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BENDING LENGTH, WICKING AND WATER ABSORBENCY PROPERTIES OF SODIUM CHLORIDE (NACL) SALT IMPREGNATED GAUZES

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Abstract: *In this study, sodium chloride (NaCl) solutions with different weight pecentages (1, 3, 5 and 10 wt %) were prepared. Gauzes were impregnated with different salt loadings and samples were padded at around 100 % pick-up ratios. The samples were let dry in 130 Cº for three hours and desiccated for 8 hours prior to testing. Absorption tests, wicking length tests, and Cantilever bending strength tests were evaluated. Absorption tests were evaluated according to droplet testing measurements. Wicking tests are good indicators of moisture transport in fibrous structures. Wicking length tests were only conducted in warp direction as the gauzes used as samples were narrow width woven structures. Gauzes need good absorption, good moisture transport and good pliability properties. Bending length results of impregnated gauzes were obtained from Cantilever method. The bending strength test shows flexibility with decreased bending lengths and stiffness with increased bending length values. Wicking heights increase as salt solutions have higher percentages, this might show that the samples have good moisture transport which is a necessary property in gauzes. Bending length increases with saline loading on impregnated samples and the flexibility properties of gauzes decrease as salt loading is increased. Flexibility is related to pliability and the increase in bending length is a challenge that have to be taken into account when using saline loaded bandages in wound healing as they will be stiffer.*
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Key words: *Gauze, medical textile, cotton, narrow width open structure, droplet testing, pliability.*

1. INTRODUCTION

Textiles are materials that not only find traditional applications but also technical applications including medical usages. Medical textiles or “biotextiles” are technical textiles that have medical or hygiene purposes. There are many ways to classify medical textiles as there is a wide range of medical textile products. One major classification of medical textiles has three main subclasses: surgical medical textiles (implantable medical textiles, non-implantable medical textiles), extracorporeal medical textiles, and healthcare-hygiene medical textiles [1].

Gauzes are among non-implantable medical textiles. Gauzes are used not only as absorbents but also as dressings in the medical sector [2]. Gauze is an open-weave structured, lightweight technical textile. Gauze fabric might be manufactured in woven or non-woven form, the fiber type of gauzes might be cotton or viscose [3]. As a result there are many types of gauzes in the medical market such as plain gauzes, paraffin-coated gauzes, saline-impregnated gauzes, and combat gauzes.

Absorbency is the ability of textiles to take fluid in their structures [4]. Beside of absorbency, good moisture transport is an important feature depending on the usage purpose of the gauze. Moisture transport determination is important as wounds are subjected to gauzes in multiple plied structures that still need a certain amount of moisture transport. Wicking test is a method that indicates moisture transport of textile materials [5].

The Cantilever bending length and bending strength measurement method is a commonly used testing method to have idea about the flexibility and stiffness of technical textile materials including medical textiles. A gauze needs to be pliable; and as the material gets more flexible and so "less stiff", plying the gauze will get easier. The flexural rigidity of a fabric is its resistance to bending. A greater resistance to bending feels stiffer [3].

M. Mumtaz et al (2023) investigated the efficacy of a kaolin-impregnated gauze in cardiac surgery and concluded that the kaolin-impregnated gauze performed well for mild (grade 1) to moderate bleeding (grade 2) in cardiac surgery compared to a control gauze as the procoagulating kaolin quickened the clotting process [6].

A.L. Strong et al (2018) studied the antibacterial efficacy of quaternary ammonium salt (QAS) impregnated gauze. Gauze samples were soaked in QAS solutions and let to dry within 24 hours and QAS impregnated gauzes were applied over the patient drains and observed with daily drain washing procedure and impregnated gauze change intervals for six days. Regular showering, drain washing with saline solutions and applying nonimpregnated gauzes daily to control group was also carried out for result comparison. The study proved that QAS impregnated gauze reduced bacterial colonization in cardiac patients for the short term study [7].

S. Kittinaovarat and W. Pinduang (2019) coated modified and unmodified cotton gauzes with silver chloride (AgCl), they modified cotton with carbocymethylation and applied ultraviolet irradiation to fix the coating process of the silver chloride onto cotton gauzes. Silver chloride coated gauzes, both modified and unmodified ones, performed good antibacterial efficacy against Staphylococcus Aureus and Eschericia Coli bacteria [8].

M. Alavi et al (2014) studied the wound healing and coagulation efficacy of bentonite and halloysite mineral impregnated gauzes. The researchers impregnated sterile gauzes into bentonite-halloysite-petroleum jelly (Vaseline) mixtures to obtain impregnated gauzes and sterilized them at 160 degree Celsius for two hours. Researchers concluded that wound healing was around 10 to 12 days and clotting time shortened with bentonite-halloysite impregnated gauzes [9].

W. Zheng et al (2021) produced a natural-materials based wound dressing using a simple layer-by-layer method to obtain coating of carboxymethyl chitosan-gelation-alginate on cotton gauze and concluded that this coated gauze was a possible candidate for wound dressing [11].

V.G. Reddy et al (2022) studied the effectiveness of normal saline and honey gauze dressing by wetting gauze dressings in normal saline solutions and commercially available tubed honey. Researchers concluded that normal saline is a better wound dressing material compared to honey as saline is a natural and cost-effective material for gauze dressings [12].

Natural sourced candidates for gauze impregnation such as kaolin, honey and natural extracts of pomegranate peels and olive leaves extract, chitosan, alginate and gelatin are being studied as antibacterial and wound healing natural materials [6, 9-12].

In this study, the aim is to assess water absorbency properties and bending length values of NaCl salt impregnated gauzes.

2. EXPERIMENTAL APPROACH

2.1 Materials and Method

Cotton gauzes at narrow width woven form having 10 wefts/cm and 10 warps/cm were used as received. NaCl was pure from Company Riedel-de Haen. Distilled water was used to form, sodium chloride (NaCl) solutions with different weight pecentages (1, 3, 5 and 10 wt %) were prepared. Gauzes were impregnated with different salt loadings and samples were padded at around 100 % pick-up ratios. The samples were let dry in 130 Cº for three hours and desiccated for 8 hours prior to testing. Absorption tests, wicking length tests, and Cantilever bending strength tests were evaluated. Absorption tests were evaluated according to droplet testing measurements.

The Cantilever bending test method, devised by Pierce, is testing a 20 x 2.5 cm sized fabric sample on a smooth low-friction surface of the cantilever platform (Figure 1). The fabric sample is advanced by the ruler and the length on the ruler "L" is the length when the sample touches the angled surfaces mirror lines. Bending length "C" is calculated as L/2 according to the method devised by Pierce.

Fig. 1. The Cantilever platform for bending length tests

The cotton gauzes were impregnated in saline solutions and padded at padded at around 100 % pickup ratios at a laboratory type pad batch equipment, brand Kucuker Company. Samples and their codes are shown in Table 1.

Table 1 samples and codes

Sample code	**Salt solution weight %**	**Salt (g) in solution**	**Deionized water (g) in solution**
G_control	_	_	100
G_s1	1 wt%	1	99
G_s3	3 wt %	3	97
G_s5	5 wt %	5	95
G_s10	10 wt %	10	90

2.2. Method

A gauze needs to be soft, pliable and absorbent [2]. Absorbency is a textile material's ability to take a fluid in its structure similar to a sponge's fluid intake [4]. Absorbency testing is a biased subject as the fluid amount and the absorbency time depends upon needs of the application usage. Absorbency testing methods include droplet test methods and sinking time methods.

For water absorption tests, droplet test time test was carried out for one layer gauzes as well the absorbed area is measured on width and length of elliptic shapes formed by the droplet on gauzes. The droplet test time and test method are valid for various applications for absorption. Droplet test method for hydrophility ranking was carried out according to the Turkish Standard TS

866. According to the sinking time test method, the textile material is released from 10 mm height onto the water reservoir surface, the time is watched and recorded for the accurate time needed for the fibrous material to be wetted and completely immersed. At least three measurements are required. Ratings are as: 0 to 50 seconds to immerse is very good, 50 sec to 100 sec is average and 100 sec and more is regarded as low hydrophility rate according to TS 866. Table 2 shows results for droplet testing for absorbency in terms of hydrophility.

Table 2. Droplet time test results of samples

Sample code	Absorbing time (sec)	Absorbed elliptic area (cm x cm)
G_control	41.08 ± 06.32	5.66 ± 0.51 x 3.30 ± 0,27 cm
G_s1	44.29 ± 13.57	5.17 ± 0.42 x 3.13 ± 0,21 cm
G_s3	47.12 ± 07.53	4.86 ± 0.37 x 3.55 ± 0,23 cm
G_s5	49.12 ± 08.24	4.61 ± 0.24 x 2.88 ± 0,12 cm
G_s10	55.38 ± 12.32	4.40 ± 0.42 x 3.42 ± 0,13 cm

As wicking tests are a sign of good moisture transport, wicking tests were conducted with wicking height on the warp direction of narrow-width woven gauzes using 1wt% potassium chromate deionized water solutions. The wicking heights according to time intervals are listed in Table 3.

Table 3. Warp direction wicking heights according to time intervals

Sample code	Wicking heights (mm)			
	10 sec	30 sec	60 sec	300 sec
G_control	4.5 ± 0.71	11.5 ± 2.12	17 ± 1.41	38 ± 4.24
G_s1	5.3 ± 0.49	13.7 ± 1.98	21 ± 2.27	43 ± 3.86
G_s3	5,6 ± 0.61	13.8 ± 2.14	34 ± 2.48	57 ± 2.73
G_s5	6.1 ± 0.56	15 ± 1.74	49 ± 2.06	69 ± 2.91
G_s10	7.5 ± 0.72	18 ± 2.83	58 ± 2.82	77 ± 3.53

Bending length gives idea about the pliability of textile materials. Bending length is tested for gauzes. Results of the Cantilever bending length “C” are given in Table 4. There is a slight increase in sample stiffness due to saline solution impregnation process. Stiffness increase means there is a decrease in flexibility with saline loading. The saline loading is a drawback as the necessary pliability is adversely affected by saline loading.

Table 4 results for bending length of gauze samples

Sample code	**“C” bending length (cm)**
G_control	1.46 ± 0.06
G_s1	1.56 ± 0.16
G_s3	1.63 ± 0.47
G_s5	1.68 ± 0.24
G_s10	1.75 ± 0.12

2.3. Results

Droplet testing results show an increase in absorbing time and a slight decrease in absorbed area by the droplet with saline solution wt % increase. Table 3 gives the wicking heights of samples, only in warp direction. Wicking heights increase as salt solutions have higher percentages, this might show that the samples have good moisture transport which is a necessary property in gauzes. Bending length increases with saline loading on impregnated samples and the flexibility properties of gauzes decrease as salt loading is increased. Flexibility is related to pliability and the increase in bending length is a challenge that have to be taken into account when using saline loaded bandages in wound healing as they will be stiffer.

3. CONCLUSION

Wound healing and absorption of gauzes depends on patient to patient as the amount and type of fluid exudates show a wide variety depending on acuteness of the wound. Specific saline loadings might be preferred for different wounds. Further investigation is aimed for antibacterial and antiviral efficacy of saline loaded gauzes.

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