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AN INVESTIGATION INTO COMFORT PROPERTIES OF POLYESTER FABRIC BY SURFACE MODIFICATION WITH POLYVINYL ALCOHOL

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Abstract

In this investigation the polyester multifilament fabric have been considered and treated with poly vinyl alcohol (PVA) in alkaline media. The fabric is treated with different concentration of PVA at different temperature and time. The effect of these factors concentration, temperature and time have been analyzed by Box- Behnken experimental design, and optimum parameters were found out. Further it is found that there is significant difference of these factors on to the comfort related properties that are air permeability and wicking. FTIR spectroscopy studies also have been carried to observe the surface modification by confirming the presence of hydrophilic group that is hydroxyl group.

Key words : Polyester, comfort properties, PVA treatment.

Introduction

Clothing comfort is an extremely complex phenomenon and has drawn the attention of many textile research workers. It can be classified into three groups, namely psychological, tactile and thermal comfort. Polyethylene terephthalate (PET), commonly called as polyester, is the widely used polymer for the production of synthetic fibres. The wide use of PET is the result of its strength combined with its resistance to chemicals, abrasion, stretching, shrinking and wrinkling. However, the disadvantage of PET fibre is its low hydrophilic character and inactive surface. PET is a hydrophobic fibre with moisture regain of only 0.4% even at 100% relative humidity. The conventional modification of PET fibre properties was done by alkaline treatment under high concentration and temperature. This way of treatment imparts changes in fabric weight, strength, wettability and aesthetics.

D Nandy, J H Thakkerb & AK Sengupta (2) have been investigated the effect of hydrolytic action of NaOH in presence of methanol on aesthetic and comfort properties of polyester fabric. Desired comfort in polyester fabric achieved by using sodium hydroxide as a hydrolytic agent provided the weight loss of the fabric is significant. The higher weight loss in hydrolysis process of polyester may deteriorate most of its mechanical and chemical properties. The aesthetic and comfort related properties of polyester fabric can be improved by treating it with 5% NaOH in presence of 20% methanol at 60°C for 60 minutes without much deterioration in its mechanical properties. *Canan Saricam & Fatma Kalaoglu* (3) have investigated the wicking and drying behavior of polyester woven fabrics. It was found out that the weave type had an influence only in the vertical wicking performance, while thickness only affected the drying characteristics. Thus different parameters were found to be influential for different types of wicking activities and drying capabilities. The capillary space and arrangement of these spaces has a high impact on the vertical performance, whereas pore sizes are more influential with respect to transfer wicking performance. *R K Nayaka, S K Punj & K N Chatterjee* (4) have studied the effects of polyester content, pick density and weave on the thermal comfort and tactile properties of polyester/viscose blended yarn fabrics. The results have been shown that the fabric with higher polyester content gives lower extensibility; the extensibility in warp direction is higher than in weft direction and twill woven fabrics give higher extensibility than the plain woven fabrics. The fabric with lower pick density shows higher air permeability. Twill fabrics give higher air permeability and lower moisture vapour transfer than plain fabric. *Arulkumar and Patil* (5) have studied the characteristics of modified polyester for its water absorption and wickability. In this study three weaves i.e plain, twill and satin with modified polyester and ends per inch of 112 was taken and weft of three types in each weave i.e modified polyester, normal polyester and cotton and three pick density in each weave. The result shows enhanced wicking behavior of modified polyester was higher than normal polyester. By varying the pick density shows no significant difference in the fabric. *Swarna Natarajana & J Jeyakodi Moses* (6) investigated the surface modification of polyester fabric using polyvinyl alcohol in presence & absence of alkaline medium. The wetting behavior of PVA treated PET fabric increases considerably due to the good linkage between PET and PVA. But there is need of further in depth analysis of effect of factors PVA concentration, temperature and time on the comfort related parameters. Therefore in this further the polyester fabric with different pick densities were taken and treated with different concentration of PVA in the presence of alkali and analyzed using

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Box-behankan experimental design and related fabric comfort properties air permeability and wicking is measured.

Materials & Methodology

In this study the polyester multifilament fabric has taken by varying the pick density (picks per cm) and treating with polyvinyl vinyl alcohol in the presence of alkali. Materials used in this study are, 100% Polyester fabric with18 tex warp &weft, End per centimeter - 35, Picks Per Centimeter-31 & 35, 2/2 twill weave, polyvinyl alcohol of 7000 degree of polymerization and sodium hydroxide of laboratory grade.

Sample preparation

100% polyester multifilament yarns of 18 tex in both warp and weft are woven into fabric with twill weave (2\2) and Picks Per Centimeter-31 & 35.Therefore two different samples were produced. These produced samples were treated with polyvinyl alcohol in the presence of alkaline medium.

Pretreatment of Polyester Fabric

Polyester fabric was treated with 10 gpl HCl at 40°C for 1 hr with 1:50 material-to-liquor ratio to remove the added impurities present in it.

Application of PVA

Application of PVA to pretreated PET fabric was done as per the treatment combinations taken from Box- Benkhen Design of experiment. There are 15 combinations in each sample group of 31 ppcm and 35 ppcm. The variables and treatment combinations were given in table 1.

Table 1 : Different Variables for the treatments

FACTORS		LEVELS		
		–1	0	1
A	PVA (g/l)	1.5	2.5	3.5
B	Temperature (°C)	80	90	100
C	Time (hrs)	0.5	1	1.5

Box- Behnken Experimental Design

Box-behnken method is used in this study for design of experiments. The list of samples are as in table 2.

The above mentioned 2 different samples (35 ppcm and 31 ppcm), each with 15 samples were treated with PVA in presence of 4% NaOH solution using HTHP Machine. The treated fabrics were taken out and immersed in water at boiling temperature for 10 min and soaped for 15 minutes to remove the physically held PVA. The fabric is then washed and flat dried at room temperature.

Testing

The Treated samples were tested for comfort properties with air permeability (ASTM- D737), wicking (AATCC Test Method 197-2011, Vertical Wicking of Textiles) and FTIR investigation were

Table 2 : Box-Behnken Experimental Design

Sl. No.	A	B	C
1	1	1	0
2	0	0	0
3	0	–1	1
4	1	0	–1
5	0	1	–1
6	0	–1	–1
7	0	0	0
8	–1	1	0
9	0	0	0
10	–1	–1	0
11	0	1	1
12	–1	0	–1
13	1	0	1
14	–1	0	1
15	1	–1	0

Sl. No	PVA Conc. (g/L)	Temperature (°C)	Time (hrs)
1	3.5	100	1
2	2.5	90	1
3	2.5	80	1.5
4	3.5	90	0.5
5	2.5	100	0.5
6	2.5	80	0.5
7	2.5	90	1
8	1.5	100	1
9	2.5	90	1
10	1.5	80	1
11	2.5	100	1.5
12	1.5	90	0.5
13	3.5	90	1.5
14	1.5	90	1.5
15	3.5	80	1

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performed for confirming the presence of polyvinyl alcohol in fabric surface.

RESULTS & DISCUSSIONS

Many trials were carried out on polyester fabric using sodium hydroxide (4%) and PVA at different concentrations (1.5-3.5gpl), time (0.5-1.5h) and temperature (80-100°C) in different proportions to find the optimum conditions to improve the comfort properties of polyester fabric. Table no.3 shows the air permeability and wicking height values for polyester fabric before the treatment has carried out.

Table 3 : Air Permeability and Wicking height values for polyester fabric (before treatment)

Sample number	Fabric thread Density (end/cm × picks/ cm)	Air permeability (mm/sec)	Wicking height (cm)	
			Warp direction	Weft direction
1	35 × 31	397	6.1	5.3
2	35 × 35	290	5/2	5.5

Effect of polyvinyl alcohol on air permeability of polyester fabric

Polyester fabric with 31 picks per centimeter was treated with polyvinyl alcohol at different concentrations ranging from 1.5-3.5 gpl in the presence of NaOH at different temperatures.

Table no. 4 shows the air permeability and wicking height values for modified polyester fabrics (31 ppcm). It shows clearly form the table that the polyester fabric treated with 1.5 gpl PVA in the presence of 4% of NaOH at a temperature of 90°C for a period of 30 minutes gives increase in the air permeability 435 mm/ sec of polyester fabric when compared with the controlled sample 397 mm/sec. This means optimum concentration of polyvinyl alcohol with minimum time and temperature showed to be the best among the various treatment combinations. This may be due to the generation of effective gap between yarns at crossover points and decrease in fibre diameter.

Figure no. 1 & 2 shows that surface plots of air permeability of modified polyester fabric sample 1 with respect to concentration of PVA, time & temperature. It is clear that these variables have significant effect on air permeability of treated polyester fabric. Fig no. 3, 4, 5 & 6 shows that the PVA concentration, time & temperature have effect on warp and weft wicking height of modified polyester fabric. Wicking height of both warp & weft way has increased from 6.1cms and 5.3 cms to 10.6 cms and 10.4 cms respectively, because of treatment with PVA incorporates OH groups in the fabric surface.

Table 4 : Air Permeability and Wicking height values formodified polyester fabric for sample 1

Sl.No	PVA Conc (g/l)	Temperature (°C)	Time (hrs)	Air Permeability of polyester fabric (mm/sec)	Wicking height warp direction (cm)	Wicking height weft direction (cm)
1	3.5	100	1	400	10.3	10.2
2	2.5	90	1	375	10.4	10.5
3	2.5	80	1.5	401	10.4	10.2
4	3.5	90	0.5	407	9.8	10.2
5	2.5	100	0.5	387	10.5	10.5
6	2.5	80	0.5	387	10.6	10.4
7	2.5	90	1	381	10.2	10.4
8	1.5	100	1	426	5.3	6.1
9	2.5	90	1	360	10.3	10.4
10	1.5	80	1	385	6.5	6.9
11	2.5	100	1.5	408	10.3	10.4
12	1.5	90	0.5	435	9.8	9.9
13	3.5	90	1.5	405	10.2	10.5
14	1.5	90	1.5	417	9.8	10.3
15	3.5	80	1	412	10.2	10.5

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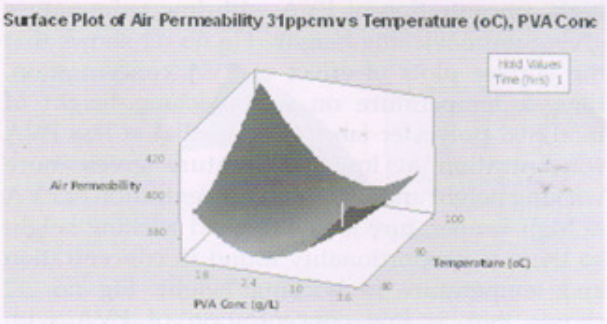

Fig No. 1 Effect of PVA conc. & Temp on air permeability of treated polyester fabric

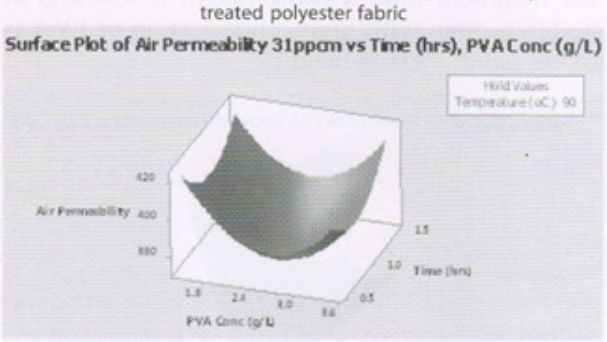

Fig No. 2 Effect of PVA conc. & Time on air permeability of treated polyester fabric

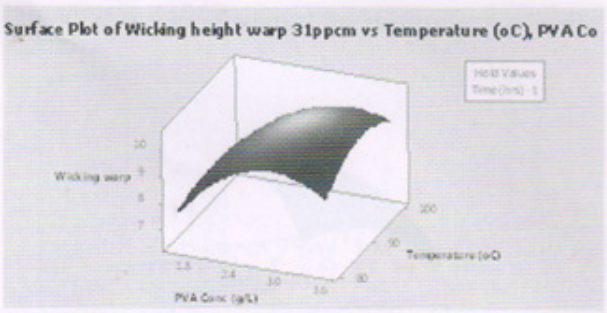

Fig No. 3 Effect of PVA conc. & Temp on wicking height (warp) of treated polyester fabric

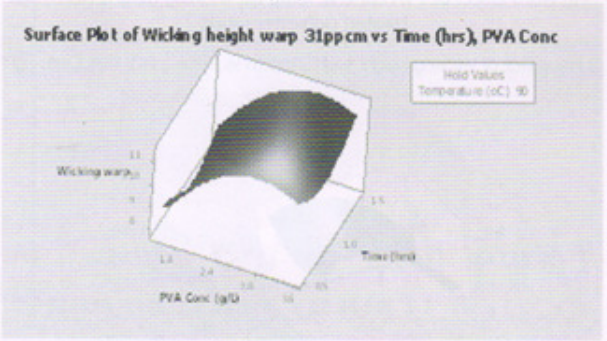

Fig No. 4 Effect of PVA conc. & Time on wicking height (warp) of treated polyester fabric

Table 5 : Air Permeability and Wicking height values for modified polyester fabric for sample 2

Sl. No	PVA Conc (g/L)	Temperature (°C)	Time (hrs)	Air Permeability of polyester fabric (mm/sec)	Wicking height warp direction (cm)	Wicking height weft direction (cm)
1	3.5	100	1	323	8.2	12.5
2	2.5	90	1	247	10.5	10.6
3	2.5	80	1.5	247	10.4	10.8
4	3.5	90	0.5	241	10.8	10.8
5	2.5	100	0.5	256	10.2	10.3
6	2.5	80	0.5	247	10.4	10.6
7	2.5	90	1	253	10.5	10.6
8	1.5	100	1	249	10.5	10.5
9	2.5	90	1	257	10.4	10.5
10	1.5	80	1	310	10.5	10.8
11	2.5	100	1.5	276	10.5	10.3
12	1.5	90	0.5	253	10.5	10.6
13	3.5	90	1.5	255	9.3	10.5
14	1.5	90	1.5	276	10.5	10.6
15	3.5	80	1	270	10.5	10.2

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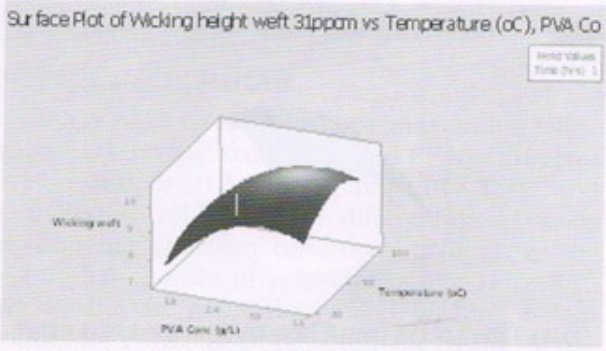

Fig No. 5 Effect of PVA conc. & Temp on wicking height (weft) of treated polyester fabric

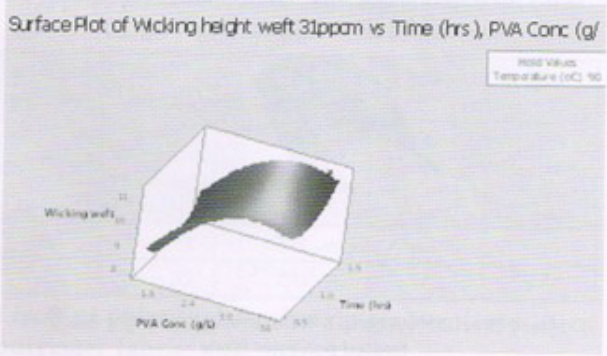

Fig No. 6 Effect of PVA conc. & Time on wicking height (weft) of treated polyester fabric

Polyester fabric with 35 picks per centimeter was treated with polyvinyl alcohol at different concentrations ranging from 1.5-3.5 gpl in the presence of NaOH at different temperatures. Table no.5 shows the air permeability and wicking height values for modified polyester fabrics (35 ppcm). It shows clearly form the table that the polyester fabric treated with 3.5 gpl PVA in the presence of 6% of NaOH at a temperature of 100oc for a period of 1 hour gives increase in the air permeability 323 mm/sec of modified polyester fabric when compared with the controlled sample 290 mm/sec. In this case since the picks per centimeter is high, so that it requires high concentration of polyvinyl alcohol, along with high temperature and time.

Figure no. 7 & 8 shows that surface plots of air permeability of modified polyester fabric sample 2 with respect to concentration of PVA, time & temperature. It is clear that with less concentration of PVA at a temperature of 800c and time of 30min give more air permeability but with increase in concentration of PVA along with temperature and time found less air permeability. In Fig no. 9 & 10 it is found that at low concentration of PVA with high temperature gives more wicking height but at high concentration of PVA with low temperature giving more wicking height. Fig no. 11 shows that the surface plots of effect of PVA concentration, time & temperature on weft wicking height of modified polyester fabric. Shows that at less PVA concentration at low temperature gives more wicking height and with high concentration of PVA at high temperature is giving good wicking height so there is proportionality found in concentration and temperature in wicking height. Fig no. 12 shows that at low concentration of PVA with less treatment time wicking height is low and at moderate time with high concentration of PVA is giving good wicking height.

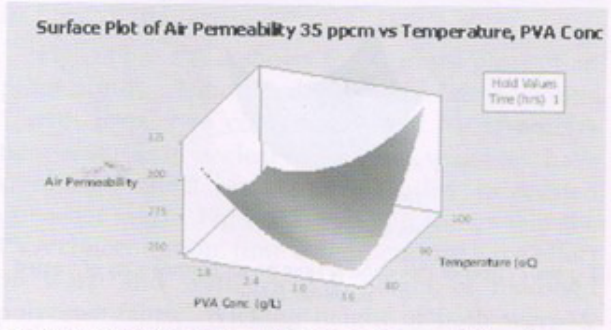

Fig No. 7 Effect of PVA conc. & Temp on air permeability of treated polyester fabric

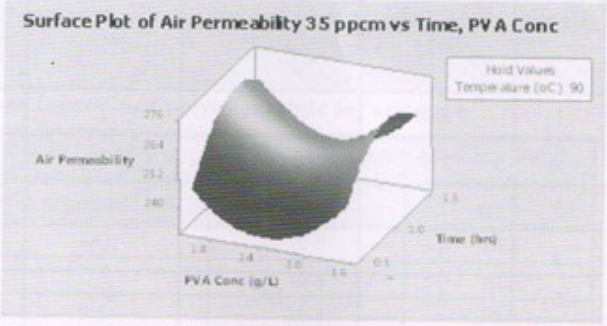

Fig No. 8 Effect of PVA conc. & Time on air permeability of treated polyester fabric

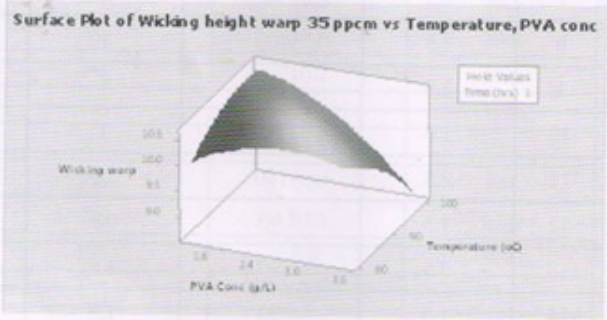

Fig No. 9 Effect of PVA conc. & Temp on wicking height (warp) of treated polyester fabric

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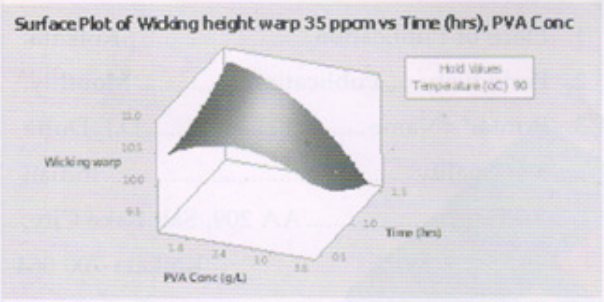

Fig No. 10 Effect of PVA conc. & Time on wicking height (warp) of treated polyester fabric

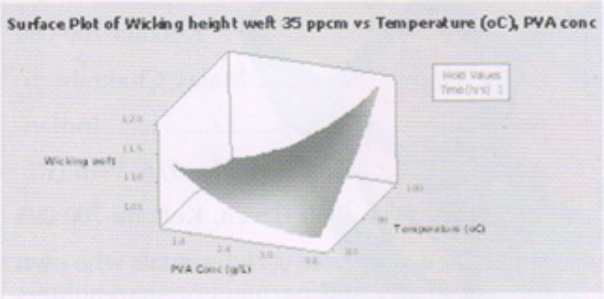

Fig No. 11 Effect of PVA conc. & Temp on wicking height (weft) of treated polyester fabric

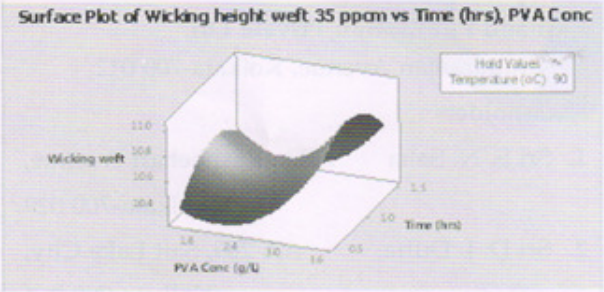

Fig No. 12 Effect of PVA conc. & Time on wicking height (weft) of treated polyester fabric

Structural investigation of modified Polyester fabric:

FTIR spectral measurements were carried out on untreated and treated polyester fabrics using an Infrared spectrophotometer which is shown in Fig no. 13 & 14. The high peaks from to 600 cm-1 to 1700 cm-1 indicate the original signals, which indicates the spectra of stretching vibration band of C=O at 1730 cm-1 and this peaks confirm the existence of ester linkage. Fig. no 14 shows the PVA treated samples at concentration of 3.5 gpl. Infrared spectra of FTIR clearly show that the PVA treated PET fabric shows a broad band in the region 3000 cm-1 to 3090 cm-1 which shows the presence of hydroxyl groups. This confirms the adsorption of PVA onto the PET surface.

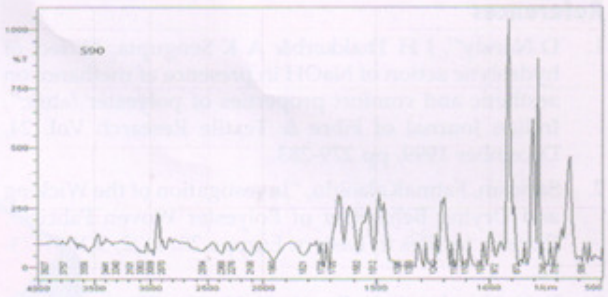

Fig no. 13 FTIR investigation of standard sample

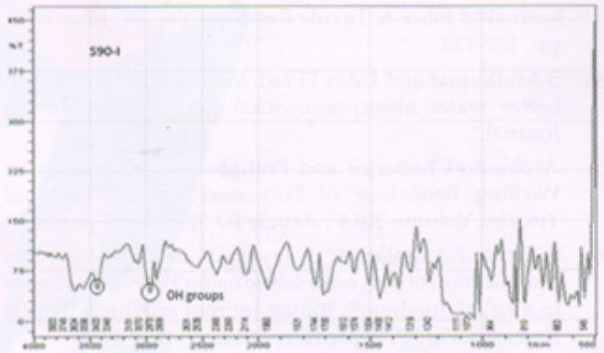

Fig no.14 FTIR investigation of treated sample

CONCLUSION

The process parameters have been optimized for the application of PVA on to the polyester fabric for air permeability and wicking. Polyester fabric of 31 ppcm treated with 1.5 gpl PVA in the presence of 6% of NaOH at a temperature of 90oc for a period of 30 minutes gives increase in the air permeability 435 mm/sec when compared with the controlled sample 397mm/sec. Polyester fabric with 35 ppcm with different concentrations of PVA does not have much influence on the air permeability values of fabric samples. Among all the treatments polyester fabric treated with 3.5 gpl PVA in the presence of 6% NaOH at 1000c for a period of 1 hr gives higher air permeability value 324 mm/sec when compared with the controlled sample 290 mm/sec. This is due to the generation of effective gap between yarns at cross over points and decrease in fibre diameter. Wickability of polyester fabric has improved significantly and almost all the samples with various concentrations of PVA at different temperature and time exhibit considerable improvement. The FTIR results of PVA treated PET fabric shows a broad band in the region 3000 cm-1 to 3090 cm-1 which confirms the presence of hydroxyl groups.

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