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DESIGN AND DEVELOPMENT OF ECO-FRIENDLY MORDANT IN NATURAL DYEING PROCESS FOR TEXTILE APPLICATION

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Abstract—*Natural dyes have been used by human beings since old age. Natural dyes are mostly non-substantive and must be applied on textiles by the help of mordants. Though the natural dyes are considered to be eco-friendly, the present day technology uses metallic mordants for permanently fixing the colour to the fabric. They are hazardous to human beings as well as to the environment. So in this project an attempt has been made to derive natural dyes and ecofriendly mordants using various experiments. In this experimental approach a cotton fabric was dyed using natural dye extracted from turmeric and pomegranate peel. The colour fastness properties of the dyed samples have been studied using different mordants such as myrobalan, eucalyptus bark extract, aluminium sulphate, copper sulphate, ferrous sulphate and sodium chloride. Natural dye from turmeric was used for dyeing a cotton fabric sample and they were tested for washing fastness. Irrespective of the mordant concentration, premordanting and dyeing time, the samples gave same colour and colour fastness. Inorder to increase the fixing property of pomegranate peel extract dye to the sample fabric, a minimum concentration-1% of salt mordants was added in the eucalyptus bark mordanting solution. Sample was tested for wash fastness and it was found that the dyed cotton sample gave better colour strength and colour fastness. For enhancing the dye ability of the cotton fabric three intermediate process are added in the dyeing methodology. Dyed Sample was tested for standard wash and rubbing fastness and the results with eucalyptus bark with salt mordants (2%) for mordanting the cotton fabric gave better colour and 3/5 of rubbing fastness for the above natural dyeing using pomegranate peel as a dye. and hence the concentration of salt mordants usage was reduced from 5% to 2% for the same result of colour fastness by using eucalyptus bark extract as a natural mordant. This will ultimately decreases the environmental impact of the natural. dyeing process.*

1. .INTRODUCTION

General Dyes or colorants are used to colour the materials like textile, leather, plastics, papers and food products. The dyes are basically classified into two groups as natural dyes and synthetic dyes. Natural dyes are derived from sources of the plants, trees, insects and minerals. Synthetic dyes are obtained through chemical reactions in factories. Due to its ready availability and cost advantage most of the textile manufacturers have shifted from natural sources to synthetic dyes. Use of synthetic dyes and metallic mordants is involved with the release of some harmful and polluting chemicals in to the environment during their dyeing process. The global consumption of textile is estimated at around 30 million tonnes, which is expected to grow at the rate of 3% per annum[3]. The colouration of huge quantity of textiles needs around 7,00,000 tonnes of dyes and reasonable amount of metallic mordants[3] which causes release of vast amount of unused and unfixed dyestuff, metals into the environment. These hazardous synthetic dyes will have to be replaced by means of ecofriendly natural dyes for safeguarding the nature earth. The natural dyes contain natural coloring matter which is neither carcinogenic nor hazardous to environment. However the natural dyes have some limitations such as reproducibility of shades because the raw material from the plants varies from one crop season to another crop season and place to place and lesser colour fastness property.

2. OBJECTIVES OF THE STUDY

The main objectives of the project are to derive natural dyes and ecofriendly mordants from plants and safe chemicals and to extract the dyestuff and mordants from those parts of the plants and trees using safe and eco-friendly extraction process and reduce the concentration of metallic mordants used in the textile mordanting process , replace the metallic mordants with suitable eco- friendly mordants, derive suitable mordanting process which are safe and eco-friendly and als to improve the effectiveness of the natural dyes by increasing the colour strength and colour fastness.

3. METHODOLOGY

The main aim is to develop the eco-friendly mordant in the natural dyeing process. Following methodology will be followed in this proposed project. Collecting the research papers related to eco-friendly dyes and mordants , Listing the various sources of dyes and mordants from the literature survey. Following are some of the mordants identified from research papers Tamrindus indica L seed , Quercus infectoria ,

Alum ,Potash alum , Aluminium sulphate , Copper sulphate , Ferrous sulphate , Potassium dichromate ,Nickel (II) sulphate hexahydrate , Stannic chloride , Ferrous chloride , Tin(II)chloride , Myrobolan ,Iron (II) sulphate hexahydrate , Lead (II) acetate trihydrate13 ,Tin (II) chloride, Oxalic acid . Identification of eco-friendly mordants from the list Properties of the mordants will be analyzed for health hazards and environmental impacts and the mordant will be grouped into different categories. Segregating and grouping the mordants based on eco-friendliness and health hazards. Identifying the unexplored mordants from similar sources of plant and trees and finding out their properties that can impact safety and health of the human beings. Preparation of dye extract from the identified sources. Collecting the sources of eco-friendly dyes and mordants. Extraction refers to separating the desired colour component by physical or chemical means with aid of a solvent. Industrial methods available for extracting colour components from the sources. Preparation of textile samples of standard sizes and imparting dye colour to the sample using identified dyeing process. Testing the textile samples using standard procedure for arriving the colour fastness properties and colour strength. Conducting experiments for deriving optimum dyeing parameters and documentation of the result. Test results will be tabulated and comparison charts will be drawn for analyzing the behavior of the samples.

3.1 TEXTILE SAMPLE PREPARATION

The plain cotton fabric is obtained from commercial textile shop. It is used for the study. The cotton fabric prepared as a ready for dyeing material by two methods. The cotton fabric is soaked in water and kept for 24 hours for removing the starch layer over the fabric. Then the cotton fabric is washed gently without soap and then dried under shade. Textile sample is cut-down to the size (8cm x 4cm), and weighed by using digital weighing balance. The weight of the single sample is 0.5g.

3.1.1 Desizing

Desizing is the process of removing the starch layer over the fabric using enzyme and acids (HCL, H2SO4)

Desizing conditions

- MLR ratio 1:20 (27.5g of textile sample for 550ml desizing solution)
- 0.5% desizing solution (2.75 ml H2SO4 for 550 ml distilled water)
- Desizing time : 12 hours
- Temperature : room temperature
- The textile samples are dried under shade
- Textile sample is cut-down to the size (8cm x 4cm)
- The weight of the single sample is 0.5g.

3.1.2 Scouring

Scouring is the process of removing the natural and added impurities present in the fabric such as oil, dirt etc.

Scouring conditions

- MLR ratio 1:20 (27g of textile sample for 540ml scouring solution)
- 5% caustic soda (27g for 540 ml distilled water)
- 1% sodium carbonate (5.4g for 540 ml distilled water)
- 1% soap oil (5.4 ml for 540 ml distilled water)
- scouring time : 4 hours18
- Temperature : 100oC
- The textile samples are dried under shade
- Textile sample is cut-down to the size (8cm x 4cm)
- The weight of the single sample is 0.5g.

3.2 DYEING OF TEXTILE SAMPLE USING TURMERIC

For the natural dyeing process, turmeric is used as natural dye stuff for dyeing the cotton fabric. The dyeing process parameters are as follows.

3.2.1 Dyeing Parameters

The natural dyeing process has many process parameters and conditions. The process conditions and parameters are listed below. These conditions are taken from literature[11]

Dye Extraction

The optimum conditions preferred for dye extraction are

- Extraction Temperature : 90oC
- Extraction Time : 60 minutes
- Extraction Solvent : Water
- MLR ratio : 1:20

Mordanting

The optimum conditions preferred for mordanting are

- Mordanting Type : Pre Mordanting
- Mordanting Temperature : Room Temperature
- Mordanting Time : 15 minutes
- Mordant concentration : 2.5%, 5%

Dyeing

- The optimum conditions preferred for dyeing are
- Dyeing Temperature : 70oC
- Dyeing Time : 30 minutes
- Dye concentration : 2%
- MLR ratio : 1:20
- pH : 6-7

3.2.2 Procedure

Natural dye raw materials (leaves, bark, peel, root) are collected and they are stored at room temperature. The dried material grounded and dye stuff is obtained then textile sample is prepared as a ready to dye fabric. Natural dye extraction was carried out based on the above mentioned extraction conditions.20 , Pre mordanting the cotton fabric was carried

out based on the optimum mordanting conditions . Mordanted cotton fabric was taken out from the mordanting bath and dried under shade. The dried pre mordanted samples used for dyeing and then Based on the optimum dyeing conditions the pre mordanted samples kept in a dyeing bath for 30 minutes after that dyeing time dyed samples taken out from the dye bath and dried under shade

3.2.3 Preparation of Myrobalan extract

Myrobalan fruit without seed is collected from the stationary shop. By using mixer grinder the myrobalan fruit is grounded then myrobalan powder is obtained. 10g of myrobalan powder alongwith100ml distilled water (10% solution) is heated at 90oC by continuously stirring it for 1 hour by using hot plate with magnetic stirrer. The resulting solution is filtered and the extracted aqueous solution is used for mordanting

3.2.4 Preparation of Turmeric Dye

Turmeric (curcuma longa l.rhizome), collected from stationary shop is used for the study. By using mixer grinder the turmeric sample is grounded and powdered turmeric dye stuff is obtained.25g of turmeric powder is soaked in 200ml of distilled water for 12 hours. The resulting coloured (yellow) solution is continuously stirred for 2 hours at 90oC by using a hot plate with magnetic stirrer. To collect the turmeric particles in the stirred solution, it is centrifuged at 6000 rpm for 15 minutes. The output of the centrifuging process is a concentrated paste. The concentrated paste is kept in hot air oven at 45o C for 12 hours. The resulting dried turmeric powder is used for dyeing.

3.2.5 Pre Mordanting using Myrobalan extract

The extracted aqueous solution is used for pre mordanting the textile sample. Five samples (8cm x 4 cm) are taken for pre mordanting process. The samples are immersed in the mordanting solution and continuously stirred for 15 minutes. After that time the pre mordanted samples are taken out from the mordanting bath and dried under shade.

3.2.6 Pre Mordanting using Chemical Mordants

The following mordants are used for pre mordanting process

Aluminium sulphate , Copper sulphate , Ferrous sulphate , Sodium chloride Turmeric Turmeric powder (Mixer grinder output) Turmeric dye (End product) . Pre mordanting of textile sample was done by two different concentration of mordants (5%, 2.5%) 5g mordant is dissolved in 100ml distilled water to obtain 5% mordanting solution. 2.5g mordant is dissolved in 100ml distilled water to obtain 2.5% mordanting solution. Textile samples are immersed in the prepared solution and continuously stirred for 5minutes. After that time the pre mordanted samples are taken out from the mordanting bath and dried under shade.

3.3.7 Textile Sample Dyeing

Dyeing is the process of boiling the textile sample with the aqueous extract of natural dye. Dyeing was done in two different stages as follows

- Pre mordanting and after 24 hours - dyeing.
- Pre mordanting and after 1 hour – dyeing

Dyeing conditions

- 5 samples (8cm x4cm) were taken for dyeing ,
- The weight of a single sample is 0.5g , total weight is 2.5 g
- MLR ratio 1:20 (2.5g of textile sample for 50ml dye solution)
- 2% dye solution (1g of dye extract for 50 ml of distilled water
- Temperature : 50oC
- Dyeing time : 30 minutes
- The textile samples are dried under shade.

3.2.8 Textile Sample Testing

There are different types of tests available to evaluate the dyed textile samples such as colour fastness to washing, rubbing, perspiration and hot pressing etc.

3.2.8.1 Washing Test

The samples were subjected to observation of different stages of successive washing

Washing condition

- 2% soap solution (2g soap powder for 100ml tap water)
- Textile sample is immersed in the soap solution for 5 min and stirred continuously.

3.2.8.1.1 Test Results

Turmeric as a natural dye is used for dyeing the cotton fabric with the help of mordants. Based on the mordants and concentration of mordants it gave various shades of yellow colour. The table 3.2 shows the colouring effects of turmeric dye in cotton fabric.

Mordants used	Mordants concentration in %	Dyed with 2% turmeric dye
Myrobalan	10	
Aluminium sulphate	5	
Copper sulphate	5	
Frerrous sulphate	5	
Sodium chloride	5	
Without mordant		

Table 3.2 colouring effects of turmeric dye

The dyed samples are subjected to observation of different stages of successive washing. Based on the washing results the mordants such as Aluminium sulphate, Copper sulphate, Ferrous sulphate gave better colour fastness to washing compare to other mordants such as (myrobalan, sodium chloride) Concentration of the above mentioned mordants were reduced from 5% to 2.5% due to their effective colour fastness to washing and the results are summarized below.

Mordant	Mordant concentration in %	Dyeing with 2% turmeric dye			
		Dyed sample	1st wash	2nd wash	3rd wash
Aluminium sulphate	5				
Aluminium sulphate	2.5				
Copper sulphate	5				
Copper sulphate	2.5				
Ferrous sulphate	5				
Ferrous sulphate	2.5				

Table 3.3 Comparison table for mordant concentration

From this table we can infer that, the irrespective of the morda nt concentration (5%, 2.5%) the dyed sample gave the same colour and colour fastness to washing Dyeing was done in two different stages such as Pre mordanting and after 24 hours – dyeing, Pre mordanting and after 1 hour – dyeing. The colour fastness to washing results are summarized in the Table 3.4

Mordants	Time interval	Dyeing with 2% turmeric dye			
		Dyed sample	1st wash	2nd wash	3 rd wash
Aluminium sulphate	24				
Aluminium sulphate	1				
Copper sulphate	24				
Copper sulphate	1				
Ferrous sulphate	24				
Ferrous sulphate	1				

Table 3.4 Comparison table for pre-mordanting and dyeing with time interval

From this table we can infer that, the irrespective of the time interval between the pre mordanting and dyeing (24 hours, 1 hour) dyed sample gave same colour and colour fastness to washing Textile sample preparation was done by two different methods. First method is cotton fabric was washed by normal tap water without soaping agents. Second method is cotton fabric was subjected to desizing and scouring process. The colour fastness to washing results summarized in the table 3.5

Mordant	process	Dyeing with 2% turmeric dye	
		Dyed sample	1st wash
Aluminium sulphate	With desizing, scouring		
Aluminium sulphate	Without desizing, scouring		
Copper sulphate	With desizing, scouring		
Copper sulphate	Without desizing, scouring		
Ferrous sulphate	With desizing, scouring		
Ferrous sulphate	Without desizing, scouring		

Table 3.5 Comparison table for cotton sample preparation

4. RESULT

Following are the findings using turmeric as a natural dye and aluminium sulphate, copper sulphate, ferrous sulphate, myrobalan and sodium chloride were used as a mordant for the natural dyeing process. The dyed sample was tested for colour fastness and found that the samples gave better colour fastness to washing for aluminium sulphate, copper sulphate and ferrous sulphate. So experiments were conducted by varying the mordant concentrations. Now the dyed samples were tested for colour fastness and it was found that irrespective of the mordants concentration (5%, 2.5%) the dyed sample gave the same colour and colour fastness to washing. Experiments were conducted by varying time interval between the premordanting and dyeing time. The dyed sample gave same colour and colour fastness irrespective of the variation (i,.e 24 hours & 1 hour) . Similarly samples were tested for colour fastness and it was found that the samples gave same colour and colour fastness irrespective of the textile sample preparation (i,.e with and without desizing, scouring).

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