IOP Conf. Series: Materials Science and Engineering **275** (2017) 012042 doi:10.1088/1757-899X/275/1/012042

Effect of Bamboo Viscose on the Wicking and Moisture Management Properties of Gauze

Abdul R Akbar[1, 2], Siwei Su[1], Bilal Amjad[2], Yingjie Cai[1, 3] and Lina Lin[1, 2, 3 *]

[1]Hubei Provincial Engineering Laboratory for Clean Production and High Value Utilization of Bio-based Textile Materials, Wuhan Textile University, Wuhan 430073, China
[2]College of Textile Science and Engineering, Wuhan Textile University, Wuhan, 430200, China
[3]Engineering Research Centre for Clean Production of Textile Dyeing and Printing, Ministry of Education, Wuhan Textile University, Wuhan, 430073, China
Email: linalin@wtu.edu.cn

Abstract: Bamboo viscose or regenerated cellulose fibers were used to check their absorbency properties effect on the wicking and moisture management in gauzes. Bamboo viscose and cotton fibers were spun into five different yarn samples with different fiber proportion by ring spinning. Fifteen different gauze samples were made of these yarn samples. The gauze samples were subjected to wicking test to check the wicking ability. Water vapor transmission test was applied to check the vapor transmission rate. These tests were applied to measure the effectiveness of bamboo viscose, cotton and blended gauze samples in wound healing. Pure bamboo gauzes and gauzes with high content of bamboo fiber, i.e. 75B:25C and 50B:50C, shows better wicking and vapor transmission properties. It makes gauzes with high bamboo viscose suitable for wound care applications because of moisture absorbency.

1. Introduction

The presence of the naturally occurring antimicrobial bio-agent, named as bamboo “Kun” makes bamboo fiber anti-microbial, order resistive and antifungal. “Kun” decreases the unpleasant odour causing bacteria on fabric and human skin [1]. Regenerated bamboo fibers from bamboo pulp have same processing method as ordinary viscose fiber so called as bamboo viscose fibers [2].

The medical application of bamboo has long history. Due to presence of phenolic compounds in chemical continents bamboo have shown antibacterial activities against both Gram-positive and Gram-negative bacteria. Some studies reported antimicrobial activity of charcoal and bamboo vinegar as well [2, 3]. Industry stakeholders presented different bamboo fabrics claiming their anti-microbial and eco-friendly behaviour. Some claimed the presence of hydroxyl group (-OH) in bamboo fibers but they all are unable to provide scientific evidences. Repeated technological analysis has shown that fibre has a fineness and whiteness grade close to normal bleached viscose also possess strong durability, stability and tenacity [3, 4]. Bamboo fabric is characterized by its good hygroscopicity, excellent permeability, soft feel, easiness to straighten and dye and splendid colour effect of pigmentation [3, 4]. Moisture management is an essential feature of gauze fabric regarding its wound management capability. A quantitative antibacterial capability test for bamboo fabrics at China Industrial Testing Centre (CTITC) showed that 100% bamboo fabric exhibits 99.8% antibacterial kill rate. Studies by the Japan Textile

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

Inspection Association (JTIA) revealed long-term antibacterial efficacy of greater than 70% bamboo fabric.

Gauze, a thin, lightweight fabric having open woven structure is usually made of natural fibers such as cotton, linen and silk. It can be also made of synthetic fibers. Gauze fabric may be manufactured through one of two methods: the simple leno weave and the plain weave but manufacturing of gauze by leno weaving method is mostly used. Through this process, the threads of the fabric cross over one another, interlacing with one or more filler threads to give the fabric a sheer appearance while making it stronger. This type of weave makes the fabric lightweight and stronger while still allowing light and air to pass through it freely [3]. Plain woven fabric is created on a loom by interlacing the warp threads tightly with the weft threads. The woven fibers of this weave produce a flat, tight surface suitable for printing and other finishes. The plain weave is the simplest to produce, making it the least expensive [5].

Wounds heal better in a moist environment. Nerve endings are protected and skin layers repair at a faster rate producing less scarring than in dry wounds. As part of the normal healing process wounds release fluid (or exudate). Too much exudate (maceration) or too little exudate (desiccation) can interfere with wound healing; therefore, it is important to manage moisture levels, particularly in chronic wounds. Selection of a dressing normally gauze is based on specific wound characteristics; the presence or absence of necrotic tissue, bacterial load, exudate volume and need for a bacterial barrier [6]. Therefore, the optimal dressing should be able to control exudate without desiccating the wound surface, act as a bacterial barrier, allow a traumatic removal with no dressing left in the wound, and provide moisture vapor permeability sufficient to prevent over hydration of the wound and surrounding skin. There are a multitude of dressings on the market and clinicians are frequently confused as to which type of dressing is the best for a particular wound. Effective dressing selection requires both accurate wound assessment and current knowledge of available dressings and these gauzes may contribute in that aspect.

These unique antimicrobial properties, natural effects of sterilization and bacteriostasis of bamboo fiber make potential of using bamboo fiber for making sanitary materials include bandage, mask, surgical clothes, nurse's wears, on application in sanitary material absorbent pads, food packing and so on. In the medical scope, it can be processed into the products of bamboo fiber gauze, operating coat, and nurse dress, etc. The finished products do not need to be added with any artificial synthesized antimicrobial agent, so it will not cause the skin allergy phenomena. Thus this experiment is conducted to check the potential of bamboo fiber gauzes in moisture management and wicking abilities and to compare these properties of bamboo, cotton and cotton & bamboo blended gauzes.

2. Experimental

2.1. Materials and Machine

Bamboo viscose (regenerated bamboo) and cotton fibers needed to make five different samples of yarn. Different machines were used in spinning process of yarn samples included blowroom, card, draw frame, simplex, ring machine, and winding machine. Sample loom was used to weave fifteen different plain 1/1 gauze fabric samples. Jigger machine was used to scouring and bleaching gauze samples. For tensile strength test of gauzes "universal tensile strength tester" was used. Wicking test performed with the help of red dye solution. Lea strength tester, wrapping real, twist tester were used for testing yarn properties.

2.2. Methods

Ring spinning technique was used to prepare 100% cotton, 100% bamboo, 50:50 cotton: bamboo, 75:25 cotton: bamboo and 25:75 cotton: bamboo yarn samples of 30 Ne count (Table 1). These yarn samples were weaved into different fifteen gauze fabric samples with the help of sample loom.

On the jigger scouring and bleaching was done and then wicking test is performed with the help of red dye solution. Water vapor transmission test was applied to check the ability of gauze fabric samples of vapor transmission. The purpose of wicking and water vapor transmission test was to check and compare the results of gauzes to manage the healing of wound with the help of wicking and vapor transmission abilities. Fifteen different gauze samples can be seen in Table 2.

2.3. Lea Strength Test

A lea strength tester measures the strength of one lea (120 yds.) of yarn. Strength is a measure of the steady force necessary to break a material and is measured in pound. The lea strength tester works in constant rate of extension. The maximum strength which was achieved was of the 100% bamboo yarn.

Table 1. Developed yarn samples of Ne 30 count.

S. No.	Samples	Lap Weight (Ounce/yard)	Roving Count	TPI	CLSP
1	100% Cotton	14	1.2	28.3	2009.60
2	75% Cotton : 25% Bamboo	9	1.1	25.3	2207.17
3	25% Cotton : 75% Bamboo	15	1.13	23.4	2309.13
4	50% Cotton : 50% Bamboo	17	1.19	22.3	1795.85
5	100% Bamboo	22	1.17	21.22	2376.12

Table 2. Fifteen gauze samples.

S. No.	WARP	WEFT
1	50C:50B	100C
2	50C:50B	100B
3	50C:50B	50C:50B
4	25C:75B	50C:50B
5	25C:75B	100C
6	25C:75B	100B
7	100C	100C
8	100C	50C:50B
9	100C	100B
10	100B	100B
11	100B	50C:50B
12	100B	100C
13	75C:25B	50C:50B
14	75C:25B	100B
15	75C:25B	100C

2.4. Wicking Test

Wicking test performed to evaluate the wicking ability of vertically or horizontally aligned test specimens, exposed to distilled or deionized water over a period of time, where wicking is influenced by gravity [6]. The rate (distance per unit of time) liquid travels along and/or through a vertical fabric specimen was visually observed, manually timed and recorded at specified intervals. Test specimens of 5 cm x 1 cm were cut and dipped 1cm into the red dye solution and after one minute the level penetration of dye solution on the surface of sample was noted.

2.5. Water Vapor Transmission Test

It is the measurement of the amount of moisture vapor in grams that pass (breathe or permeate) through an area of fabric in 24 hours at specified temperature and humidity [6]. 200 g water was filled into the glasses which then were sealed with the test specimen. Then weight of water was measured before placing in controlled atmosphere. Periodically weighed and noted down the values to calculate the gram of water vapor transmitted through the samples in 24 hrs.

3. Results and Discussion

3.1. Twist per Inch (TPI) of Yarn Samples

Twist is an important factor to impart strength in yarn. The TPI values of yarn samples are shown in figure 1. Due to lower strength of cotton fibers the cotton yarn with 30 Ne need more twist to be imparted than same count bamboo yarn. Bamboo fibers also have greater length compared to cotton other than greater strength. The increase in ratio of the bamboo fiber decreases the twist insertion because of the addition of bamboo fibers with longer lengths.

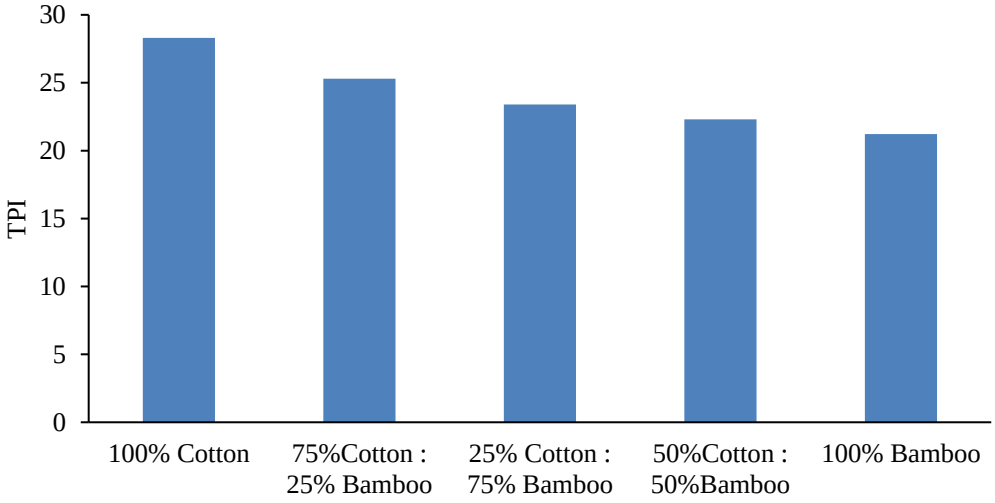

Figure 1. Twist per inch of developed 30 Ne yarn samples.

Lea strength of all five samples was measured on lea strength tester. The figure 2 shows that the 100% bamboo yarn has the highest strength because of the higher strength of fibers is better than cotton. Higher the contents of bamboo fibers in the yarn higher the strength.

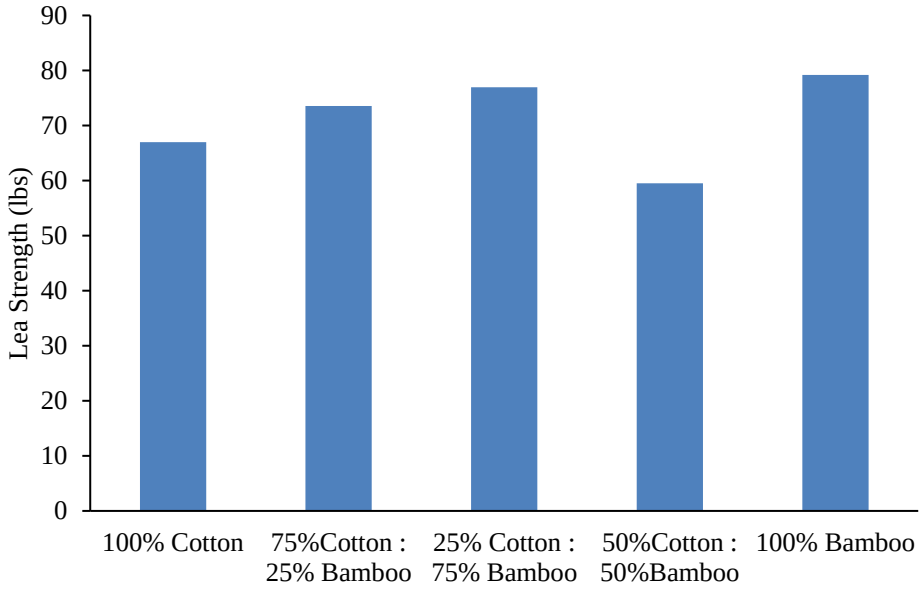

Figure 2. Lea strength of developed 30 Ne yarn samples.

3.2. Wicking

Absorption of exudate by wound dressings from wound is very important for wound healing because if proper wound management is not done, it can cause oppression, adhesion and swelling. All the fifteen were tested and results are shown in figure 3. Wicking ability of samples with 100% bamboo fiber is showing highest value due to the ability of bamboo fibre's to wick the exudate from wound while gauze made from 100% cotton fibers shows the lowest wicking value. Blended samples with high ratio of bamboo fiber i.e. samples with 100% bamboo in warp etc. showed high wicking value. Results from wicking test showed that by using 100% bamboo yarn or yarn with high ratio of bamboo fiber: we can make gauzes which would have high ability to wick exudate from wound which is very important to heal the wound.

The better wicking properties by fabric samples with higher contents of bamboo fiber can be attributed to the lower twist levels in the yarns having more bamboo fibers proportion. The more the bamboo fibers lower the twist imparted, as discussed above, leads to more capillaries inside the yarn between fibers. Higher twist increases the yarn compactness and reduces inner spaces between fibers. Lower the capillaries lower the wicking ability and large size capillaries allow more fluid to be passed through them. The fabric sample with 100% bamboo fibers in both weft and warp shown highest values of 2.83 cm of dye penetration, this is due to larger capillaries in bamboo yarns and also due to the natural ability of the bamboo fibers of absorbing moisture.

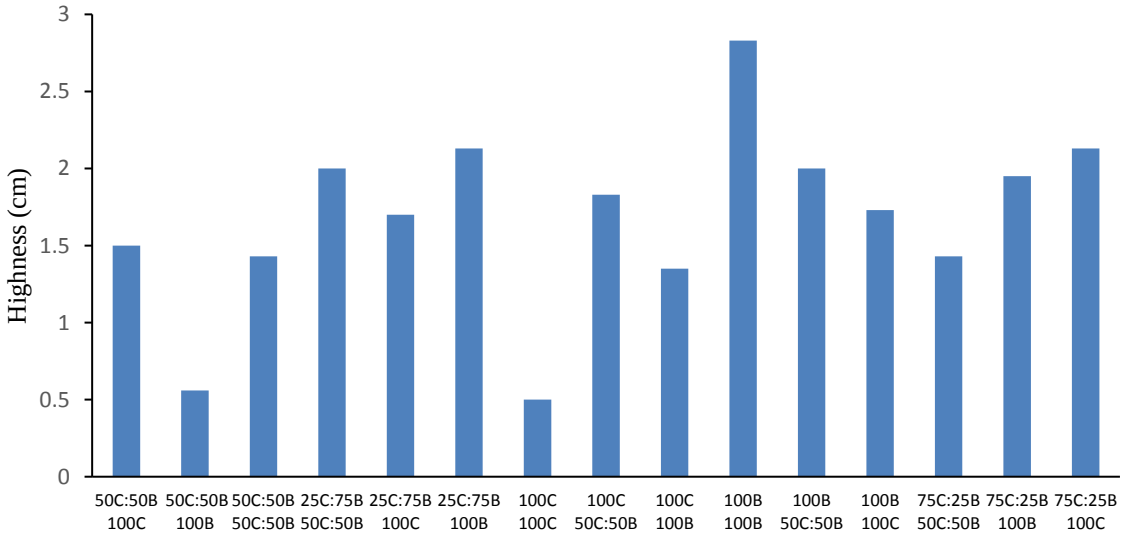

Figure 3. Dye penetration of developed gauze samples.

3.3. Water Vapor Transmission

Moisture vapor transmission should be a quality of gauze because moisture management of a wound is an important factor in healing a wound. High rate of moisture vapor transmission would minimize the bacterial growth so that there will be less chance of infection. Weight (g) of evaporated water through developed gauze samples is shown in figure 4. Results of water vapor transmission test show that samples with higher ration of bamboo fibers in it have better vapor transmission rate. This is due to low twist in yarns with higher bamboo fibers and natural quality of bamboo fiber to moisture absorption and better transmission property. Due to low twist in bamboo yarn, fibers are packed with less complexity into the yarn that's why bamboo gauze showed a higher vapor transmission rate. Also high vapor transmission rate is due to the bamboo fiber structure. Other samples with high ratio of bamboo fibers also show a good water vapor transmission rate. Results of this test clearly give an idea of good moisture

vapor transmission rate of bamboo gauzes which would be greatly helpful to understand the ability of bamboo gauzes of wound healing.

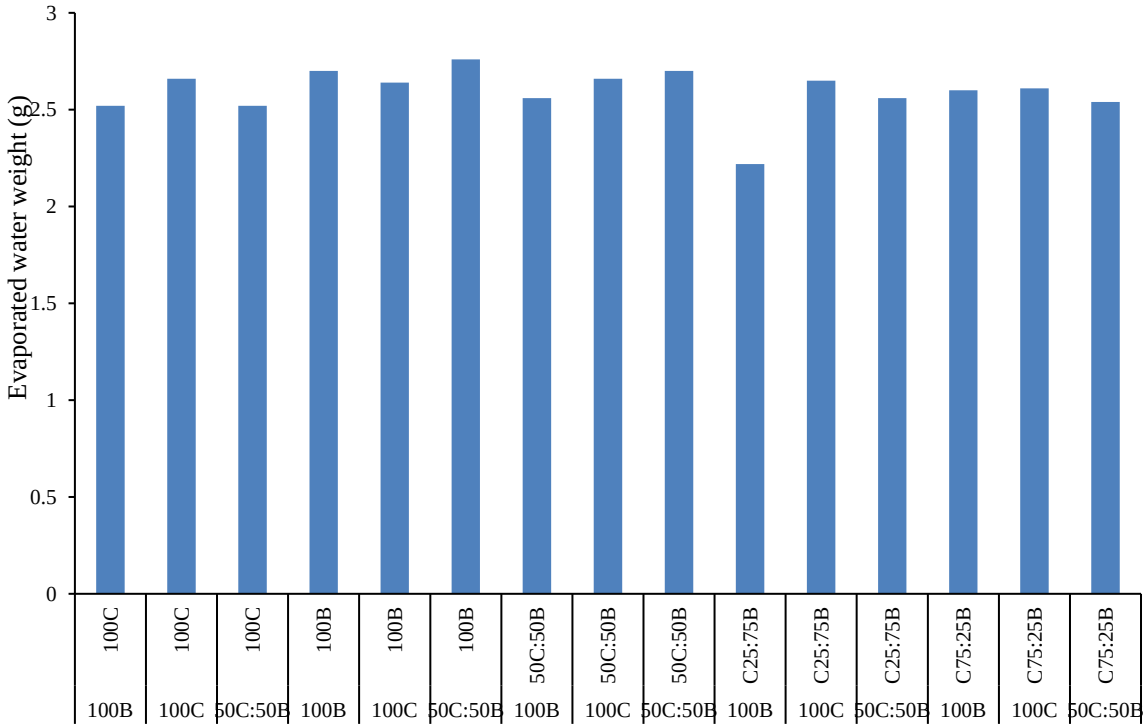

Figure 4. Weight of evaporated water through developed gauze samples.

4. Conclusion

Gauzes made of 100% bamboo found to be very impressive in wicking properties. Blended samples having high ratio of bamboo fiber (75B: 25C) shows good wicking properties. Also 100% bamboo fiber gauzes show highest vapor transmission rate which shows the potential of bamboo gauzes in wound care. Samples with high ratio of bamboo fiber shows good vapor transmission rate. 100% bamboo gauzes and gauzes having high ratio of bamboo fiber shows good wicking and vapor transmission rate; these gauzes can be used for effective wound care.

5. Acknowledgement

This work was financially supported by the China National Textile & Apparel Council (2013 “Textile Vision” Applied Basic Research, 2013-153); Hubei Province Science and Technology Support Program (Grant No. 2013BAA043) and the Collaborative Innovation Plan of Hubei Province for Key Technology of Eco-Ramie Industry (2014-8).

6. References

[1] Erdumlu N and Ozipek B 2008 *Fibres Text. East. Eur.* **16** 43
[2] Xia L and Chun D 2012 Proc. of the 55th Int. Convention of Society of Wood Science and Technology 1
[3] Shanmugasundaram O L and Gowda R V 2011 *Fiber. Polym.* **12** 15
[4] Qamar M, Amin N, Mahmood N, Ahmad I and Abass M, 2015 *J. Text. Sci. Eng.* **5** 41
[5] Tsuzuki A, Kanwar T and Wang R K 2012 *J. Text. I.* **103** 844
[6] Gericke J. van 2010 *JFECS* **38** 63