ECOLOGICAL PROCESS DEVELOPMENT FOR PRINTING ON VARIOUS FABRICS WITH MADDER*

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ABSTRACT

The applicability of madder by using printing technique over various natural fibers was investigated in the study. The effect of different factors, i.e. dye and urea concentration, type of fixation, fixation temperature and time, effect of mordant has been studied. Printed fabrics were evaluated by means of color values and fastness properties. The K/S increases rapidly as the concentration of the natural dye powder in the printing paste increases from 15 to 45 g/kg printing paste. The effect of mordant on color development was also studied. It was evaluated in printing cotton, wool and silk in presence and absence of mordant and results show that the highest K/S value was obtained by using mordant. Different color yields were obtained by using mordant and all of color fastness results were ranging between good, very good and excellent, also madder has some superior fastness properties. Application of madder with the printing technique is expected to bring a different and an ecological alternative to new designs in the scope of this study.
Keywords: Madder, Printing, Ecology, Natural Fiber, Mordant.

KÖKBOYANIN ÇEŞİTLİ DOĞAL LİFLERE BASILMASINDA EKOLOJİK OLANAKLARIN GELİŞTİRİLMESİ

ÖZET

Çalışmada çeşitli doğal liflere baskı tekniği kullanılarak kökboyanın uygulanabilirliği araştırılmıştır. Boya ve üre konsantrasyonu, fiksaj çeşidi, fiksaj sıcaklığı ve zamanı, mordan etkisi gibi değişik faktörlerin etkileri incelenmiştir. Baskılı kumaşlar, renk değerleri ve haslık özellikleri bakımından değerlendirilmiştir. Baskı patındaki doğal boya konsantrasyonu 15 g/kg'dan 45 g/kg'a kadar arttıkça K/S değerleri artmıştır. Ayrıca renk değerleri üzerinde mordan etkisi de çalışılmıştır. Pamuk, yün ve ipek kumaşlara mordan varlığında ve mordansız olarak basılarak değerlendirilmiş ve sonuçlara göre en yüksek K/S değerleri mordan varlığında saptanmıştır. Mordan kullanımı ile değişik renk tonları elde edilmiş ve renk haslıkları sonuçları iyi, çok iyi ve mükemmel arasında değişmiştir. Aynı zamanda kökboya da bazı üstün haslık özelliklerine sahiptir. Yapılan bu çalışmanın ışığında, kökboyanın baskı tekniği ile uygulanmasının yeni tasarımlara farklı ve ekolojik bir alternatif getirmesi beklenmektedir.
Anahtar Sözcükler: Kökboya, Baskı, Ekoloji, Doğal Lif, Mordan.

Introduction: The art of dyeing and printing has played an important role in adding beauty to the textiles. There are many studies about dyeing with natural dyestuffs over various fibers and they are widely used. However there are very few studies about applying natural dyestuffs over fabrics with printing techniques. Trend of natural dyestuffs is restored as the result of the awareness of some synthetic azo dyestuffs' disadvantages. As they are hydrolyzed, they reveal some arylamine compounds which are carcinogenic or allergic for human health. Nowadays, people consciously concern their health and global environment, so they require using safe and eco-friendly products (S. Boonroeng et al. 2009). It is believed that natural dyestuffs are more friendly to the human health and the environment than synthetic dyestuffs. Madder is a natural dyestuff that has been used in our country for hundreds of years and has an important place in our historical and cultural heritage. It does not only have a special place in our history and culture, but also it has some superior fastness properties. Rubia tinctorum, the common madder or dye's madder, is a plant species in the genus Rubia. The plant's roots contain several polyphenolic compounds like purpuroxanthin, quinizarin, purpurin and alizarin. The latter gives its red color to a textile dyestuff known as Rose madder. It was also used as a colorant, especially for paint (http://en.wikipedia.org/wiki /Rubia_tinctorum). In this work, madder was chosen as a natural dyestuff. It was applied on cotton, wool and silk fabrics by reactive printing method. The effects of different factors, i.e. dyestuff and urea concentration, type of fixation, fixation temperature and time, effect of mordant were investigated.

Materials and Methods, Materials- Substrate: In this study, 100 % wool woven fabrics with an area weight of 198 g/m2, 100 % cotton woven fabrics with an area weight of 136 g/m2 and 100 % silk woven fabrics with an area weight of 61 g/m2 were used.

Mordant and Other Chemicals: Potassium aluminum sulphate (KAl[SO4]2)was used as a mordant. Sodium hydroxide, sodium bicarbonate, ludigol and urea were laboratory grade chemicals. High viscosity and low viscosity sodium alginate were used under the commercial name Lamalgin G-10 and Alginat STA, respectively.

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Natural Dyestuff: Madder was used as natural dyestuff and its pigment's chemical name is alizarin. It was washed thoroughly with water and dried at room temperature. Powder form of dried madder which was obtained by crushing process was used in order to prepare homogeneous printing paste.
Methods (Mordanting): Two methods of mordanting namely, simultaneous mordanting and pre mordanting were tried to select as the best mordanting method. According to pre mordanting method, fabrics were treated into % 10 potassium aluminum sulphate (KAl[SO4]2) solution and fabric to liquor ratio was chosen as 1:50. The treated fabric was then washed to remove excess chemicals on the surface and dried. In simultaneous mordanting method, mordant was added into the printing paste together with the other chemicals.
Preparation of the Printing Paste: Printing paste with using powdered madder was prepared as follows:

Table 1: Contents of printing paste

Natural dyestuff powder	15, 30, 45 g
Thickener	25 g
Sodium bicarbonate	25 g
Soda	5 g
Ludigol	15 g
Urea	50, 100, 150, 200 g
Balance	X g
Total	1000 g

Printing: Printing pastes were applied to fabrics using the flat-screen printing technique with Johannes Zimmer MDK printing desk. (Esen Özdoğan et.al., 2009)
Fixation: Drying was carried out by Rapid Laboratory Type Dryer at 100°C for 3 minutes. Fixation was performed by thermofixation and by steaming at steamer (Mathis, Switzerland) for different durations and temperatures.
Washing: Washing of the fixed printed goods is carried out as follows: Rinsing thoroughly with warm, hot, warm and cold water, respectively for 10 minutes to each sample and finally all samples were dried at room temperature.
Measurements: The color strength values of the printed goods were measured using a HunterLab ColorQuest II spectrophotometer (D65/10°) (HunterLab, USA) over a wavelength range of 390–700 nm. Wash fastness of the samples were tested according to (ISO 105-C02), method. Dry and wet rubbing fastnesses of the samples were tested according to (ISO 105-X12) method.
Results and Discussion: This study was carried out to investigate the suitability of using madder powder as natural dyestuff in printing natural fabrics using the reactive printing technique and different printing pastes were prepared and also effects of different factors were investigated.
Effect of Urea Concentration: To investigate the effect of urea concentration on the K/S values of printing goods, different printing pastes were prepared using different amounts of the urea, 50, 100, 150, 200 g/kg pastes. The results obtained are shown in Figure 1. The printed fabrics were cured by steaming at 102°C for 10 minutes.

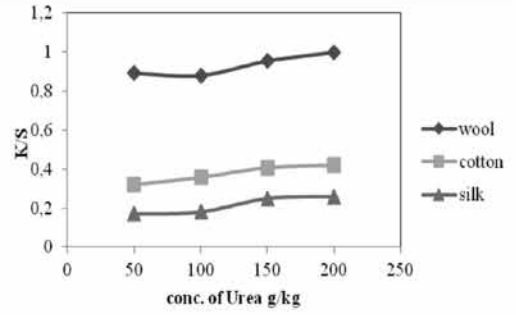


Figure 1: Effect of urea concentration

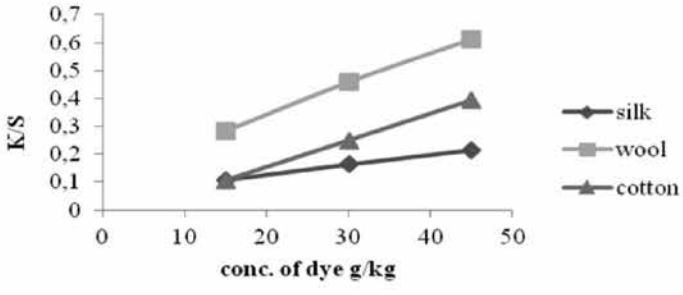
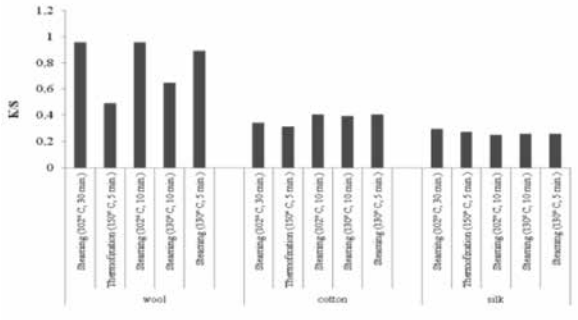


Figure 2: Effect of natural dyestuff concentration

The K/S values increased rapidly as the concentration of the urea increased from 50 to 200 g/kg in the printing paste. According to color strength values, 150 g/kg was selected as optimum concentration.
Effect of Dyestuff Concentration: To investigate the effect of dyestuff concentration on the K/S values of printing goods, different printing pastes were prepared using different amounts of the specified natural dyestuff, 15, 30, 45 g/kg pastes. The results obtained are shown in Figure 2. The printed fabrics were cured by steaming at 102°C for 10 minutes. The K/S increased rapidly as the concentration of the natural dyestuff powder in the printing paste increased from 15 to 45 g/kg printing paste.

According to color evaluation, 45 g/kg printing paste was selected as optimum concentration.
Effect of Fixation: Printed goods in optimum urea and dyestuff concentration were steamed at 102° C for 10 and 30 minutes, at 130°C for 5 and 10 minutes and also thermofixation was performed at 150°C for 5 minutes.



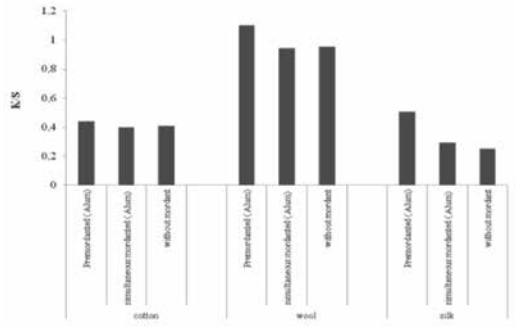


Figure 3: Effect of curing type, temperature and time. **Figure 4:** Effect of mordant

Figure 3 shows that both 102 and 130 °C temperature of steaming have a similar K/S values. Longer exposure of the fabric to high degree of steaming also brought the risk of the fabrics' yellowing. Thus, in this study the duration of steaming chosen to give satisfactory results was 10 min at temperature of 102°C for all fabrics (M. Rekaby et al., 2009). Moreover, results show that the printed goods, which were fixed by steaming, have relatively higher color strength than their corresponding samples fixed via thermofixation. This condensed water vapor may accelerate the penetration of the dyestuff molecules into the fabric and hence increases the K/S values of the printed fabrics fixed by steaming than those fixed by using conventional hot air in the thermofixation process (M. Rekaby et al., 2009).
Effect of Mordant: Mordants are often used with natural dyestuff to fix the dyestuff, keep natural ones from fading and improve their fastness properties. The dyestuff binds better to the fabric by means of mordant. By using different mordants, a variety of colors may be obtained with natural dyestuffs. In this work potassium aluminum sulphate (KAl[SO4]2) was used as a mordant in the printing paste of madder. Two methods of mordanting namely, simultaneous mordanting and pre mordanting were studied. The prepared pastes were then used in printing wool, silk and cotton fabrics. It was observed that the mordant has a remarkable effect on the obtained colors where different ranges could be obtained by using different mordants. Figure 4 shows the effect of mordanting on the K/S of cotton fabrics. As previously mentioned, cellulosic fibers have a weak affinity to the natural dyestuff compared with the protein fibers. But using mordant can increase its affinity and hence increase the K/S values.Wool has a good affinity to the natural dyestuff; its chemical structure enables the fiber to bind chemically with a wide variety of dyestuffs. Wool being a protein fiber has a high affinity to the natural dyestuffs. Although silk is categorized as a protein fiber, it differs from wool in its weight, absorbance, resilience and reactivity properties (J.I. Abd –El Thalouth, 2011).
Fastness Properties: Washing and rubbing fastness of the printed fabrics were tested, the results of simultaneous mordanting and pre mordanting with potassium aluminum sulphate printed goods were compared with unmordanted samples.
Table 2 shows that the overall fastness properties, i.e. color fastness to washing and rubbing of the mentioned printed fabrics, are nearly comparable and range from good to very good. Colorfastness to washing, all samples showed the value of staining "5". As shown table 2 mordanting had a positive effect on fastness properties of natural fabric.
Conclusion: In this study, the duration of steaming chosen to give satisfactory results was 10 min at temperature of 102°C for all fabrics. Moreover, results show that the printed goods, which were fixed by steaming, had relatively higher color strength than their corresponding samples fixed by thermofixation. In the printing process of fabrics with natural dyestuffs, a good pretreatment is essential to obtain full color yields, levelness and brightness. As shown in the K/S results, mordanting had a positive effect on the printability of natural fabrics. Application of madder with the printing technique is expected to bring a different and an ecological alternative to new designs in the scope of this study. And also the ecological and toxicological problems caused by synthetic dyestuffs can be solved to some extent.

Table 2: Fatness properties of dyed samples

Fabric type	Fixation Type	Washing fastness		Rubbing Fastness	
		Stain	Change	Dry	Wet
Cotton	Steaming (102° C, 10 min.)	5	3-4	4-5	3-4
	Steaming (130° C, 10 min.)	5	4	4-5	4
	Steaming (130° C, 5 min.)	5	3-4	4-5	4
	Steaming (102° C, 30 min.)	5	4	4-5	3-4
	Thermofixation (150° C, 5min.)	5	3-4	4-5	3-4
	Premordanted	5	4	4-5	4-5
	Simultaneous mordanted	5	3-4	4-5	4-5
	Without mordant	5	3-4	4-5	3-4
Wool	Steaming (102° C, 10 min.)	5	4	5	4
	Steaming (130° C, 10 min.)	5	4	5	4
	Steaming (130° C, 5 min.)	5	4	5	4
	Steaming (102° C, 30 min.)	5	4	4-5	3-4
	Thermofixation (150° C, 5min.)	5	4	5	4
	Premordanted	5	3-4	4-5	4
	Simultaneous mordanted	5	3-4	5	4
	Without mordant	5	4	5	3-4
Silk	Steaming (102° C, 10 min.)	5	4	5	4-5
	Steaming (130° C, 10 min.)	5	4	5	5
	Steaming (130° C, 5 min.)	5	4	4-5	4-5
	Steaming (102° C, 30 min.)	5	4-5	5	4-5
	Thermofixation (150° C, 5min.)	5	4-5	5	5
	Premordanted	5	4	5	4-5
	Simultaneous mordanted	5	4	5	4-5
	Without mordant	5	4	5	4

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