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An Investigation on Blood Barrier and Antibacterial Properties of Fluorocarbon and Gentamicin Coated Textiles

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ABSTRACT

Staphylococcus aureus and Pseudomonas aeruginosa are pathogenic, opportunistic bacteria that are often transmitted to skin lesions and wounds through contaminated sheets, utensils, and staff in hospitals. Therefore, using fabrics with antimicrobial properties in such environments decreases the chances of contamination.

In this study, a polyester/viscose fabric was immersed in fluorocarbon (FC) and gentamicin (GC) to investigate their antibacterial effect against Staphylococcus aureus and Pseudomonas aeruginosa. Additionally, the waterproof and blood-resistance characteristics of the samples were evaluated. Concentrations of 1.25, 2.,5, and 5 g/l of gentamicin and 60, 80, and 100 g/l of fluorocarbons were used for the polyester/viscose fabric immersion using the spray method. After treating the fabrics with gentamicin and fluorocarbon, they were heated at 180°C for 3 minutes for further stabilization.

The agar disk diffusion method was used to investigate the inhibitory effect of fluorocarbons and gentamicin on the growth of the aforementioned bacteria and the results were recorded after 24 hours. The durability of the antibacterial effect was investigated by transferring the discs to a regrowth culture once more and keeping them there for 24, 48, and 72 hours. 1.25 g/l of gentamicin and 60 g/l of fluorocarbons had the least inhibitory effect against the bacteria. The best durability of the antibacterial effect resulted after 2 consecutive treatments. Moreover, 60 g/l of fluorocarbon exhibited the best waterproof and blood-resistance effects.

Keywords

Fluorocarbons, Gentamicin, Antimicrobial, Waterproof, Blood-resistance.

1. Introduction

Fabrics are constantly exposed to microorganisms due to the touch of human skin after being worn. In addition, the environmental conditions of textiles greatly contribute to contamination and the growth of microorganisms, including bacteria. This can cause problems in terms of health, function, or appearance of the fabric [1,2,3].

Microorganisms produce various compounds by transforming different substances present in their surroundings, which results in unpleasant scents. Bacteria, for instance, convert sweat into odorous substances such as carbonic acid, aldehydes, and amines. The multiplication and growth of microorganisms destruct and spoil the material and cause hygiene-related problems [4]. For example:

- Dirty and sweaty work clothes, sports clothes, and homewear, are convenient environments for microorganisms.

- Household textiles such as mattresses, rugs, cushions, and pillows are also very sensitive.

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- Heavy-duty textiles in open air under certain conditions are exposed to moisture and therefore, microorganisms become active inside them. Waterproof fabrics, tents, curtains, protective clothes, sailing apparel, yarns, and geotextiles are mostly damaged by fungi and mold. As a result, the fibers lose their properties such as tensile strength and water resistance [5,6].

- Textile flooring is easily affected by microorganisms.

- Bacteria and fungi can decompose synthetic materials (such as plastics) and damage polymer additives such as softeners in films, coatings, and foams in roofs and ceilings, coated insulators, hotel furniture, and hospital furniture.

- Chemical properties of a substance, namely viscosity, could change by microorganisms. This happens especially in aqueous emulsions, preservatives, and natural products. Natural finishing materials (such as size) and dust on the surface of fabrics could be consumed as food by microorganisms. In the finishing process of textiles or leather, which include storage of solutions, printing paste, and wet storage, this problem could be prevented by proper stabilization and maintenance [7,8].

Unfortunately, these defects are not detected early enough and most of these fabrics will be used with the mentioned problems in hospitals, nursing homes, schools, hotels, and public places. In general, natural and man-made fibers are ideal places for contamination and growth of bacteria and fungi [9,10]. Natural fibers, such as cotton, are more favorable for the growth of bacteria than man-made fibers as they contain hydrophilic groups, oxygen, and food, which bacteria need [11,12]. Even man-made fibers cannot be completely protected from microorganisms; for example polyurethane fibers and recycled cellulose can be destroyed by microorganisms [13,14].

In this study, the substance that inhibits the growth of microorganisms by antimicrobial activity is called "antimicrobial agent". In general, the purposes of antimicrobial finishings are:

1- Preventing the transmission and growth of pathogenic microorganisms.

2- Eliminating the scent of microbial decomposition and spoilage.

3- Maintaining physical properties, such as tensile strength, by preventing the decomposition of the fabric caused by microorganisms [15,16].

This type of finishing must either kill the germs or stop their growth. Antimicrobial finishes should be safe for both the manufacturer and the consumer [17,18]. In addition, low concentrations of finishing ingredients should have high performance, efficiency, a reasonable price, and good compatibility with different environments and other complementary finishing possesses.

In this study, immersion of fabrics in aqueous solutions containing fluorocarbons and antibiotics was utilized as an approach to prevent contagion of clinical infections. For this matter, gentamicin (GC) and fluorocarbon (FC) were applied on Staphylococcus aureus and Pseudomonas aeruginosa. Different concentrations of gentamicin and fluorocarbon were used in the immersion of polyester/viscose fabric by spray method. The Agar method was utilized to investigate the growth inhibitory effect of Staphylococcus aureus and Pseudomonas aeruginosa. Moreover, the durability of the antibacterial effect was investigated by transferring the discs to regrowth culture. The water resistance and blood resistance of the samples were also measured.

2. Experimental

2.1. materials

65% and 35% colorless woven polyester/viscose fabric (Ardakane Yazd Company), fluorocarbon (CHT Company in Germany) and gentamicin

(Daroo Pakhsh Company of Tehran) were purchased.

2.2. Methods

1.25, 2.5 and 5 g/l of gentamicin and 60, 80 and 100 g/l of fluorocarbon were used to immerse the samples. The procedure for the first set of samples is as follows:

The samples were coated with the mentioned concentrations of gentamicin and then were sprayed on with fluorocarbon in a "wet on wet" process. Then samples were fixated at 180°C for 3 minutes. For the second set, the samples were coated with a certain concentration of fluorocarbon and then were sprayed with gentamicin. For the second set, certain concentrations of gentamicin and fluorocarbon were mixed and then sprayed on the samples. To evaluate the effect of the coating, the samples were individually exposed to gentamicin and fluorocarbon (series 4 and 5). The sequence of the steps is demonstrated in Table 1.

Table 1. Evaluation flowchart of the samples treated with fluorocarbon and gentamicin.

Series No		Sequence of Treatment	Fixation (180°, 3 min)
1		GC→FC	√
2		FC→GC	√
3		GC+FC	√
4	a	just FC	√
	b	just GC	√
5	a	just FC	×
	b	just GC	×
6		No Treatment	√
FC: Applying FC in Different Conc			
GC: Applying FC in Different Conc			
FC+GC: Mixing FC and GC before Applying			
No Treatment: Blank Sample			

In order to control the process and determine the optimum concentrations, first the samples were divided into 14 groups (Table 2). In groups 1, 2, and 3, the concentrations of gentamicin remained the same and the concentration of fluorocarbon changed. In groups 4, 5, and 6 the concentration of fluorocarbon remained the same and the concentration of gentamicin changed. In groups 7, 8, and 9, gentamicin was mixed with fluorocarbon and then sprayed on the product. In groups 10 and 12, different concentrations of fluorocarbon were sprayed on the product. Group 10 was treated, unlike group 12 which was dried at room temperature without treatment. Groups 11 and 13 were also coated with different concentrations of gentamicin. Group 11 was treated and group 13 dried at room temperature without treatment. Group 14 was the blank sample which remained as control. After the samples were tested and treated, agar diffusion, colony count, and blood-resistance tests were performed. Then, to obtain the optimal concentration, the concentrations of gentamicin and fluorocarbon were halved, and the new samples were tested. The results are demonstrated in Table 2.

2.2.1. Preparation of the Samples

A commercial anionic detergent was used to wash the fabrics. All fabrics were washed in L:R 1:20 for 2 hours at 70°C. Then, they were hot-press dried at 180°C. To make sure that no detergent remained in the fabrics, they were washed again with only water in L:R 1:20 at 90°C. After that, the fabrics were hot-press dried at 180°C. Solutions of 60, 80, and 100 g/l were prepared from carbon fluoride dispersion. In addition, 1.25, 2.5, and 5 g/l solutions of gentamicin were prepared to later be sprayed on the samples according to the test instructions.

Table 2. Specifications of polyester/viscous samples.

Series No	Group	Sequence of Treatment	Sample Code	GC Conc (g/l)	FC Conc (g/l)
1	1	GC→FC	1A1	01.25	60
			2A1	01.25	80
			3A1	01.25	100
	2	GC→FC	4A1	2.5	60
			5A1	2.5	80
			6A1	2.5	100
	3	GC→FC	7A1	5	60
			8A1	5	80
			9A1	5	100
2	4	FC→GC	1A2	01.25	60
			2A2	2.5	60
			3A2	5	60
	5	FC→GC	4A2	01.25	80
			5A2	2.5	80
			6A2	5	80
	6	FC→GC	7A2	01.25	100
			8A2	2.5	100
			9A2	5	100
3	7	GC+FC	1A3	01.25	60
			2A3	01.25	80
			3A3	01.25	100
	8	GC+FC	4A3	2.5	60
			5A3	2.5	80
			6A3	2.5	100
	9	GC+FC	7A3	5	60
			8A3	5	80
			9A3	5	100
4	10	FC	1A4	0	60
			2A4	0	80
			3A4	0	100
	11	GC	4A4	01.25	0
			5A4	2.5	0
			6A4	5	0
5	12	FC	1A5	0	60
			2A5	0	80
			3A5	0	100
	13	GC	4A5	01.25	0
			5A5	2.5	0
			6A5	5	0
6	14	No Treatment	A6	0	0

2.2.2. Disk Diffusion Test

According to the halo diameter of the treated polyester/viscose samples with Staphylococcus aureus and also the inhibitory effect of the samples in aqueous-alcoholic solvents, a number of mentioned samples were selected. Inhibition tests, colony count and blood-resistance were performed on the selected samples. First, Staphylococcus aureus was grown on a plate and then the selected sample disks were placed on the growth plate. The plate containing disks was put in the incubator for 24 hours at 37˚C. Afterward, the diameter of the emerging halo was measured in millimeters with a ruler, which is the halo diameter in the first passage. Then, a new growth plate was prepared and the first passage procedure was performed in the same way. After that discs of the first passage were removed from the growth plate with pliers and placed on the new growth plate. The new plate was put in the incubator for 24 hours at 37˚C. Similarly, the diameter of the emerging halo was measured with a ruler, which is the halo diameter in the second passage. Then, a new growth plate was prepared and the first passage procedure was performed in the exact same way and afterward the discs of the second passage were removed from the growth plate with pliers and were placed on the new growth plate (which is the third one). The third growth plate was placed in the incubator for 24 hours at 37°C and the diameter of the emerging halo was measured, which is the halo diameter in the third passage. This method of measuring the halo diameter was performed for other bacteria [19].

2.2.3. Colony count

To evaluate the effectiveness of the procedure, the "colony count" method was employed. To perform this, a standard 0.5 McFarland solution was used [20]. Here are the steps of preparing the mentioned solution:

1- 10 cc of 1% sulfuric acid solution was prepared from 100% sulfuric acid solution.

x=10/100=0.1 sulfuric acid
10-0.1=9.9 water

2- 1.175% barium chloride solution was prepared.

x=(10×1.175)/100=0.1175 This amount of barium chloride was added to 10ml of water.

3- 9.95ml of 1% sulfuric acid solution and 0.05 mL of barium chloride solution were gently mixed together.
Light absorption at a wavelength of 625nm for 0.5 McFarland solution must be 0.08 to 0.1. A test tube was filled with standard 0.5 McFarland solution. Another test tube was filled with standard 0.5 McFarland solution and Staphylococcus aureus. Comparing the turbidity of both test tubes, it was concluded that the bacteria in the second tube reached 1.5x10^8. The standard bacterial solution was poured into a 3cm plate, a sample disk was inserted into the plate and immersed in the standard bacterial solution. Afterwards, the plate was placed in a shaker incubator for 1 hour at 100rpm at 37℃ and when it was removed from the incubator, it was washed with distilled water. The disk was then placed on a pre-prepared growth plate for 15 minutes. After that, the disk was removed from the plate and the plate was placed in an incubator at 37°C for 24 hours. After the incubation, the number of growing bacterial colonies was counted 10^5 in the fully covered disk.

2.2.4. Blood Penetration Test

To evaluate the blood resistance, it is necessary to prepare a standard solution. 3 test tubes were filled with 2cc of distilled water in each and another with 4cc of distilled water. λ100 of natural blood was added to the test tube with 4cc of distilled water and the tube was shaken hard and centrifuged for 2 minutes. Then, 2cc of the centrifuged tube solution was poured into a tube with 2cc of distilled water and was centrifuged for 2 minutes. Afterwards, 2cc of the second tube was poured into another tube with 2cc of distilled water. Following centrifugation, 2cc of the solution was poured into the last tube containing 2cc of distilled water and it was centrifuged for 2 minutes. 2cc of the last tube solution was discarded. Thus, there were 4 tubes, the first one had 2cc of λ100 blood, the second one 2cc of λ50 blood, the third one 2cc of λ25 blood and the fourth 2cc of λ12.5 blood.
The light absorption of all four tubes was measured at 540nm with a spectrophotometer to plot the standard curve of blood-light absorption based on concentration. λ100 of blood was poured on the samples and left for 1 minute so that interactions between blood and samples could occur. The remained blood drop was removed from the specimen. Each sample was placed in a test tube containing 2cc of distilled water and shaken for one minute for the blood to be completely removed. Each sample was taken out of the test tube and light absorption was recorded at 540nm by the spectrophotometer [19].

3. Results and Discussion

3.1. Results of Measuring the Halo Diameter

Table 3 demonstrates the halo diameter of polyester/viscose samples being exposed to Staphylococcus aureus for three consecutive days. The largest halo diameter is for sample 4A4 or GS, on which 1.25 g/l of gentamicin was coated. No inhibitory effect was detected in the fluorocarbon-coated sample. In the first passage no considerable difference between the halo diameters of the samples was detected; however, the halo diameter of groups A, B, and C increased with gentamicin concentration increment. Nevertheless, this increase is not enough to ensure the antimicrobial effect of the samples. Groups A, B, and C equally lost their inhibitory effect in the second passage and their halo diameter decreased. The third passage samples lost

their antimicrobial effect and their halo diameter disappeared. In fact, after each passage, the concentration of the active substance in the samples decreased. In other words, the bacteria grew more and caused the halo diameter to decrease, which indicates the inhibitory effect. Groups D and E presented the best antimicrobial effect in the first passage. In the second and third passages their halo diameter completely disappeared. According to the results, the optimum concentration was 1.25 g/l of gentamicin and 60 g/l of fluorocarbon. Although fluorocarbon had no inhibitory effect, its effect on reducing the absorption of moisture and germ prevented the growth of the bacteria.

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In the case of Pseudomonas (Table 4) the results were similar to Staphylococcus aureus, except that the halo diameter in the first passage was slightly larger. The largest halo diameters were related to treatment using 1.25 g/l of gentamicin. As the concentration of gentamicin increased, the halo diameter increased. In all groups, no antimicrobial effect was observed in the third passage, however, in the first and second passage the samples presented more inhibitory effect. Repeating the process did not have a significant effect on the halo diameter. Figure 1 illustrates electron microscopy images at 9000x magnification of the samples.

3.2. Wash Fastness

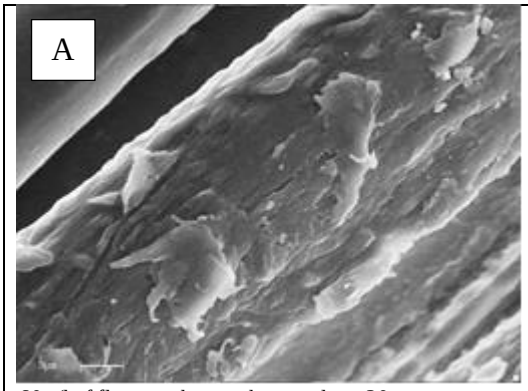
Table 5 illustrates the effect of washing the samples once and twice. The largest halo diameter is related to C2, on which the mixture of gentamicin and fluorocarbon was coated. The smallest halo diameter is related to the sample with the gentamicin coat and fluorocarbon caused gentamicin to be more durable against washing. On the other hand, samples coated with 5 g/l of gentamicin had a larger halo diameter after washing. The fluorocarbon coated sample, the same as the blank sample, did not present any inhibitory effect

Table 3. Halo diameters of Staphylococcus aureus on polyester/viscose fabrics for three consecutive days.

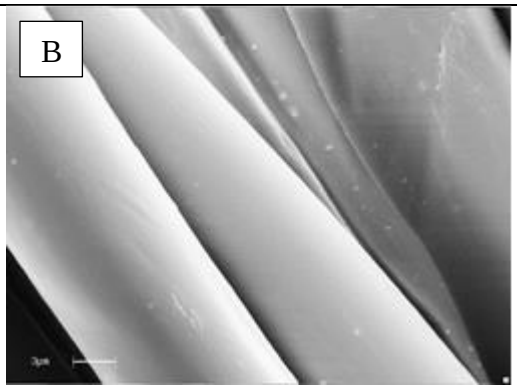
Old Sample No	Sequence	FC (g/l)	GC (g/l)	New Sample No	First Passage	Second Passage
4a	GC→FC	60	1.25	A1	25	20
10a	FC→GC	60	1.25	A2	27	18
19a	FC + GC	60	1.25	A3	25	19
1a	GC→FC	60	2.5	B1	28	22.5
22a	FC + GC	60	2.5	B2	28	22
7a	GC→FC	60	5	C1	28	21
25a	FC + GC	60	5	C2	29	22
41a	GC→FC	30	0.62	D1	28	0
42a	FC→GC	30	0.62	D2	28	0
43a	FC + GC	30	0.62	D3	28	0
44a	GC→FC	15	0.31	E1	29	0
45a	FC→GC	15	0.31	E2	29	0
46a	FC + GC	15	0.31	E3	29	0
1A4	FC	60	0	FC	0	0
4A4	GC	0	1.25	GC	30	22
A6	raw sample	0	0	R	0	0

Table4. Halo diameters of Pseudomonas aeruginosa on Polyester/viscose fabrics for three consecutive days.

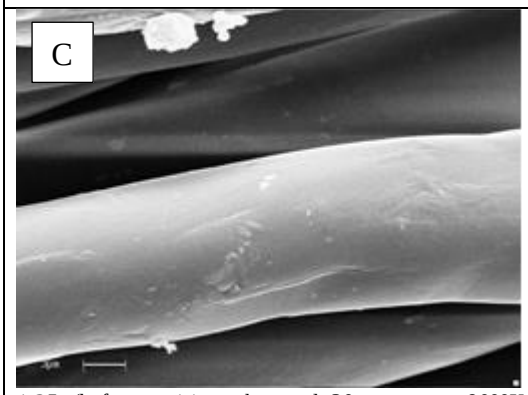
Old Sample No	Sequence	FC (g/l)	GC (g/l)	New Sample No	First Passage	Second Passage
1A1	GC→FC	60	1.25	A1	25	20
1A2	FC→GC	60	1.25	A2	29	18
1A3	FC + GC	60	1.25	A3	28	19
4A1	GC→FC	60	2.5	B1	30	22.5
4A3	FC + GC	60	2.5	B2	28	20
7A1	GC→FC	60	5	C1	30	20
7A3	FC + GC	60	5	C2	30	22
1A4	FC	60	0	FC	0	0
4A4	GC	0	1.25	GC	30	22
A6	raw sample	0	0	R	0	0



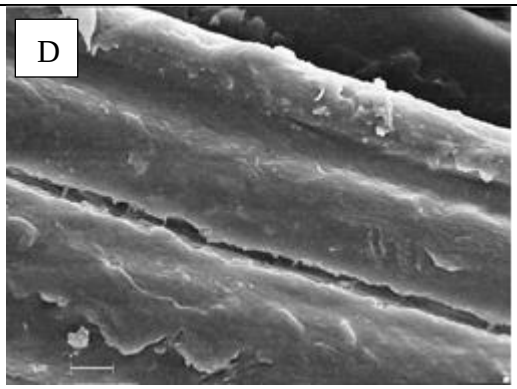
60 g/l of fluorocarbon on the sample 30µm 9000X



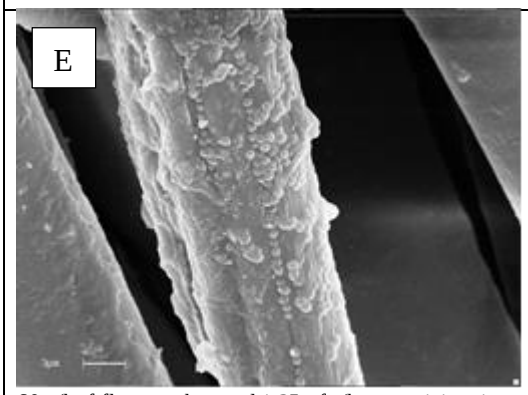
Blank sample. 30µm 9000X



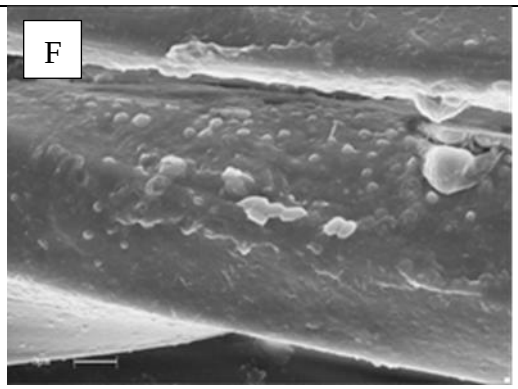
1.25 g/l of gentamicin on the sampl 30µm 9000X



60 g/l of fluorocarbon and 1.25 of g/l gentamicin mixture on the sample. 30µm 9000X



60 g/l of fluorocarbon and 1.25 of g/l gentamicin mixture with Staphylococcus aureus on specimen 30µm 9000X



60 g/l of fluorocarbon and 1.25 of g/l gentamicin mixture with Pseudomonas aeruginosa on specimen 30µm 9000X

Fig1. SEM images of polyester/viscose coated samples and the bacterial growth

All the samples retained inhibitory effect up to 2 washes, however, in general their halo diameter decreased after the second wash.

Table 6 illustrates the halo diameter of the samples which were exposed to Staphylococcus aureus, washed and exposed to the infected environment. The largest halo diameter is related to the sample coated with fluorocarbon and gentamicin mixture. Similarly, fluorocarbon increased the antimicrobial effect of gentamicin by reducing the washing effect of gentamicin and causing it to retain its inhibitory effect and increasing the concentration of gentamicin caused halo diameter to increase.

Table 7 illustrates the results of a one-time wash on halo diameter. The largest halo diameter is related to sample 25a. Increasing gentamicin concentration in all the samples resulted in a larger halo diameter. Moreover, fluorocarbon reduced the washing effect of gentamicin. All the samples showed no inhibitory effect after two days, which is due to the reduction of the effective substance in the sample. Figure 2 illustrates the images of the samples coated with fluorocarbon and gentamicin by spray method after two washes.

Table 5. The halo diameter of polyester/viscose fabrics exposed to Staphylococcus aureus, which were washed once and twice after the coating process.

Old Sample No	Sequence	FC (g/l)	GC (g/l)	New Sample No	1nd Wash	2nd Wash
1A1	GC→FC	60	1.25	A1	30	29
1A2	FC→GC	60	1.25	A2	28	27
1A3	FC + GC	60	1.25	A3	29	30
4A1	GC→FC	60	2.5	B1	30	30
4A3	FC + GC	60	2.5	B2	32	29
7A1	GC→FC	60	5	C1	33	31
7A3	FC + GC	60	5	C2	33	32
1A4	w cure	60	0	FC	0	0
4A4	w cure	0	1.25	GC	31	30
A6	raw sample	0	0	R	0	0

Table 6. Halo diameter of polyester/viscose fabrics exposed to Staphylococcus aureus and the effect of washing after bacterial growth.

Old Sample No	Sequence	FC (g/l)	GC (g/l)	New Sample No	1nd Wash
1A1	GC→FC	60	1.25	A1	27
1A2	FC→GC	60	1.25	A2	29
1A3	FC + GC	60	1.25	A3	29
4A1	GC→FC	60	2.5	B1	30
4A3	FC + GC	60	2.5	B2	30
7A1	GC→FC	60	5	C1	30
7A3	FC + GC	60	5	C2	34
1A4	w cure	60	0	FC	0
4A4	w cure	0	1.25	GS	35
A6	raw sample	0	0	R	0

Table 7. The halo diameter of the polyester/viscose fabric exposed to Staphylococcus aureus after washing the sample once and its durability on the second day.

Old Sample No	Sequence	FC (g/l)	GC (g/l)	New Sample No	First Day	Second Day
1A1	GC→FC	60	1.25	A1	29	0
1A2	FC→GC	60	1.25	A2	28	0
1A3	FC + GC	60	1.25	A3	29	0
4A1	GC→FC	60	2.5	B1	30	0
4A3	FC + GC	60	2.5	B2	31	0
7A1	GC→FC	60	5	C1	32	0
7A3	FC + GC	60	5	C2	33	0
1A4	w cure	60	0	FC	0	0
4A4	w cure	0	1.25	GC	31	0
A6	raw sample	0	0	R	0	0

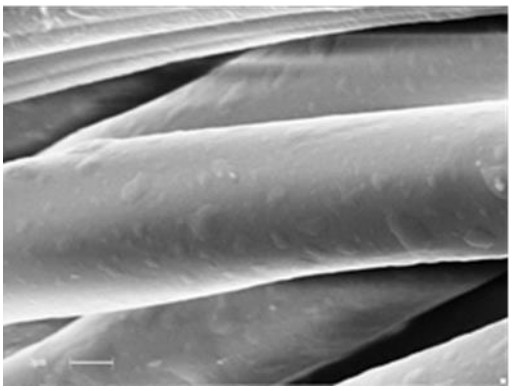


Fig 2. SEM image of the coated polyester/viscose fabrics after washing for the second time.

3.3. Colony counts

Table 8 demonstrates the colonies of Staphylococcus aureus on polyester/viscose fabrics after 24 hours. In groups A, B, and C no colonies grew since the inhibitory effect of gentamicin was enough to prevent the growth of the colonies. In groups E, and D, as the concentrations were halved, the growth of bacterial colonies was observed. Moreover, decreasing the concentrations caused more colony growth. The samples on which most colonies grew are A6 and 1A4 (the sample on which fluorocarbon is coated).

Table 9 demonstrates the colonies grown on the polyester/viscose fabrics which were exposed to Pseudomonas aeruginosa. The blank sample (R) and the sample coated with fluorocarbon did not exhibit any antimicrobial properties. The samples coated with gentamicin, even the ones with the concentration of 1.25 g/l, did not have any bacterial colony growth.

Table 8. Colony growth of polyester/viscose samples exposed to Staphylococcus aureus.

Old Sample No	Sequence	FC (g/l)	GC (g/l)	New Sample No	Colony Count
1A1	GC→FC	60	1.25	A1	0
1A2	FC→GC	60	1.25	A2	0
1A3	FC + GC	60	1.25	A3	0
4A1	GS→FC	60	2.5	B1	0
4A3	FC + GC	60	2.5	B2	0
7A1	GC→FC	60	5	C1	0
7A3	FC + GC	60	5	C2	0
41a	GC→FC	30	0.62	D1	20
42a	FC→GC	30	0.62	D2	8
43a	FC + GC	30	0.62	D3	5
44a	GC→FC	15	0.31	E1	60
45a	FC→GC	15	0.31	E2	30
46a	FC + GC	15	0.31	E3	50
1A4	FC	60	0	FC	10^5
4A4	GS	0	1.25	GC	0
A6	raw sample	0	0	R	10^5

Table 9. Colony growth count of the polyester/viscose samples exposed to Staphylococcus aureus.

Old Sample No	Sequence	FC (g/l)	GC (g/l)	New Sample No	Colony Count
1A1	GC→FC	60	1.25	A1	0
1A2	FC→GC	60	1.25	A2	0
1A3	FC + GC	60	1.25	A3	0
4A1	GC→FC	60	2.5	B1	0
4A3	FC + GC	60	2.5	B2	0
7A1	GC→FC	60	5	C1	0
7A3	FC + GC	60	5	C2	0
1A4	FC	60	0	FC	10^5
4A4	GC	0	1.25	GC	0
A6	raw sample	0	0	R	10^5

3.4. 3.4. Blood Penetration Results

Table 10 illustrates the light absorption of different blood concentrations. By doubling the blood concentration, absorption was doubled. This table can determine the amount of blood absorbed by each sample.

Table 11 illustrates the light absorption of the samples in which blood was diffused. As can be seen, the blank sample (R) and the gentamicin-coated sample have the highest absorption. Samples A1, A3 and FC1 (with 60 g/l of fluorocarbon coat) had the lowest blood absorption, which indicates the fact that fluorocarbon has a significant blood resistance effect on fabric. Regarding FC2, where the fluorocarbon coat was not treated, the efficiency was reduced and as a result, the absorption increased. In the E3 sample, the concentration of fluorocarbon was reduced to 15 g/l, which increased blood absorption. It could be concluded that 60 g/l of fluorocarbon has a blood resistance effect on fabrics.

Table 10. The light absorption of samples exposed to different concentrations of blood.

Concentration	Light absorbance
12.5λ	0.237
25λ	0.508
50λ	1.21
100λ	2.344

Table 11. The light absorption of blood.

Old Sample No	Sequence	FC (g/l)	GC(g/l)	New Sample No	BLOOD OD
1A1	GC→FC	60	1.25	A1	0.089
1A3	FC + GC	60	1.25	A3	0.121
1A4	w cure	60	0	FC1	0.091
4A4	w cure	0	1.25	GC	0.956
1A5	w cure	60	0	FC2	0.703
11A3	FC + GC	15	0.31	E3	0.188
A6	raw sample	0	0	R	1.602

4. Conclusions

According to the agar test results, it was found that coating the fabric using gentamicin and fluorocarbon could have a good inhibitory effect against Staphylococcus aureus and Pseudomonas aeruginosa. Additionally, it is possible to combine the two substances (while considering the economic aspects) and use them in mass production. Fluorocarbon alone did not have any antimicrobial effect on the samples.

It was found that all concentrations retained their antimicrobial effect after being exposed to the bacteria in the first 48 hours. Increasing the concentration of gentamicin presented a larger halo diameter. It was seen that 1.25 g/l of gentamicin had good inhibitory effect on Staphylococcus aureus and Pseudomonas aeruginosa. Although increasing the concentration of gentamicin increased the halo diameter, it did not have much effect on durability since at each passage the antimicrobial effect of the samples was reduced to some extent. As the concentration of gentamicin decreased, the halo diameter of the samples and their durability decreased as well. The samples maintained their antimicrobial effect for 48 hours in an environment that had an ideal condition for bacteria to grow; hence it is clear that in a normal environment the effect would last more than 48 hours. According to the washing tests, it was found that fluorocarbon made gentamicin more durable. Moreover, the sample on which 5 g/l of gentamicin was sprayed developed a larger halo diameter.

The colony count test indicated no bacterial growth on the samples sprayed with gentamicin at concentrations of 1.25, 2.5 and 5 g/l, however, bacterial growth was observed on the samples coated with fluorocarbon and the blank one. Decreasing the concentration of gentamicin caused bacterial colonies to grow on the said samples.

According to the antihypertensive test results, it was found that the sample treated with fluorocarbon had the lowest amount of blood absorption. Additionally, the sample containing gentamicin and the blank sample did not have a good inhibitory effect on absorbing blood

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