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TINCTORIAL PROPERTIES OF COTTON AND MODIFIED COTTON FABRICS DYED WITH DATE PITS POWDER USING CONVENTIONAL AND ULTRASONIC ENERGY

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This research work involves a comparative study on tinctorial and fastness properties of cotton and modified cotton fabrics dyed with date pits powder using conventional and ultrasonic energy. The dyeability of non-modified cotton fabric has been just succeed in acidic medium. For modified cotton fabric, the extracted dye has presented an affinity via the textile fabrics at acidic and basic medium. It was also to note, that in all the studied cases the ultrasonic treatment has presented a highest dye uptake when compared with the conventional one. The overall fastness properties were evaluated and all the dyed samples have presented, generally, good fastness properties. Also a comparative study of the hydrophilic character of cotton, modified cotton and commercially cationized cotton has been developed, and it was shown that the modification of cotton doesn't affect enormously the hydrophility of cotton when compared with the commercially cationized cotton.

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1. Introduction

Wearing comfortable and safe clothes is becoming an interest of a big part of peoples. For this reason, a special interest has been reserved to developing a combination between natural dyes and cotton fibers as a consequence to their specials properties.

1.1 The interest of cotton fibers

Cotton is the most widespread naturally hypoallergenic textile fiber. Its popularity is certainly related to those specific properties associated to its structure which offer an extra-comfort level to consumers with sensitive skin (Marc et al. 2018; Michaela et al. 2018).

1.2 The interest of natural dyes

The interest of natural dyes has increased considerably due to the world conscience about the safe and the bio-character of those colorants especially when compared with the synthetic ones (Guesmi et al. 2012; Guesmi et al 2013a; Guesmi et al. 2013b). Many advantages have been also communicated to the fibers dyed with those natural products, which causes an increase of the added value of those elements (Guesmi et al. 2013c; Geetam et al. 2017; Daniele et al. 2011).

1.3 Previous studies on dyeing cotton with natural dyes

Many researches have studied the dyeability of cotton fibers with natural dyes. Most of them have related this dyeing application to the use some metallic mordants which could damage the bio-character of those natural products (Mohd et al. 2015; Burkinshaw and Kumar, 2009). Other researches have combined the natural dyeing of cotton to the use of a cationazing agent

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which could affect both the hydrophilic character and the soft touch of cotton (Kamel et al. 2009; Kamel et al. 2011).

In this research, we propose to study the dyeing results of conventionally and ultrasonically dyed cotton and modified cotton fabric with the colored matter extracted from date pits powder, without coursing to a cationizing agent.

2. Materials and methods

2.1 Fabrics

Pre-bleached cotton fabric (160 g/m^2) was used in this study. Before using, cotton fabric was firstly treated with an aqueous solution containing 1 g/L of a non-ionic detergent, at a temperature of 95 °C during 30 min. Then, the fabric was washed with tap water and dried at room temperature.

2.2 Date pits

The variety of date used in this study, is widespread in the palm of Gabes, Tunisia (Phoenix dactylifera, Korkobbi). Experts of National Institute of Agronomic Research of Tunisia (INRAT) have identified these dates, and voucher specimens (Number 20.8) was deposited in the National Institute of Agronomic Research of Tunisia. Date pits were removed, cleaned by tap water, air dried and finally crushed to give a powdered matter. The obtained powder was taken immediately to the laboratory and subjected to the dye extraction.

2.3 Modification of cotton

Modification of cotton has been proceeded on two steps following a previously published method:

First, fabric was treated in a DMF solution containing 0.4 mL of bromoacetyl bromide at a liquor to goods ratio of 20: 1; the treatment was carried out using ultrasound. The fabric was exposed to ultrasonic irradiations of 25 kHz and 500 W. The fabric was then rinsed with tap water, dried in open air and kept for further investigation.

The acetylated cotton, obtained from the first treatment, was then treated in an aqueous solution with a large excess of triethylamine (5 mL) at liquor to good ratio of 20:1. The treatment was carried out using ultrasound at a frequency of 25 kHz and a power level of 500 W; the fabric was then rinsed thoroughly in tap water and dried in open air (Guesmi et al. 2013).

2.4 Extraction of colored components

The extraction of the colored matter from the date nucleus was proceeded as follow:

Date nucleus were powdered coarsely, and then 200 g of the powdered matter was macerated with distilled water (1500 mL), the resulted mixture was sonicated for 30 minutes (25 kHz, 500 W). The extract was filtered and the volume was adjusted to 2000 mL with distilled water. The extract was freeze-dried to give a lyophilized extract. The residue has been kept to the previous dyeing tests (Guesmi and ben hamadi 2018).

2.5 Dyeing method

Dyeing experiments have occurred in a dye bath containing 6 % owf of the dye, with a liquor ratio of 40:1. Based on previous studies, the pH values were adjusted to 4 and 9 (Guesmi et al. 2016).

Conventional dyeing tests have been developed at 90 °C for 90 minutes and ultrasonic dyeing tests have been developed at a frequency of 25 kHz and a power level of 500 W during 30 minutes. Finally, the dyed samples were rinsed with cold water and finally dried at ambient temperature.

Throughout the manuscript, conventional heating is abbreviated to ‘CH’ and ultrasonic treatment is abbreviated to ‘US’.

2.6 Colour strength measurements

The colour yield of samples was evaluated by light reflectance measurements using SF 300 spectrophotometer. Relative colour strengths (K/S values) were determined using the Kubelka–Munk equation (Judd and Wysezcki, 1975):

$$K /R= (1 R)^2/2R$$

The reflectance R of the dyed yarn was measured on a UV–vis spectrophotometer. To subtracted from the reflectance of the sample before calculation of K/S. The K/S values are calculated from six repetitive measurements.

2.7 Colour fastness testing

The dyed samples were tested for fastness properties according to standard methods, the specific tests were for colour fastness to washing ISO 105-C02:1989, colour fastness to rubbing ISO 105-X12:1987, colour fastness to water ISO 105-E01:1989 and colour fastness to light ISO 105-B02:1988 (carbon arc).

2.8 Comparison of the hydrophilic character of cotton, modified cotton and commercially cationized cotton

E-Solfixhas been largely used as an efficient cationized agent applied to cotton in order to succeed its dyeability with natural dyes. This section has been developed to compare the hydrophilic character of cotton, modified cotton and Solfix-cationized cotton. Thus the same condition of measurement was made as follows:

Cylindrical specimens of 50 mm of diameter have been prepared and placed in a plate table at ordinary conditions. 2 mL of distilled water has been injected using an electronic micropipette at the centre of each specimen. 5 minutes later, each specimen has been inversed on the other face, and immediately the diameter of the transferred water has been measured.

3. Results and discussion

3.1 Dyeing results

The objective of this section is to compare the dyeing results of conventionally and ultrasonically dyed cotton and modified cotton fabric with the colored matter extracted from date pits powder, without coursing to a cationizing agent which could affect the hydrophility of the cellulosic matter.

Table 1 resume the tinctorial properties of cotton and modified cotton fabric dyed under ultrasonic and conventional energy, at acidic and basic conditions. As shown in the table, the dyeability of non-modified cotton fabric has been just succeed in acidic medium, both for conventional and ultrasonic dyeing methods. At basic medium, the K/S values were very low to consider the dyeing results just as dirt of the treated samples. For those experiments, the dye uptake could be due to the hydrogen bonds developed between the hydroxyl groups of the fiber and the hydroxyl groups of the polyphenolic colored matter extracted from date pits powder. An additional reason for the dye uptake, could be that the bio-metal present in the extracted matter has functioned as a bio-mordant in the dyeing experiment (Guesmi et al. 2016).

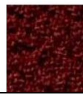
For modified cotton fabric, the extracted dye has presented an affinity via the textile fabrics at acidic and basic medium, for both conventional and ultrasonic dyeing methods.

At basic medium, the hydroxyl groups of the polyphenolic dye have been converted onto alkoxide ions which could develop an electrostatic interaction with the protonated amino groups present on the modified cotton fibers.

At acidic medium, the dyeability of the modified fabrics could be both produced by the hydrogen bonds developed between the hydroxyl groups of the dye and the non-converted hydroxyl groups of the modified fibers, and also by the functionalization of the bio-metal present in the extracted as a bio-mordant.

It was also to note, that in all the studied cases the ultrasonic treatment has presented a highest dye uptake when compared with the conventional one. This was certainly due to the more focused conditions produced by this non-conventional dyeing method (Mohammad and Khaled 2018; Venkatasubramanian and al. 2009; Guesmi et al. 2013d).

Table 1. Tinctorial properties of cotton and modified cotton fabric dyed under ultrasonic and conventional energy.

	pH	K/S	L^*	a^*	b^*	Color
Cotton, CH	4	8.57	49.13	9.00	15.73	
	9	1.53	85.47	-0.68	15.12	
Modified Cotton, CH	4	3.48	69.047	6.334	29.982	
	9	9.63	45.798	8.722	10.337	
Cotton, US	4	8.76	46.390	3.123	9.073	
	9	1.54	85.39	-0.69	15.09	
Modified Cotton, US	4	5.83	58.150	9.899	34.948	
	9	9.77	40.143	3.666	22.181	

3.2 Fastness properties

The overall fastness properties were evaluated and the results are summarized in table 2. As shown in the table, all the dyed samples have presented, generally, good fastness properties. It was also to note, when comparing the properties of the non-modified cotton, dyed at pH 4, that an improvement has been registered in case of ultrasonic treatment. This improvement has been also observed in case of modified cotton dyed at acidic and basic medium. For this reason, ultrasonic irradiation could be proposed as favorable for developing the auto-bio-mordanting process, which could be responsible for the improvement in the fastness properties of the ultrasonically dyed samples.

Nevertheless, a slight regression in the fastness properties of modified cotton fabrics, dyed at basic medium, has been detected. This regression could confirm that in basic medium the fixation of the dye on the fabric is mainly generated via an electrostatic interaction between the protonated amino site present in the fiber and the alkoxide group generated, at basic medium, in the dye.

Table 2. Fastness properties of cotton and modified cotton fabric dyed under ultrasonic and conventional energy.

	pH of dyeing	Dry rubbing	Wet rubbing	Washing	Light
Cotton, CH	4	5	4-5	4-5	4
Modified Cotton, CH	4	5	4-5	4-5	4
	9	4	4	4	4
Cotton, US	4	5	5	5	4
Modified cotton, Us	4	5	5	5	4
	9	4-5	4-5	4-5	4

3.3. Comparison of the hydrophilic character of cotton, modified cotton and commercially cationized cotton

Results on the comparative study of the hydrophilic character of cotton, modified cotton and commercially cationized cottons summarized in table 3. It was shown, from the table that the modification of cotton doesn't affect enormously the hydrophility of cotton when compared with the commercially cationized cotton.

Table 3. Comparative study of the hydrophilic character of cotton, modified cotton and commercially cationized cotton.

	Cotton Specimen	Modified Cotton Specimen	Cationized Cotton Specimen
Diameter of water (mm)	3 mm	2.8 mm	1.4 mm

4. Conclusions

Date pits powder has served as a source of natural colored components. The extracted dye was applied for dyeing modified and un-modified cotton fabrics at acidic and basic mediums, using conventional and ultrasonic dyeing methods. The dyeability of non-modified cotton fabric has been just succeed in acidic medium. For modified cotton fabric, the extracted dye has presented an affinity via the textile fabrics at acidic and basic medium. It was also to note, that in all the studied cases the ultrasonic treatment has presented a highest dye uptake when compared with the conventional one. The overall fastness properties were evaluated and all the dyed samples have presented, generally, good fastness properties. Also a comparative study of the hydrophilic character of cotton, modified cotton and commercially cationized cotton has been developed, and it was shown that the modification of cotton doesn't affect enormously the hydrophility of cotton when compared with the commercially cationized cotton.

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