JTATM
Journal of Textile and Apparel, Technology and Management

Volume 7, Issue 4, Fall 2012

Investigations on Moisture Transmission Characteristics of Blended Single Jersey Fabrics

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Moisture transmission properties of some combinations of polyester and viscose blended single jersey fabrics were studied in an effort to understand the physical basis of clothing comfort. In addition to this, an attempt has also been made to investigate the influence of enzyme treatment on moisture transmission characteristics of P/V blended single jersey fabrics. Polyester and viscose staple fibers of different deniers were ring spun with various blend proportions, which were knitted into single jersey fabrics. These fabrics were dyed and then treated with Lipase enzymes. Commercially available enzymes and enzymes cultured in the laboratory were compared for their activity of surface modification of polyester fibers. The fabrics were tested for their Liquid Moisture Transmission characteristic, expressed in terms of its wickability and Moisture Vapor Transmission which is expressed in terms of Relative Water Vapor Permeability % in grey, dyed and enzyme treated stages. From the results, it can be observed that the liquid moisture transmission of P/V-80/20 combinations has been improved well. The results indicate that the liquid moisture transmission is strongly influenced by the enzymatic treatments. This is mainly due to molecular re-orientation in the surface characteristics of polyester fiber component in the fabrics. A slight improvement in terms of moisture vapor transmission has been observed in all the fiber denier combinations, blend proportions and enzyme treated fabrics.

Keywords: Moisture vapor transmission, liquid moisture transmission, single Jersey fabrics, blend Proportion, enzymatic treatment and clothing comfort

INTRODUCTION

Textiles serve both as a barrier and a transporter of heat, air and moisture from one environment to another. In case of clothing, apparel fabrics act as a boundary between the microenvironment immediately surrounding the body and the outer environment. Clothing contributes to the temperature regulating system of the body. The term comfort is defined as "the absence of unpleasantness or discomfort" or 'a neutral state compared to the more active state of pleasure". This state of comfort can only be achieved when the most complex interactions between a range of physiological and physical factors have taken place in a satisfactory manner [1].Clothing comfort is mainly governed by the properties of textile materials which the wearer feels is good for better performance. The principal function of a fabric in a clothing assembly is to enable the body to maintain itself an acceptable physiological state with respect to thermal balance between core/skin temperature and the surrounding temperature. Sweat dissipation for all types of environmental conditions and for all degrees of body activity needs to be good. Physiologically, for a human body, skin temperature between 33 and 35^0C is being regarded as ‘feel comfortable’. For human beings to be in thermal balance with their environment, their total heat loss must approximate the metabolic heat production. If heat loss greatly exceeds heat generation for a significant period of time, cold stress will result; conversely if heat loss is less than heat production heat stress will ultimately occur. Comfortable clothing will help to moderate the heat balance and keep the wearer free from thermal stress.

In this study it is aimed to study the effect of blend proportion in the yarn on the transport phenomena of liquid moisture and moisture vapor of the single jersey fabrics. The effect of enzyme activity on the surface of the polyester component of the fabrics on the above mentioned properties has also been studied.

Factors influencing transmission characteristics:

1.1 **Liquid moisture transmission**

Fiber: Type of fiber, chemical nature of the fibers, Geometry of fibers.

Yarn: Linear density (yarn diameter), Twist, Blend level, yarn geometry

Fabric: Fabric construction (structure), Thickness and porosity.

1.2. Moisture vapor transmission:

Fiber: Micro porous nature

Yarn: Linear density, twist, blend level, yarn geometry

Fabric: Thickness and porosity

Some of the issues of clothing comfort that are most readily understood involve the mechanism by which clothing materials influence heat and moisture transfer from the skin to the environment. Heat transfer by conduction, convention and radiation and moisture transfer by vapor diffusion are the most important mechanism in very cool and warn environments [2]. The comfort of fabric is influenced by the physical and chemical attributes of the raw materials and processes involved in textile production. It is characterized by so many comfort, low stress and (high stress) mechanical properties. One of the major factors influencing the comfort is transmission characteristics of the textile structures. Many researchers have conducted experiments on these transmission characteristics which throws some light on factors involved in textile production and their effect on these characteristics.

2. MATERIALS AND METHODS

2.1 Sample Preparation

Polyester retains its shape and hence is good for making outdoor clothing for harsh climates and can be easily washed [3].Polyester staple fibers of deniers 1.0, 1.2, 1.4 with 44mm cut length, were blended with viscose staple fibers of denier 1.2 with 44mm cut length. Water retention value which is swelling index of viscose is very much higher than that of cotton. In aqueous liquors, viscose fibers tend to swell more strongly than modal fibers or cotton. This swelling process happens very quickly and is almost complete after ten seconds at the lower temperature range [4]. Polyester and viscose fiber denier combinations are given below.

A: 1.0 denier polyester + 1.2 denier viscose
B: 1.2 denier polyester + 1.2 denier viscose
C: 1.4 denier polyester + 1.2 denier viscose

The fibers were blended according to their density at drawframe stage with the following blend proportions of P/V: 80/20, 67/33, 50/50, 33/67, 20/80. Yarns were Spun in the ring frames with a linear density 24^s Ne at twist multiplier of 3.1, cleared using electronic yarn clearer and waxed during winding which makes the yarns suitable for hosiery purpose. The yarns thus produced were knitted into single jersey fabrics. Table 1 gives the combinations of fabrics produced with various fiber denier combinations.

The fabrics thus knitted were treated with perchloroethylene solvent with the material to liquor ratio of 1:30 at room temperature for half an hour in order to remove the spin finish present on the fabric. The main and unique goal of spin finish is the elimination of static electricity in fibers and fabrics. Fiber compactness is the most important technological result of spin finish [5]. These fabrics were then subjected to two stage dyeing process. In the first stage, polyester component of the fabrics were dyed in a HTHP laboratory model dyeing machine. The fabrics were washed and 2nd stage of dyeing to dye the viscose component was carried out. The process parameters for polyester and viscose dyeing are given in Table 2.

Table 1. Fabric Combinations

S. No	Specifications (P/V)	Fabric Groups
1	A 80/20	
2	A 67/33	
3	A 50/50	Group A
4	A 33/67	
5	A 20/80	
6	B 80/20	
7	B 67/33	
8	B 50/50	Group B
9	B 33/67	
10	B 20/80	
11	C 80/20	
12	C 67/33	
13	C 50/50	Group C
14	C 33/67	
15	C 20/80	

Table 2. Process parameters for Dyeing

Process Parameters	Polyester	Viscose
Type of Dye	Disperse	Reactive cold brand
Temperature	130^0 C	Room temperature
Time(in minutes)	30	60
Color	Light Blue	Light Blue
Depth of Shade % (owf)	1	1

2.2 Enzyme treatment

Enzymes are high molecular weight complex proteins, composed of chains of amino acids linked together by peptide bonds which are produced by all living cells These proteins accelerate specific chemical reactions without undergoing any alteration themselves. Although enzymes are formed in living cells, they are not living materials. These activities are usually measured in terms of the activity unit (U) [6]. The surface modification ability of lipase (enzymes A) cultured in lab was compared to that of the commercially available lipase (enzyme B). The effect of lipase enzyme on polyester fabric improves the wettability and water retention properties. The wetting behavior of enzyme treatment is higher than that of alkaline treatment on polyester [7]. These enzymes modify the surface characteristics of the polyester component and thereby improving the moisture transmission properties of the fabrics. Enzymes operate under mild condition that means each enzyme have its optimum temperature and optimum pH for activation. Enzymes are used to provide innovative products for fabric treatment by reducing process time, chemical consumption and energy costs in agreement with sustainable development [8]. The process parameters adopted are given in Table 3. Similar process parameters were selected in order to compare the effectiveness of selected enzymes.

Table 3. Process parameters for Enzyme treatment

Parameters	Enzyme A	Enzyme B
Concentration (g / lit)	1	1
Temperature (in degree	Room	Room
centigrade)	10	10
Time (in minutes)	8.00	8.00
pH		

3. TESTING PROCEDURE

The fabrics at grey, dyed and enzyme treated stages were tested for the following properties for their wicking properties, and relative water vapor permeability (%).

3.1 Vertical wicking test

Vertical wicking test is carried out to determine the ability of the fabrics to transport liquid moisture through the longitudinal axis of the fabrics when the fabrics were placed vertically. This test was performed with a sample size of 200 mm x 25 mm. The samples were hung vertically with the help of a clamp. The samples were dipped in the bottom most portion of the specimen. 0.2% soap solution was added to the water to even out the wetting process. Wicking height (in cm) was noted at different times with an interval of 1 minute up to 5 minutes and then with an interval of 5 minutes up to 30 minutes. Readings were taken at wale direction only.

3.2 Moisture vapor transmission

To assess the moisture vapor transmission Permetest instrument was used. Fabric sample size of 4.6inches in circular form was used. Fabric-sample is placed on the measuring head; water is injected on the measuring head. Water vapor is formed taking heat from measuring head. The heat lost from the wet measuring head depends upon the permeability characteristics of the fabric. Hence the output voltage would be different with a fabric as compared to the bare measuring head. Therefore, the relative water vapor permeability can be given by:

Relative water vapor permeability (%) = $\frac{\text{Heat lost when fabric is placed on the measuring head}}{\text{Heat lost from bare measuring head}}$ x 100

$$= \frac{u_1}{u_0} \text{ x } 100$$

where u_1 is the output voltage when fabric is placed on the measuring head; u_0 is the output voltage from bare measuring head. Measuring head of Permetest instrument is shown in Figure1.

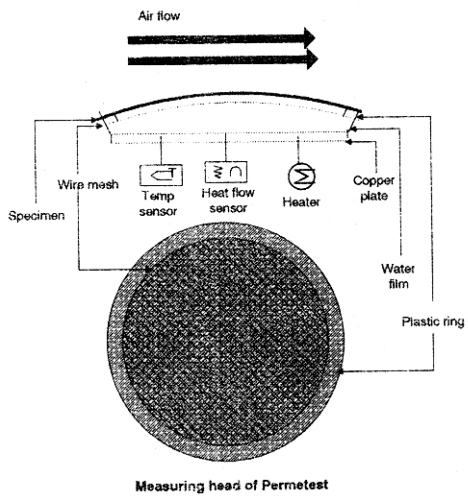


Figure1. Measuring head of Permetest

4. RESULTS AND DISCUSSION

The results of the vertical wickability test and the moisture vapor transmission test are given below. The wickability in terms of height wicked for a given time duration for fabrics of different groups (Group A, B and C) in various stages that is grey, dyed, enzyme A treated and enzyme B treated are given below.

Table 4. Wicking Height (in *cm*) of Group 'A' Fabrics in Grey stage

Specification	Time (in seconds)									
	60	**120**	**180**	**240**	**300**	**600**	**900**	**1200**	**1500**	**1800**
A 80/20	0.62	1.04	1.39	1.67	1.93	2.9	3.48	3.77	3.98	4.14
A 67/33	1.7	2.3	2.88	3.11	3.39	4.25	5.01	5.59	5.96	6.27
A 50/50	0.93	1.21	1.44	1.72	1.96	2.52	2.93	3.26	3.45	3.62
A 33/67	2.5	3.5	3.91	4.21	4.58	5.62	6.16	6.65	6.88	6.96
A 20/80	1.58	1.92	2.16	2.38	2.46	2.73	2.92	3.1	3.24	3.36

Figure 2: Wickability of Group 'A' Fabrics in Grey Stage

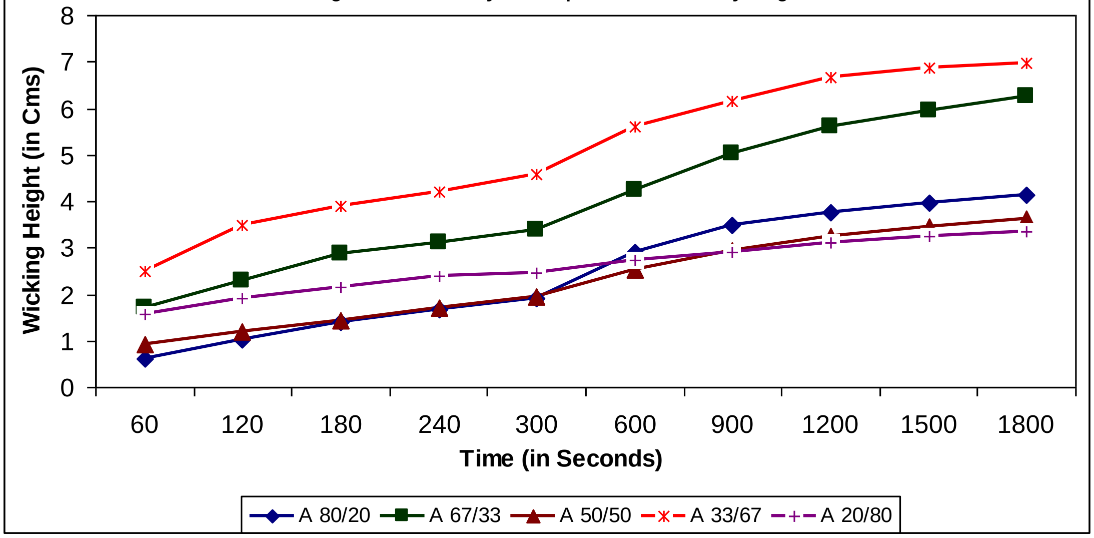
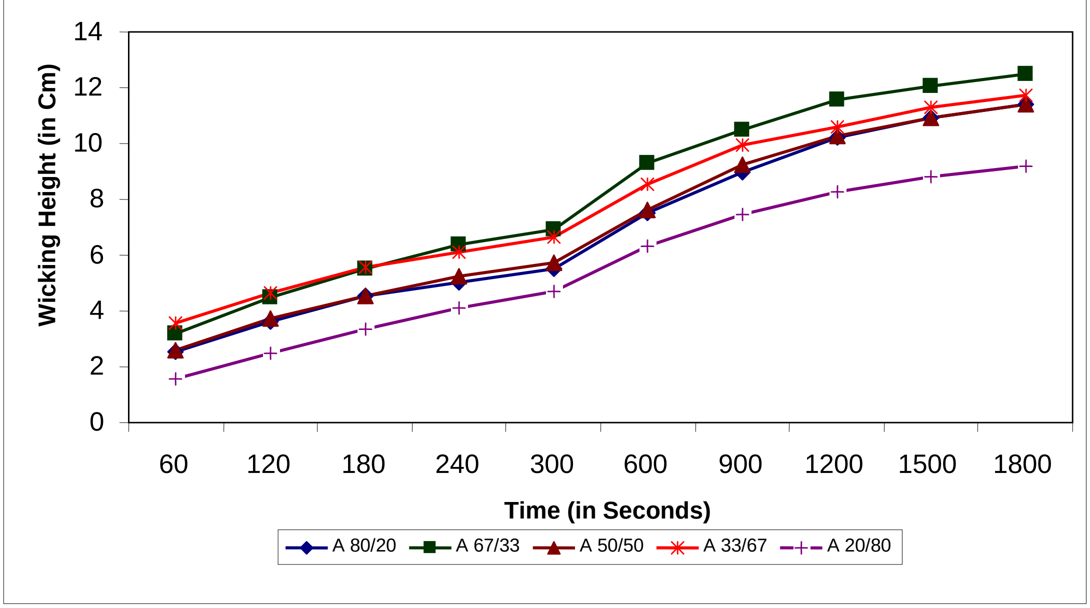


Table 5. Wicking Height (in *cm*) of Group 'A' Fabrics in Dyed stage

Specification	Time (in seconds)									
	60	**120**	**180**	**240**	**300**	**600**	**900**	**1200**	**1500**	**1800**
A 80/20	2.56	3.6	4.52	5.04	5.54	7.54	8.98	10.22	10.92	11.42
A 67/33	3.17	4.5	5.5	6.4	6.92	9.28	10.5	11.55	12.08	12.47
A 50/50	2.61	3.73	4.56	5.24	5.73	7.61	9.25	10.26	10.91	11.43
A 33/67	3.57	4.66	5.56	6.1	6.64	8.52	9.94	10.6	11.32	11.72
A 20/80	1.56	2.46	3.34	4.12	4.72	6.35	7.48	8.25	8.83	9.21

Figure 3. Wickability of Group 'A' Fabrics in Dyed Stage



For Group A fabrics of different blend proportion in various stages i.e., Grey, Dyed, Enzyme A treated and Enzyme B treated are given in Tables 4, 5, 6 and 7. The values are plotted as graphs as shown in Figures 2, 3, 4 and 5.

Tables 4 to 7 show the vertical wicking property of Group A fabrics. It can be observed from Figure 2 to 5 that the total height wicked as well as the rate of wicking is highest for fabrics treated with enzyme B. The values are highest for the higher polyester content fabric with the help of enzyme treatment. The results indicate that the enzyme B fair than enzyme A. This may be due to surface modification of the polyester component of the fabrics, which help in improving the wicking behavior that is, liquid moisture transmission of the fabrics.

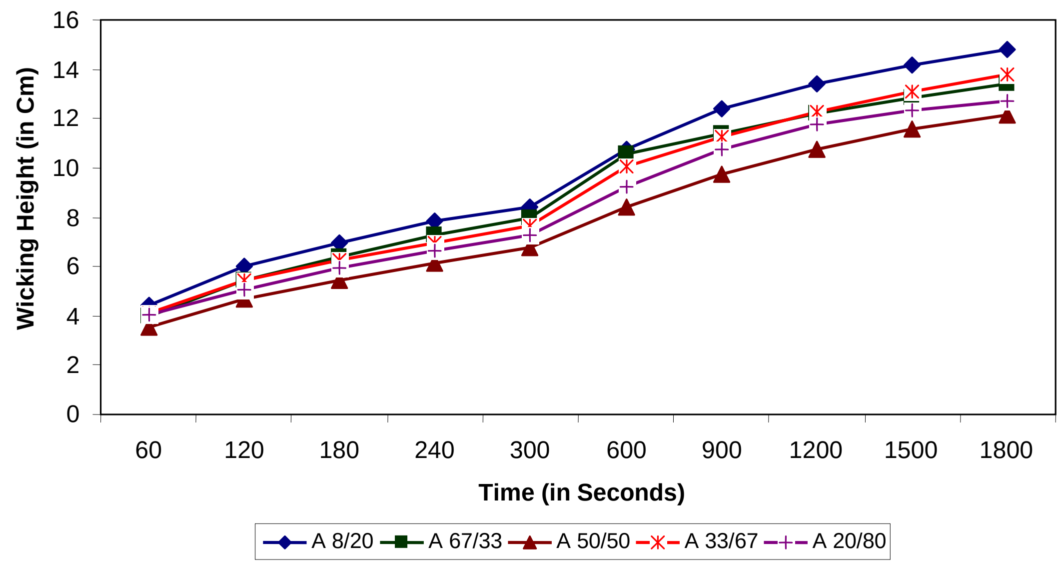
When the moisture content in the fibers reaches to saturation, capillary action starts and at saturation or above that moisture level, capillary wicking is the major mechanism of moisture transport. Although diffusion takes place but the amount of moisture transported due to the diffusion reaches maximum at around 30% regain for cotton cloth and after that remains constant; as per the study conducted by Adler and Walsh [9].

Among the Group A fabrics sample (A 80/20) showed better results with a wicking of 14.78 cm in 1800 seconds. Even though the fabric combination A 80/20 faired much lower in Grey and dyed stages, the effect of lipase enzymes had a great influence on the surface modification of polyester which is evident in Figures 4 and 5. The wicking height, measured for a period of 5 minutes, has improved from 11.4 cm in dyed stage to around 15.7 cm in enzyme B treated stage, which is around 37.5% improvement in wickability.

Table 6. Wicking Height (in cm) of Group 'A' Fabrics in Enzyme A treated

Specification	**Time (in seconds)**									
	60	**120**	**180**	**240**	**300**	**600**	**900**	**1200**	**1500**	**1800**
A 80/20	4.4	5.98	6.98	7.82	8.42	10.78	12.38	13.38	14.18	14.78
A 67/33	4	5.44	6.4	7.26	7.96	10.56	11.36	12.2	12.86	13.42
A 50/50	3.52	4.66	5.43	6.11	6.76	8.43	9.74	10.76	11.57	12.16
A 33/67	4.12	5.44	6.24	6.98	7.68	10.04	11.26	12.26	13.06	13.76
A 20/80	4.02	5.04	5.96	6.66	7.26	9.22	10.76	11.76	12.34	12.74

Figure 4. Wickability of Group 'A' Fabrics in Enzyme A treated Stage



Compared to the effect of enzyme treatment between Enzyme A and Enzyme B, the latter exhibits better results on the improvements over dyed stage of fabrics. For fabrics treated with enzyme B, the overall wickability in the measured period as well as rate of wicking from the initial point of measurement are better compared to enzyme A. This will help the moisture, in the form of sweat emerging in the microclimate, to dissipate through the fabrics faster and help the wearer to feel dry and cool and in turn keeps the wearer more comfortable.

Comparing Figure 4 and Figure 5, it could be observed the combination A 67/33, having 67% polyester 33% viscose performs better with respect to wickability after treatment with enzymes. There seems to be an almost similar performance of fabric combination A 33 / 67, with 33% viscose and 67% polyester regarding the overall wickability after a period of 1800 seconds. This could be due to micro pores in viscose fibers and the combined effect of natural moisture regain of viscose fibers.

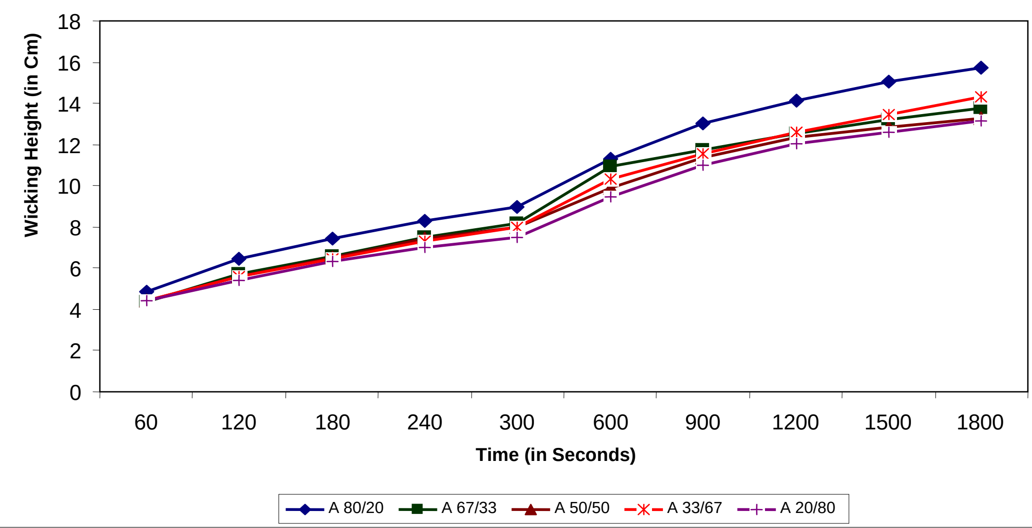
From a range of 3 cm – 7 cm of wicking height among different combinations of the fabrics used in grey stage of P/V blended fabrics, the dyed fabrics exhibits a range of 9-12.5 cm of wicking height. It is interesting to note a major improvement to the extent of around 12 -15 cm in terms of Enzyme A treated fabrics and 13-16 cm for enzyme B fabrics. This shows that even with lower percentage of polyester, the wickability has significantly increased due to enzyme treatments.

While hydrophilic fabrics can take up liquid from the skin, allowing it to evaporate away from the body, hygroscopic fabrics can move moisture without the buildup of liquid sweat on the skin, provided this affect is of significant magnitude. Clothing movement during wear may generate complex air movements [10]. However, in line with many other works done earlier, appropriate surface treatments definitely helps to improve the moisture transmission properties of the hydrophobic fibers and its blends, which is evident from the experiment conducted, as shown in different graphs.

Table 7. Wicking Height (in cm) of Group ‘A’ Fabrics in Enzyme B treated stage

Specification	Time (in seconds)									
	60	**120**	**180**	**240**	**300**	**600**	**900**	**1200**	**1500**	**1800**
A 80/20	4.88	6.46	7.46	8.32	8.96	11.32	13	14.14	15.06	15.71
A 67/33	4.36	5.7	6.6	7.52	8.18	10.92	11.74	12.52	13.22	13.78
A 50/50	4.4	5.62	6.51	7.46	7.96	9.91	11.34	12.32	12.81	13.24
A 33/67	4.4	5.56	6.48	7.28	7.98	10.34	11.58	12.58	13.48	14.34
A 20/80	4.4	5.4	6.3	7	7.5	9.48	11	12.02	12.62	13.16

Figure 5. Wickability of Group 'A' fabrics in Enzyme B treated stage



Group B Fabrics, with a fiber denier combination of 1.2 D polyester blended with 1.2 D viscose have been studied for variations in moisture transmission properties in various wet processing stages including enzyme treatments. The results are shown in Tables 8, 9, 10 and 11. The corresponding graphs are shown in Figures 6, 7, 8 and 9.

The overall wickability of this group of fabrics, at different stages, say, grey, dyed, Enzyme A and Enzyme B treated stage are comparatively lower with respect to similar treatments of group A fabrics. This could be due to a better packing structure of uniform denier fiber combinations as against a varying fiber denier combination for Group A fabrics, which was 1.0 D polyester blended with 1.2 D viscose. This is consistent with Crow and Osczevski’s findings that the amount of water wicked from one layer to another depend on the pore size and their corresponding volumes.

Table 8. Wicking Height (in cm) of Group ‘B’ Fabrics in Grey stage

Specification	Time (in seconds)									
	60	**120**	**180**	**240**	**300**	**600**	**900**	**1200**	**1500**	**1800**
B 80/20	0.61	0.99	1.3	1.59	1.8	2.49	3.05	3.49	3.82	4.05
B 67/33	0.94	1.21	1.47	1.75	1.96	2.52	2.88	3.21	3.41	3.52
B 50/50	0.83	1.12	1.34	1.52	1.61	2.3	2.6	2.82	3.01	3.11
B 33/67	1.66	2.49	3.01	3.34	3.56	4.54	5.16	5.58	5.78	5.83
B 20/80	2.19	2.85	3.18	3.45	3.75	4.53	5	5.29	5.49	5.61

Figure 6. Wickability of Group 'B' Fabrics in Grey Stage

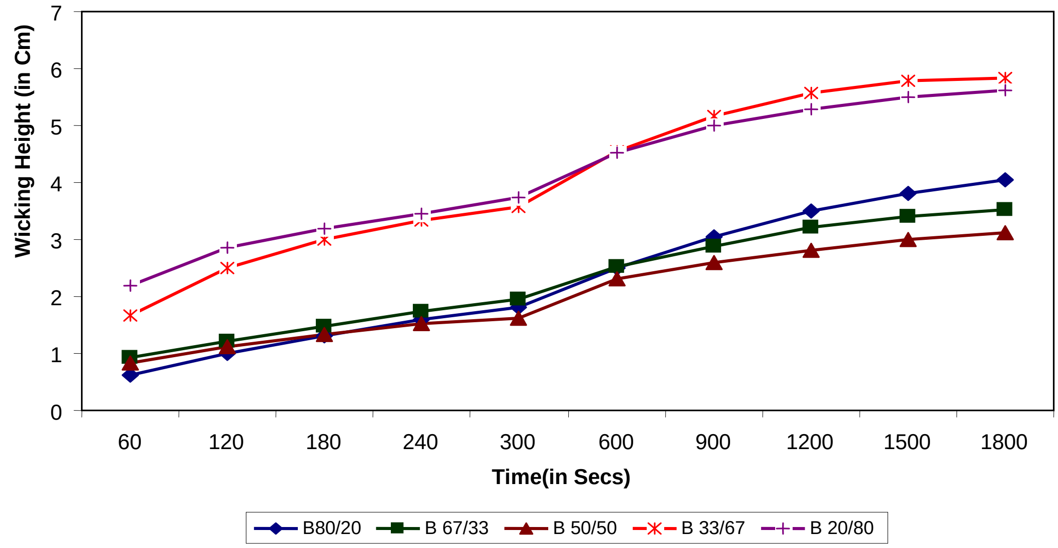
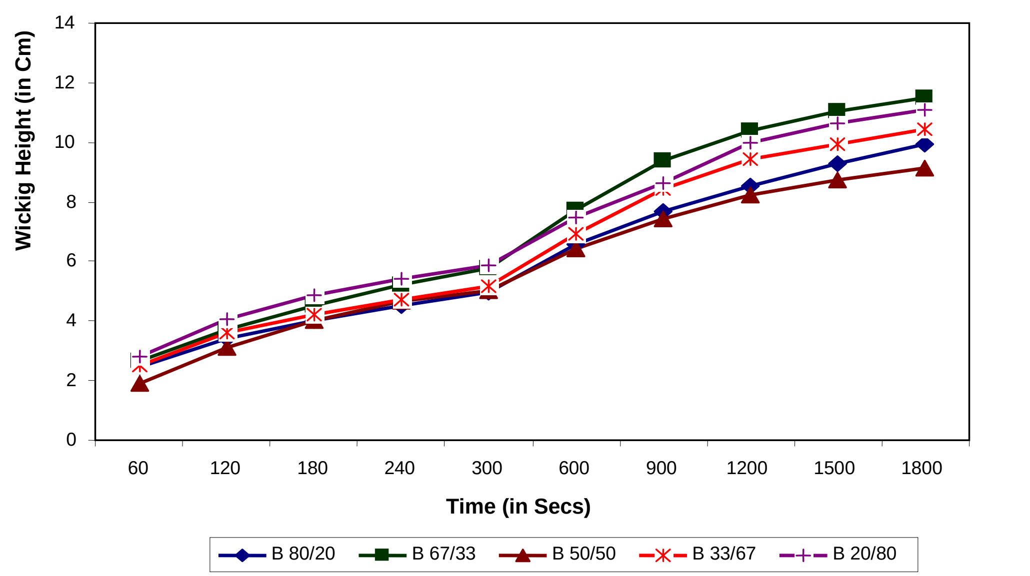


Table 9. Wicking Height (in cm) of Group 'B' Fabrics in Dyed stage

Specification	Time (in seconds)									
	60	120	180	240	300	600	900	1200	1500	1800
B 80/20	2.44	3.42	4	4.5	4.98	6.56	7.68	8.52	9.28	9.94
B 67/33	2.64	3.7	4.5	5.2	5.76	7.72	9.36	10.4	11.04	11.48
B 50/50	1.92	3.11	4.02	4.66	5.03	6.44	7.41	8.23	8.72	9.11
B 33/67	2.51	3.62	4.2	4.72	5.16	6.94	8.41	9.43	9.96	10.42
B 20/80	2.81	4.04	4.88	5.41	5.87	7.49	8.62	10.01	10.62	11.1

Figure 7. Wickability of Group 'B' Fabrics in Dyed Stage



Analyzing the wickability behavior of the fabrics within this group, it could be observed that, the polyester major combinations have performed better in terms of wickability after enzyme treatment. Fabric combination B 80/20 has exhibited the highest wicking height of 14.76 cm in enzyme A treated stage and 15.3 cm in enzyme B treated stage. This is about 27% increase in wickability in enzyme B treated stage compared to dyed stage of the fabrics.

Similar to Group A fabrics, in Group B 50/50 P/V combination has exhibited relatively lower transmission properties within the group at almost all stages of fabrics from grey stage to enzyme treated stage.

It can be observed from Figure 6 to 9 that the total height wicked as well as the rate of wicking is highest for fabrics treated with enzyme B. This is because of the surface modification of the polyester component of the fabrics caused by the action of enzyme. In this case sample B 80/20 showed better results among the Group B fabrics. This proves well that Lipase enzymes acts well on the polyester component of the fabric / fiber combinations and such fabrics can be very good for all end uses where better moisture management properties are required. This in turn would act as an alternative to cotton and would reduce the dependability on the cotton fiber and ultimately lead to reduction in cost of end product.

Table 10. Wicking Height (in cm) of Group 'B' Fabrics in Enzyme A treated stage

Specification	60	120	180	240	300	600	900	1200	1500	1800
B 80/20	4.5	5.92	6.92	7.8	8.44	10.66	12.26	13.46	14.16	14.76
B 67/33	3.42	4.66	5.66	6.32	6.92	9.1	10.6	11.68	12.44	13.04
B 50/50	2.91	4.02	4.51	4.96	5.34	6.94	8.23	9.01	9.56	9.98
B 33/67	3.35	4.66	5.11	5.64	6.12	8.14	10.56	11.62	12.31	13.06
B 20/80	3.98	5.02	5.88	6.56	7.16	8.96	10.08	11.04	11.88	12.62

Figure 8. Wickability of Group 'B' Fabrics in Enzyme 'A' Treated stage

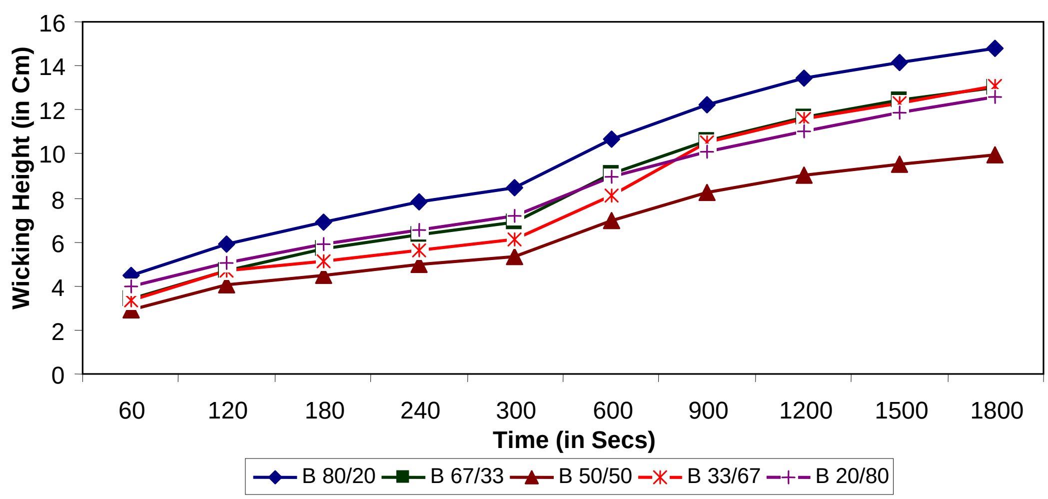
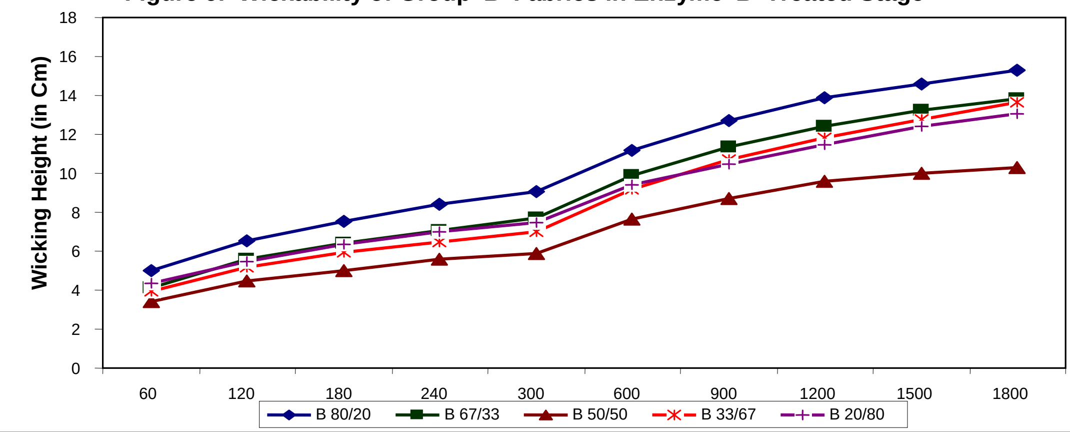


Table 11. Wicking Height (in cm) of Group 'B' Fabrics in Enzyme B treated stage

Specification	Time (in seconds)									
	60	120	180	240	300	600	900	1200	1500	1800
B 80/20	5.02	6.54	7.54	8.44	9.04	11.16	12.68	13.88	14.6	15.3
B 67/33	4.1	5.6	6.4	7.08	7.7	9.86	11.34	12.44	13.24	13.8
B 50/50	3.41	4.5	5	5.56	5.9	7.63	8.71	9.56	10	10.3
B 33/67	3.92	5.16	5.92	6.5	7	9.16	10.68	11.84	12.76	13.62
B 20/80	4.36	5.48	6.38	7	7.5	9.42	10.48	11.48	12.4	13.08

Figure 9. Wickability of Group 'B' Fabrics in Enzyme 'B' Treated Stage



Tables 12, 13, 14 and 15 shows the results for Group C fabrics of different blend proportion in various stages that is Grey, Dyed, Enzyme A and Enzyme B treated. The corresponding values are plotted as shown in Figures 10, 11, 12 and 13.

Tables 12 to 15 show the vertical wicking property of Group C fabrics, which comes with a fiber denier combination of 1.4D polyester with 1.2 D viscose. It can be observed from Figure 10 to 13 that the total height wicked as well as the rate of wicking is highest for fabrics treated with enzyme B.

Group C fabrics have exhibited slightly different trend from that of Group A and Group B fabrics, where in Group C fabrics, sample C 33/67 showed better results than the other samples among group C fabrics. This could be due to the fact that varying denier combination of polyester / viscose staple fibers. With difference in the denier combinations, the pores formed in between the fiber and yarn strands could help improve the capillary effect and helped in better moisture transmission in this category fabric.

Table 12: Wicking Height (in cm) of Group 'C' Fabrics in Grey stage

Specification	Time (in seconds)									
	60	120	180	240	300	600	900	1200	1500	1800
C 80/20	0.09	0.19	0.31	0.43	0.53	0.98	1.33	1.48	1.57	1.57
C 67/33	0.82	1.4	1.82	2.13	2.4	3.23	3.67	4.01	4.31	4.83
C 50/50	0.82	1.23	1.54	1.66	1.72	2.34	2.66	2.71	2.82	2.94
C 33/67	2.52	3.51	4.13	4.67	5.28	6.37	7.09	7.73	8.13	8.24
C 20/80	2.45	3.52	4.42	4.84	5.25	6.21	6.83	7.32	7.72	7.94

Figure 10. Wickability of Group 'C' Fabrics in Grey Stage

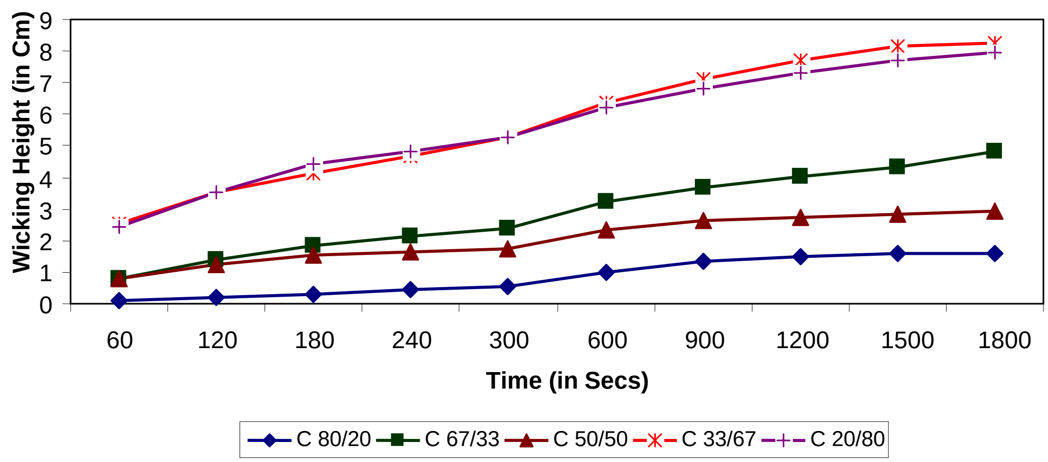


Table 13: Wicking Height (in cm) of Group 'C' Fabrics in Dyed stage

Specification	Time in seconds									
	60	**120**	**180**	**240**	**300**	**600**	**900**	**1200**	**1500**	**1800**
C 80/20	0.96	1.54	1.96	2.37	2.69	3.87	4.66	5.3	5.78	6.16
C 67/33	2.18	3.39	4.23	4.84	5.59	7.18	8.38	9.38	10.32	11.2
C 50/50	2.3	3.5	4.2	4.8	5.4	7.2	8.6	9.5	10.2	10.6
C 33/67	3.22	3.94	4.54	4.95	5.35	6.69	7.66	8.72	9.79	10.37
C 20/80	3.12	4.28	4.95	5.5	6.08	7.88	9.1	9.86	10.49	10.97

Figure 11. Wickability of Group 'C' Fabrics in Grey Stage

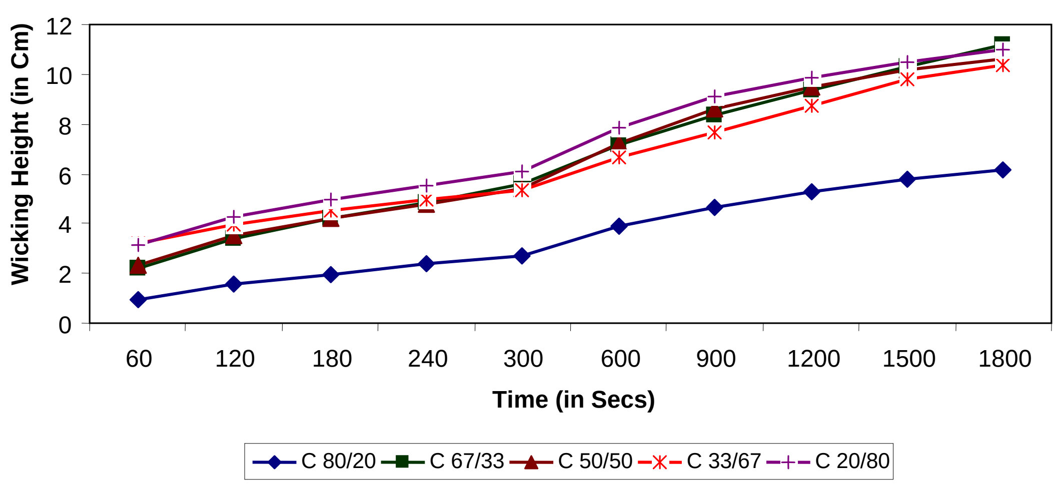


Table 14. Wicking Height (in cm) of Group 'C' Fabrics in Enzyme A treated stage

Specification	Time (in seconds)									
	60	120	180	240	300	600	900	1200	1500	1800
C 80/20	3.72	4.86	5.78	6.56	7.26	10.06	11.22	12.24	13.04	13.74
C 67/33	3.56	4.86	5.78	6.28	6.76	9.26	10.5	11.3	12	12.54
C 50/50	3.1	4.3	5	5.5	5.9	7.8	9.4	10.4	11.1	11.6
C 33/67	4.52	5.96	6.94	7.74	8.42	10.5	11.7	12.68	13.48	14.08
C 20/80	4.02	5.26	6.16	6.96	7.56	9.66	10.96	11.96	12.82	13.52

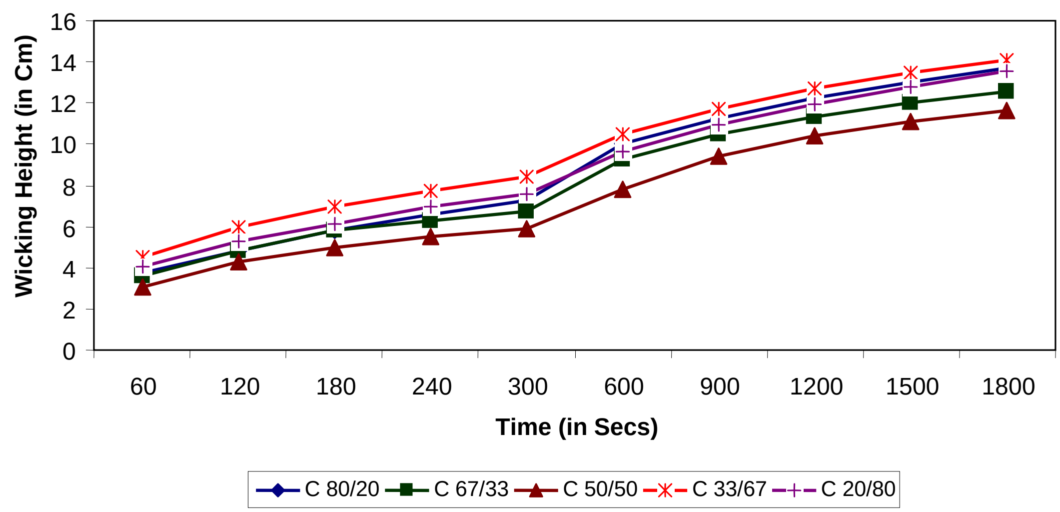


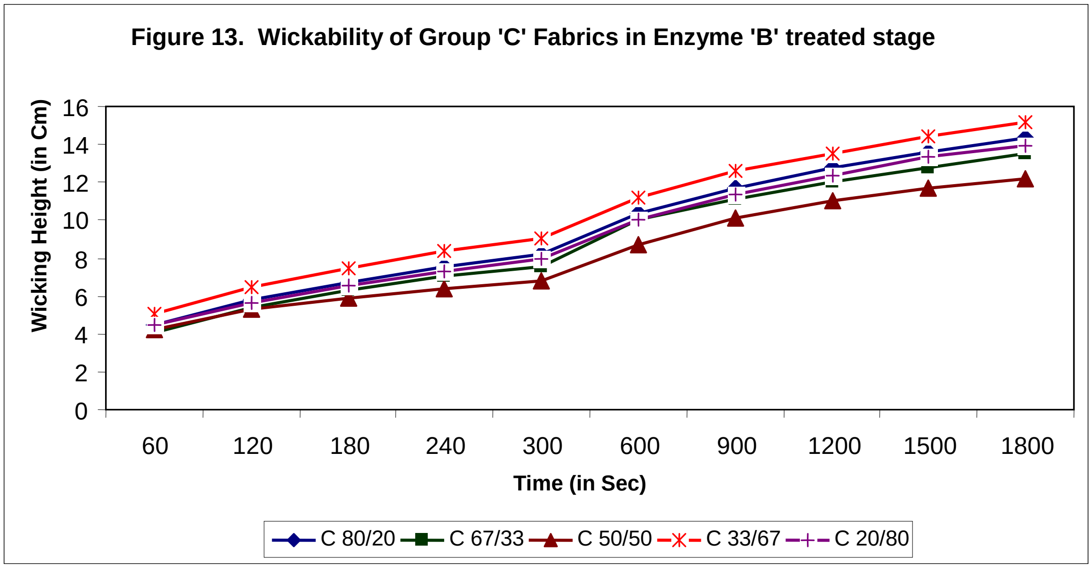
Figure 12. Wickability of Group 'C' Fabrics in Enzyme 'A' treated stage

Group C fabrics, in general have exhibited comparatively poorer moisture transmission characteristics than that of Group A and Group B fabrics. The range of wickability of Group C fabrics in grey stage was 1.57 to 8.24, exhibiting lowest and highest values of wickability in grey stage with a wide range. However, the enzyme treated stage 11.6 – 14 cm and 12.2 to 15.18 cm for enzyme A and enzyme B treated fabrics respectively.

The fabric combination C 33/67 has exhibited highest moisture transmission rates in all stages and has shown 84% improvement from grey stage to enzyme B treated stage. However the combination P/V 80/20 has exhibited marginally lower wickability in group C, compared to other groups. This combination also has shown very good improvement in wickability after enzyme treatment compared to that of grey and dyed stages, to the tune of around 133% from dyed stage to enzyme B treated stage.

Table 15. Wicking Height (in cm) of Group 'C' Fabrics in Enzyme B treated stage

Specification	Time in seconds									
	60	120	180	240	300	600	900	1200	1500	1800
C 80/20	4.48	5.82	6.72	7.52	8.22	10.4	11.66	12.76	13.56	14.36
C 67/33	4.08	5.4	6.34	7.04	7.54	10.02	11.12	12	12.79	13.54
C 50/50	4.2	5.3	5.9	6.4	6.8	8.7	10.1	11	11.7	12.2
C 33/67	5.04	6.48	7.48	8.38	9.02	11.16	12.56	13.54	14.4	15.18
C 20/80	4.46	5.66	6.52	7.32	8	10.04	11.36	12.36	13.34	13.96



Moisture Vapor Transmission

The result of the moisture vapor transmission test that is relative water vapor permeability (%) is given in Table 16. The corresponding values are plotted in Figure 14. From the results obtained it can be said that the fiber denier combination and blend level affects the moisture vapor permeability characteristics.

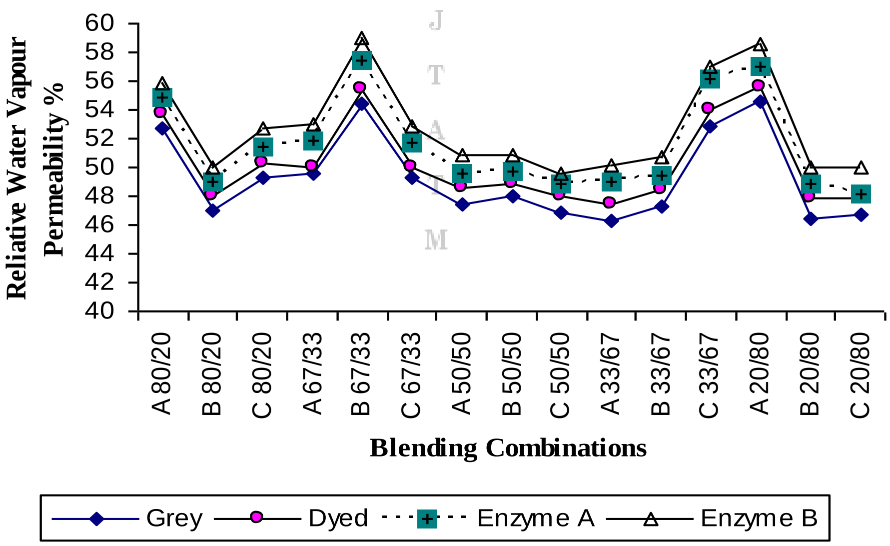
Enzymatic treatment has improved the relative water vapor permeability percentage by 3 to 5% when compared with grey fabrics. There is a mixed trend in the fiber denier combinations i.e., B 67/33 and A 20/80 which showed better results than the other fiber denier combinations in all the stages of processing. This may be due to the improved hydrophobic nature and packing of the fibers. These results can be compared with the study of Yasuda et al., [11]. (1992) were water vapor transport is not influenced significantly by surface characteristic – the hydrophilic or hydrophobic nature of fabrics.

However, analyzing the Figure 14, it is evident that almost all combinations across all the group of fabrics, treated with enzyme B, have exhibited better moisture vapor transmission characteristics.

Table 16. Moisture Vapor Transmission

Specification	Rel. Water Vapor Permeability %			
	Grey	Dyed	Enzyme A	Enzyme B
A 80/20	52.65	53.78	54.81	55.9
B 80/20	46.98	47.99	48.96	50.01
C 80/20	49.24	50.35	51.46	52.68
A 67/33	49.54	50.02	51.83	52.94
B 67/33	54.38	55.42	57.49	58.97
C 67/33	49.29	50.01	51.74	52.83
A 50/50	47.48	48.64	49.56	50.85
B 50/50	47.98	48.86	49.74	50.83
C 50/50	46.84	47.98	48.81	49.63
A 33/67	46.22	47.42	49.04	50.11
B 33/67	47.28	48.39	49.42	50.68
C 33/67	52.84	54.04	56.13	57.02
A 20/80	54.51	55.62	57.01	58.63
B 20/80	46.44	47.83	48.9	49.98
C 20/80	46.72	47.84	48.12	49.94

Figure 14. Moisture Vapor Transmission of P/V blended single jersey fabrics



5. CONCLUSIONS

From the above study it can be concluded that liquid transport properties of blended single jersey fabrics showed a significance variation with fiber type, fiber denier combination and blend level. The governing factor for the improvement in moisture transmission is the modified surface of the polyester component of the fabric due to enzyme treatment. Among the blend levels taken, P/V: 80/20 combinations showed best results than any other processes. This may be due to molecular re-orientation in the surface characteristics of polyester fiber component in the fabrics. Moisture vapor transport is slightly improved due to fiber denier combination, blend level and enzyme treatment. In this process B 67/33 and A 20/80 combinations exhibit improved results than other blend proportions. To enhance the clothing comfort in terms of moisture transmission characteristics, proper engineering of fiber denier combinations, blend proportions and enzymatic treatments should be undertaken as is can be understood from the study that with due consideration better products can be developed.

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