Natural dyes extracted from bark of Bombax ceiba Linn. locally known as semal and its application on various fabrics pretreated with eco-friendly and noneco-friendly mordant

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ABSTRACT

Synthetic dyes are hazardous and carcinogenic and also release vast amount of pollutant in the environment emphasized for this purpose. Many natural resources which are being wasted during their manufacturing thus revival of natural dyeing techniques as one of the alternative is being indiscriminately or thrown away as a waste product contain useful dyes and pigments. In the present study, natural dye extracted from bark of *Bombax ceiba Linn*. locally known as semal and its application on pre treated fabrics like Cotton, Wool, Silk and Nylon have been carried out successfully. Different shades on various fabrics have been obtained.

KEYWORDS: Natural dyes, *Bombax ceiba Linn*, Mordant, Dyeing, Eco-friendly

INTRODUCTION

Pollution may be considered one of the most important problems in recent years. Therefore, a great concern with this problem has appeared all over the world to find suitable and acceptable solutions for reducing pollution of environment. In fact there are three main methods for the reduction of pollution; these are elimination, substitution and treatment before release. One of the most important and effective ways for reducing pollution is the replacement of polluting materials and chemicals by eco-friendly natural materials.

Until the latter half of the 19th century people were using natural dyes**[1]**for colouring the textile fibre after invention of synthetic dyes, natural dyes are not used because of the advantage of synthetic dye over natural dye in respect of application, colour range, fastness properties, and availability. Some synthetic dyes are hazardous, carcinogenic and also release vast amount of pollutant in the environment during their manufacturing**.[2-9]**

Synthetic dyes are not good due to their toxic effect; and it creates allergic reaction to skin and also creates pollution. Thus revival of natural dyeing technique as one of the alternative is being emphasized for this purpose. Many natural resources which are being wasted indiscriminately or thrown away as waste product contain useful dye and pigment. Earlier studies have revealed that the waste contain many flavones which can be effectively used as dyes.**[10-11]**

India has a very rich tradition of using natural dyes. The art and craft of producing natural dyed textiles is being practiced in many villages and by some craftsmen in the country, but there is no organized effort to revive and improve the methods of dyeing and printing with natural dyes. India being tropical country has a good resource of plant dyes which can be easily integrated into textile manufacturing.

Natural dyes serve duel purposes of catering to fashion trends as well as being environment friendly. In this context, India is at an advantageous position since the country holds a rich reservoir of natural resources with potential products. According to recent studies the present Indian flora is estimated to contain about 50,000 species.**[12]**

Characteristics of natural dyes:

Majority of natural dyes have the hydroxyl groups in its structure and they are soluble or sparingly soluble in water. Some time solubility is increased by adding alkali or acid. Some of the natural dyes do not have a solubilizing group in which case a temporary solubility group is generated at time of application.
For a substance to act as a dye, certain conditions must be fulfilled:

- It must have a suitable colour.
- It must be able to fix or must be capable of being fixed to fabric.
- It must not be fugitive after fixing on fabric.

Chemistry of mordants: Most of the natural dyes are mordant dyes in nature. The mordant is the life for the vegetable colors except in the case of Indigo. Without mordant no color adheres in vegetable dyeing. The mordant acts as an agent between the fiber and the color by helping the color to penetrate into the fiber permanently, and makes it fast. Most of the natural dyestuffs will not by themselves adhere to yarn or cloth except as a surface stain which is easily washed away.

Mordant is the fixing agent which prevents the colour from either fading with exposure to light or washing out. It is a mineral salt used to help dye adhere to the material being dyed.

Some natural dyes also have the properties of mordant. There are three types of mordants:

1. Metallic mordants: Metal mordants can be defined as a polyvalent metal ion, which forms coordination complexes with certain dyes. Two types of bonds are involved in the fundamental reaction between a mordant dye and a mordant. One is a covalent bond with usually hydroxyl oxygen and the metal atom. The other is a coordinate bond with the metal with the double bonded other oxygen also referred as “chelation”. More over varying the amount of mordant with the dye is a way to exert some control over the change in hue color. The two commonest metals used in natural dyeing are aluminum and ferric ions both having valences of three.

2. Tannins: Myrobalan and Sumach are tannins used as mordant in dyeing of textile fibre.

3.Oil mordants: Oil mordants are used mainly in the dyeing of turkey red color from maddar. The main function of the oil mordant is to form a complex with alum used as the main mordant. Since alum is soluble in water and does not have affinity for cotton it is easily washed out from the treated fabric. The naturally occurring oils contain fatty acids such as palmitic, stearic, oleic, ricinlic etc. and their glycerides. The sulfonated oils which possess better metal binding capacity than the natural oils due to the presence of sulphonic acid (SO_3H) group binds metal, forming a complex with the mordant dye to give superior fastness and hue.

Eco-friendliness: The mordant that are used for fixation and development of color on textiles are mainly alum (potassium aluminium sulphate), tin (stannous chloride and stannic chloride), iron (ferrous sulphate), chromium (potassium dichromate) and Copper (Copper sulphate). Out of these, copper and chrome are red listed and have been restricted to some stipulated limits by various eco-labels. On the basis of analysis of some natural dyes like katha, jackwood, turmeric and indigo show the presence of arsenic, lead, mercury, copper and chromium less than 0.2 ppm which is much below the stipulated limit except for chromium. This shows that the natural metal contaminants in the dyes are very low and so can be used safely. But the concentrations of mordants used in dyeing are sometimes very high. Therefore optimization of mordants is necessary

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Bombax ceiba Linn. (Family Bombacaceae), the large beautiful and deciduous tree is found throughout india and other parts of tropical and sub-tropical Asia, Australia and Africa ascending the hill up to 1500m **[14]**. It is known by different names such as Red Silk Cotton tree , Indian Kapok tree (English), Shalmali (Sanskrit), Semal (hindi),semlo(gujarati), Shimul (Bengali), Mullilavu (Malyalam) Kondaburuga (Telugu) in different languages**[15]**. The plant is even mentioned in mahabharata proving its presence since a long time**[16]**.

The tree is a large sized tall, deciduous tree having straight, buttressed trunk with a clear bole and widespread branches. **The trunk and branch bark is gray in colour having hard, sharp and conical prickles**. Leaves are large, deciduous, digitate and glabrous. Leaflets 3-9, entire, lanceolate or oval, cuspidate and tip is acute. Petiole is long (up to 20 cm), petiolules 1,2-2.5 cm long, and stipules small and caducous. Flowers solitary or clustered, axillary or sub-terminal, fascicles at or near the ends of the branches, when the tree is bare of leaves. Calyx is cup-shaped usually 3 lobed. Corolla red or white, petals 5, oblong, recurved, fleshy, tomentose on the out side and sparingly pubescent inner. Staminal tube is short, more than 60 in 5 bundles. Ovary conical, glabrous, stigma 5, capsule ovoid, 5 valued dehiscing by 5 leathery, woody valves and lined with white silky hairs. Seeds are numerous, long, ovoid, black or gray in colour and packed in white cotton.

According to ayurveda, it has stimulant, astringent, haemostatic, aphrodisiac, diuretic, antidiarrhoeal, cardiotonic, emetic, demulcent, antidysenteric, alterative and antipyretic properties **[17,18]**. Besides having immence medicinal potential, it has also been used for other commercial and industrial purposes**[14]**. No adverse effect is reported on use of the plant as a drug.

Being a multipurpose uses of tree reflect intelligent approaches for its sustainable use and preservation while some are seriously causing harm to this beneficial tree species. Thousands of of *bombax ceiba* trees or branches are cut and burn in holi festival. Therefore, there is an urgent need to develop some sustainable conservation strategies and create awareness among rural and urban communities in order to preserve such a tree of immense medicinal value.

Bombax ceiba Linn :

Principal Constituents

Preliminary tests show the presence of glycosides and tannins from root, stem and leaf. **In the stem some alkaloids and in root proteins are identified. The stem bark contains lupeol and b-sitostrol** The root bark has 3 naphthalene derivatives related to gossypol (toxic principle of cotton seed) and called as 'semigossypol'. Flowers contain b-sitosterol, traces of essential oil, kaempherol and quercetin. On hydrolysis gum yield arabinose, galactose, galacturonic acid and rhamnose.

Majority of natural dyes have the hydroxyl groups in its structure and they are soluble or sparingly soluble in water. Some time solubility is increased by adding alkali or acid. Some of natural dyes do not have a solubilising group in which case a temporary solubility group is generated at time of application.

Materials and Method:
Bark with conical prickle collected were collected and dried at room temperature. Then ground and sieved.

Extraction of dye: 100 gram dry powder was taken in 1 litre water and allowed to stand for overnight. Next day the mixture was boiled for 30 minute and then filter with cotton cloth and with simple filter paper to get a clear solution. The weight of dry powder after dye extraction was taken to know the concentration of dye. pH of dye solution was measured. (Weight of the dry powder after extraction was 80 grams and pH of the dye solution was 7 to 8)

Dye solution was taken according to M:L ratio 1:30 for 10% shade and 10 % common salt solution with respect to weight of material was added. The dye bath was warm to which mordanted fabric sample was entered and the temperature was increased up to boiling (85 to 90º C) for cotton and nylon for 25-30 minute and (55 to 60º C) for wool and silk for 20-25 minute. The pH of dye bath was measured. The sample was allowed to cool in the dye bath then washed in cold water, squeeze and dried in shade.

Spectral analysis of dye extract:
IR spectra of dye extract were obtained by using-IR Spectrometer Perkin Elmer Spectrum GX Range: 10,000 cm-1 to 370 cm-1; ATR accessory for reflectance measurement; IR Quant software; Spectrum search software. Spectra were recorded in 4000-400 cm^{-1} by filling the solid dye extract under a form of thin film of potassium bromide (KBr) spectral pellets.

UV-VIS absorption spectra of dye extract were obtained by using a LAMBDA 19 UV/VIS/NIR spectrophotometer at Data interval 1.0000 nm, Scan speed 240.00 nm/min, Slit width 5.0000nm, Smooth band width 8.00nm.

Result and Discussion:

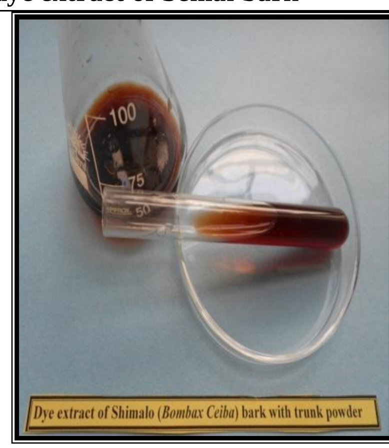
The IR spectrum was performed to identify the functional groups present in extract based on the peak values in the region of infrared radiation. IR studies enable the identification of the chemical constituents and elucidation of the structures of compounds.IR spectra and UV spectra was used to determine the functional groups present in dye extract.

$$\text{Total soluble matter content} = \left[\begin{array}{l}\text{Dry wt. of waste}\\ \text{leaves/bark}\end{array}\right] - \left[\begin{array}{l}\text{Dry wt. of insoluble matter}\\ \text{after extraction}\end{array}\right]$$

Photograph-1 Dry bark with trunk, powder of bark with trunk and dye extract of Semal bark

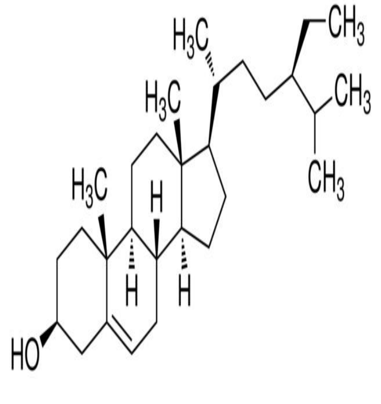
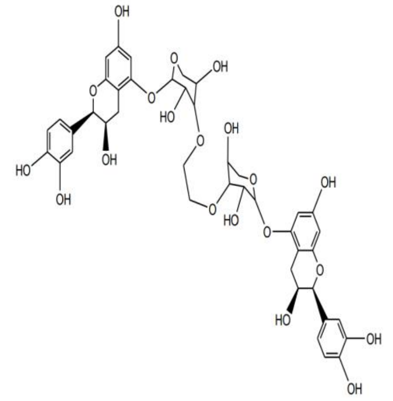
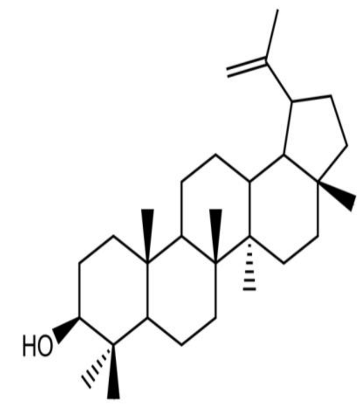
Bark with trunk of Semal

Bark with trunk powder of Semal



Dye extract of Semal bark

Dyeing procedure: Fabric samples (Cotton, Wool, Silk, and Nylon) were scoured in mild detergent solution and dried in shade then weight accurately and further soaked in water and treated with 10% mordant solution for 30 minutes at room temperature. Mordants were used eco-friendly and non eco-friendly shown in **table-1**

Figure-1 Structures of β-sitosterol, Shamimicin, and lupeol present in Semal stem bark		
		
β-sitosterol	**Shamimicin**	**Lupeol**

Source of images: Google Images

Characteristics of Semal stem bark extract

The colour was extracted in water without using any chemical reagent shown in photograph 1. pH of the extract was measured and it was 7.8 slightly alkaline. Colour of the extract was orange red. In order to get exact reproducibility in shade it is important to determine the percentage soluble matter was calculated and it was 1.8 percent.

IR spectra were recorded in 4000-400 cm^{-1} by filling the solid dye extract under a form of thin film of KBr spectral pellets.

Graph-1 IR of Semal stem bark

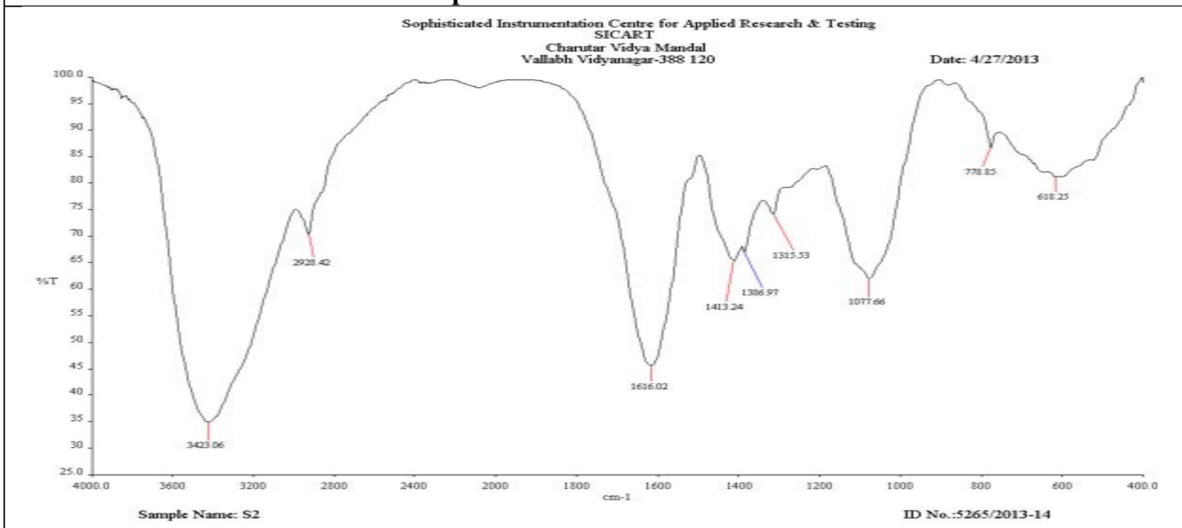
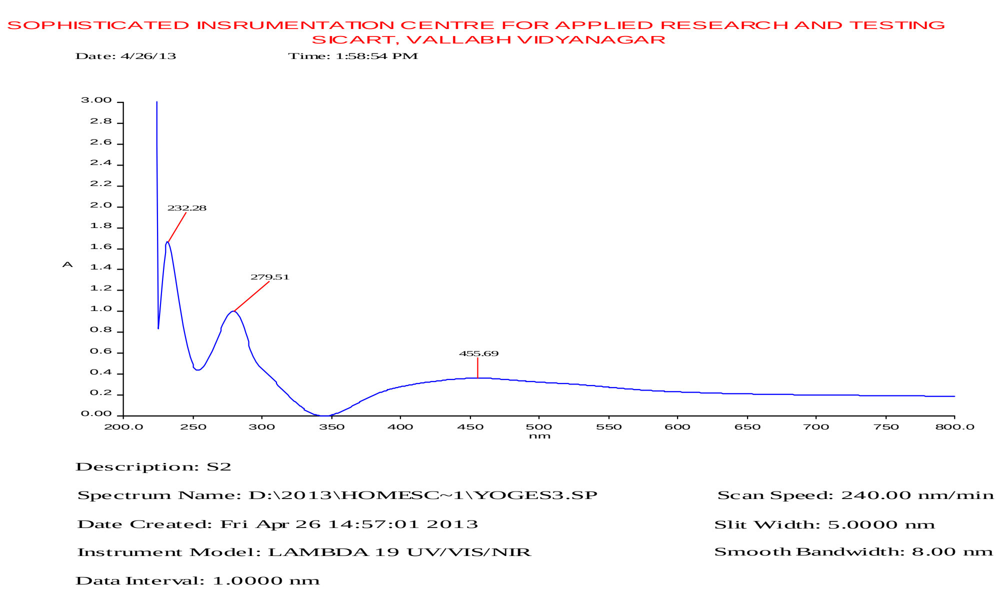


Table- 4.12 Characterization of functional group in extract of Semal stem bark

Sr. No.	Absorbency peak obtained in cm^{-1}	Intensity	Characterization of Functional Group	Inference from IR spectra
1	3423	Strong, broad (3200-3600)	O-H stretching	It can be concluded that Shamimicin present in Semal bark. And it is a derivative of anthocyanine (orange red) compounds IR data also suggest presence of anthocyanine related compounds.
3	2928	Strong 2850-3000	C-H stretching	
5	1616	Variable , medium-weak, multiple bands,(1400-1600)	-C-H bending, C=C aromatic stretching	
6	1413	Variable , medium-weak, multiple bands,(1400-1600)	-C-H bending, C=C alkenes and aromatic stretching	
7	1386	Variable , medium-weak, multiple bands,(1400-1600)	- C=C aromatic stretching	
8	1315	medium-weak (1080-1360)	C-O stretching	
9	1077	Strong (1050-1150)	C-O and C-O-C stretching	
10	778	Strong (675-1000)	=C-H bending	
11	618	Strong (450-650)	C-O-H bending	

Characterization of functional group in Semal bark extract with the help of IR spectra. IR spectra showed that -OH group is in the region of wavelength absorption 3423 cm^{-1} with a very strong and broad signal. Cluster C = C are in the catchment area with a wavelength of 1616 cm^{-1}.In the catchment area 1413 cm^{-1} indicates the presence of C=C of aromatic group. And the absorption band 1077 cm^{-1} indicates the presence of C-O group. And a catchment area with a wavelength of 778 cm^{-1} indicates =C-H group. Pick range between 450 to 650 is for C-O-H bending. All band confirm the presence of anthocyanine related compounds present on dye. There is no peak in the range of 1700 to 1800cm^{-1}indicated absence of carbonyl (C=O) group.

Graph-2 UV of Semal stem bark extract



UV-Vis spectra obtained from dye extracted from Tropical Almond leaves exhibits three absorption bands at 455.69, 279.51 and 232.28 nm. Broad peak obtained in visible region at 455nm and in UV region at 279 nm indicate presence of anthocyanine and related compound. while peak at 232nm indicate presence of conjugated isoprene related compounds.

Cotton, wool, silk, and nylon fabric dyed with Semal stem bark extract with and without mordants:

Semal stem bark extract contain several anthocyanine, flavonoids, saponines and phytosterols. Due to this chemical richness stem bark extract were used in this study to dye cotton, wool, silk and nylon. Experiment was carried out using various eco-friendly mordant and non eco-friendly mordant (for comparison only).

Due to this chemical richness extract was used in this study to dye cotton, wool, silk, and nylon. Experiment was carried out using various eco-friendly mordant and non eco-friendly mordant (for comparison only) listed in table-1 Different shades like pink, brown, yellow and grey black were obtained which are also shown in shade card.

TABLE-1

Eco-friendly mordent:

	Fabric / Mordant (10%)	Cotton	Wool	Silk	Nylon
1	Fabric before dyeing				
2	Without mordant				
3	Terminalia catappa (indian almond)				
4	Curcuma longa (Turmeric extract)				
5	Terminalia chibula (Harde extract)				
6	Tannic acid				
7	Punica Granatum (Anar Chal extract)				
8	Na_2CO_3				
9	CH_3COOH				
10	Alum				
11	$Fe(NO_3)_3$				
12	$FeSO_4$				

Non eco-friendly mordant

	Fabric Mordant (10%)	Cotton	Wool	Silk	Nylon
13	$K_2Cr_2O_7$				
14	$SnCl_2$				
15	$CuSO_4$				

Conclusion:

Natural dyes are safe and eco-friendly and textiles dyed with natural dyes are almost free from hazardous chemicals. **Red listed mordants may be either avoided or may be optimized as per eco-standard, without impairing the desirable properties (e.g. fastness) of the textiles**

Simal trees are easily found in our region. Trunk with bark can be collected and used for dyeing variety of colours on cotton, wool, silk, nylon very effectively. After extraction of dye, remaining matter can use as fertilizer So the process of dyeing is totally eco-friendly.

The present investigation deals with the waste utilization of the natural resources. The commercialization of the present process will be helpful for their viable application in handloom and textile industries. Further, this will also have great impact especially for the economic growth of the rural weaver communities.

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