

Improving the Functional Properties of the Arabian Women Headscarves by Plasma Treatment

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ABSTRACT

The basic requirements for good headscarves are no longer only aesthetically pleasing, but also related to the functional requirements that the head scarf should provide for the woman wearing it. Therefore, the study of the functional requirements of the head coverings of women in the Arab climate, which combines the heat in summer and cold winter is important to different dimensions in terms of selection of raw materials suitable for the manufacture of head covers and treatments to improve the head scarf to give a sense of comfort with the aesthetic appearance. The synthetic headscarf prevents the extraction of sweat and prevents air permeability, which causes many problems for women who wear it. In this study, polyester head scarf fabric will be treated with atmospheric pressure plasma to improve functional properties such as wettability, tensile strength, elongation, UV protection and protection from harmful bacteria to woman skin. The effectiveness of the treatment is assessed by using standard tests methods; first, the UPF test, second, the Antimicrobial test, finally, Infrared spectroscopy Analysis.

KEYWORDS: Headscarves, Plasma surface treatment; UV protection, Infrared spectroscopy Analysis, Scanning Electron Microscopy

1. INTRODUCTION

The head cover is one of the most effective clothing supplements that can be used in many styles. It is one of the easiest ways to add a distinctive touch to clothes and give them a hint of renewal and diversity. The headscarf has the ability to change the shape of old clothes and to avoid looking at the body defects when placed near aesthetic areas in the woman's body. It is also used as a function of heating in the winter season.

Scarves come in different sizes, fabrics and shapes. A scarf's fabric defines its appearance, texture, and weather-suitability. Women are among the most affected by the danger of solar radiation, especially UV radiation so women should always pay attention to fabric when they're shopping for scarves. A lot of Headscarves made from different materials in the markets, some may be inappropriate in the way wear on the head or uncomfortable or inappropriate for use; so the study of the functional requirements of the fabrics used in the Headscarves manufacturing and attention to the requirements of the society is very important.(3)

There are at least 70% of women in Egypt, Arab countries and North Africa wear headscarves for social, religious and protective reasons and sometimes for other reasons such as decorating or protection from heat and solar radiation, which increases the need to provide fabrics with high protective properties against the thermal and radiation effects of (Ultraviolet - visual - infrared) radiation, where most women suffer in these areas of damage and skin diseases such as increase the secretion of sweat and inflammation of the scalp and hair loss and lack of vitamin D and so on, causing a real problem for Arab women and psychological and moral diseases. (3)

Synthetic fibers have become an integral part of the current textile industry. Polyester fiber has been most widely used for textile materials because of high mechanical strength, good stretchability, heat-setability, rapid drying, and wrinkle resistance. The main drawback of some synthetic fibers is the low surface energy that causes a weak sensitivity to moisture and dyeability. (6)

It is known that polyester fiber has an inherent hydrophobic nature and thus polyester products are lacking in stain-release, anti-soil redeposition, water and moisture wicking and anti-electricity in textile end-use. The hydrophobicity can also be a disadvantage for certain applications like dyeing and finishing. Chemicals treatments are often used to improve the hydrophilic nature of the polyester headscarves surface; however, the usage of chemicals is accompanied by a decrease in fiber strength and leads to environmental pollution. Therefore, we used plasma treatment to enhance comfort properties and mechanical properties. (6)

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Plasma technology is based on a simple physical principle. Matter changes its state when energy is supplied to it: solids become liquid, and liquids become gaseous. If even more energy is supplied to a gas, it is ionized and goes into the energy-rich plasma state, the fourth state of matter. (2)

Plasma treatment of textile is one of the most popular methods used for textile surface treatment; it is dry, pure and used lower energy consuming than valet ordinary treating. Plasma processing of polymers was used to get desired surface properties without interfering with material properties. Non-thermal plasma techniques were developed in the atmosphere to meet the need for the textile industry. (1)

Plasma treatment causes a desirable and exactly adjustable increase in the adhesiveness and wettability of surfaces. This makes it possible to use completely new materials and environmentally-friendly, solvent-free paints and adhesives industrially. Many chemical surface treatment processes can be replaced with plasma treatment. (2)

The significance of this paper is to discussion the influence of atmospheric pressure plasma modification on women headscarves. Comfort properties, UV protection and protection from harmful bacteria to woman skin have been investigated; Methodology was undertaken using a headscarves material, with fiber content of polyester.

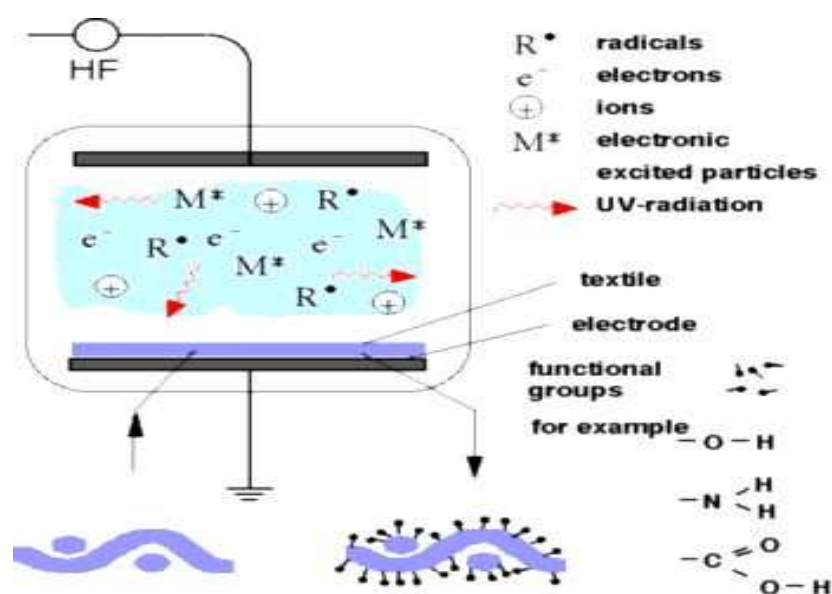


Figure (1) Working principle of plasma treatment (5)

2. MATERIALS AND METHODS

2.1 Fabrics:

Specifications of fabrics are given in table 1. Headscarves fabrics were procured from Tie shop.

Thickness obtained using thickness tester according to (ASTM D1777-96-2003).

Fabric weight obtained using digital sensitive scale according to (ASTM D3776-96-2003).

Table1
Specifications of fabric before treatment

Fabric structure	Fiber type	Warp/cm	Weft/cm	Weight (gm/m ²)	Thickness (mm)
Chiffon1/1	polyester	32	32	90	0.2

2.2. Experimental Methods

Application of atmospheric pressure plasma treatment of polyester fabric for improvement of headscarves specific properties:

The discharge can be produced between two electrodes one of them covered by two different dielectric material cement and glass, cell shown in Fig.2 consists of two metallic parallel square electrodes of 25x25 cm², 2mm gap space, separated by glass sheet through an O ring. The ground electrode stands on Acrylic sheet with inlet and out let opening for gas insertion and exhaustion. High voltage AC transformer (0-10kV) generates a 50 Hz sinusoidal voltage was used as a power source for driving discharge. (7)The live electrode is stain steel has radius 15 cm and the other electrode is covered by porous material as a dielectric with thickness 1 mm. (6) The discharge situation should be adapted to being in the glow mode through setting the used voltage and current.

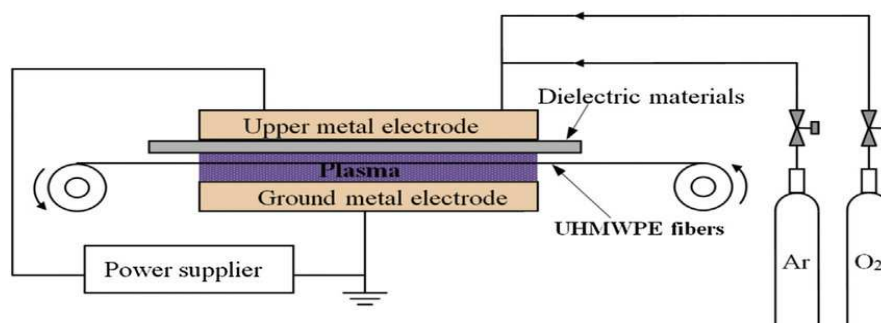


Fig. (2): The diagram of DBD discharge treatment

Polyester fabric was exposed to atmospheric pressure glow discharge plasma (APGD) at different currents and times with different gases Oxygen, nitrogen and air. Exposing time variables were 5 min, while discharge current variables were 3, 5, 7 and 10 mA.

The headscarf fabric was cut and then scoured with acetone for 10minutes to remove contaminants on the fabrics surface. After that, the headscarf fabric was rinsed with deionized water for 5minutes. Water was extracted from fabrics in a hydro extractor for 3 minutes. Lastly, the fabrics were dried in an oven at 60°C for 10minutes.

After scouring the fabrics, the fabrics were conditioned under the standard atmospheric pressure at 65% +/- 5% relative humidity and 21°C +/- 1°C for at least 24 hours before other procedure processed.

The investigation involves the application of different gases oxygen; nitrogen and air to polyester headscarf in order to improve the fabric physical properties such as wettability, tensile strength, elongation, IR- spectroscopy Analysis as well as surface morphology were also investigated.

The tensile strength test and the water drop test were applied.

The duration required for the drop of water to be absorbed into the fabric is pointed to as absorbency amount. In order to determine the changes in the chemical structure of polyester headscarf fiber as a result of plasma treatment, the untreated and plasma treated samples were studied by IR- spectroscopy Analysis.

The scanning electron microscope photomicrograph was registered to study the changes in the surface morphology of plasma treated fabrics.

3. RESULTS AND DISCUSSION

Effect of atmospheric pressure plasma on the physical and mechanical properties of polyester headscarf fabric, Time exposure 5 min:

3.1. Infrared spectroscopy Analysis:

The results are illustrated in figures (3, 4, 5 and 6). In the spectrum of the nitrogen plasma- treated fabric fig. (4), some new peaks were observed compared with untreated sample spectrum :2443.06cm characteristic of NH₂ groups, 1378.36 cm⁻¹ characteristic of C-N aromatic amine , 1234.64cm characteristic of secondary amine C-N stretch , 1227.57 characteristic of C-N aliphatic amine and 1455.18 cm⁻¹ characteristic of aromatic tertiary amine C-N stretch, As well some other peaks with intensity at 3368.64 cm⁻¹ , 3357.85 cm⁻¹, 3053.9 cm⁻¹ characteristic of hydroxyl group H-bonded OH stretch were also observed.

Fig. (5) Shows that a new absorption band with peak intensity at 1462.86 cm⁻¹, characteristic of carboxylate groups was observed.

In addition, the intensity of the hydroxyl group (-OH) peaks like 3648.27 cm⁻¹ and 3231.15 cm⁻¹ were outstandingly higher than that in figure (3) this increase in the absorption intensity indicates the introduction of more hydroxyl

groups as a result of oxygen plasma treatment, also it can be observed the absorption peak at 2032.58 cm^{-1} characteristic of carbonyl compound groups ($\text{C}=\text{O}$).

The rate of the oxygen containing groups such as $-\text{COOH}$, $-\text{C}-\text{OH}$ and $\text{C}=\text{O}$ increased on the surface of the treated fabric. This effect may be referring to the fact that some of the $\text{C}-\text{C}$ bonds in the polyester fabric surface could be broken by the oxygen plasma treatment. Then the carbon radicals, formed by the removal of hydrogen atoms from the polyester chain

The introduction of these polar groups converts the nature of the fabric from hydrophobic to hydrophilic, as shown in figure (6), some new absorption band with peak intensity at 3298.64 cm^{-1} characteristic of hydroxyl group H-bonded OH stretch was observed. Furthermore the intensity of the carboxylic acid salt group ($-\text{COOH}$) peaks like 1302.68 cm^{-1} 1403.92 cm^{-1} and 1834.46 cm^{-1} were higher than that in untreated sample spectra. Also, the intensity of the amine group ($-\text{NH}_2$) peaks like 2358.81 cm^{-1} , 2223.82 cm^{-1} 2406.63 cm^{-1} were also higher than that in untreated sample spectrum, which means additional functional groups induce to the fabric surface as a result of air plasma treatment.

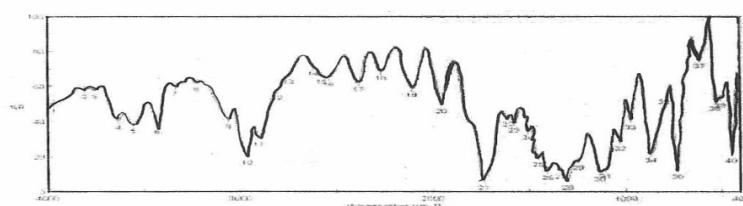


Fig. (3) IR analysis chart of untreated polyester headscarf fabric

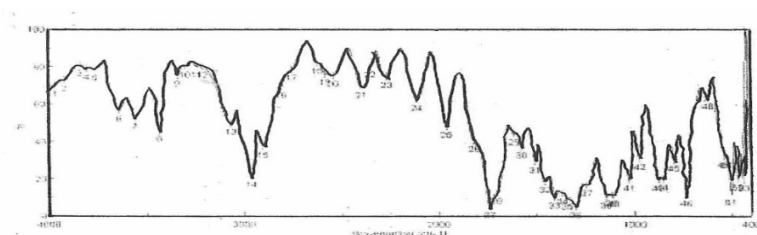


Fig. (4) IR analysis chart of treated polyester headscarf fabric with nitrogen plasma

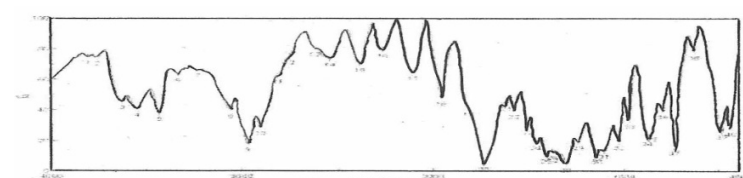


Fig. (5) IR analysis chart of treated polyester headscarf fabric with oxygen plasma

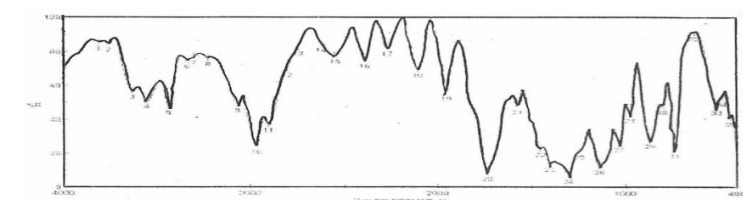


Fig. (6) IR analysis chart of treated polyester headscarf fabric with Air plasma

3.2. Wettability

Wettability expressed as wetting time of untreated and treated fabrics was measured; table (2) shows the wetting times of the polyester headscarf fabric modified by different gases under different discharge current.

Table (2):
Wetting time of polyester fabric modified with different Glow discharge gases:

Discharge current (MA)	Untreated sample	Wetting time (sec.)		
0	3.07	Air	O ₂	N ₂
3		0.72	0.82	1.02
5		0.68	0.71	0.85
7		0.61	0.65	0.79
10		0.58	0.61	0.72

It can be easily observed that the plasma treated fabrics exhibited a significant enhancement in the hydrophilicity and water absorption irrespective of gas types used under the study.

The improved wettability of polyester fabric as a result of plasma treatment is in good agreement with the results of IR analysis. It could be concluded from table (2) that increase the discharge current is accompanied with decrease in the wetting time for plasma treated samples.

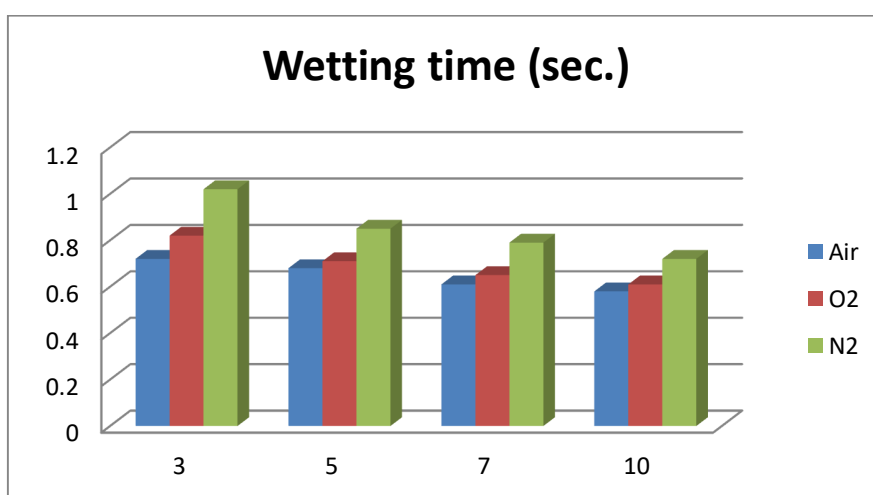


Fig. (7) Wetting time chart of treated polyester headscarf fabric

The improved wettability of polyester treated fabrics can be attributed to the increase in ion bombardment on the fabric surface which leads to formation of surface- free radicals, increasing the amount of active species formed on oxidation, besides increasing surface and increasing surface roughness according to the kind of gas used in glow treatment.

The wettability of plasma treated polyester fabric increases in the order of Air > O₂ > N₂. this increase in the surface wettability is due to formation of several hydrophilic groups (e.g., -NH₂, -CN, -N=N-, -C=O, -COOH, -C-OH, -CHO) Beside chain scission, etching, and increasing surface roughness.

Plasma treatment resulted in improvement in hydrophilicity of polyester film which was treated along with polyester fabric in air DBD.

As seen in Figure 8, an apparent decrease in water contact angle took place after 15 min plasma treatment, which suggest that a strong increase in wettability of the polyester headscarf fabric surface induced by DBD. Water contact angle was reduced from 85.7° for untreated to 29.5°, which indicate the formation of polar groups such as CO, COO, OH, etc as consequences of plasma treatment which make polyester surface more hydrophilic. (8)

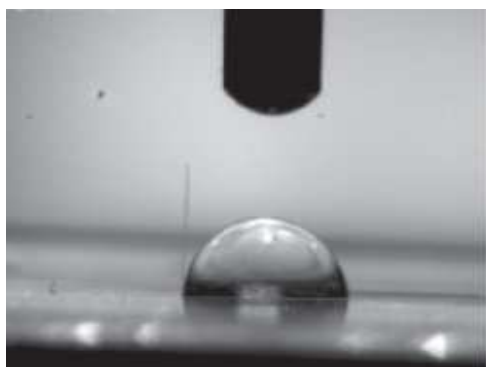


Fig. (8) Contact angle of untreated polyester Headscarf fabric

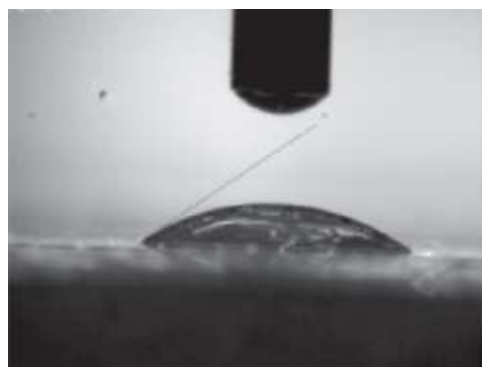
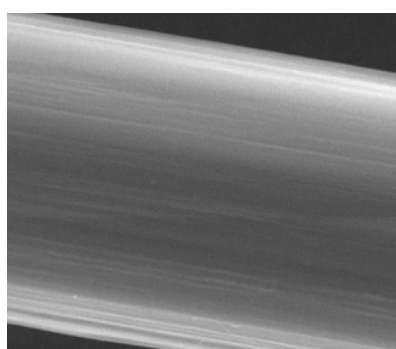


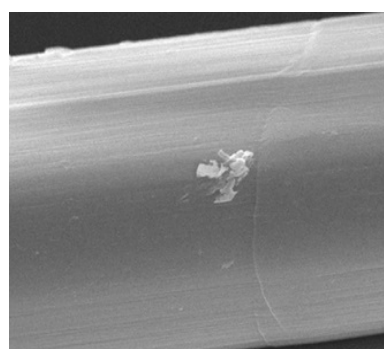
fig. (9) Contact angle of treated polyester headscarf fabric

3.3. Scanning electron microscopy (SEM):

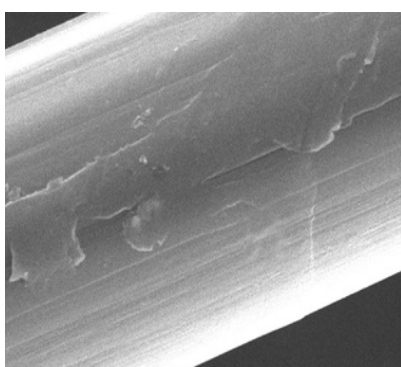
SEM Measurements Figures 10, 11, 12 and 13 show the SEM micrographs of the plasma treated polyester fabric and the untreated fabric. Surface morphology changes significantly after plasma treatment. It can be showed from Figures 10 that the untreated polyester fibers look distinct and very smooth, however Figures 11, 12 and 13 show several grooves on the surface of the fibers, with the existence of some pores and voids. These results may be due to the removal of some material by etching and roughening effect caused by the bombardment of ions/ electrons in the plasma on the fabric surface, causing surface roughness.



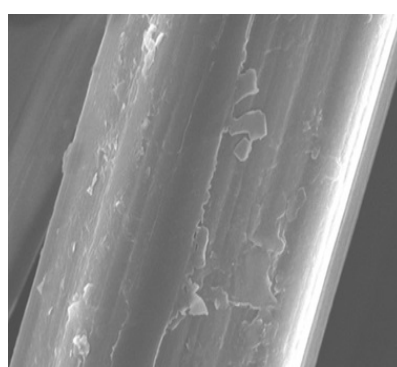
(a)



(b)



(c)



(D)

Fig. (10): SEM micrographs of the polyester headscarf fabric (a) untreated, (b) Oxygen plasma, (c) air plasma, (d) nitrogen plasma.

3.4. Tensile strength

Treated and untreated samples were subjected to measurement of tensile strength. The results are illustrated in table (3).

Table (3):
Effect of plasma glow discharge current on the tensile strength of Polyester headscarf fabric:

tensile strength			
untreated sample	68		
Discharge current (mA)	Air	O ₂	N ₂
(3)mA	68	61	67
(5)mA	66	63	64
(7)mA	65	58.5	62.5
(10)mA	64.5	57.5	63

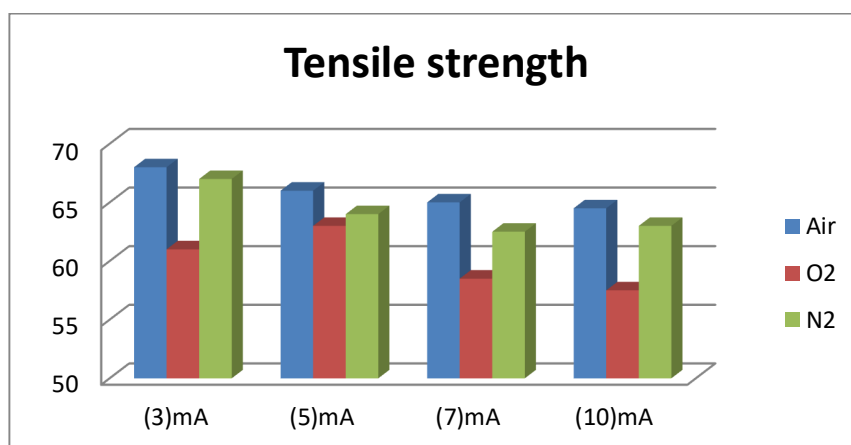


Fig. 12: Effect of plasma glow discharge current on the tensile strength of polyester headscarf fabric

Table3 and figure (12) Shows that the treatment of plasma caused a little reduce in the rate of the tensile strength in comparison with the untreated fabrics.

Long plasma treating produced deep cracks on the samples, on the other hand, higher discharge current or longer treatment time during plasma treatment may caused lose in tensile strength properties.

3.5. Ultraviolet protection factor:

it was determined using UV-VIS double beam spectrophotometer according to the standard (ASTM D6604-2000) and AATCC test method [AATCC 183-2000]. And the results showed in table 4:

Table (4):
Effect of plasma glow discharge current on the Ultraviolet protection factor Of polyester fabric:

Ultraviolet protection factor			
untreated sample	75.2		
Discharge current (mA)	Air	O ₂	N ₂
(3)	121.6	158.9	195.4
(5)	151.2	173.3	213.4
(7)	163.4	181.2	226.2
(10)	172.3	198.3	241.7

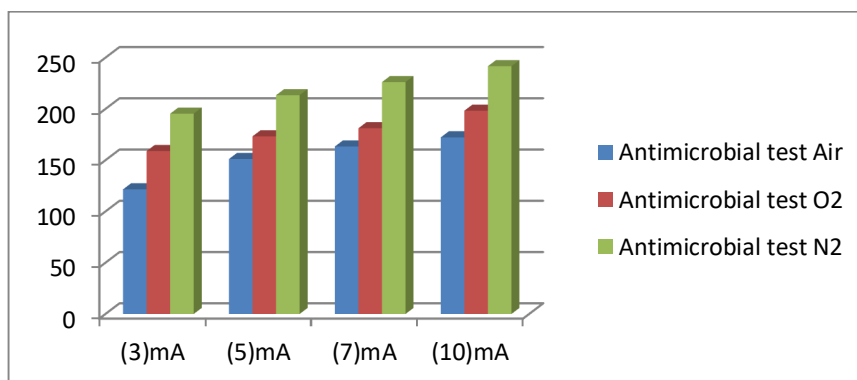


Fig. 13: Effect of plasma glow discharge current on the Ultraviolet protection factor of polyester headscarf fabric

It's clear that after the treatment of the polyester fabrics with plasma glow discharge current the Ultraviolet protection factor values increased significantly. This improvement is preferable in the woman scarves. It gives sufficient protection for women skin against UV protection.

3.6. Antimicrobial test:

The examination was done by using a modified Kirby-Bauer disc diffusion method, and the results are illustrated in table 5:

Table 5:
Results for antimicrobial activity Disc diffusion method

Antimicrobial test <i>Escherichia coli</i> (G ⁻)				
Untreated	0			
Inhibition zone diameter (mm / 1 cm Sample) <i>Escherichia coli</i> (G ⁻)	Discharge current (mA)	Air	O ₂	N ₂
	(3)	6	12	18
	(5)	7	12	16
	(7)	7	15	19
	(10)	9	17	19

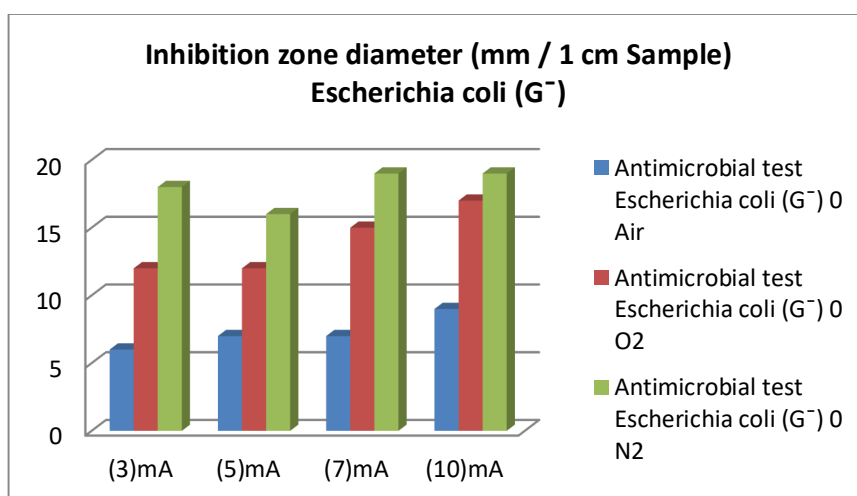


Fig. 14: Antimicrobial test *Escherichia coli* (G⁻)

Antimicrobial test Staphylococcus aureus (G ⁺)				
Untreated	0			
Inhibition zone diameter (mm / 1 cm Sample) Staphylococcus aureus (G ⁺)	Discharge current (mA)	Air	O ₂	N ₂
	(3)	8	12	12
	(5)	11	14	16
	(7)	12	15	16
	(10)	12	15	18

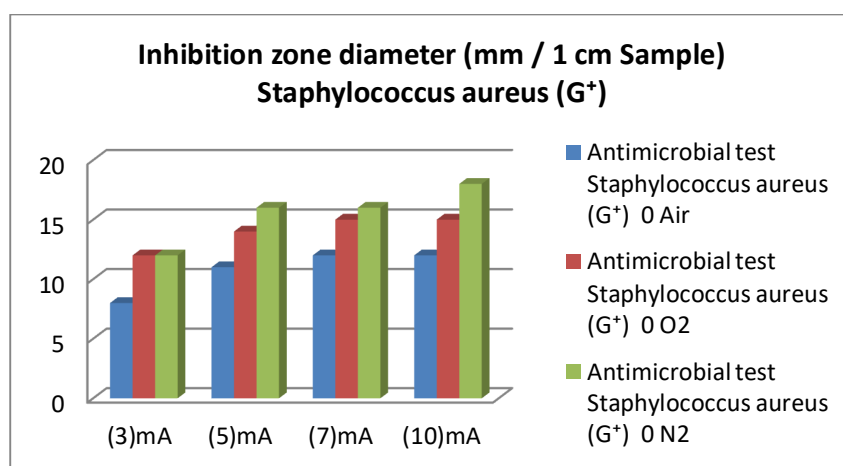


Fig. 15: Antimicrobial test Staphylococcus aureus (G⁺)

As shown from the results for the untreated sample, it doesn't have any influence on the antimicrobial effectiveness, however for the treated Samples, It's obvious that the diameters of the inhibition zones determined in millimeters were ranging from 6 – 19 millimeters refers to the improvement in antimicrobial efficiency for the polyester women head scarf.

CONCLUSION

Treating polyester women head scarf with atmospheric pressure glow discharge plasma (APGD) has a significant effect on performance and functional properties. N₂ treatment at low current, 3mA with 5min duration, showed a better resultant data, for polyester women head scarf. Plasma treatment caused formation of some new functional groups like, OH, COOH, CO, NH₂ these additional groups were detected by Infrared analysis. The UV blocking and anti microbial properties has successfully achieved after treatment. The plasma treated fabrics exhibited a significant enhancement in the hydrophilicity and water absorption irrespective of gas types used under the study.

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