

Natural Dye from Plants, Barks, Fruits and Leaves

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Abstract: Generally, the natural dyes are obtained from natural sources without any chemical processing. Every plant can be used to make a dye. The most common plant parts are used for dye preparation by the way of extracting method, accordingly Stem, Bark, Roots, Flowers, Leaves are used it. Now a days the natural dyes are in demand not only in textile industry, even also demand in pharmaceutical industry, food industry etc., In spite of, there was a demand for natural sources that would be used for medical purpose and its bio-degradable nature. So that the natural sources are eco-friendly. The natural dyes are non-toxic to human and also free from carcinogenic components. The natural dyes are used as Anti-oxidant, Anti-microbial, Anti-fungal properties. Normally the natural dyes have poor color fastness, so we used to mordant as dye fixing agent for good color fastness.

Keywords: Dye, bark, Colour fastness, Cotton, Plants, Natural, leaves and flowers.

1. Introduction

Natural dyes are obtained from animal, vegetable, leaves, bark. Because natural dyes are less toxic and allergenic than synthetic dyes and bio-degradable. Now a days, contributions of synthetic dyes more than the Natural dyes. Using natural dyes to products becoming important for avoiding the skin related issue. Textile chemical processing industry is one of the most environmental polluters. If process a one ton of textile product, one might have use as much as 230-270 tons of water. There are two ways to control the environmental pollution of textile processing. One is two build a sufficiently and high effective effluent treatment plants. Natural dyes have range of different shades that can be obtained from roots, insects, minerals, flowers, fruits, bark, and leaf. Instead of using synthetic dyes and also reduce the pollution apart from these advantages natural dyes have also some drawbacks like availability of dye source (Tree, Vegetables), natural dyestuff source might be found for a particular season, most natural dyes are unable to form strong bonds with fabric without any usage of mordant materials. The reason for mordant using to increase the binding nature and dye affinity to fabric and create a stronger bond in comparison to using any dye. Mordants are also improving the fastness properties. Mordants are classified as two main groups' basic and acidic mordants. Metal salts of Iron used as basic mordant and acid mordant like Alum. We

planned to produce the fully natural and eco-friendly fabric. So, we used banana sap as a natural mordant for fabric dyeing process. Banana sap is not only used as mordant but also improves all qualities of dyeing operation. It is cost effective as compared to chemical mordents and eco- friendly product [1]–[4].

2. Barks

Natural dyes are extracted from waste barks of Turkish red pine (*Pinus brutia* ten). The extracted dyestuff was applied to cotton, silk, wool, tencel, flax, polyamide, and acrylic fibre. The dyestuff powder was extracted from red pine bark by using the dye extraction machine. The machine operation contains milling, spiral conveyer, extraction unit & solvent tank, solvent removing and recycling unit & spray drying. This extraction method was carried out step by step. The barks are vacuum dried before launching the extractor and vacuum plant fluid was applied to instead of fresh water for further processing. After that completing the milling and spiral conveyer operation. In this extraction unit the bark particles were treated with 78% ethanol and 20% stock fluid for recovered the vacuuming process. The extracted dye powder was transfer into the solvent removing and recycling unit for removing ethanol from dye powder. This dye powder was using the dyeing operation. The dye concentration of 10% with m: l ratio of 1:40 at 100°C for 1hr. Conc. 20% of alum and oak ash used as mordant for this operation by using ATAC LAB DYE HT exhaustion dyeing machine. After that the dyed fabric tested with wash, rub and light fastness testing methods. Here the result is the alum mordant used dyed fabric has good light and wash fastness. And then oak ash used dyed fabric has good rub fastness. When oak ash used in dyeing operation, then it is considered fully eco-friendly method. Natural dye was extracted from Mangrove bark the extracted dye was applied to a silk fabric by using an exhaustion dyeing process. There are four mordants are used this process they are aluminum potassium sulphate, Ferrous sulphate, Copper sulphate, and Stannous chloride. After that dyeing the dyed fabric was investigated the fastness properties by using AATC test methods. Color fastness to light test was carried out by ISO standard. When silk fabric has naturally reddish brown in shade without mordant because mangrove barks are rich in tannin. While using mordant to generate a

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variety of pale to dark reddish brown in color shade, the mordants are aluminum potassium sulphate and copper sulphate. The bark was dried in sunlight and then milled to the small pieces for dye extraction, in this dyeing process we had used distilled water in the ratio of 1:10 and boiled it for one hour, and then the residue was removed then dye solution is filtered. There are four different conditions in dyeing process in used temperature, dyeing time, pH level, and dye concentration. By changing the temperature (30°C- 90°C) the dyeing efficiency is determined. Using the 50% of fabric weight in liquid ratio is 1:40, pH=5.4, time=60mins. By changing the dyeing time interval (10mins-50mins) the dyeing efficiency is determined by liquid ratio is 1:40, pH=5.4, time=90mins. Similarly the dyeing concentration (20-60) in changed for determining the dyeing efficiency. From the above experiment we have determined that when there is increase in temperature the color strength is also increasing, so temperature is directly proportional to the color. Maximum color strength yield at 90°C. Color fastness is good when using this mordants aluminum potassium sulphate, copper sulphate and ferrous sulphate except stannous chloride mordant. Similarly, the wash fastness and perspiration fastness will be good at aluminum potassium sulphate, copper sulphate, and stannous chloride. Except ferrous sulphate mordant [5]–[7]. The natural dye was obtained from eucalyptus camaldulensis bark. This dye was used to dyeing the cotton fabrics at different condition. Eucalyptus bark was yellowish brown color in naturally. In spite of natural dye have good properties, (S Ali) so, we used mordant for dye fixing purpose. The dye extraction method carried out at different condition like different temperature, different time interval. The crushed dye powder weighing 20 mg and mixed with 200 ml of distilled water. The dye solution beaker to stirring at room temperature for 20, 40, 60, 80 and 100 mins. Similarly, another set of 5 samples treated with 60°C for respect time intervals. This process continues for 100°C again. The sample solutions were soaked for overnight and stirring at room temperature and boiling temperature. Totally 25 dyeing solutions are used to dyeing process in this process. The 25 samples of cotton fabric are weighing for 4 mg and then dyeing process is done at 60°C with 1:15 m/l ratio for 60 mins by using exhaustion dyeing machines. Here 1.5 mg sodium sulphate used for better exhaustion. After completing the dyeing operation, the dyed fabrics were tested with color fastness methods. Likewise, wash fastness, rub fastness and light fastness are testing at proper manner. The obtained result shows the minimum color strength at room temperature. At 60°C the color strength slightly varies from room temperature and the maximum color strength is getting at 100°C (boiling temp). Here the conclusion of this process the pre-soaking color solution gives good color strength to the fabric by increasing stirring time up to 80 minutes. The other case of stirring process for 80 mins to promote the decreasing of color strength because the long stirring time causes the presence of impurities. Wash fastness and light fastness are good comparatively direct and direct and Sulphur dyes. The rub fastness gives quite well in dry condition poor at wet condition. *Juglans regia L* is the botanical name of Walnut tree. It belongs to Juglandaceae family. The walnut tree is valuable tree because the entire parts of the tree should be useful. Because the parts of the tree were tested with

potential dyeing substrate for different textile materials. Because the 5-hydroxy-1, 4-naphthoquinone are present in the bark of walnut tree. This the main reason for producing natural colorant on the bark. The method of extraction process of natural dye from the bark of walnut tree and application to the woolen yarn were explained here. The bark was collected and dry with sun shadow. And it was converted into the powder state. The required concentration of bark powder was soaked with ML ratio of 1:20 over the 12 hours. And then the solution was heated with temperature of simmering point (91°C-93°C) for 1 hour. Then the heated solution was cooled and filter with clean cotton cloth. The remaining residue was treated again for all color substances had been extracted. The extracted solution was used to dyeing the wool yarns. The mordanting of water and woolen yarn are soaked and heated at simmering point for 30 mins. Now the yarn rinsing done with cold water. Then the yarn was treated with dye solution for 1 hour at simmering point. The washing process is done with 5g/l of Ezee soap solution and drying with shade in room temperature [8]–[11]. The yarn was tested with color fastness like light, rub and wash fastness with Indian ISO standard. The tests are done with the samples of un-mordanting samples and pre-mordanting samples. The light fastness AATCC 16 e- 2004 gives the grading of woolen yarn is very good in pre-mordanting (10% potassium aluminum sulphate), (5% alum) samples, and un-mordanting samples also good lightfastness behavior. The same results are given by the wash fastness test which is done by Launder-o-meter with ISO standard. The rub fastness on crock meter gives the results are good for pre mordanting and un-mordanting samples. Here the conclusion for this study is good dyeing affinity and pre-mordanting process leads the good fastness properties. *Albizia Lebbeck* (Siris tree) it belongs to *Albizia* family. This family contains more than 150 species. *Siris tree's* native is forest in Asia to eastern Pakistan through India and Sri Lanka to Myanmar. The phytochemical test result shows the presence of tannin, steroid, phenolic compound and amino acids etc., the color which produced by the chemical components in the bark was light brown color. This extraction process contains four type of medium like aqueous, alkaline, acidic and alcoholic medium. After selecting correct medium which is alcoholic medium that gives the extracted dye powder at 70%, 50%, 30% alcohol ratio. The mordanting agents are common salts, alum, ferrous sulphate, lime, acetic acid, banana leaf, and ash, copper sulphate used this dyeing process. The samples are treated at 80°C for 1 hour with ML ratio of 1:30. The dye concentration of 5% and 10% varies for the sets of samples. After that dyed cotton fabric is tested with the colour fastness. The fastness test is carried over the all mordants. The test results show the fairly good for change in color of wash fastness and virtually not for staining. Color fastness to rub gives the result for dry and wet is good for all samples. Light fastness test results give grading of 4 for all samples which means the fastness is fairly good. Here the conclusion for fastness test is fairly good for light fastness, good for dry and wet rub fastness and fairly good for change in colour and virtually not for staining in wash fastness. *Terminalia arjuna* (*Marutha maram*) is the evergreen tree. It can be found in south Asian regions. This tree's bark was used for anti-dysenteric, anti- pyretic, astringent etc. *Terminalia* tree have phyto constituents like triter periods for cardiovascular properties,

tannin and flavonoids used for anti- cancer, anti- microbial properties. The presence of tannin which is useful to produce the natural colour on the tree's parts. The natural dyes are extracted from the bark of terminalia tree which used for dyeing the cotton fabrics. The barks were cleaned up with water and dried with direct sunlight. The bark was converted in to powder state and weighed for 100 g and mixed with 1 litre of water and heated in beaker which kept over a time of 2 hours. This solution was filtered and this is used for dyeing operation. The cotton fabrics are used this dyeing process with M:L ratio of 1:30 at 80°C for one hour. The mordants of this process is alum, copper sulphate, nickel sulphate, potassium dichromate, ferrous sulphate and stannous chloride. The natural mordants are cow dung, banana sap, turmeric and myrobolan [12]–[15]. The mordants are using by three ways there are pre-mordanting method, post-mordanting method and simultaneous mordanting methods. The colour fastness properties are tested with IS standards. The wash fastness test results show the good fastness of all commercial mordants. And then without mordanting and natural mordanting methods gives the poor and fairly good. The lightfastness (IS-2454-85) gives the result of quite good for averagely. Without mordanting method gives the fairly good fastness to the fabric. Rub fastness of the commercial mordants based mordanting methods give the good fastness to the fabric. Natural mordants based mordanting methods give fairly good fastness to the fabric [10], [16]–[18].

3. Fruits

1) Pomegranate

The pomegranate peel contains the colouring agent which is granatinine. This chemical component is present in N- methyl granatinine. The extraction of dye powder is prepared by the solvent extraction method. There are three mordanting methods are used to test the dye affinity like pre mordanting, post mordanting and simultaneous mordanting. The study deals with the comparison between the natural dyes and synthetic dyes. The pomegranate peels were dried under room temperature and it is converting into powder form and then the extraction process was started. The powder of 100 g was taken and it is mixed with 500 ml ethanol. This solution was heated with water bath at 60°C for 60 mins. The dye stuff material was filtered from the ethanol. This process is done by the using of Soxhlet apparatus. The dye stuff material mixed with one third of the distilled water and this solution kept in Soxhlet apparatus at 70°C for 3 hrs. After that the material was separate from the ethanol and dried at 60°C for overnight. This dye powder was directly used in the dyeing process with dyeing temperature of 80°C with M:L ratio of 1:40 for 60 mins. The mordant (FeSo₄, CuSo₄) concentration of 2% was used in three type of mordanting process and test the fastness properties after the dyeing process. Because of using three different mordant they give different shades of colour in the cotton fabric. The dark shade gives the poor rub fastness both wet and dry rubbing fastness process, medium shade gives good fastness and light shades give the very good to quite good fastness properties. Wash fastness test give the moderate fastness properties. Light fastness test shows the result of the cotton fabric is very good fastness properties by using the pomegranate peel dye powder.

Punica granatum is the botanical name of pomegranate fruit. The pomegranate fruit peel is a source of plant based yellow colour dye. This dye has a tannin content which is the main reason for yellow colour. The peel contains 81% of tannin and 19% of tanante along with pelletierine. The extraction of fresh and rind pomegranate is used to dyeing the cotton fabric. The one-part extract powder is mixed with 10 part of distilled water at 30°C and 60°C for 1hr. This solution was boiled at 100°C at ATM pressure for 1hr. And then this solution was soaking at 30°C for 1hr with constant speed of 50 rpm. This solution was used for cotton dyeing process. The 1 g of cotton fabric is treated with 15 ml of extract solution (M:L 1:15) at 60°C. This experiment has tested with different temperature for knowing the colour shade difference in the cotton fabric. After that the dyed fabric is tested with colour fastness tests. Likewise, the light exposing to the fabric for 48 hr to analyse the lightfastness. The test results show the very good fastness properties to the light. To test the rub fastness under the conditions of wet and dry at 50 strokes. The test results show the quite good in dry rub fastness and quite poor in wet rub fastness. The tannin contents provide the good affinity to the cotton fabric during dyeing process. The pomegranate peel contains the tannin content highly this the reason for producing natural dye colourant of yellow colour. The pomegranate peel was dried at room temperature. The dried peel was converting into powder form by using grinder. After the various treatments were tested and finally the extraction process was done at 28°C for 24 hr and 100°C for 1hr with the M: L ratio of 1:10 the pH range of 2-8. The extracted powder was directly used in dyeing process. The three mordanting process is done by the various range of temperature for adding the mordants into the dyeing process. Likewise, pre-mordanting is done at 28°C for 30 mins with M: L ratio of 1:20. Simultaneous mordanting also done at 28°C for 30 mins with equal mixture. Post mordanting process done at 28°C for 60 mins with M: L ratio of 1:20. The colour yielding property of this pomegranate peel dye is good and fastness of the dyed fabric also good. The anti-microbial property was tested the test show the points of anti-microbial is 8 for *E. coli* and *Klebsiella* sp and 10 points for *S. aureus* and 12 points for *Baciella* sp. *Punica granatum* L is the botanical name of pomegranate fruits. The peel of this fruits was taken into this dyeing operation because the peel contains the tannin components. This fruit was cultivated from mostly the Middle East. The pomegranate peel was dried and directly used in dyeing process. Here the pre-mordanting methods is used to produce the good colour affinity to the fabric. The mordanting agents are potassium aluminium sulfate, copper (II) sulfate, iron (II) sulfate, tin (II) chloride were obtained from Merck (Germany). The mordanting agents are taken into the 3% of concentration and potassium aluminium sulfate were taken into 20% for dyeing process at 100°C, p H – 7 for 1hr with M: L ratio of 1:40. To dyeing with and without mordanting methods for testing the dye shades and colour affinity to the fabric. After the dyeing process is done the test samples were washing by using washing agents and rinsed at 70°C for 15 min then the dyed fabric is ready for analyse the colour fastness properties. The washing fastness test results show the excellent fastness

behaviour of without mordanting samples. Pre-mordanting samples result shows the good fastness properties of the dyed fabric. Dry and wet rub fastness test gives the good fastness properties in both without and pre-mordanting process. Light fastness test samples show the excellent fastness properties of the dyed fabrics. Perspiration fastness test also gives good fastness on both acidic and alkaline medium [19]–[25].

2) *Grapes*

Vitis vinifera is the botanical name of grapes. Which used in beverage industry like wine, packed juices etc., the beverage industry released the certain amount of dye content materials. This waste materials used as natural dye sources for textile dyeing operation. This type of natural dyeing process has red/yellow colour dyes from their sources. These dyes are formed by the extraction of anthocyanin/ flavonoid dyes from fruits. The dye extraction process is done with boiling water extraction method. The presence of tannin content which helps to producing the dye affinity to the fabric. The aqueous extraction method is used to produce the natural dyes. The dyeing of wool is done by an exhaustion dyeing method using a liquor ratio of 1:20. The dyeing temperature of this process is 95°C. The mordanting agent like ferrous sulphate or alum was added in the dyeing process for dyeing fixing process. After the dyeing process, the unfixed dyeing materials were removed from the wool by rinsing three times in cold water. After that dyed fabric was tested with wet and light fastness. Wet fastness at 37°C which determined according to DIN 54006, the dyed samples were wetting in distilled water for 4h. Light fastness was determined using an artificial illumination with xenon arc light according to DIN 54004. Light fastness was identified to be major hint a general introduction of all tested natural dyes. Both wet and light fastness test results show the good fastness properties of the natural dyes on wool materials [26], [27].

4. Leaves

1) *Neem Leaves*

Neem is a medicinal plant and also diversified plant, Neem plant (*azadirachta indica*) belongs to the family of meliaceae, There are nearly 135 compounds have been found in different parts of neem, these compounds are classified in two classes of isoprenoids and others the isoprenoid compounds which includes diterpenoid, triterpenoid and it also contains azadirone, protomelions, limonoids and its derivatives such as azadirachtin and nimbin and salanin. The neem tree has containing a significant amount of saponin and cynade in a moderate level which is not harm to humans but effective to beetles and moth. The azadirachtin compound was isolated from neem extract and it plays a main ingredient to reduce the manifestation of insects. The dye was extracted from neem leaves, the main elements of neem leaves includes carbohydrates (22.0%), protein (1%), calcium, phosphorous, minerals, carotene, vitamin C etc., The neem leaves contain some properties like anti-inflammatory, anti-fungal, anti-malarial etc., Generally, the natural dyes were used to reduce the usage of synthetic dyes. Here we have used the neem leaf extract for dyeing process as well as include super hydrophobic coating on dyed fabric to maintain the color of the dye from

fabric. The neem leave has excellent quantity of flavonoid which may yield a dye which is in the colour of yellow. The dye was extracted from dried green leaves the process of dyeing includes 50g of dried neem leaves then those dried neem leaves were crushed and immersed in a 500ml of distilled water and then boiled for one hour. In commercial textile product maximum, they are using synthetic antimicrobial agents, the synthetic antimicrobial agents are triclosan, phenol and quaternary ammonium compounds, metals and salt. Generally synthetic antimicrobial agents are costly and also creates some environmental trouble because of its cost and global issues so that there is a huge demand for natural antimicrobial agent since it is eco-friendly to nature, the neem leaves are also used as antimicrobial agents. The methods for antimicrobial textile include substrate of spun bonded non-woven and cotton fabric were used, pasting of substrate with neem leaves extract and AgNO₃ and quaternary ammonium compound were enforced on SMS (spun bonded non-woven fabric) and 100% cotton fabric. Microorganisms were used to test the antimicrobial activity the list of microorganisms used for testing includes *E.coli*, *S.aureus*, *P.aeruginosa*, *B.subtilis* and *C.albicans* agar diffusion test (AATCC) was carried out for qualitative ammonium testing method, in this test the microorganism were placed above inoculated nutrient agar plate where the textile samples are placed above in close contact to the plate and then the plates were inoculated at 37°C for 18 to 24 hours. The bacterial growth has analyzing the inhibition zone if there is no bacterial growth has under the fabric while in direct contact it indicates the presence of antimicrobial activity in fabric. The extracted dye from neem leave exhibits average light fastness and good washing fastness property. The neem leaf extract shows almost same antimicrobial activity when compared to AgNO₃ and QAC treated fabric. The neem leaf extract has excellent antimicrobial activity on *E. coli* microorganism test compared to other microorganism whilst poor antimicrobial activity on *S.aureus* microorganism test [28]–[33].

2) *Mango Leaves*

Generally, *Mangifera Indica* is a medicinal plant and it belongs to *Anacardiaceae* family. Naturally the mango leaves have polyphenol component by itself. Due to the presence of polyphenol in mango leaves it plays a several pharmacologic properties such as antifungal and antibacterial and antioxidant. The Chemical structure of mangifera indica leaf is 1,3,6,7 tetrahydroxyanthane-C-2β-D glucoside. Before extracting the dye from leaves firstly we have to remove the dirt from leaves and then leaves were thoroughly washed with water and dried under sunlight after that grinded into very small particles while grinding we must remove the waste particles. The colour was extracted from the dried leaves of *mangifera indica* by using aqueous extraction process. The dye molecular structure of *mangifera indica* is a green colour. The optimize extraction medium was pH 3-12 in a liquid ratio 1:10 at 98°C for 60 min. The *mangifera indica* compounds are occupied by negatively charged hydroxide functional group. Due to the negative charge extracted dye was not directly interacted with a fabric. So that we have used mordant for dyeing process. Pre-Mordanting for silk fabric using 5% of mordants are used. The mordants are

ferrous sulfate alum, ferrous sulfate alum & tin, alum & tin, alum tin tannic acid is used in the liquid ratio 1:30 at 60°C for 1 hour. Mordanting for cotton (knit & woven) fabric which mordant has used for silk fabric the same mordant has used for cotton fabric except alum tin tannic acid, only changes in the temperature (80°C) otherwise same parameters should be followed. Mordanting of Polyester fabric only with ferrous sulfate alum tin and ferrous sulfate alum here also only changes the temperature (100°C). The dyeing parameter was 1:30 liquid ratio at 80°C for 60 minutes under pH 5. The sample was carried out in a conical flask. The dyeing process was carried out in an oscillating dyeing machine. After completing the dyeing process, the dyed fabrics were dried and investigated with the fastness properties. The ferrous sulfate mordant dyed sample shows excellent light fastness for all fabric and it shows average washing fastness for cotton fabric and it shows poor washing fastness for polyester fabric. Rubbing and Perspiration fastness also good for all fabric. Natural dye was also used in solar cells. Now a days the solar cells are mostly based on Nano structured semi-conductor composite material to achieve for high efficiency. DSSC is based on TiO₂. DSSC is a breakthrough in the field of solar cells, because it is eco-friendly, lightweight & less expensive. In this study *Mangifera indica* leaves and bougainvillea flower were used to extract the dye solution by using aqueous extraction method. The extracted dye solution was immersed in the sintered photoanode for sensitization. The UV absorption spectra of *Mangifera indica* is 380nm while bougainvillea flower extract is 360nm. The DSSC sensitized by *Mangifera indica* leave extract has high conversion efficiency and also it has higher photosensitized performance when compared to bougainvillea flower because of this better charge transfer between the TiO₂ surface and the dye molecule which depends on the dye structure [34]–[38].

5. Conclusion

The *tecoma capensis* dyes were extracted from the flowers of the *tecoma capensis* plant. The aqueous extraction method was used to extract the dye from the *tecoma capensis* plant. The extracts are yellow in colour by nature. The extracted dyes were applied on 100% cotton fabric. Mordants were used to apply the natural dye. The mordants like Alum, Copper Sulphate, Potassium Dichromate, Aloe vera and Neem were used. Three concentrations (10%, 20% and 30%) of mordant were used to apply the natural dye. The dyeing was carried out in beaker dyeing machine. After that the dyeing, the fabric samples were subjected to various testing. The wet and dry rubbing fastness of the natural dyed samples exhibits very good fastness properties against Alum, Aloe vera-Neem and Copper sulphate mordant. The natural dye exhibits good wash fastness with copper sulphate and potassium di chromate than other mordants. The other fastness properties, colour fastness to washing, light were excellent against all the mordants. The increase the concentration of mordant doesn't influence much on the colour fastness properties. Overall, the natural dye extracted from the *tecoma capensis* flower exhibits good fastness properties. So, it can be used as an alternative natural dye for mustard yellow colour. The dyed sample showed anti

microbial activity when it is introduced to the cell cultures consisting of *E. coli* and *Bacillus* microbes. It can be an added advantage when going for dyeing using this extract.

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