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Study of moisture management properties of bamboo, wool and cotton trilayer knitted fabrics

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K E Y W O R D S

Moisture management

Micro denier polyester

Bamboo

Cotton

Comfort

A B S T R A C T

Moisture management is a critical feature of any sportswear, as it improves the fabric's comfort level. Comfort differs from person to person depending upon the perception of the wearer. Comfort is the relation between a psychological and physiological behavior of the wearer. The moisture transmission of the fabric is the key determinant of thermophysiological comfort. The moisture management features of trilayer knitted fabrics constructed of a range of yarns on the inner and outer sides, including micro denier filament polyester, Monofilament, wool, bamboo, and cotton, are examined in this article. The sample B/MDPF/C, which included an inner layer of bamboo, a middle layer of Micro denier Filament polyester, and an outer layer of cotton shows appreciable moisture management property, providing an excellent comfort nature due to its appreciable property required for a moisture management fabric.

1. Introduction

The efficiency of the active sportswear increases when two or more parameters are combined together and made out to a fabric. Multi-layer fabric generally shows betterment in all properties needed for an active sportswear. Nitin et al. [1] carried out his research in bi-layer fabrics making use of combination of fibers possessing wicking and hydrophilic properties to improve moisture handle and aesthetics. His research came out with a finding that moisture vapor transmission and adsorption both are good in a bi-layer fabric. The bi-layer fabric made out of polypropylene and viscose is said to possess a better wicking behaviour, drop absorbency and stretch ability property. And air permeability is found to be good in polyester - viscose combination and thermal properties in polypropylene - cotton combination. As an outcome of this research bi-layer fabric made out of polypropylene and viscose is said to possess all characters suiting an active sportswear. The thermal characteristics of single and double layer fabrics were studied by Gupta et al [2]. In this study fabrics were layered with and without an air gap between them, and the effect of a multilayer garment was evaluated. When the inner and outer layers of the fabric are linked together, the thermal insulation rises, making the fabric more comfortable to wear. Geetha Margret and Kavitha

[3] developed a bi-layer fabric of Modal and polyester yarn and it is found that plaited jacquard fabric is better when compared to that of Interlock jacquard structure making it more suitable for sportswear with good moisture absorbency, thermal resistance and wicking property. Plaited jacquard fabric has a good absorbency and quick drying nature. The dimensional stability and wrinkle free nature is also good in this fabric. Kandhavadivu et al. [4] carried out their research work in trilayer fabrics and found that the trilayer weft knitted fabric shows good functional characteristics due to their structural factor. Geetha Margret and Kavitha [5] developed a wool and polyester bi-layer fabric. The bi-layer fabric structure is discovered to have a stronger impact on water vapour permeability. The moisture absorbency of the bi-layer knitted construction improves as the stitch density and tightness factor increases. This combination of polyester as the inner layer and wool as the outer layer produces good perspiration, making it more ideal for active sportswear. Suganthi and Senthilkumar [6] studied the comfort qualities of six uniform bi-layer textiles made of Tencel™ yarn as the outer layer and micro fibre polyester yarn as the inner layer. The bi-layer fabric with less tuck points, constructed from micro fibre polyester as the inner layer, has good air permeability, water vapour permeability, drying rate, and wick ability, as well as low thermal resistance. Also found that thickness and porosity of the fabric determines the water vapor permeability, so the thinner fabric with more pores has good water vapor permeability.

2. Materials and Methods

Three trilayer knitted fabrics were developed on a Pailung Double Knit Interlock Knitting Machine PL-KD2.5D Taiwan with 36 feeders, 28 gauges, and 84 feeders. Three samples of trilayer knitted structured fabrics were developed in which inner layer i.e. the skin contact layer was made up of Bamboo (40 s) and outer layer i.e. environment exposed layer is Cotton (40s). The middle layer yarns have been varied such as either Polyester (72 f) or Monofilament (20 D) or Wool (60s).

Table 1

Combination of trilayer knitted fabric structures

Sample code	Inner layer	Middle layer	Outer layer
B/MDPF/C	Bamboo	Micro filament Polyester	Cotton
B/MF/C	Bamboo	Monofilament	Cotton
B/W/C	Bamboo	Wool	Cotton

Moisture Management tester is used for measuring fabric moisture management properties according to the method, AATCC 195:2012. The instrument has been designed such that it measures the liquid moisture transport in multiple directions [7-8].

3. Results and Discussions

3.1 Wetting Time

A high wetting time is observed in the sample 3, i.e. B/W/C. The sample with the inner layer bamboo, middle layer of wool and outer layer of cotton. This means sweat is slowly absorbed compared to other fabrics. The top and bottom surfaces in sample 1, i.e. B/MDPF/C. The sample with the inner layer bamboo, middle layer of Micro denier Filament polyester and outer layer of cotton fabrics have the lowest wetting time values. The middle layer made from the Micro denier Filament polyester shows an excellent wicking property that supports the transfer of the sweat between the layers of the fabric. In general a hydrophilic nature is possessed by the cotton fiber having a good surface bonding nature for water molecules. The sample, B/W/C, confirms that there is a very poor transfer of liquid to the bottom layer of the fabric [9]. The bamboo generally possesses an excellent wicking property in coherence with the micro denier polyester making this sample highly suitable for moisture management.

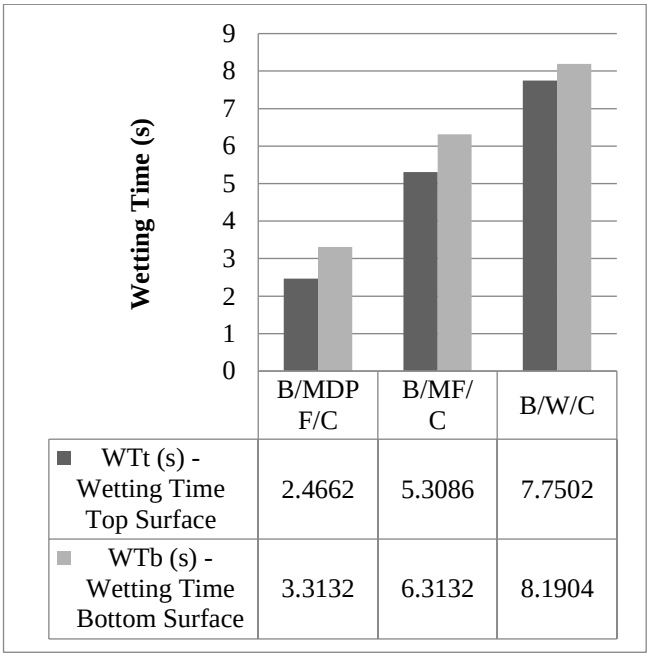
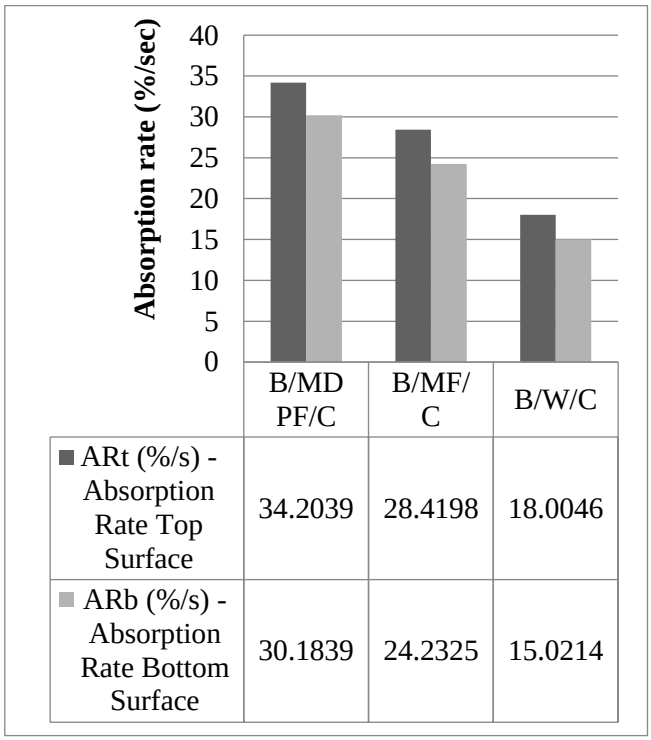


Fig. 1. Wetting time of trilayer knitted fabrics

3.2 Absorption Rate

In general the top layer of the fabric absorbs well on comparison with that of the bottom layer [10]. Fig. 2 depicts the absorption rate of the tri layer knitted fabric. In B/MDPF/C trilayer knitted fabric the absorption rate

is highly appreciable. The micro denier filament polyester which is present as the middle layer has an excellent wicking nature supporting the moisture transport between the layers. Sweat is promptly communicated by the bamboo and MDPF layer, which is in direct touch with the skin, and is well transported to the environment-exposed layer via diffusion. The passage of water from the top to the bottom surface takes longer in sample 3, B/W/C, resulting in a lower bottom absorption rate due to the thickness imposed by the wool layer. Wool fabric, in general, causes sweat to accumulate in the microclimate, causing discomfort to the wearer since sweat transmission to the exposed layer to the environment takes longer. It can be concluded that the fabric made from bamboo and micro-fiber polyester yarn transmits the sweat well through the diffusion process and transmitted to the next layers [11-13].

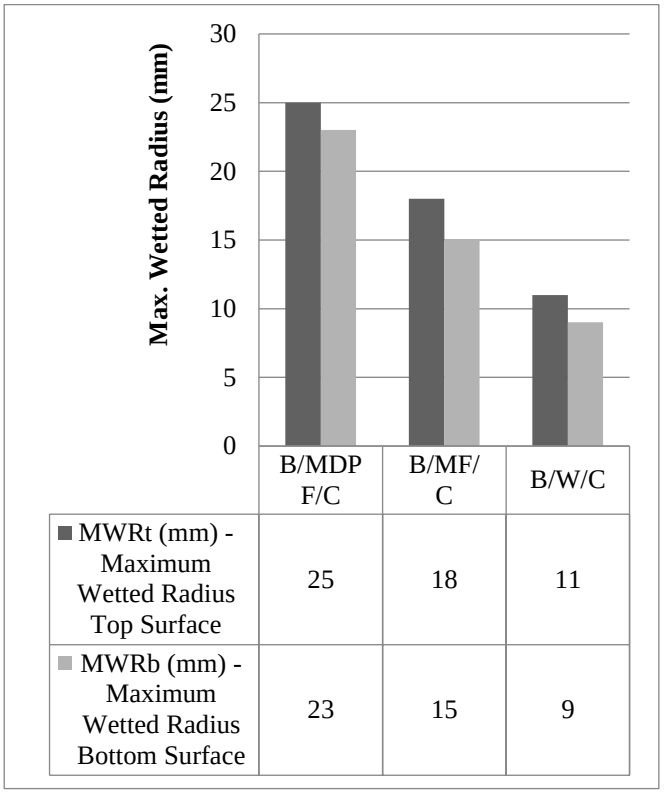


	B/MDPF/C	B/MF/C	B/W/C
ARt (%/s) - Absorption Rate Top Surface	34.2039	28.4198	18.0046
ARb (%/s) - Absorption Rate Bottom Surface	30.1839	24.2325	15.0214

Fig. 2. Wetting time of absorption rate of trilayer knitted fabrics

3.3 Maximum Wetted Radius

From the Fig. 3, the highest maximum top wetted radius values are seen on B/MDPF/C tri layer knitted fabric. The capillary forces facilitate the easy transmission of the moisture through the filamentous surface of the MDPF fibers. Because of the excellent capillary action the wetted radius on either sides of the fabric are very high. Compared to the other entire tri layer knitted fabrics, sample 1 is observed to possess higher MWR when compared to the other fabrics. The lesser diffusion property of the wool and cotton trilayer knitted fabrics as compared to other trilayer knitted fabrics is the main reason for the drop in performance. The micro filaments of the MDPF has a good capillary nature in comparison to all the other developed samples making it more suitable with a maximum wetted radius [14-15].



	B/MDPF/C	B/MF/C	B/W/C
MWRt (mm) - Maximum Wetted Radius Top Surface	25	18	11
MWRb (mm) - Maximum Wetted Radius Bottom Surface	23	15	9

Fig. 3. Maximum wetted radius of trilayer knitted fabrics

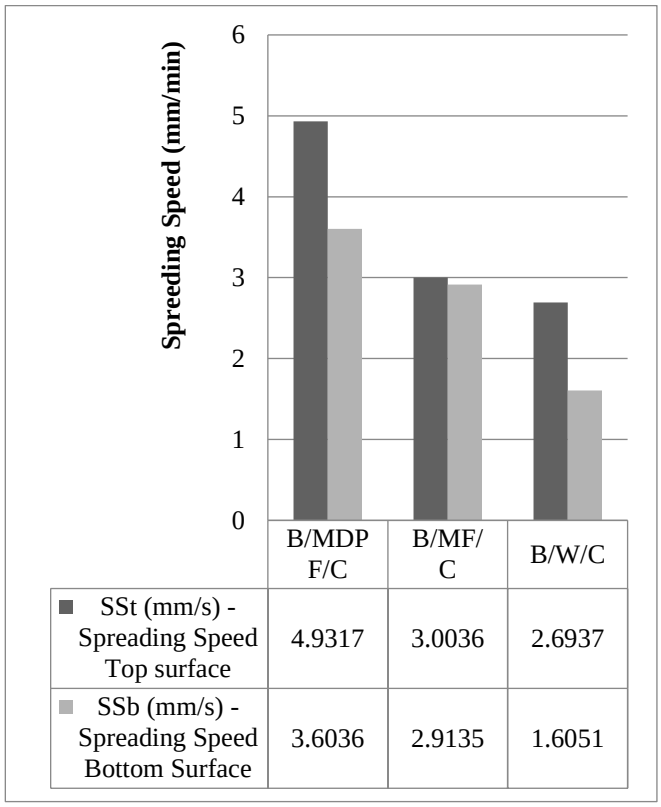
3.4 Spreading Speed

Minimum level of air is entrapped within the surface of the fabrics because of the finer filamentous nature of the micro denier filament polyester. Less drying time is one of the most important physiological parameters for comfort. The spreading speed values of the cotton layer are lower in Fig. 3 due to the bamboo/wool/cotton layer's smaller maximum wetted radius. The sweat is well absorbed by the fibers due to its excellent hydrophilic characteristic of bamboo and micro denier polyester fibers in both sides of the fabric, making it to possess a high spreading speed compared to all other fabric samples.

3.5 Accumulative One Way Transport Index and Overall Moisture Management Capacity

By using a wide variety of the yarns different moisture transport properties are achieved and the sweat can be easily transmitted giving an excellent dry feel, making the wearer feel comfortable. Figs. 5 and 6 exhibits the values of AOTI and OMMC of the trilayer knitted fabrics. B/MDPF/C trilayer knitted fabric is determined

as a good grade (OMMC: 0.4–0.6). The fabric that touches the skin becomes dry at a faster rate due to the excellent absorption rate and higher maximum wetted radius and spreading speed. Fabric sample B/MDPF/C followed by the sample B/MF/C and B/W/C sample possess a good moisture management capacity [16-17].

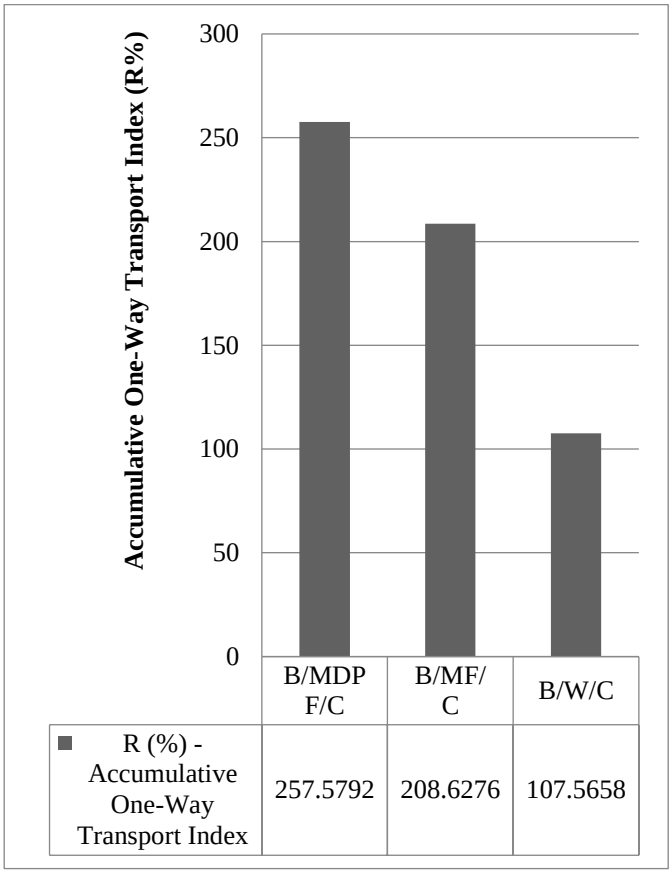


	B/MDP F/C	B/MF/ C	B/W/C
SSt (mm/s) - Spreading Speed Top surface	4.9317	3.0036	2.6937
SSb (mm/s) - Spreading Speed Bottom Surface	3.6036	2.9135	1.6051

Fig. 4. Spreading speed of trilayer knitted fabrics

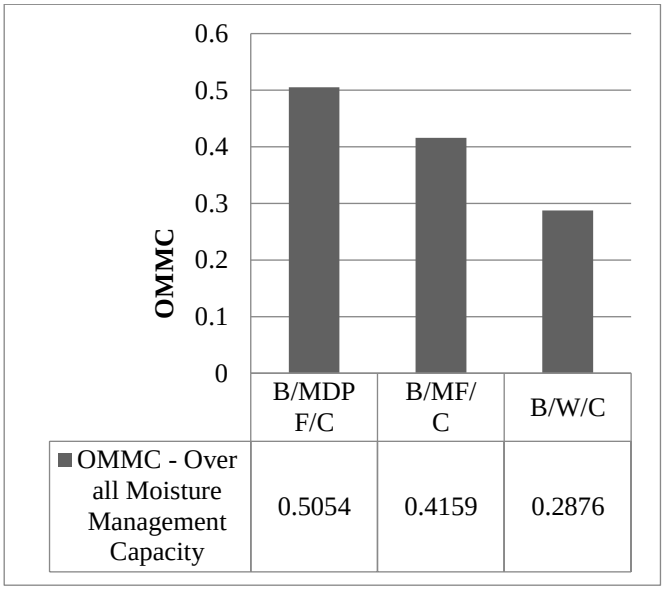
4. Conclusion

The moisture management features of produced trilayer knitted structures made of a range of fibres in the outside, middle, and interior layers are investigated in this study. The overall moisture management capacity of the B/MDPF/C fabric is determined to be quite good. As evidenced by OMMC values, the B/MDPF/C fabric has a good MMT property. The MWR and the MVT of fabric influences the spreading area fabric moisture having micro denier filamentous polyester yarns as its middle layer. The capillary nature of the yarn is mainly the reason for a good moisture management property. Good moisture management properties are exhibited by the fabrics sample B/MDPF/C. The B/MDPF/C trilayer knitted fabrics are suitable for textiles and fabrics used for the sports due to the faster release of the perspiration and sweat from the skin and giving an excellent dry and comfort feel to the wearer making them perform well in their activities.



	B/MDP F/C	B/MF/ C	B/W/C
R (%) - Accumulative One-Way Transport Index	257.5792	208.6276	107.5658

Fig. 5. Accumulative one way transport index of trilayer knitted fabrics



	B/MDP F/C	B/MF/ C	B/W/C
OMMC - Over all Moisture Management Capacity	0.5054	0.4159	0.2876

Fig. 6. Overall moisture management capacity of trilayer knitted fabrics

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