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Study the effect of ammonia post-treatment on color characteristics of annatto-dyed textile substrate using reflectance spectrophotometery

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ABSTRACT

This research is aimed to study the influence of ammonia after-treatment on color behavior in wool yarns dyed with annatto extract. The dyeing was carried out using 15% (o. w. f.) dye concentration in presence of stannous chloride as a mordant and then treated with different percentages of ammonia solution. At the same time, color strength, CIE-Lab values and fastness properties of all dyed woolen yarns were also assessed. It was concluded that, in all cases after treatment with ammonia caused a decrease in lightness (L^*) values, there was less lightness in the red hue of the wool yarns with the increase of ammonia percentage in solution. The K/S value of annatto dyed wool was found to increase after treated with ammonia. In addition, it was also observed that dyed wool yarns after post-treatment with ammonia did not return to their original color on acidification.

1. Introduction

In recent years, synthetic dyes and textile finishing agents have come under severe criticism for their high environmental pollution at the stage of manufacturing as well as application (Javadian et al., 2014; Khan et al., 2013; Islam et al., 2013a). On the other hand, dyes obtained from plants, insects/animals and minerals have better biodegradability and generally higher compatibility with the environment (Islam et al., 2013b; Khan et al., 2011). Several investigations have been undertaken and are currently underway on the use of different plant species such as *Allium cepa* (Fazal-ul-Rehman et al., 2013), *Alternanthera bettzickiana* (Khan et al., 2014), *Cassia fistula* (Adeel et al., 2013), *Curcuma longa* (Adeel et al., 2012; Bhatti et al., 2012), *Foeniculum vulgare* (Haddar et al., 2014), *Lawsonia inermis* (Fazal-ul-Rehman et al., 2012; Yusuf et al., 2011, 2012), *Quercus infectoria* (Shahid et al., 2012), *Rheum emodi* (Khan et al., 2012), *Rhizophora apiculata* (Punrattanasin et al., 2013), Chicken gizzard (Batool et al., 2013) and *Rubia cordifolia* (Yusuf et al., 2013) as promising sources of natural dyes. Therefore, there is a worldwide interest generated in the development of natural dyes for their diversified use in textile dyeing (Samanta and Agarwal, 2009), functional finishing (Gupta et al., 2005; Gupta and Bhaumik, 2007; Gupta and Laha, 2007), food coloration (Delgado-Vargas et al., 2000), cosmetics (Dweck, 2002), histological staining (Tousson and Al-Behbehani, 2011), pH indicator (Mishra et al., 2012), dye-sensitized solar cells (Ludin et al., 2014; Zhou et al., 2011), and several other application disciplines (Khan et al., 2012; Shahid et al., 2013).

Bixa orellana L. is an evergreen tree from family Bixaceae growing in several tropical countries of the world and is one of the prominent natural dye plant yielding carotenoid type pigments. In India it is grown in the states of Andhra Pradash, Maharashtra and Orissa (Gulrajani et al., 1999). The fruit of the *B. orellana* tree consists of 10–50 seeds of the size of grape seeds covered with a thin layer of soft, slightly sticky vermilion pulp. Picture of annatto seeds and powder dye is illustrated in Fig. 1a and b. The extract from the seed is rich in tannin but contains a mixture of eight colorants of carotenoid group; the major colorants are bixin (Fig. 2a) and nor-bixin (Fig. 2b) (Das et al., 2007). Bixin is an oil soluble diapocarotenoid contains two carboxylic acid groups, one of which is esterified while nor-bixin is derived from bixin by hydrolysis of the ester group. Both these pigments normally occur in *cis* form and *cis* bixin is the major coloring matter of annatto seeds, accounting for more than 80% of the annatto pigments (Ramamoorthy et al., 2012; Sekar, 2004).

Annatto extract is widely used in food industry as natural colorant in many food formulations, including ice cream,

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(a) (b)

Fig. 1. *Bixa orellana*: (a) seeds and (b) powder dye.

cheese, sausages, yogurt and margarine. It is also used by the pharmaceutical and cosmetic industries (Rao et al., 2007). Very few studies are reported on its use in textile applications. Owing to the high water absorption of wool, good dyeability, high elasticity, bulkiness, comfort, and high resistance against fire has been used in textile industry since antiquity. Wool yarns dyed with natural dyes find use in handwoven carpets. The post-treatment of ammonia on naturally dyed woolen yarns provide a way to achieve better performance on handwoven carpets (Montazer and Parvinzadeh, 2007). However, little research has been done so far to study the effect of ammonia post-treatment on textile fibers dyed with natural dyes (Montazer et al., 2004; Montazer and Parvinzadeh, 2004, 2007).

In this research wool is first mordanted with stannous chloride as mordant and then dyed using annatto dye followed by application of ammonia. The work investigates the changes in color properties of dyed woolen yarns described in terms of CIELAB system of Lightness (L^*), redness-yellowness (a^*), blueness-greenness (b^*), chroma (c^*), and hue (h^0).

2. Experimental

2.1. Materials

2.1.1. Dye and wool yarn

100% semi worsted 60 count wool yarn was purchased from MAMB Woolens Ltd., Bhadohi, UP, India. Powdered *B. orellana* dye was obtained from Sir Biotech India Ltd., Kanpur, UP, India. All chemicals used were of laboratory grade.

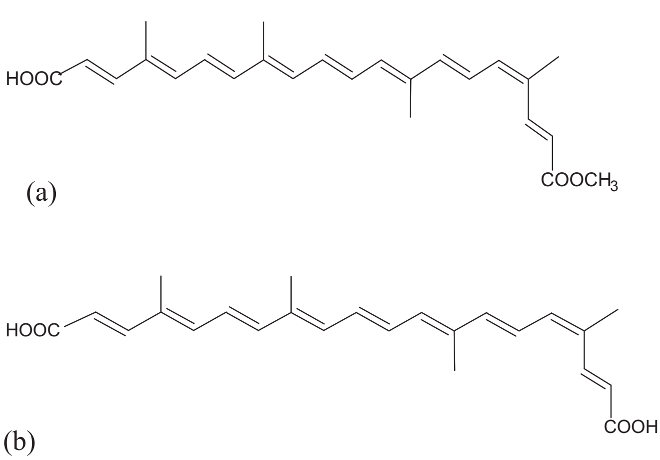

Fig. 2. Structures of (a) bixin and (b) nor-bixin.

Taxonomy of *Bixa orellana* L.

Kingdom:	Plantae
Order:	Malvales
Family:	Bixaceae
Genus:	Bixa
Species:	*Bixa orellana*

2.2. Methods

2.2.1. Mordanting and dyeing

Woolen yarns were mordanted by pre-mordanting method using stannous chloride (1% o. w. f.) as mordant. Before the application of stannous chloride, woolen yarns were soaked in water. The mordant was dissolved in water and material to liquor ratio (M:L) for mordanting was kept at 1:40. Water soaked woolen yarn samples were immersed in the mordant solution. Temperature of the mordant bath was raised till simmering point (91–93 °C) and left at that temperature for 1 h with constant stirring. The mordanted woolen yarn samples were rinsed with tap water in order to remove superfluous mordants (unused).

Dyeing experiments were performed using material to liquor (M:L) ratio at 1:40 in separate baths with manual agitation using 15% o. w. f. (on the weight of fabric/yarn) dye concentration. Woolen yarns were drenched into dyeing baths containing warm dye solution. Dye bath temperature was raised to simmering point (91–93 °C) and maintained at that level for 1 h.

2.2.2. Ammonia after treatment

The after treatment of ammonia was done based on recent research works (Montazer et al., 2004). The woolen yarn samples dyed with annatto were divided into four parts. One part was kept untreated as reference sample and the remaining parts were treated with various ammonia solutions (1, 3, and 5%, w/w) at 25 °C for 10 min. The L:G (liquor ratio) was kept at 20:1. The ammonia treated samples were also acidified with a weak acid (acetic acid) using L:G 20:1 for 10 min.

2.2.3. Color measurement

The colorimetric properties of dyed woolen yarn samples were obtained with Gretag Macbeth Color-Eye 7000 A Spectrophotometer in terms of CIE Lab values (L^*, a^*, b^*, c^* and h^0) and color strength (K/S). The color strength (K/S) in the visible region of the spectrum (400–700) was calculated based on the Kubelka–Munk equation:

$$\frac{K}{S} = \frac{(1-R)^2}{2R} \tag{1}$$

where (K) is the adsorption coefficient, (R) is the reflectance of the dyed sample and (S) is the scattering coefficient.