# Preparation and Characterization of Antibacterial Nonwoven Fabrics

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**ABSTRACT**

This research is mainly concerned with designing non-woven disposal fabrics (gowns, masks, drapes, over-head, and over-shoes) used in surgical operation rooms. The non-woven technique was applied to produce these fabrics, using different substrates (cotton, viscose, polyester, viscose blend with polyester and polypropylene). The produced fabrics were treated with both an antimicrobial and water repellency agents. Different parameters were studied including, the fabric construction (nonwoven), 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; air permeability, stiffness, thickness ,weight, water repellency, and antimicrobial, were evaluated according to the finial product needs.

## 1.Introduction

The twentieth century is the period of science technological advancement innovation and improvement in every walk of life .the use of textiles in medicine has grown rapidly over the past few years and covers almost every thing . Healthcare and hygiene products are an important sector in the field of medicine and surgery, the range of products available is vast , but typically they are used either in the operating theatre or on the hospital ward for the hygiene care and safety of staff and patients .Over years medical personnel have warn protective clothing in the operating theater . [1] The purpose of these garments is to prevent the spread of bacteria from surgical staff to patients . During surgical procedures, these personnel may be exposed to sprays of blood or other fluids that potentially contain blood -borne pathogens. Therefore surgical fabrics should have repellent and antimicrobial properties not only to reduce hospital -acquired infections of patients, but also to protect surgical staff from infectious fluids. Protective healthcare textiles include operation and emergency room textiles, barrier products, breath membrane, surgeon and nurses gowns, overheads, masks foot wear, coats…. etc . [2] Nonwoven fabrics have become so vast produced and, its varieties are countless of various specifications and of individual packing. The term nonwoven refers to textiles structures produced by bonding or interlocking of fibers or both accomplished by mechanical, chemical, thermal or combinations of them. Nonwoven can be found in a wide variety of medical and related areas. [3] Where there are many applications for nonwoven textile products in the medical and healthcare sectors. Nonwovens have distinct advantages over more traditional forms of fabrics formation as they can be manufactured directly from fibers and have relatively low cost. The nonwoven method for fabric formations is therefore highly suitable for the productions of disposable products , which contribute greatly to the high levels of hygiene required in medical applications by limiting the incidence of cross infection .[4] Nonwoven fabrics are the most commonly used in operating rooms ,for surgical gowns ,masks overhead ,over shows ,laboratory coats and other kinds of protective clothing .Products used in operation room surgery include drape, gown , mask ,over head and over shoes [5]

There are basic requirements for a protective textile garment, it should be affordable, breathable, comfortable, dependable and effective. The protective material has to be waterproof but breathable, and it must allow transmission of moisture vapour. They are usually made of polyurethane, polyester or other copolymers. These garments consist of micro porous membranes, which provide comfort by allowing body perspiration to be transmitted from the skin surface to the air through a fabric. Health care garments can be woven, knitted or nonwoven.

**Surgical Drapes,** drapes are used in the operating room to cover patients and the area around him to reduce the risk of the wound becoming contaminated by skin cells shed by the patient. [2] Drapes are made from woven cotton or linen, and usually supplied cut to a variety of different shapes appropriate to different surgical procedures and contain an opening according to the position of the surgical site. [5] Nonwoven could also fabrics used as backing material on one or both sides of a film, while the film is impermeable to bacteria. Nonwoven backing is high absorbent to both body perspiration and secretions from the wound. The general requirements for surgical drapes include liquid repellency ,bacterial barrier, conformability, tactile softness, comfort, strength, fiber tie-down properties lint propensity and abrasion resistance, flame resistance, static safety and toxicity .[5]

**Gowns,** surgical gowns should act as a barrier to prevent the release of pollutant particles into the air. They should be an effective aseptic barrier between the under cloths of the surgeon and the aseptic field, and between the patient body other than the prepared area and the sterile field.

Gowns manufacturers are responding to higher demands of protection by producing products with increased barrier level [6] Gowns are often made from polyester cellulose and composite polypropylene fibers , and are supplied in sterile packs and have the additional advantages of being used in the event of major emergency [3] Woven cotton fabrics are traditionally used in some surgical gowns because cotton does not produce static electrical charges that can build up and produce electric sparks, however it may release particles from the surgeon and also generate high levels of dust , also non woven surgical gowns are used to prevent sources of contamination [2] .

The general requirements for surgical gowns include liquid repellency, bacterial barrier properties, and aesthetics flame resistance static safety and toxicity, the fabrics should also be sufficiently flexible, with adequate strength , tear resistance and comfort [7]

**Surgical mask** ,Masks often have a multiple layers structure to ensure more efficient filtration of the breath .[5] They are made of three layers, the middle layer consists of extra fine glass fibers or synthetic micro fibers covered on both sides by an acrylic bonded parallel-laid or wet-laid nonwoven fabrics. [6] The inner layer consists of a melt – blown polypropylene and outer layer which consists a spun– bonded viscose web to provide strength and to prevent the loss of polypropylene fibers .[5] Masks also contain tapes which are sewn to enable them to be tied firmly into place over the nose and mouth. [6] The performance requirements for surgical face masks are high bacterial filtration capacity, high air permeability , light weight and non-allergenic.

**Surgical caps and overshoes**, surgical caps and overshoes**,** are often made of cellulosic fibers, with the parallel– laid or spun laid process . [5] They made in one piece or from two or three pieces sewn to give a better fit. . Elastic threads are sewn into the edges of the openings to provide simple efficient closure. [2]

## 2.Experimental work

Surgical materials are known to be major sources of cross infection, so all textile materials used in the surgical field should prevent or minimize infection or transmission of diseases where in the operating room. [3] However liquids such as blood , sweat ,and saline solutions can carry bacteria with them , and if a liquid is wicked from a surgical gown to a non sterile surface , one or both sides will become contaminated .

Currently there is great interest in protecting healthcare workers from diseases that might be carried by patients in the operating room, a patients, s blood can penetrate surgical fabrics material and possibly contaminate surgeon skin if not well protected, therefore surgical fabrics materials should have antimicobial properties and blood repellency properties , [5]

There are rare previous studies about developing materials for surgical fabrics with barrier properties for both microorganisms and blood, we therefore undertook this study to develop function of surgical fabrics. In this study, a combination of repellent and antimicrobial finishes was applied to the samples.

Previous studies show that fabrics treated with 1-% Chitosan concentration dissolved in 1% acetic acid exhibits higher antimicrobial properties and hence all samples treated with 1% concentration of Chitosan.

All samples were also treated with novo solution 5 %, 10 % and 15 concentration to achieve water repellency,.

There are two methods used to reduce the spread of microorganisms, one of these methods is to make the fabric repellent or a barrier to fluids and the other method is to treat fabrics with antimicrobial finishes that kill microorganisms came in contact with the fabric surface if they are transmitted through them, therefore, the presence of live microorganisms is reduced causing reduction in microorganism transmission

### Tests

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

Air permeability, this test was carried out according to the B.S. 2925: 88 [8]
Fabrics stiffness, this test was carried out according to the ASTM-D 1388 "[9]
Fabric thickness, this test was carried out according to the ISO 2094 & BS 4052 [10]
Fabrics weight, this test was carried out according to the ASTM-D 3776- 79 [12]
Standard test method for weight ”
Antimicrobial, this test was carried out according to the AATCC standard test method 90-1977 [11]
Water repellency, this test was carried out according to the AATCC standard test method 3392-1963 [12]

## 3.Results & discussion

In this study the researches have developed surgical fabrics materials with antimicrobial and water barrier properties using Chitosan and Novo NB with various concentrations

It is also obvious from table (2) and figures from (1) to (5) that samples with low weights have recorded high rates of air permeability while samples produced with high weights have recorded the low 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 blend with viscose and then cotton, 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 Novo NB concentration and air permeability .I can state that the increase in concentration causes a formation of a thin layer on the fabric surface ,thus blocking its pores and decreasing its air permeability properties.

Polypropylene samples have achieved the highest rates of stiffness, followed by, polyester, cotton, viscose, and then polyester blend with viscose, but the difference was insignificant. From the statistical analysis of stiffness results and diagrams from (6) to (10) it is clear that there is a direct relationship between weight/$m^2$ and stiffness. It could be stated that high weight samples contain more fibers and hence the total shear force within the fabric is higher. From the statistical analysis of stiffness test it is clear that there is direct relationship between novo NB concentrations and fabric stiffness .I can state that the increase of concentrations causes an increase in weight and thickness and hence an increase stiffness.

From the statistical analysis of the thickness test a direct relationship between weight /$m^2$ and fabric thickness is reported. Where it could be stated that an increase of fibers in unit area caused an increase in fabric thickness. From the statistical analysis and diagrams from (11) to (15) of thickness test, it is clear that the deference in thickness between all materials is insignificant. And from the statistical analysis of thickness test that a direct relationship between Novo NB concentrations and thickness. Meanwhile the increase of concentrations 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 Novo NB concentrations and weight .I can state that the increase of concentration ratio cause an increase in weight.

From tables (6 ) and figure (18) that there is a direct relationship between Novo NB concentrations and water repellency. Where it could be reported that an increase in concentration causes a decrease in fabrics pores ( blocking of the surface ) and an increase in fabrics compacted, and thus increasing in fabric water repellency

From the statistical analysis of antimicrobial test it could be stated that the efficiency of the antimicrobial finish is not affected by the repellent finish, but the effectiveness of the repellent finish varies with the add-on level of the antimicrobial.

## Conclusion

In this study the researches have developed surgical fabrics materials with antimicrobial and blood barrier properties ( with respect to water repellency done) .All samples were produced with nonwoven technique and they were treated with Chitosan and Novo NB. Antimicrobial finishes were applied to fabrics to prevent the growth of microorganisms exposed to the fabrics during surgical operations. For the samples 5%, 10 % and 15 % add-on level of Novo NB finish and 1% Chitosan add-on level of antimicrobial finish was the optimum percent .The antimicrobial finish inhibited the growth of microorganisms exposed to the fabrics. Results showed that the effectiveness of the antimicrobial finish was not influenced by addition of the Novo NB finish and viscose sample produced with 20 g/$m^2$, 5% Novo NB concentration, 1% Chitosan has achieved the best results of antimicrobial and water repellency properties (sample no 13)

**Acknowledge**

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## References

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8**-B.S. 2925- 1988** " British standard method for determining the air permeability"

9**-ASTM-D 1777- 1984,** " Standard test method for measuring thickness of textile materials"

10**-ASTM-D 3776- 1979** " Standard test method for weight (Mass per unit area) of textile materials"

11- **AATCC 90-1977,** " Standard test method for measuring antimicrobial of textile materials"

12- **AATCC 392-1963,** " Standard test method for measuring water repellency of textile materials"

## List of tables

**Table 1:** summarizes the specifications of the all samples used in this research

| Samples construction | | | | |
|---|---|---|---|---|
| **Sample No** | **Fiber type** | **We-formation** | **Web - bonding** | **Weight g/m$^2$** |
| **Sample .1** | Polyester | Spun-lace | Calendring | 20 |
| **Sample .2** | Viscose | Spun-lace | Calendring | 20 |
| **Sample. 3** | Viscose | Spun-lace | Calendring | 40 |
| **Sample. 4** | Viscose | Spun-lace | Calendring | 60 |
| **Sample. 5** | Viscose / polyester 50/50 | Spun-lace | Calendring | 40 |
| **Sample. 6** | Cotton | Spun-lace | Calendring | 40 |
| **Sample. 7** | Cotton | Spun-lace | Calendring | 60 |
| **Sample. 8** | polypropylene | Spun-lace | Calendring | 20 |
| **Sample .9** | polypropylene | Spun-lace | Calendring | 30 |
| **Sample .10** | polypropylene | Spun-lace | Calendring | 40 |
| **Sample .11** | polypropylene | Spun-lace | Calendring | 100 |

**Table 2:** the results of the air permeability test applied to used samples

| **The test** | **Air permeability (Cm$^3$/Cm$^2$/S)** | | | |
|---|---|---|---|---|
| **No** | **Novo N B concentration** | | | |
| | **0%** | **5 %** | **10 %** | **15 %** |
| **1** | 314 | 284 | 269 | 267 |
| **2** | 531 | 520 | 516 | 497 |
| **3** | 152 | 138 | 137 | 131 |
| **4** | 126 | 125 | 114 | 101 |
| **5** | 292 | 265 | 259 | 250 |
| **6** | 231 | 204 | 175 | 173 |
| **7** | 120 | 117 | 115 | 105 |
| **8** | 469 | 430 | 394 | 319 |
| **9** | 220 | 179 | 147 | 140 |
| **10** | 132 | 131 | 122 | 100 |
| **11** | 36.4 | 34.4 | 32.5 | 22.8 |

**Table 3:** the results of the stiffness test applied to used samples

| **The test** | **Stiffness (m.g.cm)** | | | |
|---|---|---|---|---|
| **Sample No** | **Novo N B concentration** | | | |
| | **0%** | **5 %** | **10 %** | **15 %** |
| **1** | 26.62 | 1319.68 | 2037.55 | 9821.25 |
| **2** | 160 | 699.26 | 1381.12 | 7436.24 |
| **3** | 320 | 811.2٢١ | 4973.12 | 65914.722 |
| **4** | 1620 | 12406.25 | 31344.64 | 108518.4 |
| **5** | 2026.12 | 63055.47 | 103926.24 | 105697.7 |
| **6** | 1080 | 17490.93 | 36164.07 | 57525.82 |
| **7** | ٣٨٤٠ | 37584.45 | 121171.8 | 173804.96 |
| **8** | ١٦٠ | 1621.04 | 6063.72 | 6470.165 |
| **9** | 2733.75 | 22569.8 | 31240 | 55676.16 |
| **10** | 6655 | 17381.25 | 25780.96 | 44100 |
| **11** | 133100 | 223839.44 | 252532.89 | 284443.04 |

**Table 4:** the results of the thickness test applied to used samples

| The test | Thickness (mm) | | | |
|---|---|---|---|---|
| | Novo N B concentration | | | |
| **Sample No** | **0%** | **5 %** | **10 %** | **15 %** |
| **1** | 0.19 | 0.20 | 0.20 | 0.21 |
| **2** | 0.15 | 0.16 | 0.16 | 0.17 |
| **3** | 0.36 | 0.39 | 0.40 | 0.45 |
| **4** | 0.38 | 0.39 | 0.39 | 0.41 |
| **5** | 0.43 | 0.43 | 0.44 | 0.47 |
| **6** | 0.28 | 0.29 | 0.34 | 0.41 |
| **7** | 0.40 | 0.41 | 0.42 | 0.46 |
| **8** | 0.21 | 0.22 | 0.22 | 0.22 |
| **9** | 0.28 | 0.29 | 0.30 | 0.31 |
| **10** | 0.30 | 0.32 | 0.32 | 0.32 |
| **11** | 0.51 | 0.52 | 0.53 | 0.55 |

**Table 5:** the results of the weight test applied to used samples

| The test | Weight ($g/m^2$) | | | |
|---|---|---|---|---|
| | Novo N B concentration | | | |
| **Sample No** | **0%** | **5 %** | **10 %** | **15 %** |
| **1** | 20 | 20.62 | 22.36 | 23.28 |
| **2** | 20 | 21.34 | 21.58 | 21.68 |
| **3** | 40 | 42.6 | 42.96 | 43.34 |
| **4** | 60 | 61.22 | 62.8 | 63.52 |
| **5** | 40 | 41.46 | 42.01 | 42.24 |
| **6** | 40 | 41.38 | 42.18 | 43.22 |
| **7** | 60 | 61.2 | 62.04 | 63.34 |
| **8** | 20 | 21.88 | 22.08 | 23.56 |
| **9** | 30 | 30.96 | 31.24 | 32.22 |
| **10** | 40 | 41.2 | 41.98 | 44.1 |
| **11** | 100 | 101.52 | 102.64 | 103.66 |

**Table 6:** the results of the antimicrobial and water repellency tests applied to used samples

| The test | Antimicrobial (mm) | | Water repellency (Numerical value ) |
|---|---|---|---|
| **Sample No** | **Staphylococcue** | **Echirichiacoccie** | **Novo NB** |
| **2** | Negative | Negative | 50 |
| **18** | 5.4 | 4.5 | 60 |
| **24** | 5.2 | 3.5 | 75 |
| **42** | 5 | 3.5 | ٧٥ |

## List of figures

$20\ g/m^2$ Y= -142X+536.4 R=-0.983176
$40\ g/m^2$ Y= -142X+156.4 R=-0.947509
$60\ g/m^2$ Y= -188X+141. 6 R=-0.942833

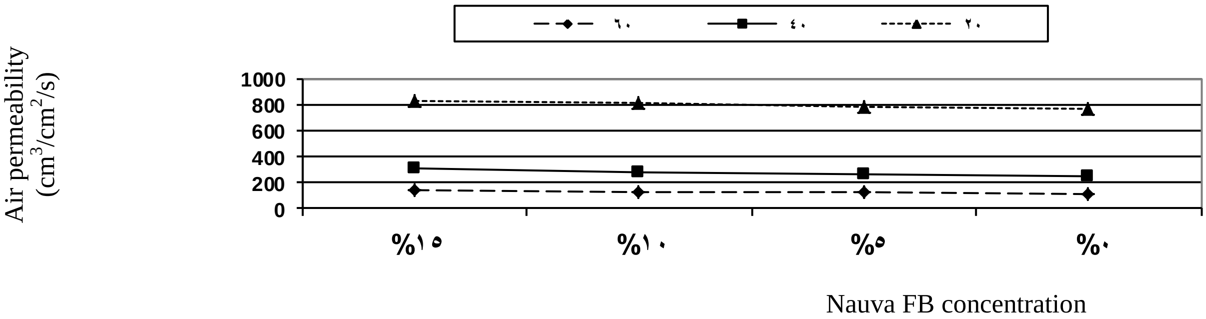



**Fig (1)**
**Effect of concentration and weight on air permeability, for viscose samples**

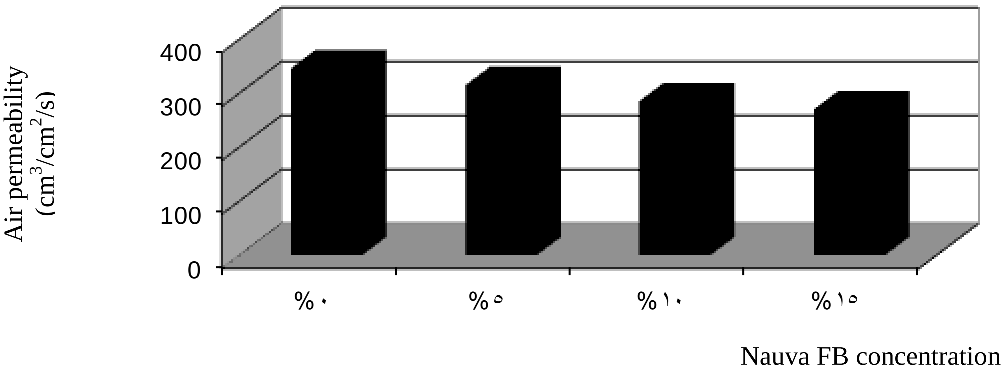



**Fig (2)**
**Effect of concentration and weight on air permeability for polyester samples**

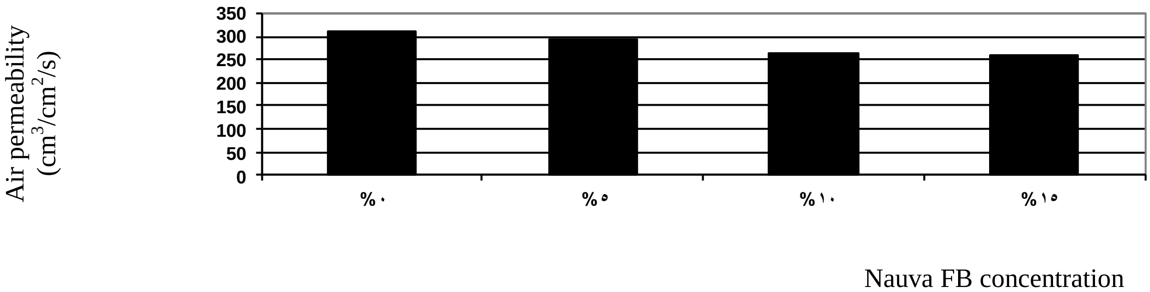
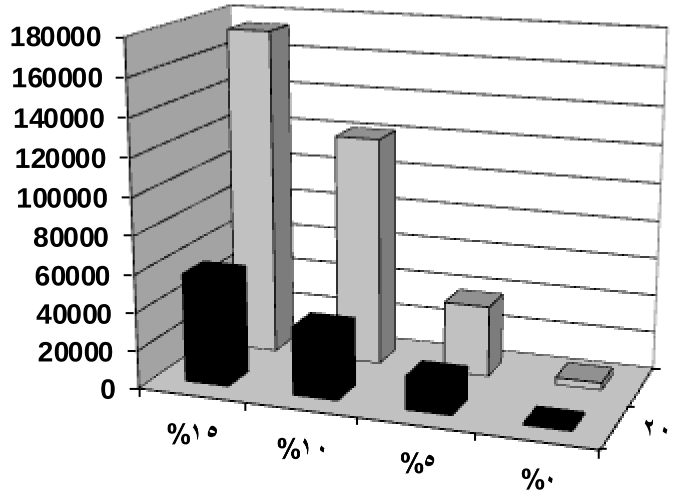



**Fig (3)**
**Effect of concentration and weight on air permeability for samples blend with viscose and polyester.**

Z=-9.95625 X+157.33 Y+652.783 R =-0.885761952



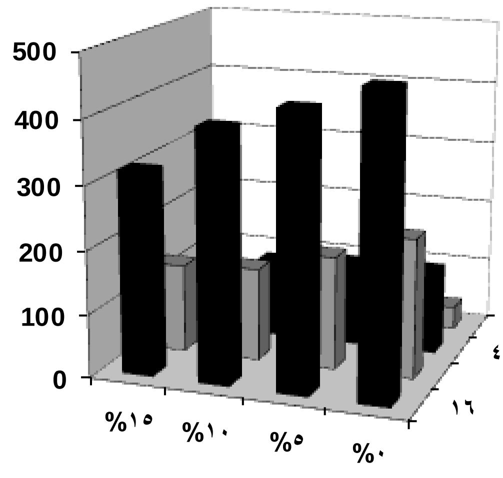

Weight g/m$^2$

Nauva FB concentration

**Fig (4)**
**Effect of concentration and weight on air permeability for cotton samples**

Z=-3.3442 X-452.85 Y-379.28133 R = -0.80694047

Air permeability (cm$^3$/cm$^2$/s)




Weight g/m$^2$

Nauva FB concentration

**Fig (5)**
**Effect of concentration and weight on air permeability for polypropylene samples**

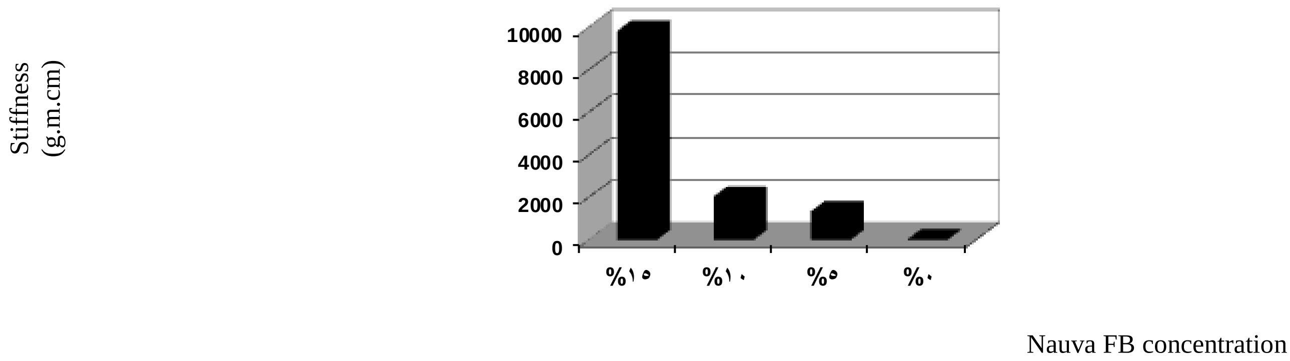



**Fig (6)**
**Effect of concentration and weight on stiffness for polyester samples**

Z=-207992.8 X+901.3292 Y-30270.5 R = -0.80694047

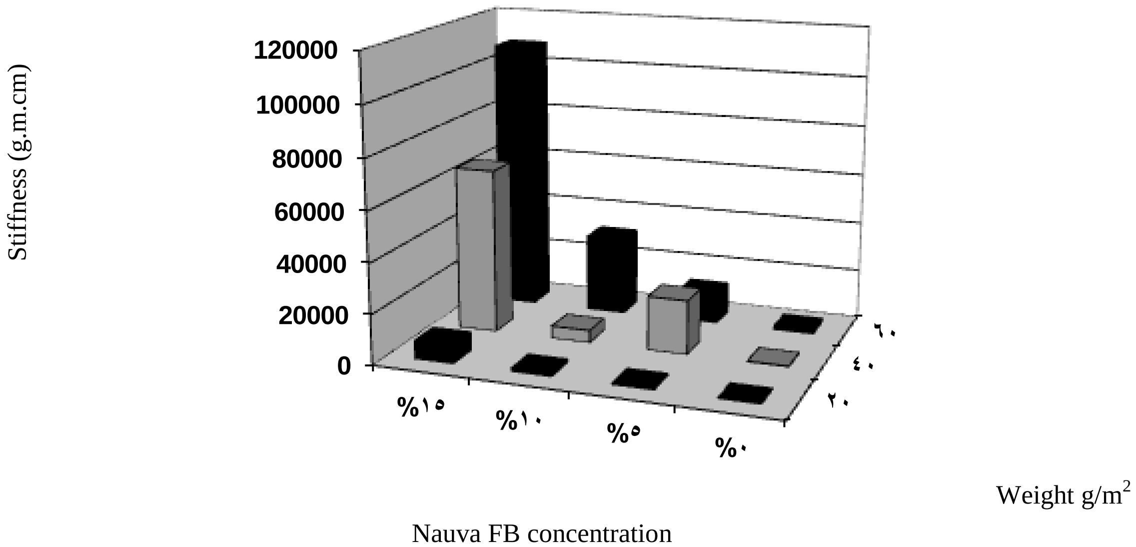



**Fig (7)**
**Effect of concentration and weight on stiffness for viscose samples**

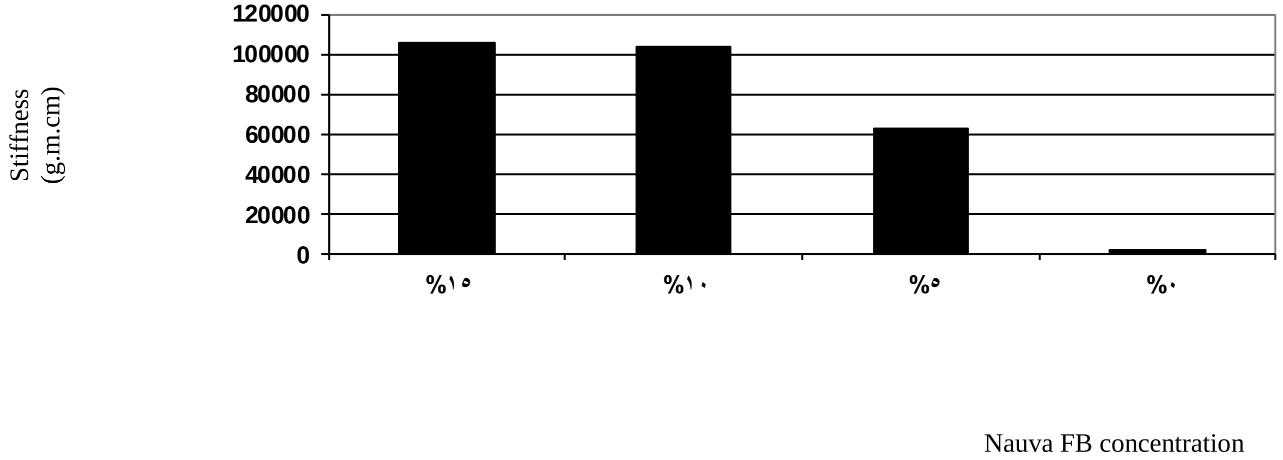



**Fig (8)**
**Effect of concentration and weight on stiffness for samples blend with polyester and viscose**