A Study on the Development of Cost Effective Dyeing Method for Dyeing Of 100% Polyester Fabric

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ABSTRACT :

The need for cost effective dyeing method for dyeing of 100% polyester (PET) fabric necessitated the present study. 100 % PET fabric was subjected to pretreatments using two different azeotropic mixtures of organic solvents for different durations with a view to improve the dyeability and to cause changes in physico chemical behaviours such as crystallinity and dyeability. The effect of pretreatments on different physico chemical properties of fibre including its dyeability has been investigated using SEM, FTIR , DSC, XRD studies. Two different diperse dyes were used to study the changes in dyeing behavior and the results are presented.

Key words : Polyester fabric, Azeotropic mixture, pretreatment, Disperse dyes, Scaning Electron Microscopy, Fourier Transform Infra Red analysis, Thermal Analysis, X-ray Diffraction studies, Dye uptake , Fastness properties.

1. INTRODUCTION

Polyester fibre, by virtue of its hydrophobic nature, its tightly packed molecular structure and its lack of reactive groups, is un reactive to most dye molecules. Disperse dyes were found to be suitable for dyeing polyester with the dyeing process taking place through hydrogen bond formation between amino groups in the dye molecule and carbonyl groups in the fibre polymer or through electrostatic attraction between the dye molecules and the fibre[1].

Commercially polyester is dyed by high temperature dyeing method. This process involves high cost dyeing machinery. The modification of the internal structure of polyester, either at fibre stage or at yarn stage, is possible by suitable solvent pretreatments[3-14] or by thermal means [15-23]. Both the treatments produce induced crystallization in the polymer matrix which lowers the glass trasition temperature (Tg) and enhances the segmental mobility. The main difference between thermal crystallization and solvent induced crystallization is that in the former there is no external molecular species involved to crystallize the polymer whereas in the latter the presence of another molecule is required.

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The organic solvent acts on polyester either by plasticizing or swelling action with or without some molecular degradation, creating more voids and reducing glass transition temperature. It diffuses into polymer matrix, swells the polymer, breaks some weak intermolecular forces between polymer chains and peoduces increased segmental mobility. This reduces glass transition temperature (Tg), causes some structural rearrangement and rebuilds the secondary intermolecular forces in a plasticized polymeric fibre involving also the sliding, rotation and physical separation of crystalline lamalle with permissible shrinkage [6-14].

The present study was made with an aim to develop a cost effective dyeing method for dyeing of 100% PET fabric by using two azeotropic mixture of organic solvents. The effect of solvent pretreatments on the dye uptake was studied and the extent of improvement achieved are presented. The effect of solvent pretreatments on the various physico- chemical behaviour was also studied using Scanning Electron Microscopy(SEM), Fourier Transform Infra Red (FTIR), Differrential Scanning Calorimetry (DSC) and X-ray Diffraction studies (XRD) and the results are presented.

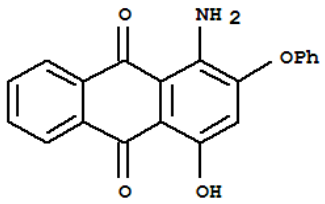
The term Azeotrope (Greek) means " To boil unchanged " that is the vapour boiling from a liquid has the same composition as the liquid. The composition of the ternary mixtures were fixed by referring to azeotropic data published by Ryland [24] and Lecat[25].

2. MATERIALS AND METHODS

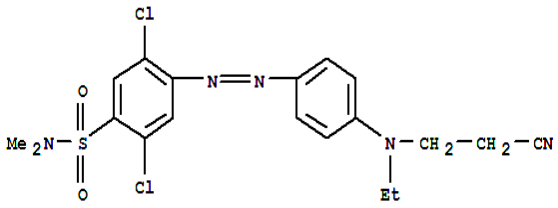
2.1 Polyester Fabric: A plain woven commercially available 100% polyester fabric made of filament yarn with 104 ends per inch and 54 picks per inch from Mafatlal fabrics, Mafatlal Industries Ltd, Mumbai India was used

2.2 Dyes: The following commercially available Foron disperse dyes (Parishi chemicals, Surat, India) were used for dyeing 100% polyester fabrics as supplied by the manufacturer without further purification in the present study.

a.Foron Brilliant Red E-2BL200 F(C.I. Disperse Red 60)



b. Foron Brilliant Orange S-FL(C.I.Disperse Orange 96)



2.3 Chemicals Used:

Carbon tetrachloride(CTC), sec-Butyal alcohol(s-BA), Formic acid(FA) and Propionic acid(PA) were used for preparing following azeotropic solvent mixtures used in the current study. The composition of the solvent mixtures are given in parantheses as reported in literature[24-25].

(i) Water : CCl_4: s-Butyl Alcohol (W:CTC: s-BA = 4.05:91:4.95) B.P.65^0 C

(ii) Water : Formic Acid : Propionic Acid (W:FA:PA = 18.6:71.9: 9.5) B.P.107.2^0 C

Phenol was used as carrier for conventional dyeing. 3% Acetic acid was used to maintain the pH 4.5 -6. All chemicals used were Fisher Scientific – LR Grade.

2.4 Apparatus:

Padding mangle was used to squeeze the pretreated fabric which aided the penetration of solvent mixture into the interior of the fibre samples. Dyeing was performed using the Rota – dyer bath (Rota dyer 18x100-N machine, R.B.Electronics & Engineering Pvt Ltd, Mumbai – 53. India)

2.5 Pretreatments:

Solvent pretreatments of 100% PET fabrics were carried out at room temperature for various time intervals, viz 2, 4, 8, 10, 20, 30 and 60 minutes with a material to liquor ratio (MLR) of 1:40 in a specially designed closed air tight trough without escape of solvent to atmosphere. The pretreated fabrics were then taken out and squeezed in a padding mangle and then air dried in an oven for removal of residual solvent mixture. Then the fabrics were subjected to dyeing.

2.6 Dyeing Recipe:

Dye	-	2% (over the weight of fabric)
Acetic Acid	-	1-3 gpl to maintain pH acidic
MLR (Material to liquor ratio)	-	1:50
Temperature	-	70^0C , 80^0C & boil
Time	-	30, 45, and 60 minutes

The dye bath containing required amount of aectic acid and water was set at 50^0C. The pretreated samples were introduced into the above said dye bath and kept under these conditions for 10 minutes. Then calculated amount of dye solution was added into the dye bath and then required temperature was set within 10 minutes. Dyeings were carried out for 45 minutes using the above said recipe. After the completion of the dyeing time, the temperature was brought down to room temperature gradually, then the dyed fabrics were taken out and washed with cold water. For comparision conventional dyeing of untreated polyeater fabric was also carried out using phenol as carrier for dyeing untreated fabric.

The fabrics after dyeing and washings were reduction cleared by using 2gpl each of sodium hydrosulphite (hydros) and sodium carbonate at 60^0C for 20 minutes, then washed with cold water and neutralized by acetic acid, washed twice with hot water and cold water respectively and then dried in a hot air oven.

2.7 Calibration graphs:

Calibration graphs for the dyes Foron Brilliant Red E-2BL200 F, Foron Brilliant Orange S-FL (C.I. Disperse Orange 96) were obtained by measuring the optical density of the dye

solution of various known concentrations at their respective λ_{max} values viz 530nm, 490 nm using spectro photometer

2.8 Measurement of dye uptake:

The amount of dye pick up by polyester fabrics during dyeing was determined spectrophotometrically using Spectronic 20D Spectrophotometer (Milton Roy, USA). After each dyeing, the optical density of the residual liquor was measured. From the optical density, the concentration of the residual liquor was determined by referring to the calibration graph. Since the initial concentration of the dye bath was known, the difference in concentration before and after dyeing was determined and thereby the percentage dye uptake was determined.

2.9 Evaluation of Fastness Properties:

ISO4 method was used for assessing the washing fastness of dyed fabrics with and without pretreatment. The light fastnes of the dyed samples were studied using test procedures ISO BS1006 (B04/1) and BS 1006 X 121978. The change in color and staining to adjacent fabic were assessed in accordance with the SDC grey scales. The AATCC blue wool standards were used to assess light fastness of fabric. A similar test procedure was carried out for the untreated sample also for comparison. The rubbing fastnes was determined by using crock meter.

2.10 Scanning Electron Microscopic Studies:

Scanning Electron Microscopic (SEM) studies were carried out for solvent pretreated and untreated samples using SEM of model JEOL840A-USA to analyse the surface modification of the fabric if any caused by solvent treatment.

2.11 FTIR Studies:

Fourier Transform Infra Red (FTIR) spectroscopic studies were made for analyzing chemical modification in molecular structure of the polymer molecule if any caused due to solvent treatments using Perkin-Elmer, Spectrum-BX, USA spectrophotometer with built in spectral matching computerized software.

2.12 DSC Studies: Thermal analysis of both untreated and treated PET samples was studied as differential scanning thermographs using PERKIN ELMER Pyris 6 model-USA. Approximately 10 mg of each sample was fed into the instrument for each run. Pure Nitrogen gas was used to provide inert atmosphere at a rate of 20 mL / min. All the observations were done at a heating rate of 50°C/min.

2.13 X-ray Diffraction Studies:

XRD studies were carried out to study the change in the crystalline and amorphous nature of the fabric after solvent treatment using PANalytical - Model X'pert PRO, The Netherlands.

2.14 Mechanical properties:

25 specimens were taken to measure each experimental parameter and the average of measured values are reported with a standard deviation of 0.023

2.15 Measurement of shrinkage:

The percentage of shrinkage of the pretreated and untreated samples were measured using the formula

Shrinkage % = I_0 - I / I_0 where
I_0 is the Length of the sample before treatment
I is the Length of the sample after treatment

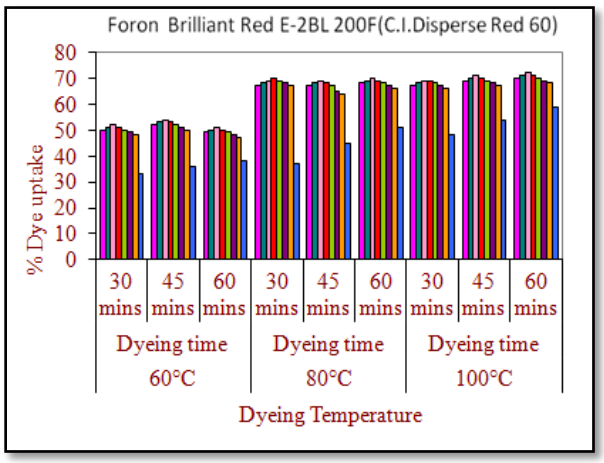
2.16 Measurement of weight loss:

An electronic balance of accuracy ±0.0001 g (Sartorius-GD 503-Germany) was used for Weight loss measurements of the solvent treated samples by measuring the weights before and after the pretreatments.

3. RESULTS AND DISCUSSIONS

3.1 Dyeing behaviour of 100% polyester fabric:

The effect of azeotropic mixture of solvent pretreatments on the dyeing behaviour of 100% PET fabrics were studied by dyeing the pretreated and untreated fabrics for different dyeing time intervals (30, 45 and 60 minutes) and at different temperatures(60, 80 and 100°C) using two different dyes. The dye uptake results are presented in Figs.1- 4. It is clear from the figures that maximum dye uptake is observed in the case of samples pretreated for 6-8 minutes with W-CTC- s-BA solvent system and 4-6 minutes with W- FA- PA solvent system. As the pretreatment time increased , the dye uptake was found to decrease with increase in dyeing temperature and duration of dyeing. The change in dyeing behaviour of the treated fabrics reflects changes in fibre structure of the treated fabrics caused by azeotropic mixtures of solvents. The major changes in fibre structure depend on the extent of interaction, significant effect on dyeing takes place. The increase in dye uptake may be due to solvent induced crystallization which occurs due generation crystallites and amorphous region. Solvent treatment leads to plasticizing effect due to which the chain molecules move past each other enhancing segmental mobility and creation of more voids.



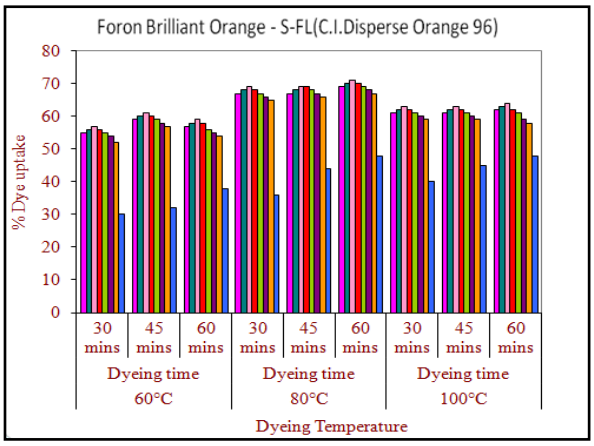
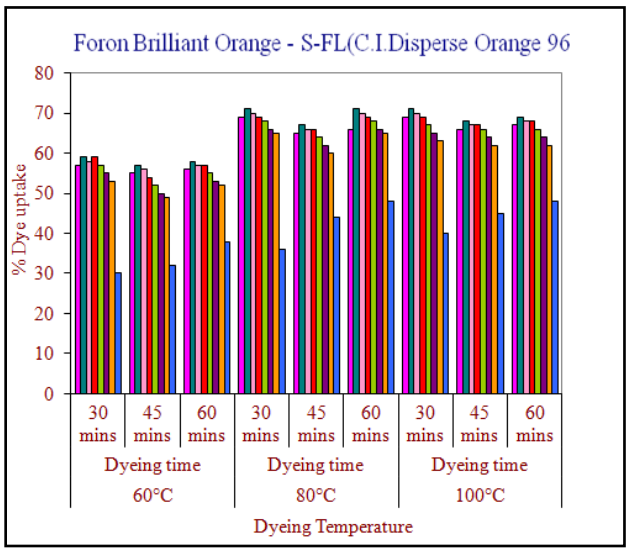


Fig.1: Dye uptake of 100% PET Fabric with and without treatment with W-CTC-sBA

Fig.2: Dye uptake of 100% PET Fabric with and without treatment with W-CTC-sBA



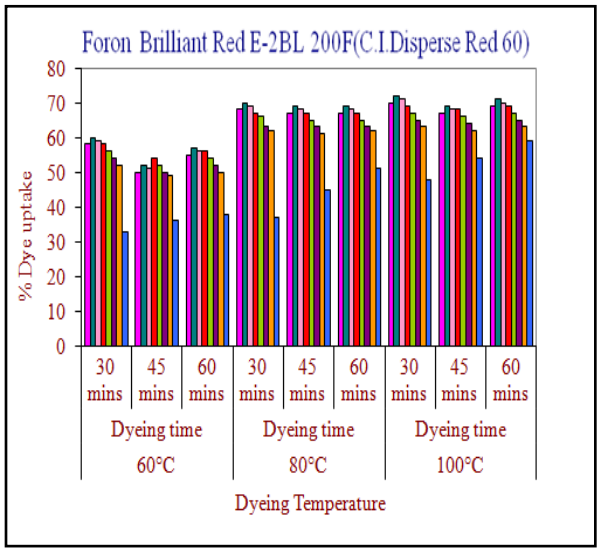


Fig.3: Dye uptake of 100% PET Fabric with and without pretreatment with W-FA-PA

Fig.4: Dye uptake of 100% PET Fabric with and without pretreatment with W-FA-PA

During pretreatment, the molecular structure of the fabrics gets loosened due to breaking of intermolecular forces of attraction resulting in increased dye uptake. The improvement in the dye uptake of treated samples is probably due to the large increase in inter surface area by swelling or plasticizing action, greater segmental mobility of polymer molecules, decreased glass transition temperature (Tg), formation of micro voids and so on [26-28]. The pretreatment enabled to get better dye uptake even at a lower temperature of 80^{o}C and in most of the cases as the dyeing temperature is raised above 80^{o}C the dye uptake is found to decrease which may be due to more desorption of adsorbed dye from the fabric. The extent of improvement in dyeing behaviour was found to be different for different dyes.

3.2 Fastness properties:

Tables 1-3 show the wash, light & rubbing fastness properties of the treated and untreated 100% PET fabrics. The results indicate that the solvent treatment involving azeotropic mixture of solvents have not affected the fastness properties of the dyed polyester fabrics rather an overall improvement in fastness properties have been observed. This may be due to the fact that the solvent has not disturbed the stability of dye – fibre bond and the pretreatments have improved the penetration of the dyestuff molecules into the interior of the fibre matrix.

Table 1. Light fastness properties of dyed 100 % PET fabric(treated and untreated)

Solvent System	Name of the Dye	Dyeing Temp. (^oC)	Light Fastness							
			Pretreatment time (mts)							
			Untreated	2	4	6	8	10	30	60
W-CTC-sBA	*Foron Brilliant Red E-2BL200 F*	60	4	4	4	5	5	5	5	5
		80	4	5	5	5	5	5	5	5
		Boil	5	6	6	6	6	6	6	6
	Foron Brilliant Orange S-FL	60	4	4	4	5	5	5	5	5
		80	4	5	5	5	5	5	5	5
		Boil	5	6	6	6	6	6	6	6
W-FA-PA	*Foron Brilliant Red E-2BL200 F*	60	4	4	5	5	5	5	5	5
		80	4	5	5	5	5	5	5	5
		Boil	5	6	6	6	6	6	6	6
	Foron Brilliant Orange S-FL	60	4	4	5	5	5	5	5	5
		80	4	5	5	5	5	5	5	5
		Boil	5	6	6	6	6	6	6	6

Table 2 Washing fastness properties of dyed 100 % PET fabric (treated and untreated)

Solvent System	Name of the Dye	Dyeing Temp. (^oC)	Washing fastness							
			Pretreatment time (mts)							
			Untreated	2	4	6	8	10	30	60
W-CTC-sBA	*Foron Brilliant Red E-2BL200 F*	60	4	4	4	4	4	4	4	4
		80	4	4	4	4	4	4	4	4
		Boil	4	5	5	5	5	5	5	4
	Foron Brilliant Orange S-FL	60	4	4	4	4	4	4	4	4
		80	4	4	4	4	4	4	4	4
		Boil	4	5	5	5	5	5	5	4
W-FA-PA	*Foron Brilliant Red E- 2BL200F*	60	4	4	4	4	4	4	4	4
		80	4	4	4	4	4	4	4	4
		Boil	4	5	5	5	5	5	5	4
	Foron Brilliant Orange S-FL	60	4	4	4	4	4	4	4	4
		80	4	4	4	4	4	4	4	4
		Boil	4	5	5	5	5	5	5	4

Table 3. Rubbing fastness properties of treated and untreated 100 % PET fabric

Solvent System	Name of the Dye	Dyeing Temp. (^oC)	Untreated	Pretreatment time (mts)						
				2	4	6	8	10	30	60
W-CTC-sBA	*Foron Brilliant Red E-2BL200 F*	60	4	5	5	5	5	5	5	4
		80	4	5	5	5	5	5	5	4
		Boil	5	6	6	6	6	6	5	5
	Foron Brilliant Orange S-FL	60	3	4	5	5	5	5	5	4
		80	4	5	5	5	5	5	5	4
		Boil	5	6	6	6	6	6	5	5
W-FA-PA	*Foron Brilliant Red E-2BL200 F*	60	4	5	5	5	5	5	5	4
		80	4	5	5	5	5	5	5	4
		Boil	5	6	6	6	6	6	5	5
	Foron Brilliant Orange S-FL	60	4	5	5	5	5	5	5	4
		80	4	5	5	5	5	5	5	4

		Boil	5	6	6	6	6	6	5	5

3.3 Weight loss and Abrasion reistance measurements:

Table 4 shows the changes in weight and abrasion resistance of the solvent pretreated fabrics in comparison with untreated fabrics. It was found that the % weight loss of the solvent treated fabric is very less and is dependent upon the pretreatment time. As the pretreatment duration increases there is a slight increase in weight loss. The abrasion resistance was found to gert affected to a very less extent which was also found to be dependent on the durationof the solvent pretreatment. However the effect of solvent pretreatment was found to affect these parameters to a very less extent.

Table 4 Weight loss/Abrasion resistance of treated and untreated 100 % PET fabric

Solvent System	Pretreatment Time (mins)	Initial weight (gm)	Final weight (gm)	Percentage loss (%)	Abrasion Resistance No. Cycles
W-CTC-sBA	2	2.000	2.000	0.0	7480
	4	2.000	1.999	0.05	7450
	6	2.000	1.980	1.00	7425
	8	2.000	1.960	2.0	7420
	10	2.000	1.940	3.0	7400
	30	2.000	1.930	3.5	7200
	60	2.000	1.920	4.0	7150
W-FA-PA	2	2.000	1.990	0.50	7465
	4	2.000	1.985	0.75	7425
	6	2.000	1.975	1.25	7410
	8	2.000	1.955	2.25	7400
	10	2.000	1.930	3.50	7380
	30	2.000	1.925	3.75	7150
	60	2.000	1.910	4.50	7120
untreated	-	2.000	2.000	0.0	7500

3.4 Scanning Electron Microscopy Studies:

Scanning Electron Micrographs of 100 % PET fabrics treated with azeotropic solvents along with untreated control sample are presented in Figs. 5-9.

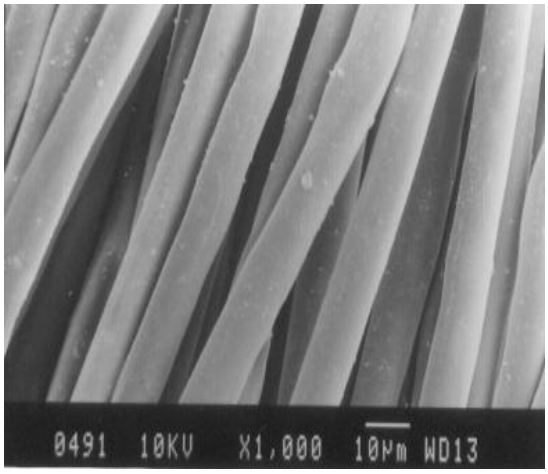


Fig.5: SEM photograph of untreated 100% PET fabric

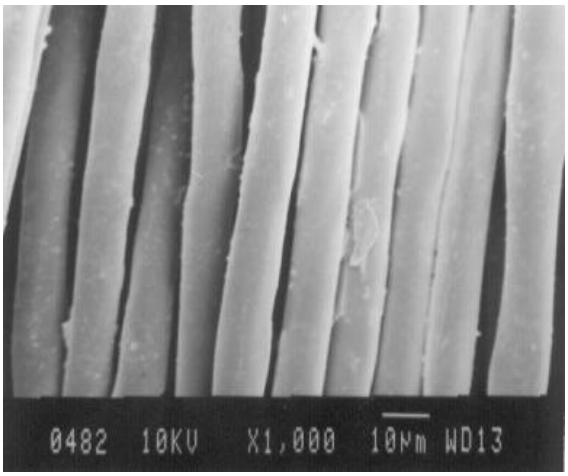


Fig.6: SEM photograph of 100% PET fabric treated with W:FA:PA (4 mins)

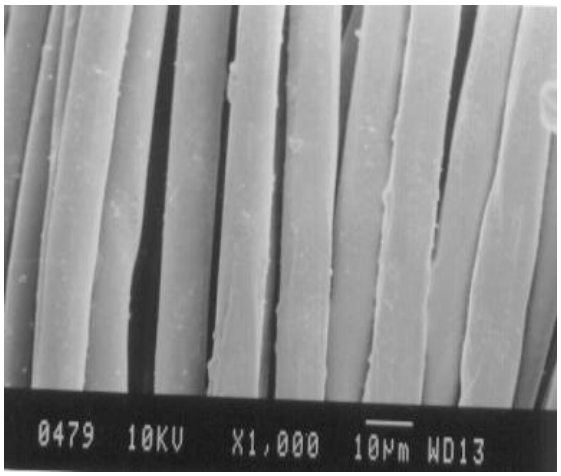


Fig.7: SEM photograph of 100% PET fabric treated with W:CTC: sBA (4 mins)

Fig.8: SEM photograph of 100% PET fabric treated with W:CTC: sBA (30 mins)

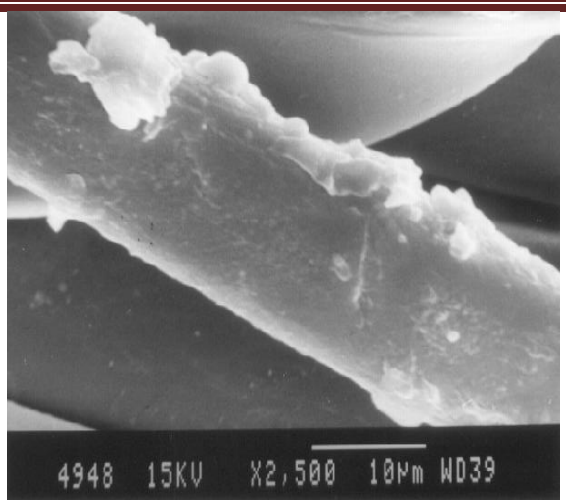


Fig.9: SEM photograph of 100% PET fabric treated with W:FA:PA (30 mins)

The untreated samples exhibit smooth surface texture . In the treated samples, it appears that the solvent attacks almost the entire surface cf the fibre compared to untreated samples. As the duration of pretreatment increases, there is progress in attack and erosion propagate inside the fiber resulting in the formation of elongated pits or cavities on the surface . This is also supported by the fact that the dye uptake of solvent pretreated PET materials has improved because of development of voids. In all the solvent treated polyester, as the time of treatment increased migration of the oligomer to the surface of the polymer was found. The observed changes on the fibres may be caused by swelling . There was etching of However there is no serious damage on the surface of the fabric during solvent pre treatments carried out in the present study which is reflected in the weight loss studies also. This observation is consistent with the findings quoted in literature [9,10]. These studies indicate that the variation in morphology can be produced using azeotropic solvent mixtures.

3.5 FTIR Analysis:

Fourier Transform Infra red spectral analysis of the treated and untreated fabrics were recorded in the range 4000-400 cm^{-1} using Perkin-Elmer, (Spectrum-BX, USA) spectrophotometer with built in spectral matching computerized software was used. The resolution was kept at 4 cm^{-1} and the optical path difference velocity was set at 0.2 cm /s. The powdered samples were dispersed in KBr pellets for these measurements. FTIR Spectrum of 100 % PET fabrics before and after W-FA-PA solvent treatment is shown in Fig 10. FTIR was recorded to assess structural change if any made in the fibre or the alteration of existing functional groups as a consequence of azeotropic solvent mixture pretreatments.

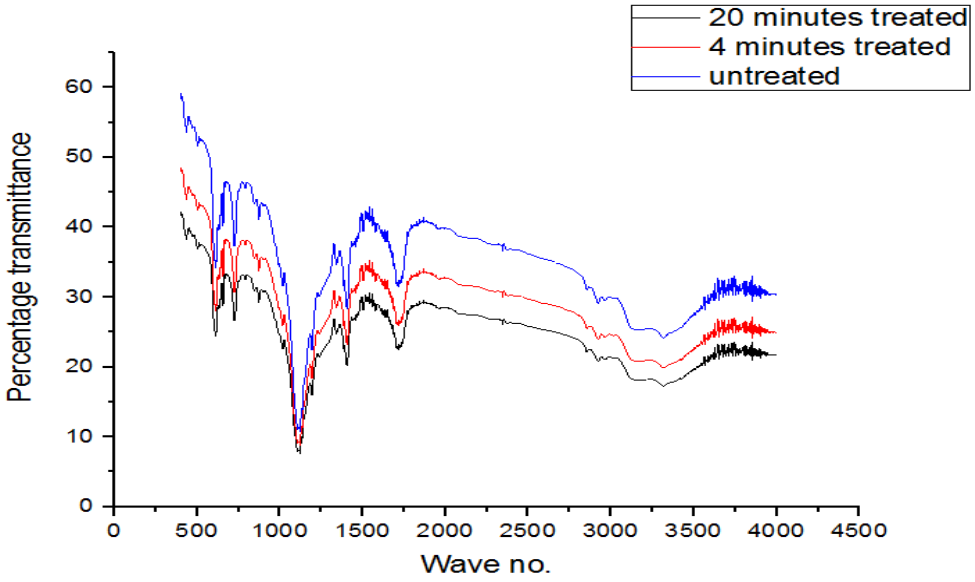


Fig.10: FTIR spectra of 100% PET Fabric pretreated with W-FA-PA

In the spectrum of untreated PET fabric, a prominent peaks at 600 to 756 cm^{-1} is due to the out of plane bending of aromatic systems. The peak at 1132 cm^{-1} , 1198 cm^{-1} may be due to the C-O stretching of the polymer backbone. A well defined peak at 1483 cm^{-1} due to the C=C stretching of aromatic ring was observed. A peak around 1720 cm^{-1} was clearly noted and assigned as C = O stretching of esters. The observations correspond with the values reported in literature[29]. The treated samples show significant variation from the corresponding peaks observed for the parent untreated PET fabric. It is interesting to note that no additional peaks were observed for solvent pretreated samples which infers that the solvent does not modify the polymer chemically and there is no introduction of any new functional group in the fibre matrix.

3.6 Differential Scanning Calorimetric studies:

Differential Scanning Calorimetric studies were made for the untreated and solvent mixture pretreated 100% PET fabric using Perkin – Elmer DSC2 at a temperature range of 100-400^0 C with a heating rate of 10^{0}C/min under inert atmosphere. The DSC curves obtained is as shown in fig.11. In each case, the starting temperature and peak melting temperature is noted. The final melting temperature corresponds to the melting of the most stable crystallite whereas the peak melting temperature taken is noted. The final melting temperature corresponds to the melting of the most stable crystallite whereas the peak melting temperature is taken as the temperature at the maximum of melting endotherm [30]. The starting temperature is the starting of the melting endotherm and can be regarded as the melting of the smallest crystallite in the sample.

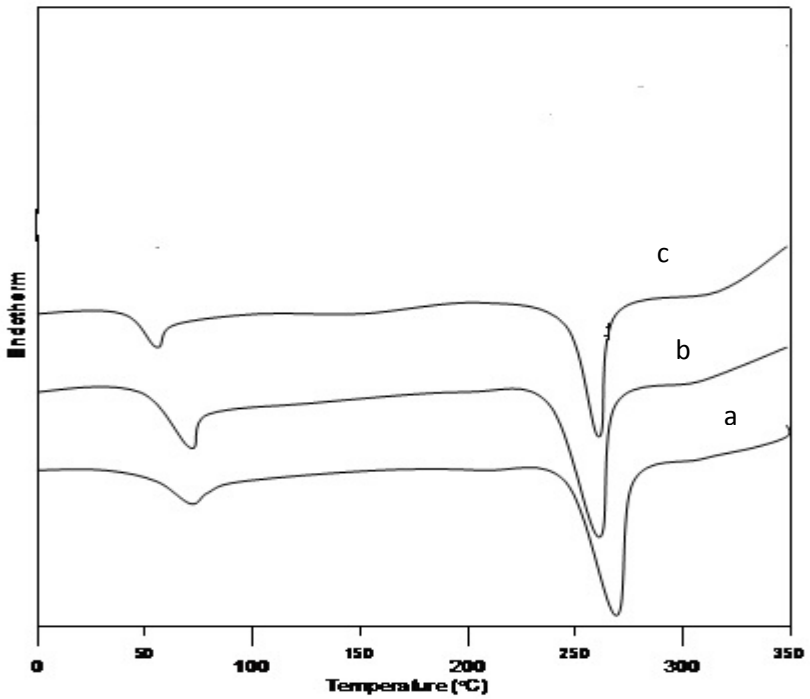


Fig.11. DSC thermograms of (a) untreated 100% PET fabric, (b) W-CTC-sBA treated (c) W-FA-PA treated 100%PET fabric (Treatment Time -8 minutes)

The DSC thermograms obtained are found to be almost identical with small changes in terms of starting temperature. Peak temperature, melting temperature and melting range. The interaction of the polymer with the solvent is strongly influenced by morphological and structural parameters. In general, the solvent enters into the polymer structure, weakens polymer – polymer interaction, replaces it with polymer – solvent interaction, induces extensive segmental motion and lowers the effective glass trasition temperature of material. The polymer chain rearrange themselves into a lower free energy state. This induces crystallization even in the swollen state [31]. The interaction of solvent with the polymer may be of two types. viz intercrystalline interaction and intracrystalline interaction. In the case of intercrystalline interaction , the solvent penetrates inside the amorphous region only. The polymer chains within this region are under lower stress and generally results in the rearrangement of molecular chains. In this case , crystallization takes place in the swollen state and crystalline areas of the sample increases. On the other hand, in the case of intra crystalline interaction the interacting solvent penetrates inside the crystalline region, decrystallizes the sample and affects higher lateral order parts of the fibre. In the present study, the interaction of solvent with the fibre material is found to be intra cryatalline interaction. This is evident from a small decrease in starting temperature, peak temperature and melting temperature. As a consequence of this there is a small increase in the amorphous region of the treated materials. This is further supported by tearing strength measurements wherein a small decrease in the strength of treated material is observed without causing much damage. This increase in amorphous region can be attributed as the reason for improvement in the dye uptake.

3.7 XRD studies of 100% PET fabrics:

XRD pattern were recorded for the untreated and pretreated 100% PET fabric to evaluate the effect of pretreatment (Fig.12).

X-ray diffraction studies on a polymer is mainly concerned with study of crystalline, amorphous and semicrystalline regions / phases which are responsible for observing their respective electrical and mechanical properties. X- ray diffraction pattern of most polymers containsboth sharp as well as broad and diffuse peak. The Sharp peak correspond to crystalline regions, the diffuse and the broad ones refer to amorphous region [9,32]. The interaction of solvent with polymer results in recrystallization and decrystallization of the corresponding polymer contents.

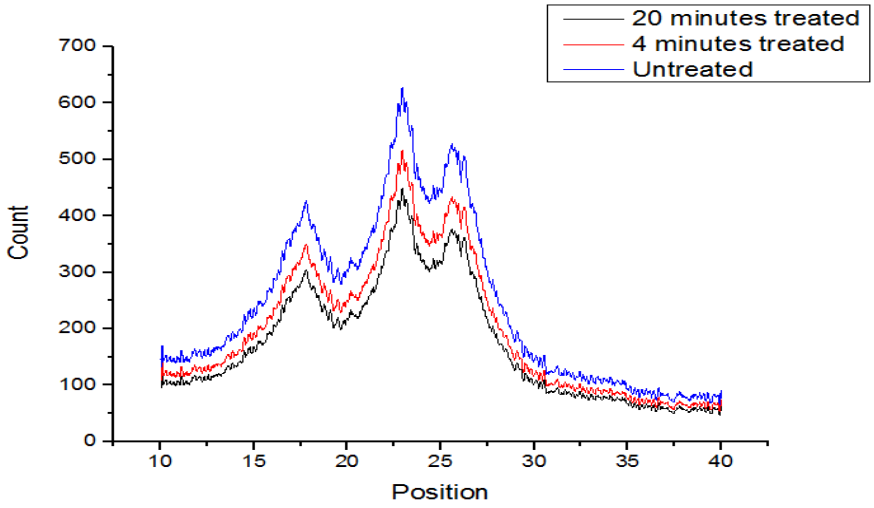


Fig.12. XRD of 100% PET Fabric pretreated with W-FA-PA for different time durations

The peak intensity of the peaks corresponding to2θ values at 17.54, 22.60 and 26 of untreated 100% PET fabric is found to be altered by solvent treatments. The maximum reduction in peak intensity is observed for the W – FA –PA treated PET compared with other solvent.

The results from XRD reveals that the solvent treatment disturbs the crystalline distribution, probably creates more cavity and pores resulting in the opening up of the structured assembly enhancing more dye uptake when compared with the untreated. Increase in pretreatment duration causes much pronounced effect on the treated materials, which leads to improved dye uptake. These observations are in conformity earlier reports[9,32].

3.8 Cost effectiveness :

The cost of energy is increasing every day. As we can see there are many reasons that conservation is important, ranging from the environment to the economy. The world's dependence on fossil fuels is creating a problem that will affect generations to come. It is important that energy not only be conserved, but also that research continues to find cleaner and better solutions for future generations. Textile industry is one of the major consumers of energy.

Development of cost efeective dyeing and finishing operations are very much essential to conserve energy. The current method employed is found to give better dyeing results at even at a lower temperature of 80^{o}C compared to conventional high pressure high temperature (HPHT) dyeing which is normally done at 130^{o}C. HPHT involves use of pressure equipments which involves initial equipment cost and running cost as well. A saving in cost of dyeing to the tune of 60% can easily be achieved.

A number of trial dyeings were carried at laboratory scale taking 1 Kg of the fabric to assess the energy and cost saving involved in the proposed dyeing method using pretreatment of material to be dyed with azeotropic solvent mixtures in comparison to conventional HPHT dyeing method . Table 4 shows the energy saving achieved through the present method in comparison with the conventional high temperature dyeing method.

Table 4 Energy saving comparison of pretreatment and conventional dyeing methods

Dyeing Method	**Material to liquor ratio**	**Time required for the dyeing process alone (min.)**	**Energy Consumption KWH**	**Percentage of saving in energy consumption**
Pretreatment method (80^{o}C)	1:50	65	1.625	61.5
Conventional high temperature method (130^{o}C)	1:50	80	2.666	-

4. CONCLUSION

Azeotropic solvent mixture pretreatments of 100% PET were found to improve the dyeing behaviour. As the pre-treatment time increased, the dye uptake increased up to 8-10 minutes pre-treatment duration, beyond which it decreased which may be due to increased irreversible open structure of fibre material during prolonged pre-treatment. Study of wash, light and rubbing fastness properties of treated and untreated fabric material indicated that the solvent pre-treatment has not affected the fastness of dyed fibre samples as well as the stability of dye-fibre bond. Weight loss measurements showed very less change in weight of the solvent pre-treated material indicating that there was no much damage to the fibre due to solvent treatment. SEM studies indicated generation of pits and voids inside the fibre material leading to improved dye uptake. The results of FTIR studies showed that there is no introduction of new functional groups in the fibre matrix. XRD studies revealed the disturbance caused to the crystalline distribution, substantiating solvent induced crystallization which was supported by DSC studies. This dyeing method saves time and energy with better dyeing results than conventional dyeing methods.This pretreatment method could save time and energy. Hence cost of dyeing to a range of 60% as compared to the conventional dyeing method.

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