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ASSESSEMENT OF COLOR FASTNESS OF LINEN FABRIC DYED BY TEA SUBSTANCE WITH AN ECO-DESIGN APPROACH

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ABSTRACT

Nowadays, textile products have found a wide range of application in apparel, domestic and industrial area. The applications include not only clothing and accessories, bedding and interior decoration, but also textile structures that are used to make cables, cords, parachutes, hot-air balloons, tents,... The ever-increasing application of textile products in various fields is making the design task more important and challenging.

Consumers are increasingly considering the sustainability of their purchases as they gain access to an array of attractive fabrics. Is it possible to make a sustainable and high-appealing fabric?

Increasing awareness about safe products in textiles has developed the worldwide choice of natural colour based textile. For the present study tea has been selected as source of natural dye.

The color of the fabrics was investigated in terms of fastness properties against light, washing and rubbing and different dyeing process was also compared. To enhance the textile designer using an eco-design approach while using natural textile with natural colour to deliver 'green' textile product, this study develop an environmentally friendly dyeing process and good fastness properties.It represents a 'green' product choice that can enhance any sustainable design.

KEYWORDS— colour fastness, ecodesign, linen fabric, mordant, natural dyeing, tea waste.

INTRODUCTION

By the 1960s, designers were beginning to actively consider the wider implications of design for the environment. Several approaches emerged, including green design, ecodesign and sustainability (Cooper 2007). The increasing public awareness and sense of social responsibility related to environmental issues have led the textile industry to manufacture products with improved environmental profiles (Almeida 2008).

The majority of the work undertaken into improving the environmental impact of textile products takes an almost entirely 'green design' or single issue approach (Evans 2002; Velden 2003; Dewberry 1996; Bertolini 1999). This focuses on the selection or reduction of materials, such as the selection of biodegradable/renewable/single materials or the reduction of types/volume of materials in order to improve recyclability (Lewis 2001; Holdway et al, 2002; Bhamra et al, 1999; Wimmer et al, 2004).

To be competitive textile products need to be highly attractive to strengthen the upbeat emotional appeal of environmentally-friendly products (Kueny 2008), they must remain visually attractive; otherwise it will not be commercially successful (Ottman 1997).

Hence, in finishing steps of textile product, there is an increasing demand for natural dyes which are renewable, bio-degradable and eco-friendly. These natural colorants are non-allergic and non-toxic to human body (Rehman et al.

2012; Prabu et al. 2011; Bhuyan and Saikia, 2005; Samanta and Agarwal, 2009; Hwang et al. 2008; Bhuyan & Saikia, 2005; Debajit and Tiwari, 2005).

For successful commercial use of natural dyes for any particular fibres, the appropriate and standardized techniques for dyeing need to be adopted and trying to improve color strength and fastness properties of different natural and synthetic fabrics dyed with natural dyes through various techniques (Saakshy et al. 2013; Tutak & Korkmaz 2012).

Different methods have been used to improve extraction of (Kamela et al. 2011) allowing more dye to be fixed. Of such methods there are plasma treatments (Haji et al. 2013), bio polishing, cationization (Shahidi et al. 2010), ultasonic, gamma ray microwave and UV radiation, (Adeel et al. 2014; Ajmal et al. 2014; Khan et al. 2014; Bhatti et al. 2014; Rehman et al. 2013; Adeel et al. 2013; Batool et al. 2013; Chandravanshi and Upadhyay 2012; Adeel et al. 2012; Zuber et al. 2012; Bhatti et al. 2012).

Nowadays, natural dyes derived from plant-based materials have proved to be important alternatives to the use of synthetic dyes in the textile industry. In this context, some work on the application of tea on wool, silk (Vankar 2006; Kaur et al. 2012), jute and cotton were dyed with an aqueous extract of tea, containing tannins as the main colorant species (Deo and Desai 2006; Tsatsaroni & Liakopoulou-Kyriakides 1995) are available in the literature.
The purpose of this study is to develop an environmentally friendly dyeing process and good fastness properties by using tea waste on linen fabric. Dyeing without any mordant was compared with those obtained with the three different mordanting methods. The dyeing behaviors of different mordanting process and combination of mordants have been studied with respect to their influence on fastness properties. This dyeing method can enhance textile designer to use such method, to add an aesthetic touch to fabric by using natural colours.

MATERIAL AND METHOD

'Green' fashion or the 'eco-look' strongly influenced mainstream fashion in the early nineteen nineties. It was characterised by the specification of natural looking colours and natural fibres. However the popular message of 'natural is green' misrepresents the complex range of impacts that all textile fibres have on the environment (Fletcher 1999).

One of the criteria that can strengthen the emotional appeal of eco-friendly textile product is the colour. Nowadays, natural dyes have become more and more popular recently mainly due to concern associated with the health and environmental effects of synthetic dye chemicals. The naturally dyed fabrics recently have attracted both consumers and manufacturers in fashion markets (Chattopadhyay et al. 2009; Haji 2012; Tayade et al. 2013).

In the recent years, there has been a trend to revive the art of natural dyeing. The shades produced by natural dyes/colourants are usually soft, lustrous and soothing to the human eye. Natural dyestuff can produce a wide range of colours by mix and match system. And natural dyestuffs produce rare colour ideas and are automatically harmonizing. Unlike non-renewable basic raw materials for synthetic dyes, the natural dyes are usually renewable.

Textile support

With the big growth, in the last decades, of the consumption of synthetic fiber for essentially economic and mechanical reasons, the consumption of natural fiber and especially the linen fibers decreases although their beneficial properties for comfort and ecology (Behera 2007; Goswami 1947). But, the originality and freshness of the linen fibers plus the environmental friendliness of recycling clothing quickly popped them into eco fashion awareness.
Linen fibre is totally biodegradable and recyclable. It needs 5 times less fertilisers and pesticides than cotton to grow and this linen fiber is one of the leading of ecological textile fibers (Schneider 1991; Margaret 1955). It is considered an ecological textile raw material as:

- The production of linen is often carried out without the use of agricultural chemicals and in particular fertilisers and herbicides to control weeds.
- The linen is often grown in cooler climates than other natural fibres, such as cotton, and extensive irrigation is not required, so avoiding environmental impacts associated with water consumption and soil pollution.

– It is also suggested that fibres like linen grow well on land unsuitable for food production and may help re-cultivate soils polluted with contaminants such as heavy metals (Fletcher 1999).

In this survey, linen fabric used in dyeing was colourless and had a weigh per unit area equal to 205 g/m², a thickness of 0,65 mm.

After choosing ecological fibers we will also use ecological techniques to strengthen the emotional appeal of ecological textile product to be more attractive.

Method: natural dye
Natural dyes can be used on most types of material or fibre but the level of success in terms of fastness and clarity of colour varies considerably (Richards 1977; Garcia 2002).

In this survey, we dyed linen fabric with tea substance. Tea is a substantive dye (Latin name Camellia sinensis). The annual world tea production is approximately 1,000,000 metric tons and a largest importer of tea is United Kingdom, totalling more than 250,000 tons. If we recycle only 1% of this tea production, we can use it in dyeing the majority of the linen world production with less polluting techniques.

This dyeing substance need also to have good performances to increases the durability, one of the principles of the eco-design. That's why we need to evaluate the colour fastness performance of this dyeing method by exploiting different mordanting techniques and by using the alum as mordant substances.

Dyeing without Mordant
Linen fabric that was damped previously was boiled in dye extract for one hour like represented in figure 1. During boiling, when the amount of the water decreased, more water was added. After one hour, dyed fabric was cooled, then rinsed with cold water and dried at shading and airy place.

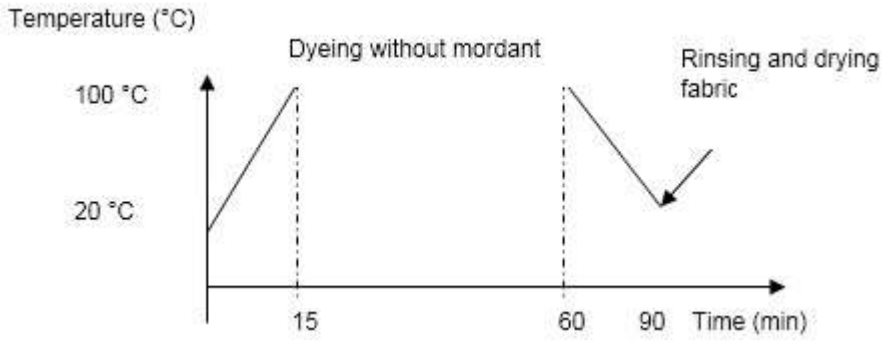

Figure 1. Fabric tea dyeing without mordanting.

Pre Mordanting
In the present study, linen fabric was treated with the mordant product. Out of linen fabric weight, different mordant rates (1%, 2% and 3%) were used. Mordant taken according to linen fabric weight was dissolved in the tepid water that was 50 times heavier than the linen fabric. Fabric dampened previously was boiled in this water about one hour. Linen fabric taken from water was ready to dye after pressing. This method is represented in figure 2.

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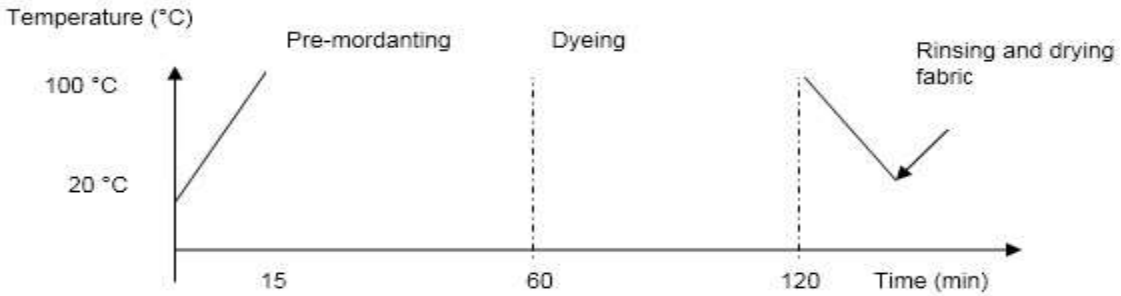

Figure 2. Fabric tea dyeing with pre mordanting.

Last Mordanting

Firstly, linen fabric was dyed the same as without mordanting dyeing. Then, out of linen fabric weight, different mordant rates (1%, 2% and 3%) were used. Mordant taken according to linen fabric weight was dissolved in the tepid water that was 50 times heavier than the linen fabric. Fabric was treated with mordant and boiled for one hour. Thus, the last mordanting was performed. This method is represented in figure 3.

After cooling, it was rinsed with abundant cold water and dried at shading and airy place.

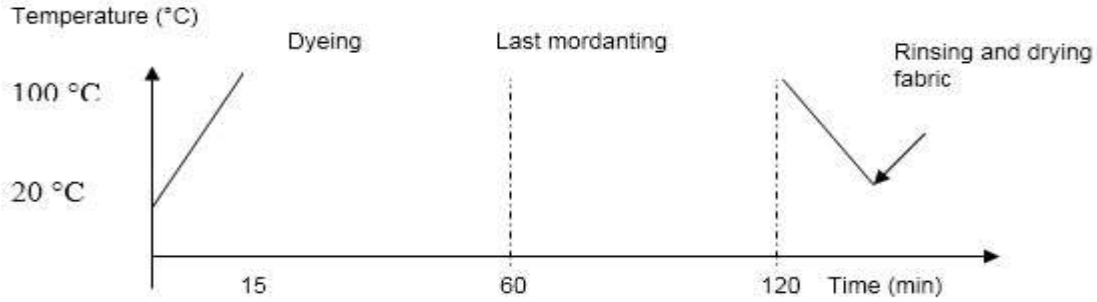

Figure 3. Fabric tea dyeing with last mordantin .

Treatment with mordant

When linen fabric was put in dye extract, at the same time, previously determined mordant amounts (1%, 2% and 3%) were added in extract and boiled together for one hour. Thus, it is not only dyed but also mordanted. After cooling, it was rinsed with abundant cold water and dried at shading and airy place. This method is represented in figure 4.

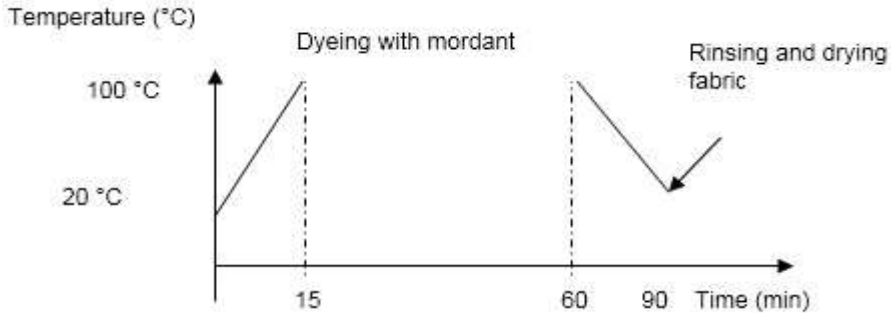

Figure 4. Fabric tea dyeing with mordanting.

Preparation of Dye Extract

Dyeing methods with and without mordanting methods were used. Preparation of dye extract was the same in all dyeing methods.

The weights of recycled tea dye material, which are equal to linen fabric, are taken separately and boiled in water at a rate of 1/50 for one hour. The water that decreased during boiling was added. Later, plant remainders were filtered, and the extract was obtained.

Colour fastness evaluation technique
Tests can be carried out for light, rubbing and wash fastness using simple standard test methods described in this part.

Light Fastness Test
Light fastness tests were carried out according to NF G 07- 067 method (colour fatness determination methods according to artificial light by using a Xenotest). The changes in color of the samples were assessed against the appropriate blue scale for fading.

Rubbing Fastness Test
Rubbing fastness determination was carried out according to NF G 07- 016 method (determination of colour fatness according to abrasion) and TS 423 method (using methods of grey scale for sum up the staining "leaking of dye" and discolouring "changing of colour", in the determination of colour fastness of textiles).

Wash Fastness Test
Wash fastness tests were carried out according to NF G 07- 200 method (determination of colour fastness according to laundering test)) and TS 423. A specimen of the textile in contact with two specified adjacent fabric is mechanically agitated under specified condition of time 30 min and 50 °C for temperature in a soap, then rinse and dried. The change in color of the specimen and the staining of the adjacent fabric, were assessed with the reference to the original fabric, using the grey scale according to TS 423 method.

RESULTS AND DISCUSSION

Colours are obtained as a result of dyeing and the fastness of colours such as light, rubbing and washing are determined and given in Table 1. When the colour fastness index increases the dyeing performance increases.

Table 1. The light, dry and wet abrasion and wet laundering fastness of linen fabric.

Fastness	*Norm*		*Fastness index*								
			Dyeing Without mordanting	*Dyeing With Pre mordanting*			*Dyeing With Last mordanting*			*Dyeing With mordanting*	
				1%	*2%*	*3%*	*1%*	*2%*	*3%*	*1%*	*2%*	*3%*
Light Fastness Determination	*NF G 07-067*		*4*	*5*	*6*	*6*	*5*	*5*	*6*	*5*	*5*	*6*
Abrasion Fastness Determination	*NF G 07-016*	*Wet*	*4*	*4*	*5*	*5*	*4*	*4*	*5*	*4*	*4*	*5*
		Dry	*5*	*5*		*5*	*5*	*5*	*5*	*5*	*5*	*5*
Wet laundering Fastness Determination	*NF G 07-200*		*3*	*4*	*5*	*5*	*4*	*4*	*5*	*4*	*4*	*5*

3.1. Influence of mordanting on light colour fastness

In Table 1, when light fastness values are investigated, it is seen that they vary between 4-6. The lowest value is 4, obtained from dyeing without mordant. Mordant substance improves the light colour fastness. A 2% mordant rate gives the same light fastness as using 3% mordant rate.

The resistance of a dye or pigment to chemical or photochemical attack is an inherent property of the dye chromophore, but at the same time the auxochrome may also substantially alter the fastness either way (Jothi 2008). Samples dyed with tea extract by using alum as a mordant have a good light fastness. This is can be due to the formation of a complex which protects the chromophore from photolytic degradation.

3.2. Influence of mordanting on rubbing fastness

The wet rubbing fastness values were between 4 and 5 and dry as 5. This indicated that dry rubbing fastnesses were found at good level, and that no staining was seen on the linen, after water dried. The used mordant doesn't improve considerably the rubbing fastness.

3.3. Influence of mordanting on wash fastness

Wash fastness of dye is influenced by the rate of diffusion of dye and state of dye inside the fiber. According to the results, wash fastness values were found to vary between 3-5, which is at medium and good level.
This can be due to the fact that tea extracts are characterized by low molecular weight as compared to synthetic dyes. Another reason is that they have a tendency to aggregate inside the fiber (thereby increasing the molecular size) and hence exhibit good wash fastness Besides, researchers pointed that fastness grades of 3-4 for natural dyestuff are good and very good fastness data (Hartl and Vogl, 2003).

Finally, on one hand, the pre mordanting stage gives better results than the other stages of mordanting. On the other hand, there is no big difference between using mordanting and without using mordanting in the tea dyeing. This can be due to the tannin in the tea substance (12.9 % tannin in the tea (Reid 1977)) that acts as a mordant to fix the colour. So the process without mordanting can be chosen to reduce the amount of chemical product, the water quantity and the energy consumption.

CONCLUSION

From the results, tea is promising dye-yielding plant and could be exploited as sources of textile dyes. Aqueous extract of natural dye, tea was dyed on the linen fabric. The mordant salts Alum, was used to dye fabric using three different dyeing methods: without mordanting, pre-mordanting, and post-mordanting. The color fastness of the fabric was investigated.

The studied performance of tea dyeing linen fabric with different mordanting techniques and mordant rates was studied. Dyeing without any mordant was compared with those obtained with different mordanting process with respect to their influence on fastness properties. The resulting wash, rubbing and light fastnesses of the dyed fabrics were good to excellent.

The results show that the mordant substances don't improve considerably the light, rubbing and washes fastness. Dyeing without mordant gives a good performance and permits to reduce the amount of chemical products, reduce the water and the energy consumption.

Finally, this natural dyeing can also alter the uniformity of the linen material; that may also strengthen the upbeat emotional appeal of environmentally-friendly products by using for example the tie-dyeing technique. So textile designer can use this technique to obtain colors which are earthly, warm, highly appealing and also durable. Besides, those fabrics are non-allergic, non-toxic to human body and perpetuate an ancient tradition.

These environmental improvements in textile design only form a small part of sustainable design. The textile sector has a long way to go in order to make real advances in innovation and, therefore, greater gains towards sustainability.

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