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Eco-friendly dyeing of wool fabric with a natural dye extracted from barks of *Odina wodier*

P. Saravanan[1], G. Chandramohan[2], J. Mariajancyrani[2] and K. Kiruthikajothi[3]

[1]*Department of Chemistry, Kings College of Engineering, Punalkulam, Thanjavur, Tamil Nadu, India*
[2]*Department of Chemistry, A. V. V. M. Sri Pushpam College, Poondi, Thanjavur, Tamil Nadu, India*
[3]*Department of Chemistry, Bharathiyar University, Coimbatore, Tamil Nadu, India*

ABSTRACT

*The present investigation was carried out to eco-friendly dyeing of wool with natural dye from barks of Odina wodier. It belongs to family Anacardiaceae, commonly known as votiyar tree. The dye has good scope in the commercial dyeing of wool in textile industry. In the present study, bleached wool fabrics were dyed with different chemical and natural mordants. Dyeing was carried out by pre-mordanting, post mordanting and simultaneous mordanting. The dyed wool fabrics have shown good washing, light and rubbing fastness properties. The various colour changes on wool were measured by computer colour matching software. The range of colour developed on dyed fabrics were evaluated in terms of (L*a*b*) CIELAB coordinates and the dye absorption on the wool was studied by using K/S values. ICPMS studies have proved that, heavy metals such as antimony, arsenic, cadmium and lead were not present in the dye extract.*

Keywords: *Extraction, natural dye, barks, Odina wodier, wool, textiles.*

INTRODUCTION

The natural colourants that are safer and eco-friendly in nature are emerging globally, leaving synthetic colourants behind in the race. Natural dyes have many advantages over synthetic dyes [1]. Natural dyes are known for their use in colouring of food substrate, leather, wood as well as natural fibers like cotton, silk, wool and flax as major areas of application since ancient times. Natural dyes may have a wide range of shades and can be obtained from various parts of plants including leaves, seeds, roots, bark, flowers, fruit, etc. Since the advent of widely available and cheaper synthetic dyes in 1856 having moderate to excellent colour fastness properties, the use of natural dyes having poor to moderate wash and light fastness has declined to a great extent. However, recently there has been revival of the growing interest on the application of natural dyes on natural fibers due to worldwide environmental consciousness [2]. In many of the world's developing countries, natural dyes can offer not only rich and varied source of dye stuff, but also the possibility of an income through sustainable harvest and sale of these plants [3].

The use of natural dyes for textile dyeing purposes, decreased to a large extent after the discovery of synthetic dyes in 1856. As a result, with a distinct lowering in synthetic dye stuff costs, the natural dyes were virtually unused at the beginning of 20th century [4]. Presently there is an excessive use of synthetic dyes, estimated at around 10 $x10^6$ tons per annum, the production and application of which release vast amount of waste and unfixed colorants causing serious health hazards and disturbing the eco-balance of nature. Nowadays, fortunately, there is increasing awareness among people towards natural dyes. Natural dyes are preferred in developed countries, because they are non-allergic, non-carcinogenic and have lower toxicity and better biodegradability than the synthetic dyes [5].

Odina wodier is a large tall tree (Fig.1) found in de-ciduous forest in India, Myanmar, Srilanka, China, Malaysia, Cambodia and Philippine Islands. It is popularly known as Kashmala, Odiamaram and in English it is called Rhusodina. Various parts of this plant have been found to be used as medicines in Ayurveda. The leaves have been reported to use in Elephantiasis of the legs. Juice of green branches is used as an emetic in case of coma or insensibility produced by narcotic. The dried and powdered bark is found to use as tooth powder by poor villagers. The bark extract has been reported to be useful in vaginal trouble, curing ulcer, heart diseases, etc. [6]

MATERIALS AND METHODS

2.1 Materials

2.1.1 Source

The barks of *Odina wodier* was collected from saliyamangalam village, Thanjavur district as shown in figure – 1 and figure – 2.

Figure -1 :*Odina wodier* Tree **Figure -2 : Barks of *Odina wodier***

2.1.2 Substrates

The bleached wool fabric was used for dyeing.

2.1.3 Chemicals used

AR grade metallic salts such as copper sulphate, ferrous sulphate, alum, potassium dichromate, nickel sulphate stannous chloride and tannic acid were used as chemical mordants. Myrobolan and cow dung were used as natural mordants.

2.2 Experimental Methods

2.2.1 Dye extraction

The barks of tree were cut into small pieces and washed with running water. The small pieces of barks were soaked with distilled water and heated in a beaker kept over a water bath for 2 hours to facilitate quick extraction. Then it was filtered and the filtrate was collected in a separate bottle.

2.2.2 Dyeing procedure

The wool fabrics were dyed with dye extract keeping different M : L ratio such as 1:10, 1:20, 1:30 and 1:40. Dyeing was carried out different temperature such as 40^{o}C, 60^{o}C and 80^{o}Cand continued for 1 hour.

2.2.3 Mordanting

The wool fabrics were treated with different chemical and natural mordants by following three methods [7].

***(i) Pre-mordanting (PM)*:** In this method, wool fabrics were pretreated with the solution of different chemical and natural mordants and then dyed with dye extract.

***(ii) Post mordanting (POM)*:** In this method, dyed wool fabrics were treated with solution of different chemical and natural mordants.

***(iii) Simultaneous mordanting (SM)*:** In this method, the wool fabrics were dyed with dye extract as well as different chemical and natural mordants.

2.2.4 Colour fastness

The colour fastness of the dyed wool fabrics were tested according to IS standards. Colour fastness to washing, light and rubbing were determined from standard test methods IS-687-79, IS-2454-85 and IS-766-88 respectively [8].

2.2.5 Measurement of colour strength
The colour strength of the dyed wool fabrics were determined by K/S values. The light reflectances of the dyed wool fabrics were measured using a Text flash spectrophotometer (Data colour corp.). The K/S values were calculated by Kubelka-Munk equation.

$$K / S = (1 – R)^2 / 2R$$

Where, R is the decimal fraction of the reflectance of the dyed samples at λ_{max}. K is the absorption coefficient and S is scattering coefficient [9].

2.2.6 ICPMS studies
The presence of heavy metals like antimony, arsenic, cadmium and lead in the dye extract causes dermatological problems to the wearer and also eco-friendly dye should not contain these heavy metals [10]. The presence / absence of these heavy metals were tested by Inductive Coupled Plasma Mass Spectrometer (ICPMS).

RESULTS AND DISCUSSION

3.1 Preparation and optimization of aqueous extract of Odina wodier
The barks of *Odina wodier* were found to discharge colour in distilled water very easily. Increasing the quantity of barks 5 g to 20 g per 100 mL of distilled water and boiled for 1 hour is accompanied with the increase in colour strength and depth in colour [11]. It was observed that, colour of the dye extract was dark red colour as shown in figure - 3.

Figure 3 : Aqueous extract from barks of *Odina wodier*

3.2 Effect of mordanting
The dye extract was found to be suitable for wool fabric. The wool fabrics were dyed with different chemical and natural mordants. It was noticed that, the dye uptake was found to be good in post mordanting (POM) method is shown in figure-4.

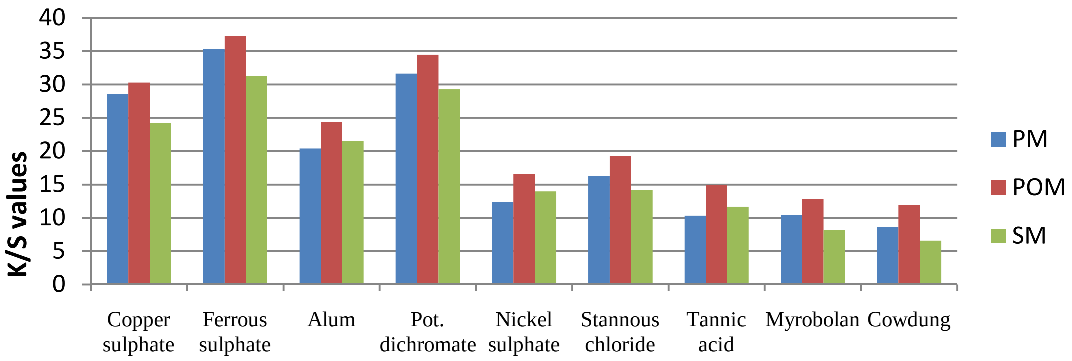

Figure 4: Surface colour strength (K/S values) of dyed wool fabrics after pre (PM), post (POM) and simultaneous mordanting (SM)

3.3 Effect of M : L ratio
The wool fabrics were dyed with dye extract keeping various M : L ratio such as 1:10, 1:20, 1:30 and 1:40. It has been noted that, the dye uptake was good in M : L ratio 1:30.

3.4 Effect of dye bath temperature

The effect of temperature on the dyeability of wool fabric with the dye extract was conducted at different temperatures like 40°C, 60°C and 80°C. It was clear that, the intensity of colour (K/S values) increased with increase of dyeing temperature.

3.5 Optimization of mordants with K/S value and colour hue changes

The different hues of colour were obtained from pre, post, simultaneous mordanted wool with ferrous sulphate, copper sulphate, alum, potassium dichromate, nickel sulphate, stannous chloride, tannic acid, myrobolan and cow dung as shown in table-1. The various mordants not only cause difference in hues of colour and significant changes in K/S values but also changes in L* values and brightness index value. The effect of mordants on K/S values of wool dyed with barks of *Odina wodier* is shown in figure-5.

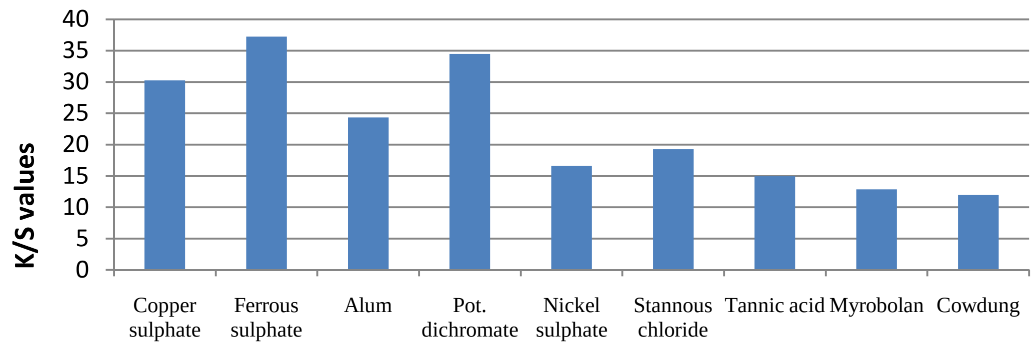

Figure 5: Effect of post mordants on K/S values of dyed wool fabrics

Table-1: Colour produced on wool by different mordants in pre (PM), post (POM), simultaneous mordanting (SM)

S. No.	Metallic salts	Pre mordanting	Post mordanting	Simultaneous mordanting
1	Copper sulphate			
2	Ferrous sulphate			
3	Alum			
4	Potassium dichromate			
5	Nickel sulphate			
6	Stannous chloride			
7	Tannic acid			
8	Myrobolan			
9	Cow dung			

The results listed in the table-2 shows the L*, a*, b* and K/S values of wool fabric dyed with bark extract of *Odina wodier*. It can be seen that, mordants which show higher value of L* show lighter shades while lower L* value show darker shades of wool. Similarly, negative values of a* and b* represent green and blue respectively. Among all the chemical mordants used, the ferrous sulphate was exhibited highest intensity of colour (K/S = 37.24) and tannic acid was exhibited lowest intensity of colour (K/S = 14.94). Natural mordant like myrobolan showed the higher colour strength (K/S = 12.84) than the cow dung (K/S = 11.97).

Table-2 : Different post mordants, L*, a*, b* and K/S values for wool dyed with barks of *Odina wodier*

S. No.	Mordants	L*	a*	b*	K /S value
1	Copper sulphate	47.34	1.857	12.46	30.28
2	Ferrous sulphate	42.54	0.893	8.32	37.24
3	Alum	54.56	0.654	7.51	24.36
4	Potassium dichromate	44.21	1.673	11.26	34.47
5	Nickel sulphate	68.53	1.563	2.51	16.61
6	Stannous chloride	65.14	0.768	5.28	19.31
7	Tannic acid	68.27	1.945	5.59	14.94
8	Myrobolan	69.13	1.734	6.89	12.84
9	Cow dung	69.62	1.852	6.34	11.97

3.5 Fastness properties

The fastness properties of the dyed wool were tested by standard IS methods. It was observed that, wool fabrics dyed with *Odina wodier* have shown good fastness properties. The fastness properties of dyed wool fabrics are presented in table-3. Overall, it could be used for commercial dyeing purposes and attain acceptable range.

Table-3: Fastness properties for wool fabric dyed with barks extract of *Odina wodier*

S. No	Mordants	Washing (IS-687-79)	Light (IS-2454-85)	Rubbing (IS-971-83)	
				Dry	Wet
1	Copper sulphate	4 – 4/5	V	3 – 4/5	3 – 4
2	Ferrous sulphate	4 – 5	V	4 – 5	4 – 5
3	Alum	3 – 4	IV	4 – 5	3 – 4
4	Potassium dichromate	4 – 5	IV	3 – 4	4
5	Nickel sulphate	3 – 4/5	IV	4	3 – 4
6	Stannous chloride	3 – 4	IV	4	3 – 4
7	Tannic acid	3 – 4	IV	4	3
8	Myrobolan	4 – 5	IV	4	4
9	Cow dung	3 – 4	III	3 – 4	3 – 4

3.6 ICP-MS studies

Inductive Coupled Plasma Mass Spectrometer (ICPMS) studies have revealed that, heavy metals such as antimony, arsenic, cadmium and lead were not present in the dye obtained from barks of *Odina wodier* and will not cause any skin problems to the wearer.

CONCLUSION

The present work shows that, barks of *Odina wodier* can be used as a dye for colouring textiles. *Odina wodier* is grown throughout India and it is an easily available plant. The different shades of colour can be obtained using different chemical and natural mordants. The washing, light and rubbing fastness of all dyeing with mordants were quite good. The dye has good scope in the commercial dyeing of wool.

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