PROGRESS IN COLOR, COLORANTS AND COATINGS

available online @ www.pccc.icrc.ac.ir

Prog. Color Colorants Coat. 10 (2017), 129-133

Ministry of Science, Research and Technology
Institute for Color Science and Technology

Green Dyeing of Silk Fabrics in the Presence of Pomegranate Extract as Natural Mordant

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ARTICLE INFO

Article history:
Received: 28 Feb 2017
Final Revised: 18 Apr 2017
Accepted: 22 Apr 2017
Available online: 29 Apr 2017

Keywords:
Natural dyeing
Pomegranate
Biomordant
Extraction
Fastness

ABSTRACT

An ecological approach has been obtained by using natural dyes and mordants for dyeing process. Silk fabrics were dyed using natural mordants including powder of sour pomegranate, sweet pomegranate and their mixture. A beautiful red color was obtained using theses mordants. The color of dyed silk fabrics was investigated in CIELab (L^*, a^* and b^*) and K/S values. Finally, all dyed fabrics were tested for wash and light fastness properties as per ISO standard test methods. The results of using biomordants for silk dyeing were comparable with that of metallic mordants in terms of color strength and fastness properties. Pomegranate extract as biomordant produced red color with medium fastness properties and thus offer full potential to replace metal salts in silk dyeing process. Prog. Color Colorants Coat. 10 (2017), 129-133© Institute for Color Science and Technology.

1. Introduction

Dyeing is an important part of processing of textile or carpet preparation in which using organic dyes and mordant materials is the weak point due to carcinogens and environmental pollution [1, 2]. Natural dyes and green mordant are suitable alternatives for organic dyes due to environmentally friendly, low cost, reproduction and biodegradable properties [2-4]. Usually, natural dyes do not have good affinity for adsorption onto fibers thus in most cases, mordant materials are used for improving dyeing properties [5-7]. Natural dyes have limitations such as difficulty of color matching, color reproduction, lack of standard methods in natural dyeing and low color absorption rate [6, 8]. In recent years, much research has been done to solve these problems.

Mehrparvar et al. [9] used clean and eco-benign process for wool dyeing with natural dyes and achieved good properties and fastness for dyed fibers. Drgru et al. [10] dyed wool fabrics with natural dyes such as juglone, lawsone, berberine and quercetine using a casein enzyme. Their results indicated the wool lawsone-casein enzyme complex to be the most appropriate insoluble substrate among all the tested enzymes on the wool-dye complex, with an emphasis on the selectivity of the substrate-dye with the enzyme [10]. Cunningham et al. [11] presented a detailed review on natural mordant and application in natural dyeing. They emphasized on the prerequisite of knowledge of chemistry, cultural requirements and

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resource management for effective utilization of several other possible sources of natural plants in addition to traditionally used plants [11]. Vankar et al. [12] observed that Euriya acuminate when used as mordant in conjunction with Rubia cordifolia dye was found to enhance the dye-ability of silk fabrics by chelation due to the high Al content present in their leaves [12]. These investigators presented a very interesting study on biosorption efficiency of waste pulp generated after natural dye extraction from some selected biomaterials. They demonstrated that using natural dye waste as heavy metal adsorbents can be very effective in remediation of groundwater and surface water of chrome metals in contaminated sites of tannery operation [13].

In this study, two natural mordants containing anthocyanin were extracted for the first time from sweet and sour pomegranate grown in Iran. The effect of biomordants on silk dyeing was investigated in terms of colorimetric data (a*, L* and K/S values) and fastness properties (light and wash fastness).

2. Experimental

2.1. Materials and instrumentation

The sample of pomegranate used in this study was obtained from seven-years-old pomegranate tree grown in Iran. The sour pomegranate and sweet pomegranate were from Behshahr and Saveh in the north and center of Iran, respectively. The samples of pomegranates were collected at random from natural source. The samples were harvested during the 2016 growing seasons. The silk fabrics was bleached with a solution containing 5 g/L of sodium carbonate and 3 g/L of non-ionic detergent (Labolene) under boiling condition for 2h, after which time it was thoroughly rinsed and air dried at room temperature.

2.2. Sample preparation

Fresh pomegranates of 1 g were extracted in 100 mL of water at 50 ºC for 15 min. Solid residues were filtrated out to obtain clear dye solutions. A mixed dye was prepared by mixing sour pomegranate solution and sweet pomegranate solution at a ratio of 1:1 by volume.

2.3. Dyeing Procedure

Silk fabrics (1 g) were dyed in a dyeing apparatus using acetic acid (pH = 4-5) and L: R=40:1. The buildup properties of the synthesized dyes on wool fabrics were obtained by dyeing with dye solutions with 0.1, 0.5, 1, 1.5, 2 and 4% owf. Dyeing was carried out by raising the dye bath temperature from 30 °C to 90 °C at the rate of 2 °C/min, holding at this temperature for 45 min and cooling down at 70 °C at the rate of 3 °C/min. The light, wash and perspiration fastnesses of each dyed fiber were determined according to ISO 105-B02:1994(E), ISO 105-C02:1989(E) and ISO 105-E02:1994(E), respectively.

3. Results and Discussion

Anthocyanins are the most abundant and palmate those adsorb light at longest wavelength with functional groups such as carbonyl and hydroxyl substituents [14]. Anthocyanin compounds exhibit a wide band in UV-Vis region of the spectrum due to charge transfer transition [15]. The pomegranate, botanical name of punica granatum, is a fruit bearing deciduous shrub or small tree in the anthocyanin family that grown between 5 and 8 m (16 and 26 ft) tall. Pomegranate dye (containing tannin) is one of the dyes that provide such beneficial properties [16, 17]. The extraction yield from sour and sweet pomegranate was 22.3% and 25.1%, respectively. The extraction yield can be improved by using sophisticated techniques [18]. Mordants play very important role in imparting color to fabrics. The mordants used in different ratios gave varying shades. However, biomordants can serve with no or minimum environmental impact [18-20].

The silk fabrics dyed with green dyes at 90 °C for 1 h by using natural mordants that 20 g/L biomordants according to simultaneous mordanting method were evaluated. The dyeing process of silk fabrics is illustrated in Figure 1. The natural dye was applied to mordanting silk fabric at concentrations of 0.1, 0.5, 1, 1.5, 2 and 4% owf with liquor to good ratio of 40:1 at 90 °C. For color comparisons, color coordinates (CIEL*a*b*) and visual evaluation should be taken into consideration in addition to color yield values to evaluate the samples accurately. Although a sample has maximum color yield, it may not be replaced with an alternative one due to having different nuances and visual appearance. For this reason, visual appearances of all samples were also mutually assessed and compared with each other in addition to color measurements. Control sample (almond shell dyeing without mordant) was used as reference to evaluate the effects of the mordants on color and fastness properties. Figure 2 and Table 1 show K/S values and

CIEL* a* b* coordinates for dyed fibers. Figure 2 illustrates the build up curves of natural dyes with three mordant from which it is apparent that they generally reached saturation at concentration of <1.5% owf. The results show that using mixture of extraction as biomordant displayed the highest build up. Fabric dyed with biomordants which possess positive a* and negative b* have blue-red hue [21].

Table 1: CIELab values for dyes samples with natural mordants (1% owf).

mordant	L*	a*	b*	Color obtained
Sour pomegranate	35.79	41.06	-6.76	Blue-Red
Sweet pomegranate	30.79	50.30	-6.37	Blue-Red
Mixed mordants	32.29	42.68	-6.45	Blue-Red

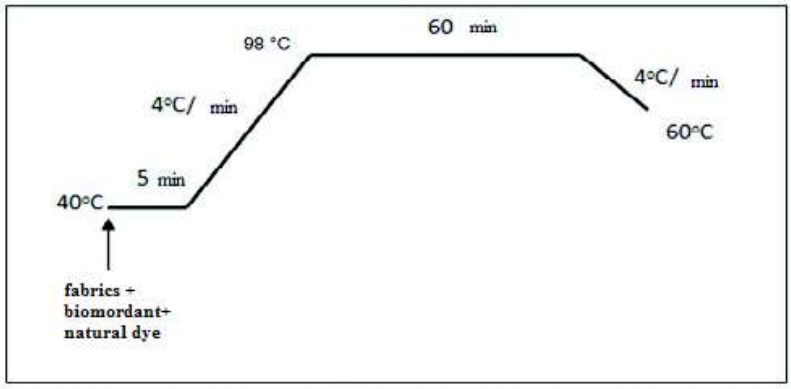

Figure 1: Dyeing process of fabrics.

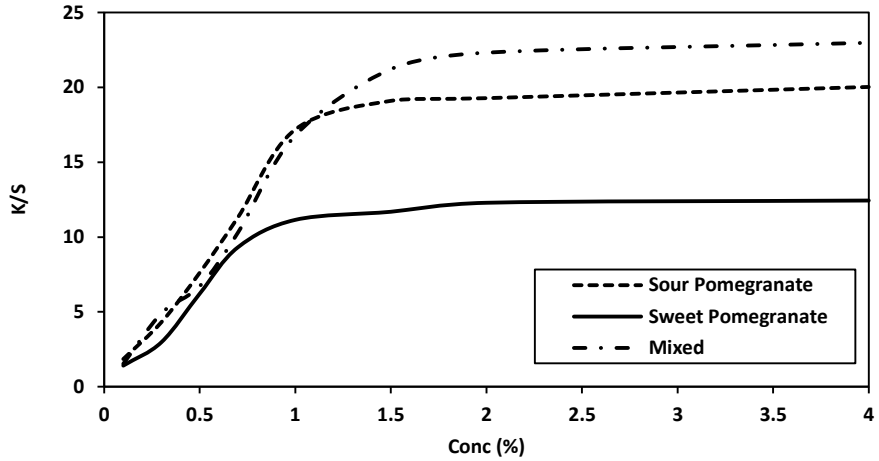

Figure 2: K/S values for dyed fibers with natural mordants.

Table 2: Wash and light fastness value.

biomordant	Light fastness	Change in color	Staining				
			Cotton	Nylon	Polyester	Wool	Acrylic
Sour pomegranate	3	3-4	4-5	4-5	4-5	4-5	4-5
Sweet pomegranate	2-3	3	4-5	4-5	4-5	4-5	4-5
Mixed mordants	2-3	3	4-5	4-5	4-5	4-5	4-5

The wash and light fastness of dyed silk fabrics was tested according to ISO 105-C02:1989(E) and ISO 105-B02:1994(E), respectively. Wash and light fastness values are summarized in Table 2. The fabrics dyed by biomordants have a color change of 3-4 and staining of 4-5 and light fastness of 2-3. Considering these properties, a slight increment in color change caused by sweet pomegranate. However, the color change and light fastness of sour pomegranate was higher than that of other biomordants. The dyed fabrics showed medium wash and light fastness. Fastness properties of dyed fabrics using sour and sweet pomegranate as mordants was similar to other biomordants [22-24].

4. Conclusions

An environment friendly approach was presented for development of eco-friendly hues by sour and sweet pomegranate extracts as natural mordants (biomordants). In this study was to investigated dyeing properties on silk fabrics using biomordants such as sour pomegranate, sweet pomegranate and mixed extract as renewable sources. The biomordants exhibited altogether different behavior and can serve as an alternative to metal mordants in terms of color characteristics and fastness properties which in turn depend on their concentrations. The biomordants can be used with no or minimum environmental impact and can be discharged into the environment without any chemical treatment. However, more analytical research is required to enhance the biomordanting potential of these biomordants by proper dye standardization procedures to get wide range of eco-friendly shades with acceptable colorimetric and fastness properties.

Acknowledgement

The authors sincerely thank the Center of Excellence for Color Science and Technology for making this investigation possible.

5. References

1. M. B. Kasiri, S. Safapour, Exploring and exploiting plants extracts as the natural dye/antimicrobials in textile processing, *Prog. Color Colorants Coat.*, 8(2015), 87-114.
2. A. Purohit, S. Mallick, A. Nayak, N.B. Das, B. Nanda, S. Sahoo, Developing multiple natural dyes from flower parts of glumbur, *Curr. Sci.*, 92(2007), 1681-1683.
3. N. Arivithamani, S. A. Mary, M. S. Kumar, V. R. Giridev, Keratin hydrolysate as an exhausting agent in textile reactive dyeing process, *Clean Technol. Environ. Policy*, 16(2014), 1207-1215.
4. Z. Bahreini, A. Kiumarsi, A comparative study on the dyeability of stabraq (milkweed) fibers with reactive dyes, *Prog. Color Colorants Coat.*, 1 (2008), 19-26.
5. L. J. Rather, S. Islam, M. Shabbir, M. N. Bukharine, M. Shahid, M. A. Khan, F. Mohammad, Ecological dyeing of woolen yarn with adhatoda vasica natural dye in the presence of biomordants as an alternative copartner to metal mordant, *J. Environ. Chem. Eng.*, 4(2016), 3041-3049.
6. P. S. VAnkar, R. Shanker, Eco-friendly pretreatment of silk fabrics for dyeing with delonix regia extract, *Color. Technol.*, 125(2009), 155-160.
7. A. Guesmi, N. B. Hamadi, N. Ladhari, F. Saidi, H. Maaref, F. Sakli, Spectral characterization of wool fabric dyes with indicaxanthin natural dye: study of the fluorescence property, *Ind. Crop. Prod.*, 46(2013), 264-267.
8. A. Kiumarsi, R. Abomahboub, S.M. Rashedi, M. Parvinzadeh, A chillea millefolium: a new source of wool dyeing, *Prog. Color Colorants Coat.*, 2 (2009), 87-93.

9. L. Mehrparvar, S. Safapour, M. Sadeghi Kiakhani, K. Gharanjig, A Cleaner and eco-benign process for wool dyeing with madder, rubia tinctorum L, root natural dyes, *Int. J. Environ. Sci. Technol.*, 13(2016), 2569-2578.
10. M. Dogru, Z. Baysal, C. Aytekin, Dyeing of wool fibers with natural dyes: effect of proteolytic enzymes, *Prep. Biotechem. Biotechnol.*, 36(2006), 215-221.
11. A. B. Cunningham, I.M. Maduarta, J. Howe, W. Ingram, S. Jansen, Hanging by a thread: natural metallic mordant processes in traditional Indonesian textile, *Econ. Bot.*, 65(2011), 241-259.
12. P.S. Vankar, R. Shanker, D. Mahanta, S. C. Tiwari, Ecofriendly sonicator dyeing of cotton with Rubia cordifolia linn using mordants, *Dyes Pigm.*, 76(2008), 207-212.
13. P.S. Vankar, R. Arswat, A. K. Dwivedi, R. S. Sahu, An assessment and characterization for biodorption efficiency of natural dye waste, *J. Clean. Prod.*, 60(2013), 65-70.
14. M. R. Narayan, Review: Dye sensitized solar cells based on natural photosensitizers, *Renew. Sust. Energy Rev.*, 16(2012) 208-215.
15. N. J. Cherepy, G. P. Smestad, M. Gratzel, J. Z. Zang, Ultrafast Electron Injection: Implications for a Photoelectrochemical Cell Utilizing an Anthocyanin Dye-Sensitized TiO_2 Nanocrystalline Electrode, *J. Phys. Chem. B.*, 101(1997) 9342-9351.
16. S. Adeel, S. Ali, L. A. Bhatti, F. Zsila, Dyeing of cotton fabrics using pomegranate (pumice granatum) aqueous extract, *Asian J. Chem.*, 21(2009), 3493-3499.
17. S. S. Kulkarni, A. V. Gokhale, U. M. Bodake, G. R. Pathade, cotton dyeing with natural dye extracted from pomegranate (punica granatum) peel, *Uni. J. Environ. Res. Technol.*, 1(2011), 135-139.
18. H. Goodarzian, E. Ekrami, wool dyeing with extracted dye from pomegranate (punica granatum) peel, *world Appl. Sci. J.*, 8(2010), 1387-1389.
19. W. Sricharussin, C. Sopajaree, T. Maneerung, N. Sangsuriya, Modification of cotton fabrics with β-cyclodextrin derivative for aroma finishing, *J. Text. Inst.*, 100(2009) 682-687.
20. M. Shahid, A. Ahmad, M. Yusuf, M. J. Khan, S. A. Khan, N. Manzoor, F. Mohammad, Dyeing, fastness and antimicrobial properties of woolen yarn dyed with gallunt (quercus infectoria oliv.) extract, *Dye Pigm.*, 95(2012), 53-61.
21. M. Hosseinnezhad, A. Khosravi, K. Gharanjig, S. Moradian, The comparison of spectra and dyeing properties of new azonaththalimide with analogues azobenzene dyes on natural and synthetic polymers, *Arab. Chem. J.*, DOI:http://dx.doi.org/10.1016/j. arabjc. 2013.12.027.
22. R. R. Mahangade, P.V. Varadarajah, H. Verma, J.K. Boscoo, New dyeing technique for enhancing color strength and fastness properties of cotton fabrics with natural dyes, *Ind. J. Fiber. Text.*, 34(2009), 279-282.
23. E. H. Lee, D. G. Song, J. Y. Lee, C. H. Pan, B. H. Um, S. H. Jung, Flavonoids from the leaves of thuja orientalis inhibit the aldose reductase and the formation of advanced glycation and products, *J. Korean Soc. Appl. Biol. Chem.*, 52(2009), 448-455.
24. A. Mohammadi, M. Tahavor, Z. Dehghan, Dyeing properties of some new disperse dye contain piperzine moiety, *Prog. Color Colorants Coat.*, 8 (2015) 197-206.

How to cite this article:
M. Hosseinnezhad, K. Gharanjig, S. Belbasi, S. H. Seied Saadati, Green Dyeing of Silk Fabrics in the Presence of Pomegranate Extract as Natural Mordant. Prog. Color Colorants Coat., 10 (2017), 129-133.