UV Protection Properties of Cotton, Wool, Silk and Nylon Fabrics Dyed with Red Onion Peel, Madder and Chamomile Extracts

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Abstract

Red onion peel, madder, chamomile and red onion/chamomile mixture (40 g/l, 50%wt) are extracted using aqueous solution at different temperatures (80-100°C). Cotton, wool, silk and nylon fabrics are dyed using a traditional method at pH 4 (except cotton at pH 8) using 25-40 g/l colorant extract, at specified temperature and time, without or with potash alum or FeSO₄ (1.5 g/l). Colorimetric data (L*, a*, b*), Color strength (K/S) and ultraviolet protection factor (UPF) are measured. Fastness properties of control and mordanted fabrics are assessed. UPF measurements reveal excellent UV protective properties for different fabrics colored with red onion, madder, chamomile and red onion peel/chamomile mixture (50 wt%, 40 g/l) with or without mordants. Dyeing of fabrics without or with mordants gives excellent UPF factors (50+), except nylon which has an insufficient UPF with madder. These natural colored fabrics are suggested to prevent skin cancer and their colorants are recommended for textile coloration industry.

Keywords: Red onion peel; Madder; Chamomile; Dyeing; Fabrics; UV protection

Introduction

Recently, a great attention for application of natural colorants is survived for agriculture availability, ease and safe production. Synthetic colorants produce different shades which are available in low price, but cause environmental pollution, so natural dyes are a good alternative for textile coloration. Many researchers studied the functional finishing of textiles using natural dyes [1-4]. Also, extraction of colouring matter from Flos Sophorae and UPF values of silk were investigated [5].

Many researches have been conducted to determine the influence of the UV rays on different living organisms, particularly humans [6-14] as there is a strong correlation between skin cancer and UV dose. Hurtable UV radiation can be absorbed by Skin cells through sunlight, then the body gets red of these radiation by excretion. However, an extra dosage of UV radiation has some repercussions as it can cause skin cancer, damage of cells and inflammation of human skin which are considered the clear outcomes of erythema or sunburn [15].

Related work about UPF of natural colored yarns with mordants and its biological efficiency was reported [16]. Similar work about natural colorants and their application on selected fabrics, which provided antibacterial and ultraviolet protective level [17,18]. A study for colorimetric determination and antimicrobial analysis of colored fabrics using “Peony, Pomegranate, Clove, Coptis Chinenis and Gallnut extracts” was performed against different micro-organisms [19,20]. Fastness and UPF properties of colored fabrics using EucaLyptus were studied [21].

The following are some natural dyes which are studied in this article and their chemical structure (Tables 1-3)

**Red onion peel**: is a natural by-product waste from food industry. It gives bright reddish brown color in textile coloration. It is grown all over the world. The outer layer was known as a red onion peel which is a by-product waste of the food industry. The color of red onion peel extract is reddish brown. Previous studies on red onion peel [22,23] investigated the flavonoids which contain large amounts of flavonols, flavones, and anthocyanidins (flavylium cations dyes). The most known of the last compound is cyanidin dyes derivatives (Table 3).

Figure 1 shows the relationship of absorbance/wavelength of colorant at different pH was studied [24]. The absorbance of red onion colorant extract has two peaks; at 290 and 363 nm in UV region. The colorant shape and stability is similar in acidic medium and maximum absorption is achieved at wavelength 363 nm. At pH 8 the curve has different shapes and maximum absorption is achieved at wavelength 376 nm. High UV absorption of the colorant reveals that it could be extracted at the boil in acidic conditions. Figure 1 shows the colorant absorption radiation in the UV-B region (290-320 nm) and UV-A region (320-400 nm) (Table 4).

**Madder**: is an important natural colorant, as it is recognized in Egyptian pharaonic textile. It consists of anthraquinone compounds containing hydroxyl auxo-chromic groups [25]. Madder roots were reported to contain about 35 anthraquinone compounds (Table 4). The major components of Indian madder (Rubia cordifolia) are purpurin 66%, 1% munjistin and 10% nordarnmacanthal. The major component of European madder (Rubia tinctorium) is alizarin. The aurochomatic groups (OH, COOH) in madder colorants are able to form complex compounds, so they are called mordant dyes depending on the appropriate groups which are capable of forming complex with the metal ion (Table 5).

**Chamomile**: It is an Egyptian crop [26,27]. The duration of cultivation is 1-2 years and the structure of chamomile is illustrated in Table 5. Terpenoids and flavonoids are found in the dried flowers of chamomile, which have a healing effect. Many human diseases can be cured by the chamomile preparations such as: insomnia, gastrointestinal disorder, inflammation, menstrual disorder, rheumatic pain, ulcers, muscle, spasms, hemorrhoids, wounds, and hay fever.

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The oil chamomile is paramount as it can be used in a wide scale in cosmetics and aromatherapy [28].

In the present investigation, Red onion peel, madder, chamomile (25-40 g/l) and chamomile/red onion peel mixture (50% wt.) are extracted using aqueous solution at different temperatures (80-100°C). Then these extracts are used for coloration of different fabrics. UV protective properties of the colored fabrics are studied. The coloration of fabrics using natural colorants is performed without or with mordants (1.5 g/l) to minimize pollution. Color measurements, fastness properties, and UPF properties are also determined.

Table 1: Characteristics of red onion peel, madder, and chamomile.

| Plant                        | Botanic name            | Colour index CI | Components of colors                  | Family                      |
|------------------------------|-------------------------|-----------------|---------------------------------------|-----------------------------|
| Red onion peel               | Allium cepa L           | Red, yellow or, orange | Red, yellow or orange colours         | Flavonoid (flavonols flavones) and cyanidin |
| Madder genus (European)      | Rubia tinctorium L      | Natural Red 8    | Natural Red                           | Alizarin                    |
| Madder genus (Idian)         | Rubia Cordifolia L      | Natural Red 16   | Natural Red                           | -Rubiladin                   |
|                              |                         |                 |                                       | -Nardamina canthal          |
|                              |                         |                 |                                       | -Lucidin                    |
| Chamomile                    | Composite               | Yellow          | Flavonoid                             | Anthemins tinctorial        |

Table 2: Chemical structure of Tannic acid and Gallic acid (found in red onion peel extract, madder and chamomile).

| Compounds | Structure | \( R_1 \) | \( R_2 \) |
|-----------|-----------|------------|------------|
| Flavonols |           |            |            |
| Quercetin | OH        | H          |            |
| Kaempferol| H         | H          |            |
| Myricetin | OH        | OH         |            |
| Flavones  |           |            |            |
| Apigenin  | H         |            |            |
| Luteolin  |           |            |            |
| Anthocyanidines |     |            |            |
| Cyanidin  | H         | OH         |            |
| Delphinidin| OH       | OH         |            |
| Pelargonidin| H        | H          |            |
| Peonidin  | OH        | OMe        |            |

Table 3: Chemical composition of red onion peel extract.
Materials and Methods

Materials

Natural dyes such as red onion peel extract were used, a vegetable by-product waste from the onion food industry, in addition to the imported madder and locally cultivated chamomile crop.

Chemical reagents: Chemical reagents used for adjusting the pH are glacial acetic acid and anhydrous sodium carbonates. The mordants used are potash alum (Al₃K(SO₄)₂·24H₂O), ferrous sulphate (FeSO₄·7H₂O) and Tannic acid for cotton fabric. Non-ionic detergent (Triton X-100) and sodium sulphate are used in the washing process.

Fabrics: Different natural fabrics are used such as cotton (weight 133.78 g/m², thickness 0.37 mm), wool (308.8 g/m², 0.55 mm), silk (58.08 g/m², 0.18 mm) and nylon fabric (89.14 g/m², 0.31 mm). All the fabrics were produced by The Misr Spinning and Weaving Company, El-Mahalla El-Kubra with the exception of silk.
Methods

Extraction Method: Red onion peel (40 g) was extracted in 1 L of boiled water for 1 h, and then the extract was cooled down to room temperature and filtered to get rid of insoluble materials. The percentage of extracted colorants was calculated and the absorbance of the colorant extract was measured to determine the λmax of the colorant [29]. Also madder and chamomile were extracted in hot water at 80°C using different concentrations (25-40 g/l). Extraction percentage (%) of different colorants was as follow; red onion peel 15, madder 29, chamomile 37.

Scouring of fabrics:

- Silk fabric was added to a bath containing 2 g/l nonionic detergent (Triton X-100) and water at liquor ratio 1:50. Then the temperature of the entire bath was raised to 60°C and was maintained for 1 hr. Finally, Silk was rinsed with warm water and air dried.
- Wool and nylon fabrics were added to a bath containing 2 g/l nonionic detergent and 5 g/l sodium sulfate at liquor ratio 1:50. Then the temperature of the entire bath was raised to 45°C and the temperature remained constant for 30 min. Finally, wool and nylon were rinsed with warm water and air dried.
- Cotton fabric was added to a bath containing 2 g/L Na2CO3 and 5 g/l nonionic detergent at liquor ratio 1:50. Then the temperature of the entire bath was raised to boiling and was maintained for 1 h, then rinsed and air dried.

Pre-mordanting method: In the pre-mordanting method, fabrics were treated before dyeing process. Wool, silk, and nylon fabrics were added to a bath containing alum or FeSO4 (1.5 g/l) at liquor ratio 1:50. Then the temperature of the entire bath was raised to 45°C and continues stirring at this temperature for 30 min. The mordanted fabrics were rinsed with warm water to remove the excess mordants.

Cotton fabrics were treated with 8% tannic or gallic acid (owf) at liquor ratio 1:30 then the temperature of the entire bath was raised to 90°C and hold for 30 min. Then cotton fabrics were removed from this bath and put in another bath containing alum or ferrous sulphate (1.5 g/l) at liquor ratio 1:50. Then the temperature of the entire bath was raised to 90°C and maintained for 30 min, rinsed and air dried (Table 1).

Dyeing method: Dyeing of cotton fabrics was carried out using exhaustion method utilizing infrared dyeing machine (Roaches Co., England) with natural colorant extract (25/40 g/l). Cotton fabric was pre-mordanted with 8% tannic acid (owf) and then treated with alum (1.5 g/l) at 100°C for 60 min. After extraction of natural colorant, it was added to the dyeing bath at pH 4 for all fabrics except cotton at...
Spectrophotometer 3101, using an integrating sphere loaded with UV light is given by the ultraviolet protection factor (UPF)

The difference can be seen. The sample and the standard, from which some indication of the nature of the difference can be seen.

The equation used by the software to calculate the UPF value for a flat [35], tensionless dry fabric:

\[
\text{UPF} = \frac{\sum_{400}^{290} E_\lambda S_\lambda \Delta_\lambda}{\sum_{400}^{290} E_\lambda S_\lambda T_\lambda \Delta_\lambda}
\]

Where: (UPF)-ultraviolet protection factor value through fabrics, \(E_\lambda\) relative erythemal spectral effectiveness (W/m²·nm⁻¹), \(S_\lambda\) solar spectral irradiance (Melbourne), \(\Delta_\lambda\)-measured wavelength interval (nm), and \(T_\lambda\) spectral transmittance of the sample (%). The percentage blocking of UVA range (315-40 nm) and UVB range (315-290 nm) was calculated from the transmittance data.

Generally, in all the cases in which UPF reached at least the good protection level and UVA transmittance was also below 5%, which the European standard for Sun Protective Clothing [36] and also the Chinese National standard GB/T18830-2002 [5] consider the threshold above which photosensitive skin disorders, like chronic actinic dermatitis and solar urticaria, can be aggravated (Table 6) [37].

Results and Discussions

Effect of mordants on K/S and colour data of pre-mordanted dyed cotton, wool, silk and nylon fabrics with red onion peel, madder, chamomile, and mixture of red onion peel/chamomile extracts [25,29]

Effect of mordants on K/S and colour data of pre-mordanted dyed cotton, wool, silk and nylon fabrics with red onion peel extract: Table 7 shows that all mordanted fabrics displayed higher color strength values as compared to non-mordanted ones with this order: FeSO₄>alum>control fabrics. This may be linked to the mordanting process that increases interaction between colorant and fabrics through coordination complex formation, which, after all, boosts the colorant uptake.

Table 7 indicates that the darkest color hue is achieved with FeSO₄ compared to mordanted fabric with alum and control fabric, which is clear from the decrease of \(L^*\) values of dyed mordanted fabrics with FeSO₄. From all colorimetric data, the difference of color is due to the type of mordant used. In case of cotton, tannic acid was combined with FeSO₄>alum>control fabrics. This may be linked to the mordanting strength values as compared to non-mordanted ones with this order; FeSO₄>alum>control fabrics. This may be linked to the mordanting process that increases interaction between colorant and fabrics through coordination complex formation, which, after all, boosts the colorant uptake.

Table 7 reveals the colorimetric data of the dyed fabrics, The largest
decrease of $a^*$ and $b^*$ values has occurred with FeSO$_4$ more than alum and control samples, that means a little shifted towards green co-ordinate in red yellow zone of CIE Lab color space.

**Effect of mordants on K/S and colour data of pre-mordanted dyed cotton, wool, silk and nylon fabrics with madder extract:** Table 8a illustrates the effect of mordants on dyed wool, silk and nylon fabrics using madder extract on K/S and color data.

There is a significant enhancement of K/S of pre-mordanted colored fabrics using alum and FeSO$_4$ as a result of metal complex formation among dye, fabric, and mordant.
From Table 8a, it is clear that pre-mordanted colored fabric with FeSO$_4$ gives the highest K/S among pre-mordanted colored fabrics with alum and control fabrics. This is attributed to the change of ferrous to ferric form through oxygen of the air. Ferrous and ferric forms are on the surface of the fabric and their spectra overlapped, resulting in change of K/S and consequently dark hue was obtained [24]. The color of fabrics is dependent on the mordant used.

Table 8a shows that adding mordants leads to a decrease of L* values, that means darker shade is obtained. Pre-mordanted colored fabric with FeSO$_4$ gives the darkest shade among pre-mordanted colored fabrics with alum and control colored fabrics.

From Table 8a, it is clear that $a^*$ and $b^*$ values of pre-mordanted colored fabrics with alum increase compared to the control fabrics, that means a little shifted towards red co-ordinate in red yellow zone of CIE Lab color space. Conversely, $a^*$ and $b^*$ values of pre-mordanted colored fabrics with FeSO$_4$ decrease in comparison to control colored fabric that means a little shifted towards green co-ordinate in red yellow zone of CIE Lab color space. The colored nylon fabric is not affected by the alum treatment in comparison to the control colored fabric.

**Effect of mordants on K/S and colour data of pre-mordanted dyed cotton, wool, silk and nylon fabrics with Chamomile extract:** Table 8b shows the results of mordanted dyed wool, silk and nylon fabrics with chamomile extract in comparison to non-mordanted dyed one. The effect of mordants on K/S and colorimetric data is demonstrated.

For wool fabric, K/S increases with FeSO$_4$ to 22.28 and for alum to 17.45 in comparison to control (15.74). For silk fabric, K/S increases with FeSO$_4$ to 8.65 and for alum to 3.75 in comparison to control (3.16). For nylon fabric, K/S increases with FeSO$_4$ to 12.32 and to 10.21 using alum in comparison to control (9.88). Pre-mordanted colored fabrics with FeSO$_4$, gives the highest K/S, then Pre mordanted colored fabrics with alum and everyone one of them is higher than the colored control fabrics.

In general, the dyeing affinity of fabrics is dependent on the content of functional polar groups in fabrics. It is well known that the number of functional group in wool is larger than that of silk, and polarity of protein fibres is higher than that of cellulose fibre. The K/S value was in the order of wool>nylon>silk>cotton fabric for all natural colorants. It was found that this order of dyeing affinity matched the order of polarity/functional group content of fabrics very well.

For L* values (lightness), the fabrics shade becomes darker by using mordants and fabrics mordanted with FeSO$_4$ is darker than fabrics mordanted with alum and everyone of them is darker than the control fabrics.

Also, the increase of $a^*$ and $b^*$ values of mordanted colored fabric with alum, means a little shift towards red co-ordinate in red yellow zone of CIE Lab color space. In the opposite, the decrease of $a^*$ and $b^*$ values of mordanted colored fabric with FeSO$_4$, means a little shift towards green co-ordinate in red yellow zone of CIE Lab color space, except mordanted colored nylon fabric with FeSO$_4$ which shifted towards red co-ordinate.

**Effect of mordants on K/S and colour data of pre-mordanted dyed cotton, wool, silk and nylon fabrics with mixture of red onion peel/chamomile extract:** Table 9 shows the effect of mordants on color strength and color data of wool, silk and nylon fabrics colored with natural colorants extracted from a mixture of red onion peel/chamomile (50% wt).

Mordants have a slight effect on K/S of wool and silk fabrics. For nylon, the mordants don’t improve the K/S compared to the colored control fabric. It is clear from Table 8 that the color of fabrics depends on the type of mordant used.

For L* values (lightness), the shade of pre-mordanted wool and silk fabrics with FeSO$_4$ turns into darker shade than with alum. For nylon, a little change is observed by using FeSO$_4$ and alum.

For $a^*$ and $b^*$ values, a little shift towards red co-ordinate in red yellow zone of CIE Lab color space in case of pre-mordanted colored fabric with alum in comparison to colored control fabrics in case of wool and silk fabrics. While using FeSO$_4$ as a mordant leads to a little shift towards green co-ordinate in red yellow zone of CIE Lab color space in comparison to the colored control fabrics in case of wool and silk fabrics. However, using FeSO$_4$ and alum as mordants with colored nylon fabrics have a slight effect on the color compared to the control one (there is no remarkable shift of color as for wool and silk fabrics).

**Colorfastness properties**

Table 10 reveals that pretreatment with tannic acid/FeSO$_4$ and FeSO$_4$, improves colorfastness to washing of cotton. Mordants don’t affect colorfastness to rubbing.

Also, Table 10 illustrates all colorfastness properties of colored control and pre-mordanted colored fabrics with red onion peel. From these results, it is obvious that colorfastness to washing and rubbing are fair to very good. While, colorfastness to light is very good to excellent.
Table 10: Colorfastness of cotton, wool, silk and nylon fabrics colored with colorants extracted from red onion peel.

| Fabric | Mordant | Rubbing fastness | Washing fastness | Light fastness |
|--------|---------|------------------|------------------|---------------|
|        |         | Dry  | Wet  | St. | St** | Alt. | |
| Cotton | Dyed control | 3-4  | 4    | 3-4 | 4    | 4    | 5-6 |
|        | Tannic acid/alum | 3    | 4    | 3-4 | 4    | 4    | 5-6 |
|        | Tannic acid/FeSO4 | 3    | 4    | 3-4 | 4-5 | 4-5  | 5-6 |
|        | Alum    | 4-5  | 3    | 3    | 3    | 3-4  | 6   |
|        | FeSO4   | 3    | 4    | 3-4 | 4-5 | 4-5  | 5-6 |
| Wool   | Dyed control | 3-4  | 3-4  | 2-3 | 2-3  | 3-4  | 6   |
|        | Alum    | 2    | 1-2  | 3    | 3    | 4    | 6   |
|        | FeSO4   | 1-2  | 2    | 3    | 3    | 3-4  | 6   |
| Silk   | Dyed control | 3    | 3-4  | 3-4 | 3    | 4    | 6   |
|        | Alum    | 2-3  | 3    | 3-4 | 2-3  | 4    | 6   |
|        | FeSO4   | 2    | 3    | 3    | 3    | 4    | 6   |
| Nylon  | Dyed control | 4-5  | 3-4  | 2-3 | 2-3  | 3-4  | 6   |
|        | Alum    | 4-5  | 3    | 3    | 3    | 3-4  | 6   |
|        | FeSO4   | 3    | 2-3  | 2-3  | 3    | 3-4  | 6   |

St.* staining on cotton  
St.** staining on wool  
Alt. Alteration

Table 11a clarified the colorfastness properties of colored control and pre-mordanted colored fabrics with madder. Comparing colorfastness properties, it is clear that colorfastness to washing is fair to very good. Also, colorfastness to rubbing is fair to good. While, colorfastness to light is very good to excellent. It is clear that pre-treatment of fabrics using mordants enhances colorfastness to washing, except for FeSO4/wool and FeSO4/nylon. Colorfastness to Light and rubbing doesn’t improve by mordants.

Table 11b illustrates colorfastness properties of colored control and pre-mordanted colored fabrics with chamomile. By comparing colorfastness properties, it is appear that, colorfastness to washing and to light is very good to excellent. Also, it is clear that pre-treatment with mordants improves colorfastness to light and to washing of all fabrics, but colorfastness to rubbing doesn’t improve by using mordants.

Table 12 illustrates colorfastness properties of colored control and pre-mordanted colored fabrics with red onion/chamomile mixture (40 g/L, 50% wt). These results show that colorfastness to washing is good to very good and colorfastness to rubbing is fair to good. While, colorfastness to light is very good to excellent. Pre-treatment with mordants enhances colorfastness to light and washing, but colorfastness to rubbing is not affected by mordants.

UPF properties of colored fabrics

In this study the measurement of UPF based on UV protective properties for colorants namely; red onion peel, chamomile, madder and red onion peel/chamomile mixture (50% weight) of colored fabrics is investigated [5,35,37–40]. Coloration is performed without mordants (control) or using tannic acid (2.6 g/L for cotton) or with a low concentration of FeSO4 or alum (1.5 g/L).

Figures 2-5 of UV transmittance Percentage of different colorants and Figure 6 of UPF and UV-A of all colored wool with different colorants show that wool fabrics colored with 4 colorants used, acquire excellent UPF values (50+) and the order of the UPF values are as follows, red onion peel> mixture of red onion peel/chamomile>madder>chamomile. Also, the addition of FeSO4 as a mordant increases the values of UPF and show excellent UPF values (50+) with this order, red onion peel+FeSO4>madder+FeSO4> mixture of red onion peel/chamomile+FeSO4>madder+FeSO4. Also, the values of T (UV-A) in both cases (mordanted and non-mordanted fabrics) are lower than 1%. Results of Tables 7-9 reveal that increasing K/S of colored wool fabrics with/without mordants accompanied by increasing UPF of these fabrics.

Accordingly, it can be concluded that wool fabrics are ranked as “excellent UV protection” after dyeing with or without a mordant because wool fabric has some properties such as; low porosity and high weight and thickness. Hence, wool fabric gives a high UPF by allowing the penetration of less UV. All wool fabrics colored with 4 colorants extracts without/with mordant (alum-FeSO4) have much higher UPF values and lower T(UVA) and T(UVB).

Figures 2-5 of UV transmittance Percentage of different colorants and Figure 7 of UPF and UV-A of mordanted colored silk fabrics with different colorants using FeSO4 and alum, acquire excellent UPF values.
Percentage UV transmittance - wavelength for the fabrics colored with red onion peel

Figure 2: Percentage UV transmittance - wavelength for the fabrics colored with red onion peel.

Percentage UV transmittance - wavelength for the fabrics colored with madder

Figure 3: Percentage UV transmittance - wavelength for the fabrics colored with madder.

Percentage UV transmittance - wavelength for the fabrics colored with chamomile

Figure 4: Percentage UV transmittance - wavelength for the fabrics colored with chamomile.
According to this order; red onion peel+FeSO4>mixture of red onion peel/chamomile+FeSO4>madder+alum and the values of T(UV-A) is lower than 5%.

From Figure 7, it is clear that different mordants have different impacts on the spectral transmittance of silk fabrics colored with 4 used colorants. Comparing with the colored silk fabric without mordant, the values of the spectral transmittance are reduced, but the UPF values are augmented by using mordants such as FeSO4 and alum and show excellent UPF values.

In this experiment, the UPF of the fabrics colored with these natural dyes was higher than 50 according to Figure 7, and the value of the T(UV-A) was lower than 5%, except with madder (without mordant).

Actually, when the UPF value of the colored silk fabric was higher than 50 and the value of the T(UV-A) was lower than 5%, the colored silk fabric was supposed to be a solar ultraviolet protector [40]. This means that the fabrics colored with natural dyes can greatly prevent the penetration of UVR. Consequently, these colored silk fabrics could effectively shield skin from sunlight UV radiation.

From Figures 2-5 of UV transmittance Percentage of different colorants and Figure 8 of UPF and UV-A of mordanted colored cotton
and nylon fabrics with different colorants using alum and FeSO₄, it is obvious that non-mordanted/mordanted colored cotton fabric acquire very good UPF values (50+) according to this order; red onion peel + tannic acid + FeSO₄ > red onion peel + tannic acid + alum > red onion peel + tannic acid (without mordant) and the values of T (UV-A) is lower than 5%.

The tannin molecules contain functional groups which absorb UV radiation, in this way, the colored cotton fabric treated with tannin—demonstrates higher UV protection than fabric without tannic acid [40], as appeared by the higher UPF value and a lower T (UV-A) rate. Cotton fabrics indicated an additional enhancement of UV protection which could be accounted for high uptake of tannin because of formation of the complex with metallic salt (mordant). Tannin molecules which turned into the ligands in the metal tannate complex

Figure 7: UPF and UV-A of non-mordanted and mordanted dyed silk with red onion, madder and mixture of red onion/chamomile extracts using alum and FeSO₄.

Figure 8: UPF and UV-A of non-mordanted and mordanted dyed cotton and nylon with red onion, madder and mixture of red onion/chamomile extracts using alum and FeSO₄.
hold their capability to absorb UV and, alongside the metal ions from the mordant, the overall UV protection effectiveness of the cotton fabrics is assigned to them.

Conversely, it is clear from Table 8, Figures 2-5 and 8 that the colored nylon fabric with madder has insufficient UPF value (13) as well as with alum (14) and the values of T (UV-A) is higher than 5%, which mean that this fabric hasn’t any protection against UV radiation (Table 8a and Figure 8).

This study is important to increase natural dyes cultivation in our country for domestic market in addition to produce UV protective apparel clothing and carpets (wool and silk), curtains, and blankets with beautiful colors.

Conclusions

The coloration of fabrics with colorants of red onion peel, madder, chamomile and red onion/chamomile mixture (50% wt) extracts without mordant, the overall UV protection effectiveness of the cotton fabrics is assigned to them. Wool fabrics or mordanted fabrics according to this arrangement; wool fabric>>silk fabric>>cotton fabric>>nylon fabric, which confirmed UV protection of fabrics colored with the 4 mentioned colorants. When the UPF value of the colored fabrics was higher than 50 and the value of the T (UV-A) was lower than 5%, then the colored fabrics with colorants such as red onion, madder, chamomile, red onion peel/chamomile mixture were supposed to be a solar ultraviolet protector. This further explained that the fabrics dyed with natural dyes strongly blocked UV radiation. Thus, these colored fabrics efficiently protect skin from UV radiation. Thus, these colored fabrics could efficiently protect skin from UV radiation. This study is important to increase natural dyes cultivation in our country for domestic market in addition to produce UV protective apparel clothing and carpets (wool and silk), curtains, and blankets with beautiful colors.

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