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Towards high Performance Viscose, Polyester and their Blended fabrics in garment using Nano Silicon dioxied

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ABSTRACT

The effect of treatment of the viscose, polyester fabrics and their blends fabrics with nano silicon dioxide on some their properties of are studied. The anti pilling, roughness, tensile strength, elongation %, antistatic charge, tear strength, FAST tests (formability, bending rigidity, extensibility and thickness) and seam pucker, are investigated. The study evaluates the possibility of using the mechanical properties of fabric measured by FAST instruments to optimize the effect of treatment of viscose, polyester and their blended fabrics with nano silicon dioxide not only on their performance and appearance but also in garment manufacturing.

KEYWORDS: Viscose, Polyester fabrics, mechanical properties, seam puker and FAST.

1. INTRODUCTION

The alteration of materials' surface properties by nano size SiO_2 particles improves the mechanical properties and durability of materials and also influences material's functionality, activity or can enhance its stability. [1, 2] Microbiological tests were carried out on these textiles and confirmed their good antimicrobial activity. The role of silica spheres in SiO_2/Ag is as Ag metal carriers and effective matrix causing good dispersion of silver nanoparticles in polymer matrix. [3, 4] Treatments with different softeners and sanforising on polyester fabrics enhancement anti pilling, and in all cases, sanforising after softening adversely affects the fabric pilling performance. [5]

Fabrics undergo a complex combination of deformations like extension, longitudinal compression, bending and shear. The shearing behavior of fabrics is of the most important to fabric producers, garment manufacturers and the composite industry. It plays a crucial role in fabric formability when doubly curved surfaces must be covered. The ability of fabric to shear within a plain enables it to fit three-dimensional surfaces without fold. [6, 7] The presence of acrylate-based copolymer binder with nano silicon dioxide increases the percent reduction of bacteria on pretreated viscose, for both E. coli and S. aureus as well as a durable antibacterial activity after 10 laundering cycles has been achieved. [8]

In blends of polyester or acrylic fibers with cotton or viscose the synthetic component provides crease recovery, dimensional stability, tensile strength, abrasion, resistance and easy care properties, whilst the cellulosic fibers contributes moisture absorption, antistatic characteristics and reduced pilling. [9, 10]

The visual appeal of the garment is a principal factor deciding its value. Seam pucker, which is a wrinkled appearance along the seam, influences the appearance to a considerable degree. Seam pucker, identified as a sew ability problem about seventy years ago, has been regarded as one of the most important parameter of quality control in garment manufacturing industries. [11] There are causes of seam puckering (SP) structural jamming, differential feed sewing thread tension, sewing thread shrinkage and mismatched patterns.[12] Charts and equation have also been developed for the determination of seam pucker grade, but they can only provide guidelines and cannot offer specific predictions of how the seam pucker might perform in garment manufacturing.[13]

Fathy et al studied the relation between the construction and the sewability of garment as well as the effect of some treatments on performance properties of garment. The fabric mechanical properties tests were measured using FAST. [14] There are many factors which relate to seam pucker e.g. type of yarn construction, fabric design, finish of fabric, type of sewing machine used, stitching conditions and the behavior of the sewing thread. visible effects of pucker can be reduced but can't be totally eliminated. The different types of seam pucker are defined as follows according to Amman. Seam pucker can be categorized into: Displacement puckers, Tension pucker and Feed pucker. [15] Also, there was study to clearly demonstrate a profound influence of nano treatment on dimensional and compression properties of viscose, polyester and their blend fabrics. [16] The predictions are based on fabric mechanical properties measured on the KESF system and structure properties calculated by Peirce model. Eight

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designed fuzzy systems in two groups enable to predict seam pucker. Testing results indicate that designed fuzzy systems are effective for predicting seam pucker grades in clothing manufacturing. [17]

In this study, surface treatments of viscose, polyester and blend fabrics with using nano silicon dioxide (SiO_2) are carried out to improve some of their mechanical properties such as antipilling, antiasiatic charge, roughness, seam pucker, formability, extensibility bending rigidity**,** and thickness surface. The obtained results will surely help to identify the design criteria for clothing so as to produce high quality garments.

2. EXPERIMENTAL

2.1. Materials

2.1.1. Fabrics

Polyester and viscose and their blend (viscose/ polyester 60/40 and polyester/ viscose 70/30) fabrics were supplied by Misr El Mahalla Co., for Spinning and Weaving, El Mahalla El Kobra, Egypt. The fabrics were soaped with (2 g/L) nonionic detergent solution (Hostapal C V., from Clariant, Egypt) with a liquor ratio 1 : 25, at 45ºC, for 30 min, then rinsed twice in cold tap water, and dried at room temperature.

2.1.2. Chemical

The nanoparticle used in this study is SiO_2, obtained from Sigma – Aldrich, Germany. Potassium hydroxide and Methyl alcohol are of laboratory grade.

2.2. Alkaline pretreatment of polyester

To improve the adhesion of SiO_2 nanoparticle to the smooth surface of polyester fabric, an alkaline pretreatment in water solution containing 5 g/L of KOH for 30min at 98ºC with a liquor ratio 1: 25 was performed. Subsequently, the samples were rinsed twice in cold tap water and then dried at room temperature.

2.3. Treatment

The polyester and viscose and their blend fabrics were immersed in solutions of (12.5 g/l) SiO_2 nanoparticle with a liquor ratio 1: 10 (ethanol: water) for 1hr. at room temperature. The fabrics were then padded at 100% pick up using a laboratory padding machine. One series of the padded samples are cured at 150ºC for 10 min. The samples were rinsed with cold water then rinsed with tap water, and finally air dried.

2.4. Measurements

2.4.1. Roughness

Surface roughness of treated and untreated fabrics was measured according to JIS-94 standard using surface roughness tester Model SE 1700∞ (Kosaka Laboratory Ltd.
Japan).

2.4.2. Antistatic property measurement

Antistatic property measurement Static electricity of treated and untreated polyester fabrics was measured using electricity collect type potentiometer model KS-525 (Kasuga Denki, Inc., Japan). The antistatic property measurements were carried out according to Test Method of specified requirements of Antistatic Textiles FTTS – FA- 2009.

2.4.3. Tensile strength, elongation % and tear strength

The tensile properties of viscose, polyester and their blend fabrics before and after treatment with nano silicon dioxide were evaluated using a Instron Tensile Tester (USA) according to ASTM D 76 Standard Specification for Textile Testing Machines. The average was taken for samples (5x 20 cm). These tests were carried out to determine the change in tensile strength and tear strength for the untreated and the treated viscose fabrics only.

2.4.4. Pilling test

Pilling tester is used to determine the pilling resistance of all kinds of textile structures. Sample was rubbed against the same material of sample at low pressures and the amount of pilling is compared against standards parameters. Pilling test was carried out according to standards ASTM standard D4970 (pilling), all samples and standard fabrics should be conditioned in the standard atmosphere for testing (20ºC - + 2 and 65% RH - , + 2%). The specimens assed are using the 5 point scale.

2.4.5. Seam puckering:

Method based on thickness measurement

This method is based of measurement of fabric thickness. The fabric thickness increases due to distortion of fabric layers from fabric plane. The thickness of unpuckered fabric seam equals the addition of thickness of individual fabric plies. The increase of thickness can be used as an indicator of the extent of puckering.

$$SP\% = \frac{(T_2 - T_1)}{T_1} \times 100$$

Where SP is seam pucker %, T_2 is thickness of puckered seam; T_1 is thickness of fabric seam (thickness of individual fabric plies added together).This method though considered better than subjective evaluation, but suffers the limitation like more time consumption and inconsistency. [17]

2.4.6. FAST - Fabric Assurance by Simple Testing

FAST is a set of instruments and test methods for measuring mechanical and dimensional properties of fabrics. These measurements allow the prediction of fabric performance in garment manufacture and the appearance of the garment during wear. . [21] The instruments were developed by the Australian CSIRO.

FAST consists of three instruments and a test method

FAST-1 is a compression meter that measures fabric thickness. [18]
FAST-2 is a bending meter that measures the fabric bending length. [19]
FAST-3 is an extension meter that measures fabric extensibility. [20]
FAST-4 is a test procedure for measuring dimensional properties of fabric. [21]

3. RESULTS AND DISCUSSION

3.1. Antistatic charge

Figure 1 shows the antistatic charge of untreated and treated polyester fabrics and its blend with nano silicon dioxide. It is found that the treatment reduces the antistatic charge of treated fabrics than untreated ones. This enhancement may be attributed to improved moisture regain of the treated fabrics. [8] The increase of moisture regain for the treated fabrics could be attributed to the opening of the fiber structure with the aid of SiO2 nanoparticle, which allowed more water vapor molecules to penetrate the fiber structure.

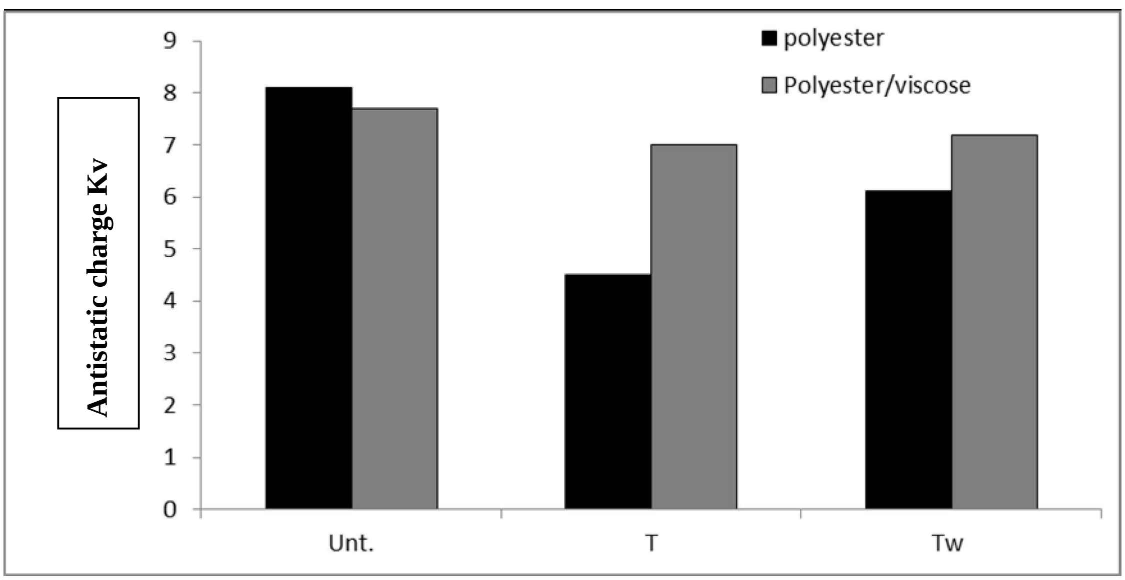


Fig. 1: Antistatic charge of untreated and treated polyester fabrics

Unt: untreated polyester fabric **T:** treated polyester fabric **Tw:** washed treated fabrics

Treatment: The fabrics were immersed in a solution containing 12.5 g/l (1:10 ethanol: water) (o. w .f) of Nano silicon dioxide (at room temperature for 1h, then padded to pick up 100% and then fixed at 150°C for 10 min. Finally the fabric is washed thoroughly with tap water and air dried.

3.2. Tensile strength, elongation %, roughness and tear strength

The treated fabrics are tested for tensile strength, elongation % at break and roughness. Results of this analyses are tabulated in table 1. The results o show that, there are limited increase in the tensile strength properties of the treated fabrics; the tensile elongation % decreased while the tear strength increased in both warp and weft directions. In the roughness data show some change for treated fabrics than untreated one. The tear strength test is carried out on untreated and treated viscose fabrics only. It was found that the treatment improved the tear strength from 1.02 kg for untreated fabrics to 1.25 kg for treated fabrics in both warp and weft direction. This may be attributed to an increase hydrogen bonds between the chains of viscose fibres. [8]

Table 1: Tensile strength, elongation % and roughness of untreated and treated fabrics

Samples	Tensile strength Kgf/m^2	Elongation %	Roughness µm
Untreated Viscose 10g/l	0.545	55.8	19.0
Treated Viscose10g/l	0.720	26.27	20.2
Untreated viscose/polyester(60/40)	1.7	33.1	19.2
Treated viscose/polyester(60/40)	1.8	31.0	20.61
Untreated polyester/viscose (70/30)	3.72	69.6	15.1
Treated polyester/viscose (70/30)	3.5	46.5	15.3
Untreated polyester	2.43	2.47	2.47
Treated polyester	2.47	2.43	2.43

Treatment condation see figure 1

3.1. Effect of treatment on pilling resistant

The effect of treatmenr of viscose, polyester and their blends fabrics with nano silicon dioxide on pilling resistance is studied. Results of this investigation sumarised in table1 show that the pilling resistance increases for all treated fabrics than untreated one. It can be seen that the treatments of viscose fabrics with nano silicon dioxide led to significant enhancement in their pilling resistance. Moreover, it is found that washing has significant change in the results of anti-pilling.The improvement in the pilling resistance of treated polyester and viscose/ polyester blends is lowerthan that of viscose one. The increase in pilling resistance may be attrubited to increase in tensile strength with treatment ith nano silicon dioxide. This may be attributed to found some new hydrogen donds between the chains of treated fibres.

Table 2: Pilling of untreated and treated fabrics

Samples	Pilling After 1000 cycle	Pilling After 2000 cycle	Pilling After 1000 cycle (After washing)	Pilling After 2000 cycle (After washing)
Untreated Viscose	1	1	1	1
Treated Viscose	3-4	3-4	3	3
Untreatedviscose/polyester(60/4)	2-3	2	2	2
Treated viscose/polyester(60/40)	3-4	3-4	3	3
Untreatedpolyester/viscose(70/3)	3-4	1-2	3	2
Treated polyester/viscose (70/30)	4-5	4-5	4	4
Untreated polyester	4-5	4-5	4-5	4-5
Treated polyester	5	5	4-5	4-5

Treatment condation see figure 1

3.4. Evaluation of seam puckering

The data of seam puckering % (SP %) for treated and untreated fabrics as show in figure 2 (a & b) and table 3. Figure 2 (a) indicates to little decrease SP% for untreated and treated fabrics and its blend at warp direction for all treated fabrics than untreated fabrics. But figure 2 (b) indicates to increase in SP % for treated than untreated fabrics for both viscose and polyester and its blend in weft direction. It is observed from this comparison that the SP % increased after treatment at weft direction for both polyester and viscose fabrics and its blend than warp direction.

Table 3: Seam pucker % of untreated and treated fabrics

Samples	seam pucker % of weft	seam pucker % of warp
Untreated Viscous	11.516	15.26
Treated Viscous	26.35	18.15
Untreated viscose/polyester(60/40)	31.56	55.129
Treated viscose/polyester(60/40)	36.364	42.471
Untreated polyester/ viscose (70/30)	38.742	32.885
Treated polyester/viscose (70/30))	47.13	44.35
Untreated polyester	46.4286	51.04
Treated polyester	76.673	44.7205

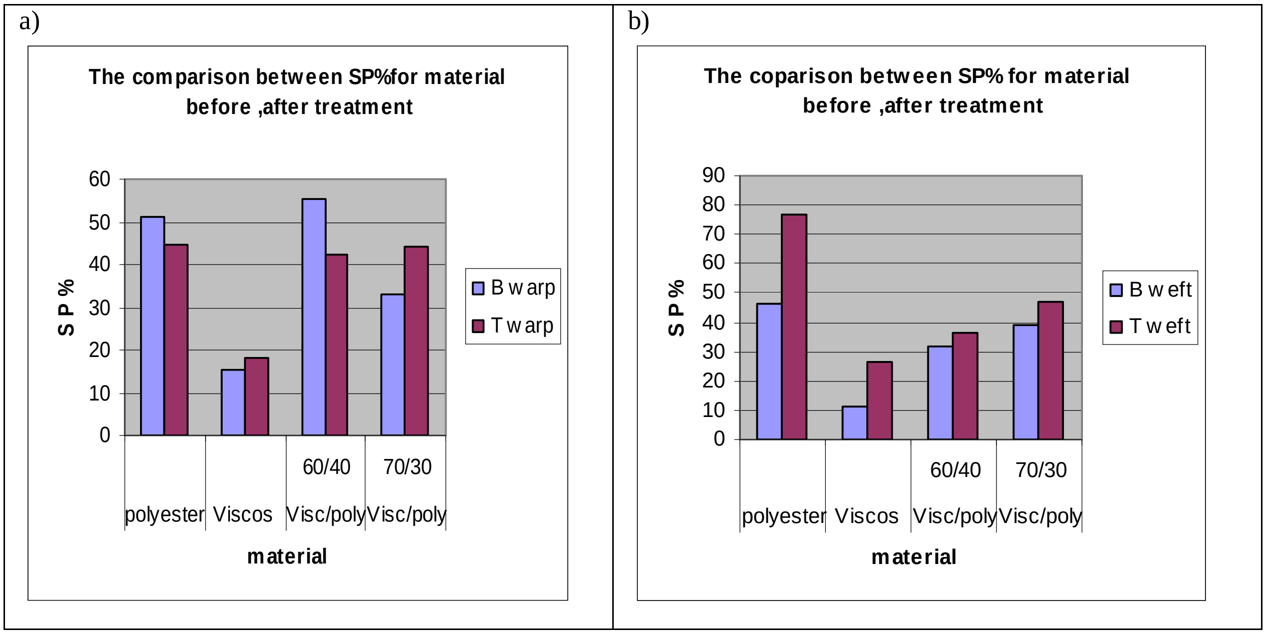
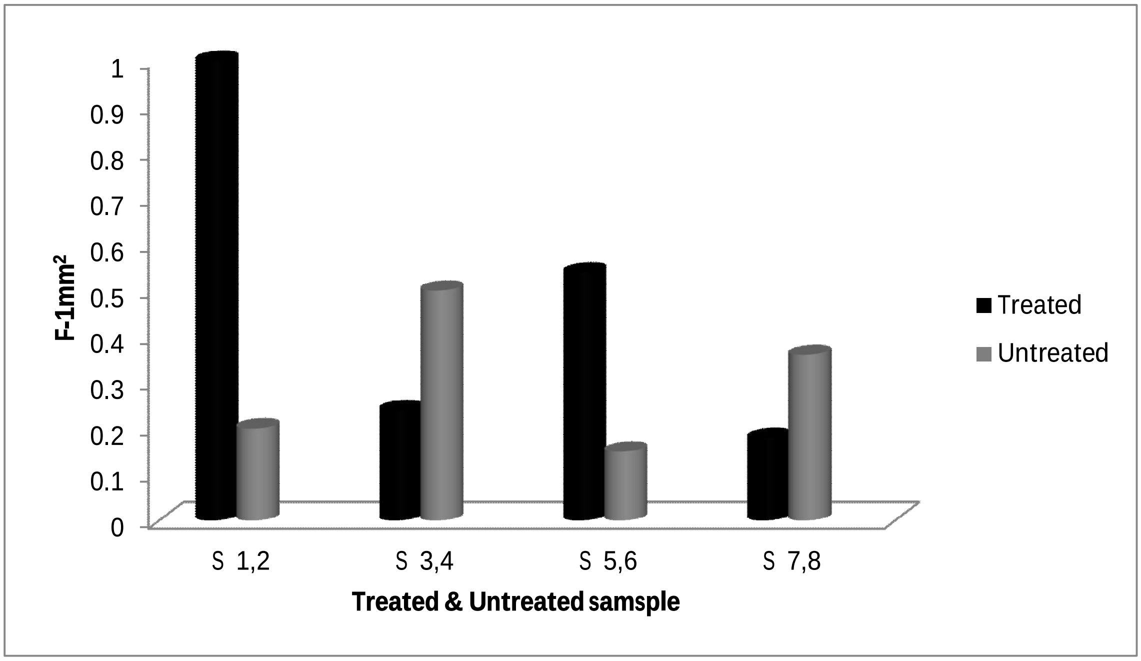


Fig. 2 a) Seam puckering (SP) % for untreated and treated fabrics
B: Untreated fabric **T:** treated fabric **a) warp direction** **b) weft direction**
Treatment condation see figure 1

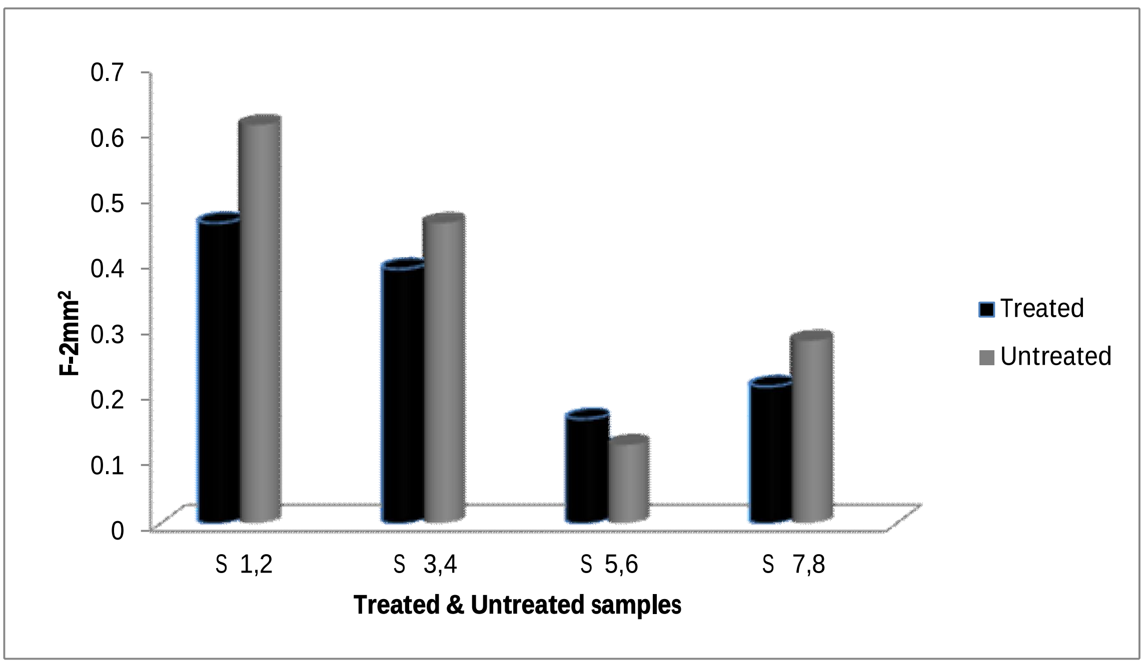
3.5. FAST Results

3.5.1. Formability

The values of formability of untreated and treated fabrics as shown in figure 3 a, b. Fabric formability can be used to predict the limit of overfeed buckling. The lower of formability cause more seam pucker because a fabric is unable to accommodate the small compression placed on the fabric by the sewing thread[5]. The values of formability ranged from 0.18 mm^2 to 0.54 mm^2 in treatment fabric warp (F-1) and 0.16mm^{2}to 0.46mm^2 in weft. The maximum and minimum limits of fabric formability will also depend on the sewing thread, needle size and thread tension, as well as the skill of the operators. Puckering or sleeve-setting problems are known to occur easily only in fabrics with formability less than 0.25mm^2 in both direction. [16]



a



b

Fig 3 a, b: Formability warp and weft of untreated and treated fabrics

F- 1-U: Formability warp of untreated F- 1-T: Formability warp of treated
F- 2-U: Formability weft of untreated F- 2-T: Formability weft of treated
Treatment condation see figure 1
S 1, 2: sample 1from treated 100% Viscous, sample 2 from untreated 100% Viscose
S 3, 4: sample 3 treated from viscose/polyester (60/40), sample from 4 untreated viscose/polyester (60/40)
S 5, 6: sample 5 treated from polyester/ viscose (70/30)sample from 6 polyester/ viscose (70/30) untreated
S 7, 8: samples 7 treated from 100% Polyester and sample 8 untreated from100% Polyester

Figures 3 a, b show the formability of untreated and treated fabrics. Fabrics S3, S5and S7 recorded values less than 0.25 mm^2 in both the direction after treatment, which might result in serious problems in seam puckering and sleeve setting. As the warp formability is more important than weft formability in fabric manufacturing[6]all the fabric samples previously are expected to pose problems in garment manufacturing as the values of the (50%pol:50%V),(100%V)and (100% pol) in both direction.

3.5.2. Extensibility

Extensibility is a measure of the fabric's ability to be stretched during making up. Both excessive and insufficient extensibility is known to cause problems during the manufacture of the garment. [18] The Extensibility results shown in figures 4 a, b. The values of Extensibility ranged from 1.6% S3 to 6.5% S5 in treated warp and 3.1% S3 to 3.9% S5 in weft directions.

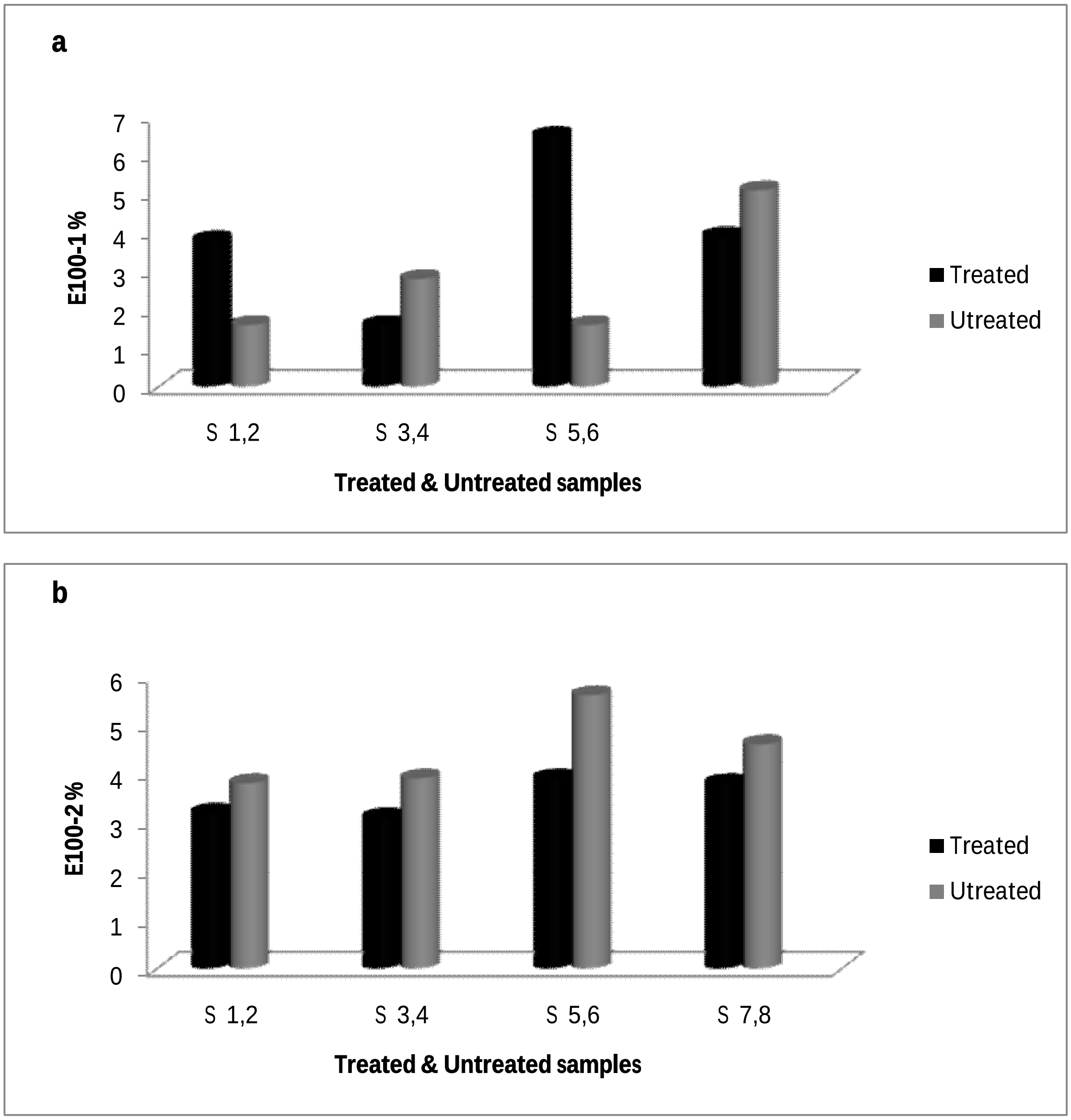


Fig 4 a, b: Extensibility warp and weft of untreated and treated fabrics

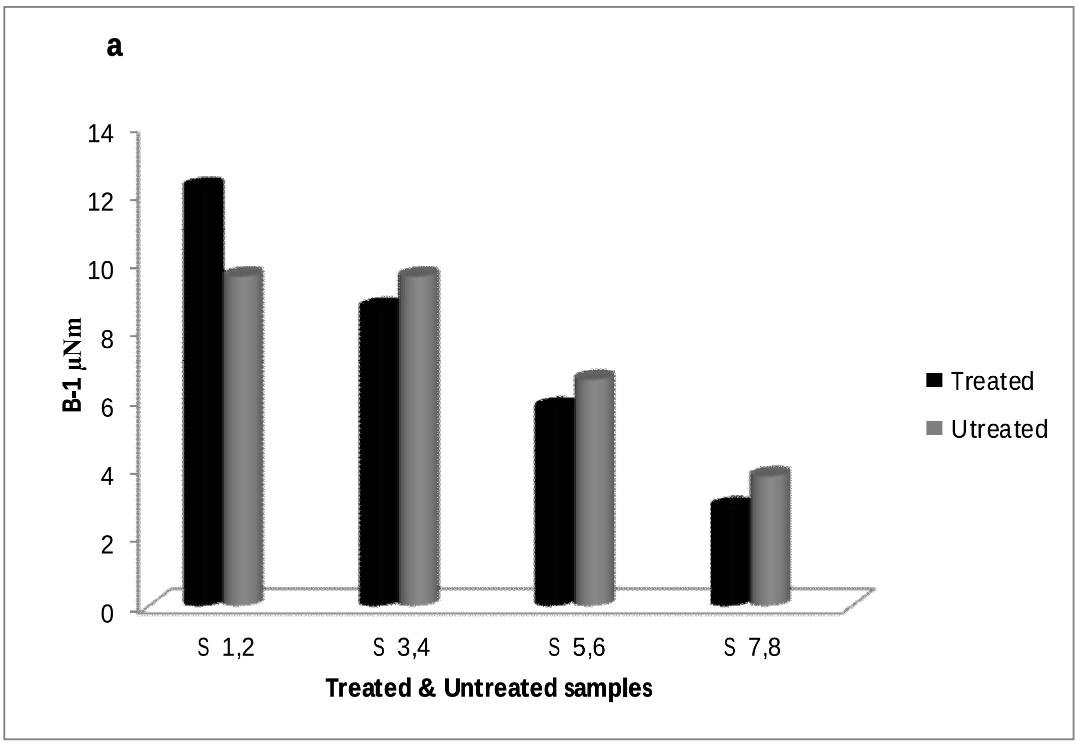
E- 1-U: Extensibility warp of untreated E- 1-T: Extensibility warp of treated
E- 2-U: Extensibility weft of untreated E- 2-T: Extensibility weft of treated
Treatment condation see figure 1 and 3

Though the minimum limit is 2% in both directions and maximum limits are 4 and 6 % in warp and weft[6]. The fabrics less than 1.84 % are known to cause difficulties during seam overfeeding. Extensibility greater than 2.53 %

in warp and 4.07 % in weft allows the fabric to be easily stretched during spreading and sewing unsupported. Fabric may shrink or relax after being cut. The higher the extensibility the more difficult will be the laying up, cutting and sewing[6]. All the fabrics are found to have values less than the minimum limit in warp direction. S2 (1.6%), S6 (1.6%) recorded the lowest in warp untreated which cause difficulties during seam overfeeding. The treatment improves the fabric extensibility warp. S6, S8 (5.6%, 4.6%) recorded high values in untreated fabrics which cases problem during laying up, after treatment the problem improves in weft direction . Extensibility of all the fabrics tested did not exceed the maximum limits both in warp and weft direction, thus producing problem during laying up. The extensibility values both in warp and weft directions were found to be significantly different for all the

3.5.3. Bending Rigidity

The Bending Rigidity of untreated and treated fabrics is shown in figure 5 a and b. Fabrics with high of bending rigidity will not generally cause problems in making up, but will feel stiffer and so bending rigidity can be a useful indicator of changes or variations in fabric handle[5].The values of bending rigidity ranged from 2.9 μNm to 12.2 μNm in warp and 3.2 μNm to 8.8 μNm in weft direction. Fabrics with 2.9 μNm in warp and 3.2,3.6 μNm in weft were regarded as soft and easy to bend, and the fabrics are known to be difficult to handle and cut[6]; S7,S5 (100%polyester,100%viscose treated) have low values in both warp and weft. Directions and expected to give a number of difficulties in the tailoring process. Fabrics can be difficult to cut as they distort easily. The treatment improves the lower values but the problem for those makers who do not have the benefit of vacuum cutting tables. In sewing operation low bending rigidity can be a major contributory cause of seam pucker.



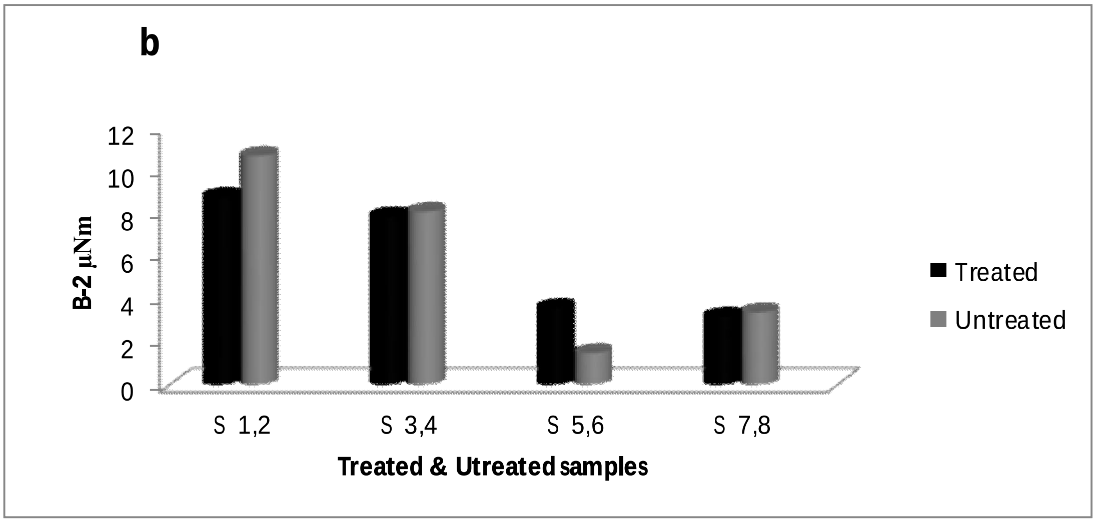


Fig 5 a, b: Bending Rigidity warp and weft of untreated and treated fabrics

B- 1-U: Bending Rigidity warp of untreated B- 1-T: Bending Rigidity warp of treated
B- 2-U: Bending Rigidity weft of untreated B- 2-T: Bending Rigidity weft of treated
Treatment condation see figure 1 and 3

3.5.4. Surface Thickness

Figure 6 shows surface thickness of untreated and treated fabrics. Surface thickness does not themselves has any great impact upon the tailoring performance of a fabric but are useful indicators of any change or variation in fabric handle[5.] The treatment improved surface thickness samples values which indicating the finish on the fabric is unstable.

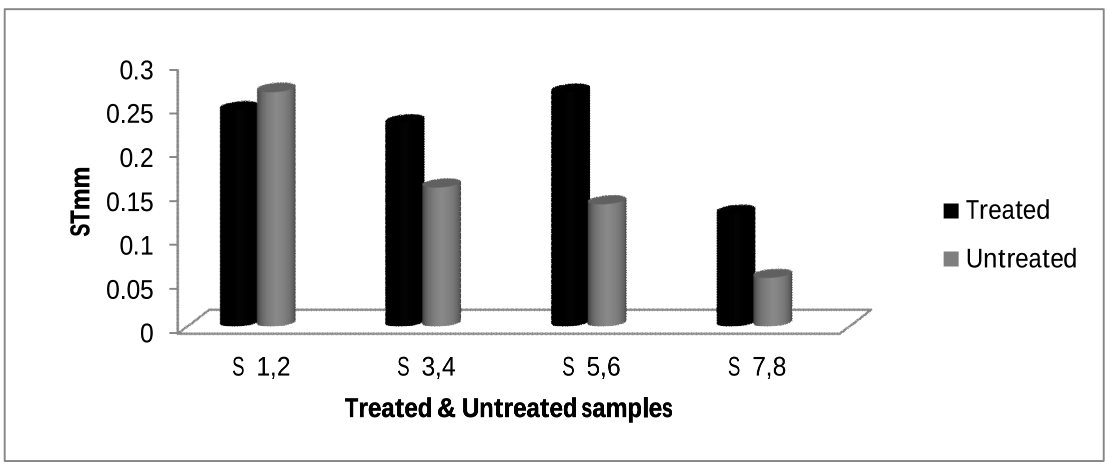


Fig 6: Surface Thickness of untreated and treated fabrics

ST: Surface Thickness of untreated
Treatment condation see figure 1 and 3

4. Conclusion

The treatments with nano silicon dioxide led to significant enhancement in anti-pilling behaviour of treated viscous fabric than other treated fabrics. Washingof treated fabrics led to little change in the results of anti-pilling.

The treatment improved the antistatic charge for treated polyester fabrics than untreated fabrics. There is limited increase in the tensile strength of the treated fabrics. Furthermore, it was found that the treatment improved the tear strength from 1.05 kg for untreated fabrics to 1.2 kg for treated fabrics in both warp and weft direction, as a result of increase in the hydrogen bonding between the chains of viscose fibres.

It is observed from this comparison that the SP % increased after treatment at weft direction for both polyester and viscose fabrics and its blend than warp direction.

After treatment of the said fabrics except S1, S3, S5 (70% viscose 30% polyester, 50% viscose: 50 % polyester, 100 % viscose)) expected to pose problem (seam pucker) in garment manufacturing as the formability values are less than limits.

As the extensibility of all fabrics were found to have values in the acceptable range before and after cases problem during laying up. S7 (100 % polyester) recorded lower shear rigidity values and are expected to result in serious shaping problem during sewing operation. The bending rigidity values were all in the acceptable range except S5, S7 (100 %viscose,100 %polyester) which may give difficulties during cutting.

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