Application of Antimicrobial Non Woven Fabrics in Nursing Pads

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Abstract: Nursing pads are widely used by nursing mothers to prevent strike-through of milk onto their clothing. This research aims to produce fabrics suitable for being used as a breast-milk absorbent pad. The produced nurse pad consists of three layers. The non-woven technique was applied to produce the outer layers, using different substrates where the outer layers were made of (cotton, viscose, polyester, viscose/ polyester blend and polypropylene), and the wadding layer were made of cotton and viscose. The produced fabrics were treated with an antimicrobial agent. Different parameters were studied including, fabric construction (using nonwoven technique), material used and weight. Their influence on the performance of the end-use fabric and the achieved properties were studied. On the other hand physical-chemical properties including roughness, thickness, absorption, and antimicrobial, were evaluated according to the final product needs.

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Key wards: nursing pads, nonwoven fabrics, antimicrobial.

1 Introduction

Textile materials have a wide range of properties such as flexibility, elasticity, strength, etc. Based on these properties, textiles have invaded many industrial fields. (1) Industrial fabrics feature a great variety of applications; in today's technology, the significance and use of industrial fabrics are increasing in agriculture, architecture, medical textiles, military textiles, automotive industry, storage and packaging, etc. (2)

Medical textiles are an emerging field with high potential. The term (medical textiles) literally means textiles used for medical purposes ranging from surgical dressing, sutures to cardiovascular prosthesis (1).

Nursing pads

The feeding of a baby is essential for its correct development and for good nutrition and it is strongly advised by pediatricians, midwives and other experts in breastfeeding. (3)A period of time (several days to few weeks) elapses during which the demands of infant gradually influences the hormonal production of the mother which, in turn, adjusts the volume of milk production.

Two types of milk are produced by the human female breast: fore-milk and bind-milk. The majority of milk which nourishes the baby is called hind-milk and is produced during nursing. However, fore-milk is produced between feedings and may constitute a significant leakage problem to the mother.

Because of variations in the human physiology, some women who are breast feeding their children may simply experience overproduction of milk between feedings and the associated leakage. This problem is especially acute during the night (4) .

In order to prevent staining of clothing and embarrassment caused by leaking of milk, nursing mothers employ pads to absorb leaking fluids and decrease skin irritation for the mother breast and, such pads are commonly placed inside the bra (5-7) .

Types of nursing pads

There are two major types of nursing pads .The first is a therapeutic breast pad for heating or cooling the female breast during nursing to alleviate the symptoms of clogged milk duct (8). The second type (which is concerned in this research) is the brassier pad used by nursing mother for absorbing breast milk leakage after nursing her baby to prevent seepage into and through her garments, principally during the night (1).

Brassier pad devices for absorbing breast milk leakage are available on the markets and fall also into two general categories: disposable and re-useable pads (4).

Nursing pads construction

Nursing pad is constructed of a plurality of substantially coextensive layers having different characteristics: a non-permeable layer (backing layer) for preventing transfer of breast milk from the liner to clothing , an absorbent layer (inner layer) which comprises an absorbent material for holding the milk within the liner, and a wicking layer (facing layer) to draw the liquid away from the breast and into the absorbing layer.(9-11).An adhesive may be applied to the outer portion to hold the pad in place in the bra (10) .

Characteristics of nursing pads

The presently available nursing pads suffer from a number of disadvantages. The primary disadvantage is inadequate absorbency, particularly during the night when the breast continue to produce fore-milk when the mother sleeps.(4) Another problem is that of the undesirable soggy feel to the mother after she has worn the pad for a period of time. Yet another problem is that of the nursing pad sometimes disintegrated while being used. Thus, there is a need for an improved nursing pad which minimize the strike-through problem and which enhance comfort of the nursing mother while in use. (9) Thus the nursing pad must provide increased comfort and absorbency and improved wear ability when not nursing and decrease skin irritation (4).

2. Experimental Work

This research concerns with producing fabrics suitable for being used as nursing pad. Five kinds of textile materials were used in this research, polyester, viscose, viscose/ polyester blend, cotton and polypropylene. Nonwoven construction, using random- laid technique for forming the web and spun-laced process for web bonding, was used for producing the inner and outer layers for all samples under study. Samples were treated with a chemical formula called triclosan (organic antibacterial) of 15 % concentration as an antimicrobial agent.

Antimicrobial treatment (using triclosan)

In this study, antimicrobial finishes was applied to all samples. Antimicrobial treatment were applied to fabrics to prevent the growth of microorganisms exposed to the fabrics and so provide increased comfort and improved wear ability when not nursing because of the decrease in skin irritation.

Samples were padded in an aqueous solution containing 100% triclosan and then squeezed to a wet pick up 100%. Samples were dried at 45 ^{0}C for 15 min, then thermo-fixed at 120^{0}C for 20 sec.

Tests applied to samples under study

In order to evaluate the performance properties of the produced samples, the following tests were carried out:

Tests

Several tests were carried out in order to evaluate the produced fabrics, these tests were:

1-Antimicrobial, this test was carried out according to the AATCC standard test method 90-1982 (12).

2-Roughness, this test was measured according to AATCC standard test method using a Surfacoder (1700a) (13).

3- Air permeability, this test was carried out according to the ASTM-D737-1996(14)

4- Water absorption, this test was carried out according to the AATCC Standard Test Method, D-79-1968 (15)

5-Fabric thickness, this test was carried out according to the (ASTM-D1777/1996) (16).

3. Results and Discussion

Results of experimental tests carried out on the produced samples were statistically analyzed and presented in the following tables and graphs.

Table (1) Specifications of all produced samples

Sample No .	Samples Construction				
	The outer layers				Wadding
	Fiber type	Web - bonding	We-formation	Weight g/m2	
1	Cotton	Calendaring	Spun-lace	55	Viscose
2	Cotton	Calendaring	Spun-lace	55	Cotton
3	Viscose	Calendaring	Spun-lace	20	Viscose
4	Viscose	Calendaring	Spun-lace	20	Cotton
5	Viscose	Calendaring	Spun-lace	45	Viscose
6	Viscose	Calendaring	Spun-lace	45	Cotton
7	Viscose	Calendaring	Spun-lace	100	Viscose
8	Viscose	Calendaring	Spun-lace	100	Cotton
9	Polyester	Calendaring	Spun-lace	100	Viscose
10	Polyester	Calendaring	Spun-lace	100	Cotton
11	Polypropylene	Calendaring	Spun-lace	16	Viscose
12	Polypropylene	Calendaring	Spun-lace	16	Cotton
13	Polypropylene	Calendaring	Spun-lace	24	Viscose
14	Polypropylene	Calendaring	Spun-lace	24	Cotton
15	Polypropylene	Calendaring	Spun-lace	32	Viscose
16	Polypropylene	Calendaring	Spun-lace	32	Cotton
17	Polypropylene	Calendaring	Spun-lace	40	Viscose
18	Polypropylene	Calendaring	Spun-lace	40	Cotton
19	Polypropylene	Calendaring	Spun-lace	48	Viscose
20	Polypropylene	Calendaring	Spun-lace	48	Cotton
21	Viscose /polyester 70/30	Calendaring	Spun-lace	32	Viscose
22	Viscose /polyester 70/30	Calendaring	Spun-lace	32	Cotton
23	Viscose /polyester 70/30	Calendaring	Spun-lace	50	Viscose
24	Viscose /polyester 70/30	Calendaring	Spun-lace	50	Cotton

Table (2) Results of the antimicrobial test applied to the produced samples

Tests	Antimicrobial			
	After treatment			
	Inhibition zone diameter (1 cm sample)			
No.	*Escherichia coli* (G^-)	*Staphylococcus aureus* (G^+)	*Aspergillus flavus (Fungus)*	*Candida albicans (Fungus)*
1	14	16	13	9
2	16	17	10	6
3	18	21	7	5
4	20	22	3	3
5	17	19	13	12
6	18	20	7	3
7	12	13	4	3
8	12	14	6	5
9	11	13	1	0
10	12	12	2	1
11	11	12	4	2
12	12	15	5	3
13	10	12	3	1
14	10	11	3	2
15	9	11	2	1
16	10	10	2	2
17	12	13	1	1
18	14	15	0	0
19	11	13	1	1
20	12	15	2	1
21	16	18	6	3
22	17	19	7	5
23	14	17	8	4
24	15	18	13	5

(G^-) =Gram negative (G^+)= Gram positive

Antimicrobial test

From table (2), that the data revealed untreated fabrics did not provide any resistance against microbes. Treatment of fabrics with triclosan led to an improvement in properties of the anti- microbes and it was found that treatment of fabrics with cellulose-based substance with triclosan provided good microbe resistance.

It can also be seen that the diameter of free activated bacterial zone has increased from 10 to 22 at *Staph* , from 9 to 20 mm at *E.Coli*, from 0 to 13 at *Aspergillus flavus (Fngus)*,and from 0 to 12 mm at *Candida albicans (Fungus).*

It can also be seen that samples of high weights ,viscose 20 g/m^2 ,cotton 45 g/m^2 and cotton /polyester 32 g/m^2 have achieved the highest diameters of free activated bacteria zone , whereas polypropylene16 g/m^2 has achieved the lowest diameter of free activated bacterial zone.

the results in the present work can state that cellulose samples have absorbed the treatment material more than the synthetic samples, also the increases of weight has increased the absorption of the treatment material leading to the increase in the free activated bacterial zone.

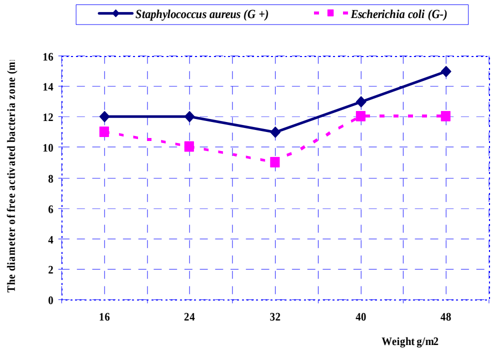

Fig.(1) The effect of weight g/m^2, on antimicrobial (the diameter of free activated bacteria zone) , at viscose wadding and polyproplene for outer layers.

Table (3) Regression equation and correlation coefficient for the effect of viscose wadding layer on, at viscose for inner and outer layer.

The variable	Regression equation	Correlation coefficient
Escherichia coli (G-)	Y = 0.05X + 9.2	0.785071
Staphylococcus aureus (G +)	Y = 0.0875X + 9.8	0.8298

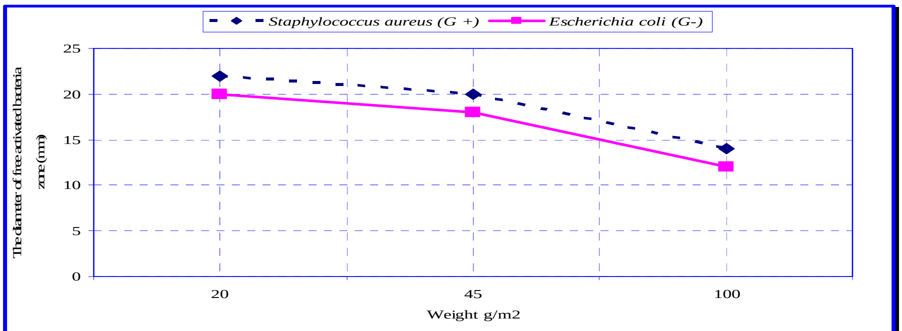

Fig.(2) The effect of weight g/m2, on antimicrobial (the diameter of free activated bacteria zone) , at cotton wadding and viscose for outer layers..

Table (4) Regression equation and correlation coefficient for the effect of viscose wadding layer on the diameter of free activated bacteria zone , at viscose for inner and outer layer.

The variable	Regression equation	Correlation coefficient
Escherichia coli (G-)	Y =- 0.10149 X +22.24876	0.997701
Staphylococcus aureus (G +)	Y = -24.24875X + 0.10149	0.997701

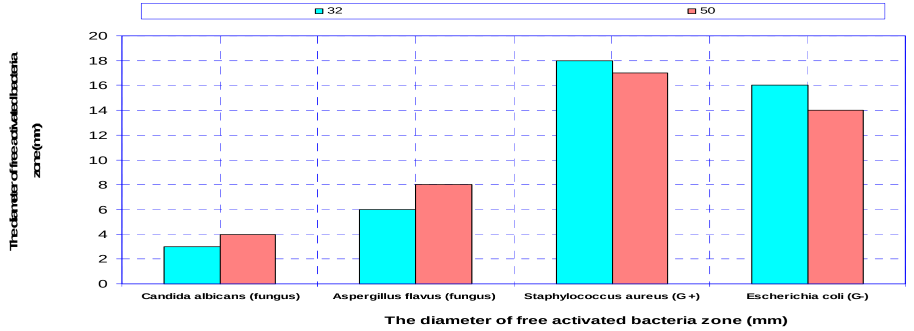

Fig.(3) The effect of weight g/m^2, on antimicrobial (the diameter of free activated bacteria zone) , at viscose wadding and Viscose 70/polyester 30 layers.

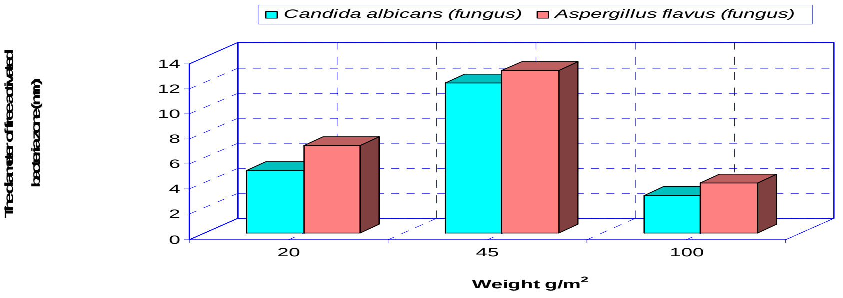

Fig.(4) The effect of weight g/m^2, on antimicrobial (the diameter of free activated bacteria zone) , at cotton wadding and viscose outer layers.

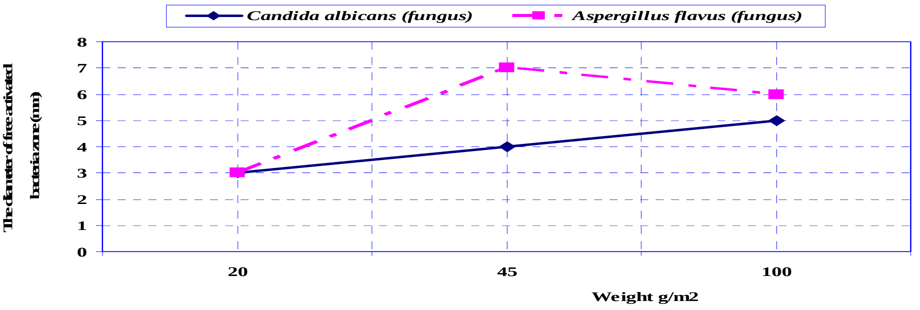

Fig.(5) The effect of weight g/m^2, on antimicrobial (the diameter of free activated bacteria zone) , at cotton wadding and viscose outer layers.s.

Table (5) Results of the roughness and air permeability tests applied to the produced samples

Tests	Roughness (Ra. µ) m		Air permeability (L^3/min. m ^{2})	
No.	Before treatment	After treatment	Before treatment	After treatment
1	16.23	17.01	15.07	14.11
2	16.75	17.49	15.66	14.56
3	14.30	15.63	26.95	25.62
4	15.21	16.21	27.41	26.45
5	16.02	16.85	18.02	17.19
6	16.35	17.12	18.66	17.92
7	22.01	22.91	10.06	9.13
8	23.36	24.11	10.82	9.84
9	23.96	24.83	11.74	10.03
10	24.49	26.38	12.18	11.45
11	16.01	16.70	30.25	29.32
12	16.34	17.13	31.80	30.72
13	18.00	18.94	24.36	23.53
14	19.07	19.89	25.15	24.65
15	18.65	19.36	21.45	20.22
16	19.35	20.27	22.05	21.37
17	15.42	16.23	20.34	19.72
18	16.49	17.11	20.97	20.05
19	21.18	22.14	19.65	18.92
20	22.09	22.85	20.01	19.23
21	16.70	17.42	22.66	21.81
22	17. 23	18.19	23.85	23.17
23	17.45	18.78	16.97	15.08
24	17.98	19.82	18.43	17.79

Roughness test

From the table (5) of roughness results and diagrams it is clear that, there is a direct relationship between weight/m^2 and roughness. It could be stated that samples of high weights contain more fibers compared to samples of low weights and hence the total shear force within the fabric is higher.

From the results of roughness test it is clear that there is direct relationship between treated samples and fabric roughness. The results in the present work can state that can state that antimicrobial treatment causes an increase in weight and thickness and hence an increase in samples roughness. This is due to higher fabrics coarseness after antimicrobial treatment because the treatment was made using alkali and high temperature, these factors cause decrease in fabric smoothness.

It is also obvious from table (5) that polypropylene samples have achieved the highest rates of roughness, followed by, polyester, cotton, viscose, and then polyester/ viscose blend, but the difference was insignificant, so that viscose samples of 20 g/m^2 are considered the most smooth, whereas samples produced from cotton /polyester blend had the lowest rates of smoothness this is mainly due to that viscose fibers have a naturally regular cross section due to its serrated circular shape which resulted in a flat surface in the longitudinal view of the fibers, whereas the longitudinal view of cotton fibers show non uniform surface due to the presence of convolutions in the fibers which form a natural crimp texture to the fibers making their surface lower in smoothness compared to viscose fabrics.

Air permeability test

In this study the researcher has treated nursing pad samples with triclosan to improve their antimicrobial and water barrier properties.

It is obvious from table (5) that samples with low weights have recorded high rates of air permeability while samples produced with high weights have recorded the lowest rates, because low weights means a decrease in fibers amounts per unit area which permit the air passage.

It is also obvious that viscose samples have achieved the highest rates of air permeability, followed by polypropylene, polyester, polyester/ viscose blend and then cotton respectively, but the relationship between them is not clear.

From the statistical analysis of air permeability test, it is clear that there is an inverse relationship between treated samples and their air permeability. Where it could be reported that the treatment caused a decrease in fabrics pores (blocking of the surface) and so the fabrics become more compacted, and thus decrease fabric air permeability.

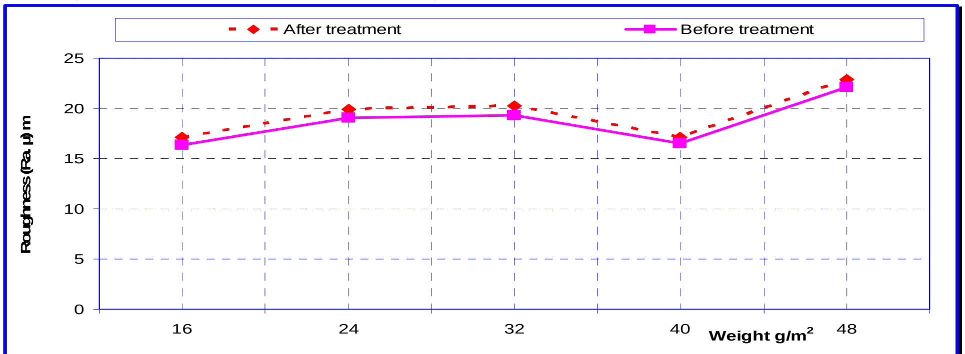

Fig.(6) The effect of samples weight on roughness ,at cotton wadding and polyproplene outer layer

Table (6) Regression equation and correlation coefficient for the effect of cotton wadding layer on roughness, at polypropylene for outer layers.

The variable	Regression equation	Correlation coefficient
Before treatment	Y = 0.1115X + 15.1	0.76753
After treatment	Y = 0.10825X + 15.986	0.64666

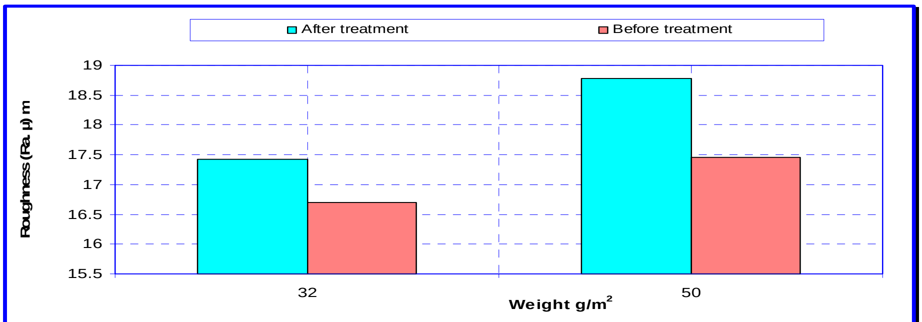

Fig.(7) The effect of samples weight on roughness ,at viscose wadding and Viscose /polyester 70/30 outer layers.

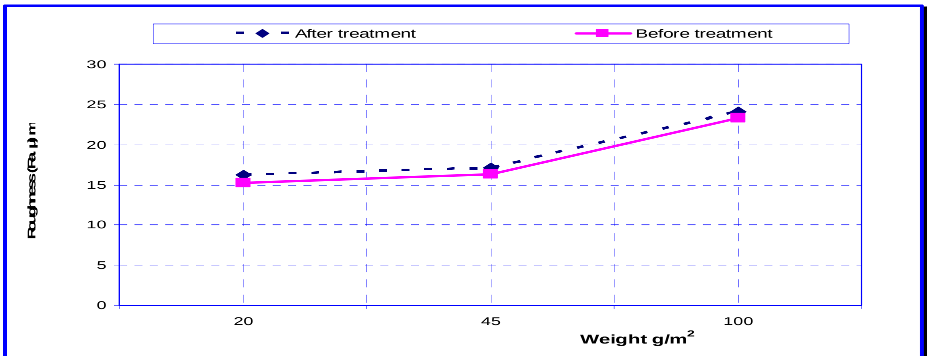

Fig.(8) The effect of samples weight on roughness ,at cotton wadding and viscose outer layers..

Table (7) Regression equation and correlation coefficient for the effect of cotton wadding layer on samples roughness, at viscose for outer layers.

The variable	Regression equation	Correlation coefficient
Before treatment	Y = 0.106075X + 12.47256	0.983688
After treatment	Y = 0.103403X + 13.4595	0.979077

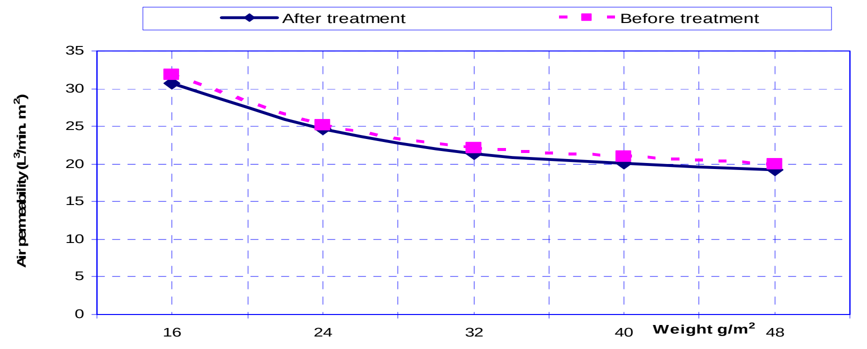

Fig.(9) The effect of weight, on air permeability, for cotton wadding, at polypropylene outer layers samples

Table (8) Regression equation and correlation coefficient for the effect of cotton wadding layer on air permeability, at polypropylene for outer layers.

The variable	Regression equation	Correlation coefficient
Before treatment	Y =-0.347X + 35.1	-0.919902
After treatment	Y = -0.34475X + 34.36	-0.931389

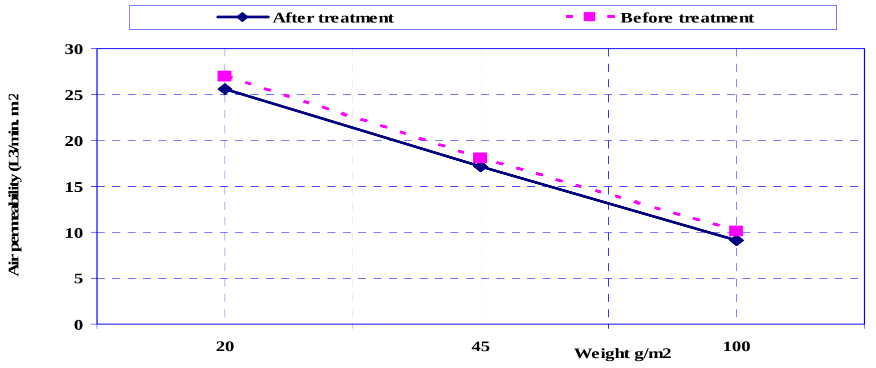

Fig.(10) The effect of weight on air permeability for viscose wadding at viscose outer layers samples ..

Table (9) Regression equation and correlation coefficient for the effect of viscose wadding layer on air permeability, at viscose for outer layers.

The variable	Regression equation	Correlation coefficient
Before treatment	Y =-0.20022X + 29.35565	-0.969806
After treatment	Y = -0.19634X + 28.11221	-0.97453

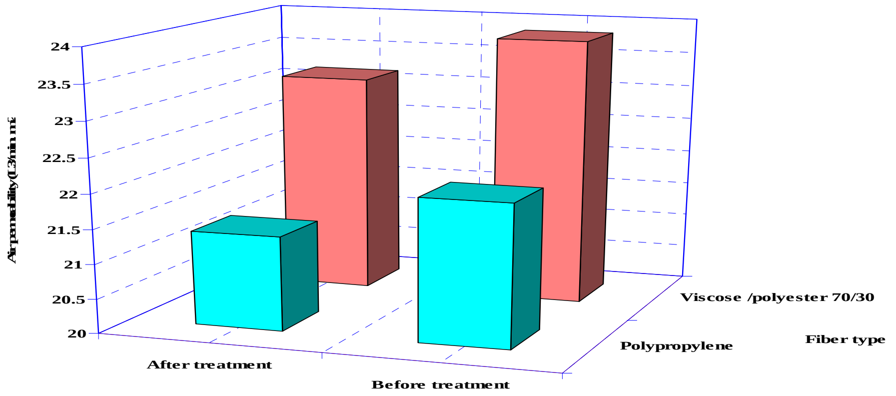

Fig.(11) The effect of outer layers fiber type, on air permeability for cotton wadding samples at 32 g/m2 .

Table (10) Results of the water absorption and thickness tests applied to the produced samples

Tests	Water Absorption (sec.)		Thickness (mm)	
No.	Before treatment	After treatment	Before treatment	After treatment
1	2	3	4.97	5.06
2	2	2	5.11	5.19
3	1	2	4.02	4.13
4	1	3	4.11	4.26
5	1	2	4.53	4.64
6	2	4	4.65	4.75
7	1	3	6.20	6.31
8	3	5	6.11	6.18
9	180<	180<	6.23	6.37
10	180<	180<	6.14	6.25
11	6	6	3.86	3.94
12	8	8	3.98	4.11
13	11	12	4.21	4.39
14	13	14	4.27	4.42
15	17	19	4.25	4.38
16	18	18	4.14	4.23
17	70	71	4.43	4.55
18	72	75	4.54	4.69
19	170	172	4.52	4.59
20	175	176	4.65	4.71
21	2	3	4.26	4.29
22	3	5	4.31	4.36
23	2	2	4.77	4.88
24	3	5	4.89	5.98

Water absorption test

It is obvious from results that samples of viscose wadding have achieved the highest rates of absorption, whereas cotton samples have achieved the lowest rates. This is due to the molecular structure of viscose fibers have large areas of amorphous regions (represent 2/3 of viscose molecular structure), whereas the molecular structure of cotton fibers has large areas of crystalline regions (represent 2/3 of cotton molecular structure).

From the results it is obvious that samples produced of viscose fiber have achieved the highest rates of water permeability among all produced samples .This is due to that viscose fibers have higher absorbency (14%) compared to polyester fibers (0.4%), and so allow the free passage of water through the fabric.

It is also clear from pervious diagrams that samples of low weights have recorded the highest rates of water permeability compared to samples of higher weights, and this is because low weight samples means decrease in number of fibers per unit area which allow water to be passed easily.

From tables and figures it can be seen that there is a direct relationship between treated samples and their water absorption. Where it could be reported that treatment decrease fabrics pores (blocking of the surface) and, and thus decrease fabric absorbency, but the differences were insignificant.

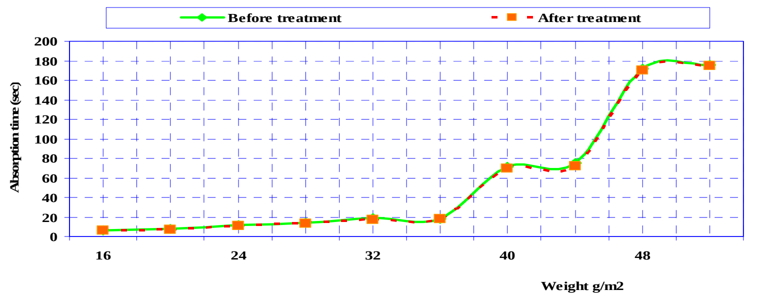

Fig (12) The effect of weight, on water absorption for viscose wadding at polypropylene outer layers samples.

Table (11) Regression equation and correlation coefficient for the effect of viscose wadding layer on water absorption, at polypropylene for outer layers .

The variable	Regression equation	Correlation coefficient
Before treatment	Y =- 4.925X + 100.5	-0.883811
After treatment	Y = -4.8875X + 100.5	-0.881506

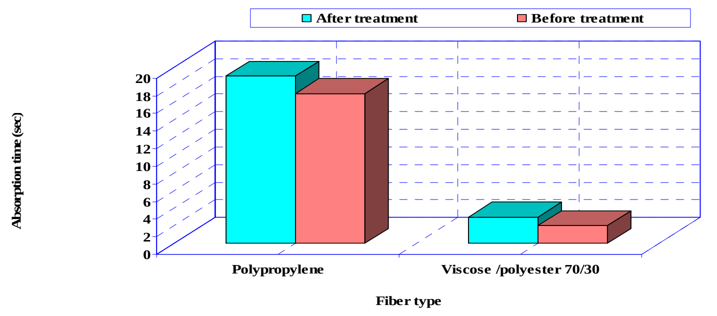

Fig. (13) The effect of fiber type on water absorption at viscose wadding and 30 g/m2 weight

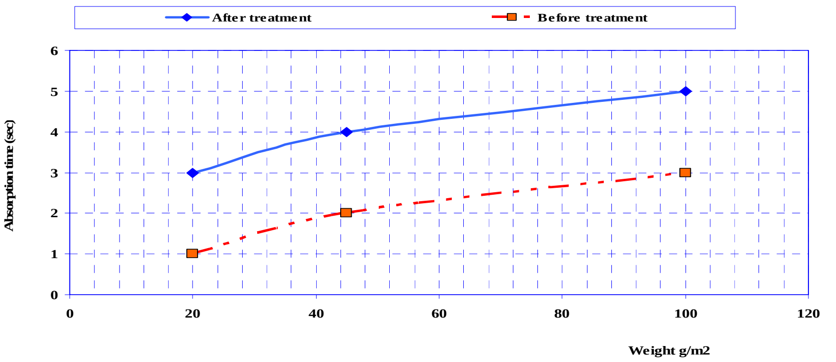

Fig.(14) The effect of samples weight on water absorption at cotton wadding and viscose outer layers

Table (12) Regression equation and correlation coefficient for the effect of cotton wadding layer on water absorption, at viscose for outer layers.

The variable	Regression equation	Correlation coefficient
Before treatment	Y =- 0.023881X + 2.686567	-0.977356
After treatment	Y =- 0.023881X + 2.686567	-0.977356

Thickness

From the statistical analysis of the thickness test, it is obvious that there is a direct relationship between weight /m^2 and fabric thickness, as it could be stated that the increase in fabric weight means increase in number of fibers per unit area leading to the increase in fabric thickness. It is clear that the differences in thickness between all samples are insignificant.

From the statistical analysis of thickness test, it is clear that there is a direct relationship between treatment and thickness. Meanwhile the treatment causes an increase in weight and hence an increase in thickness. It is also obvious from the statistical analysis of weight test that there is direct relationship between triclosan and weight .I can state that the increase of concentration ratio cause an increase in weight.

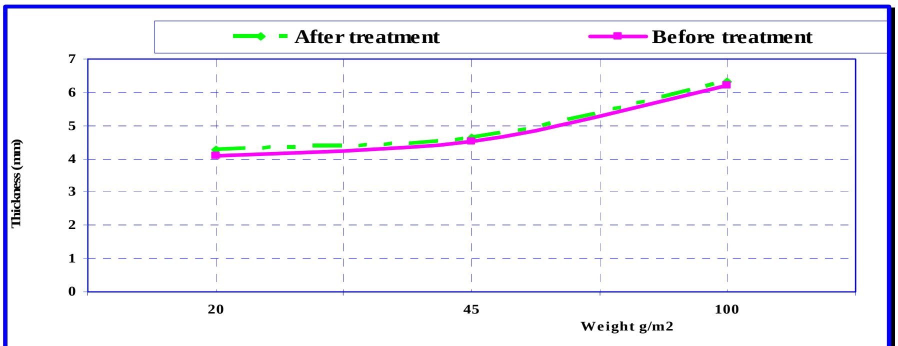

Fig.(15) The effect of samples weight on thickness at viscose wadding and cotton outer layers

Table (13) Regression equation and correlation coefficient for the effect of viscose wadding layer on samples thickness, at cotton outer layers.

The variable	Regression equation	Correlation coefficient
Before treatment	Y = 3.471517X + 0.026821	0.992896
After treatment	Y = 3.617836X + 0.026403	0.990660

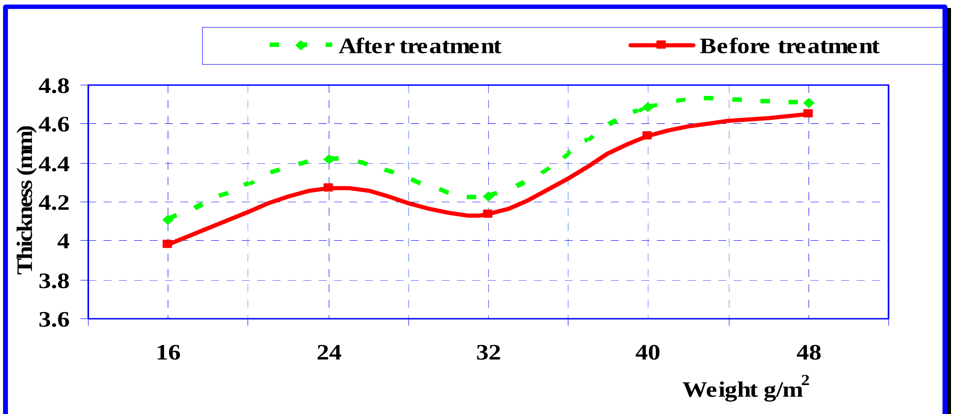

Fig.(16) The effect of samples weight on thickness at viscose wadding and polypropylene outer layers..

Table (14) Regression equation and correlation coefficient for the effect of viscose wadding layer and weight g/m^2, on thickness, at polypropylene for outer layers

The variable	Regression equation	Correlation coefficient
Before treatment	Y = 3.672X + 0.020125	0.9178
After treatment	Y = 3.844X + 0.018375	0.865485

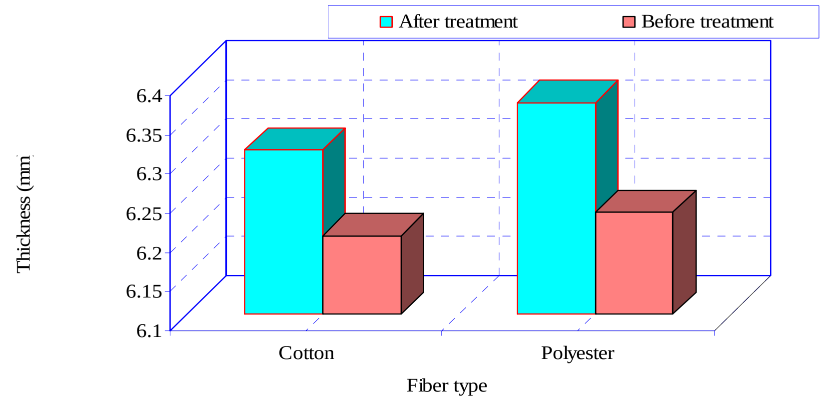

Fig.(17) The effect of fiber type on thickness at cotton wadding and 100 g/m^2 weight.

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