (BDH), England. The apparatus consist of conventional lab equipment, glass wares and modern technique.

Sample collection and preparation

The bark of *Swietenia macrophylla King* (Mahogany) was collected from WYU Campus, Htan-ta-bin Township, Yangon Region. The sample was washed with tap water to remove impurities and then air-dried under shade to prevent some reaction of sunlight with organic constituents of sample. The dried sample was separately cut into pieces and ground in a grinding machine. The powder sample was separately stored in the air-tight container so that the sample was free from getting molds to prevent moisture as well as other contaminations and ready to be used for the experimental works.

Scientific classification of *Swietenia macrophylla* King

The scientific name of *Swietenia macrophylla* King (Mahogany) was identified by authorized botanist at Botany Department, West Yangon University.

Family	:	Meliaceae
Botanical name	:	*Swietenia macrophylla* King
Myanmar name	:	Mahogany
English name	:	Mahogany
Part used	:	Bark

Extraction of dye powder with water

Air-dried (Mahogany) bark powder (1g) was boiled with 300 mL of distilled water at 60°C for 3 hours to obtain pre dye solution. It was cooled, filtered and heated until pasty and dried in oven at 150℃ for 30 minutes. It was ground and sieved with 80 μ aperture size, 16.5% of reddish brown dye powder sample was obtained (Paul *et al.*, 1996).

Cleaning of cloth

Cloths were washed in a solution containing 1 gL^{-1} sodium carbonate and 2.5 gL^{-1} non-ionic detergents at 60°C for 30 minutes, keeping the material to liquor weight by volume ratio at 1:40. Then the cloths were thoroughly washed with tap water and dried at room temperature.

Preparation of mordant solution

Mordant (1 g) was dissolved in 100 mL of distilled water.

Preparation of dye solutions

Dye powder (1 g) was dissolved in 100 mL of distilled water.

Characterization of natural dye extracted from *Swietenia macrophylla* King (Mahogany) bark

The adsorbent spectrum of natural dye extracted from *Swietenia macrophylla* King (Mahogany) was recorded by using fourier transform infrared spectrometer (IR-Tracer 100 Shimadzu, Japan).

Dyeing Lining Cloths with Water Extract

Dyeing with pre mordanting

In pre-mordanting processes, the cloths were dip in 1% of any one of the mordants solution such as alum, aloe vera, copper (II) sulphate, potassium dichromated and ferrous sulphate at 60°C for 30 minutes.

Dyeing with simultaneous mordanting

In simultaneous-mordanting processes, the cloths were dip in mixture of 1% of dye and 1% of any one of the chemical mordant solution at 60°C for 1 hour.

Dyeing with post mordanting

In post-mordanting processes, firstly, the cloths were soaked in 1% dye solution. After 10 minutes, the dyed cloths were taken out, squeezed and dip in 1% of any one of the chemical mordant at 60°C for 30 minutes.

Dyeing without mordanting

Cleaned cloths were soaked in 1% dye solution and heated to 60°C for 1 hour.

Determination of colour fastness

The dyed materials were tested for light fastness and wash fastness. Light fastness was analyzed by exposing the dyed material to direct sunlight for 48 hours. The wash fastness was carried out by washing the dyed fiber with non- ionic soap solution (1 gL^{-1}) for six times.

Determination of colour density

The colour density of the dyed cloths before and after lighting and washing fastness were determined by Reflection Transmission Colour Densitometer at Universities' Research Center, Yangon.

Results and Discussion

Characterization of Natural Dye Extracted from *Swietenia macrophylla* King (Mahogany)) Bark by FT- IR Method

Myanmar is one of the countries which possess the natural wealth in the form of plantation in plenty. The raw materials for the production of natural dyes were plentifully available. Natural dyes do not cause any harm to human skin and no hazards. FT-IR investigation is widely used for the study of natural dye. The Fourier Transformed Infrared spectra of natural dye Extracted from *Swietenia macrophylla* King (Mahogany) are shown in Figure 1 and the band assignments are represented in Table 1.

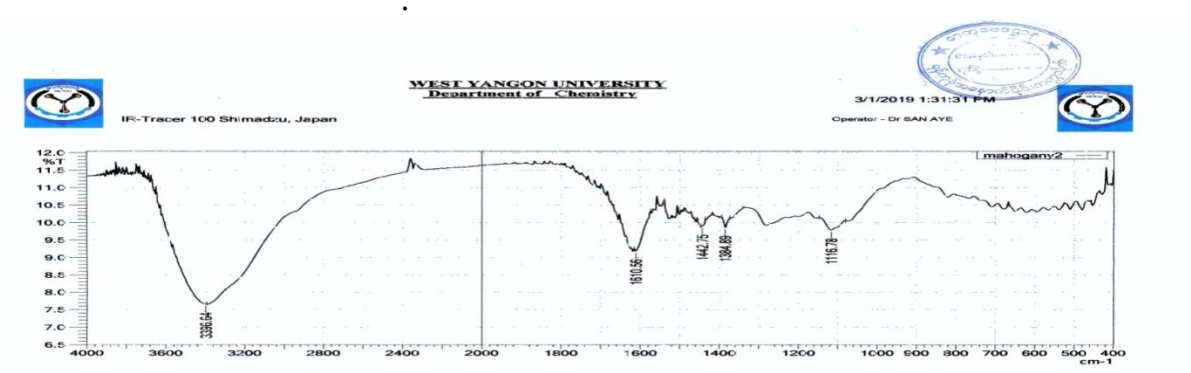

Figure 1. FT IR spectrum of natural dye extracted from *Swietenia macrophylla* King (Mahogany) barks

Table 1. FT IR Spectrum Assignments of Natural Dye Extracted from *Swietenia macrophylla* King (Mahogany) bark

Wave number (cm^{-1})	Literature wave number(cm^{-1})	Band Assignment
3396	3600–3200	ν_{O-H} of hydroxyl group
1610	1660–1600	$\nu_{C=C}$ aromatic ring
1442	1400–1500	δ_{C-H} of CH_2 and CH_3
1384	1400–1370	δ_{CH_3} aliphatic-CH_3 group
1116	1200–1050	δ_{C-OH} phenolic group

*Silverstein and Terence, (1991)

Determination of colour density on lining cloths with three dyeing process after light and wash fastness

The colour densities of lining cloths were studied by three dyeing processes such as pre-mordanting, simultaneous-mordanting and post-mordanting processes. The colour of Lining cloths varies with different mordant and different mordanting processes used. The colour densities on the Lining cloths were very significant by using different mordant. The average colour density is shown in Table 2 and Figure 2.

Table 2. Colour Densities of Dyeing Lining Cloths Dyed with Water Extract

Type of mordanting	Colour density					
	Without (S_1)	Alum (S_2)	Aloevera (S_3)	$CuSO_4$ (S_4)	$K_2Cr_2O_7$ (S_5)	$FeSO_4$(S_6)
Pre mordanting	1.01	0.45	0.54	1.09	1.13	0.98
Simultaneous mordanting	1.01	0.40	0.50	1.14	0.84	1.09
Post mordanting	1.01	0.42	0.53	0.65	1.13	1.23

Figure 2. Colour of dyeing of lining cloths with water extract (i) pre-modanting (ii) simultaneous-mordanting (iii) post-mordanting

Determination of Colour Densities after Light and Wash Fastness Test

In wash fastness test, the specimen was rinsed with water for (6) times and dried at room temperature. The change in colour of the specimen was assessed by comparing with before dyed lining cloths.

In light fastness test, the specimen was dried under the sunlight for 48 hours. The change in colour of the specimen was faded by comparing with the before dyed lining cloths.

Washing and lighting fastness properties of dyed lining cloths were tested for each of mordants and three dyeing processes. The colour density is measured with colour densitometer. Before fastness test in dyeing of lining cloths using three mordanting method, it was found that all mordant was good in colour. The colour density is good in before fastness test. After wash and light fastness test, lining cloths have a little fade in colour.

Pre-mordanting

Colour fastness of lining cloths samples were studied by using pre-mordanting, processes. The comparison of before and after light and wash fastness test of six dyed cloths were shown in Table 3and Figure 3.

Table 3. Comparison between Colour Densities of Lining Cloths after Light and Wash Fastness Test (Pre-Mordanting)

Pre-mordanting	Colour density					
	Without (S_1)	Alum (S_2)	Aloevera (S_3)	$CuSO_4$ (S_4)	$K_2Cr_2O_7$ (S_5)	$FeSO_4$ (S_6)
Before	1.01	0.45	0.57	1.09	1.13	0.98
Washing	1.00	0.42	0.54	1.06	1.06	0.98
Lighting	0.83	0.52	0.37	0.71	1.11	0.92

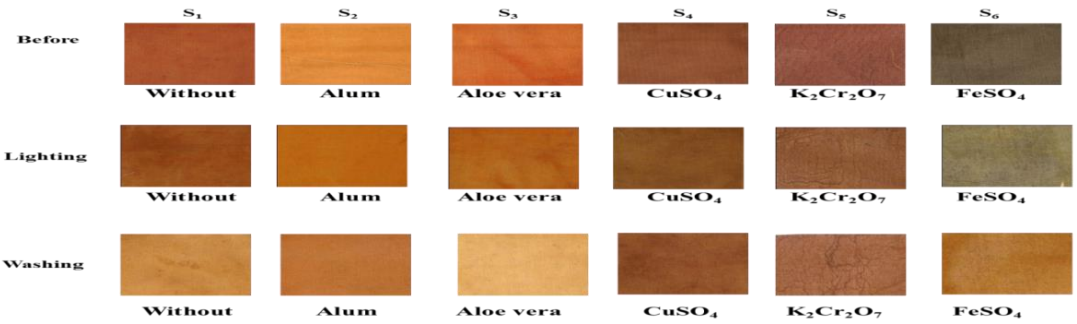

Figure 3. Variation in colour of lining cloths after fastness test (Pre-mordanting)

Simultaneous-mordanting

Colour fastness of lining cloths samples were studied by using simultaneous-mordanting processes. The comparison of before and after light and wash fastness test of six dyed cloths were shown in Table 4 and Figure 4.

Table 4. Comparison between Colour Densities of Lining Cloths after Light and Wash Fastness Test (Simultaneous Mordanting)

Simultaneous mordanting	Colour density					
	Without (S_1)	Alum (S_2)	Aloevera (S_3)	$CuSO_4$ (S_4)	$K_2Cr_2O_7$ (S_5)	$FeSO_4$ (S_6)
Before	1.01	0.40	0.50	1.14	0.84	1.09
Washing	1.00	0.39	0.47	1.06	0.57	1.09
Lighting	0.83	0.46	0.36	0.54	0.47	0.56

Figure 4. Variation in colour of Lining cloths after fastness test (Simultaneous mordanting)

Post-mordanting

Colour fastness of lining cloths samples were studied by using post-mordanting, processes. The comparison of before and after light and wash fastness test of six dyed cloths were shown in Table 5and Figure 5.

Table 5. Comparison between Colour Densities of Lining Cloths after Light and Wash Fastness Test(Post Mordanting)

Post mordanting	Colour density					
	Without (S_1)	Alum (S_2)	Aloevera (S_3)	$CuSO_4$ (S_4)	$K_2Cr_2O_7$(S_5)	$FeSO_4$(S_6)
Before	1.01	0.42	0.53	0.65	1.13	1.23
Washing	1.00	0.40	0.44	0.63	1.05	1.19
Lighting	0.83	0.44	0.36	0.51	0.91	1.06

Figure 5.Variation in colour of Lining cloths after fastness test (Post mordanting)

Application of Reddish-brown Natural Dye Extracted from Mahogany Bark

Many natural dyes can be extracted from trees and other materials. People have been using these types of materials for cloths and in decoration because of their glorious naturals. These have been revival of the growing interest on the application of natural dyes on natural fibers due to worldwide environmental consciousness. Therefore, S_3 (natural mordant or Aloevera) and S_5 ($K_2Cr_2O_7$ or chemical mordant) and S_6 ($FeSO_4$ good colour fastness mordant) can be applied in home-made dyeing process. The results were shown in Table 6 and Figure 6.

Table 6. Application of Reddish Brown Natural Dye Extracted from Mahogany Bark for Home-made Dyeing Process

Post mordarding	Color density		
	Aloevera (S_3)	**$K_2Cr_2O_7$ (S_5)**	**$FeSO_4$ (S_6)**
Origin	0.45	0.77	0.82
Lighting test	0.44	0.76	0.81
Washing test	0.40	0.70	0.78

Aloevera (S_3) $K_2Cr_2O_7$ (S_5) $FeSO_4$ (S_6)

Figure 6. Application of reddish brown natural dye extracted from mahogany bark for home-made dyeing process
S_3 –aloevera
S_5 –potassium dichromate
S_6 – ferrous sulphate

Conclusion

From the overall research, the following conclusion may be drawn. The natural dyes were extracted from Mahogany bark with water extraction and dyeing processes was studied by applying dye on 100% pure lining cloths. The visual colour of dye solution was reddish-brown. Before wash and light fastness, mordant used for ferrous sulphate the highest colour density in post mordanting. In the determination of wash and light fastness test, 6 times washes with market detergent powder and 48h sun dried mordant used for aloe vera and potassium dichromate had the best dyeing after wash and light fastness among three different mordanting conditions. Therefore, *Swietenia macrophylla* King (Mahogany) bark can serve as a source of raw material for dyeing lining cloths in the future.

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