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Extraction and Dyeing Behavior of Pomegranate dye on Tencel Fabric

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Abstract:

Application of natural dyes for textile is increasing due to the awareness of ecology, environment and pollution control. The objective of this study is to dye Tencel fabric with pomegranate peel natural dye for comparative analysis of colour efficiencies (K/S), CIE $L^*a^*b^*$ values and the colour fastness properties. The mordants used were ferrous (II) sulphate and copper (II) sulphate. For the extraction of dye, aqueous extraction method was used. Pre-mordanting method was used and dyeing effect on tencel fabric was analyzed at temperatures 80°C and 90°C. It was found that mordant type has an influence on color efficiency and the color coordinates of fabric dyed with pomegranate peel dye. The colour efficiency (K/S: 4) and color fastness to washing, light, rubbing and perspiration were better and outstanding (grade 4-5) at 90°C temperature in all dyed samples. In overall results, pre-mordanting method at 90°C temperature gives best results of color efficiency and color fastness properties.

Keywords: Natural dyes, Pomegranate Peel, Tencel, Extraction, Mordant, Color fastness.

1.0 Introduction:

The synthetic dyes are generally in use since 1856, to apply solid colors to the textile fibers and fabrics due to its economical price and moderate-to-excellent color fastness properties (Swami *et al.,* 2012). However, these dyes are very toxic and cause inhibition of benthic photosynthesis and carcinogenicity (Adeel *et al.,* 2009). Therefore, many countries have criticized and restricted various particular azo-dyes (-N=N-) for their applications and manufacturing (Patel, 2011).

Alternatively, natural dyes are completely biodegradable, anti-allergic, non-toxic and have deodorizing properties (Kulkarni *et al.,* 2011). Moreover these dyes have eco-friendly nature, green approach and biocompatibility (Shahid *et al.,* 2013). Therefore have not any environmental issues (Kulkarni *et al.,* 2011). Since Bronze Age natural dyes are in use for the coloring of textiles materials (Godarzian and Ekrami, 2010). But in recent years, their applications are extended to antimicrobial finishing of textiles, UV protective clothing, food colorations, cosmetics and pharmaceuticals etc (Shahid *et al.,* 2013). The natural dyes demand continuously increasing because it does not require any strong acids and alkalis in their applications and productions (Kulkarni *et al.,* 2011; Jung, 2016).

The word 'Natural Dye' includes all the dyes which derived from natural sources like plants, minerals and animals (Davulcu *et al.,* 2014). As compared to synthetic dye, the pure dye content and color yield in dye plant is typically very low (Lokesh and Kumar, 2013). Natural dyes contain those colorants that are attained from vegetable and animal matter without applying any chemicals (Mahanta and Tiwari, 2005). In plants, coloring agents are obtained from roots, leaves, flowers, barks and fruits. Some important natural dyes are pomegranate, eucalyptus, kamala, madder, henna, turmeric etc (Adeel *et al.,* 2009; Kechi *et al.,* 2013).

Natural dyes have many technical shortcomings as well. They have color fastness problems like color yield, reproducibility results, difficulties of dying procedure, mixing problems and poor fastness properties (Sachan and Kapoor, 2007; Siva 2007). Therefore textile companies apply mordants with natural dyes to make their affinity with textile materials and hence provide an extensive variety of shades with adequate levels of colorfastness (Farooq *et al.,* 2013; Pruthi *et al.,* 2008; Win and Swe, 2008).

A mordant is an element which makes chemical reaction between the dye and fibers (Samanta and Agarwal, 2009). Mordants are metal salts which make a bridge between the dye and fabrics and also increase the dye uptake properties (Vankar, 2009). Natural dyes without mordants have very low fastness properties because they have very low affinity towards fibers and fabrics (Ali *et al.,* 2007). Mordants play very vital role in giving color to the fabric. It gives different shades when used with each other and in different percentages (Wanyama *et al.,* 2015). The better color strength depends upon on how much concentration of metal salts has been used as well as the rise in temperature (Kamel *et al.,* 2009). Metal ion of mordants is used to form co-ordinate bond with dye molecule to accept electron from donors, which are not soluble in water (Mongkholrattanasit *et al.,* 2011). Mordants mostly used are Alum, ferrous sulphate, copper sulphate, chrome and stannous chloride etc (Siva, 2007; Samanta and Agarwal, 2009; Mahangade *et al.,* 2009).

Tencel is a natural, manmade regenerated cellulosic fiber which is made from wood pulp and is marvelous ecofriendly fabric that represents a milestone in the progress of environmental sustainable textile (Borbely, 2008).
The botanical name of Pomegranate is '*Punica granatum*' which belongs from the family of Punicacea. The Punica granatum is firstly a native of Persia and neighboring countries, but nowadays it cultivates in all warm countries of the world (Sheets *et al.,* 1994). The pomegranate rind contains a significant amount of tannin approximately 19% with pelletierine (Kulkarni *et al.,* 2011; Tiwari *et al.,* 2010). Pomegranates are reported as antimicrobial agents and the fabrics which are dyed with pomegranate peel dye are used as anti-allergic and antibacterial (Alihosseini and Sun, 2011). In pomegranate peel, granatonine is the main coloring component which is present in the form of N-methyl granatonine (Satyanarayana *et al.,* 2013). Figure 1 explains the chemical structure of Granatonine which is a dyeing material in pomegranante peel. This compound provides color to the dye and the study of this enables to know about the structural chemistry of the coloring compound (Goodarzian and Ekrami, 2010).

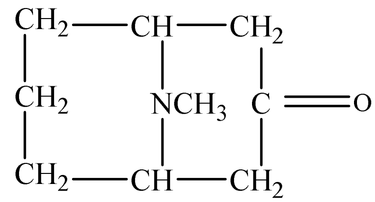

Figure 1: Chemical structure of Granatonine (dyeing material) in Pomegranate Peel

In this present work, Pomegranate peel natural dyes are used to dye Tencel fabric with two mordants i.e. copper sulphate and ferrous sulphate and used to evaluate the application of excellency with the tencel fabric. Aqueous extraction method was used to extract dye from pomegranate peel and pre-mordanting method were used to analyze the color strength and washing, light, rubbing and perspiration fastness properties of tencel fabric.

2.0 Materials and Methods:

2.1 Materials

2.1.1 Dye Plant: Punica granatum (Pomegranate Peel) were collected from local market in Shanghai, China.

2.1.2 Fabric: 100% Tencel fabric was used for dyeing, which was obtained from Hangzhou Xinsheng Printing and Dyeing Company LTD (Xiaoshen Hangzhou).

2.1.3 Chemicals: Laboratory grade metallic salts such as (copper (II) sulphate, $CuSO_4.5H_2O$ manufactured by Sinopharm Chemical Reagent, CO.LTD) and ferrous (II) sulphate, (FeSO4.7H2O manufactured by Sinopharm Chemical Reagent, CO.LTD) were used as a mordants.

2.1.4 Raw Material Preparation: Peels were separated from pomegranates and washed with water to remove the dust particles and other wastes. The peel was kept in direct sunlight for drying. After drying, the dried peels were grind into powder with the help of grinder machine. The grinded powder was used for the extraction process. Figure 3 delineates the preparation of raw material.

2.1.5 Equipments: Weighing balance, Water bath, Soxhlet extractor, Water Shaker, Hot air oven, Data color.

Figure 2: (a) Pomegranate Peel (b) Dried peel (c) Powder of pomegranate peel

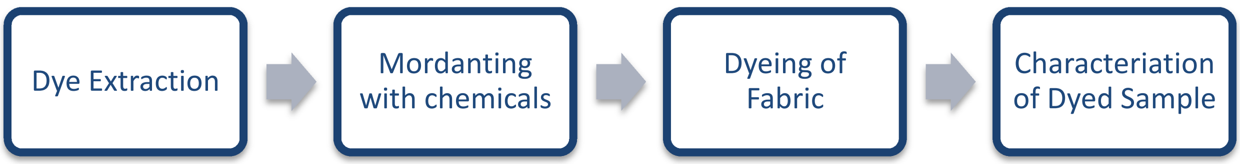

Figure 3: Flow chart of Methodology

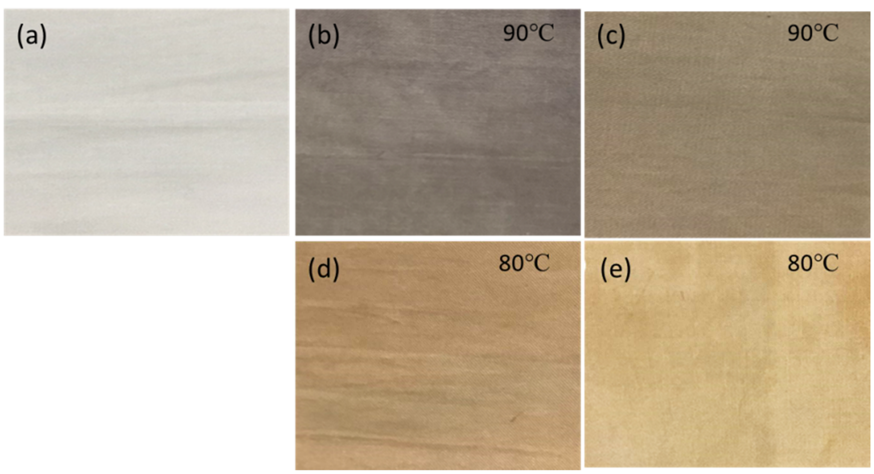

Figure 4: Samples of Dyed Tencel Fabric

(a) Raw Material, (b) dyed with ferrous sulphate on temperature 90°C, (c) dyed with copper sulphate on temperature 90°C, (d) dyed with ferrous sulphate on temperature 80°C, (e) dyed with copper sulphate on temperature 80°C.

Table 1: K/S values and CIE L* a* b*C* h* values of dyed Tencel fabric

Mordant	Temperature(°C)	K/S	L*	a*	b*	C*	h*
$FeSO_4$	80	2.81	54.86	2.18	3.61	4.02	82.97
	90	4.0	44.93	0.31	1.25	1.28	75.85
$CuSO_4$	80	2.06	80.05	4.67	25.71	26.13	79.72
	90	2.93	76.05	4.33	24.94	25.31	80.15

2.2 Methods:

2.2.2 Extraction of Natural Dyes: Aqueous extraction method was used to extract dye from pomegranate peel. 10g powder of pomegranate peel was placed in round bottom flask. 200 ml distilled water was added into flask and material to liquor ratio (M.L.R) was kept 1:20. The flask was heated in water bath for 1 hour at temperature 90°C. After extraction, the solution was filtered through whatman filter paper and further this solution was used for dyeing process.

2.2.3 Mordanting: Samples of tencel fabric were treated with two mordants (ferrous sulphate and copper sulphate) for 1 hour at temperature 80°C. Pre-mordanting technique was used with liquor ratio 1:20. After mordanting, the samples were washed and dried at room temperature and further used for dyeing process.

2.2.4 Dyeing: Tencel fabrics were dyed through batch wise method with pomegranate peel extracted dye. The samples were dyed at different temperatures (80°C and 90°C) in order to compare the effectiveness results. Tencel fabric was dyed for 1 hour with (M.L.R) 1:40. After dyeing, the dyed tencel fabrics were washed with water and soaping agents, and then applied for testing for results.

2.2.5 Characterization: After dyeing, dyed sample were examined for different color fastness properties. Different color fastness testes were according to ISO standards like color fastness to washing (ISO 105- C01), light (ISO 105-B02), rubbing (dry and wet) (ISO 105-X12) and perspiration (ISO 105-E04). Color strength and dye absorption of the dyed sample were measured by K/S value. Given figure shows the flow chart of methodology.

3.0 Results and Discussions:

Two types of mordants (copper sulphate and ferrous sulphate) were used for dyeing tencel fabric with pomegranate peel extracted dye at temperature 80°C and 90°C. With the same natural dye, different shades and colors were obtained by changing mordanting agents. Different fastness properties were also evaluated. In this study, the pre-mordanting method was applied as a mordanting process.

3.1 Dye Absorption and Colour Measurement:

K/S values are used to determine the color shade and dye absorption of dyed tencel fabric. Data color, SF-600 was used to measure the dye absorption concentration. Also different color range were found on tencel fabric by using L*, a*, b*, C*, h*. Figure 4 indicates the raw material and different shades of dyeing on the tencel fabric with copper and ferrous sulphate at temperature 80°C and 90°C

Table 1 shows the complete color shade and L*, a*, b*, C* and h* values, and it indicates that higher value of L* have lighter shades and lower value of L* have darker shades for tencel and also negative values of a*and b* denote green and blue (Maha-in *et al.,* 2016). Due to mordants, the highest color value (K/S: 4) was obtained with ferrous sulphate and lowest color value (K/S = 2.06) with copper sulphate. The experimental outcomes show that chemical ferrous sulphate with temperature 90°C has provided good results on tencel fabric with pomegranate peel extracted dye.

Figure 5 (a) shows the color shade (K/S) values of tencel fabric with chemical (ferrous sulphate and copper sulphate) at temperature 80°C and 90°C. The figure depicts that the color shade values of tencel fabric with chemical ferrous sulphate has higher values at both temperatures then copper sulphate. The bar colors in the Figure 5 represents the outcomes of shade difference at both temperatures with the utilization of both mordants. The highest K/S value i.e. 4 was achieved at temperature 90°C with ferrous sulphate and lowest K/S value (2.06) with copper sulphate at temperature 80°C.

3.2 Color Fastness Properties of Dyed Tencel:

Extracted dye from Pomegranate Peel contribute good washing, light, rubbing and perspiration fastness properties on tencel fabric with copper sulphate and ferrous sulphate.

3.2.1 Light Fastness:

Figure 5 (b) shows the result of light fastness of tencel fabric with Pomegranate Peel dye with chemical copper sulphate and ferrous sulphate. It is found that ferrous sulphate shows good light fastness results than the copper sulphate. Through ferrous sulphate, there was no change in color and no color fading. In Figure 5 (b) it is evident that dyeing with mordant ferrous sulphate at temperature 90°C has highest light fastness (4-5) whereas through copper sulphate light fastness is the lowest (3-5) at temperature 80°C. Result shows that chemical ferrous sulphate at temperature 90°C is suitable to dye tencel fabric.

3.2.2 Washing Fastness:

Figure 5 (c) reveals the washing fastness result of dyed fabric. The mordant ferrous sulphate shows highest value of washing fastness at both temperatures than copper sulphate. However, at temperature 90°C, the results are better (4-5). While with mordant copper sulphate the results are lowest with value (3-4) particularly at temperature 80°C. All the samples show a slight change in color (4-5). Figure 5 (c) also reveals that chemical ferrous sulphate is much better than copper sulphate.

3.2.3 Rubbing Fastness (Dry and Wet):

Figure 5 (d) shows rubbing fastness results of tencel fabric dyed with pomegranate peel extracted dye at temperature 80°C and 90°C. The dark brown and light brown color bars represent treatment at 80°C while dark grey and light grey bar colors represent the performance at 90°C. The mordant ferrous sulphate shows very good to excellent (4-5) dry rubbing and (4) wet rubbing at 90°C. Mordant copper sulphate shows very good (4) dry and wet rubbing fastness at both 80°C and 90°C temperatures. Furthermore, the result depicts that, dry rubbing is better than wet rubbing. Ferrous sulphate contributed good results as compared to copper sulphate at temperature 90°C.

Figure 6 (a) and Figure 6 (b) shows the result of perspiration fastness (acidic and alkali) of tencel fabric dyed with extracted dye from pomegranate peel. It is found that sample treated with copper sulphate and ferrous sulphate exhibit good perspiration fastness at both temperature i.e. 80°C and 90°C. In acidic and alkaline perspiration tests, the fabrics have slight color change (4/5). The staining is also very light with both chemicals at both temperatures.

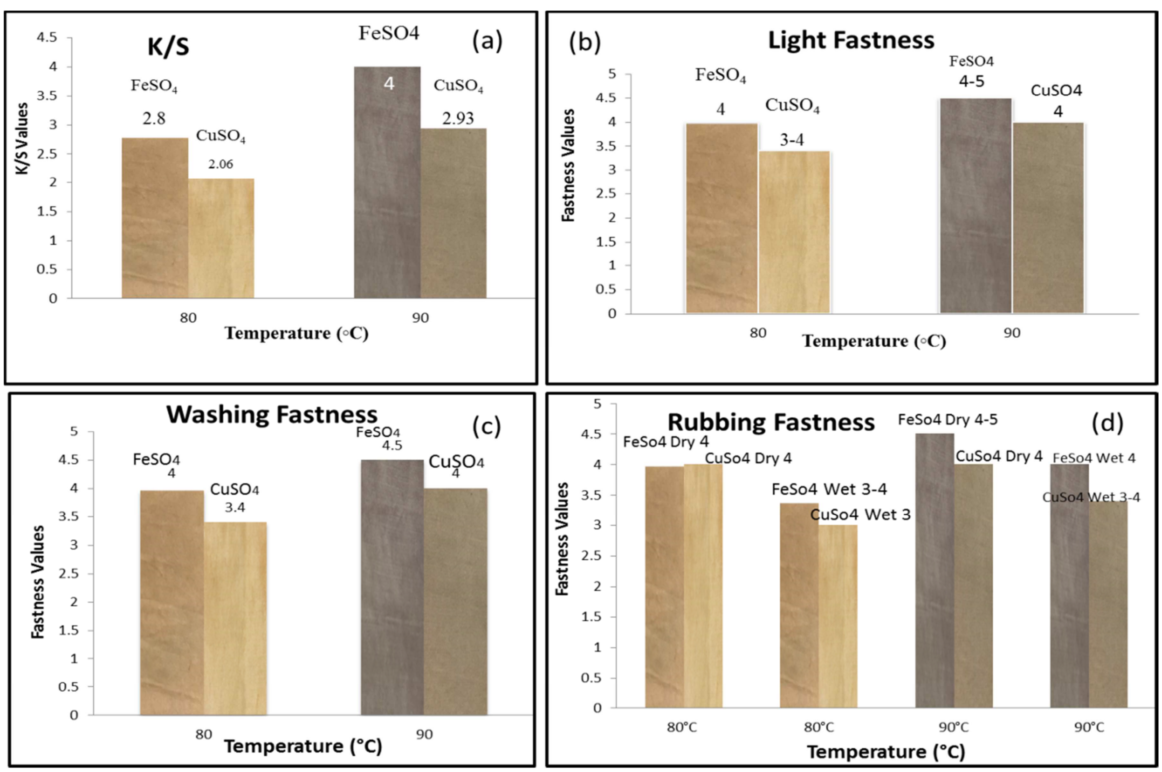

Figure 5: Color fastness Values of Dyed Tencel

3.2.4 Perspiration Fastness:

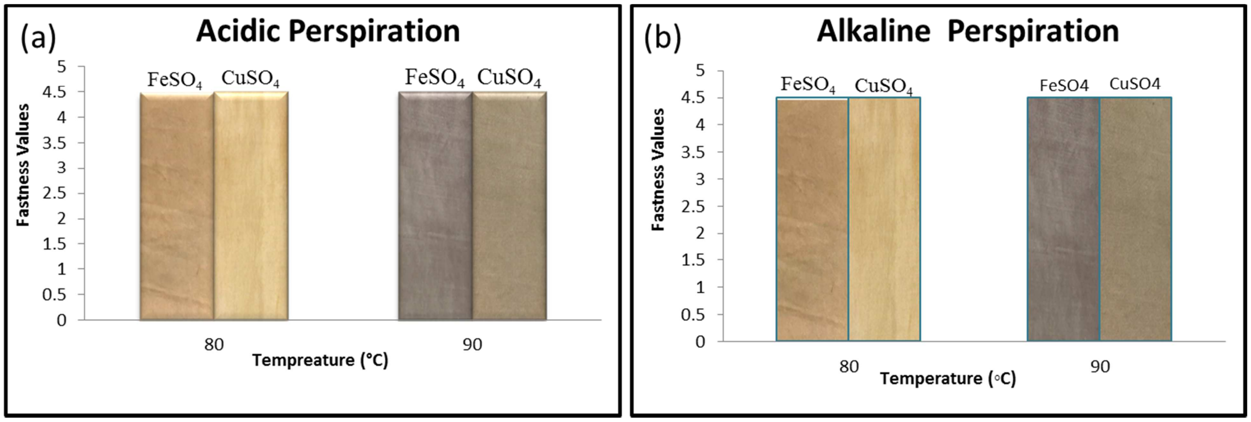

Figure 6: Perspiration fastness Result of Dyed Tencel

Table 2: Color Fastness properties of Tencel Fabric dyed with Pomegranate Peel

Mordant	Temperature (◦C)	Washing Fastness ISO 150-C01	Light Fastness ISO 105-BO2	Rubbing Fastness ISO 105-X12		Perspiration Fastness ISO 105-E04	
				Dry	Wet	Acidic	Alkali
$FeSO_4$	80	4	4	4	3-4	4-5	4-5
	90	4-5	4-5	4-5	4	4-5	4-5
$CuSO_4$	80	3-4	3-4	4	3	4-5	4-5
	90	4	4	4	3-4	4-5	4-5

Table 2 shows the overall result of color fastness to washing, light, rubbing (dry and wet) and perspiration fastness of tencel fabric dyed with pomegranate peel extracted dye with copper sulphate and ferrous sulphate at temperature 80°C and 90°C.

4.0 Conclusion:

In the present study, Tencel fabric is dyed with pomegranate peel. Aqueous extraction method was used to extract dye from pomegranate peel. Two mordants, copper sulphate and ferrous sulphate were used to analyze the color strength and washing, light, rubbing and perspiration fastness properties of tencel fabric. Pre-mordanting method was used with 80°C and 90°C temperatures to evaluate effect of color shades. Both mordants show good results on tencel fabric but ferrous sulphate results are better than copper sulphate. The overall result shows that at temperature 90°C, ferrous sulphate is better choice for tencel fabric dyeing since it has good color efficiency (K/S: 4) and color fastness to washing (4-5), rubbing (4-5), light (5), and perspiration (4-5). Also, Tencel fabric dyed though pomegranate peel is recyclable, helpful for environmental protection and safety purposes for the surrounding community.

5.0 Acknowledgement:

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