ROLE OF SOLVENTS IN IMPARTING SILKY HANDLE TO POLYESTER AND POLYESTER BLENDED FABRICS

[1]N Dhiraj Kumar, [2]Prof.J.Hayavadana
Department of Textile Technology,
University College of Technology, Osmania University, Hyderabad, Telangana, India.

Abstract: This study was aimed at comparatively investigating the comfort properties of polyester, polyester/cotton and polyester/Modal blended fabrics treated with, without alkali and solvents viz Ethyl alcohol, Methyl Amine, Pyridine and Poly-Vinyl Alcohol. Appropriate process parameters were selected based on earlier research works for solvent treatment. To study the effect of various treatments on comfort related properties air, water vapor permeability, bending, Tear strength and compression were measured. The effect of different treatments on comfort properties were evaluated by calculating the quantitative differences among them. The polyester blended fabrics were modified more strongly by alkali than by pure solvents alone. The results show that solvent treatments can be effective in the presence of alkali. The methyl Amine and PVA treated polyester blended fabrics in presence of alkali showed significant improvement in hydrophilic characteristics over intact and sodium hydroxide treated polyester blended fabrics. The results found were a proof to show solvent treatment can be used to improve the comfort properties of polyester and polyester blended fabrics. The results of this investigation clearly suggest that solvent treatment in presence of alkali, a low-cost alternative in improving the comfort properties by the surface modification of polyester and polyester blended fabrics. The mechanism of the surface modification of polyester blended fabrics by solvents in the presence of alkali was discussed.
Keywords: Solvent Treatment, NaOH, PVA, Methyl Amine, Ethyl alcohol, Pyridine, Comfort Properties.

1.0 Introduction

The modification of fibres using solvents depends upon the extent of interaction of solvents and their solubility parameters. The presence of solvent can cause disturbance in the structural order of the fibre and the polymer matrix get restructured after the removal of solvents. Many reports are available on modification of the polymer fibres through solvent pre-treatments and induced crystallization. In these treatments solvents are reported to disrupt the secondary bonds in the fibre and enhance the segmental mobility of the polymer chains and result into the formation of stable crystallites after the removal of the solvent molecules. During the solvent pre-treatment process, the solvent attacks the more susceptible amorphous region and reduces the strength of polymer interaction compensating with polymer solvent interaction. Dave *et al.,* (22) worked on the hydrolysis of polyester fabrics with sodium hydroxide has been studied with a view to imparting hydrophilicity and other comfort-related properties to polyester textiles. Effect of reaction parameters such as treatment time concentration of alkali, and temperature on the extent of hydrolysis is examined and the modified fabrics are evaluated for their important physical, mechanical, and physicochemical properties. The mechanism of hydrolytic degradation of polyester fabrics, as determined by the weight loss, has also been ascertained. Vasantha (54) worked on the surface modification of polyester fabrics by alkaline hydrolysis. alkaline hydrolysis of polyester is an important industrial treatment which leads to significant improvement in the fabric properties. Hayavadana (20) worked on Surface modification of polyester fibres. In one phase of his work, it is observed that Weight reduction of jute/polyester blended fabric under the treatment conditions used in this study leads to a linear reduction in weight with an enormous improvement in fabric bending, shear, tensile, compression and surface properties. Brojeswari *et al.,* (9) studied the Moisture Flow through Blended Fabric and effect of Hydrophilicity. Moisture flow through blended material is a complex phenomenon. Clothing should possess good water vapour as well as liquid moisture transmission property, for providing the thermo-physiological clothing comfort. Moses *et al.,* (35,36) worked on surface modification of polyester fabric using polyvinyl alcohol in alkaline medium. Chemisorption of Polyvinyl alcohol onto polyester fabric in alkaline medium has been conducted. The treatment of fabric is characterized by scanning electron microscope, ATR-FTIR spectroscopy, contact angle, differential scanning calorimetry and dyeability. PVA treated polyester fabric shows improvement improved hydrophilic character over intact and sodium hydroxide treated fabrics.

2.0 Materials and Methods

2.1 Materials

The Experimental materials viz. Polyester fabric, Polyester/Cotton fabric and Polyester/Modal fabric were procured from the local market and weaving industry. In this present work the above said fabrics were treated with Chemicals viz. Sodium Hydroxide, HCL, Ethyl alcohol, Methyl Amine, Pyridine and Polyvinyl alcohol coming from various manufacturers having their different chemical composition. All the Chemicals were L/R grade and were not purified further. De-ionised water was used for entire work. Geometrical Properties were measured as per IS: 1963-1969.

Table 2.1 Geometrical Properties of the fabrics

Sample (Code)	n_1	n_2	N_1	N_2	C_1	C_2	GSM	K_1	K_2	K
100 % Polyester(S1)	100	50	36	36	3	5	100	16.7	8.3	20.04
Polyester/Cotton (S2)	100	82	2/80	2/80	8	14	140	15.8	12.9	21.5
Polyester/Modal (S3)	164	128	60	60	4.8	9.6	140	21.17	16.52	25

2.2 Solvent Treatment

The de-sized fabrics were then treated with each solvent mentioned, in the presence of Sodium Hydroxide and in the absence of sodium Hydroxide in two phases. M:L ratio taken was 1:30. The wet fabric was added into the bath at room temperature and the temperature was raised to 90ºc and stirring was done for every five minutes till 45 min. After 60 minutes, the fabrics were removed and rinsed with cold water for 5 min with soap solution, squeezed and dried. Percentage weight loss and shrinkage in both warp and weft were noted. (35,36)

Table 2.2 Process parameters for solvent treatment

S No	Code	M:L ratio	Solvent used	Solvent Conc.	Temp (°C)	Time (mins)
1	EA	01:30	Ethyl Alcohol	1.50%	90ºc	60 min
2	MA	01:30	Methyl Amine	1.50%	90ºc	60 min
3	PD	01:30	Pyridine	1.50%	90ºc	60 min
4	PVA	01:30	Poly-Vinyl Alcohol	1.50%	90ºc	60 min
5	AEA	01:30	NaOH	4%	90ºc	60 min
		01:30	Ethyl Alcohol	1.50%		
6	AMA	01:30	NaOH	4%	90ºc	60 min
		01:30	Methyl Amine	1.50%		
7	APD	01:30	NaOH	4%	90ºc	60 min
		01:30	Pyridine	1.50%		
8	APVA	01:30	NaOH	4%	90ºc	60 min
		01:30	Poly-Vinyl Alcohol	1.50%		

3.0 Research Methodology

Tearing strength of the fabric samples were measured on Elmendrof Tear Tester as per IS: 6489-1971.
Shirley Air permeability tester was used for the measurement of air permeability as per standard test method ASTM- D 737.
Drape meter was used for testing drapability according to the standard ASTM –D3691.
Cantilever Bending length was used for testing the bending length according to the standard ASTM-D1388.
Wicking height of the control and treated fabrics were measured as per IS: 2349- 1963

4.0 Results and Discussion

4.1 Effect on Weight Loss Of Polyester Blended Fabrics

Any fabric when processed under specific conditions will lose weight depending on the type and nature of fibre / yarn. However, the loss in weight in any process to be under control else it may affect cost of the finished product. Table. 4.1 give some idea about the weight loss of samples following solvent treatment.

Table 4.1 Effect on Weight Loss of Polyester blended fabrics

Sample	Control	Weight Loss%							
		Without NaOH				With NaOH			
		EA	MA	PD	PVA	AEA	AMA	APD	APVA
S1	1.5	0.11	1.09	1.28	0.22	8.9	9.13	7.9	8.8
S2	8	1.8	0.9	1.6	2.7	5.3	6.2	4.9	6.75
S3	8.4	1.2	1.8	2.6	1.12	4.6	5.1	4.1	6.1

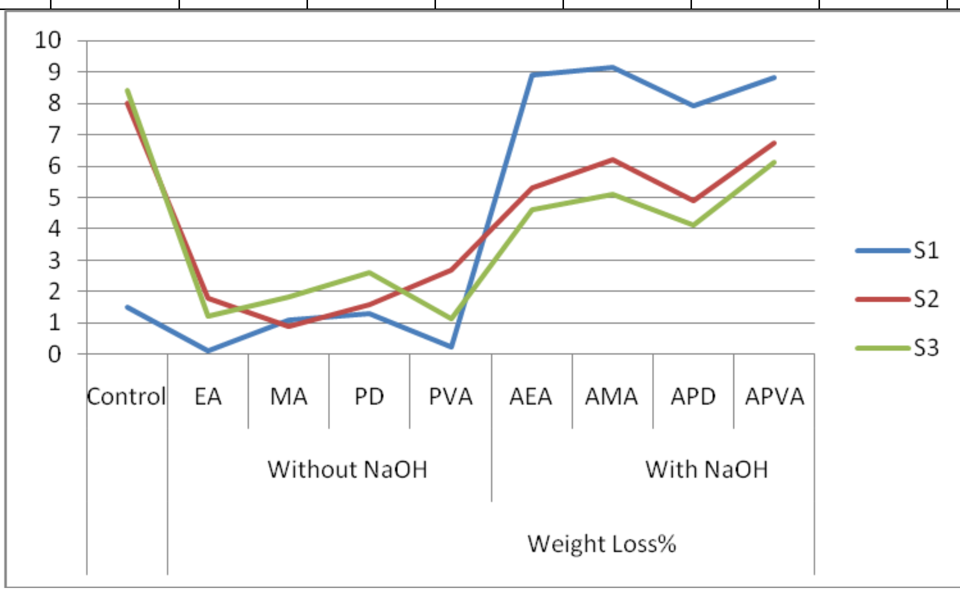

Figure 4.1 Effect on Weight Loss of Polyester blended fabrics

From Greige to De-size fabric, it is seen that more weight loss has occurred in de-sizing. Further there is more weight loss in solvent treatment in presence of alkali. Figure 4.1 show that more weight loss found in 100% PET fabrics compared to Polyester/Cotton and Polyester/Modal blend. This is due to the fact that, cotton and modal fibres have shown more resistance to surface hydrolysis.

4.2 Effect on Compressibility of Polyester Blended Fabrics

Generally, any fabric if meant for apparel purpose should exhibit excellent compressibility and this can be further improved by wet processing. Compressibility is derived from the thickness of the fabric under different loads. The behaviour of fabrics can be very well understood by measuring the compressibility of the fabric.

Table 4.2 Effect on Compression of Polyester blended fabrics

Sample	Control	EMC %							
		Without NaOH				With NaOH			
		EA	MA	PD	PVA	AEA	AMA	APD	APVA
S1	10.6	3.5	4.9	2.7	7.2	8.6	9.4	8.7	12
S2	8.8	8.6	4.1	8.4	9.3	10.1	7.4	9.6	12.6
S3	7.2	7.9	3.5	6.6	10.5	9.2	8.3	7.7	11

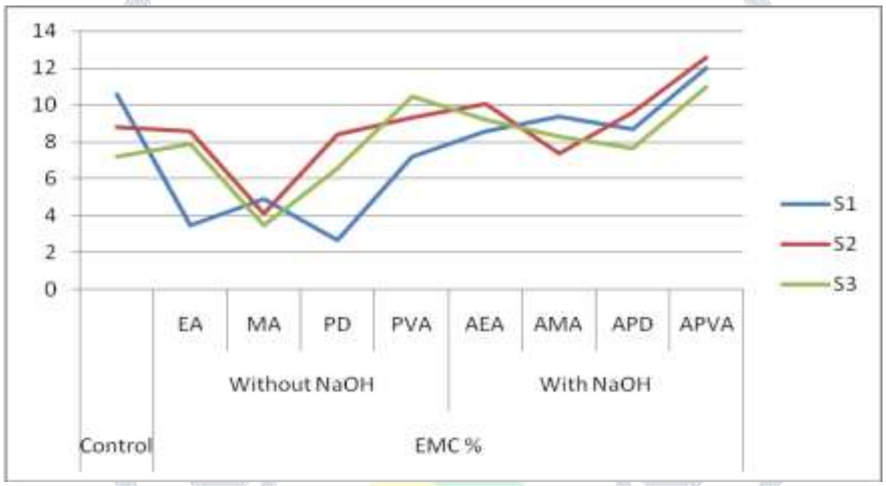

Figure 4.2 Effect on Compression of Polyester blended fabrics

4.3 Effect on Air Permeability of Polyester Blended Fabrics

Among the several properties governing Comfort of fabrics, permeability to air is one of the important factors specially goods like sportswear. Generally, it's expected that fabric do exhibit a good amount of permeability to air. In the present investigation, air permeability is affected by finishing process.

Table 4.3 Effect on Air Permeability of Polyester blended fabrics ($cm^3/cm^2/sec$)

Sample	Control	Air Permeability							
		Without NaOH				With NaOH			
		EA	MA	PD	PVA	AEA	AMA	APD	APVA
S1	172	164	158.4	158.4	180	144.3	137	142	158
S2	44	38.3	37	41.7	44	33.7	32	33.4	37
S3	94	91.9	97.6	92	92	80.9	78.1	75.8	89

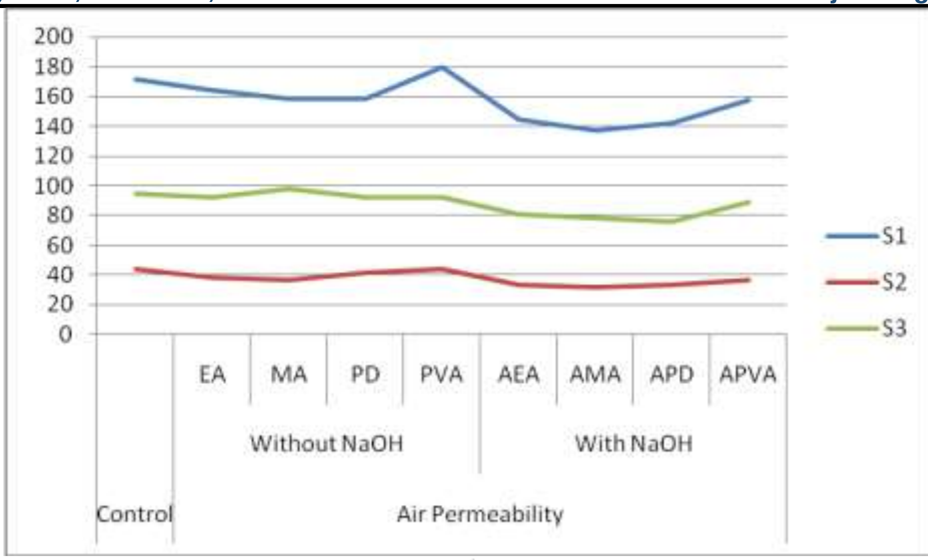

Figure 4.3 Effect on Air Permeability of Polyester blended fabrics

The air permeability is seen reduced from Greige to De-size despite the size is removed. This is due to the increased compactness due to shrink effect of weft and warp. The shrink leads to reduced cover factor thereby allowing less air flow. The reduction in air permeability is seen from De-size to Solvent treatment and further reduction solvent treatment in presence of NaOH. The reduction in air permeability varied considerably among different solvents and addition of alkali. From figure 4.3 it is clear that air permeability in $cm^3/cm^2/s$ is reduced by wet processing treatment. This may be due to the increase in cover or in term due to increase in ends and picks per inch on account of stress relaxation of warp and weft. Analyzing the % shift in terms of fabric, it can be said that air permeability decreased in polyester/Cotton and polyester/Blends compared to 100% polyester.

4.4 Effect on Drape of Polyester Blended Fabrics

Any apparel fabric is expected to exhibit an excellent drapability to provide comfort to wearer. In this regard all wet processing treatments are aimed to improve the drapability depending on the conditions of the wet processing. The results in the current study show a similar trend as observed from the Table 4.4.

Table 4.4 Effect on Drape of Polyester blended fabrics

Sample	Control	Drape							
		Without NaOH				With NaOH			
		EA	MA	PD	PVA	AEA	AMA	APD	APVA
S1	0.35	0.33	0.31	0.33	0.36	0.27	0.26	0.36	0.24
S2	0.42	0.29	0.28	0.29	0.3	0.24	0.25	0.26	0.27
S3	0.34	0.24	0.29	0.23	0.17	0.26	0.22	0.24	0.16

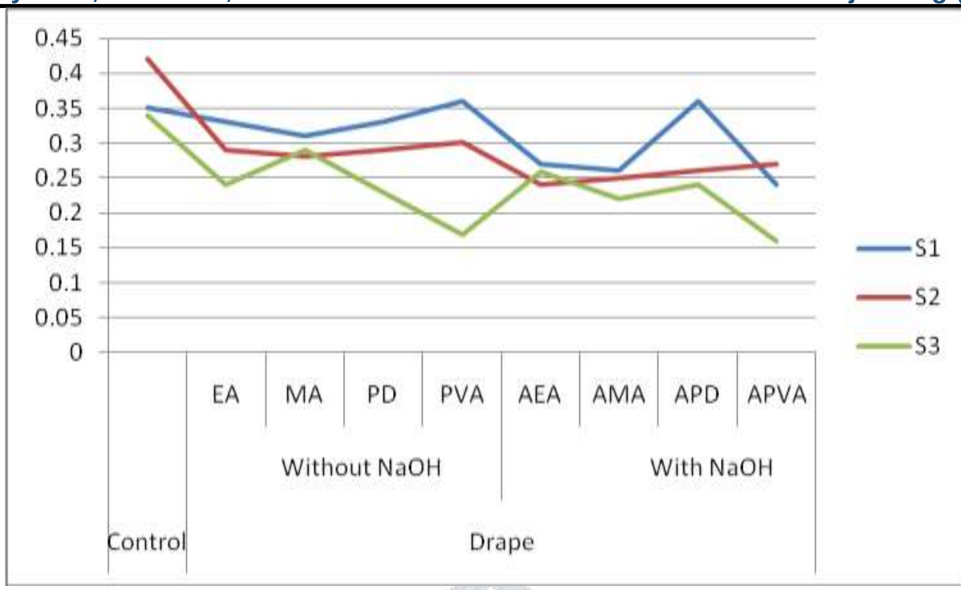

Figure 4.4 Effect on Drape of Polyester blended fabrics

After solvent treatment, Drape Coefficient is seen decreased. This may be due to decrease in weight of the fabric i.e., grams per square meter. Also the thickness of the fabric reduces from de-sizing to solvent treatment. PVA+NaOH treatment improved the drapability of the fabric in case 100% polyester but not in the case of polyester/Cotton blended fabric. Drape Coefficient is seen reduced from Greige to solvent treatment in the presence of NaOH because the weight of the fabric per square meter get reduced. Based on the percentage shift from process to process, drape coefficients are reduced significantly in polyester/cotton blended fabrics.

4.5 Effect on Overall Flexural Rigidity of Polyester Blended Fabrics

This is one of the most important fabric properties having significant effect on fabric drapability. Generally, any wet processing stage will improve the bending length and for finer counts the length will decrease and for coarser count it increases.

Table 4.5. Effect on Overall Flexural Rigidity (mg.cm) of Polyester blended fabrics

Sample	Control	Flexural Rigidity (mg.cm)G_0							
		Without NaOH				With NaOH			
		EA	MA	PD	PVA	AEA	AMA	APD	APVA
S1	23	20.96	18.77	20.45	20.6	19.2	17.01	18.6	17.9
S2	22.27	21.67	20	21.01	17.2	20	18.4	19.3	13.4
S3	16.77	15.89	17.12	16.83	13.3	14.3	15.89	15.4	11.8

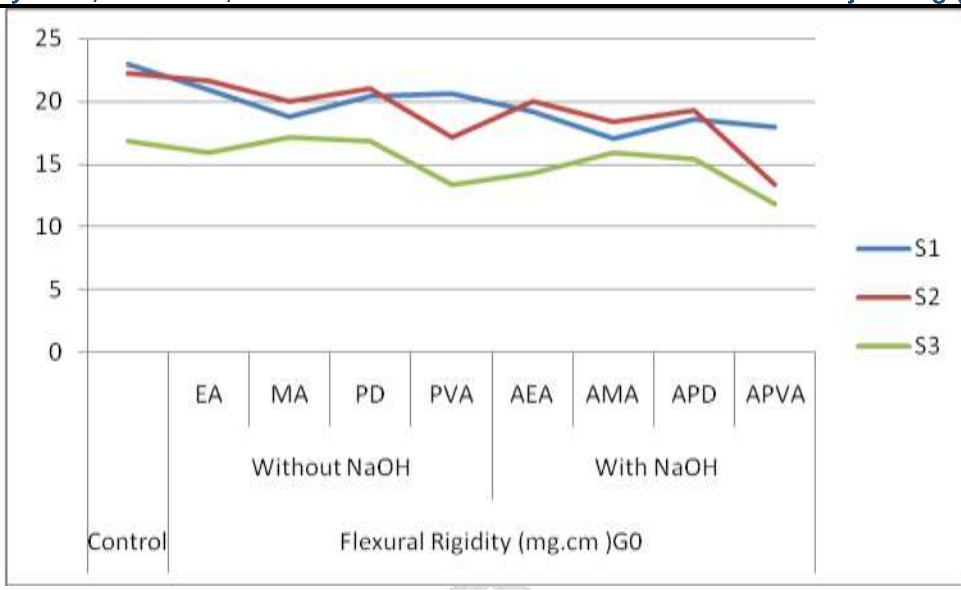

Figure 4.5. Effect on Overall Flexural Rigidity (mg.cm) of Polyester blended fabrics

Flexural rigidity is seen decreased. This is because surface hydrolysis of the fabrics. It is more significant in case of Poly vinyl alcohol with alkali. From Greige to solvent treatment, the flexural rigidity is seen decreased. This is because the flexibility occurred due to size removal and removal of impurities and weight loss due to surface hydrolysis.

4.6 Effect on Wicking Nature of Polyester Blended Fabrics

Wicking is one of the important comfort properties and the performance of the fabrics is most expected in many situations of sports events where sweat is generated in body. Generally, it is expected that following any wet processing treatment, wicking behaviour is improved and the present investigations support these aspects. Wicking height after 20 min is reported.

Table 4.6. Effect on Wicking Nature Of Polyester Blended Fabrics

Sample	Control	Warp way Wicking Sec							
		Without NaOH				With NaOH			
		EA	MA	PD	PVA	AEA	AMA	APD	APVA
S1	10	4	5.5	5.5	3	6	7	6.5	7
S2	2	1	0.5	0.5	0.5	1	1	1	1
S3	7	9	8	7	6	8	10	8	7

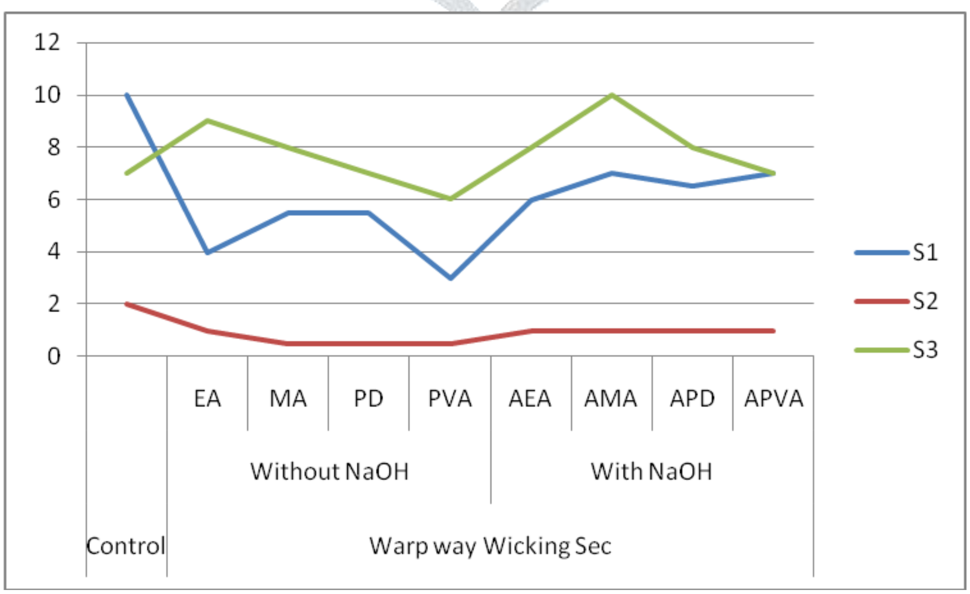

Figure 4.6. Effect on Wicking Nature of Polyester Blended Fabrics

From De-size to solvent treatment, the wicking is seen increased. The rise in wicking property is almost 50% more in solvent treated fabric than that of the desized. Methyl amine + NaOH (AMA) treated fabric found with more wicking. PVA treated fabrics are seen with less wicking property.

5.0 Conclusions

Although a considerable amount of work done on the alkaline hydrolysis of polyester, This research shows the method of producing of multifunctional polyester blended fabrics with comfort properties. Following are the set of conclusions from the study undertaken.

1. The general trend in the Weight loss results indicates a significant increase up to 9% in solvent treated samples with NaOH, when compared to both the untreated and solvent-treated without alkali.
2. The solvent-treated polyester blended fabrics in presence of alkali show a decrease in the Drape coefficients values. It means better drapability of the fabrics.
3. A decrease in Air-permeability has also been noticed in solvent treated fabric from the percentage shift from the control samples.
4. It is also inferred that the solvent treatment generally improved the bending properties of the fabrics. Since the flexural rigidity G0 values reduced after the solvent treatment.
5. Methyl Amine and Poly Vinyl Alcohol as solvents in presence of sodium hydroxide, exhibited better fabric handle properties in terms of drapability, compression and air permeability within the process conditions used in this research work compared to the other two solvents viz Ethyl alcohol and pyridine. These are therefore considered the best in terms of stable handle properties.
6. Change in wicking behaviour has majorly depended on the blend composition. More polyester proportion higher the wicking and fabric with cotton and modal fibres have shown less wicking height. PVA treated polyester blended fabrics found with improved wick-ability compared to that of other solvents.

References

1. Ahsan Nazir, Tanveer Hussain, Ali Afzal, Sajid Faheem, Waseem Ibrahim and Muhammad Bilal (2017), "Prediction and Correlation of Air Permeability and Light Transmission Properties of Woven Cotton Fabrics", Autex Research Journal, Vol. 17, No 1, No.3.

2. Arthur S. Ribnick, Hans-Dietrich Weigmann and Ludwig Rebenfeld (2015), "Interactions of Non-Aqueous Solvents with Textile Fibres-Effects of Solvents on The Mechanical Properties of a Polyester Yarn", Textile Research Institute, USA.

3. Arthur S. Ribnick, Hans-Dietrich Weigmann, Ludwig Rebenfeld (1973), "Interactions of Nonaqueous Solvents with Textile Fibers: Part II: Isothermal Shrinkage Kinetics of a Polyester Yarn", Text. Res. J., No.3.

4. Bagherzadeh R., Montazer M., Latifi M., Sheikhzadeh M., And Sattari M. (2007) "Evaluation of Comfort Properties of Polyester Knitted Spacer Fabrics Finished with Water Repellent and Antimicrobial Agents", Fibers and Polymers, Vol.8, No.4, pp.386-392.

5. Bendak.A and El-Marsafi.S.M. (1991), "Effects of Chemical Modifications on Polyester Fibres", Journal of Islamic Academy of Sciences 4:4, 275-284.

6. Brojeswari Das, Ph.D., Apurba Das, Ph.D., Vijay Kothari, Ph.D., Raul Fanguiero, Ph.D. And Mario D. Araujo, Ph.D. (2009), "Moisture Flow Through Blended Fabrics –Effect of Hydrophilicity", JEFF, No.12.

7. Chavan R B and Jain A K (1988), “The Role of Ethylene Glycols During Sublimation Transfer Printing of Cotton”, JSDC, Volume 104 No. 5/6.

8. Dhinakaran M (2010), “Modification of Polyester and Polyester Cotton Fabrics By Alkali Treatment”, Ph.D. Thesis, Anna Univ.

9. Ellison. M. S., Fisher L. D., Alger.K. W. and Zeronian S. H. (1982), “Physical Properties of Polyester Fibers Degraded by Aminolysis And By Alkalin Hydrolysis”, JAPS, Vol.27, Issue-1, pp. 247-257, No.1.

10. Graecia Lugito , Lai-Yen Wang , Eamor M. Woo (2014), “Chemical and Morphological Alterations Effected by Methylamine Reactions on Polyesters”, Macromol. Chem. Phys., 215, 1297−1305.

11. Hayavadana J.(1997), “Surface Modification of Polyester Fibres”, Ph.D. Thesis, Anna Univ.

12. Jaime Gisbert-Paya, M Ángeles Bonet-Aracil, Petar Jovančić, Manuel J. Lis and Luisa Coderch (2021), “Increased Comfort of Polyester Fabrics”, Polymers, 13, 3010.

13. Jayshree Dave, Raj Kumar and H. C. Srivastava (1987), “Studies on Modification of Polyester Fabrics I: Alkaline Hydrolysis “JAPS, No.2.

14. Jong-Jun Kim (1992), “Softness Properties of Fabric Like Tissues”, Ph.D Thesis, North Carolina State University.

15. Kalid Gashaw And Amare Worku (2017), “Surface Modification of Polyester Fabrics Using Sugarcane Bagasse”, IJSER, Issn (Online): 2347-3878.

16. Khurram Shehzad Akhtar, Sheraz Ahmad , Ali Afzal, Wardah Anam, Zulfiqar Ali and Tanveer Hussain (2019), “ Influence and Comparison of Emerging Techniques Of Yarn Manufacturing On Physical–Mechanical Properties Of Polyester-/Cotton-Blended Yarns And Their Woven Fabrics”, J. Text. Inst.

17. Muhammad Umair, Tanveer Hussain, Khubab Shaker, Yasir Nawab, Muhammad Maqsood and Madeha Jabbar (2016), “Effect of Woven Fabric Structure on The Air Permeability And Moisture Management Properties”, J. Text. Inst., Vol. 107, Issue 5.

18. Muhammad Umair, Tanveer Hussain, Khubab Shaker, Yasir Nawab, Muhammad Maqsood and Madeha Jabbar (2016), “Effect of Woven Fabric Structure on The Air Permeability And Moisture Management Properties”, J. Text. Inst., Vol. 107, Issue 5.

19. Perkins W.S. , Hall D.M. ,Slaten B.L. . Walker R.P. and Farrow J. C. (1977), “ Use of Organic Solvents in Textile Sizing and Desizing”, EPA-600/2-77-126, No.7.

20. Pitchai S, Jeyakodi Moses J. And Swarna Natarajan (2014), “Study on The Improvement of Hydrophilic Character on Polyvinylalcohol Treated Polyester Fabric”, PJCT, 16, 4, 21 —27.

21. Pitchai. S, Jeyakodi Moses J. and Swarna Natarajan (2014), “ Study on Polyester Fabric Using Polyvinyl Alcohol in Alkaline Medium to Enhance the Hydrophilic Character”, Kuwait J.Sci. 41 (3) pp.177-190.

22. Rajendran S., Ramasamy S. S. and Mishra S. P. (1996), “Tensile Behaviour of Polyester Yarns Modified by Trichloroacetic Acid-Methylene Chloride Treatment”, Journal of Applied Polymer Science, Vol. 59, 99-108.

23. Raju M. V. S. and Dweltz N.E. (2015), " Influence of Macromolecular Orientation and Crystallinity On Critical Dissolution Times Of Polyester Fibers", ATIRA.

24. Rakesh M. Musale and Sanjeev R. Shukla (2016), "Weight Reduction of Polyester Fabric Using Sodium Hydroxide Solutions with Additives Cetyltrimethylammonium Bromide And [BMIM]Cl", J. Text. Inst., Volume 108, Issue 4.

25. Roya Dastjerdi And Majid Montazer (2010), "A Review on The Application of Inorganic Nano-Structured Materials in The Modification of Textiles: Focus on Anti-Microbial Properties", Colloids and Surfaces B: Biointerfaces 79.

26. Shanthi. B (1995), "A Study of Comfort and Other Properties of Polyester and Cellulosic Blends", Ph.D. Thesis, Anna Univ.

27. Shet R. T.,Zeronian S. H., Needles, H. L. And Siddiqui, S. A. (2021), "Modification of Polyester and Polyester/ Cotton by Alkali Treatment", Textile Chemist & Colorist . Nov82, Vol. 14 Issue 11, P21-25.

28. Swarna Natarajan And J Jeyakodi Moses (2012), "Surface Modification of Polyester Fabric Using Polyvinyl Alcohol in Alkaline Medium", IJFTR, Vol. 37, Sep.2012,pp.287-291.

29. Vasantha M. (1991), "A Study on The Surface Modification of Polyester Fabrics by Alkaline Hydrolysis", Ph.D. Thesis, Anna Univ.

30. Venkataraj R. and Gulrajani M L (1989), Bleaching of Polyester/Cotton Blended Fabrics with A Foamed Composition", IJTR,Vol.14, pp.35-38.

31. Venkatesh B., Siva Jagadish Kumar M., Govardhan Rao Ch. And Vaseem Chavhan Md.(2018), "An Investigation Into Comfort Properties Of Polyester Fabric By Surface Modification With Polyvinyl Alcohol", Textile Trends-No.3.

32. Vigneswari S.(2015), "A Study on Solvents Assisted Dyeing of Polyester and Polyester Cotton Blended Yarns And Fabrics", Ph.D. Thesis, Periyar M. Univ.