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Silk Dyeing Using Saw-Wood of the Zelkoa Forest Tree

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Abstract: In the present study the saw-wood of the zelkoa forest tree was used as a source of natural dye for dyeing of silk samples. A variety of interesting reddish, brownish and yellowish shades were obtained by applying the extracted natural dye on silk textile samples. The shades produced differed by changing the mordanting agent. Colorimetric evaluations were carried out and fastness properties of the dyed samples were also assessed. The fastness properties of the studied natural dye were quite good.

Key words: Textile · Natural dye · Zelkoa tree · Saw-wood · Silk · Dyeing

INTRODUCTION

Dyeing is a very ancient art that have been practiced since prehistoric times throughout the world. Primitive dyeing methods involved sticking coloring substances to fabric or rubbing crushed pigments to the texture. But nowadays dyeing has become a specialized science and has a very complex system.

Until the introduction of the synthetic dyes in the nineteenth century, all dyeing materials were derived directly from natural sources such as the roots, leaves, flowers or stems of special plants, from insects for example cochineal and even a number of minerals. Natural dyes are generally environmental friendly and can provide a wide range of beautiful shades with acceptable levels of colorfastness [1-5]. The use of natural dyes for textile dyeing purposes, decreased to a large extent after the discovery of synthetic dyes in 1856. As a result with a distinct lowering in synthetic dyestuff costs, the natural dyes were virtually unused at the beginning of twenties century [6, 7]. Nowadays in most of the countries, natural dyeing is practiced only as a handcraft and synthetic dyes are being used in all commercial dyeing processes.

As the main problem in natural dyeing is the limited sources of natural coloring materials, in recent years a variety of projects have been developed in order to discover newer sources for natural coloring agents especially from by-products of farming and forestry e.g. bark or saw-dust from timber production as well as wastes from the food and beverage industry, e.g. pressed berries, onion peels and black tea residues. [8-13]. In addition with the global concern over the use of eco-friendly and biodegradable materials, considerable research work is being undertaken around the world on the application of natural dyes in textile industry. The effluent problems of synthetic dyes occur not only during their application in the textile industry, but also during their manufacture and possibly during the synthesis of their intermediates and other raw materials. Application of the waste materials as sources of natural dyes can also assist in the preservation of the environment and also decrease the cost of natural dyeing.

Zelkoa (serenata zelkoa), a genus of the elm family (*Ulmace*), is a common forest tree that is represented by a number of species in China, Korea, Taiwan, Japan and in Eurasia where it is a valuable timber tree. Outer bark flakes off exposing an orange-brown layer beneath. The leaves are dark green in summer and turn yellow, orange, or rusty red in autumn. High oil content makes the wood resistant to moisture [14]. The wood of zelkoa tree that has a dull reddish shade is known to contain extractable water soluble natural dyes. Because of lack of knowledge of the practice implicated in extracting, processing and dyeing by using the zelkoa tree wood; little utilization is done for this natural resource. The literature survey indicates that there is hardly any work reported on the reuse of zelkoa trees saw-wood as sources of natural dye for dyeing in textile applications. In the present study, saw-wood of forest trees that are removed during wood processing were used to be a source of natural dyes.

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Experimental

Materials: The material used for the dyeing experiments was Iranian silk yarn which was degummed in a soap solution of 15% on weight of sample (o.w.s.) at 80-90°C for 15 min, at a liquor ratio (L:R) of 30:1 and washed thoroughly in water. Then, it was treated in 1% (v/v) acetic solution at 50°C for 15 min and washed by tapped water. Finally, it was dried at room temperature.

The nonionic detergent used was obtained from the Shirley Development Ltd. Aqueous solutions containing 10 g/l of ferrous sulphate [$FeSo_4$], aluminium potassium sulphate (alum) ($KAl(So_4)_2.12H2O$), copper sulphate [$CuSo_4.2H_2O$], Stannous chloride ($SnCI_2.2H_2O$), silver nitrate ($Ag\ No_3$) and Potassium Dichromate ($K_2Cr_2o_7$) were used as mordants that all the chemicals were supplied by Merck.

Extraction of Dye: For the purpose of extraction of natural dye, all samples of saw-wood were from the zelkoa tree collected from Iranian northern forest trees timber and wood processing. The material was stored at room temperature in an air-dried state. Subsequently the dried material was ground and a fine powder of dyestuff was obtained. To improve the extraction efficiency, the dried powder of saw-wood was wetted 48 hours before the extraction. In extraction of natural dye, fine powdered saw-wood, was mixed with water (L:R, 1:40), boiled for 60 Minute and filtered while hot to obtain the extracted dyestuff. Volume loss due to evaporation was compensated at the end of the extraction period. The extract left standing in a room until the temperature had dropped sufficiently and then filtered through a filter paper.

Dyeing Procedure: A pre-mordanting procedure was used in which the silk samples were mordanted prior to dyeing by treating with different mordants at boil for 45 min. The liquor ratio was 1:40 and the concentration of mordants was 5% on weight of the samples. Extracted dyes at concentrations of 50%, (o.w.s) were used for dyeing of the wool samples. The liquor-goods ratio was 40:1. Samples were introduced into the dyeing solutions at room temperature. Temperature was raised to the boil and dyeing continued at the boil for 1 hr. At the end of the dyeing period, the dye bath solution was removed and the rinsing procedure started. Excess dye was removed by rinsing three times with cold water.

Colorimetric Evaluation: The spectral reflectance of the dyed samples was measured using a (Texflash spectrophotometer, (Datacolor Corp.). The K/S values were calculated by the Kubelka-Munk equation. (Eq.1) [15, 16]

$$\left(\frac{K}{S}\right)_\lambda = \frac{(1-R_\lambda)^2}{2\times R_\lambda} \quad (1)$$

Where R is the reflectance of dyed fabric at wavelength (λ), K is the absorption coefficient and S is the scattering coefficient. CIELAB coordinates [17,18] (L*, a*, b*, C*, where, L* defines lightness; a* denotes the red/green value; and b* the yellow/blue value and C* is the saturation) were calculated from the reflectance data for 10° observer and illuminant D_{65}.

Fastness Properties: The dyed samples were tested according to ISO standard methods. The specific tests were as follows: ISO 105-X12(1987), color fastness to rubbing; ISO 105-C02 (1989), color fastness to washing; and ISO 105-B02 (1988), color fastness to light (carbon arc).

RESULT AND DISCUSSION

Most of the natural dyes have poor fastnesses properties on fibers and usually need the use of mineral salts, so called mordants. Mordanting agents are usually used in order to increase the absorption and fixing efficiency and prevent fading against washing and exposure to light. Mordants form chemical bonds between the dye molecules and the proteins of the fibers. They may also change the color produced by the dye. In most recipes mordants are used on the fiber before dyeing (premordanting) but they can also be used during (simultaneous or meta-mordanting) and after dyeing (after-mordanting). Using a different mordant with the same dyestuff may produce different shades, for example, iron is usually used for darkening the colors, copper sulphate also makes the shades darker but can give shades which are otherwise very difficult to obtain, tin brightens the colors and, chrome is good for obtaining yellow shades. Figure 1 shows the reflectance spectra of different samples dyed with zelkoa forest tree saw-wood and by using different mordanting agents. The effect of mordants used in this study on colorimetric coordinates

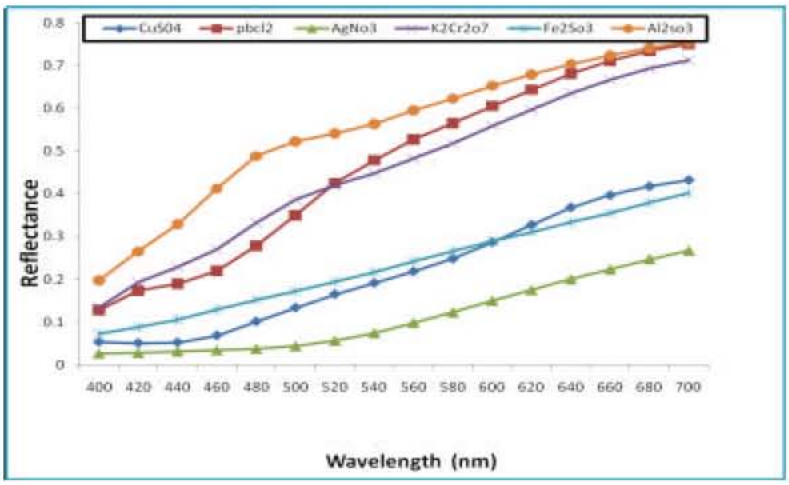

Fig. 1: Reflectance spectra of the silk samples dyed with zelkoa tree saw -wood and different mordants

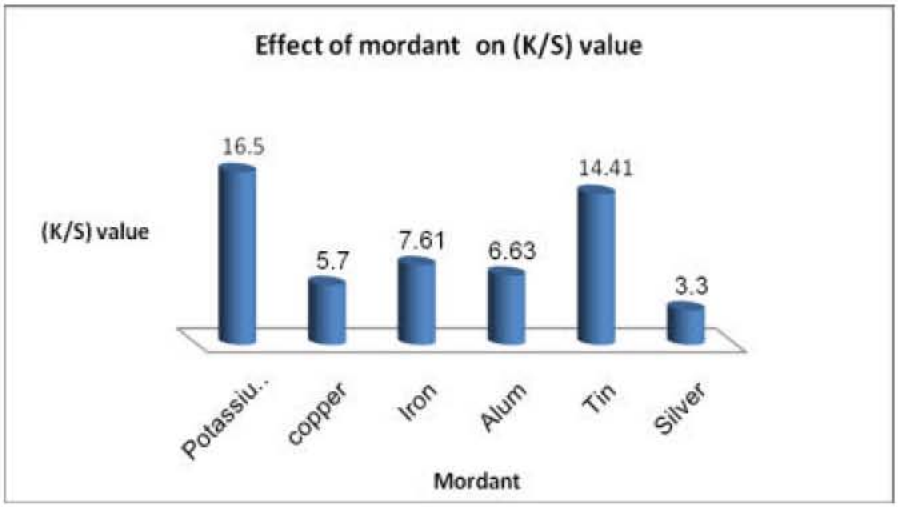

Fig. 2: Effect of mordants on color values of dyeing of silk with zelkoa tree saw -wood

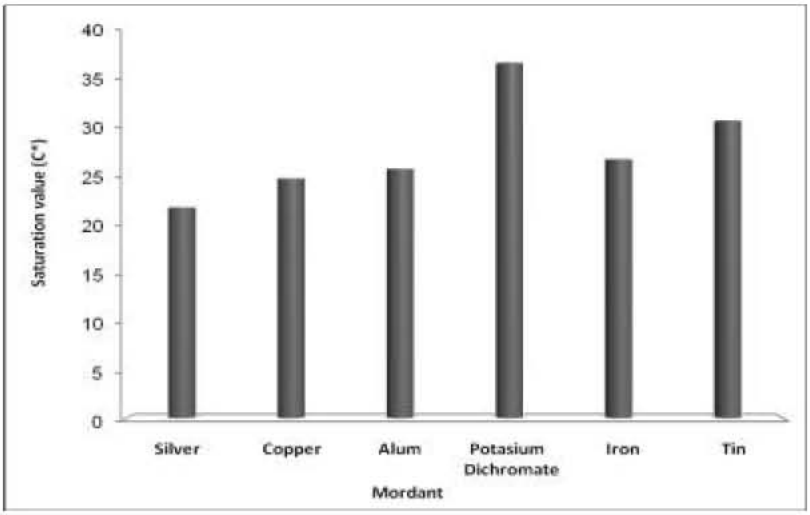

Fig. 3: Effect of mordants on saturation value (C^*) of dyeing of silk with zelkoa tree saw -wood

Table 1: Color and CIELAB values for dyeing of silk with zelkoa forest tree saw-wood

No.	Mordant	L*	a*	b*	Color
1	(Alum) ($KAl(SO_4)_2.12H_2O$)	80.763	0.961	22.027	Beige
2	(Ferrous sulphate) ($FeSO_4.7H_2O$)	55.790	9.695	36.822	Dull brown
3	(Copper sulphate) ($CuS0_4.2H_2O$)	52.980	10.460	36.594	Orange
4	(Silver nitrate) ($AgNo_3$)	36.981	16.457	26.676	Magenta
5	(Stannous chloride) ($SnCI_2.2H_2O$)	75.392	5.938	36.995	Light brown
6	(Potassium Dichromate) ($K_2Cr_2o_7$)	74.056	4.518	27.611	Brown

Table 2: Fastness properties of silk samples dyed with zelkoa tree saw-wood and different mordants

No.	Fastness Mordant	Alum	Iron	Copper	Silver	Tin	Potash
1	Washing Fastness	4-5	4	4	4	4	4-5
2	Light Fastness	4-5	3-4	4	4	3-4	4
3	Rubbing Fastness	5	4-5	4-5	5	4-5	4-5

L*, a*, b* and obtained color of silk samples dyed with the zelkoa forest tree saw-wood are also given in the Table (1). Generally the colors obtained through application of various mordants ranged from beige to dull-brown. The darkest color (dull-brown) was obtained by using silver nitrate as mordant (L*=36.98) and the lightest color, beige (L*=80.76) was achieved by mordanting with alum.

The effect of mordants on color values of Silk dyed with zelkoa forest tree saw-wood is shown in Figure 2. Among the mordants used, potash showed the highest color value (K/S =16.5) followed by tin (K/S=14.41), while in dyeing with silver as mordant the lowest amount of (K/S) was achieved (3.3). From the Figure (3) it can be noted that dyeing with silver as mordant resulted the lowest saturation value (C*) while using of potash as mordant resulted the highest amount of saturation.

Fastness Evaluation: Results for fastness properties of dyeing with zelkoa forest tree saw-wood and by using different mordants are given in Table 2.

When all the samples were subjected to wash and rubbing fastness evaluation, it was observed that almost all s howed good washing fastness (4) and good-to-excellent rubbing fastness (4-5). The samples mordanted with alum and silver showed the best rubbing fastness and the samples mordanted with copper and iron had the best wash fastness (4-5) among all. Light fastness of the samples was found to reach the fair values of 4 according to the blue scale standard. While the sample dyed using alum mordant was found to have the best light fastness among others.

CONCLUSION

This research was aimed to show how some type of waste materials such as zelkoa tree saw-wood that is usually removed during wood processing can serve as inexpensive raw materials for the extraction of natural dye-forming substances. The zelkoa tree saw-wood as a natural gave a variety of shades by mordanting with different mordants used in this study. The shades produced differed from mordant to mordant. Mordanting with silver and iron gave dull shades while alum and tin gave brighter shades. The fastness properties of the studied natural dye on wool fiber were also acceptable (4-5) for textile applications.

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