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Enhancing the Functional Properties of Car Cover Fabrics Using Nanotechnology

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Abstract

Car covers have continuous development in recent years. It is one of the most important car accessories that can help maintain the car's appearance, and are considered one of the necessary things due to their effective role in protecting the car from all climatic fluctuations that negatively affect the car's appearance (dust and dirt, acid rain, ultraviolet sunlight). Therefore, this research aims to achieve the best functional properties of the car cover, so that it has the following properties (high tensile strength - lightweight - resistance to dirt). To achieve this goal, nine woven samples were produced with different variables (textile structure and weft density per units of measurement) and treated with nano titanium dioxide) TiO_2(and Honey bee propolis. It was evaluated by conducting various tests on it to determine the best functional properties, our results showed the extent of the effect of the density of the weft in cm on the fabrics, becomes clear, as the higher the density of the weft threads in cm, the higher the rate of saturation of the material with the treated substance, which increases its effectiveness, and thus increases the fabric's resistance to water and increases its self-cleaning rate. The length of the fabric float in weave structure is considered one of the most important elements that directly affects the fabric's resistance to water and increases its self-cleaning rate. The best sample performance evaluated by radar chart is sample (S12) manufactured with cotton in warp and Microfiber polyester in weft material for 40 wefts with double weave structure (Face: matt rib 2/2 Back: matt rib 2/2).

Keywords: Nanotechnology, Microfiber Polyester, Self-Cleaning, Double cloth weave.

1. Introduction

The textile industry is considered one of the largest global industries and the most Provides basic human needs.[1] The development and progress of society is linked to the development of the textile industry, as technical fabrics play an effective and vital role in all fields of life, such as: the economic field, the social field, etc. Technical fabrics can be distinguished from traditional fabrics in terms of its focus on the descriptive properties by designing its structural and engineering composition through integrated work teams to reach the final product and use it in non-traditional, high-performance fields. [2,3] The rapid progress in science and technology for this industry has contributed to its development in quantity and quality, and the great development in science, raw materials, production technology, machines and engineering concepts has led to the possibility of utilizing them effectively in the production of untraditional products, as technical fabrics are considered among the most widespread fabrics in the world, as Its growth rate reaches 3-5% annually.[4] These fabrics are used in various fields, such as medical - soil - agricultural - protection and insulation - building and construction - transportation especially for car. fabrics used in the field of cars and other various fields.[5] Technical fabrics contribute a large share to the automotive industry for the purpose of providing comfort and safety, such as using them in tires, lining the interior wall of the car, sound and

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heat insulation, safety units in the car, and car covers.[6]

The automotive sector consumes a lot of textile materials that may be visible or invisible in cars. The global consumption of textiles used in the automotive industry is estimated at more than 16% of the total global consumption of technical textiles. [7,8]

The percentage of textiles used in cars Figure 1 is estimated at 2% of the total weight of the car, where about 20-25 kg of textiles are used in the car. [9,10]

Figure 1. Use of fabrics in cars

Despite the expansion of the global market in general and the local market in particular for different types of car covers produced from cotton, polyester, and a mixture of cotton and polyester, each type differs from the other in its ability to provide some means of protecting cars, as each type is distinguished by targeting one of the properties (Resistance to sunlight - resistance to tearing - resistance to dirt - non-absorption of water - lightweight - self-cleaning) with the inability to provide the rest of the properties. [10,11,12,13]

The use of nanotechnology and its various applications, especially in the field of textiles, is considered one of the most important technologies that give fabrics many technical functions, including resistance to ultraviolet rays, self-cleaning, resistance to water, resistance to bacteria and fungi, and other properties. Nano materials also improve the functional performance of fabrics in terms of physical properties and the ability of fabrics to be dyed. In this regard, many nano metals and metal oxides are used, such as nanoparticles silver, zinc oxide, titanium dioxide, etc. [11].

Titanium dioxide is a titanium oxide with the formula TiO_2. A naturally occurring oxide sourced from ilmenite, rutile and anatase, it has a wide range of applications. TiO_2 nanoparticles have alone properties such as higher stability, it lasted long, safe and broad-spectrum antibiosis. This makes TiO_2 nanoparticles applicable in many fields such as self-cleaning, antibacterial agent and UV protecting agent. Titanium dioxide (TiO_2) is nontoxic and chemically stable when exposed to both high temperatures and UV [14]. After treatment, there is less than 5% decrease in textile strength and tearing strength, the air permeability of the fabric remains unchanged, and washing durability of the coatings is also good. [15,16] Self-cleaning of surfaces treated with nanomaterial can result in saving detergents and energy, Therefore, it was used in processing research samples. [17,18]

Honey bee propolis is a natural compound that is used as an alternative to chemicals in the textile industry. It is a natural resinous product that honey bees collect from several plants and mix with beeswax and salivary enzymes. [19,20] It has an aromatic smell and a different color. It is worth noting that there is great importance in replacing natural materials with chemicals in the textile industry, in order to achieve many goals, most important of them is preserving the environment. Whereas preserving the environment is considered one of the most important goals of sustainable development, that development that meets the needs of humans at the present time without compromising the right of future generations to use available materials, in order to achieve economic, social and environmental growth, [21,22] Honey bee propolis gives many properties to the fabrics treated with it, such as making it water resistance, protection from ultraviolet rays, anti-bacterial, and durability of washing the treated fabric. Therefore, it was used in processing research samples.

The car cover is one of the car accessories that maintains the lifespan of the exterior parts, especially for cars that are parked under direct sunlight, or exposed to the humid atmosphere of coastal cities for long hours day after day. Direct sunlight damages the car’s body, especially the paint, while humidity affects Directly on the car's body and spreading rust in one part after another. [23,24]

Exposing the car directly to sunlight for a long period of time leads to the trapping of radiation through the car windows as long-wave thermal radiation, thus increasing the temperature of the car’s components and rising the car’s temperature externally and internally to 80 degrees Celsius. This accumulates thermal energy inside it and, thus decomposes the internal parts. Because they are usually susceptible to corrosion and damage, thus shortening the lifespan of various components inside the car, especially electronic devices, rubber and plastic parts. The graph below Figure 2 show the percentage of use of car covers by car owners for the year 2021, It is clear that a large number of people use car covers because of their great importance, with the percentage of users 36%. [25]

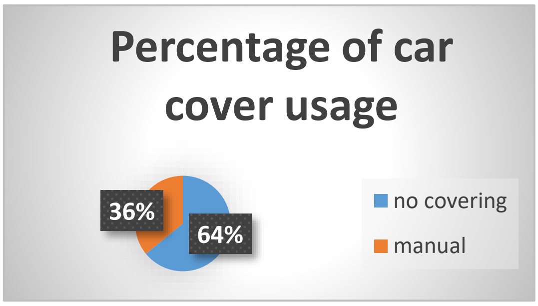

Figure 2. Percentage of car cover usage

2. Materials and Methods:

Microfibers polyester is half the diameter of a fine silk fiber, one-third the diameter of cotton, one-quarter the diameter of fine wool, and one hundred times finer than human hair. In order to be classified as a microfiber, the fiber must be less than 1 d Tex in width. Microfibers Fabrics made from microfibers are generally lightweight, retain shape, and resist pilling. They are also relatively strong and durable in relation to other fabrics of similar weight, they are more breathable, Super-absorbent, and absorbing over 7 times their weight in water, dries in one-third of the time of ordinary fibers, environmentally friendly and insulates well against wind, rain and cold.

Nine woven samples were produced using material cotton in the warp and polyester microfibers in the weft Figure 3 with three density of weft per unit, and three different weaving structures were used by the Electronic Dobby machine (ITEMA) as shown in Figure 4 and Table 1

Figure 3. Car cover made produced of from polyester material

Figure 4. Electronic Dobby machine

Table 1. electronic Dobby machine specifications

Property	Specification
Manufacturing company	ITEMA
Machine model	R9500
Manufacturing country	Italy
Width of warp without selvedge	190Cm
The power of electronic dobby	20 Harness
Speed of the machine	300 picks / min.

2.1. Weave Structure: (see Figure 5 and Table 2)

The double cloth weave structure was used, as the main advantage of these structure is the production of a fabric with high durability, It also enables us to obtain a heavier weight and greater thickness for the fabrics produced.

- Weave Structure 1: Double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2)
- Weave Structure 2: Double cloth weave (Face: Twill 2/2, Back: Twill 2/2)
- Weave Structure 3: Double cloth weave (Face: Satin4, Back: Satin4)

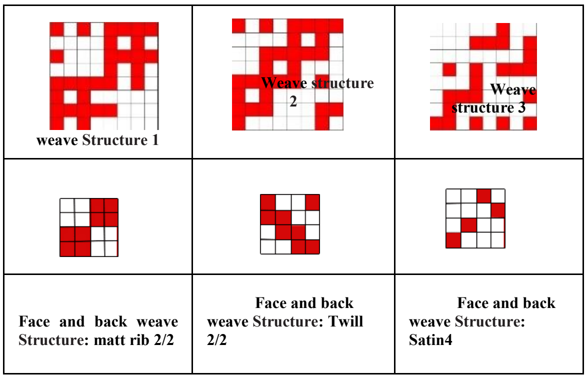

Figure 5. Weave structure used

2.2. Produced Blended fabric (cotton and polyester):

Polyester Microfiber yarn was used as weft to produce car cover fabrics

Table 2. Research Samples

no.	Warp material	Warp density/cm	weft material	Picks density/cm	Weave structure
S1	Cotton 50/2 NE	36	Microfiber polyester 300 denier 288 in the yarn cross section	35	Weave Structure 1
S2				38	
S3				40	
S4				35	Weave Structure 2
S5				38	
S6				40	
S7				35	Weave Structure 3
S8				38	
S9				40	

2.3. Test and analysis

Samples were placed under standard conditions for 24h in accordance with ASTM D1776/ D1776M (2020)

Weight test was carried out by using Precisa 1300 c apparatus according to the American Standard Specification of (ASTM D3776 -09). Thickness test was carried out by using Mituoyo thickness digital gage no. 7301 produced by Turlock Japan company according to the American Standard Specification of (ASTM D1777 – 96 (2015)). Tensile strength in weft direction test was carried out according to ISO 13934-1:2013(En) by using Tinius Olsen Testing Machine. The basic idea of a tensile test is to place a sample of a material between two fixtures called "grips" which clamp the material. The material has known dimensions, like length and cross-sectional area. We then begin to apply weight to the material gripped at one end while the other end is fixed. We keep increasing the weight (often called the load or force) while at the same time measuring the change in length of the sample. Water absorption test the absorbency time test determines the suitability of a fabric for a particular use. A drop of water is allowed to fall from a fixed height onto the taut surface of a test specimen. A drop of water is placed on the sample, and the time it takes for the drop to be fully absorbed into the material is measured, the result is given in seconds (s). [26,27,28,29,30]

Self-cleaning of the treated and nano metal oxides-loaded fabric samples was evaluated by immersing the samples in methylene blue dye solution (0.2 g/L) for 5 min for staining, then dried and exposed to sun rays, the total exposure time was 24 h. The change in color strength of the stained samples, expressed as K/S value, was evaluated according to equation (1), K/S value was evaluated using the Kubelka Munk equation [13]. The decreasing K/S values refer to the extent of dye degradation, expressed as the self-cleaning capacity (SCC) according to equation (2). Wetting time was evaluated according to AATCC Test Method 39-1980. The time between the contact of a water drop, carefully deposited onto the fabric's surface, and its disappearance into the fabric matrix. The shorter the wetting time, the better the fabric hydrophilicity is water contact angle of the water repellent was measured on OCA-15EC (Data physics GmbH, Germany) with software using 10 μL drops of triple distilled water. [31,32]

1- $K/S = (1-R)2/2R$

R: the reflectance of the stained samples

K and S are the absorption and scattering coefficient

2- $SCC = (K/S)\ b - (K/S)\ a\ /\ (K/S)\ b \times 100$

a: Color strength after exposing to daylight

b: color strength before exposing to daylight

2.4. Treatment:

Titanium dioxide P25 powder was provided by Degussa, Glyoxal 40% solution, was purchased from Merck, GmbH.

2.4.1. The first stage: - (Titanium dioxide treatment)
Figure 6

A diluted solution of titanium dioxide with a concentration of 1% was prepared. The solution is stirred for 30 minutes. Samples were padded in the previously prepared solution in two dip and nip and then squeezed to a wet pick-up of 100%. the samples are placed in an oven for drying for 5 minutes at a temperature of 80 degrees Celsius.

Figure 6. Titanium dioxide treatment solution

2.4.2. The second stage: - (treatment with honey bee propolis)

5 gm sample of propolis was frozen and cut into small pieces and ground in a morter then extracted at ambient conditions with 100 ml of (70/30ethanol/H2O) Figure7. then added 5ml of glyoxal solution was added as a crosslinking agent aluminum chloride hydrated was added 1g/L as a catalyst that helps speed up the reaction. Then the solution is stirred for 30 minutes at a temperature. after that the samples are placed in the solution (figure 7) for half an hour and the samples are placed in the solution for half an hour at a temperature of 80 degrees then samples were then padded through laboratory padder with two dips and two nips to give a wet pick up of 100% (owing of weight of fabric) owf. the samples were simultaneously dried at 850 C for 5 min and cured at 1400 C for 3 min.

Figure 7. Treatment with honey bee propolis solution

3. Results and Discussion:

This research part shows the results of the evaluation tests that were conducted on the produced samples produced before and after the various treatments to study the effect of these treatments on the research variables, and their statistical analysis.

Table3. Results of tests for samples before chemical treatments

Number	Weight (g/m2) [27]	Thickness (mm)[28]	Tensile strength in weft direction (kg/cm2) [29]	Self-Cleaning [31] %	Water absorption (sec) [30]
S1	**278**	**0.98**	**1610**	**12**	**1**
S2	**300**	**0.95**	**1810**	**9**	**1**
S3	**320**	**1.28**	**1990**	**8**	**1**
S4	**254**	**0.90**	**1560**	**11**	**1**
S5	**258**	**0.83**	**1700**	**10**	**1**
S6	**260**	**1.25**	**1770**	**9**	**1**
S7	**238**	**0.90**	**1055**	**11**	**1**
S8	**263**	**0.82**	**1616**	**8**	**1**
S9	**282**	**0.77**	**1660**	**12**	**1**

Table4. Results of tests for samples after chemical treatments

Number	Weight (g/m2)	Thickness (mm)	Tensile strength in weft direction (kg/cm2)	Self-Cleaning [31] %	Water repellent (contact angle) [32]
S10	**399**	**1.18**	**1449**	21	**123.2^{0}**
S11	**400**	**1.15**	**1629**	49	**123.8^{0}**
S12	**480**	**1.47**	**1790**	77	**132.3^{0}**
S13	**300**	**1.11**	**1404**	35	**127.9^{0}**
S14	**319**	**1.04**	**1530**	78	**128.9^{0}**
S15	**394**	**1.46**	**1591**	89	**137.9^{0}**
S16	**300**	**1.11**	**1020**	36	**136^{0}**
S17	**310**	**1.03**	**1550**	66	**136.9^{0}**
S18	**390**	**0.97**	**1580**	92	**143.8^{0}**

3.1. Weight of fabrics results:

Analysis of results of fabric weight for the produced samples indicates a clear effect of each of the research variables on the weight of the fabrics produced:

It is clear from Table 3 and 4 and Figure 8 that the highest percentage of fabric weight in sample No. (3) was recorded before treatment (320 g) and after treatment sample No. (12) was recorded (480 g), double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2), and weft yarn density 40/cm.

3.1.1. The effect of different textile structure on the weight of fabrics:

Table 3 and 4 and Figure 8 show extent the textile structure used affect the weight of the fabrics produced. the double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2) is highest in weight, followed by double cloth weave (Face: Twill 2/2, Back: Twill 2/2), then double cloth weave (Face: Satin4, back: Satin4)**.**

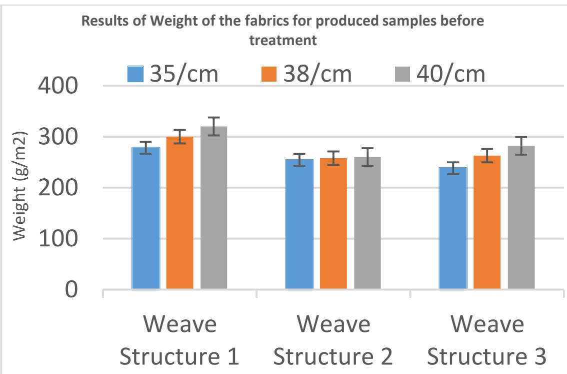

Figure 8. Results of Weight of the fabrics for produced samples before treatment

This is due to the effect of the variation in the number of intersections in each weaving structure, as the number of intersections increases, the crimp of the threads increases, and their impregnation increases, is, the length of the thread, thus the weight increases. Since double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2) has the highest intersections, equal to him double cloth weave (Face: Twill 2/2, Back: Twill 2/2) in the number of intersections, then they are followed by then double cloth weave (Face: Satin4, back: Satin4).

3.1.2. The effect of weft yarn density on the weight of fabrics:

Table 3 and 4 show extent of the effect of the density of the weft threads in cm on the fabrics produced (g/m), There is a strong relationship between the density of the wefts per unit of measurement and the weight of the fabrics, as the density of the wefts increases, the weight per square meter increases.

The highest readings are recorded for samples with density (40 weft), followed by (38 weft), then followed by (35 weft). This is because with increasing density, the percentage of impregnation stored inside the fabric increases, and thus the length of the thread increases, and the weight per square meter of the fabric increases.

3.1.3. The effect of treatments used on the weight of the fabrics

Table 3 and 4 and Figure 9 show There is a significant effect of the difference in both weaving compositions and weft densities on the weight of fabrics before and after treatment. the weaving structure, the double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2), and by double cloth weave (Face: Twill 2/2, Back: Twill 2/2), recorded the highest weight is the result of the chemical material being absorbed by the material during treatment.

It is also clear that the effect of weft density on the weight of fabrics after treatments, as the density of 40 recorded the highest weight values in all treatments, in order to increase the number of weft per cm, which allows the absorption of a large amount of the treatment material.

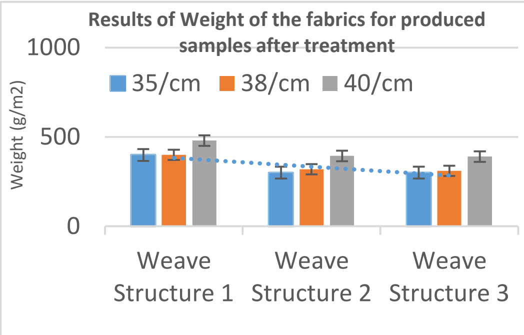

Figure 9. Results of Weight of the fabrics for produced samples after treatment

3.2. The Thickness of the fabrics:

Analysis of the results of fabric thickness for the produced samples indicates a clear effect of each of the research variables on the weight of the fabrics produced:

It is clear from Table 3 and 4 and Figure 10 that the highest percentage of fabric thickness in sample No. (3) was recorded before treatment (1.28mm) and after treatment sample No. (12) was recorded (1.47 mm), double cloth weave (Face: matt rib 2/2, Back: matt rib 2/2), and weft yarn density 40/cm.

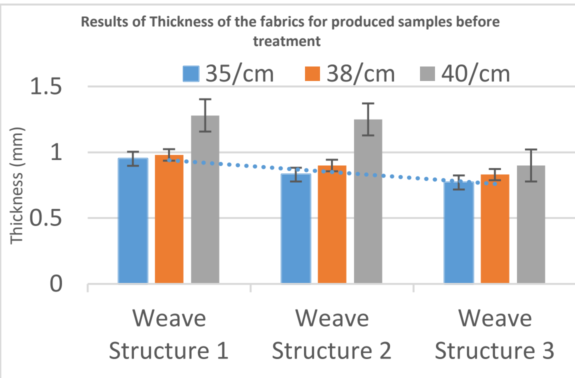

Figure 10. Results of Thickness of the fabrics for produced samples before treatment

3.2.1. The effect of different textile structure on the thickness of fabrics:

Table 3 and 4 and Figure 10 show extent the textile structure used affect the thickness of the fabrics produced. the double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2) is highest in thickness, followed by double cloth weave (Face: Twill 2/2, Back: Twill 2/2), then double cloth weave (Face: Satin4, back: Satin4).

3.2.2. The effect of weft yarn density on the thickness of fabrics:

Table 3 and 4 show that there is a relationship between the difference in the number of wefts/cm and thickness, as the density of wefts/cm increases, the thickness of the fabrics increases.

The highest readings are recorded for samples with density (40 weft), followed by (38 weft), then followed by (35 weft). This is because with increasing density, the percentage of impregnation stored inside the fabric increases, and thus the length of the thread increases and the thickness increases.

Also, increasing the intersection of the wefts per centimeter leads to an increase in intersections, which causes the wefts to become more prominent on the surface of the woven fabric, which leads to an increase in thickness.

3.2.3. The effect of treatments used on the thickness of the fabrics:

Table 3 and 4 and Figure 11 show extent of the effect of the treatments used on the thickness of the fabrics. There is an effect of the difference in both the textile structure and the number of wefts in thickness on the thickness of the fabrics before and after treatment, as the thickness of the samples increased after the treatments as a result of the absorption of the material used (polyester microfiber + cotton) from the treatment material during treatments, which forms a layer on the surface of the fabric.

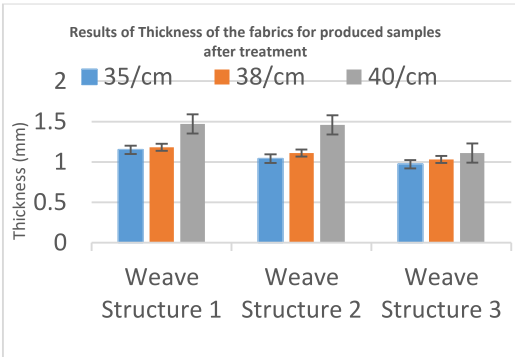

Figure 11. Results of Thickness of the fabrics for produced samples after treatment.

3.3. The Tensile strength in weft direction of fabrics:

Analysis of the results of the Tensile strength of fabrics for the produced samples indicates a clear effect of each of the research variables on the weight of the fabrics produced.

Table 3 and 4 and Figure 12 that the highest percentage of fabric weight in sample No. (3) was recorded before treatment (1990) and after treatment sample No. (12) was recorded (1790), double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2), and weft yarn density 40/cm.

3.3.1. The effect of different textile structure on the Tensile strength in weft direction of fabrics:

Table 3 and 4 and Figure 12 show extent of the influence of textile structure on the tensile strength in weft direction of fabrics. the double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2) is highest in Tensile strength in weft direction, followed by double cloth weave (Face: Twill 2/2, Back: Twill 2/2), then double cloth weave (Face: Satin4, back: Satin4).

This is due to double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2) having the highest percentage of intersection between threads and wefts, which gives these fabrics durability due to the friction resulting from those intersections.

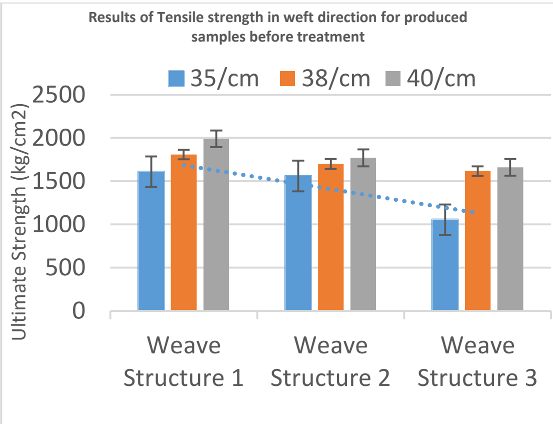

Figure 12. Results of Tensile strength in weft direction for produced samples before treatment.

3.3.2. The effect of weft yarn density on the Tensile strength in weft direction of fabrics:

Table 3 and 4 and show extent the density of wefts affects the tensile strength in weft direction of fabrics. the greater the number of wefts/cm, the greater the tensile strength of the fabrics. samples with a density of 40 wefts per cm recorded the highest values, followed by samples with a density of 38 weft/cm, then Samples with a density of 35 weft/cm.

It turns out that the tensile strength in the direction of the weft increased in all types of fabrics produced in the research by increasing the number of wefts in the unit of measurement due to the increase in the number of weft threads under the influence of the tension zone, so their resistance to cutting due to the tensile force increases compared to the fabrics produced in the research using a smaller number of wefts.

3.3.3. The effect of treatments used on the Tensile strength in weft direction of fabrics:

Table 3 and 4 and Figure 13 show extent of the effect of the treatments used on the tensile strength of the fabrics. there is an effect of the difference in both the textile structure and the number of wefts in the thickness on the tensile strength of the fabrics before and after treatment, as the tensile strength in weft direction of the samples decreased after the treatments as a result of the absorption of the material used (polyester microfiber + Cotton)from the processing material during processing, which led to a decrease in the tensile strength of the treated samples compared to the raw samples by a rate ranging from (10-20%).

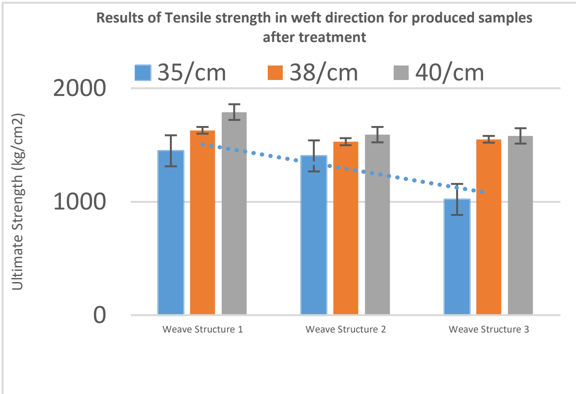

Figure 13. Results of Tensile strength in weft direction for produced samples after treatment.

3.4. Water repellent of the fabrics:

Treated to obtain a water-resistant finish. It exhibits enhanced resistance to water penetration, achieved primarily through treatments. This makes the fabric have superior water absorption protection. When water encounters these fabrics, it causes water to build up instead of allowing it to pass through. As a result, water cannot easily penetrate hydrophobic materials.

Analysis of the results of water repellent of fabrics for the produced samples indicates a clear effect of each of the research variables on the weight of the fabrics produced. It is clear from Table 3 and 4 and Figure 14 that the highest percentage of water repellent in sample No. (18) was recorded (143.8^0)

double cloth weave (Face: Satin4, back: Satin4), and weft yarn density 40/cm.

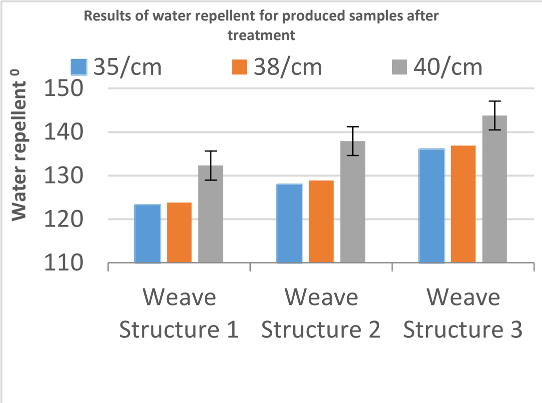

Figure 14. Results of water repellent for produced samples after treatment.

3.4.1. The effect of different textile structure on water repellent of fabrics:

Table 3 and 4 and Figure 14 show extent of the influence of textile structure on water repellent of fabrics. double cloth weave (Face: Satin4, back: Satin4) is highest in water repellent, followed by double cloth weave (Face: Twill 2/2, Back: Twill 2/2), then double cloth weave (Face: Satin4, back: Satin4).

The spaces between the whiskers on the fabric are smaller than the typical drop of water, thus remains on the top of the whiskers and above the surface of the fabric.

3.4.2. The effect of weft yarn density on water repellent of fabrics:

Table 3 and 4 and Figure 14 show that the best samples that achieved the highest percentage of water repellent were weft yarn density 40/cm.

This is because the higher the density of the weft, the higher the rate of saturation of the material with the treatment substance, which increases its effectiveness, and thus increases the fabric's resistance to water.

3.5. Self-Cleaning of the fabrics:

Nanosphere impregnation involving a three-dimensional surface structure which repel water and prevent dirt particles from attaching themselves are also used. Once water droplets fall onto them, water droplets bead up and, if the surface slopes slightly, will roll off. As a result, the surfaces stay dry even during a heavy shower. Furthermore, the droplets pick up small particles of dirt as they roll, and so the fabric surface keep clean even during light rain. By altering the micro and nano-scale surface features on a fabric surface.

Analysis of the results of The Self-Cleaning of fabrics for the produced samples indicates a clear effect of each of the research variables on the weight of the fabrics produced.

It is clear from Table 3 and 4 and Figure **15** that the highest percentage of Self-Cleaning in sample No. (18) was recorded (92%) double cloth weave (Face: Satin4, back: Satin4), and weft yarn density 40/cm.

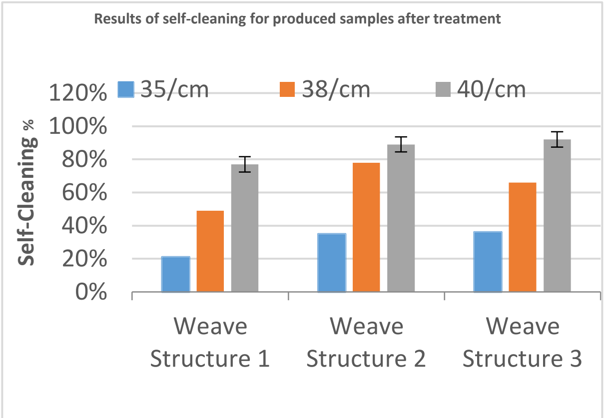

Figure 15. Results of self-cleaning for produced samples after treatment.

3.5.1. The effect of different textile structure on Self-Cleaning of fabrics:

Table 3 and 4 and Figure 15 show extent of the influence of textile structure on the Self-Cleaning of fabrics. the double cloth weave (Face: Satin4, back: Satin4) gave the highest Self-Cleaning results, followed by double cloth weave (Face: Twill 2/2, Back: Twill 2/2), then double cloth weave (Face: Satin4, back: Satin4).

This is due to double cloth weave (Face: Satin4, back: Satin4) .having the High float length that allows the treatment material to be absorbed easily.

3.5.2. The effect of weft yarn density on Self-Cleaning of fabrics:

Table 3 and 4 and Figure 15 show that the best samples that achieved the highest percentage of self-cleaning were weft yarn density 40/cm.

This is due to the fact that the higher the density of the weft, the higher the saturation rate of the material with the processing material, and thus, when exposed to sunlight, the efficiency of self-cleaning increases.

3.6. Produced fabrics Quality Evaluation:

The produced fabrics were evaluated to determine the best samples which fulfill the functional performance it is produced for and these through studying the quality factor of each sample. The averages Results measurements of the samples tests were converted to comparison relative values (without units) ranges from (0% – 100%) called quality factor , where the greatest comparative value is the best with all the properties. Then the total area was calculated from the following equation

S=1/2(SIN360/7)×((AB)+(BC)+(CD)+(DE)+(EF) +(FG)+(GA))

A = Fabric weight
B=Fabri thickness
C = Tensile strength - weft
D = water repellent
E = Self-Cleaning

Table 5. Illustrate the Relative Value Equivalent to the Samples Tests Results

Number	Weight Percentage	Thickness Percentage	Tensile strength in weft direction Percentage	Self-Cleaning Percentage	Water repellent (contact angle) Percentage	Total Area
S 1	**58**	**67**	**81**	**0**	**0**	**1175**
S 2	**63**	**65**	**91**	**0**	**0**	**1259**
S 3	**67**	**87**	**100**	**0**	**0**	**1842**
S 4	**53**	**61**	**78**	**0**	**0**	**1020**
S 5	**54**	**56**	**85**	**0**	**0**	**997**
S 6	**54**	**85**	**89**	**0**	**0**	**1544**
S 7	**50**	**61**	**53**	**0**	**0**	**797**
S 8	**55**	**56**	**81**	**0**	**0**	**963**
S 9	**59**	**52**	**83**	**0**	**0**	**945**
S 10	**83**	**80**	**90**	**38**	**86**	**3515**
S 11	**83**	**78**	**90**	**85**	**86**	**4536**
S 12	**100**	**100**	**98**	**97**	**92**	**6025**
S 13	**63**	**76**	**86**	**23**	**89**	**2641**
S 14	**66**	**71**	**89**	**53**	**90**	**3358**
S 15	**82**	**99**	**96**	**84**	**96**	**5293**
S 16	**63**	**76**	**51**	**39**	**95**	**2565**
S 17	**65**	**70**	**78**	**72**	**95**	**3623**
S 18	**81**	**66**	**79**	**100**	**100**	**4653**

3.7. Illustrate Radar Chart for all samples after treatment:

The best sample for weave structure1 performance evaluated by radar chart for the given properties is sample (12) manufactured with cotton in warp& Microfiber polyester in weft material for 40 wefts & weave structure double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2).

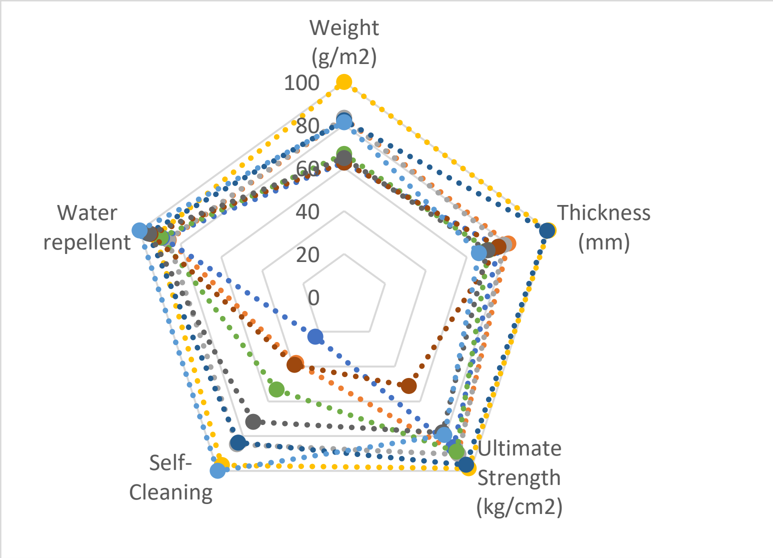

Figure 16. chart radar for all samples

3.8. Illustrate Radar Chart for the Samples Produced by Using weave structure1:

The best sample for weave structure1 performance evaluated by radar chart for the given properties is sample (12)

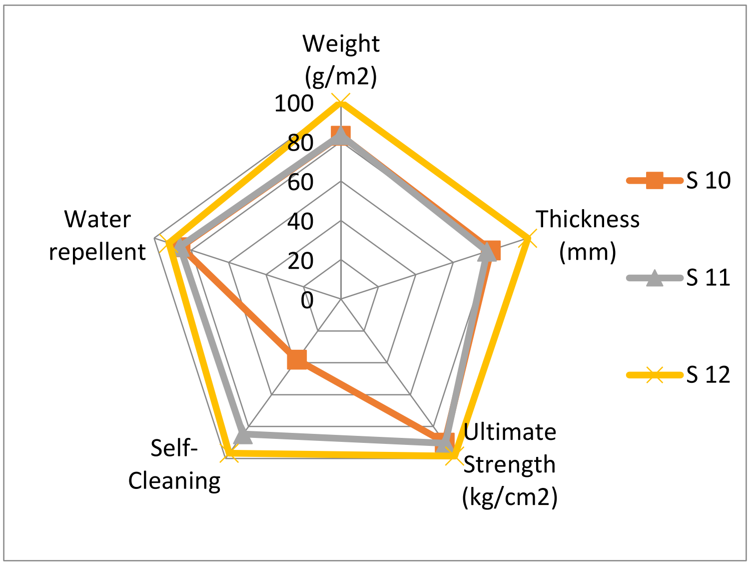

Figure 17. sample (10,11,12)

3.9. Illustrate Radar Chart for the Samples Produced by Using weave structure 2:

The best sample for weave structure2 performance evaluated by radar chart for the given properties is sample (15)

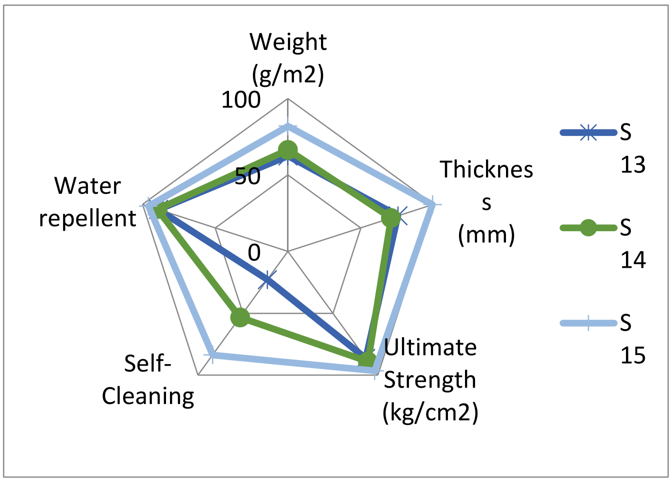

Figure 18. sample (13,14,15)

3.10. Illustrate Radar Chart for the Samples Produced by Using weave structure 3:

The best sample for weave structure3 performance evaluated by radar chart for the given properties is sample (18)

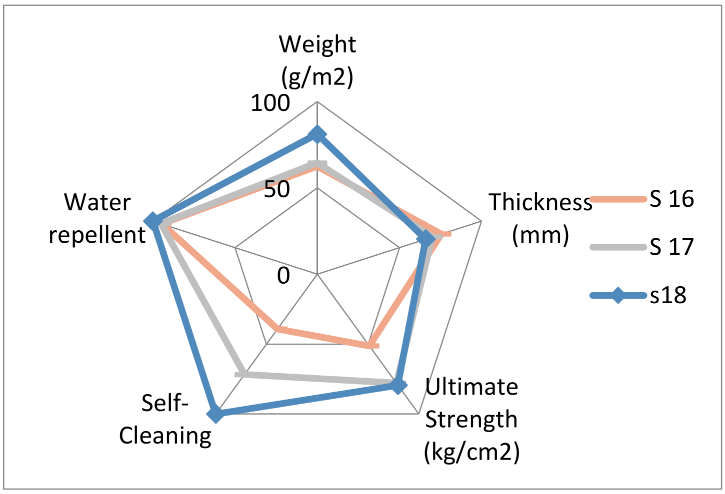

Figure 19. sample (16,17, 18)

3.11. Illustrate Radar Chart for the Samples Produced by Using weft density 35:

The best sample for weft density 35 evaluated by radar chart for the given properties is sample (15)

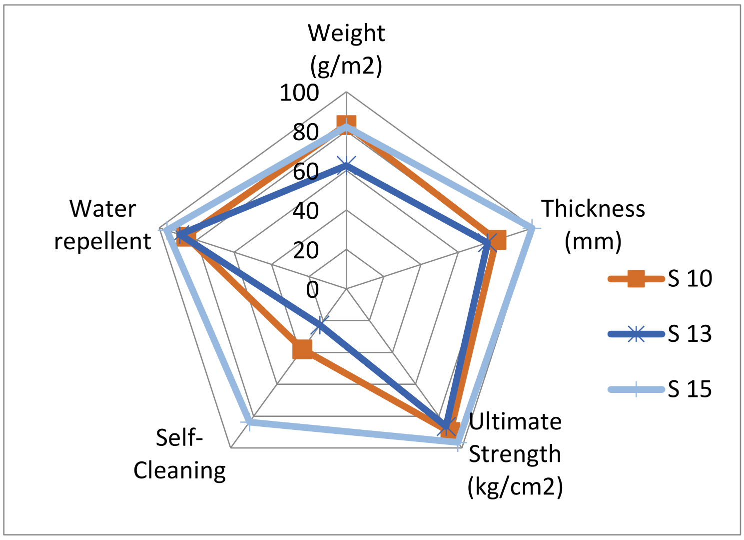

Figure 20. sample (10,13,15)

3.12. Illustrate Radar Chart for the Samples Produced by Using weft density 38:

The best sample for weft density 38 evaluated by radar chart for the given properties is sample (11)

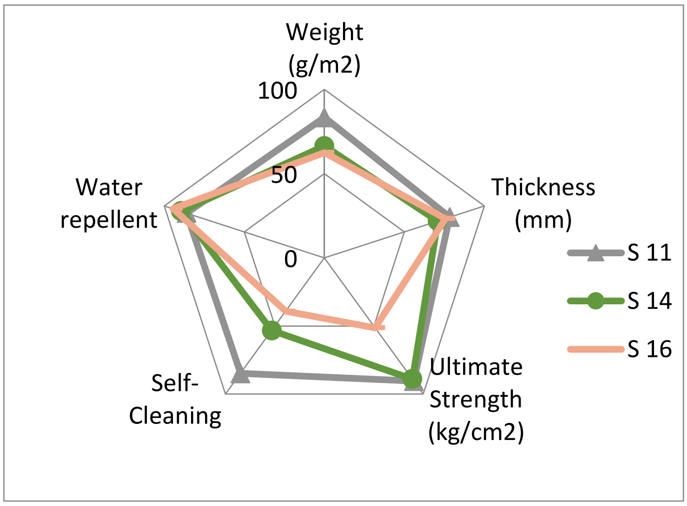

Figure 21. sample (11,14, 16)

3.13. Illustrate Radar Chart for the Samples Produced by Using weft density 40:

The best sample for weft density 40 evaluated by radar chart for the given properties is sample (12)

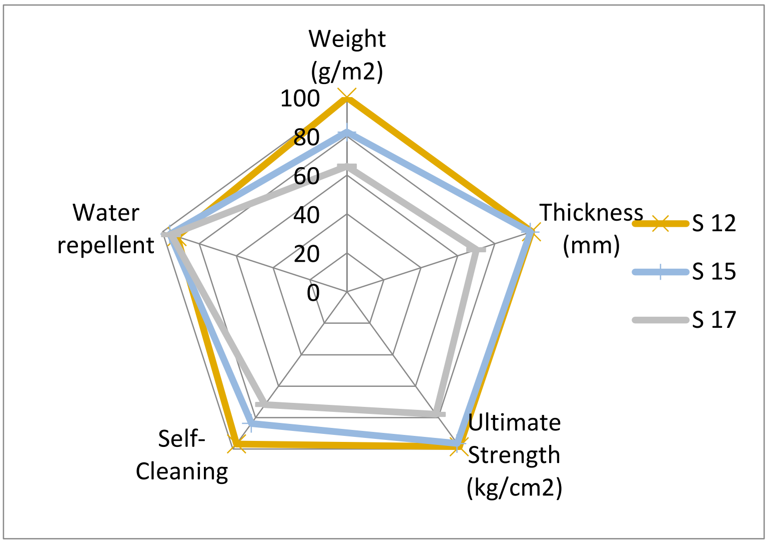

Figure 22. sample (12,15,17)

4. Conclusion:

The highest percentage of fabric weight in double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2), and weft yarn density 40/cm. Figure 17,18 and 19

The extent of the effect of the density of the weft threads in cm on the fabrics produced (g/m) becomes clear, as by increasing the density of the weft threads in cm the weight per square meter of the fabrics increases when all textile specifications are constant. Samples with 40 wefts/cm recorded the highest weight. Figure 20 and 21

Regarding the effect of the fabric structure on the tensile strength of the weft, it was found that the tensile strength of the weft is affected by the change in the structure of the fabric. Structure double cloth weave (Face: matt rib 2/2 Back: matt rib 2/2), and weft yarn density 40/cm. showed high rates of tensile strength in the weft.

The length of the fabric float is considered one of the most important elements that directly affects the thickness of the fabric.

the double cloth weave (Face: Satin4, back: Satin4) is highest in self-cleaning, followed by double cloth weave (Face: Twill 2/2, Back: Twill 2/2), then double cloth weave (Face: Satin4, back: Satin4).

The best samples that achieved the highest percentage of water repellent were weft yarn density 40/cm. This is because the higher the density of the weft, the higher the rate of saturation of the material with the treatment substance, which increases its effectiveness, and thus increases the fabric's resistance to water.

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