Multi-criteria decision analysis for supporting the selection of car upholstery fabric under degradation due to UV exposure

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Abstract
Automotive textiles are one of the most important markets in the technical textile sector. Various types of requirements must be considered in the development of the interior fabrics to satisfy both esthetic and functional demands. Many factors are affecting the properties of the car upholstery fabrics, for instance textile material, yarn specifications, fabric construction, and finishing material as well as combined with UV and light resistance. The influence of UV radiation on the degradation rate involves several parameters such as fabric tenacity, elongation, abrasion resistance, and flammability, under exposure to sunlight for several exposure times. Consequently, it’s important to determine the degradation of the automotive textiles according to area where it will be served. Generally, several properties are prerequisites should be all together considered to selected car upholstery fabric, basis on overseeing several requirements and ranking the candidate fabric properties. In this paper, an approach to choose the optimal material for a given component is described, and fabric properties are classified given each a suitable weight. In a simulation of a car cabin in shape and conditions, a radiation chamber was constructed to expose different fabric specimens to sun light. Two evaluation methods were proposed for the ranking of the car upholstery material, made of different fabrics, according to its property loss due to UV exposure during severability. It was found that polyester and nylon are ranked to be the best materials for automobile upholstery.

Keywords
Automotive fabrics, fabric, fabric design

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Introduction
The mobiltech segment of technical textiles has the largest revenue share of the global technical textiles, it’s expected to lead the other the technical textiles market.1 In the year 2021, about 20%–25% of the global textile market is technical textiles which are growing faster than traditional textiles.2 One of the largest markets for technical textiles is the automobile industry, which uses on average of 20 kg for each of the 45 million or so cars produced globally each year.3,4 The automotive interior fabric properties are a function of different variables such as fiber type, yarn construction, fabric weight, fabric structure and type of finishing. The properties of polyester and polyamide make

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it an ideal material for automotive industry due to their abrasion and UV resistance.² An average car uses 18% of the automotive textiles for upholstery (seating fabric) Automotive textiles.³ Polyester fibers had been established as the most popular fiber for automotive textile due to their super mechanical performance concerning good abrasion resistance, high dimensional stability, and high light fastness. Nylon 66 was the first fiber introduced into the manufacturing of automotive textiles because of its excellent wear resistance, appearance retention, soil shedding properties, and low cost, as well as a full range of colors and luster were available. At a molecular level, the thermal degradation in polypropylene was more difficult to control due to the presence of tertiary carbons, so polypropylene was more susceptible to UV degradation and therefore, had less resistance to sunlight compared with polyester or nylon.⁴ Fabrics, produced for cars, might include knitted fabric at 50%, woven fabric at 40%, and leather/plastics at 10%.³ Both, textile fibers and dyes, could be damaged by the action of sunlight due to UV radiation.⁵ To minimize such degradation reaction, stabilizers were added to the polymer in the form of UV absorbers. This absorbs the UV portion of the sunlight and converts it into non-radiate thermal energy. UV absorbers were used in textile finishing processes to produce especially lightfast dyeing for the automotive industry.⁸

The exposure of a fabric to UV radiation will cause the chain of molecules of the fiber to begin break down, causing physical and chemical changes for both natural and manmade fibers. All the physical properties of the fabric will be influenced by UV radiation and the time of exposure, the material can lose strength, become less flexible, disintegrated, and fade in color due to photo degradation.⁹ Ultraviolet radiation that reaches the earth’s surface consists of 6% of the total solar radiation and has wavelengths ranging from 290 to 400nm.¹⁰ The stratospheric ozone blocks radiation below 290 nm, and the remainder of the radiation comprise visible (52%) and infrared (42%). Most polymers have their bond dissociation energies corresponding to 290–400 nm of wavelengths and hence, are significantly affected by this part of the solar radiation the energy transfer that causes the temperature of the substance to rise takes place at the molecular scale.¹¹,¹² Polymer morphology (amorphous and crystalline regions) plays an important role in oxidation and/or photo oxidation reactions. As a result of degradation, the molecules, which connect the crystallites through the amorphous phase, are split, and as result the elongation reduces and there are changes in other physical properties as well.¹²

There are several types of car upholstery fabric using man-made fibers, natural fibers, or combinations of both in various weave designs, either woven or knitted. The photo degradation is the mechanism stimulated by ultraviolet (UV) irradiation and oxygen concentration on the surface of the material. As the UV exposure penetrates a few microns of the material’s surface,¹³ it causes the breakage of polymer chains producing free radicals and reducing the molecular weight of the polymers. This would lead to the surface degradation and reduction in the mechanical properties of the material.¹⁴ It should be mentioned that the UV index differs according to the geographic location, closer to equatorial regions the UV radiation levels will be higher. The problem of the material ranking to choose the appropriate material for a particular product is one of the critical tasks for the designers. Designers need to identify materials with the specific functionalities in order to find feasible design concepts and fulfill the product’s end requirements. The requirement of the end-use is a function of multi properties of the material, especially for the technical textiles.¹⁵ There is a huge array of the materials with diverse properties available to the designers to satisfy different design requirements. The large number of available materials together with the complex relationships between various selection criteria often makes the material selection process a difficult and time-consuming task since the objectives and the properties of the material may conflict.¹⁶ Several methods are subjected for different applications such as analytical hierarchy process, the technique of order preference by similarity to an ideal solution, graph theory and matrix approach, evaluation of mixed data, and linear assignment method, simple multi-attribute rating technique.¹⁷–²⁸ But there is still a need to search for other mathematical tools and techniques for the accurate ranking of the alternative materials for a given engineering application. In this work, two simple evaluation ranking methods were proposed for the ranking of the upholstery car material made of different fabrics, according to its property loss due to UV exposure during its serviceability. All fabrics used as seat coverings must be able to withstand UV radiation, temperature range from below 0⁰ to well over 120⁰C, in addition to being sat upon for many years.²

For the present study, several types of car upholstery fabric of were irradiated to UV radiation for different times under simulating condition in car application. The effect of the UV radiation on the different fabric properties was determined. A method for ranking the fabrics was developed.

Material and methods

Fabric samples specifications

Eight fabric samples of different specification utilized in car upholstery were chosen as the most used in Egypt. Table 1 gives the specifications of the samples. Samples No. 1, 2, and 3 are from the imported materials and samples 4, 5, 6, 7, and 8 are locally produced and most usable for car upholstery.
UV illumination experiments

To study the effect of duration of UV illumination, four samples of each fabric were laid in UV exposure chamber and left in the radiation chamber unit for 24 h. The first one was tested after exposure to UV radiation for 3 months while the second sample was tested after exposure for 6 months, third one for 9 months, and the fourth for the year. Four chambers were needed for each type of fabric while exposing to the sunlight around the clock out. Each fabric was tested in 3 months interval with the sun exposure time 1003, 2243, 3458, and 4435 h. Radiation chamber unit was provided with automotive glass cover, as shown in Figure 1, and inclined to fabric at the angle of 35° to simulate the inclination of the front glass in the actual automobile. The sample size was 300 × 300 mm. The schematic of the UV chamber is illustrated in Figure 1. The testing procedure was repeated five times and five specimens were not exposed to UV light as the control samples.

Testing the fabric samples

Tensile test. Tensile tests were carried out on five samples in warp and weft directions with the uniaxial tensile testing machine under the standard conditions, according to ASTM D 1682-59 T.

Abrasion resistance. An abrasion resistance test was carried out on an inflated diaphragm abrasion tester, according to ASTM D 1175. The number of specimens was 5, each of radius 55 mm, at pressure 20.7 kPa and normal load 13.6 N. The operating speed was 115 rubbing cycles/min.

Flammability test. The average time of flame spreading, according to ASTM D1230/16, was measured using Atlas flammability tester at flame inclination of 45° degrees to the specimen surface. The testing procedure was repeated on all five specimens.

Table 1. Samples specifications.

| Sample ID | Fabric structure | Fabric design | Fiber type | Yarn count Ne | Fabric density ends/cm | Fabric areal density g/m² |
|-----------|-----------------|--------------|------------|---------------|-------------------------|--------------------------|
|           |                 |              |            | Warp          | Weft                    | Warp                     | Weft                     |                        |
| 1         | Woven           | Fancy twill  | Nylon/Polyester 50/50 | 13/2         | 11.6/2                  | 11                       | 10                      | 473.7                   |
| 2         | Woven           | Twill 3/1    | Polyester   | 7.5          | 7.5                    | 19                       | 13                      | 431.6                   |
| 3         | Woven           | Plain        | Cotton/(Polyester/ Polypropylene) 80/20 | 30/2         | 30/2                   | 33                       | 20                      | 410.5                   |
| 4         | Woven           | Plain        | Warp yarns Polyester/ Acrylic 50/50 Weft yarns Cotton 100% PES 30/2, Acrylic28/2 | 24/2 | 26 | 14 | 452.6 |
| 5         | Woven           | Plain        | Cotton/(polyester/ acrylic) | 10 | 10 | 23 | 15 | 432.1 |
| 6         | Woven           | Plain        | Acrylic 100% | 17.5         | 17.5                    | 35                       | 18                      | 274.7                   |
| 7         | Woven           | Satin 5      | Polyester 100% | 35 | 30 | 42 | 16 | 109.5 |
| 8         | Warp knitted    | Knitted      | Polyester   | 35 | 35 | 30 | 20 | 589.5 |

Figure 1. Radiation chamber unit.
Results and discussion

Effects of radiation on car upholstery fabric

Figure 2 shows the analysis of the effects of UV radiation on the fabric layer fixed in the setup.

The radiation:

\[ I = (I_{fr} + I_{fr}) + (I_n + I_{mf}) \]

Where:
- \( I \) – radiation,
- \( I_{fr} \) – fabric reflected radiation,
- \( I_{mf} \) – fabric material transmitted,
- \( I_n \) – fabric pore transmitted.

Index of fabric directional transmitted radiation:

\[ \text{Inxt} = \frac{(I_{fr} + I_{mf})}{I} \]

Index of fabric scattered transmitted radiation:

\[ \text{Inxs} = \frac{I_{fr}}{I_{mf}} \]

\( \text{Inxt} \) depends on the fabric design, the cover factor, and fabric tightness as well as the material of the fibers. In the case of fabric with a high cover factor and high ability to absorb UV, the value of \( \text{Inxt} \) will be high. While index of fabric scattered transmitted radiation \( \text{Inxs} \) is affected by how much the UV will reflect from the surface of the fabric. The destruction of the material will depend on the value of:

\[ \text{In dis} = \frac{(I - (I_{fr} + I_{fr} + I_n + I_{mf}))}{I} \]

Index of fabric destruction by UV radiation can be given as:

\[ \text{In dis} = \left( K - (I_{mf} + I_{mf}) \right) \]

\[ K = (1 - (I_{fr} / I)) \]

Table 2 shows the designs of woven fabric indicating that for plain weave, \( \text{Inxs} \) is higher than for the other fabric designs and at the same time, \( \text{Inxs} \) is lower. Consequently, \( I_{dis} \) is expected to be lower.

The cover factor is considered as a fraction of the total fabric area covered by the component yarns. Table 2 illustrates the various fabric designs with different cover factors, that will affect the value of the Index of fabric scattered transmitted radiation \( \text{Inxs} \), that is, influencing the residual UV radiation. It will be absorbed by the material, causing internal fiber destruction, and reducing the tensile properties of the fabric. Consequently, the fabric with a high cover factor and fiber volume fraction is expected to reflect more UV radiation from its surface and less fiber destruction. The plain weave has the highest tightness compared to the other designs. The fiber volume fraction of the plain weave unit is equal to the ratio of the volume of the fibers to the volume of the unit weave and simply can be computed from the equation (6):\(^{30-32}\):

\[ V_{textured} = \phi \left( \frac{d_{warp}n_1 + d_{weft}n_2 - \left( d_{warp}n_1d_{weft}n_2 \right) / 10}{10} \right) \]

Where:
- \( d_{warp} \) is the average diameter of the weft yarns at the side of the unit cell, mm.
**Table 2.** Some woven fabric designs.

| Fabric pattern | Fabric pattern | Fabric pattern |
|----------------|----------------|----------------|
| Plain 1/1      | Twill 3/2      | Twill 1/4      |
| Twill ½        | Basket 2/2     | Satin 5       |

$d_{wef}$ is the average diameter of the warp yarns at the side of the unit cell, mm.

$n_1$ is the number of warp yarns per cm.

$n_2$ is the number of weft yarns per cm.

$\phi$ is the yarns fiber volume fraction.

The yarn’s fiber volume fraction also will play a significant part in determining its fiber volume fraction. It was revealed that the yarn’s fiber volume fraction of the spun yarns is less than of the continuous filament (0.4 up to 0.75) and depends on the yarn evenness. The fiber volume fraction represents the weight of the fibers subjected to UV radiation, consequently, the deterioration of the material in practical exposure time will be less for a fabric having higher fiber volume.

**Figure 3.** UV index, daylight in hours, sunshine hours versus the different months of the year at Alexandria – Egypt.

UV index, the daylight hours, and the sunshine hours in Alexandria Egypt

Figure 3 illustrates the UV index, the daylight hours, and the sunshine hours throughout the months of the year in Alexandria, Egypt. The values of UV index in the above figure is the strength of the sunburn to produce ultraviolet (UV) radiation at Alexandria in the above-mentioned times. An index of 0 corresponds to zero UV radiation, as is the case at night. The value of UV index at each month represents the average value of UV intensity in the corresponding month around the sun’s highest point between sunrise and sunset in the day. This occurs between 11:30 and 15:30. An index of 12 corresponds to midday summer sunlight with a clear sky and means extreme. According to the recommendations for
UV index In January and December is between moderate, in February and November, is moderate, in March and October is high, in April, May and September is very high, and in June, July, and August is extreme.35

Effect of UV radiation exposure time on the fabric tenacity and elongation
Photodegradation causes changes in all scales of polymer dimension, including the monomer unit (oxidation), the chain (cross-linking or chain scission), the morphology (breakdown of tie molecules and crystal), and on the macroscopic scale.36 The photo-oxidation process also occurs in amorphous regions because of their higher permeability to oxygen.37 Figure 4 presented a schematic diagram of the degradation of fibers due to UV exposure.38

Figure 5 shows an increase in fabric tenacity loss percent with increasing exposure time. The eight fabric samples clearly show different deterioration in fabric tenacity in the warp direction. This variation can be attributed to the composition of the material as well as outside forces like wind, rain, and sun damage. No doubt, that by increasing the time exposure to the environmental conditions, sunlight can be one of the biggest contributing factors to reducing fabric tenacity. Sunlight radiation leads to the degradation of the fabric tenacity over time by breaking down the molecules and polymer chains in fabric fibers. All fabric samples absorb sunlight radiation at the different levels. Fabric samples ID 3 and ID 5 consist of cotton in warp and weft direction while fabric sample ID 4 consists of cotton in the weft direction. The samples made from synthetic material show a slow increase in a percentage.
loss of fabric tenacity at the start and until 4500 exposure hours. Fabric sample ID 7 has a slight increase in % loss until between 2000 and 2500 exposure hours and after that becomes constant. Fabric samples ID 3 and ID 4 have continued increase in % loss of fabric tenacity. This may be due to the variation in fabric samples composition, fabric construction, and areal density. Generally, thick, dense, and plain weave fabric has good withstand to fabric degradation.

From Figure 6 it is obvious that all woven fabrics have an approximately constant increase in % loss in fabric elongation, while the warp knitted fabric has a slight increase until 2500 h, after that increasing in the tensile percentage loss is rapid till 4500 h. The results revealed that areal density and small yarn float with higher fabric crimp and consequently, higher fabric cover factor are the most important factors that affected the withstand to the percentage loss in fabric elongation due to the exposure to sunlight. Therefore, warp-knitted velour composite fabric has a higher resistance to loss in elongation due to its higher stitch inter looping. It was noticed that in the polyester woven fabric UV exposure can be a significant trigger on lowering tenacity.39

Testing of UV degradation of both Polyamide (PA) and Polyester (PET) indicates that surface degradation was more pronounced for PA fibers than PET.40 This leads to more loss of the fabric’s mechanical properties.

Figure 7 shows an increase in fabric tenacity loss % with increasing exposure time. The eight fabric samples clearly show different deterioration in fabric tenacity in the weft direction. This variation can be attributed to the composition of the material of the weft yarn and fabric design. Fabrics ID 1, ID 2, and ID 4 show approximately the same % loss in fabric tenacity until exposure time between 2000 and 3000 h, after that there is a variation in % loss of fabric tenacity but less than in the other fabric samples. Fabric sample ID 5 shows a higher % loss in fabric tenacity because of the fabric with singed raised. Fabric sample ID 7 shows a constant increase in % loss of fabric tenacity. Sample ID 6 indicates a sudden increase at the start till 2000 h, after that there is a slight increase in fabric tenacity loss % till 4500 h.

As evident from Figure 8, all woven fabrics have a different increase in % loss in fabric elongation in the weft direction while the warp knitted fabric has the lowest % loss in fabric elongation. Plain-woven fabric with singed raised has the highest % loss in fabric elongation. The other fabric samples are with different values of % loss. Plain woven fabrics, fancy twill, and twill 3/1 two layers lay between the fabric with singed raise and warp knitted velour composite fabric. The difference in elongation loss percentage can be referred to the fabric construction.

**Figure 6.** Fabric elongation loss % in warp direction versus the exposure time in hours of different fabrics.

**Effect of UV exposure on fabric tenacity after 1 year**

Figure 9(a) shows a variation in fabric tenacity for the eight fabric samples. Polyester 100% woven satin 5 fabric shows higher fabric tenacity, after that comes the acrylic 100% plain-woven fabric, the polyester 100% woven fabric fancy twill, nylon50%/polyester50% reversed twill, polyester/acrylic plain weave with weft cotton yarn,
cotton – polyester – acrylic plain weave with singed raised and finally the warp-knitted velour composite fabric with the lowest value of tenacity.

The introduction of cotton in fabric ID 3 and ID 4 causes a higher loss in fabric tenacity after exposure to sunlight than satin 5 and the warp-knitted velour composite fabric. This variation can be due to the material composition and the structure of the fabric. Figure 9(b) shows fabric tenacity (g/tex) for weft direction and its loss after an exposure time of 4435 h. of the different tested fabric samples. The highest % loss is in fabric ID 3 and ID 4.

**Effect of UV exposure on fabric flammability**

Figure 10 illustrates the flame resistance loss of the different fabric samples against the exposure time. In this figure, fabric sample ID 1 is absent because this fabric has a flame retardant agent finish, that is, a chemical treatment to
impart flame resistance. Fabric sample ID 7, composed of 100% polyester, has a higher % loss of flame resistance. Plain woven fabric sample ID 4, composed of polyester / acrylic warp and cotton weft yarn has the lowest flame resistance loss %. The other fabric samples have flame resistance loss % between the lowest one and the highest one due to the presence of polyester with different percentages.

Figure 9. Fabric tenacity in gm/tex and percentage of loss in fabric tenacity in (a) warp and (b) weft directions after exposure to sunlight.

Figure 10. Fabric flammability loss % versus the exposure time.
Effect of UV exposure on fabric flammability after 1 year

As the time of flammability in seconds increases, the flame resistance loss % decreases as shown in Figure 11. Also, in the above figure fabric sample ID 1 is absent because it is treated against the flame.

Effect of UV exposure on fabric abrasion resistance

The abrasion resistance of the fabric depends mainly on the yarn material, fabric design, the float length of the warp and weft yarn, and the fabric density. If the fabric is dense, compact with higher crimp%, the fabric abrasion resistance will be high. The fabric sample ID 7, woven fabric satin 5, has a higher abrasion resistance loss percentage due to the lower crimp percentage, while other plain woven fabrics, ID 4 and ID 5, and reversed twill, fancy twill, and 2 layers 3/1 twill showed less abrasion resistance loss % as illustrated in Figure 12. The lowest fabric sample in abrasion resistance loss % is the warp-knitted velour composite due to its higher interloping and compactness.

Ranking model of the samples

Material selection is an onerous process of design activities which needs to be carefully carried out to increase the probability of success. A lot of multi criteria decision-making methods have been proposed in material selection, many of which require quantitative weights for the attributes.41

A large number of current and on growing materials coupled with the complex relationships between the
different selection parameters often make the selection of a material for a given component a difficult task.42 Ranking of the samples, which have a different performance during their working serviceability, is the measure of the different characters of a product to meet the customers’ requirements. The efficiency of the material to perform its function may be the sum of the individual performance characteristics (attributes/criteria) of a particular product. yj is the measure of performance of jth attribute (criterion) and there are alternatives in the entire property selection space.

**Star rating system.** In this work, we suggested ranking the samples according to the star rating system. Star rating is a method of grading accommodation to help customers make a choice that best suits their needs. It was introduced initially for hotels by motoring organizations like the AA (Automobile Association) and RAC (Royal Automobile Association) as early as 1912. Our case introduced to classify the different fabrics according to the different chosen parameters that are important from the point of view of their effect on fabric utilization. The ranking of the samples depends on the importance of each property considered and measured. In our case, we need to know how the exposure to the sun will affect the different properties of the fabric which presented by the property’s percentage loss after the exposure in the set up for 1 year. The importance of each property depends on many factors and is rated by different rates ranging from 1 to 5. The more rating a fabric receives the more reliable the rating value is considered to be. Assume, wj is the relative importance (weight) of jth criterion. Table 3 shows three evaluation systems for the relative importance of the different properties loss of the fabric wj, yj is the fabric loss in the property (j).

The ranking of each fabric can be obtained after assigning weights to the attributes:

\[ U(y_1, y_2, y_3, ..., y_n) = \sum_{j=1}^{n} w_j U_j(y_j) \]  

Table 3. Decision matrix for fabric material for ranking systems.

| Ranking system fabric properties | I | II | III |
|---------------------------------|---|----|-----|
| Flame resistance                | 5 | 5  | 5   |
| Color fastness                  | 4 | 5  | 5   |
| Abrasion resistance             | 3 | 3  | 3   |
| Tensile strength loss           | 2 | 2  | 2   |
| Elongation loss                 | 1 | 1  | 3   |

Table 4. The ranking of the samples.

| Sample ID | I | II | III |
|-----------|---|----|-----|
| 1         | ★★★★★ | ★★★★★ | ★★★★★ |
| 2         | ★★★☆   | ★★★★   | ★★★★   |
| 3         | ★★★★★ | ★★★★   | ★★★★   |
| 4         | ★★★★★ | ★★★★   | ★★★★   |
| 5         | ★★★★★ | ★★★★   | ★★★★   |
| 6         | ★★★★★ | ★★★★   | ★★★★   |
| 7         | ★★★★★ | ★★★★   | ★★★★   |
| 8         | ★★★★★ | ★★★★   | ★★★★   |

The ranking of the samples, according to this procedure, indicates that sample 1 occupied the first place, other samples ranked differently as given in Table 5.

Table 5. Ranking of the tested samples.

| Ranking System I | Ranking System II | Ranking System III |
|------------------|-------------------|-------------------|
| 1*               | 1*                | 1*                |
| 2*               | 5*                | 2*                |
| 5*               | 2*                | 5*                |
| 3*               | 3*                | 6*                |
| 4*               | 4*                | 3*                |
| 6*               | 6*                | 4*                |
| 7*               | 7*                | 7*                |
| 8*               | 8*                | 8*                |

*1,2,3,4,5,6,7,8 Fabrics ID

5 stars | 4-3 stars | 2-1 stars

Table 4 gives the ranking of the different samples according to the different weighting systems.

The ranking of the samples, according to this procedure, indicates that sample 1 occupied the first place, other samples ranked differently as given in Table 5.

**Utility concept system.** Another approach is the utility concept. It is the measure of the characteristic of a product to meet the customers’ requirements. The fabric serviceability Pj is the sum of the individual performance characteristics (attributes/criteria) of a particular product. In this case, the weight of each property will be given.

Table 4. The ranking of the samples.

| Sample ID | I | II | III |
|-----------|---|----|-----|
| 1         | ★★★★★ | ★★★★★ | ★★★★★ |
| 2         | ★★★☆   | ★★★★   | ★★★★   |
| 3         | ★★★★★ | ★★★★   | ★★★★   |
| 4         | ★★★★★ | ★★★★   | ★★★★   |
| 5         | ★★★★★ | ★★★★   | ★★★★   |
| 6         | ★★★★★ | ★★★★   | ★★★★   |
| 7         | ★★★★★ | ★★★★   | ★★★★   |
| 8         | ★★★★★ | ★★★★   | ★★★★   |
The overall index value (U) can now be calculated as follows:

$$U = \sum w_j p_j$$

(subject to the constraint that \(\sum w_j\) use on the 1)

$$p_j = \log \left(\frac{y_j}{y_j'}\right)$$

Where: \(y_j\) and \(y_j'\) are the observed and the just acceptable values of each property, for example the values of \(w_j\) are given in Table 6.

The ranking of the data of the different fabric samples is given in Table 7.

Comparing the two ranking methods in Table 7 shows a satisfactory agreement of the two methods.

**Table 6.** Weight of different fabric properties.

| Criteria          | Flame resistance | Color fastness | Abrasion resistance | Tensile strength loss | Elongation loss |
|-------------------|------------------|----------------|---------------------|-----------------------|----------------|
| Weight            | 0.3333           | 0.2667         | 0.2                 | 0.1333                | 0.0667         |

**Table 7.** Comparison between the two ranking systems.

| Sample ID | \(p_j\) | Ranking according to star |
|-----------|---------|--------------------------|
| 1         | 0.932789 | ★★★★★                   |
| 5         | 1.976078 | ★★★★                   |
| 2         | 2.066348 | ★★★☆                  |
| 6         | 2.134276 | ★☆☆☆☆                  |
| 8         | 2.158227 | ★☆☆☆☆                  |
| 4         | 2.172114 | ★☆☆☆☆☆                 |
| 3         | 2.265133 | ★☆☆☆☆☆                 |
| 7         | 2.269326 | ★☆☆☆☆☆                 |

The conclusion of this study is that Ultraviolet (UV) effects, as one of the environmental destructive factors on the mechanical properties of car upholstery fabric, were studied. The mechanical properties of the eight types of fabrics before and after exposure to UV radiation for 1 year were measured, and the percentage loss in their tenacity, elongation, abrasion resistance and flammability were allocated. Regarding fabric flammability, automotive upholstery fabrics should have a chemical treatment (flame-retardant material) to impart flame resistance for safety, consequently, it will be given the highest weight for ranking. Tightly woven structures provide higher abrasion resistance. Also, warp knitted velour fabric is preferable. Two methods of ranking the different samples were introduced. The eight different fabric types were affected differently by exposure to UV corresponding to natural sunlight, all the samples primarily exhibited changes in surface morphology after 3 months of UV exposure. While samples containing the polyester fiber identified fabrics degradation at a lower rate. The worst sample was light woven satin fabric. Both methods of ranking star rating system utility concept system were proved as a good tool for the fabrics classification according to UV resistivity.

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