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Physical and Mechanical Properties of Treated Acrylic Fabrics Using Nano-Bentonite

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The acrylic fabrics were treated with different concentrations of nano-bentonite (nano clay) using pad-dry cure technique in presence of sodium polyacrylate as a resin. Mechanical and Physical properties of treated acrylic fabrics such as tensile strength and elongation %, bending length thickness, weight, abrasion resistance, pilling resistance, air permeability and electrostatic charge were studied. The substantively of the treated fabrics in terms of dye exhaustion % towards basic dyes as well as washing fastness were studied. The effect of treatment and dyeing on performance properties of garments were evaluated by radar chart. To know the effect of treatments on the acrylic fabric properties, analysis of variance; ANOVA and t-Test have been applied.

Keywords: Acrylic fabrics, Nano-Bentonite, Dyeing, Mechanical and Physical properties ANOVA.

Introduction

Acrylic fibers are important materials with many unique properties and became one of the most commonly used synthetic fibers all over the world. The polymer chain having acrylonitrile groups that are highly polar and lead to strong interactions among the chains. The acrylic fibers are moderately stiff and have good resiliency as well excellent recovery from bending deformation. Also, the acrylic fibres have low thermal conductivity, good durability and easy-care properties. The softness of touch and bulk properties makes acrylic fibres attractive for use in the knitwear sector. The other unique properties on acrylic fibres are quick drying, resilient, retaining shape and resistant to moths, sunlight, oil and chemicals. The acrylic fibers are also positive features in blends with wool or other natural fibers [1-3]. The results of its unique properties 75% of acrylic fibers are used in apparel (in jumpers, waistcoats, cardigans, jackets, socks, knee-high stockings, and training and jogging suits), 20% in home furnishings, and 5% in industrial uses [1].

The applying nanotechnology in textile industry producing smart textile of multifunctional or special functions, such as antibacterial, coloration, UV-protection [4, 5], super hydrophobic [6], and fire-retardant products [7]. In conventional methods, such as dip coating, nano colloidal has been used in coating process [8]. Nanomaterials such as layered silicate, clays, carbon nanotubes, nanosilica, nano TiO_2 have been incorporated in the base polymeric coating to enhance the performance of coated textiles to achieve some properties of fabrics [9]. Nanoclay particles in textile coating are one of the modern technologies which bring revolutionary changes

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in textile finishing [10]. Nanoclay particle, as for example montmorillonite, acquires, hydrous aluminum silicates group with layer structure and very small size, which can be organically modified to render the clay organophilic and to enable its dispersion onto a polymer. Such dispersion refers to a nanocomposite including nano-sized clay particles surrounded by a polymer [11]. Application of the nanocomposites to textiles may be exemplified by: nanoclay particle incorporated with hyper branched polymer [12], nanoclay modified with quaternary ammonium salts for creation of dye sites on polypropylene fibers, nanoclay modified and used as sorbent for nonionic, anionic and cationic dyes. [13] The treatments with organic nanokaolin, nanochitosan and nanocellulose impacted some multifunctional properties such as antibacterial activity in viscose fabrics. [14].

The main target of this paper is utilization of nano clay (nanobentonite) on acrylic fabrics. Some physical and mechanical properties of treated acrylic fibres such as bending Stiffenss, weight, thickness, pilling as well as the tensile strength were studied. The dyeability enhancement of basic dye and washing fastness are studied. Analysis of variance ANOVA and radar chart between different physical and mechanical properties have been applied.

Material and Methods

Materials

Fabrics

Acrylic fabric was used supplied by Masr El Mahalla Company, El Mahalla Elkobra, Egypt. A plain woven acrylic fabric weighing is 175 g/m^2. The fabric was washed in 2g/l nonionic detergent (Egyptol) solution at 45 °C for 30 minute, thoroughly rinsed with cold water and air dried at room temperature.

Chemicals

Acrylate polymer was purchased from M.D. Binder SME (Acrylate- Based). Nano Bentonit purchased from ICMI Company, Cairo, Egypt**.** All chemicals used were of laboratory grade and used without further purification. The distilled water was used for all preparations.

Methodology

Scouring of fabrics used in the treatments:

Acrylic fabrics were scoured using 2 g/l nonionic detergent (Hocstapal CV from Clariant, Egypt) with a liquor ratio 25: 1, at 45 °C, for ٤٥ min. Then it is rinsed twice in cold tap water and dried at room temperature.

Modification of acrylic fabrics

Modification of acrylic fabrics with sodium hydroxide

Acrylic fabrics were hydrolyzed with 10% NaOH at 80^{o}C for 1 hours to convert the nitrile groups (CN) on the polymer chain to carboxylic groups. After modification, the fabrics were cooled, rinsed multiple times in the mixture of ethanol and water solutions and left to dry at ambient temperature [15].

After-treatment of Alkali-treated acrylic fabrics with citric acid

The modified acrylic with sodium hydroxide fabrics were treated with citric acid to increase the number of carboxylic groups on the polymeric structure of the fabrics. The treatment was performed using pad-dry cure method, where the modified acrylic fabrics were immersed in 10% citric acid, padding to 100% wet pick up (pressure 3 bar) dried at 80 ^{o}C for 10 min and cured at 160 °C for ٥ min. The pretreated fabrics were washed with running water and kept dried at room temperature. [16]

Treatment of acrylic with bentonite using sodium polyacrylate as a resin

10 gm of nanoclay namely; bentonite was dispersed in distilled water using ultrasonic homogenizer for 1 hr. Different amounts of dispersed bentonite (1, 3, 5% w/v) were added to 20% sodium polyacrylate, then this mixture was well homogenized using ultrasound homogenizer 100 watt for 1 hr to incorporate the mentioned nanoclay into the polymer matrix and forming polymer/bentonite nano-composite. Scoured fabrics (20 x 15 cm) were treated with the prepared composite by pad dry-cure technique. After treatment; the samples were padded using SVETEMA laboratory padder; the padding pressure was adjusted at 3 bar to allow a pickup of 100%. The padded samples were dried at 80 °C for ٥ min and cured at ١٦٠ °C for ٣ min. using ROACHES laboratory thermo fixation. The cured samples were then washed with running water and left to dry at room temperature. Table 1 shows the description of treated acrylic fabrics.

TABLE 1. Samples description

Sample cod	Specification
U	Untreated
S	Treated with sodium hydroxide
P	Treated with 20% polyacrylate
C	Treated with sodium hydroxide and Citric acid
S1	Treated with sodium hydroxide and 1% bentonite
S3	Treated with sodium hydroxide and 3% bentonite
S5	Treated with sodium hydroxide and 5% bentonite
B1	Treated with 1% bentonite
B3	Treated with 3% bentonite
B5	Treated with 5% bentonite
C1	Treated with sodium hydroxide and Citric acid then with 1% bentonite
C3	Treated with sodium hydroxide and Citric acid then with 3% bentonite
C5	Treated with sodium hydroxide and Citric acid then with 5% bentonite
PB1	Treated with polyacrylate /1% bentonite nano composite
PB3	Treated with polyacrylate /3% bentonite nano composite
PB5	Treated with polyacrylate /5% bentonite nano composite

Measurements

1- Bending stiffness of fabrics measured according to (ASTM - D 1388-96) Shirey stiffness tester.
2- Thickness (mm) measured according (ASTM-D1777).
3- Weight (gm. /m²) measured according (ASTM-D3776).
4- Abrasion Resistance (cycles) measured according to (ASTM-D4966)
5- Pilling for fabric measured according ASTM D4970-02
6- Tensile strength measured according to (ASTM - D 3822) Instron.
7- Air permeability (cm²/cm³/s) measured according to (ASTM - D 737).
8- Colour exhaustion %: using spectrophotometer. [17]
9- Washing fastness: colorfastness to washing The colorfastness to washing was determined according to the AATCC test method (AATCC Technical Manual, Method 36, (1972), 68, 23, (1993)) using Launder Ometer. [18]

Results and Discussion

Physical and mechanical properties of the treated acrylic fabrics

Weight, thickness, bending length, pilling resistance and abrasion resistance of untreated and treated acrylic fabrics

Data of Table 2 illustrated the weight, thickness, bending length, pilling resistance and abrasion resistance of the treated acrylic fabrics as well as the untreated one. The results show increased in weight and thickness of the treated acrylic fabrics than untreated one. The more increased in both weight and thickness with the treatment with both citric/ nanobentonite and polyacrylate/nanobentonite, followed by treatment with nanobentonite and treatment with sodium hydroxide/ nanobentonite. It was foundthat the increased in weight and thickness depended on the concentration of nanobentonite material increases. This increase may be due to the dispersion of nanobentonite throughout the acrylic fabrics, [19] leading to an increase in the interfacial adhesion between the nano and the fabric filaments. Also, the results of bending length of all the treated fabrics increased as compared to the untreated one. It was observed that the bending length of fabric treated with sodium poly acrylate/nanobentonite is highest. This can be referred to the coating layer formed on the surface of the treated fabrics due to the application of resin polymer.

Results of pilling on Table 2 show that the pilling resistance at 2000 cycle increases only on treated fabrics with polyacrylate/nanobentonite than untreated one. This result may be attributed to the thin layer formed on the acrylic fabric surface due to the treatment of the fabrics with polyacrylate this result can be confirmed by SEM micrograph. It can be seen that the treatments of acrylic fabrics with nanobentonite not significant effect. But, the value of pilling decreases with treatments with both citric/ nanobentonite and sodium hydroxide/ nanobentonite.

Also, from Table 2 illustrate the values of cycles abrasion, it was found that the treatment by with nanobentoniteled to increase cycles of abrasion overall. And the highest increased in cycles of abrasion of treated acrylic fabrics that the one treated with citric/ nanobentonite. The increase in abrasion cycles about 300% for the treated fabric than untreated one. Also, the treatments with both nanobentonite and sodium hydroxide/ nanobentonite increased in cycles of abrasion of treated acrylic fabrics as compared with the untreated fabrics. [10, 19]

Stress, Strain, Air permeability and Static charge

Data of table 3 illustrated the stress, strain, air permeability and static charge of untreated and treated acrylic fabrics. The results clarify an improvement of the stress all treatments as well as the concentration of nanobentonite increases. Samples treated with both polyacrylat/ nanobentonite and citric/ nanobentonite have increased in stress about 100% than untreated samples. This increase may be due to the dispersion of nanobentonite throughout the acrylic fabrics, [15, and 19]. Leading to an increase in the interfacial adhesion between the nanobentonite and the fabric filaments. The stress and strain data indicate to the tensile strength of fabrics.

TABLE 2. Weight, Thickness, Bending, length pilling and Abrasion of untreated and treated acrylic fabrics

Sample Cod	Weight (g/m^2)	Thickness (mm)	Bending length(cm)	Pilling at 2000 (cycles)	Abrasion (cycles)
U	161.43	0.61	2.5	4	250
S	158.57	0.57	4.2	4	310
P	185.50	0.67	9.0	5	168
C	189.14	0.70	3.3	3	450
S1	179.42	0.61	3.8	4	450
S3	179.87	0.60	5.2	4	520
S5	183.42	0.65	4.7	3	550
B1	182.14	0.60	3.8	3.5	380
B3	180.14	0.61	4.1	3.5	350
B5	181.14	0.60	3.9	4.5	350
C1	194.57	0.75	3.5	3	650
C3	194.85	0.72	4.3	3.5	700
C5	197.14	0.72	4.2	3	590
PB1	188.61	0.64	12.4	5	313
PB3	192.80	0.63	12.9	5	355
PB5	196.07	0.63	14.6	5	345

TABLE 3. Stress, Strain, Air permeability and Static charge of untreated and treated acrylic fabrics

Sample Cod	Stress (kg f/mm^2)	Strain (%)	Air permeability (cm^3/cm^2/sec)	Static charge (kv)
U	0.951	26.250	286.5	0.055
S	0.604	27.500	210.0	0.000
P	1.187	16.167	215.0	0.010
C	0.847	25.250	160.0	0.010
S1	1.434	16.000	160.0	0.010
S3	1.596	16.250	158.0	0.010
S5	1.286	25.250	145.0	0.000
B1	1.556	18.750	198.0	0.010
B3	1.127	26.660	197.0	0.020
B5	1.050	26.660	192.0	0.010
C1	1.462	27.000	173.0	0.010
C3	1.715	27.500	165.0	0.000
C5	1.802	25.750	145.0	0.000
PB1	1.772	15.833	197.0	0.010
PB3	1.763	14.583	195.0	0.010
PB5	1.671	16.666	181.5	0.010

Dyes Exhaustion % and washing fastness

Table 4 shows the exhaustion % and washing fastness of treated and untreated dyed acrylic fabrics with both cationic dyestuffs C.I. Basic Blue 45 (Methylene blue La D extra) and (C.I. Basic Red 18). The data of the exhaustion % of both dyestuffs were increased with all treatments. It was found that pretreated fabrics with sodium hydroxide and treated bentonite give high dye exhaustion % than untreated one as well as the treated fabrics with sodium hydroxide/ bentonite (S, S1, S2 and S3). Also, the treatment of acrylic fabrics with citric acid after pretreated with sodium hydroxide then treated with bentonite (C, C1 and C3) led to enhancement the dye exhaustion % for both dyestuffs. The exhaustion % increased from 81.1 % for untreated acrylic fabrics to be 96.8 % for the treated acrylic fabrics with polyacrylate/ 5% bentonite, which gives a highest exhaustion %. But, the treated acrylic fabrics with nanobentoite only (B1, B2 and B3) give incensement in dye exhaustion % to be 94.7% for B3 (5% nanobentoite) and 96.4% for C3 (5% citric acid/ nanobentoite). The results show that the presence of polyacrylate lead to increase adsorption of basic dyes on the acrylic fabric as compared with pretreated/ bentonite and treated with bentonite (S, S1, S2 and S3), (C, C1, C2 and C3), (B, B1, B2 and B3), this may be attributed to the structure of the bentonite as layers and to polyacrylate is an anionic polyelectrolyte with negatively charged carboxylic groups in the main polymer chain. It was found that the highest exhaustion% of basic dye (C.I. Basic Red 18) depended on the increases the concentrations of nanobentonite.

The washing fastness for the untreated and treated acrylic fabrics are comparable to each other as shown in Table 4. It was found that the staining increases with both adjacent polyester and acrylic fabric for the untreated fabric more than the dyed treated acrylic fabrics. The treated samples (C1, C2 and C3) have shown the best anti staining results, followed by treated samples (B1, B2 and B3).

TABLE 4. The Exhaustion % and washing fastnesses for the untreated and treated acrylic fabrics

Sample Cod	Exhaustion % C.I. Basic Blue (Methylene blue)	Washing Fastness C.I. Basic (Methylene blue)			Exhaustion % C.I. Basic Red 18	Washing Fastness C.I. Basic Red 18		
		Alt	St_A	St_P		Alt	St_A	St_P
U	81.1	4	4	3-4	84.0	2	4-5	4-5
S	88.1	4	4	3	84.1	4	4	4-5
P	85.1	3	4	4	85.2	3	4	3-4
C	88.9	4	4	4	84.8	4	4	4
S1	93.3	4	4	3-4	85.5	4	4	4-5
S3	94.5	4	4-5	3	86.2	4	4	4
S5	95.6	3-4	4-5	3	87.4	4	4-5	4
B1	93.8	3	4	3-4	83.5	3	4	4
B3	94.1	3	4	4	89.3	4	4-5	3-4
B5	94.7	3-4	4	4	92.2	4	4-5	4
C1	94.1	4	3-4	3-4	86.3	4	3-4	4
C3	95.3	4	4	3-4	88.1	4	3-4	4-5
C5	96.2	3-4	4	3-4	91.8	4	4	4
PB1	94.8	4	4	4-5	86.5	4	3-4	3-4
PB3	96.1	4	3-4	3-4	88.5	4	3-4	3-4
PB5	96.8	3	3-4	3	93.4	3-4	3-4	3-4

Alt: Colour alteration, St_A: staining on acrylic fabric, St_P: staining on polyester fabric

Statistical Analyses

Statistical analyses were performed, (analyses of variance; ANOVA single factor, test and quality assessment) to show the significance of treatments on the tested fabric properties, and to compare between the untreated and treated values. Finally evaluated and assessed the quality of these fabric samples in terms of the whole tested fabric properties in order to reach the functional performance when they are used in clothing industry.

i. Analyses of variance; ANOVA

Analysis of variance is a powerful statistical tools a test of significance. It is used to know how much an influencing parameter statistically affects a property.

Fabric weight

To know the effect of different treatments on the fabric weight, analysis of variance ANOVA has been applied.

Table 5 shows that there is a significant effect of the treatments on the weight (p-value=0.008) as the highest goes for the C treatment, followed by P then B then S.

Fabric thickness

To know the effect of different treatments on the fabric thickness, analysis of variance ANOVA have been applied. Table 6 shows ANOVA for fabric thickness.

Table 6 shows that there is a significant effect of the treatments on the thickness (p-value=0.0001) as the highest goes for the C treatment.

TABLE 5. ANOVA for fabric weight

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B	3	543.42	181.14	1
C	4	775.7	193.925	11.50136667
S	4	701.28	175.32	127.895
P	4	762.98	190.745	21.54896667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	865.469373	3	288.4897911	6.545280677	0.008415578	3.5874337
Within Groups	484.836	11	44.076			
Total	1350.30537	14				

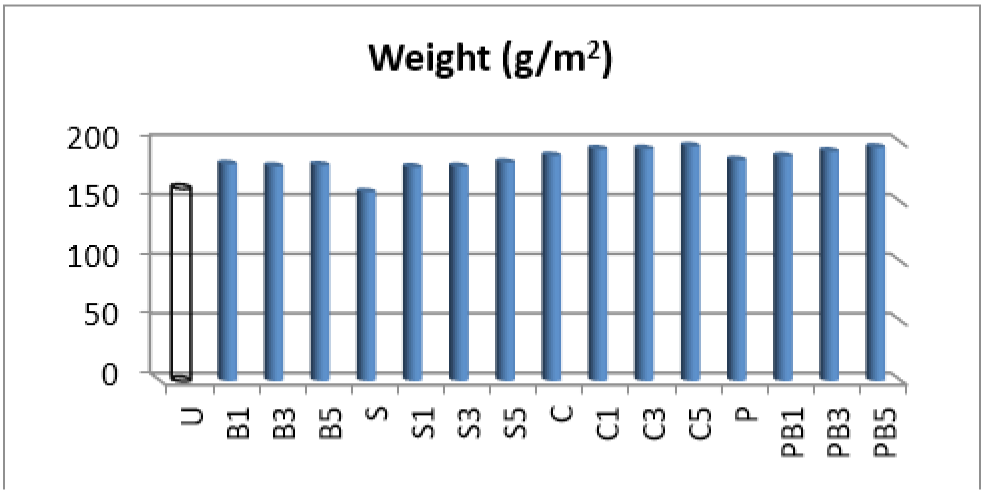

Fig. 1. Fabric weight.

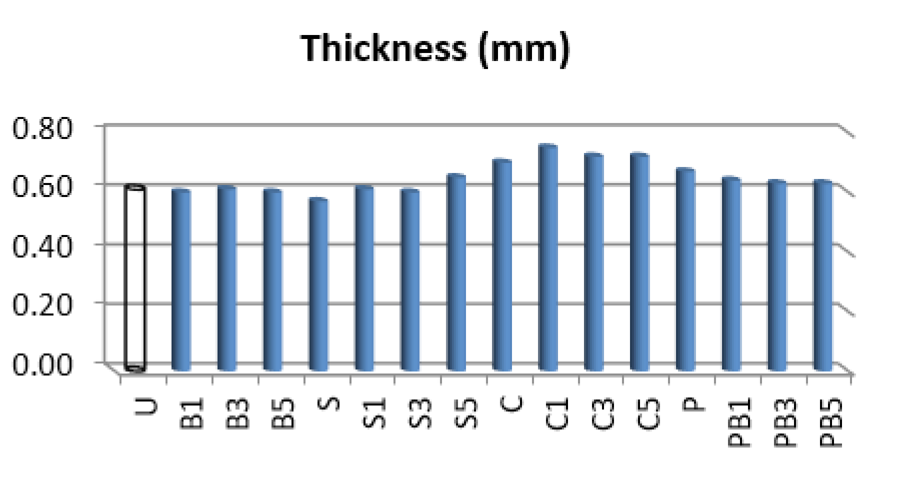

Fig. 2. Fabric thickness

Fabric abrasion resistance

To know the effect of different treatments on the fabric abrasion resistance, analysis of variance ANOVA has been applied.

Table 7 (a) shows that there is a significant effect of the treatments on the Abrasion Resistance (p-value=0.004) as the highest goes for the C treatment.

Fabric pilling resistance (at 2000 Cycles)

To know the effect of different treatments on the fabric pilling resistance, analysis of variance ANOVA has been applied.

Table 8 shows that there is a significant effect of the treatments on the Pilling Resistance (p-value=0.0002) as the highest goes for the P treatment.

TABLE 6. ANOVA for fabric thickness

SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
B	3	1.81	0.603333333	3.33333E-05		
C	4	2.89	0.7225	0.000425		
S	4	2.43	0.6075	0.001091667		
P	4	2.57	0.6425	0.000358333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.03484167	3	0.011613889	22.44558321	5.4191E-05	3.5874337
Within Groups	0.00569167	11	0.000517424			
Total	0.04053333	14				

TABLE 7. ANOVA for fabric abrasion resistance

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B	3	1080	360	300
C	4	2390	597.5	11691.66667
S	4	1830	457.5	11425
P	4	1181	295.25	7517.583333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	202516.183	3	67505.39444	8.027429875	0.004103268	3.5874337
Within Groups	92502.75	11	8409.340909			
Total	295018.933	14				

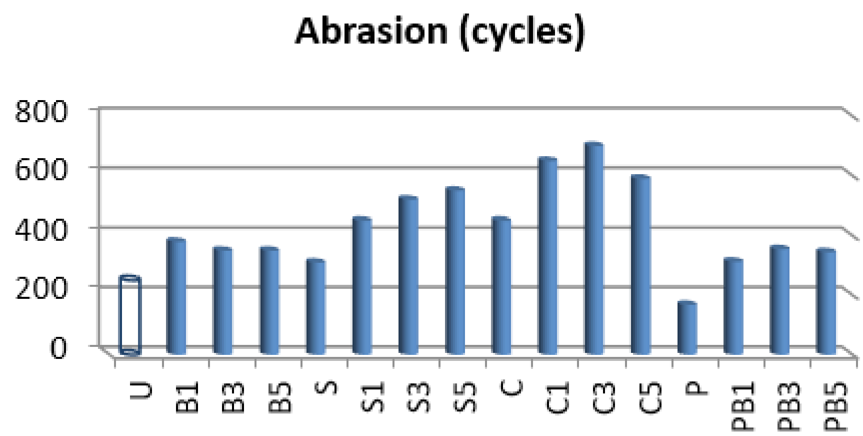

Fig. 3. Fabric abrasion resistance

TABLE 8. ANOVA for Fabric pilling resistance

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B	3	11.5	3.83	0.333333333
C	4	12.5	3.125	0.0625
S	4	15	3.75	0.25
P	4	20	5	0

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7.32916667	3	2.443055556	16.75238095	0.000205606	3.5874337
Within Groups	1.60416667	11	0.145833333			
Total	8.93333333	14				

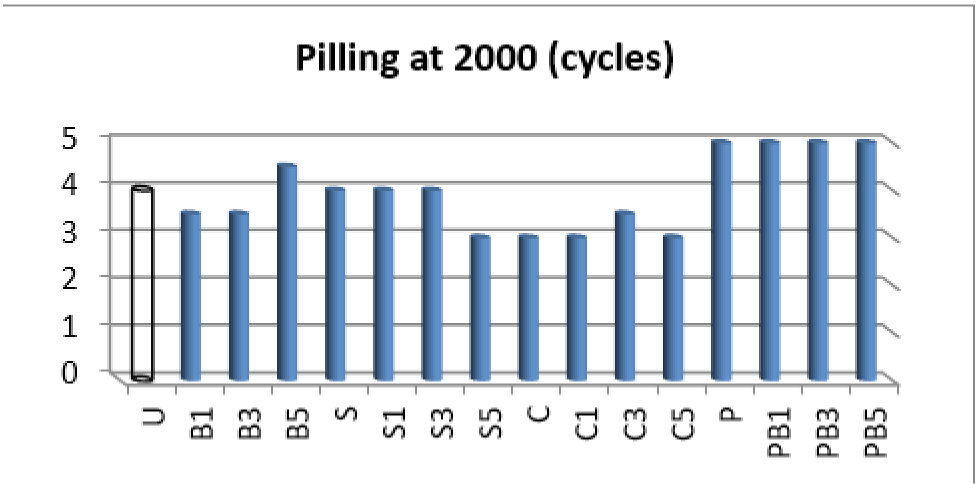

Fig. 4. Fabric pilling resistance

Fabric bending length (cm)

To know the effect of different treatments on the Fabric bending length. Analysis of variance ANOVA has been applied.

Table 9 shows that there is a significant effect of the treatments on the bending length (p-value=0.000) as the highest goes for the PB treatment but the best comes for C.

Fabric tensile stress (kgf/mm^2)

To know the effect of different treatments on the fabric tensile stress. Analysis of variance ANOVA has been applied.

Table 10 shows that there is an insignificant effect of the treatments on the tensile stress (p-value=0.86).

TABLE 9. ANOVA for Fabric bending length

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
B	3	11.75	3.916666667	0.030833333
C	4	15.25	3.8125	0.233958333
S	4	17.85	4.4625	0.378958333
P	4	48.85	12.2125	5.487291667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	195.085042	3	65.02834722	38.95547639	3.75532E-06	3.5874337
Within Groups	18.3622917	11	1.669299242			
Total	213.447333	14				

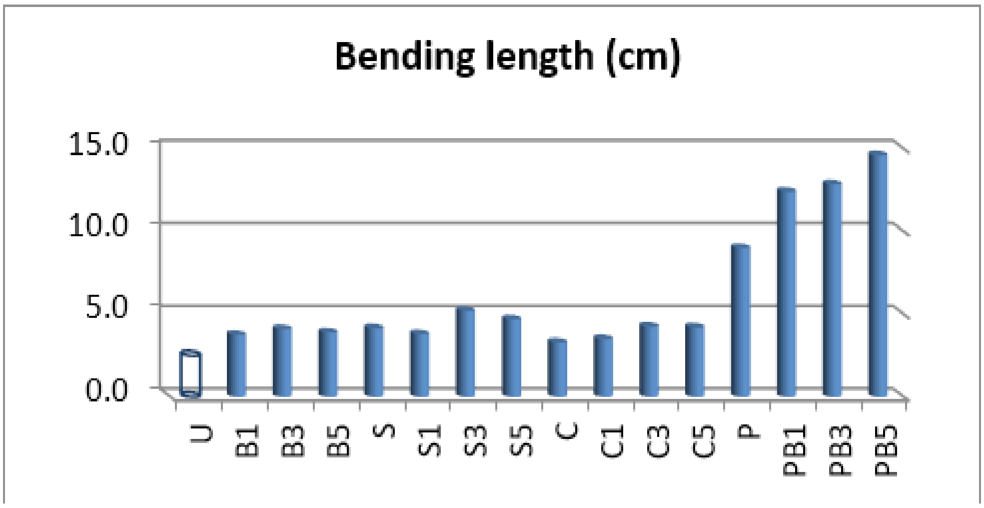

Fig. 5. Fabric bending length

TABLE 10. ANOVA for fabric tensile stress

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B	3	3.733	1.244333333	0.074334333
C	4	5.826	1.4565	0.185904333
S	4	4.92	1.23	0.190194667
P	4	6.393	1.59825	0.07725025

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.35718532	3	0.119061772	0.868075325	0.486625726	3.5874337
Within Groups	1.50871642	11	0.137156038			
Total	1.86590173	14				

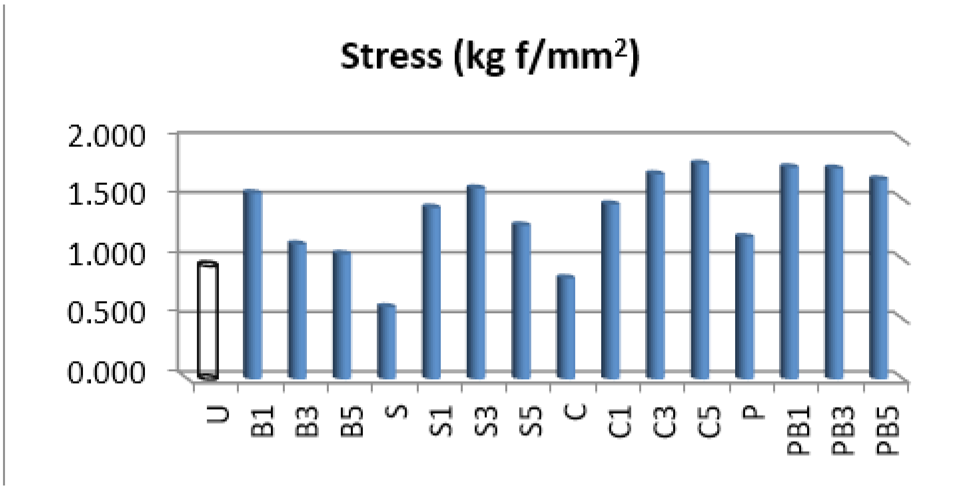

Fig. 6. Fabric tensile stress

Fabric tensile strain (%)

To know the effect of different treatments on the fabric tensile strain. Analysis of variance ANOVA has been applied.

Table 11 shows that there is a significant effect of the treatments on the tensile strain stress (p-value=0.013) as the highest goes for the C treatment.

Fabric air permeability (cm3/cm2/sec)

To know the effect of different treatments on the Fabric air permeability. Analysis of variance ANOVA has been applied.

Table 12 shows that there is a significant effect of the treatments on the air permeability (p-value=0.021) as the highest goes for the P treatment.

TABLE 11. ANOVA for fabric tensile strain

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B	3	72.07	24.02333333	20.85603333
C	4	105.5	26.375	1.104166667
S	4	85	21.25	35.875
P	4	63.249	15.81225	0.788740917

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	243.08175	3	81.02724984	5.749735247	0.012900087	3.5874337
Within Groups	155.015789	11	14.09234449			
Total	398.097539	14				

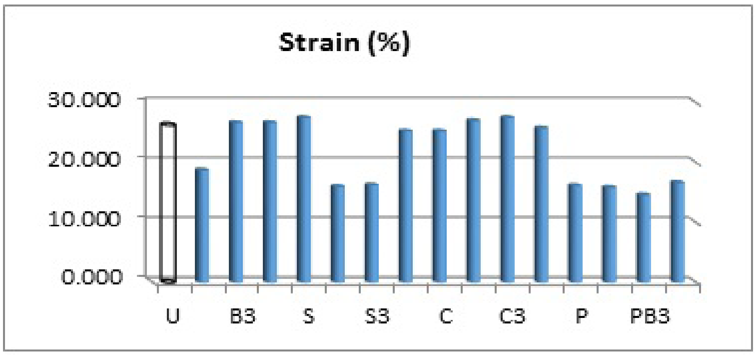

Figure 7: Fabric tensile strain

TABLE 12. ANOVA for fabric air permeability

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B	3	587	195.6666667	10.33333333
C	4	643	160.75	138.9166667
S	4	673	168.25	818.9166667
P	4	808.5	202.125	207.7291667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4720.07917	3	1573.359722	4.920447622	0.020899974	3.5874337
Within Groups	3517.35417	11	319.7594697			
Total	8237.43333	14				

Fabric static charge (kv)

To know the effect of different treatments on the fabric static charge. Analysis of variance ANOVA has been applied

Table 13 shows that there is an insignificant effect of the treatments on the static charge (p-value=0.492).

Color fastness to washing (Methylene Blue)

To know the effect of different treatments on the washing fastness (Methylene Blue), Analysis of variance ANOVA has been applied

Table 14 shows that there is an insignificant effect of the treatments on the washing fastness (Methylene Blue) (p-value=0.988).

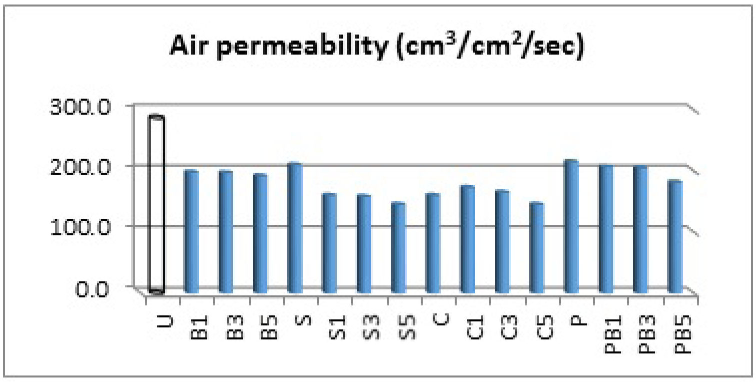

Fig. 8. Fabric air permeability

TABLE 13. ANOVA for the fabric static charge

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
B	3	0.04	0.013333333	3.33333E-05
C	4	0.02	0.005	3.33333E-05
S	4	0.02	0.005	3.33333E-05
P	4	0.04	0.01	0

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.00017333	3	5.77778E-05	2.383333333	0.124996111	3.5874337
Within Groups	0.00026667	11	2.42424E-05			
Total	0.00044	14				

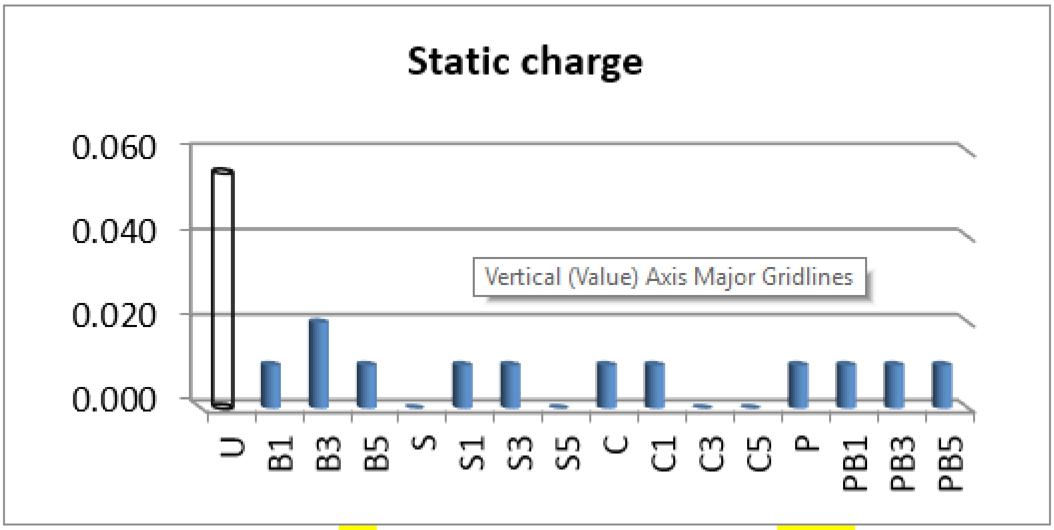

Fig. 9. Fabric static charge (kv)

TABLE 14. ANOVA for washing fastness (Methylene Blue)

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
B	3	11.25	3.75	0.0625
C	4	15	3.75	0.041666667
S	4	15.25	3.8125	0.057291667
P	4	15	3.75	0.208333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.01145833	3	0.003819444	0.04013267	0.98867915	3.5874337
Within Groups	1.046875	11	0.095170455			
Total	1.05833333	14				

Color fastness to washing (C. I Basic Red 18)

To know the effect of different treatments on the washing fastness (C. I Basic Red 18), Analysis of variance ANOVA has been applied

Table 15 shows that there is a significant effect of the treatments on the washing fastness (C. I Basic Red 18) (p-value=0.032) as the best result comes with treatment S (4.09)

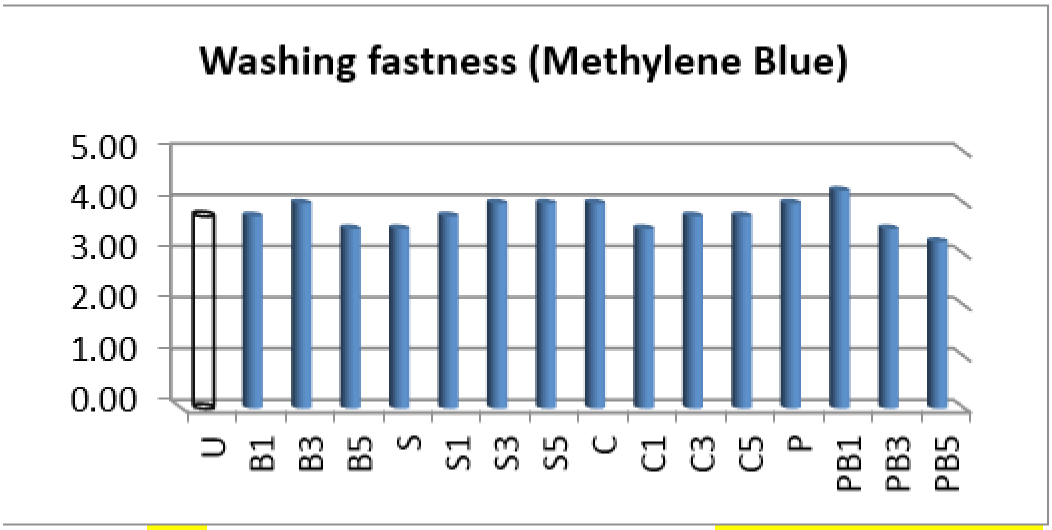

Fig.10. Color fastness to washing (Methylene Blue)

TABLE 15. ANOVA for washing fastness (C. I Basic Red 18)

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B	3	11.625	3.875	0.109375
C	4	15.625	3.90625	0.03515625
S	4	16.375	4.09375	0.00390625
P	4	14.375	3.59375	0.03515625

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.51067708	3	0.170225694	4.242084562	0.032047393	3.5874337
Within Groups	0.44140625	11	0.040127841			
Total	0.95208333	14				

Exhaustion % (Methylene Blue)

To know the effect of different treatments on the exhaustion % (Methylene Blue). Analysis of variance ANOVA has been applied.

Table 16 shows that there is an insignificant effect of the treatments on the Exhaustion % (Methylene Blue) (p-value=0.969).

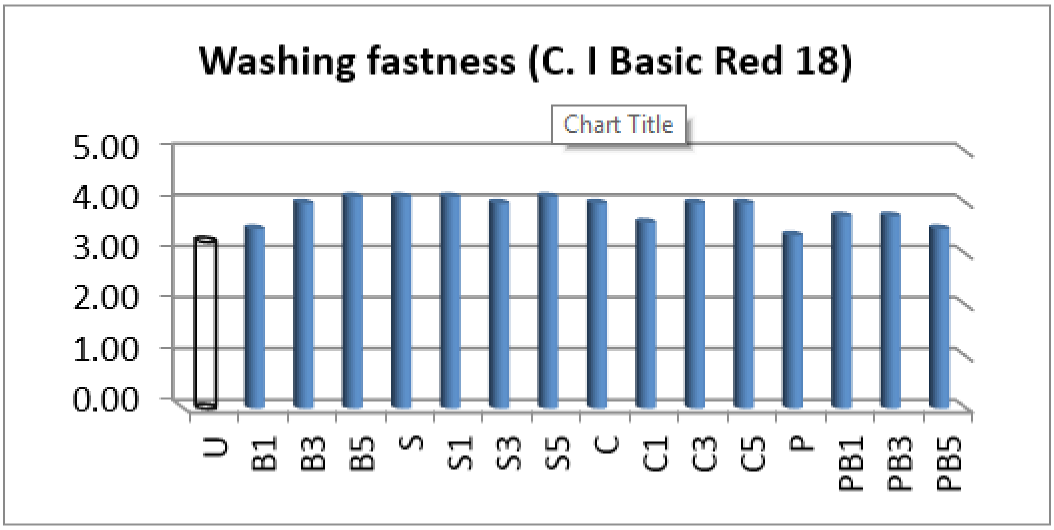

Fig. 11. Color fastness to washing (C. I Basic Red 18)

TABLE 16. ANOVA for exhaustion % (Methylene Blue)

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
B	3	282.6	94.2	0.21
C	4	374.5	93.625	10.6625
S	4	371.5	92.875	11.015833
P	4	372.8	93.2	29.846667

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.374333333	3	1.1247778	0.0798255	0.9696206	3.5874337
Within Groups	154.995	11	14.090455			
Total	158.3693333	14				

Exhaustion % (C. I Basic Red 18)

To know the effect of different treatments on the exhaustion % (C. I Basic Red 18). Analysis of variance ANOVA has been applied.

Table 17 shows that there is an insignificant effect of the treatments on the exhaustion % (C. I Basic Red 18) (p-value=0.649).

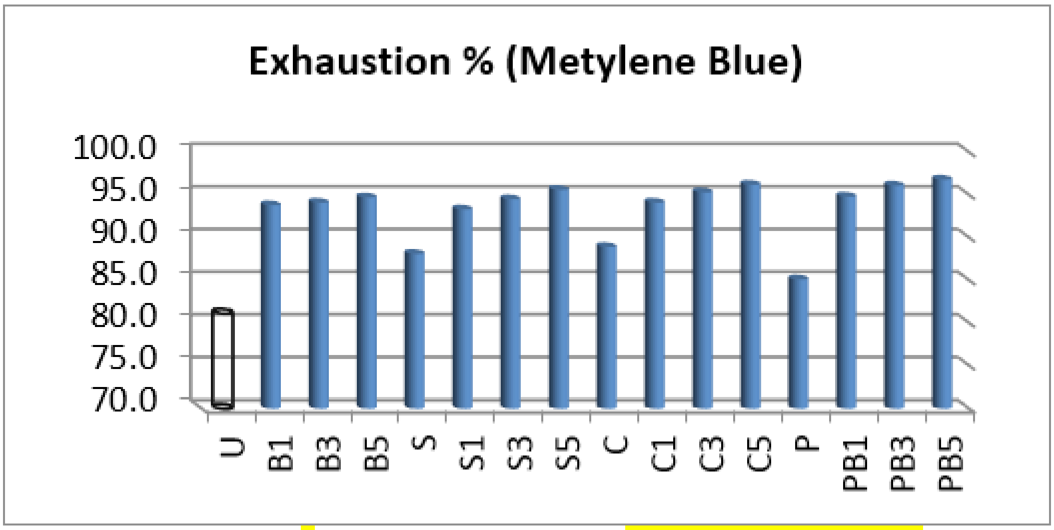

Figure 12. Exhaustion % (Methylene Blue)

TABLE 17. ANOVA for exhaustion % (C. I Basic Red 18)

SUMMARY

Groups	Count	Sum	Average	Variance
B	3	265	88.333333	19.623333
C	4	351	87.75	9.11
S	4	343.2	85.8	1.9
P	4	353.6	88.4	12.953333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	17.12733333	3	5.7091111	0.565072	0.6492642	3.5874337
Within Groups	111.1366667	11	10.103333			
Total	128.264	14				

ii. t-Test

To know the effect of treatments against the untreated fabric properties, t-Test has been applied.

Table 18 shows that there is a significant difference between the treated and untreated fabrics with Weight, Air permeability, Static charge, washing fastness (C. I. Basic Red 18), and exhaustion % (Methylene Blue) (p-value=0.016, 0.0004, 0.000, 0.02, 0.00 resp.) as the fabric weight has increased due to treatment.

The air permeability has significantly decreased due to treatment.

Even though there is a statistically significant difference in Static Charge but Static Charge of the untreated fabric does not reflect that it is conductive as it is only 0.05 kv.

The washing fastness (C. I. Basic Red 18) has significantly improved due to treatment from 3.25 to 3.87.

Exhaustion % (Methylene Blue) has also improved significantly due to treatment from 81.1% to 93.43%.

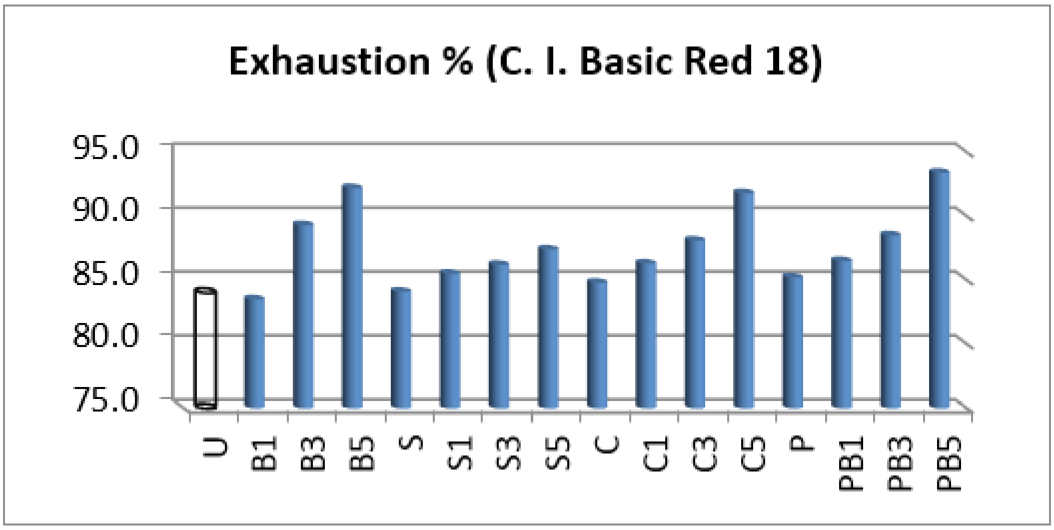

Fig. 13. Exhaustion % (C. I Basic Red 18)

TABLE 18. t-Test for fabric properties

t-Test	Weight (g/m²)	Thickness (mm)	Bending length (cm)	Pilling at 2000 (cycles)	Abrasion (cycles)	Stress (kg f/ mm²)	Strain (%)	Air permeability (cm³/cm²/ sec)	Static charge	Washing Fastness (Methylene Blue)	Washing Fastness (C. I Basic Red 18)	Exhaustion % (Methylene Blue)	Exhaustion % (C. I Basic Red 18)
Treated	185.56	0.65	6.25	3.93	432.07	1.39	21.72	180.77	0.01	3.77	3.87	93.43	87.52
Untreated	161.43	0.61	2.50	4.00	250.00	0.95	26.25	286.50	0.06	3.75	3.25	81.10	84.00
t Stat	2.38	0.66	0.93	-0.08	1.21	1.17	-0.82	-4.22	-7.61	0.06	2.29	3.55	1.13
P(T<=t) one-tail	0.02	0.26	0.18	0.47	0.12	0.13	0.21	0.00	0.00	0.48	0.02	0.00	0.14
t Critical one-tail	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.78	1.76	1.76	1.76	1.76

iii. Quality assessment

Quality factor has been calculated for all the samples to show the overall effect of different treatments on the sample functional performance when used in clothing manufacturing. Radar charts have been drown to the samples of different treatments as shown in Fig. 14 (S, C, PB)

From Table 19 it is clear that the c treatment is giving best quality factors and the C3 is best of all treatments.

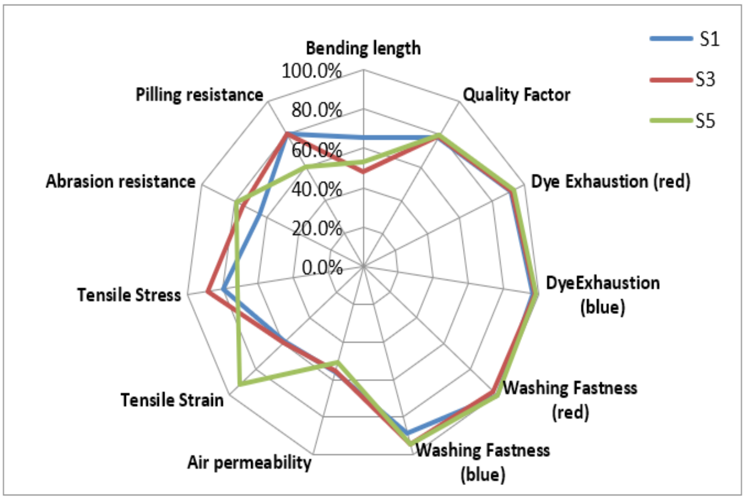

Fig. 14S. Treatment with S1, S3 and S5

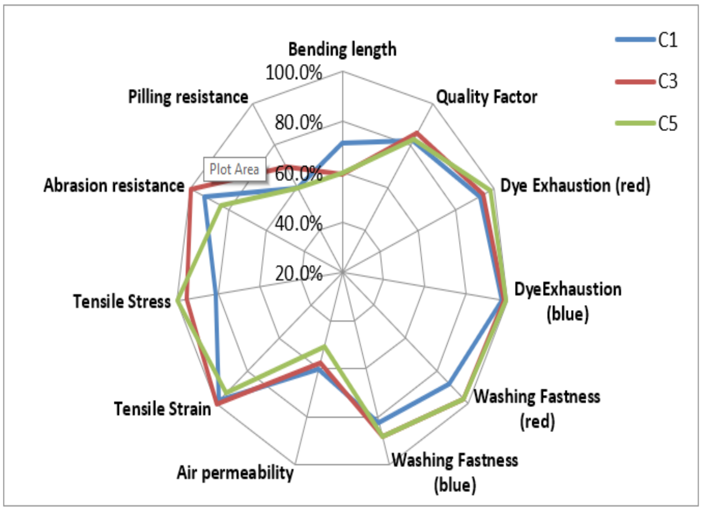

Fig. 14C. Treatment with C1, C3 and C5

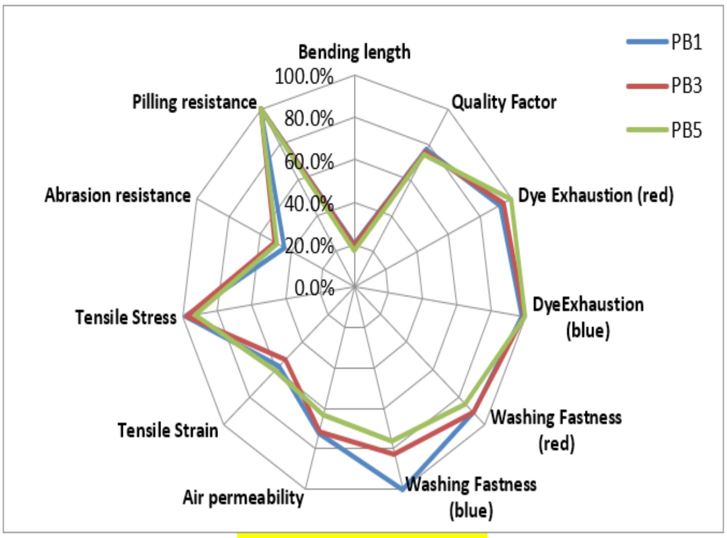

Figure 14PB. Treatment with PB1, PB3 and PB5

TABLE 19. Quality factor for the samples under study

Sample Cod	Bending length	Pilling at 2000 (cycles)	Abrasion	Stress	Strain	Air permeability	Washing Fastness (Methylene Blue)	Washing Fastness (C. I. Basic Red 18)	Exhaustion % (Methylene Blue)	Exhaustion % (C. I. Basic Red 18)	Quality Factor
U	100.0%	80.0%	35.7%	52.8%	95.5%	100.0%	88.2%	78.8%	83.8%	89.9%	80.5%
B1	66.7%	70.0%	54.3%	86.4%	68.2%	69.1%	88.2%	84.8%	96.9%	89.4%	77.4%
B3	61.0%	70.0%	50.0%	62.6%	96.9%	68.8%	94.1%	97.0%	97.2%	95.6%	79.3%
B5	64.1%	90.0%	50.0%	58.3%	96.9%	67.0%	82.4%	100.0%	97.8%	98.7%	80.5%
S	60.2%	80.0%	44.3%	33.6%	100.0%	73.3%	82.4%	100.0%	91.0%	90.0%	75.5%
S1	65.8%	80.0%	64.3%	79.7%	58.2%	55.8%	88.2%	100.0%	96.4%	91.5%	78.0%
S3	48.1%	80.0%	74.3%	88.7%	59.1%	55.1%	94.1%	97.0%	97.6%	92.3%	78.6%
S5	53.2%	60.0%	78.6%	71.4%	91.8%	50.6%	94.1%	100.0%	98.8%	93.6%	79.2%
C	75.8%	60.0%	64.3%	47.1%	91.8%	55.8%	94.1%	97.0%	91.8%	90.8%	76.8%
C1	71.4%	60.0%	92.9%	81.2%	98.2%	60.4%	82.4%	87.9%	97.2%	92.4%	82.4%
C3	58.8%	70.0%	100.0%	95.3%	100.0%	57.6%	88.2%	97.0%	98.5%	94.3%	86.0%
C5	59.5%	60.0%	84.3%	100.1%	93.6%	50.6%	88.2%	97.0%	99.4%	98.3%	83.1%
P	27.8%	100.0%	24.0%	65.9%	58.8%	75.0%	94.1%	81.8%	87.9%	91.2%	70.7%
PB1	20.2%	100.0%	44.7%	98.4%	57.6%	72.3%	100.0%	90.9%	97.9%	92.6%	77.5%
PB3	19.5%	100.0%	50.7%	97.9%	53.0%	71.6%	82.4%	90.9%	99.3%	94.8%	76.0%
PB5	17.1%	100.0%	49.3%	92.8%	60.6%	63.4%	76.5%	84.8%	100.0%	100.0%	74.5%

Conclusions

- The acrylic fabrics are pretreated with of sodium hydroxide as well as citric acid to confirm the nitrile groups to carboxylic groups.

- The results clarify an improvement of the strain and stress as the concentration of polyacrylate and nanoclay material increases.

- The bending length of fabric treated with sodium poly acrylate is higher than that compared to the untreated one and that treated with only nanoclay (nanobentonite).

- Air permability of treated acrylic fabrics were increased than untreated acrylic fabrics this result can be confirmed by date of both moisture regain

- The acrylic fabrics are treated with mixture of sodium poly acrylate as risen and nano bentonite enhancing the mechanical and physical properties.

- The treatments of acrylic fabric with the mixture of nano-bentonite under different conditions led to high enhancement the dye exhaustion % as well as washing fastness for both basic dyes (C. I. Basic Red 18 and Methylene Blue).

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الخواص الفيزيقية و الميكانيكية لاقمشة الاكريليك المعالجة باستخدام النانو بنتونيت

لمياء الجابرى ومحمد عزت و اميرة ابو الخير وزينب عبدالمجيد

تم معالجة أقمشة الاكريلليك (بولى اكريلونتريل) بإستخدام نانو بينتونيت تحت ظروف معالجة مختلفة باجراء معالجة سابقة للاقمشة باكسيد الصوديوم و حمض الستريك وايضا استخدام بولى أكريلات الصوديوم كمادة راتنجية.

تم قياس الخواص الميكانيكية و الفيزيائية لاقمشة الاكريليك المعالج مثل قوة الشد والاستطالة والصلابة والسمك و مقاومة الاشعة البنفسيجية واستعادة الرطوبة و مقاومة الاحتكاك و الكهربة الاستاتيكية للالياف ونفاذية الهواء.

وقد تم استخدام الصباغات القاعدية لصباغة العينات المعالجة بالمواد النانو وكذلك العينات غير المعالجة وتم تحديد نسبة استنفاذ الصبغة فى حمام الصباغة ومقاومة الاقمشة للغسيل للعينات التى تم صباغتها. لمعرفة تاثير المعالجة على خواص القماش المعالج تم عمل دراسة احصائية (انوفا). كما تم عمل رسم تجميعى للخواص التى تناسب الملابس (radar chart.) للحصول منه على افضل ظروف المعالجة وايضا للخواص الملائمة للسجاد.