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Ultrasonic dyeing of cotton fabric with aqueous extract of *Eclipta alba*

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Abstract

The dyeing of cotton fabric using *Eclipta* as natural dye has been studied in both conventional and sonicator methods. The effects of dyeing show higher color strength values obtained by the latter. Dyeing kinetics of cotton fabrics were compared for both the methods. The time/dye uptake reveals the enhanced dye uptake showing sonicator efficiency. The results of fastness properties of the dyed fabrics were fair to good. CIELAB values have also been evaluated.

Keywords: Ultrasonic dyeing; Natural dye; *Eclipta alba*; Cotton

1. Introduction

Before the turn of the century natural dyes were the only source of color available and, therefore, they were widely used and traded, providing a major source of wealth creation around the globe. The synthetic dyes led to the collapse of a huge industry and gave rise to a redistribution of wealth, to the small companies now providing a large proportion of the world's coloring matters. However, due to German ban on azo dyes, currently there is a move to find renewable sources to supplement the need for safe dye industry and this trend has led to research into the production of natural dyes on a commercial-scale.

It is necessary to study and optimize the dye production in species of interest so that the crop that produced dye can compete in a world market dominated by relatively cheaply produced synthetic products. Several natural plant dyers were used alongside indigo, before dyes were produced synthetically, including species from many different genera and families. *Eclipta alba* [1,2] is an annual herb, with leaves which are rich source of natural dyes.

In continuation with our work using ultrasonic dyeing [3–9], the present study investigates the dyeing and fastness properties of *Eclipta* for cotton fabrics. Different factors affecting dyeability and fastness properties were investigated to show the commercial viability of *Eclipta* and also to meet the ecofriendliness parameters.

Ease of growing the *Eclipta* plantation, abundance and ease of extraction of colorant make it very interesting source of natural dye. The revival of natural dyes has prompted to screen newer natural dye sources, therefore, it is with this aim that the present paper is to investigate the dyeing property with *Eclipta*, a cheap and abundantly available plant, and develop methods to optimize its dyeing characteristics of natural dyes.

2. Materials and methods

2.1. Dye material

E. alba is an erect or prostrate, much branched, strigosely hirsute, annual herb often rooting at the nodes,

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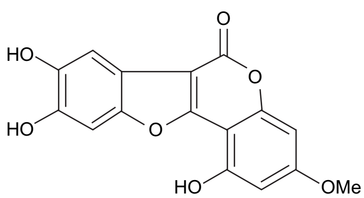
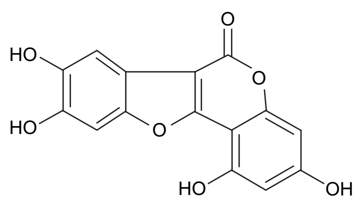
with opposite and sessile, leaves. The herb is used as a tonic and de-obstruent in hepatic and splenic enlargements and in skin diseases. The plant juice is administered in combination with aromatics for catarrhal jaundice. The fresh juice of leaves is applied on the scalp for promoting hair growth. The plant possesses anti-hepatotoxic and anti-inflammatory activities. The fresh plant is considered anodyne and absorbent.

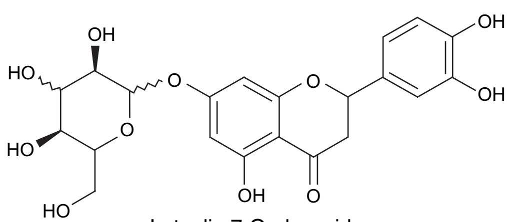
The methanolic extract is a dark green solution with a characteristic odor. Its principal constituent is the herb which contains wedelolactone [10] and demethyl wedelolactone which were isolated by column chromatography. The presence of flavones apigenin and luteolin, as the flavone-7-*O*-glycoside and the flavone-*C*-glucosides are the main colorant.



Wedelolactone



Demethyl-wedelolactone



Luteolin 7-O-glucoside

2.2. Fabric and mordants

Plain weave, white cotton broad cloth, which is generally used for dyeing was selected.

The mordants used for study were alum, stannous chloride, stannic chloride, ferrous sulphate, copper sulphate and potassium dichromate.

2.3. Preparation of the fabric

The fabric was desized in a liquor containing 5 g of nonionic soap in a liter of water. The material to liquor ratio was taken as 1:40. The fabric was boiled at 95 °C for 1 h and rinsed thrice in cold water, and dried under shade. The desized cotton fabric was treated with tannic acid solution. The material to liquor ratio was 4% (owf). The fabric was soaked in the tannic acid solution for 4–5 h and then air dried.

2.4. Dye extraction

Development of standard methods of extraction could considerably reduce the time required for dyeing and also assist in standardization of shades. In our case dye was extracted in aqueous medium by boiling in water for dyeing. The extraction was carried out for 3–4 h. The solution was then evaporated to half of the original volume and used for dyeing. The UV–VIS spectrum was recorded at wavelength 400–800 nm with the maximum absorbency of 1.300. The peak at 402 nm is characteristic peak for flavanoids while the peaks at 532, 608 and 665 nm is for chlorophyll pigment.

2.5. Mordanting

To fix the dye on the cotton fabric, the method of mordanting tried is pre-mordanting involving treatment of fabric with metal salts such as alum, stannic chloride, stannous chloride, ferrous sulphate, copper sulphate and potassium dichromate followed by dyeing.

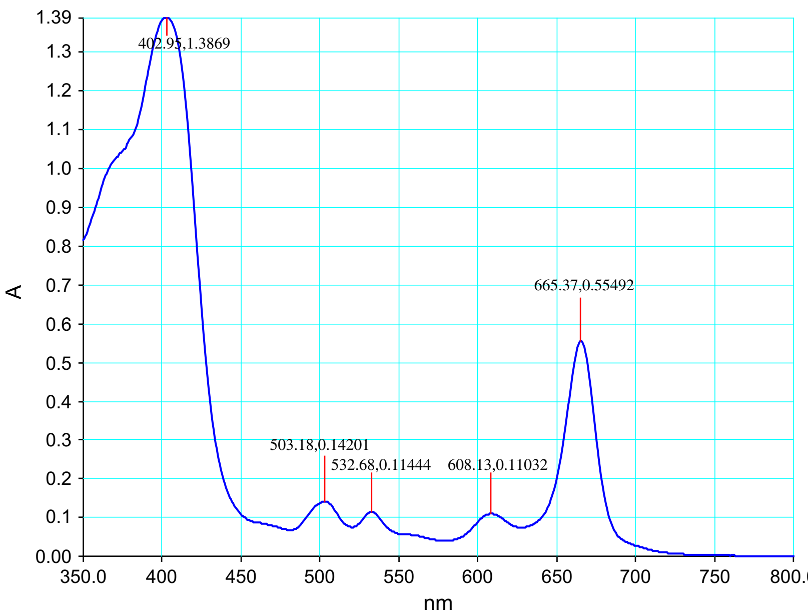
2.6. Dyeing in sonicator

Ultrasound can enhance a wide variety of chemical and physical processes, mainly by generating cavitation in liquid medium. The sonicator used is of 20 kHz frequency [11] which is found to be suitable for inducing cavitation. It is well known that cavitation which causes formation and collapse of microbubbles is most effective for better dye uptake. The microbubbles which are unstable slowly grow in the process of oscillation. Finally they implode violently, thereby generating momentary localized high pressures and temperature. This activated state causes chemical reaction between the fabric and the dye by forming shock waves and severe shear force capable of breaking chemical bonds.

2.7. Fastness testing

The dyed cotton fabrics were tested according to standard methods: the specific tests were for color

Eclipta alba



Visible spectrum of Eclipta extract

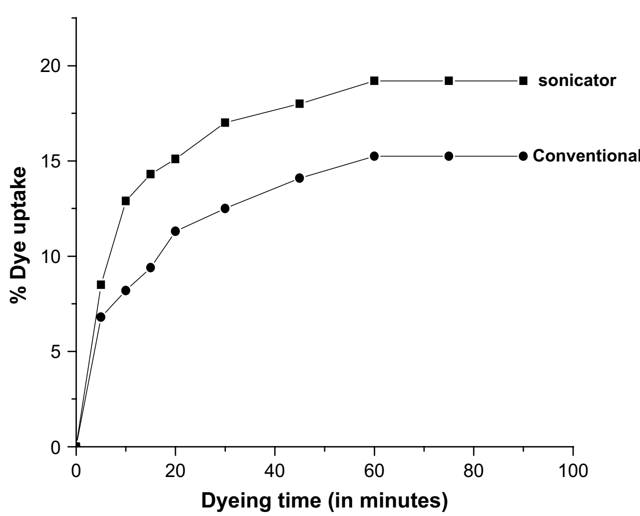


Fig. 1. Results of better dye uptake by sonicator.

Table 1
Color obtained and L^*, a^*, b^* values for dyed cotton with *Eclipta* dye

Pre-mordanting	Color obtained	L^*	a^*	b^*
Alum	Brown green	73.222	−5.145	38.737
Ferrous sulphate	Blackish green	63.333	−4.154	28.878
Stannous chloride	Yellowish brown	77.546	−3.011	35.209
Copper sulphate	Dark mehndi green	63.127	−1.158	36.267
Potassium dichromate	Light mehndi green	65.034	−3.312	35.050
Stannic chloride	Khaki	69.213	−4.355	40.897

fastness to washing IS-687-79, color fastness to rubbing IS-766-88, color fastness to light IS-2454-85 and color fastness to perspiration IS-971-83.

3. Results and discussion

It has been experienced by us as well as Kamel et al. [12] that ultrasound energy has great potential in industrial processes as it offers reduction in cost, time, energy and effluents. Dyeing with *Eclipta* leaf extract by sonicator gives better dye uptake as compared to conventional method as shown in Fig. 1, and it also does give some variation in color unlike Tulsi leaf extract [13] which dyes only in shades of green. The color adherence to fabric is good. Since the dyeing process involves a fast adsorption process and subsequently a slow diffusion process, the latter will determine the rate of dyeing with *Eclipta* extract. The absorbances are recorded at initial and final time to calculate the rate of the reaction as absorbance of the dye bath is directly related to concentration of dye bath.

3.1. Shades obtained

The CIELAB values shown in Table 1 show that copper sulphate and ferrous sulphate show darker color as compared to other mordanted fabrics. With stannic chloride, stannous chloride and alum khaki brown, yellowish brown and brownish green shades are obtained, respectively. With ferrous sulphate blackish green color is obtained. *Eclipta* extract dye is good in terms of color fastness as shown in Table 2. In general we can conclude that *Eclipta* dye exhibits fair to good fastness to rubbing and good fastness to light and washing. Hence this dye is well suited for cotton which

Table 2
The fastness properties of *Eclipta* dye extract

Mordant	Dyed fastness properties						
	Pre	Wash	Light	Rubbing		Perspiration	
				Dry	Wet	Alkaline	Acidic
Stannic chloride	Khaki brown	4/5	4−5	4	3/4	4/5	4/5
Stannous chloride	Yellowish brown	3/4	4	3	3/4	4	4
Ferrous sulphate	Greenish black	4	4	3−4	3−4	4	4
Alum	Brownish green	4	4	3/4	3−4	3−4	3−4
Potassium dichromate	Light mehndi green	4	4	3−4	3−4	3−4	3−4
Copper sulphate	Dark mehndi green	4	4	4	4	4	4

Shades obtained by Eclipta alba on Cotton fabric with different mordants

1 = $CuSO_4$, 2 = $FeSO_4$, 3 = K_2SO_4-$Al_2(SO_4)_3$, 4 = $SnCl_2$, 5 = $K_2Cr_2O_7$, 6 = $SnCl_4$

is subjected to laundering more often than their synthetic counterparts.

3.2. Sonicator efficiency

The efficiency of the sonicator was calculated by the extent of dye uptake over a period of time.

$$\text{Sonicator's efficiency }\% = \frac{\text{Dye uptake by fabric}_{\text{son}} - \text{Dye uptake by fabric}_{\text{con}}}{\text{time}}$$

As shown in Fig. 1, the value of sonicator dyeing efficiency is higher than conventional dyeing which indicates that sonicator dyeing is more effective. As the use of sonicator is for more economical dye uptake it eventually works out to be cost effective too.

4. Conclusion

The environmental activists are supportive of using natural colorants as they are seen to be exploiting renewable resources, causing minimum pollution and having less risk to human health. There is currently a demand for natural dyes in a niche market that could be expanded. The large scale production of textiles dyed with natural dyes is a new concept for the textile industries. We hope that *Eclipta* dye extract will definitely find great use in cotton industry especially in green, brown and yellow color range dyeings. The sonicator dyeing shows 7–9% efficiency higher than conventional dyeing.

Acknowledgement

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