Research Article

The Environmentally Benign Extraction of Peanut Red Skin for Textile Coloration and its UV Protection Properties

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ABSTRACT

Customer requirement for environmentally dyes leads to the resuscitation of natural colorants for textiles, using newer energy adequacy dyeing processes and reproducible shade developing processes. This article reports a study for extraction of dyes from peanut red skin by using microwave heating and its application for textile print via flat screen method. Dyestuff concentration and pH factors were studded. Effect of print paste conditions namely; pH, dyestuff concentration, kind of thickener and mordant type were studied. Color strength, color data and fastness properties of the printed textiles were also investigated. UPF protection factor was determined for the mordanted and unmordanted fabrics. The results showed that the printing paste that contains 30% of extracted dye, thickened with seed My pro gum at pH 9 and fixed by hot steam at 100°C for 30 min. gives the highest K/S value.

Keywords: Natural dyes, Microwave, Wool, Nylon, Polyester/cotton fabric, printing, Peanut red skin, UPF.

INTRODUCTION

Peanut is the shell, (husk) or legume, of Arachis hypogaea L., of the family Leguminosae. Generally, peanut is grown mainly for its seed oil. It is also a vital food source of protein in developing and developed countries. Peanut include kernels, skins (seed testate, coats) hulls. Peanut skins and hulls have small economic value by-products of peanut that are still untapped economic value processing operations**.** Nuts are used in production of peanut margarine, roasted peanuts snack, peanut confectioneries, and peanut oil. The membrane becomes the waste of industry mentioned above, and is primarily used as animal feed for lower than a pound[1]. Peanut red skins are the seed coat of peanut. China have lot of Peanut resources, as it is country of the greater production of peanut and the largest export volume, the existence of share about (41.5%) for total world production, then India (18.2%) and USA (6.8%)[2]. Peanut consists of pod, seed layer (hull) and cotyledon. Peanut membrane is rich in polyphenols, Flavonoids (or bioflavonoids), flavonols, and isoflavones. Peanut skin shade differs from light brown to dark red and most shading color in plants particularly red, purple and blue follow the flavonoid class of anthocyanins, with other flavonoid compounds acting as co-pigments. Anyway, red seed skin peanuts are the greatest popular and commonly consumed all over the world[3-5].

The use of microwave heating for materials processing has the possibility to afford many benefits in reducing the required times and energy savings. On traditional heating, energy is transform to the substance by convection, conduction, and radiation of heat to the surfaces of the material. Conversely, microwave energy is directly delivered to fabrics by molecular interaction with the electromagnetic field. In heat transmission, energy is transmitted as a result of thermal gradients; while in case of microwave technique, it is the transmission of electromagnetic energy into thermal one and energy is transformed, instead of heat transfer. This difference in the way of transferring energy can lead to several potential features of using the microwave for material processing. In microwave, it is possible for the heat to be generated all over the material volume, so microwave can penetrate the material. Energy transfer processes do not depend on heat spread from the surfaces, and the possibility of achieving rapid and homogenized heating of thick materials. In conventional heating, the cycle time is always dominated by slow heating rates that are selected to limit the sharp thermal gradients that lead to stresses induced process.

In using microwave technique, the heating process occurs through the electromagnetic field directly to the material. This leads to fast heating procedure takes place in all parts of the fabrics and minimize thermal gradients. Volumetric heating can also minimize reaction durations and energy saving. Microwave field in addition to the dielectric heating is responsible for controlling on the capability of fabrics heating by using microwave irradiation. Electromagnetic theory and dielectric heating Knowledge is necessary for improving the processing of fabrics heating by using microwave technique.

There are a lot of researches [6-13] work in the field of utilization of microwave in textile dyeing and extraction of natural dyes but textile printing is not yet fulfilled. The aim of current work is to evaluate microwave technique as a source of heat to extract dyes from Peanut red skin. The usefulness of microwave as an innovative extraction and dyeing method and its efficiency in increasing dye fixation in comparative with the conventional method

(steaming and thermo-fixation) on different fabrics has been explained.

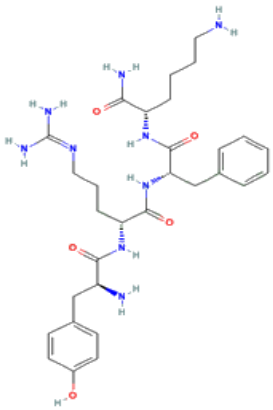
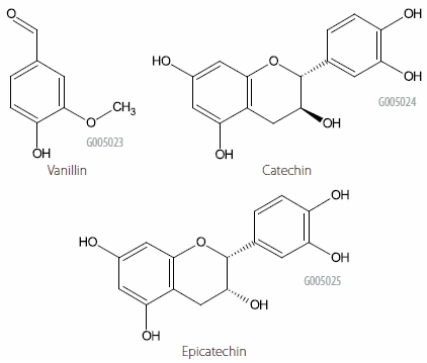
MATERIALS AND METHODS

Materials

Plants

A commercial peanut red skin is used; its properties and chemical structure are listed in table 1.

Table 1: peanut red skin (*Arachis hypogaea* L)

Property	peanut red skin	Structure of Peanut red skins	Polyphenolic Compounds in Peanut red Skin
Botanical name	*Arachis hypogaea* L		
C.I. Name	Natural brown		
Class	Alkaloids		
Part used	Outer crust		
λ_{max}.(nm)	350		

Fabrics

Mill-scoured wool fabric (100%) and nylon fabric are supplied by Misr Co. for spinning and weaving company, El-Mehalla El-Kubra, Egypt. Polyester/cotton blend fabric 65/35 is supplied by El-Shorbagy for spinning and weaving company, Egypt.

Thickening agent

High-viscosity sodium alginate was supplied by Ceca Kolloid Chemie., France and was used at 3% concentration. Meypro gum NP-16 (Meyhall) is a non-ionic thickening agent which is based on modified plant seed gum, and was used at 8% concentration. Synthetic thickener: Daicothick was supplied by Daico company, Cairo, Egypt, and was used at 3% concentration.

Mordants and other chemicals

Aluminum- ammonium Sulphate ($NH_4Al(SO_4)_2$, 12 H_2O), Ferrous Sulphate ($FeSO_4$), Copper Sulphate, Potassium Iodide, Urea and Di ammonium phosphates were of laboratory grade.

Microwave Heating Systems

Extractions were carried out using microwave synthesis systems: Lab station, which is equipped with a magnetic stirrer, and a non-contact infrared continuous feedback temperature system, Milestone Inc., USA.

Methods

Dye extraction

Conventional heating and microwave irradiation were used as a source of heating for different methods of dye extraction. The two methods of extraction were used under these conditions; dye concentration (10-50/100 g/ml), extraction temperature (60-90°C), extraction time (40-60 min.), extraction pH (3-9), using different microwave power level (300-1200). The best result was obtained when using 30% of peanut red skin at 80°C for 60 min. at power level 500 watt using microwave extraction.

Preparation of the printing paste

Soft water was used to prepare the printing paste by adding different concentrations of peanut red skin extract and all the components were stirred heavily. The extraction process of peanut red skin was carried out using conventional heating and/ or microwave irradiation. The printing paste was prepared using 600 ml thickener, 40 g urea, 12.5 g di-ammonium Sulphate, 120 ml Binder BD in addition to 20 g mordant in some cases. Also, 2 ml balance was added to each printing past to make the total volume 1000 ml and the printing paste was stirred for 10 minutes. Then the print paste properties were measured using Brookfield Viscometer and the viscosity was 21,000 cps at rate of shear 2.180 [14].

Printing technique

Each printing paste was applied separately to these fabrics; wool fabric, Nylon fabric and Polyester/cotton blend fabric using flat screen printing method.

Fixation

After printing and drying, the printed fabrics were subjected to fixation either by steaming at 100°C for 20/ 30/ 40 min. or thermofixation at 130/ 140/ 150 °C for 2/ 4

min. in a thermal static oven (Mathis, Switzerland)., or by microwave at different power level (60-90 watt) for intervals times (5-15 min.)

Washing

After printing and fixation via microwave irradiation, steaming or thermofixation, the printed fabrics were subjected to washing through 3 stages as follows: first, Rinsing thoroughly with cold and warm water. Second, washing with a solution containing 2 g/L Hosptapal CV-ET (non-ionic detergent) for 15 min. at 60°C. Third, rinsing with warm and cold water to remove the unfixed dye and finally air drying.

Evaluation of printed fabric

Color measurements

The color strength of the printed fabric was assessed by reflectance method [15], which performed on Ultra-scan PRO spectrophotometer (Hunter Lab, USA) under illuminant D65, 10° standard observer. The colour strength (K/S) in visible region of the spectrum (400–700) nm was calculated based on Kubelkae–Munk equation:

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

Where, (K) is adsorption coefficient, (R) is reflectance of dyed sample and (S) is scattering coefficient. In terms of CIE Lab values (L*, a*, b*) and colour strength (K/S)

Fastness properties

Color fastness to washing, rubbing and perspiration was evaluated by using the standard method. Printed fabrics were tested by standard ISO methods [16]. Wash fastness (ISO 105-C02 (1989)) [17] and crock fastness (ISO 105-X12 (1987)) [18] were evaluated using the visual ISO Gray Scale for both colour change (AATCC Evaluation Procedure (EP 1- similar to ISO 105-A02) and colour staining (AATCC EP 2- same as ISO 105-A03). Light fastness (Xenon arc) was evaluated using ISO 105-B02 [19].

Measurement of UPF factor

The ability of the printed fabric to block UV light is given by the ultraviolet protection factor (UPF) value. The measurement of UPF values was performed in UV/ visible Spectrophotometer 3101 PC with a software version, using an integrating sphere loaded with the fabric sample from 290 nm at an interval of 10 nm.

The measurements of UV- penetration characteristics of the compressed fabric were carried out in the range of 290-400 nm using the UV penetration and protection measurement system. Before measurements the fabric was conditioned at NTP for 24 hours. During the measurements, four scans were obtained by rotating the sample 90o each time and the spectral data were recorded as the average of these four scans.

The equation used by the software to calculate the UPF value for a flat, tensionless dry fabric [20]:

$$UPF = \frac{\sum_{290}^{400} E\ (\lambda) \times S(\lambda)\ \times \Delta\ (\lambda)}{\sum_{290}^{400} E\ (\lambda) \times T\ (\lambda) \times S(\lambda) \times \Delta\ (\lambda)}$$

Equation for calculating the UPF value (1)

Where E (λ) is the solar irradiance (Wm-2nm-1) measured; S(λ) is the arythematic action spectrum; Δ(λ) is the wavelength interval of the measurements ; and T(λ) is the spectral transmittance at wavelength λ 290 nm .The percentage blocking of UVA (315-400 nm) and UVB(315-290 nm) was calculated from the transmittance data.

RESULT AND DISCUSSION

Over the last decade, microwave dielectric heating as an ecologically benign processes have progressed a highly valuable technique, offering a different effective heat source of several chemical reactions and procedures [21-24]. It has several advantages comparing to traditional heating such as; non-contact heat, energy transfer instead of heat transfer, higher heating rate, quick start-up and stopping of heating, homogeneous heating with negligible thermal gradients, choosy heat properties, reversal thermal effects (heating start from the internal of material body), energy savings and higher yields in shorter reaction time. In this context, applying microwave in textile coloration was of interest, thus, exploiting microwave power level in extraction and printing with peanut red skin as a natural colorant was carried out.

Microwave extraction

Printing and fixation of various dyestuffs on different kinds of fabrics using microwave heating have been studied and compared with traditional printing process. Based on experiments the outcomes indicated that, the colorant uptake and fastness properties of printed fabric with microwave technique were higher than the traditional one. The microwave technique could save energy and time greatly [25]. While utilization of microwave in colorant extraction and fixation of printed fabrics is not yet investigated. Hence, a trial was made here to investigate the possibility of using microwave in extraction of peanut red skin and fixation of different kinds of fabrics printed with extracted peanut red skin and comparing the results with the ordinary thermo-fixation technique.

To achieve this goal, different concentrations of the peanut red skin (10-40%) were extracted by heating at 80°C for 60 min using power level 500 watt. Printing pastes were prepared using peanut red skin extract according to the formulas mentioned in the experimental part. Wool, polyester/cotton blend (65/35) and nylon fabrics were printed via screen printing method, dried at room temperature and exhibited to hot steam fixation at 100°C for 30 min. After fixation, all fabrics were washed according to the procedure explained in the experimental part followed by drying at room temperature. Then the color strength and color data were measured.

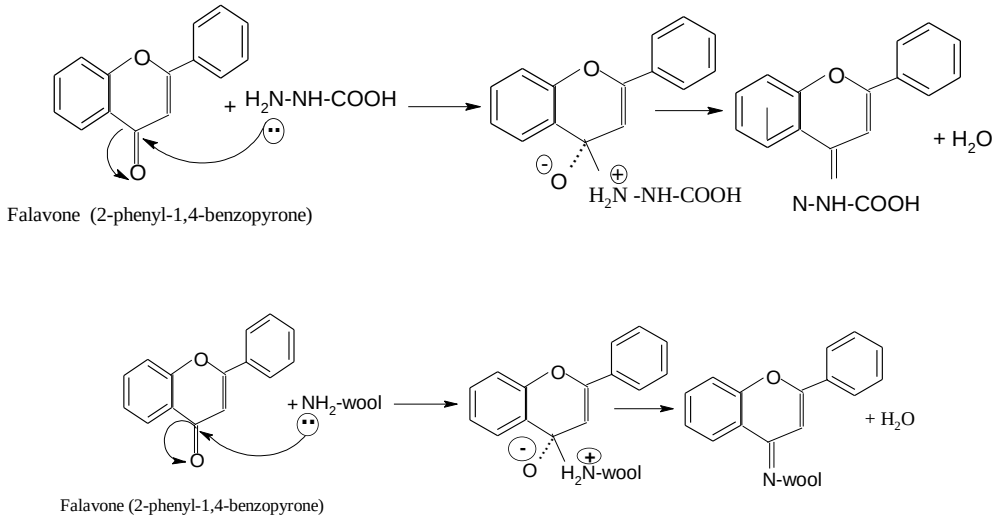
Impact of colorant concentration:

It is obvious from data of Figure 1a that, increasing of colorant concentration accompanied with increasing of K/S values of printed nylon, polyester/cotton blend and wool fabrics from 4 to 7.5, from 3.8 to 4.3 and from 2.2 to 3.4 respectively until 30% then the K/S values decreased dramatically. The highest color strength was obtained using nylon fabric then blend fabric and the lowest one was wool fabric.

Impact of pH of printing past

Printing paste's pH is an essential factor in textile coloration especially when using natural colorants. Like other dyestuffs, natural colorants can be applied at alkaline, natural or acidic medium. Moreover, wool is a natural protein fiber which has a complex chemical structure and is so sensitive to alkaline medium (pH > 9). So, printing of wool fabric that used in this work needs special care to obviate fiber damage. In addition, wool fiber contains equal amounts of amino groups (NH_2) and carboxylic groups (-COOH) bonded together to form salt linkages which bridges the main peptide chains. In the other hand, all polyamide fibers have the following groups, terminal amino group-NH_2, terminal carboxyl groups –COOH and imido groups along the chain –NH-, this can be simplified to -H_2N-NH-COOH-

The impact of printing paste's pH on color intensity of the printing fabrics (wool, nylon, polyester/cotton blend fabrics) was studied by applying the printing process at different pH values (3, 5, 7, and 9) and the results are shown in Figure 1b.



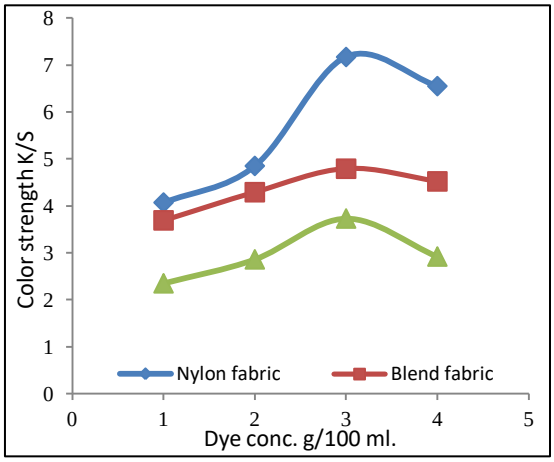
Scheme 1: Schematic diagram of bonds composition Between wool and flavones found in peanut red skin extract

From Figure 1b, it was observed that K/S increased progressively as the printed paste pH increased. With augmenting pH, more colorant transferred to the printing paste and depth of color increased. Color intensity in acidic medium was very low; it increased sharply in weak acidic from pH 3 to 7 and reached the maximum color depth at pH 9. This result attributed to the structure feature of colorants and fibers. Below the isoelectric point (acidic medium); (+) charges are formed on both of colorant and fibers, repulsion between colorant and fibers are occurred, resulting in low K/S. In alkaline condition, more (-) charges are formed on the fibers, so the colorant can be held with amino group by forming ionic bond (NH_3^+) in case of wool as well as nylon fabrics and (H^+) group in case of polyester/cotton blend fabric. Considering that cotton has few basic groups (OH), the colorant might be involved by ionic and hydrogen bonding. Reaction between the colorant in printing paste and fabric may be illustrated in Scheme 1.

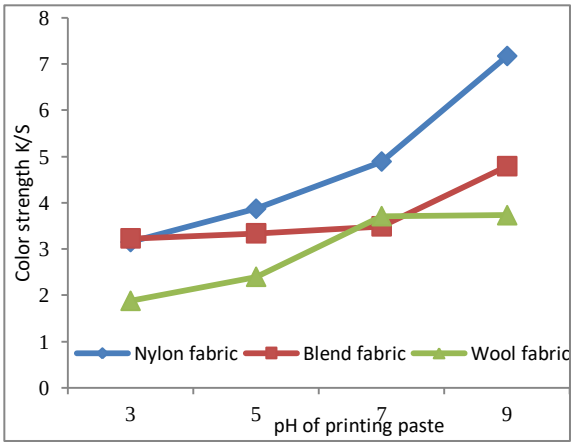
Impact of thickener kind

Printing pastes were prepared by using 30% of extracted colorant and containing 60 gm/100 ml H_2O of different thickeners; Mypro gum (8%), Alginate (4%) and Synthetic thickener (3%) separately, according to the recipes explained in the experimental part. Samples of wool, nylon and polyester/cotton blend (35/65) fabrics were printed via screen printing technique; printing process was performed at pH 9 then drying at room temperature and finally fixation using hot steam at 100°C for 30 min. After fixation, fabrics were washed according to the procedure mentioned in the experimental part followed by drying at room temperature. Then different color measurements were conducted.

Data listed in Figure 1c indicated that K/S depends on the type of thickener as well as the fabric type. The highest K/S was obtained by using Mypro gum as a thickener, followed the order Mypro gum > Alginate > Synthetic thickener with the following fabrics; Nylon > Blend > wool respectively.



(a)



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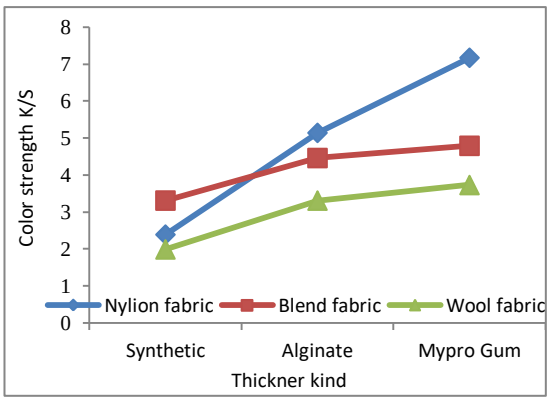


(c)

Figure 1: Effect of extracted colorant concentration **(a)**, pH of printing paste **(b)** and thickener type **(c)** on color strength of different printed fabrics

Impact of fixation type

For comparison, the printing paste thickened with Mypro gum (8%) and containing 30% of extracted colorant, pH of the printing paste was adjusted at 9 before printing. This prepared printing paste was applied to the fabric using screen printing technique then drying at room temperature. Finally, fixation process was carried out using three different techniques; the first one was thermofixation at 140°, 150°, and 160°C for 2 and 4 min., the second one was hot steam at 100°C for 20, 30, and 40 min., and the third one was microwave technique at different power levels (60-90) for time intervals (7-15 min.). The color strength (k/S) and the color data of the printed fabrics were measured. Also, the fastness properties were assessed for all printed fabrics.

Figure 2 (a and b) showed the effect of fixation type and fixation time on K/S of the printed fabrics. These figures illustrated that the highest value of K/S was achieved at160°C for 2 min. by using thermofixation with Nylon and blend fabrics (6.44, 4.30). When using steaming method the highest K/S values were obtained at 100°C for 30 min. with nylon, blend and wool printed fabrics (7.17, 4.79 and 3.73 respectively). Figure 2 (c and d) showed the impacts of exposure to microwave heating and the duration of exposure. When different printed fabrics were exposed to microwave using different power levels for constant time (5 min.), the highest K/S values were achieved at 80 watt with this order; nylon (6.59) > blend (3.6) > wool (2.03). When using microwave heating with different exposure times (7, 9, 11, 15 min.) at constant power level (80 watt), the highest value was achieved at 15 min. in this order [nylon fabric (4.59) > blend fabric (3.94) > wool fabric (2.29)]. So, the best power level was 80 watt, while the best exposure time was 15 min. for all fabrics. From all the previous data the best fixation method for all printed fabrics was steaming method at 100°C for 30 min.

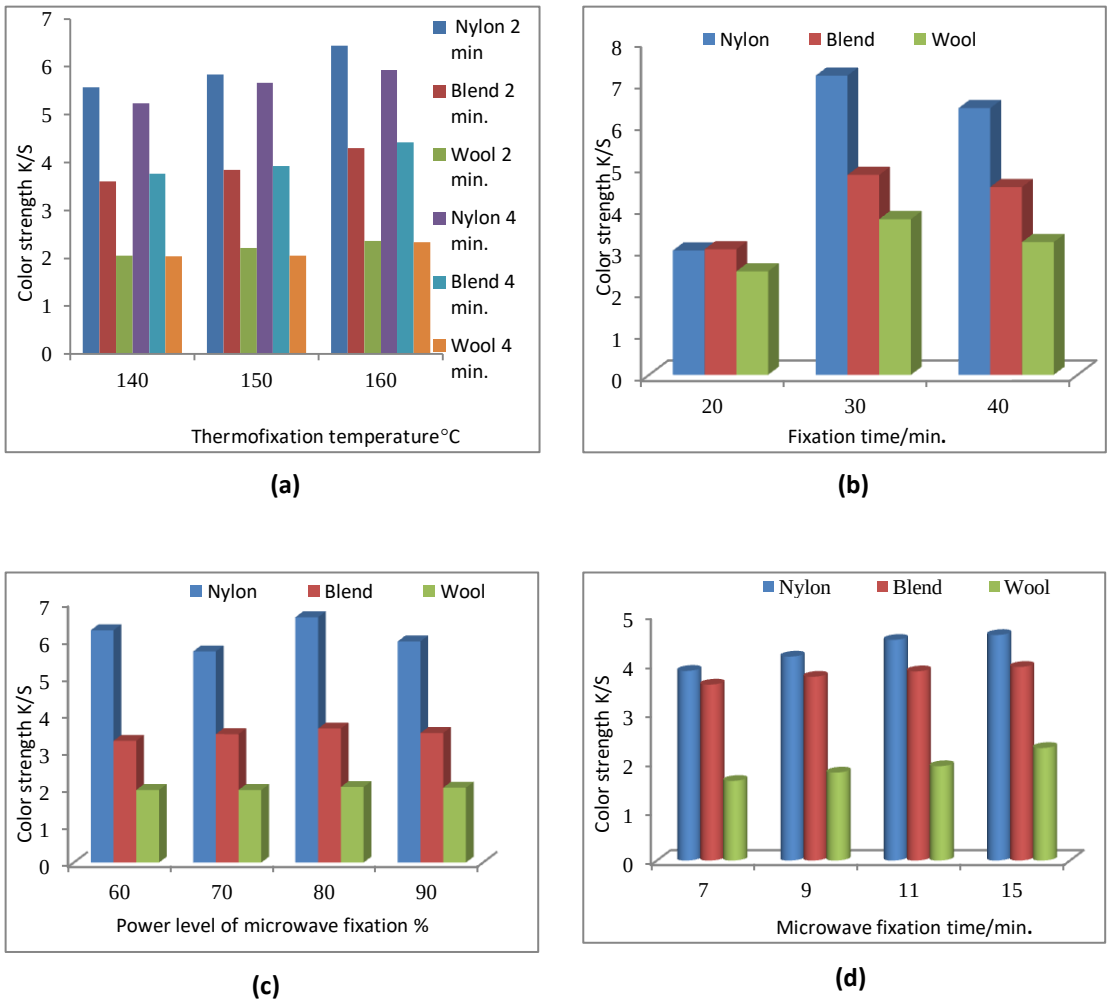


Figure 2: Impact of thermofixation **(a)**, time of steaming fixation **(b)**, power level of microwave **(c)** and microwave fixation time **(d)** on K/S of printing different types of fabrics.

Impact of mordants:

For studying the effect of mordanting with copper, ferrous, aluminum and potassium salts on the properties of printed fabrics, different printing paste thickeners were prepared using Mypro gum with one mordant or with mixture of them (copper/potassium, ferrous /potassium, alum./potassium and alum./ferrous) at pH 9. After printing, all printed fabrics were subjected to hot steam fixation at 100°C for 30 min.

Table 2 illustrated the results of K/S and colour data (L*, a* and b*) of mordanted and non-mordanted printed fabrics using peanut red skin extract. It can be observed that the K/S of printed nylon fabrics mordanted with different kinds of mordants is lower than the blank (7.17). While K/S of the printed mordanted blend fabrics with copper, potassium and ferrous salts (5.05, 5.58 and 5.22 respectively) was higher than the blank (4.79), but in case of using aluminum salt, K/S of the printed mordanted blend fabrics (3.15) was lower than the blank (4.79). Also, K/S of printed mordanted wool fabrics with copper and/ or potassium salts (7.98 and 6.74) was higher than the blank (3.73). While K/S of printed mordanted wool fabrics with aluminum and/ or ferrous salts (2.28, 3.21) was lower than the blank (3.73).

Table 2 indicated that there was a remarkable decrease in L* values in case of using blend and wool fabrics with ferrous and copper salts which mean a darker shade compared to the blank, while in case of nylon an increase of L* values was happened which mean a lighter shade compared to the blank. A noticeable decrease of a* and b* values was occurred with ferrous salt which mean a shift of colour towards green and blue color in case of nylon, blend, and wool fabrics as a result of metal complex formation between the dye, the fabric and the mordant used.

The auxochromic groups (OH, COOH) in polyphenolic compounds in peanut red skin extract are able to form complex compounds, depending on the number of these groups suitable for forming complexes with metal ions of mordants and combined with the fabric with hydrogen bonding.

Table 2: Effect of mordants on K/S, color data, UPF, UV.B, and UV.A of different fabrics printed with Peanut red skin.

Mordant	K/S	L*	a*	b*	UPF	UV-B (290-315 nm)	UV- A (315-400 nm)
Nylon fabric							
Blank	7.17	50.21	9.82	9.42	10.03	8.41	17.25
Copper salt	4	63.3	3.89	9.99	14.03	5.82	13.32
Aluminum salt	3.23	64.89	7.12	3. 59			
Potassium salt	3.5	62.11	4.48	11.03			
Ferrous salt	3.22	57.27	3.23	-0.65	14.59	5.89	11.43
Blend fabric							
Blank	4.79	64.3	11.4	6.72	61.89	1.34	2.94
Copper salt	5.05	61.74	5.4	11.73	64.30	1.28	3.13
Aluminum salt	3.15	69.28	9.17	3.76			
Potassium salt	5.58	63.34	6.92	13.97			
Ferrous salt	5.22	52.91	4.55	0.16	75.08	1.12	2.37
Wool fabric							
Blank	3.73	59.64	11.68	15.67	284.07	0.19	1.5
Copper salt	7.98	52.41	5.52	19.29	1275.80	0.04	0.40
Aluminum salt	2.28	69.84	5.28	13.9			
Potassium salt	6.74	58.00	7.22	20.92			
Ferrous salt	3.21	53.28	1.27	3.16	717.10	0.07	0.68

Ultra- violet (UV) protection

The UV blocking property for printed mordanted and non-mordanted wool, nylon and blend fabrics was studied by measuring the diffuse transmittance in the UV radiation range through textile fabrics and the results were recorded in Table 2 and Figures 3, 4 (a, b and c).

From these results, it can be observed that, in case of fabrics printed with Peanut red Skin without or with the addition of $CuSO_4$ and/or $FeSO_4$ Table 2 and Figures 3, 4 (a, b and c), excellent transmission blocking were gotten in case of wool samples, and very good UPF results were gotten in case of blend fabrics, but printed nylon fabrics gave a bad transmission blocking which was clear from the low UPF results. Figure 4a showed that the addition of ($CuSO_4$) highly increased the UPF values and the protection of the printed wool fabrics as a result of high copper content. Thus, the addition of ($FeSO_4$) highly increased the UPF values and the protection of the printed wool fabrics as a result of high Iron content.

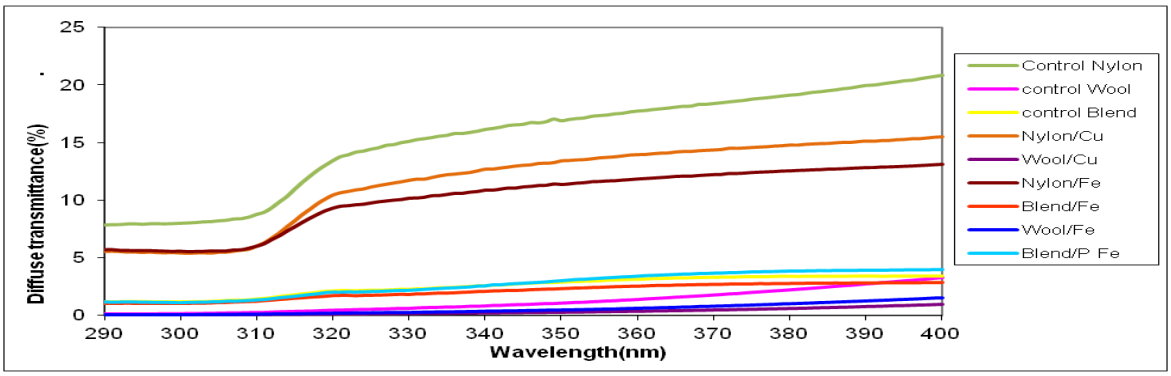
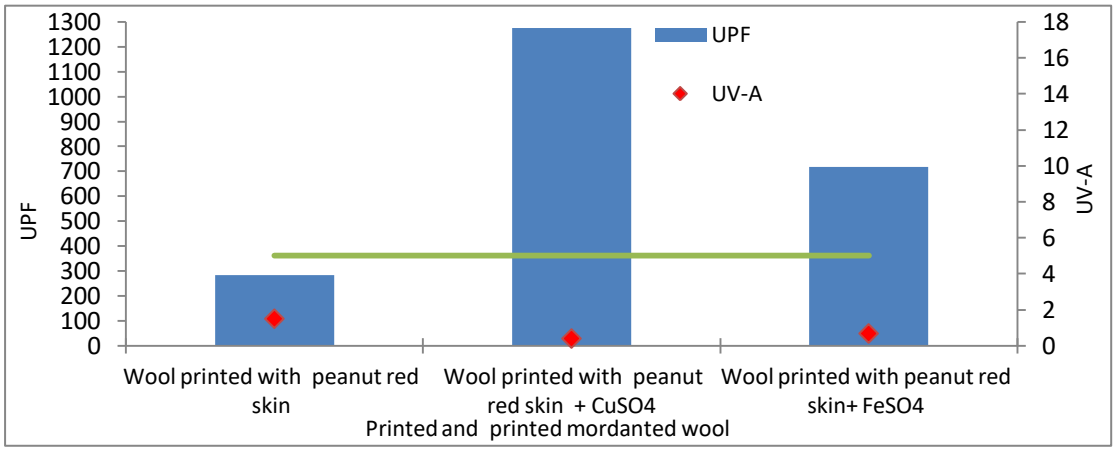


Figure 3: Impact of using different mordants on the diffuse transmittance (%) at different wavelength.

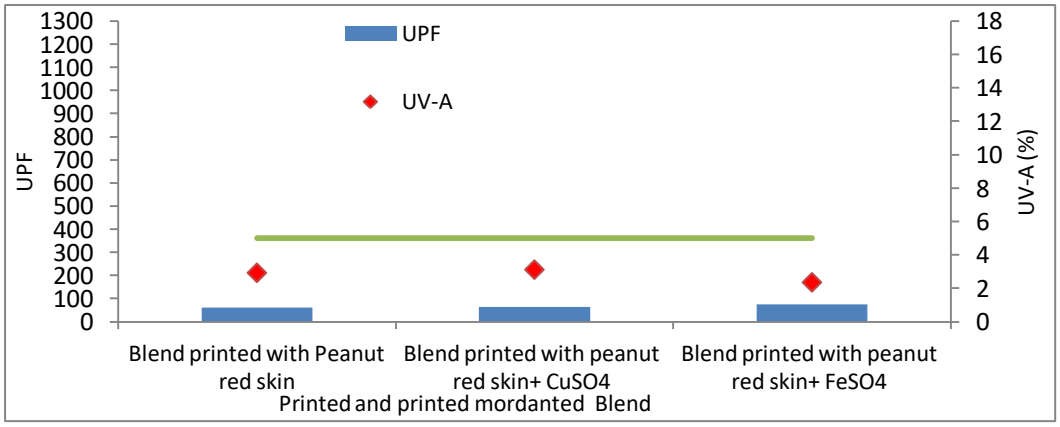
The distribution of transmittance spectra in Figure 3 in the UV-A Transmittance (315-400 nm), moving from the lowest to the highest (wool fabrics < blend fabrics < nylon fabrics) seemed to be inversely correlated to fabric cover factor and UPF and independent of fabric type [26-28]. Figure 4 (a, b and c) showed that the UV-A Transmittance for the wool fabric was highly below 5 (excellent UV blocking), and the UV-A for the blend fabric was below 5 (very good

UV blocking), but for the nylon fabric; the UV-A was higher than 5 (bad UV blocking).

From Table 2 and Figures 4 (a, b and c), it can be noticed that mordanting with $CuSO_4$ with different fabrics gave good results; first printed wool fabric gave excellent UPF values results through increasing from 284.07 to 1275.80, second one; printed blend fabric exhibit slight improvement in UPF values through increasing from 61.89 to 64.30 (very good results), but with third one; printed nylon fabric exhibit slight improvement in UPF values through changing from 10.03 to 14.03 (bad UPF results).



(a)



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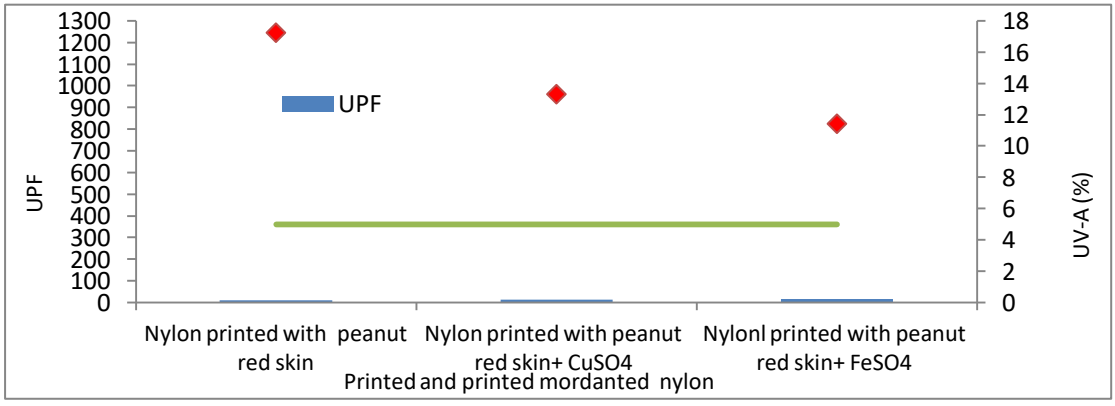


(c)

Figure 4: UPF and UV-A of non-printed and printed fabrics **[a-c]**, wool **(a)**, blend **(b)** and nylon **(c)**

On the other hand, using $FeSO_4$ as a mordant with different fabrics gave these results; in case of wool fabrics, the values of UPF were excellent through increasing from 284.07 to 717.10 then with blend fabric the UPF values were very good through increasing from 61.89 to 75.08 and finally the UPF values of nylon fabric increased from (10.03) to (14.59) (bad UPF results).

From the previous results it can be concluded that mordanted printed fabrics using $CuSO_4$ gave higher UV protection compared to the control samples. Finally, the printed nylon fabric using peanut red skin have high K/S but gave lower UPF results than other fabrics printed with the same colorant. This may be attributed to the fact that the UV blocking properties of the fabrics are affected by different factors such as structure and physiochemical nature of the fibre.

Infrared spectrum results

Figure 5a showed the Infrared spectra of peanut red skin extract. From this figure it can be noticed that, absorption peaks at 3406 cm^{-1} (No. 1) and 2924 cm^{-1} (No. 2) were assigned for vibration absorption of –OH and stretching vibration band of aromatic ring (Ar-H) respectively, which represented for aromatic ring of the colorant extract. Absorption peak at 2856 cm^{-1} (No. 3) was attributed to the vibration absorption of aliphatic ring. Finally, there was absorption band at 1736 cm^{1} (No. 5) pointed to C=O group. Through infrared spectrum analysis, the extract had OH group, aromatic ring, aliphatic ring and C=O group which were clearly observed from catechin structure.

FT-IR spectra of non printed wool (blank) and printed woolen fabrics were given in Figure 5b. Wool fabric contains more than 18 amino acids. Carboxyl (–COOH), amino ($–NH_2$), and hydroxyl (–OH) groups are the main functional groups of wool. FTIR spectra of wool fabrics showed characteristic absorption peaks particular for peptide bond [29,30] specified as amide-I, amide-II, and amide-III bands [31]. The IR spectra of wool fabric (blank) showed specific absorption bands: a broad one in the range of 3448–2966 cm^{-1} (–NH-stretching, –SH and OH stretching), strong peaks at 1690, 1562, and 1304 cm^{-1} are referring to amide I, amide II, and –C–N stretching of amide III, respectively [32].

There was a remarkable change in the peaks between non printed wool (blank) and printed wool. Whole characteristic peaks of non printed wool fabric (blank) were found in the printed wool fabric with low intensities. Low intensity and shifting of peaks relating to amide-I and C–N stretching frequency of amide-III bands of printed wool fabrics at 3648 cm^{-1} and 1278 cm^{-1} were observed. Additionally new peaks at 1496 and 2877 cm^{-1} are recorded. These are indicating to the involvement of amino groups in the interaction between wool fabric and colorant in the print paste[29, 30].

Figure 5c indicated that, non printed blend (blank) has a vibration absorption peak of C=O group at 1736 cm^{-1}, while vibration absorption peaks of –CH were recorded at 2966 and 2907 cm^{-1}. The aromatic ring and alcoholic group (OH) were observed at 3032 and 3432 cm^{-1}, respectively. After printing with peanut red skin, it is obviously seen that intensities of OH and C=O groups were significantly decreased, this change attributed to interaction between cotton and colorant in the print paste which could be carried out as hydrogen bonding between OH of cellulose carboxylic group and (C=O) of functional group (Polyphenolic Compounds) of colorant in the print paste.

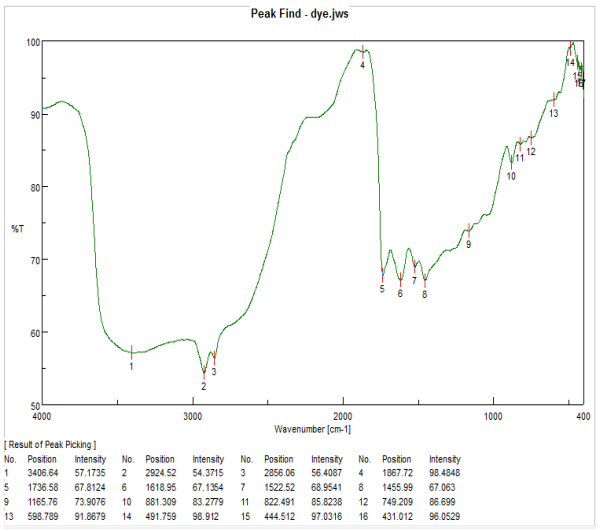
Figure 5d showed that non printed nylon (blank) has a vibration absorption peak of C=O group at 1734 cm^{-1}, while vibration absorption peaks of –CH were recorded at 2968 cm^{-1} and 2904 cm^{-1}. The aromatic ring and alcoholic group (OH) were observed at 3062 cm^{-1} and 3431 cm^{-1}, respectively. After printing with peanut red skin, it is obviously seen that intensities of OH and C=O groups were significantly decreased which reflects the interaction between nylon and colorant via these groups.

Fastness properties:

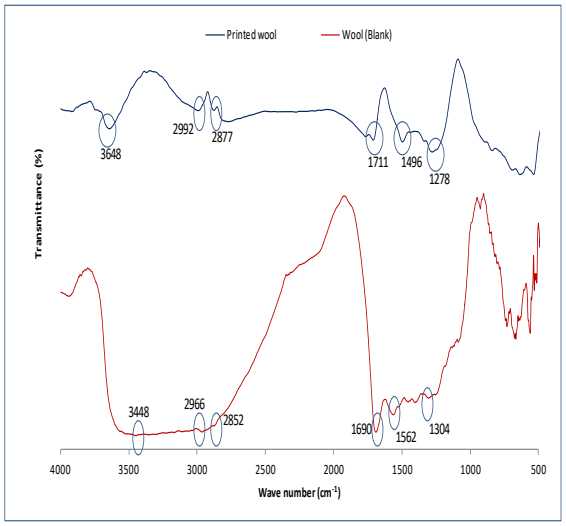
Table 3 represented the overall color fastness of printed fabric at optimum condition (30 g/L extracted dye, Mypro gum (8%) as a thickener, with and/or without mordants, at pH 9. After printing, all samples fixed by steaming at 100°C for 30 min. It was clear from the data listed in table 4 that all fastness properties ranged from very good to excellent when using non-mordanted fabrics or mordanted fabrics with one mordant or mixture of mordants.

CONCLUSIONS

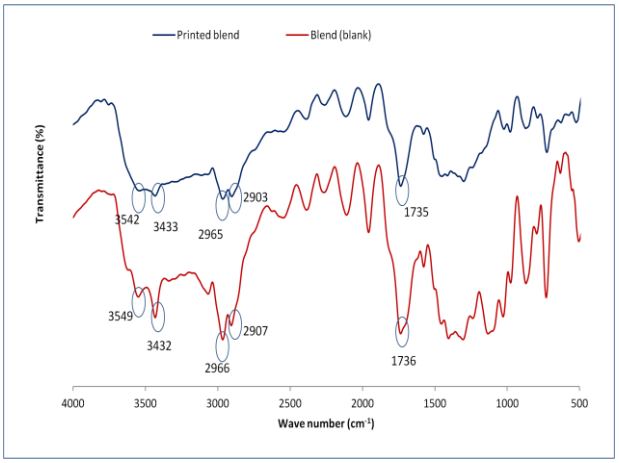
It was noticed that the printing paste that containing 30 g/L of peanut red skin extract, thickened with Mypro gum at pH 9 and fixed by steaming at 100°C for 30 min. gave the maximum K/S value. Printing of non-mordanted and mordanted nylon, blend and wool fabrics with Peanut red Skin extract using $CuSO_4$ as a mordant revealed an excellent protection level UPF (50+) by almost all printed fabrics with the exception of nylon fabric. These results confirmed UV protection properties of fabrics printed with natural colorant extracted from Peanut red Skin. The excellent UPF (50+) of wool fabric printed with Peanut red Skin extract which was mordanted with $CuSO_4$ will prevent skin cancer for the humanity in the world. Also $FeSO_4$ gave good UPF values when used as a mordant in case of wool and blend fabrics. Mordanting of different printed fabrics using various mordants did not affect the results of fastness properties of different printed fabrics using peanut red skin extract.



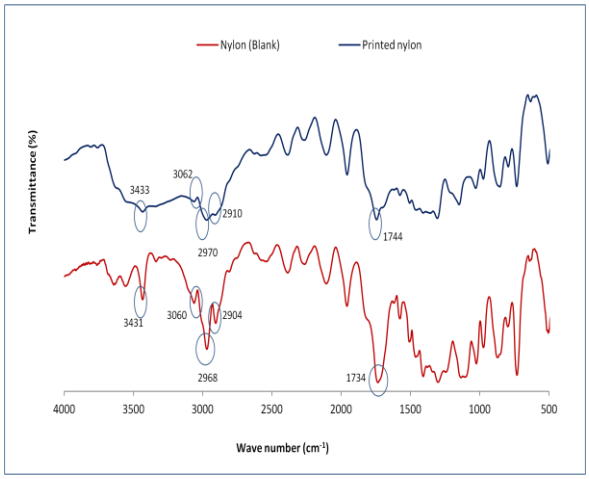
(a)



(b)



(c)



(d)

Figure 5: Infrared spectra of peanut red skin extract **(a)**, non-printed and printed fabrics **[b-d]**, wool **(b)**, blend **(c)** and nylon **(d)**.

Table 3: Color strength and fastness properties of mordanting and un-mordanting printing fabrics

Mordant	K/S	Washing Fastness		Rubbing Fastness		Perspiration Fastness				Light
		St.	Alt.	Dry	Wet	Acidic		Alkaline		
						St.	Alt.	St.	Alt.	
Nylon fabric										
Blank	7.17	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6.7
Copper salt	4.00	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Aluminum salt	3.23	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Potassium salt	3.50	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Ferrous salt	3.22	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Blend fabric										
Blank	4.79	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Copper salt	5.05	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Aluminum salt	3.15	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Potassium salt	5.58	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Ferrous salt	5.22	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7

Wool fabric										
Blank	3.73	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Copper salt	7.98	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Aluminum salt	2.28	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Potassium salt	6.74	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7
Ferrous salt	3.21	4-5	4-5	4-5	4	4-5	4-5	4-5	4-5	6-7

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