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Cotton Dying with Natural Dye Extracted from Flower of Bottlebrush (*Callistemon citrinus*)

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Abstract:

A renewed international interest has arisen in natural dyes due to increased awareness of the environmental and health hazards associated with the synthesis, processing and use of synthetic dyes. The present investigation was carried out to extract natural dye from *Callistemon citrinus* plant. The dye was extracted by boiling method. A part of the extract was autoclaved. Both the autoclaved and non-autoclaved *Callistemon citrinus* flower dye was used for dying the scoured cotton cloth using two mordants viz. Copper sulphate and ferrous sulphate. Study about fastness tests of dyed clothes was undertaken. The relative colour strength of the dye was determined in terms of K/S value with respect to autoclaved and non-autoclaved extract. Good light fastness, rub fastness and wash fastness was observed in fabrics mordanted with ferrous sulphate. The relative colour strength of the dye was found to be more in case of cotton clothes mordanted with ferrous sulphate.

Keywords: Natural dye, *Callistemon citrinus*, Mordants, Fastness

1.0 Introduction:

Dyeing is an antediluvian art, which predates written records. It is the most important part in the production of fabric. But the use of natural dyes for textile dyeing purposes, decreased to a large extent after the discovery of synthetic dyes in 1856 (Krani and Goodarzian, 2010). Although available at a cheaper cost, use of synthetic dyes led to such consequences as carcinogenicity and inhibition of benthic photosynthesis (Adeel *et al*., 2009). The chemicals used for dying purpose are toxic to the environment also. Textile processing industry is one of the major environmental polluters. In order to process a ton of textile, one might have to use as much as 230 to 270 tons of water. The effluent generated by this much water would pollute the environment as it contains a heavy load of chemicals including dyes used during textile processing (Ali, 2007). Over 7 x 10^5 tones and approximately 10,000 different types of dyes and pigments are produced world-wide annually. It is estimated that 10-15% of the dye is lost in the effluent during the dyeing process (Iqbal and Ashiq, 2007). Thus, there are two main ways to limit the environmental impact of textile processing. One is to construct sufficiently large and highly effective effluent treatment plants, and the other way is to make use of dyes and chemicals that are environment friendly (Ali, 2007). Therefore, more interest has been shown in the use of natural dyes and a limited number of commercial dyes since the mid-1980s, and small businesses have started to look at the possibility of using natural dyes for coloration (Jothi, 2008). Plants are known to produce some of the most valued dyes in the world for their natural, beautiful and durable colors. Natural dyes have better biodegradability and generally have higher compatibility with the environment. The natural dyes are clinically safer than their synthetic analogues in handling and use because of non carcinogenic and biodegradable nature (Aminoddin and Haji, 2010).

Dyeing textile using natural dyes was found to yield poor colour, have inadequate fastness properties. To overcome such hassle mordants are used. Metal ions of mordants act as electron acceptors for electron donors to form co-ordination bonds with the dye molecule, making them insoluble in water (Mongkholrattanasit *et al.*, 2011). Common mordants used are alum, chrome, stannous chloride, copper sulphate, ferrous sulphate etc. (Kulkarni *et al*., 2011). The flower of *Cordia Sebestena* dye could be successfully used for dyeing of cotton to obtain a wide range of soft and light colours by using combination of mordants (Kumaresan *et al.* 2012). *Callistemon citrinus*, commonly known as Bottlebrush plant belongs to the family Myrtaceae. This tree derives its name from the fact that the bright red flowers that it bears have the shape of a bottle brush. Bottlebrush trees grow superbly in the regions where the climate is warm, humid, and receive full sunlight.

In the present investigation flowers from bottlebrush plant was used for extracting the dye and examined its possible usage in textile colouration. The effect of mordants employed in the dyeing with the bottle brush flower dye was also studied.

2.0 Methodology, Materials and Methods:

2.1 Materials:

2.1.1 Source:

The garden ornamental flower Bottlebrush *(Callistemon citrinus)* was collected from the Gauhati University campus.

Fig. 1: Bottle brush *(Callistemon citrinus)*

2.1.2 Substrate:

The 100% cotton cloth was used as substrate.

2.1.3 Chemicals:

The basic chemicals used were:
Sodium-carbonate (Merck)
Ferrous-sulphate (Merck)
Copper-sulphate (Merck)

2.2 Methods:

The dyeing of the cotton clothes was basically done in four stages; pre-treatment, extraction of dyes from flower, mordanting and Dyeing as described by Jothi, 2008.

2.2.1 Preparation of Raw Material

The samples were collected from their natural bindings and washed thoroughly with running water and then with de-ionized water to remove the impurities.

2.2.2 Extraction of colorant

The cleaned samples were crushed, dissolved in de-ionized water and then boiled for 2 hours in a hot water bath for quick extraction. At the end of 2 hours, the total color was extracted. The solution was then double filtered and used to carry out our study.

2.2.3 Scouring of Cotton

Cotton clothe was washed in a solution containing 0.5 g/L sodium carbonate and 2 g/L non-ionic detergent solution at 50 ^{0}C for 25 min. The non-ionic detergent used here was Neutral Rankleen (RFCL limited). The ratio maintained during scouring was 1:40.This was followed by washing of the scoured material thoroughly with running water and then with de-ionized water which was then allowed to dry out completely at room temperature.

2.2.4 Mordanting

The scoured material was soaked in de-ionized water for 30 min and then mordanted with ferrous-sulphate and copper-sulphate. 16g mordant was dissolved in 200ml de-ionized water to make the liquor. The wetted sample was then entered into the mordant solution which was then brought to heating in the dye bath at 80^{0}C for a period of half an hour and was left in that state of heating for half an hour. The mordant material was then rinsed, squeezed and dried. Mordant cotton clothes needed be used immediately for dyeing because some mordants are very sensitive to light.

2.2.5 Dyeing

The cotton cloth samples was dyed with flower extract solution directly and gently boiled for 45 min by maintaining the temperature at 75 ^{0}C on a hot plate. The pH was maintained at 4. The samples were kept overnight along with the boiled flower extract, next day then air dried. Washing of the clothes were performed first with running water and then with washing soap to see the consistency of the color.

2.2.6 Autoclaving

One part of the extracted dye was autoclaved at 15lb/inch^2 for 15 minutes and then dying was followed in the similar procedure as mentioned above. Autoclaving of the extracts was done to avoid contamination and in order to observe any change in the colour intensity.

2.2.7 Fastness Test

The dyed material was tested for wash fastness, light fastness and rub fastness. The colour fastness is usually rated either by loss of depth of colour in original samples or it expressed by staining scale. Wash fastness of dye is influenced by the rate of diffusion of dye and state of dye inside the fiber (Jothi, 2008). The wash fastness was carried out by washing the dyed fiber with non-ionic soap (1g/L) (Kulkarni *et al*., 2011). Direct sunlight was used for determination of Light fastness of the dyed samples for tenure of 8hrs for two consecutive days. The rub fastness of the dyed fiber was carried out by rubbing the fiber and checking for fading of color (Kulkarni *et al*., 2011).

2.2.8 Measurement of Color Strength:

The K/S values were calculated by The Kubelka - Munk equation (Salikhov and Idriskhodzhaev, 1978).

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

Where R is the reflectance of the dyed fabric at λmax, K is the absorption coefficient and S is the scattering coefficient. The relative color strengths (K/S values at λmax) was determined with respect to autoclaved and non-autoclaved extract as follows:

$$\text{Relative Color Strength} = \frac{(K/S)_{\text{autoclaved}}}{(K/S)_{\text{non-autoclaved}}}$$

2.2.9 Absorption Spectra:

The absorption spectra of the dye solutions were measured using a UV-VIS spectrophotometer.

3.0 Results and Discussion:

Purple colour pigment was obtained from the crude extract of bottlebrush flower. However, the consistency of the color became a bit dark in case of autoclaved extract. It was observed that the absorbance of autoclaved solutions was more than the non-autoclaved solutions (Fig. 2). This showed that the dye content of the autoclaved bottle brush solution is more than the non-autoclaved solution. Similarly, the reflectance spectra of the autoclaved bottlebrush extract was considerably less than that of the non-autoclaved extract indicating that the color strength of autoclaved extract was higher than its non-autoclaved counterpart (Fig. 3). Mordants play very important role in imparting color to the fabric. The mordants used in combination in different ratios gave varying shades. Better color strength results are dependent on the metal salt used (Kamel *et al.*, 2009).

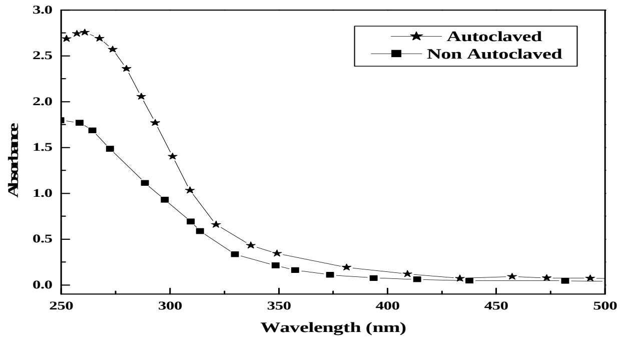

Fig. 2: Absorbance spectra of autoclaved and non-autoclaved bottlebrush flower extract

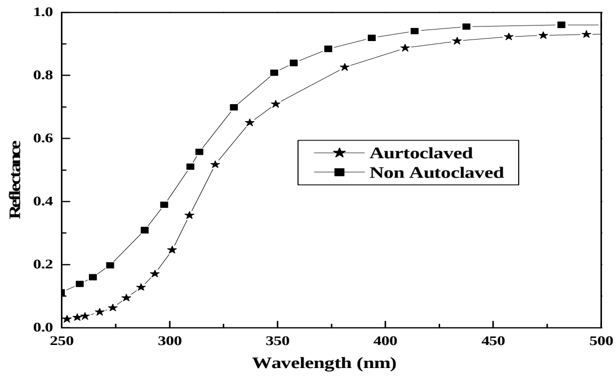

Fig. 3: Reflectance spectra of autoclaved and non-autoclaved bottlebrush flower extract

$FesO_4$ and $CuSO_4$ used as mordants in our study played an important role in imparting color to the fabric. Ferrous sulphate and Copper sulphate have the ability of forming co-ordination complexes (Coordination numbers are 6 and 4 respectively). Functional groups such as amino and carboxylic acid on the fiber can occupy the unoccupied sites on interaction with the fiber. Thus, a ternary complex is formed by the metal salt on which one site is with the fiber and the other site is with the dye (Mongkholrattanasit *et al*., 2011). Different shades of yellow were obtained from the dye extracted from the flowers of *Tecoma stans*. These different shades are obtained from a single dye, using different mordants like Copper sulphate, Ferrous sulphate, Ferric chloride, Potassium dichromate, myrobolon and cow dung (Chandra Mohan *et al.* 2012). The mordanted cotton clothe was immediately used for dyeing because some mordants are light sensitive. The chromatophore of the dye makes it resistant to photochemical attack, but the auxochrome may alter the fastness (Jothi, 2008). In the present study the cotton cloth mordanted with $FeSO_4$ showed comparatively good colour yield (Fig. 4).

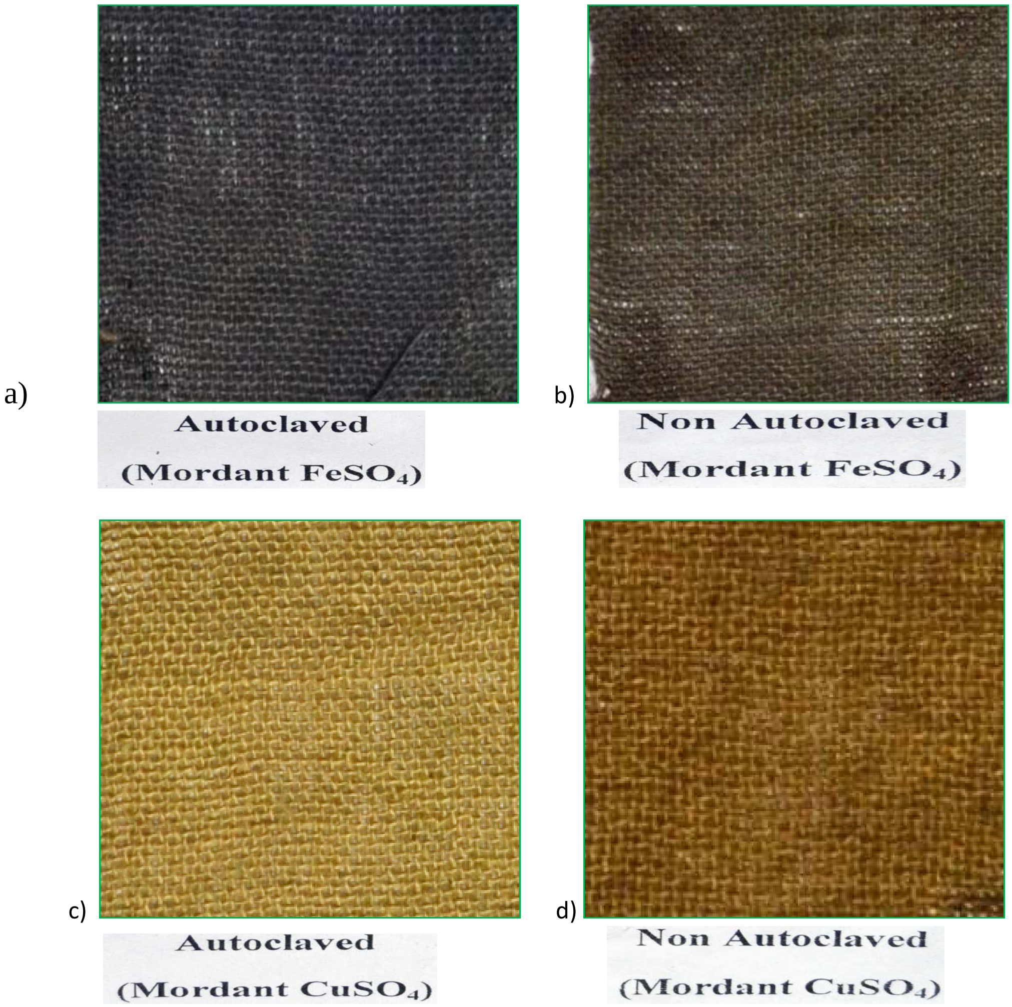

Fig. 4: Application of dye on cotton cloth

The fiber dyed with bottlebrush flower extract showed good wash fastness, good rub fastness and good light fastness as well. The good light fastness is due to the formation of a complex with transition metal which protects the chromophore from photolytic degradation, and the photons sorbed by the chromophoric group dissipate their energy by resonating within the six member ring thus formed, and hence protecting the dye. Mordants resulted different shades to the fabric. It has been observed that the washing conditions also caused shade changes on dyed fabrics (Tepparin *et al.* 2012). Similarly, wide range of soft and light colors was also reported on silk using the dye extracted from flower of *Spathadia campanulata* (Kumaresan *et al.* 2011).It has also been reported that that the ethanolic extract of *Sesbania aculeata* yields a range of camouflage shades (Swami *et al.* 2012). The two mordants used not only caused differences in hue colour but also significant changes in the K/S values. Dyeing the cotton clothes mordanted with $FeSO_4$ showed comparatively high K/S value irrespective of whether the extract was autoclaved or not (Fig. 5). Most of the metal salts exhibited highest K/S values due to their ability to form coordination complexes with dye moles. This strong co-ordination tendency of Fe enhances the interaction between the fiber and the dye, resulting in high dye uptake, while all other metals show similar coordination (Jothi, 2008).

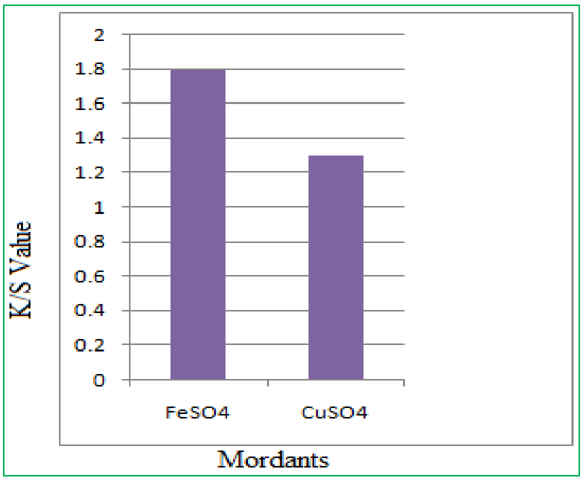

Fig. 5: K/S values of cotton dyed with Bottlebrush Flower extract with two different mordants

4.0 Conclusion:

The present investigation unveiled that the bottlebrush flower has the dying potential as a source for cotton dyeing. The use of mordants, on the other hand resulted in good fastness exhibited by the cotton clothes. Moreover, autoclaving of the extract was also reported by us for the first time, which led to good colour yield and fastness. The significance of the above study lies in the ecofriendly approach of the experiment. Furthermore, detailed scientific studies with natural dyes have established that in most cases their properties are comparable to those of synthetic dyes. Therefore, if natural dyes have to be commercialized, they need to conform to the same stringent standards of performance that are applied to synthetic dyes. It thus follows that much more research and developmental effort needs to go in this area. The traditional practices may have to be substituted by modern, more scientific practices in order to overcome some of the so-called disadvantages of this dye.

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