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ANTI-ODOR TREATMENT ON 100 % WOOL FABRIC USING COLORANTS FROM COFFEE GROUND RESIDUES

Bui Mai Huong*, Le Thi Huong Thinh

Department of Textile–Garment Engineering, Faculty of Mechanical Engineering
Ho Chi Minh city University of Technology, HCMUT–VNUHCM
268 Ly Thuong Kiet, Ward 14, District 10, Ho Chi Minh City

*Email: bmhuong@gmail.com

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Abstract. Ground coffee residues are considered as biomass and organic wastes that can be used for further applications due to their deodorant properties. The purpose of this study is to confer anti-odor treatment on 100 % wool fabric by bi-functional dyeing process with the colorant extracted from ground coffee residues. The extraction was carried out using water at 100 ºC with different extracting ratios. The knitted wool fabrics were IR dyed with extracting solutions at 80 ºC for 90 minutes, then dried at 60 ºC for 30 minutes. The treated wool fabrics were evaluated by colour strength K/S and FT-IR spectra. The colour fastness to hand-washing was tested according to AATCC standard, and the results exhibited good grade of 4-5. The anti-odor effect was also evaluated according to AATCC method for textile materials after laundering. The results confirmed deodorization of fabrics treated by ground coffee residues extraction, even with strong odor like onion.

Keywords: coffee, biomass, wool, anti-odor, fabric.

Classification numbers: 1.1.6, 2.7.1.

1. INTRODUCTION

Anti-odor treatment is not a new story in textile finishing, however this technology has also made great progresses with the development of chemical technology and the trend of eco-friendly products. The origin of odor in textiles comes from the emission of impurities and contaminants during the process, transport, storage and handling of the products or after contact with skin. The interactions between bacteria on human-skin and textiles are rather good, as many bacteria adapt to the physiological skin conditions (30-35 ºC, pH from 5 to 6.5) and various nutritive substances [1, 2]. Textiles, therefore, can act as barrier to block the water evaporation, the consequent moisture combined with the presence of nutrients at the interface between the skin and the textile induce the growth of micro-organism.

Many advanced methods for odor elimination in textiles have been developed. Textiles controls the releases of bad odor by masking agents or neutralizing agent in sensory

deodorization method. In chemical odor elimination method, reactive groups on the surface of nanoparticles catch odor components and turn them into odorless substances. It controls acetic acid or ammonium odor from sweat and body odor. The entrapment deodorization is based on the trapping charges such as cyclodextrins, active-carbon, zeolite, which can fix odorous substances on active sites at the surface of the materials [1, 3]. In odor capture technologies and antimicrobial technologies, treatments usually use heavy metals like silver, zinc, copper and some other chemicals. The anti-odor treatments are normally required to be effective for up to 25 laundries, following the normal life cycles of garment.

Despite that consumers wish to obtain odor control in textiles, they also care about the environmental effects that caused by finishing chemicals. Many efforts have been developed to applying anti-odor treatment on textiles with natural wastes. The activated carbon produced from coconut and oil palm shells has been applied in different percentages on polyester and cotton fabrics through coating and printing techniques. Odor measurements were conducted to evaluate the effectiveness of the anti-odor through the human olfactory tests and by using a device called portable electronic nose [4, 5]. In some investigation, researchers also applied activated carbon from coffee in odor processing in order to utilize an efficient and economic absorbent waste from coffee [6, 7].

Following the green solutions trend for anti-odor as mentioned above, this study chose 100 % woven wool fabric to apply bi-functional anti-odor and dyeing treatment with ground coffee residues. Merino wool was selected, as it is mid-low odor intensity together with cotton. However, the number of bacteria declined more slowly on cotton or wool fabrics than on polyester fabric. The relationship between fiber type and odor was not influenced by bacterial numbers present [2]. The anti-odor effect in our study was evaluated according to the AATCC 2017 methods for odor evaluation of textiles and other materials for fabric before and after laundering. The results proved the efficiency of deodorization of treated fabric by coffee residues extraction, even with strong odor like onion.

2. MATERIALS AND METHODS

2.1. Materials

Ground residues of Arabica coffee beans were taken after being extracted by Espresso machine at Café shops. These amounts of coffee wastes were divided into two different types, approximately 10 grams for each part. 100 % Merino Wool single jersey knits used for experiments were purchased from Lien Phuong Joint Stock Company (LPTEX). Warp density is 38 threads cm^{-1}, weft density is 40 threads cm^{-1}, fabric weight is approximately 250 g/m^2 for each sample.

2.2. Extraction of ground coffee residues to prepare the dyeing solution

Ground coffee residues were dried at 90 ºC for 30 mins, sieved and dried again at 100 ºC for 30 mins. Extracts from ground coffee residues were obtained through pour-over method with filter papers, distilled boiled water and beckers. Three extracting ratios were prepared by adding 5 g, 15 g and 25 g (named as samples A, B, C) ground coffee residues into 200 ml distilled water respectively at pH 4.5.

2.3. Dyeing process

The dyeing process was carried out using the Infrared dyeing machine - Laboratory of Mesdan S.p.A IR Dyeing Machine. Dyeing process was implemented at temperature of 80 ºC

for 90 minutes, a consequent rinsing stage was performed at 60 ºC, the bath rotational speed was 45 rpm. After dyeing, the wool samples were completely washed with deionized water and naturally air dried.

2.4. Dip – pad dyeing wool fabric by carbonized coffee residues

To prepare the coffee residues carbonization, 10 g of ground coffee residues was fully extracted until entirely afloat on water surface, then dried at 100 ºC for an hour and finally carbonized in Nabertherm furnace at 500 ºC for 1 hour in inert gas (heating rate was 10°C min^{-1}). After this process, carbonized coffee pulp was washed with distilled water until neutral pH was reached. Pyrolyzed coffee residues and wool fabric were placed in the container comprising of deionized water and 1 % acetic acid solution under stirring condition at 60 ºC in 30 minutes. The samples were padded under 3 kg of pressure to ensure pick-up rate of 80 % and then dried in a chamber at 60 ºC for 15 mins.

2.5. Anti-odor measurements

The effective evaluation survey of anti-odor characteristic of the treated wool fabrics with coffee grounds by human olfactory was conducted. Prior to these measurements, all types of wool fabric samples were exposed to chopped onion, which odor as substitution to body odor in glass bottles. The samples were placed in glass bottles containing 2 g of peeled white onions. After 12 h, the samples were taken out from the containers and placed individually in bottles with odor-free air inside. The human olfactory survey was conducted in accordance with relevant ISO standards at a temperature and humidity range of 22 ± 3 ºC and 38 ± 7 % R.H. Ten volunteers with different ages and careers ~~to~~ evaluated the samples based on standard odor levels. The rating process was done in an air-conditioned room, with no smell, and each volunteer was given about 2 min to evaluate each sample. During the survey, it was prevented from communicating among volunteers to avoid biasness in the results. The panels were given coffee to neutralize their sense of smell between samples to avoid errors in the evaluation. The odor intensity levels were shown as below: 1- Not perceptible; 2- Perceptible, but not disturbing; 3- Disturbing; 4- Strongly disturbing; 5- Unbearable.

2.6. Characterization

The structure and morphology of these treated wool sample with 3 approaches were investigated using scanning electron microscopy (SEM, Hitachi S4800). The chemical composition of the samples was identified by Fourier-transform infrared spectroscopy (FT-IR). The characterization experiments were implemented at Biotechnology Center Ho Chi Minh city, Vietnam.

2.7. Color measurement

The CIEL*a*b* values were measured using spectrophotometer (Color i5 Benchtop Spectrophotometer). The L* value shows luminance in CIELab colour space and its values from 0 (black) to 100 (white). The +a* value indicates red and -a* values indicates green, while +b* values indicates yellow and -b* values indicates blue. The colour fastness to washing and rubbing of the dyed samples was determined according to ISO 105-C06 A1S: 1994, respectively.

3.

3. RESULTS AND DISCUSSION

3.1. Assessment of anti-odor ability of wool fabrics treated with extraction from ground coffee residues

Assessment of anti-odor ability from coffee ground extraction on wool fabric are displayed in Table 1 and Table 2 after undergoing onion smell interaction then conducting odor ranking survey. The result was assessed, confirming bi-functional of anti-odor and dyeing effect on treated wool fabric. The anti-odor effect can stay after hand washing with light anti-odor level.

Table 1. Anti-odor ability for wool fabric dyed with coffee ground residues extraction.

	Grading before washing			Grading after washing		
	Sample A	Sample B	Sample C	Sample A	Sample B	Sample C
Volunteer 1	3	3	2	3	3	2
Volunteer 2	3	2	2	3	2	1
Volunteer 3	3	3	2	3	2	2
Volunteer 4	2	2	1	3	2	1
Volunteer 5	3	2	1	2	3	1
Volunteer 6	2	2	1	3	2	1
Volunteer 7	3	2	1	3	2	2
Volunteer 8	2	2	1	2	3	1
Volunteer 9	2	2	1	3	2	1
Volunteer 10	3	2	2	3	2	1
Mode	3	2	1	3	2	1
Average	2.6	2.2	1.4	2.8	2.3	1.3
Standard deviation	0.516	0.422	0.516	0.422	0.483	0.483

Table 2. Anti-odor ability for wool fabric padded with coffee ground residues extraction.

	Grading before washing	Grading after washing
Volunteer 1	1	1
Volunteer 2	2	2
Volunteer 3	1	1
Volunteer 4	1	1
Volunteer 5	1	1
Volunteer 6	1	2
Volunteer 7	1	1
Volunteer 8	1	1
Volunteer 9	2	1
Volunteer 10	1	2
Mode	1	1
Average	1.2	1.3
Standard deviation	0.422	0.483

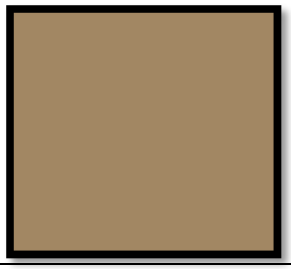
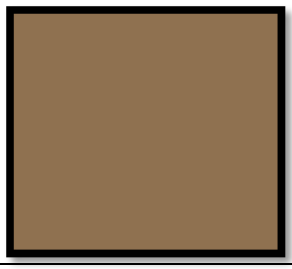
According to the result of survey of deodorant on wool fabrics treated with three different concentrations from coffee ground extraction, we found that fabrics obtain certain anti-odor level. Before washing, more than 50 % percentage of samples A was accounted at level 3 (Disturbing – onion smell detection). Meanwhile, samples B was assessed mainly at level 2 (80 %). Up to 70 % of level 1 (no onion smell detection) was analyzed at sample C, which dyed with the highest coffee extraction. There is no percentage of rating for level 4.5. Besides, the percentage of odor level assessments, after washing, was relatively relevant to non-wash condition of sample B and C. Especially, it was increased strongly in sample A rated at level 3 (80 %) and also no percentage of ratings for level 4, 5.

The tables show that the smell before and after washing was of quite the same level on wool fabric. The majority of level is level 1 (odorless) accounts for 80 %, the rest is for level 2. There is no rating for level 3, 4 and 5.

3.2. Assessment wool fabrics of treated with coffee ground residues extraction

Appearance assessment of wool fabric after dyeing and padding methods were carried out with color measurement and SEM images. Light to dark yellow brown can be found in treated wool fabrics as shown in Table 3. The higher concentration of coffee residues, the darker yellow brown displayed in fabric. The values of L * (brightness) gradually decrease, while a * and b * increase with the extraction rates. This brown pigment compound is also typical color of coffee, which proved the combination of color compound from coffee onto wool fabric.

Table 3. Color assessment of wool fabric treated with coffee ground residues extraction.

	Sample A	Sample B	Sample C
L	61.46	53.02	46.79
a*	7.35	9.32	11.94
b*	26.02	28.26	30.78
Visual color			
Colorfastness to accelerated laundering			
Color change	4	4	4-5
Color staining	4-5	4-5	4-5

Considering the color fastness of the wool fabrics dyed with three different ground coffee residues extractions, the wool fabrics showed a high level of color fastness to washing (4 - 5 grade). Respectively, they exhibited somewhat inferior color staining (4 - 5 grade), which demonstrated the levels of color fastness of the wool fabrics dyed with the ground coffee extract and mordanted with acetic acid show the highly desirable overall with other natural pigments.

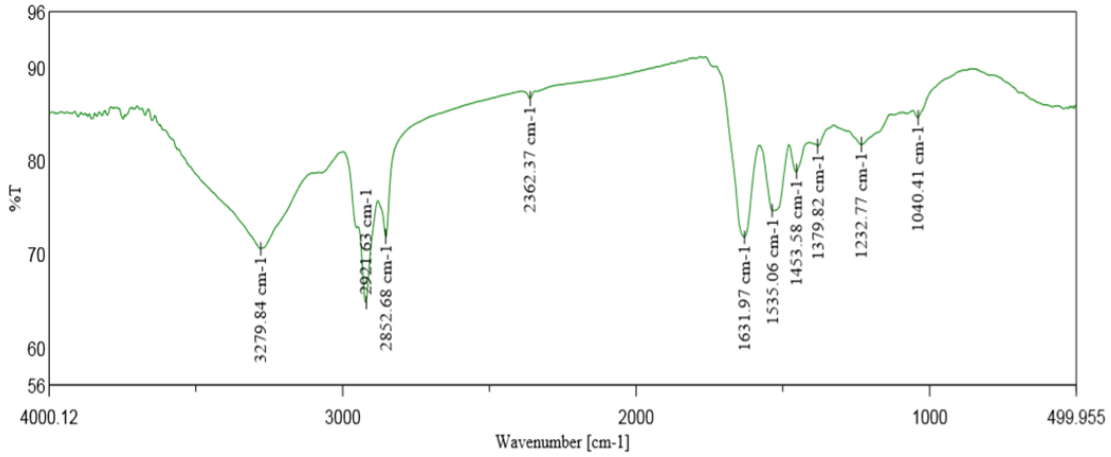


Figure 1. FT-IR of wool fabric dyed with coffee residues extraction (samples C).

In order to ensure the bonding of coffee extraction on fabric, FT-IR method was used and the spectrum is displayed in Figure 1.

The result showed that besides the functional groups in wool fibers such as carbonyl (COOH), hydroxyl (-OH), amino (-NH_2), according to Figure 1, we can find the peaks of 3279.84 cm^{-1} (NH and OH), 2852.68 cm^{-1} (-CH_2) and amino group at 1232.77, 1535.06, 1631.97 cm^{-1} NH-). The peak of the C-O ester group also found in woolen fabrics are the chemical bonding groups of phenol compounds from extracts in coffee grounds. The brown nitrogen compounds in the coffee grounds are the product of the Maillard reaction between the reducing sugar and the free amino acids to form a combination of many products including Melanoidins [8].

Regarding the padding process with charcoal coffee residues, the samples exhibited smoky gray color shown in Table 4 due to the pigment from the carbonization process in the process of coal coffee grounds. According to the naked eye observations and performing colorimetric measurement in different locations on the fabric sample, the irregular color phenomenon occurs. The cause might come from many influencing factors such as uneven coal particle size, the density of coal particles is not uniform.

Table 4. Appearance assessment of wool fabric padded with charcoal coffee pulps.

L	59.89
a*	-0.33
b*	3.7
Visual color	

In order to get a clearer comment on the ability to colorize and create a link between coal and wool materials, Figure 2 showed the density of coffee ground coal distribution on woolen material after padding.

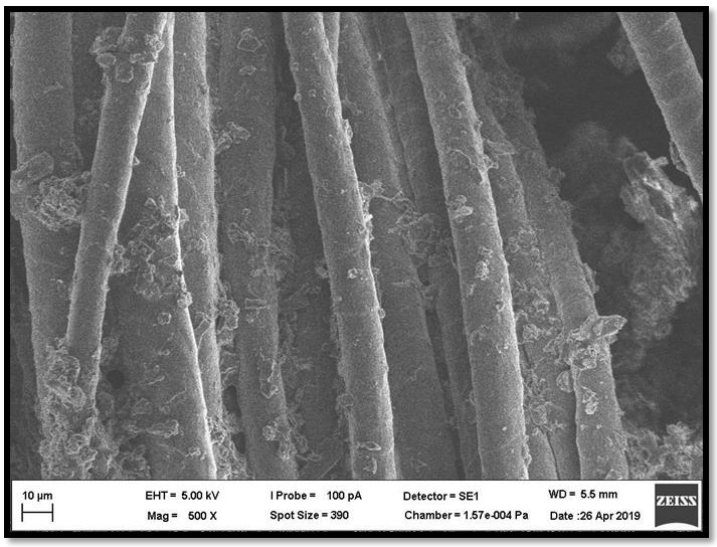


Figure 2. SEM images (500x) of distribution of coffee ground coal on woolen material after padding.

The position of coal particles (black dots) were observed by microscope. Particle less than 10 µm diameter were allowed to enter the capillaries of wool fibers, while large size particles were stuck up in the fabric structure. The density of coal particle distribution is uneven on wool fibers then caused a color irregularity after padding.

4. CONCLUSIONS

Wool fabrics were dyed with three different ground coffee residues extraction with acetic acid and dip-padded carbonized coffee residues to obtain both anti-odor and dyeing effect. For dyeing method from coffee residue extract, the assessment is very positive in terms of uniform color, good color staining after washing. Vividly, the high grade of color fastness and color staining to washing is 4-5 grade. However, only sample C with the highest concentration extraction indicated particularly anti odor ability (no onion smell detection). In addition, in the anti-odor assessment, the level of this option is not full satisfactory because there is still another odor on the fabric. In order to demonstrate the deodorizing of coffee grounds with the effect of chromophore and odor, increasing concentration, extraction rate and use of mordant is necessary to investigate this theoretical basis. In padding method from coal coffee grounds, the evaluation results are very positive, leaving no onions on the fabric even after 24 hours of contact. However, the occurrence of color staining and color fastness after washing at medium level have shown the drawback of this option. The reason comes from the majority of coal coffee residue material still has not reached the enough small size to expose and penetrate the capillary of wool fiber, most of them are attached to fabric structure. In order to overcome this situation, the coffee coal needs to be done with pyrolysis higher than 700 ºC and prolonging the decay time of the material. After turning into coal, it is necessary to treat finely ground and filtered to create coal residue of uniform size.

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