

Characterization of Mechanical Properties of Blended Yarn Developed from Anti-Microbial Viscose and Bamboo Fibers for PPE Suit

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Abstract - The aim of personal protective equipment is to act as a layer of protection for the healthcare workers and act as a barrier from contact with the biological hazards. These PPE are mostly nonwoven made by polymer fibers since it has good protection but these nonwoven PPE are disposable and non-biodegradable. Also the strength of non-woven fabrics are comparatively low. The regenerated bamboo fiber possess natural anti-microbial properties and has been used in the production of medical textiles. The new age anti-microbial fiber, where the anti-microbial agent has been injected in the regenerated viscose fiber tends to be high protective. The mechanical properties of yarn is so important in the development of woven PPE. The fabric weave should be more compact structure to act as a barrier and the yarn used should be of fine count so that the thread count of the fabric can be higher. Higher the thread count, more compact weave can be achieved. Thus in this paper the mechanical properties of yarn developed from the bamboo fiber, anti-microbial fiber and its different blend ratio of 50:50, 65:35 and 35:65 has been studied. The mechanical properties of yarn such as yarn count, yarn twist, yarn strength and elongation has been analyzed for five samples and the result conclude the best for the development of reusable PPE.

Key Words: Tensile strength, mechanical properties, bamboo fiber, anti-microbial viscose

1. INTRODUCTION

The main function of a protective clothing used by the medical personals is to protect them from biological hazards such as bacteria and virus while treating the infected patients. At the same time they should possess good comfort and strength as they are wearing these clothing for a prolonged period of time. The medical protective clothing are mostly non-woven fabrics made of polymer fibers and they do not have good comfort and they are non-reusable and non-biodegradable products. To replace this types of fabric, a sustainable oven reusable fabric can be developed. For the development of reusable fabric, proper type of fiber properties and yarn properties should be selected to achieve high protective clothing. The bamboo fiber has good anti-microbial property by its nature and the fiber is also hydroscopic, hypoallergenic and a natural deodorizer and used in many applications of medical textile [1]. The latest innovation by the Birla cellulose is the anti-microbial fiber, where the anti-microbial agent is injected into the staple

viscose fiber. This anti-microbial fiber tends to be more protective to the wearer from bacteria and virus, lasting over multiple washes while retaining comfort, fluidity and softness of the fabrics [2]. They type of spinning, yarn count, yarn twist, yarn strength and elongation are the important parameters which determine the strength of the fabric to be developed. Thus in this paper the mechanical properties are tested for five different ring spun yarn samples of count 40's Ne.

2. LITERATURE REVIEW

Bamboo fiber is an eco-friendly and biodegradable fiber with anti-fungal and anti-bacterial properties. It is a hydroscopic fiber and have high strength comparable to conventional glass fiber. The surgical wear developed from 100% bamboo fiber results in inhibiting bacteria growth with good tensile property and provide better hygiene and safety for the hospital workers [3]. The bamboo fiber also have great advantage over thermoregulation property. The viscose fiber has been tested for its comfort and mechanical properties and it is found that due to its lesser crystallinity and more amorphous region, they lack in strength [4]. The anti-microbial injected viscose fiber inherently possess anti-microbial properties which inhibits the growth of microbes (bacteria and virus) on textile, and kills them to the extent of 99% [2]. Another important property of PPE is its strength. Since, the health care workers were working for a longer period of time during a pandemic, their clothing should have good strength and flexibility, retaining their comfort state. To achieve good strength of the fabric, with good protection, the fabric weave should be tightly woven, which provides more compact structure to act as a barrier [5] and the yarn used should be of fine count so that the thread count of the fabric can be higher. Higher the thread count, more compact weave can be achieved. The mechanical properties of ring spun yarn and its strength was comparatively higher than rotor spun yarn in relation with yarn count, yarn twist and strength of long-staple fibers, it results in high precision of relative strength of yarn [6,7]. The physical properties of bamboo yarn including breaking tenacity and elongation at break decreases as the yarn becomes thinner. So that the yarn count in ring spinning is most important parameter to obtain good strength of yarn [8, 9]. And the elongation vales of bamboo yarn are relatively high. TPI helps to determine the fabric property. The increase in TPI decrease the strength [10].

3. MATERIAL AND METHODOLOGY

The Bamboo fiber is sourced from Pallava Group, Erode. It is a recycled cellulose fiber specially made from the bamboo pulp, which has the natural property of anti-bacterial and odor-proof. The Anti-microbial fiber is sourced from Birla Cellulose. Antimicrobial fibers by Birla Cellulose, are enhanced with Antimicrobial attributes at fibre stage. During the fibre manufacturing process, an active agent is injected, which becomes an integral part of the fibre and provides durable Antimicrobial properties.

Table -1: a) Physical Properties of Fibers

Fiber Properties	Bamboo	Anti-microbial Viscose
Fiber Denier	1.2 D	1.2 D
Fiber Length	38mm	38 mm
Dry (g/tex)	34.3	30
Elongation	16%	20%
Hydroscopic Nature	Absorbent	Absorbent
Moisture Regain %	13%	13%
Fibres Density (g/cm ³)	1.3	1.49

Table -1: b) Blend Ratio

Blends	Ratio
Bamboo	100
Anti-microbial	100
Bamboo: Anti-microbial	50:50
Bamboo: Anti-microbial	65:35
Bamboo: Anti-microbial	35:65

The purchased fiber are separated and converted to sliver formation using computerized carding machine. The sliver are then processed in drawframe where the 6 carded sliver are converted to one drawframe sliver. The sliver obtained from draw frame is then converted into rover using computerized simplex machine. The rover is then converted into yarn using computerized ring spinning machine.

Table -2: Roving Parameters and Ring Spinning Parameters

Roving Parameters	
Spindle Speed	400RPM
Twist	38TPM
Roving Count	1.5 Ne

Feed hank	0.2684g/m
Bobbin Speed	0% to 2%

Ring Spinning Parameters	
Spindle Speed	1100 RPM
Roving count	1.47Ne
Yarn Count	40's Ne
Twist Multiplier	4.4
Twist Direction	Z twist
TPI	27.83
Break Draft	1.7
Yarn Length	10000 meters
Yarn Contraction	1.84

4. RESULT AND DISCUSSION

The obtained yarn is taken to test its strength and elongation using Instrone tester to determine its mechanical property and also the yarn TPI is tested using yarn twist tester to measure the average twist per inch of the yarn. The testing parameters of Instrone tester is mentioned in table 3.

Table -3: Instrone tester parameters

Specimen label	Yarn Count	Rate	Length
100% bamboo	40s	40.00 mm/min	250.00 mm
100% viscose	40s	40.00 mm/min	250.00 mm
50% Bamboo, 50% viscose	40s	40.00 mm/min	250.00 mm
65% Bamboo 35% Viscose	40s	40.00 mm/min	250.00 mm
65% Bamboo 35% Viscose	40s	40.00 mm/min	250.00 mm

4.1 Tensile Strength:

The tensile strength of the yarn samples has been given in table 4. The results shows that the 100% Bamboo fiber has good tensile property of the yarn compared to other samples. Nearer to that 65 Bamboo: 65 Anti-microbial fiber and 50 Bamboo: 50 Anti-microbial fiber have good tensile values. From the results it shows that higher the ratio of Bamboo fiber higher the strength obtained for the yarn. The 35 Bamboo: 65 Anti-microfiber fiber shows the least value of strength of the yarn.

Table -4: Tensile strength values of yarn samples

Sl. no	Blend Ratio/ Bamboo: Anti-microbial	Tenacity at Maximum Load (gf/tex)	Standard Deviation	Coefficient of Variation
1.	100 % Bamboo	13.370	3.37108	25.18965
2.	100% AM	9.747	2.57734	19.68031
3.	50:50	10.944	2.93424	23.57985
4.	65:35	12.207	3.75541	24.86343
5.	35:65	9.078	2.98326	20.25883

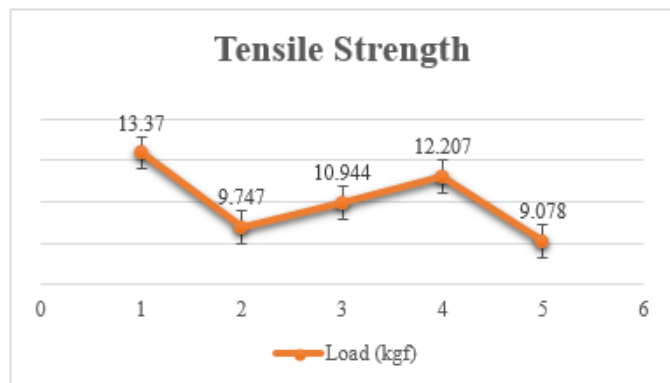


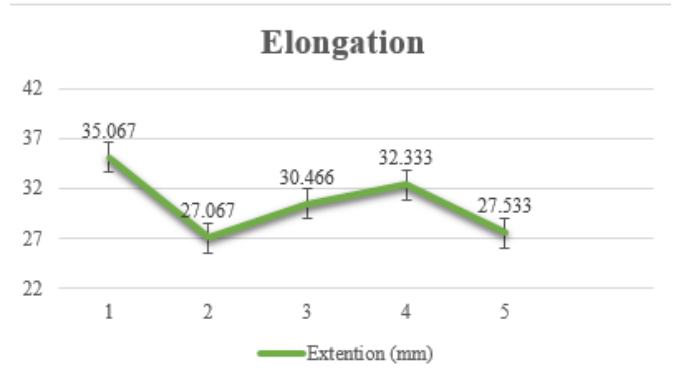
Chart -1: Tensile strength range of five yarn samples

4.2 Elongation

The Elongation values of the yarn samples has been given in table 5. The results shows that the 100% Bamboo fiber has higher extension of the yarn compared to other samples. Nearer to that 65 Bamboo: 65 Anti-microbial fiber and 50 Bamboo: 50 Anti-microbial fiber have good elongation property. From the results it shows that similar to tensile strength, higher the ratio of Bamboo fiber higher the elongation of the yarn. The 100% Anti-microfiber fiber shows the least value of elongation of the yarn.

Table -5: Elongation property of yarn samples

Sl. No	Blend Ratio/ Bamboo: Anti-microbial	Extension at Maximum Load (mm)	Standard Deviation	Coefficient of Variation
1.	100 % Bamboo	35.067	13.81782	78.27360
2.	100% AM	27.067	8.93353	62.03902
3.	50:50	30.466	9.27360	70.51592
4.	65:35	32.333	10.03418	71.15717
5.	35:65	27.533	7.29493	51.68726



4.3 Twist Per Inch (TPI):

The TPI of the yarn samples has been tested using Twist Tester. The obtained results are given in table 6. From the results it shows that 65 bamboo: 35 Antimicrobial fiber has TPI of 18.4. Next to that 100% Bamboo and 50:50 blend fiber has TPI of 19.1 and 19.8. The 100% Anti-microbial fiber and 35:65 blend shows higher TPI of 21.2.

Table -6: Twist Test

Sl. no	Blend Ratio/ Bamboo: Anti-microbial	Twist Per Inch
1.	100 % Bamboo	19.1
2.	100% AM	21.2
3.	50:50	19.8
4.	65:35	18.4
5.	35:65	21.2

5. CONCLUSIONS

The yarn properties such as yarn strength and elongation and yarn twist for five different samples has been analyzed and it is found that higher the ratio of bamboo has higher the strength and elongation of yarn. The weaving performance is depending on the quality of yarn. The even twist and more parallel yarn helps to obtain good efficiency and less fabric damages. As TPI increases the tenacity and strength gets decreases. Thus from the results obtained 100% Bamboo, 65 Bamboo: 35 Anti-microbial and 50 Bamboo: 50 Anti-microbial fiber has higher strength and elongation and lower TPI compared with other blend and suitable for the construction of reusable PPE with good strength and elongation property.

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