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Mango Bark Mordant for Dyeing Cotton with Natural Dye: Fully Eco-Friendly Natural Dyeing

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Abstract Use of metal salts mordants in naturally dyed textile products make them not fully environmental friendly. We have investigated mango bark extract possibility of being used as a mordant. The natural dye used was extracted from bitter leaves and pre or post mordanted with mango bark extract, the amount of dye in the sample after dyeing and after washing was tested using CIELAB equipment, UV-Vis absorption spectroscopy and wash fastness test. Comparing the mango bark mordanted sample with control samples which included; un-mordanted sample and samples mordanted with copper II sulphate, significant mordanting effect was confirmed which was even better than the conventional mordant used. Further investigation revealed that post mordanting with mango extract gives better wash fastness performance than pre-mordanting. This study forms an important basis on which many more natural materials can be developed to be used as mordants when dyeing not only cotton but other textile products made from other fibers.

Keywords Natural dye, Natural mordant, Fastness property, Eco-Dyeing, Cotton

1. Introduction

The use of non-allergic, non-toxic and eco-friendly natural dyes on textiles have become a matter of significant importance due to the increased environmental awareness in order to avoid some hazardous synthetic dyes [1, 2]. Natural dyes are considered to be eco-friendly as these are obtained from renewable resources as compared to synthetic dyes which are derived from non-renewable petroleum resources [3]. Most of the natural dyes have no substantivity for the fiber and mordants must be used. Mordants are usually derived from metallic salts, the commonly used metal salts include alum, chrome, stannous chloride, copper sulphate and ferrous sulphate [4-7]. These chemicals act as mordant by fixing themselves on the fiber and also combines with the dyestuff. Therefore, mordants form a link between the fiber and the dye, which allows certain dyes with no or little affinity for the fiber to be fixed [8, 9]. However, the use of metallic mordants during natural dyeing often puts a question mark on the eco-friendliness of natural dyes. Only a small amount of these metal salts gets fixed onto the textiles and the rest is discharged as effluent which leads to the contamination of land and water resources. Furthermore, the presence of some of these metal salts in the finished goods exposes the wearer to some harm.

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Much study has already been dedicated to developing mordanting agents which are non toxic and eco-friendly. Some of the approaches which have been explored include use of metal salts which are considered to be ecologically safe like alum and iron sulphates, use of natural oil product as mordants has also been reported [10]. Tannins and other natural extracts from plants have also been investigated for mordanting natural dyes [11-13]. In this work we investigate the possibility of dyeing cotton fabric using two natural dye extracts. One dye extract is supposed to act as a mordant while the other acts as the main coloring material. To achieve this objective, we have extracted green dye from Bitter leave (vernonia amygdalina) and used it as the main natural dye. Vernonia amygdalina plant is member of the Asteraceae family, is a tropical shrub, 1-3m in height with petiole leaf of about 6mm in diameter, and elliptic in shape. The leaves are dark green colored with a characteristic odor and a bitter taste. This plant occurs naturally along rivers and lakes, in forest margins, woodland and grassland, up to 2000 m altitude. It often occurs in disturbed localities such as abandoned farmland, and can be found growing spontaneously in secondary forest making its readily available for use. Extracts from the bark of the Mango tree (Mangifera indica) with a yellowish color has been used as a mordant. After dyeing the amount of color in the fabric and amount of color extracted from the solution were evaluated for both freshly dyed and washed samples to establish the mordanting effect of the mango tree using CIELAB equipment and UV-Vis spectroscopy.

2. Experimental

2.1. Materials and Equipments

Dried and crushed powder of bitter leaves and mango bark, acetone, copper II sulphate (synthetic mordant), bleached cotton fabric cut into several 5g pieces to be used for dyeing in different conditions. The dyeing results were compared using CIELAB equipment and UV-Vis spectroscopy. Machines used for dyeing, washing, padding were all from Mesdan Lab company

2.2. Extraction of Dye from Bitter Leave and Mango Bark Powder

The bitter leaves were collected from the trees, dried and crushed into powder, the mango barks were also separately dried and crushed into powder as shown in Figure 1. The extraction of the two dyes was done separately since they were to be used for different functions. 30 g of powder bitter leaves were extracted using 100 ml of acetone (an organic solvent which gave higher yield than water) at 50°C for 1 hour. After extraction, acetone was evaporated leaving behind the dye concentrate which was diluted with water to form 100ml solution to be used for dyeing without further dilution. For mango bark, 15 g of the powder was extracted using 200 ml of water at 90°C for 1 hour. The extract was directly used without any dilution.

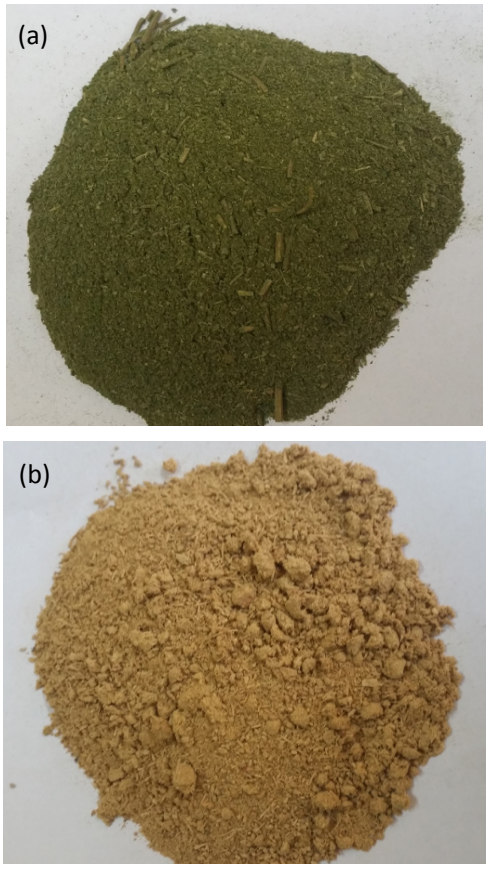

Figure 1. Dried and crushed powder of a). Bitter leaves and b). Mango bark

2.3. Pre-Mordanting

Two pieces of fabric samples were pre-mordanted one with mango extract and the other with copper II sulphate. For mango bark, the extract was used while for copper II sulphate 2g/l concentration was used. Both the two samples were placed in 50 ml of respective mordant solution and heated at 60°C for 1 hour. The fabric were then padded to remove excess water and dried in open air.

2.4. Dyeing Using Bitter Leaves

A total of 5 samples prepared as follows: the two fabrics samples previously pre-mordanted and three fabric samples only bleached but not mordanted were all dyed separately using the same conditions. Each fabric was placed in similar 100 ml bitter leave dye solution and dyed at 80°C for 2 hours. After dyeing the samples were padded and dried.

2.5. Post Mordanting

Two of the un-mordanted dyed samples were post mordanted using mango and copper II sulphate following the same procedure as pre-mordanting. The last piece remained as the control sample.

2.6. Washing

The dyed samples were tested for wash fastness according to the conditions of ISO 105 standard test method.

3. Results and Discussions

To investigate the effect of mordanting from mango extract, bleached cotton fabrics were dyed using bitter leaves dye and mango extract as a mordant and compared with those dyed with similar dye but mordanted using conventional mordant in this case copper II sulphate under similar dyeing conditions. The effect was measured using CIELAB equipment to establish the K/S values after dyeing and after washing, results obtained are as represented in Figure 2.

From the results it can be seen that fabrics dyed without any mordant (control fabric) and that pre-mordated using mango had the highest K/S value before washing which was closely followed by post mordanted with mango. Fabrics mordanted with copper II sulphate recorded low K/S values. This can be explained by the fact that since mango extract apart from being used as a mordant it also functioned as a dye thereby increasing the color effect on the fabric unlike copper II sulphate which did not have color addition effect. On washing the samples, a clear mordanting effect of the mango was confirmed. As expected, the control sample due to its unfixed dye had the highest percentage of color loss leading to the greatest color difference between before washing and after washing. Fabric pre-mordanted with the mango extract showed some improvement in color retention compared to the control sample. The greatest retention of

color in the fabric after washing was obtained when the mango extract was post mordanting on the dyed fabric. These results were also confirmed visually whereby the color of the washed sample of mango extract post mordanted was deeper than pre-mordanted and non mordanted as displayed in Figure 3 (a), (b) and (c) respectively. Also the color values of the samples showed darker shades being obtained from post mordanting where the L values was lower as summarized in table 1.

After washing the samples mordanted with mango, the waste water was collected and the amount of dye in the water established using UV-Spectroscopy. The results are as presented in Figure 4.

The interpretation of the UV-Vis spectrum is based on the fact that higher maximum absorption bands of the dye indicate higher concentration of the dye in the waste water. From the results it is clear that more dye was lost from post mordanted fabric as compared to pre-mordanted. This is contrary to expectation as per the previous discussion where post mordanting showed highest color retention after washing. This difference is simply caused by the running out of mango extract which did not take part in mordanting during post mordanting leading to addition of color in the waste water. Unlike post mordanting, in pre-mordanting, due to the dyeing conditions these free mango extract are suppressed.

To study the effect of increasing the concentration of mango mordant, the mango bark powder weight was varied during the extraction from 10g to 35g and extracted in water following the same procedure explain previously. Post mordanting was then done on samples dyed with bitter leave dye using the different concentration of mango extracted. The K/S values of the dyed fabrics before and after washing was tested and the results were as presented in Figure 5. From the results it was observed that the K/S value increase when the mango extract concentration was increased was unpredictable since there was no clear trend. However, some slight reduction in fastness was witnessed on increasing the mordant concentration beyond 10g. This is evidenced by the larger difference in K/S values between before washing and after washing especially for 15, 20 and 25g concentration. At 30g there seems to be some difference in the trend which is unexpected, this may be due to some errors and can be regarded as an outlier. The reduction in fastness on increase in mango extract concentration can be explained by the fact that since the dye concentration is constant, just a small amount of the mordant is required to fix the dye before the active sites are exhausted. Higher concentration of the mordant leads to excess of the mordant which does not find active sites to participate in mordanting. These extra molecules of mango extract remains loose on the fabric and since they also have coloring effect, they end up contributing to low fastness to washing.

Table 1. K/S values and hue values of dyed samples

Method of mordanting	K/S before washing	K/S after washing	l	a	b
Post	5.2058	5.1092	54.64/55.93	-0.13/2.68	27.43/25.98
Pre	5.0369	3.6086	56.00/61.05	-2.81/-1.73	30.21/26.71
simultaneous	3.667	2.8315	61.70/64.02	-0.92/0.61	26.38/22.88

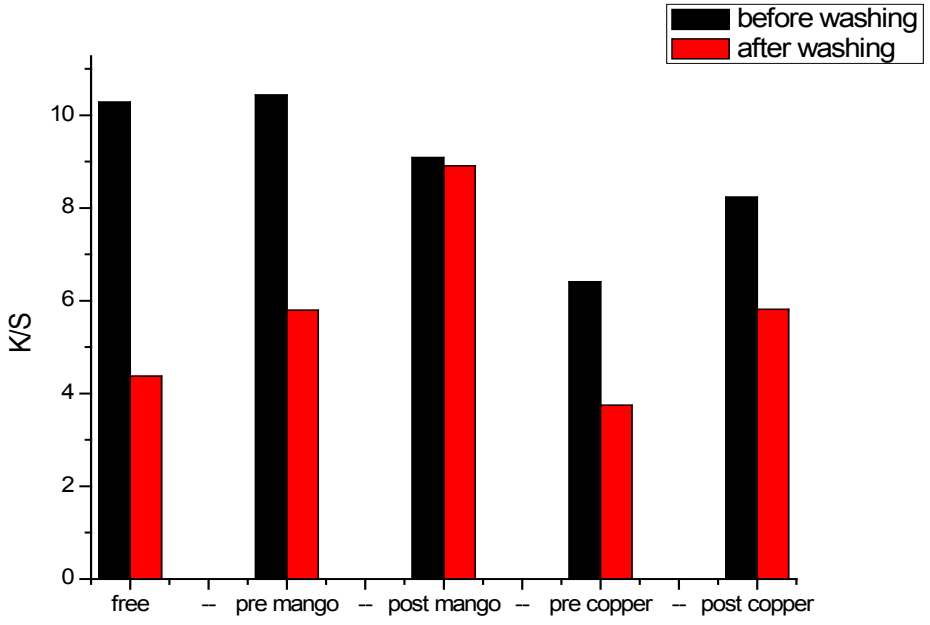

Figure 2. K/S values of dyed and washed samples mordanted differently

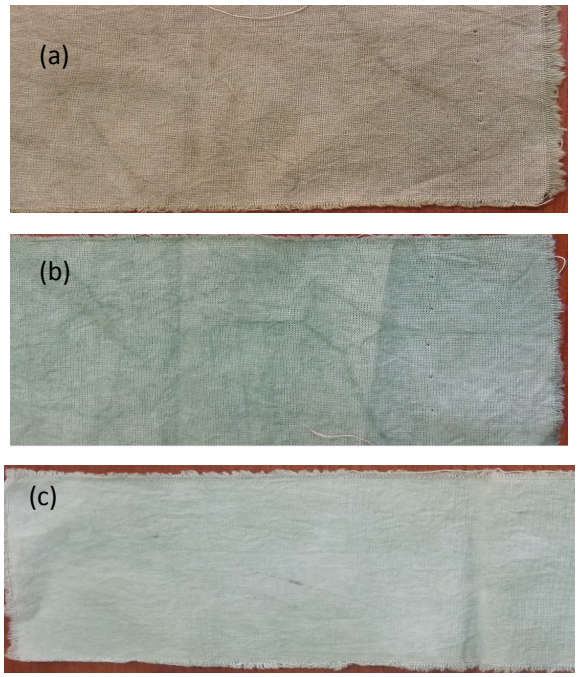

Figure 3. Dyed and washed samples a). post mordanted with mango, b). pre mordanted with mango and c). No mordant added

Further experiments were done to establish wash fastness effect of mango extract either pre or post mordanted and compared to samples without mordant and sample with copper II sulphate mordant. The results are as presented in table 2.

The fastness results clearly shows that post mordanting with mango extract had the best results even much better than using copper II sulphate. These results are in agreement with earlier results.

Table 2. Wash fastness values of dyed samples

Mordant	Method of application	Wash fastness
No mordant	nill	1
Mango	post	3
Mango	Pre	2/3
Copper II sulphate	post	2
Copper II sulphate	pre	2

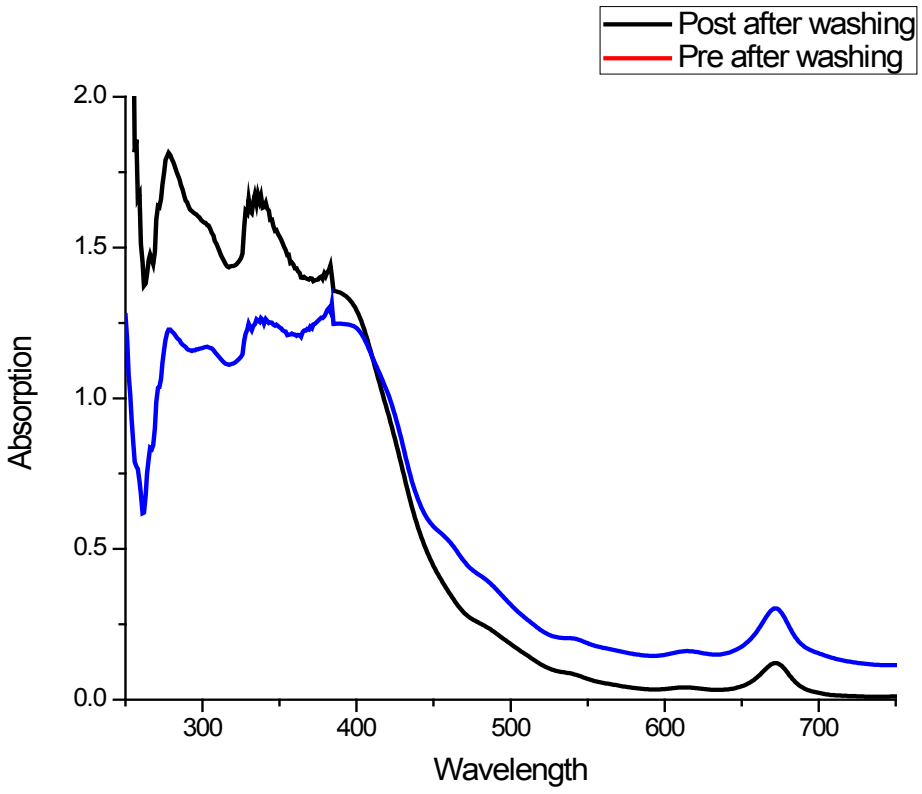

Figure 4. UV-Vis absorption spectra of water collected after washing from samples differently mordanted

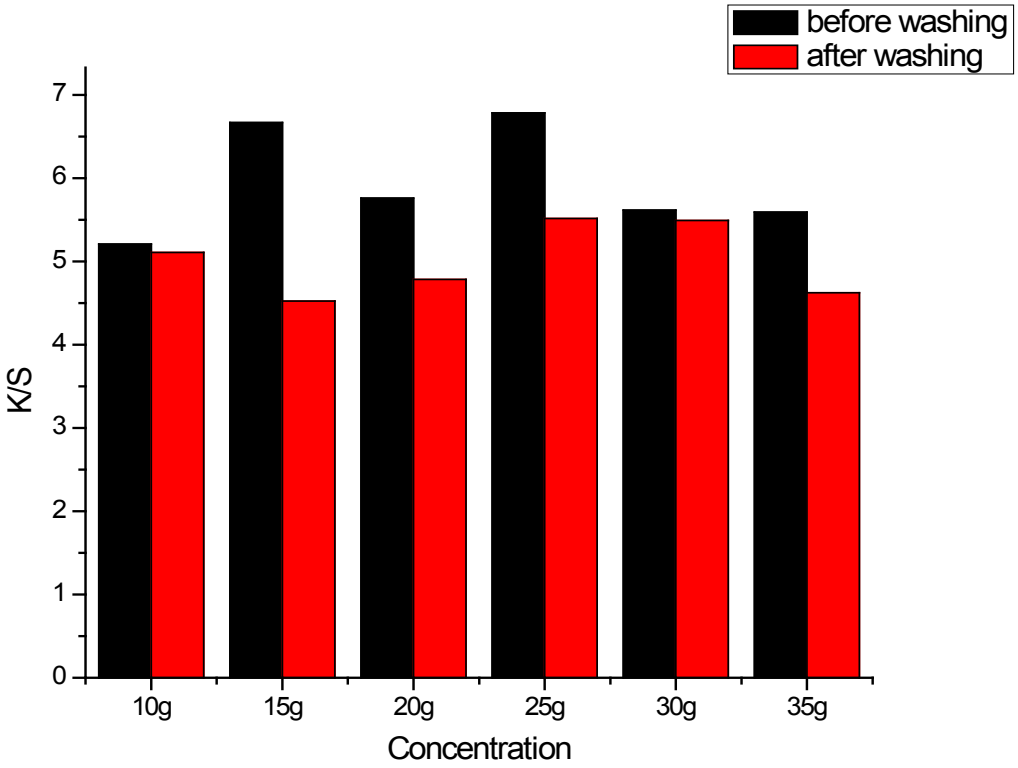

Figure 5. Effect of varying the concentration of mango mordant on K/S value during post mordanting

4. Conclusions

For naturally dyed fabric to be referred as fully eco-friendly products their processing must eliminate the use of metal salts for mordanting. In this study we have successfully investigated the possibility of using extract from mango bark as a mordant to dye natural dye (bitter leaves). Using the same dyeing conditions we have shown that mango extract even can mordant bitter leave dye better than the conventional metal salt under similar conditions; in this case copper II sulphate was used to compare. Further investigation revealed that post mordanting with mango extract gives better wash fastness performance than pre-mordanting. This was purported by the deeper color shade visually observed on the post mordanted dyed sample as compared to pre-mordanted. However there was more dye color in waste water collected after washing from post mordanted sample than pre-mordanted an effect attributed to contribution of unused mango extract during post mordanting. This study forms an important basis on which many more natural materials can be developed to be used as mordants when dyeing not only cotton but other textile products made from other fibers.

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