Using of Nanotechnology to Reduce the Electrostatic Charges in Saudi men's Robe in Taif Governor

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Abstract: Clothing should be comfortable during use beside to stability and durability. Synthetic fabrics are more stable than cotton fabrics, while the latter allow garments to fit closely and snugly also it is comfortable and safely concerning static electricity. Therefore, blended cotton with synthetic can increase comfort and stability. The changes in fabric characteristics after a specific treatment by using Nanotechnology for fabrics produced from cotton, polyester and their blends were studied. From which the effect of cotton addition on comfort and stability was detected. This was obtained by measuring the static charges built up on the surface, roughness, thickness, drapability and dimension stability of fabric. The fabrics characteristics were analyzed using multi regression analysis. The changes in fabric characteristics due to treatment were determined. The significant trends of these changes percentage in relation to the parameters were investigated in equations and their correlation analysis was also obtained. The tendency of electrostatic charge decreased as a result of treatment however it increased the fabric thickness, drapability and surface smoothness. The dimensional stability increased when increase percentage quantity of PES yarns in fabric composition. The characteristics of the fabrics due to treatment can be predicted.
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1. Introduction

Human body is an electro conductor and as such it accumulates static electricity up to several hundred volts in a dry atmosphere (Kowalski, J.M., and Wróblewska, M., 2006). Electr-ostatic charge during the walk is created from the contact of a shoe and the material covering the ground. Electric capacity of an average human body is about 250 pF and it is directly connected with both the human's height (not weight) and the martial covering the ground one walks on (www.iapa.ca 2008).

Many synthetic fibers in textile fabrics are insulating materials with much higher resistivity than the desired for anti electrostatic purposes (Safarova, V., and Gregr, J.2010). Static electricity is increased in low humidity.Taif located in the Sarawat Mountains at an elevation ranging from about 1,500 to 1,700 meters (4,920 to 5,600 feet). Its summer climate (85 degrees F to 95 degrees F with low humidity),Taif has dry periods in January, February, March, April, May, June, July and August. Saudi men's traditional rope called "the *thawb*". This piece of clothing was traditionally made of cotton, but now it is made of mixed fabric (cotton and polyester) to give it some desired properties (anti-shrink, anti crease, drapability, etc). Polyester has a tendency toward static cling. Static cling often occurs when polyester rubs against itself or dry skin, generating static electricity. A positive electrical charge on the skin attracts the negative charge on polyester, causing the fabric to cling to skin. So this project deals with the danger situations caused by static electricity and offers a specific treatment by using Nanotechnology to reduce it.

In textile industry static charge generates at high-speed textile processes, and during walking on carpets or static cling in fabrics which become to be complicated by the development of manmade fibers (Seyam A.M., Liu,L., Hassan, Y.E., and *et al*, 2008; &. Seyam,A.M.,Oxenham,W.,and Castle, P, 2007). Also the lower humidity poses the problem of static charge generating. In the main time the textiles generating static electricity can cause its wearer from simple uncomfortable sensation to serious hazards in explosive working environment, or damage to the sensitive electronic equipments (Kothari, V.K., and Bhagwat, V.M., 2008) Despite these negatives attributes, textile static is used in some manufacturing processes such as flocking, selected nonwoven fabrics and in electrets filters to assist in the absorption of airborne dust. (Seyam, A.M., Oxenham, W., and Castle, P.2007). A better understanding of this phenomenon is critical to the future of the textile industry. The surfaces exchanges of electrons when they contact with one another, if they are conductive excess charges will dissipated to ground, but if they are insulators the charge will retained, separate them and static charge appears and will attempt to dissipate

(Seyam A.M.,Liu,L.,Hassan,Y.E.,and *et al 2008;* & Seyam,A.M.,Oxenham, W.,and Castle,P.2007). The ionizing atmosphere or air conduction can control static charge. So Fabrics and yarns could be designed to reduce the negative impact of static generation (Seyam A.M., Liu,L., Hassan,Y.E., and *et al,2008*) Two methods are used to control electrostatic energy in power transmission products and reduce the potential for electrostatic energy build-up. First method is to make the non-conductive material sufficiently conductive so the electrostatic energy is dissipated as it builds-up. Making the material static conductive in this manner is the best method for more hazardous environments. Second method consists of adding an anti-static agent to prevent static from transferring between materials, or make the material static non-generating.Anti-static agents have limiting capability in some environment since it depends on atmospheric humidity (Gates Product Application Notes, 17654-5 2007; 54 (5):1-2,2007). The higher efficiency of anti-static protective clothing depends upon the arrangement of electro conductive fibers, the type of the basic yarn, and the structure of the textile material. This always give better result than using anti-electrostatic finishes, regarding their low washing and abrasion resistance during use. In the main time they allow the application of various chemical agents as finish in order to obtain other protective properties [3]. For heavier fabric weight the static charge is decayed faster rate. Also the potential of static charge generation is higher for fiber with higher surface to volume ratio, lower electrical conductivity and hydrophobic nature (Kothari, V.K., and Bhagwat, V.M., 2008).

Static charges usually build up in synthetic fibers such as nylon and polyester because they absorb little water. Cellulosic fibers have higher moisture content to carry away static charges, so that no static charge will accumulate. As synthetic fibers provide poor anti-static properties, research work concerning the improvement of the anti-static properties of textiles by using nanotechnology were conducted. It was determined that nano-sized titanium, zinc oxide whiskers, nano antimony –doped ten oxides (ATO) and silane nanosol could impart anti-static properties to synthetic fibers. TiO_2, ZnO and ATO provide anti-static effects because they are electrically conductive materials. Such materials help to effectively dissipate the static charge which is accumulated on the fabric. On the other hand, silane nanosol improves anti-static properties, as the silane gel particles on fiber absorb water and moisture in the air by amino and hydroxyl group and pound water. Nanotechnology has been applied in manufacturing an anti-static garment. Eclectically conductive nano-particles are durably anchored in the fibril of the Gore- Tex^R membrane of Teflon, treating an electrically conductive network that prevents the formation of isolated chargeable areas and voltage peaks commonly found in conventional anti-static materials. This method can overcome the limitation of conventional methods, which is that the anti-static agent is easily washed off after a few laundry cycles (Kumar Singh et al, 2006). Carbon nanofibers and carbon black nanoparticles are among the most commonly used nanosize filling materials. Carbon nanofibers can effectively increase the tensile strength of composite fibers due to its high aspect ratio, while carbon black nanoparticles can improve abrasion resistance and toughness. Both of them have high chemical resistance and electric conductivity. Several fiber-forming polymers used as matrices have been investigated including polyester, nylon and polyethylene with the weight of the filler from 5% to 20%.The impact of nanotechnology in the textile finishing area has brought up innovative finish as well as new application technique. Particular attention has been paid in making chemical finishing more controllable and more thorough. Ideally, discrete molecules or nanoparticles of finishes can be brought individually to designated sites on textile materials in a specific orientation and trajectory through thermodynamics, electrostatic or other technical approach (Phil Brown, Kate Stevens, Eds, 2007). Properties of the composites. In this work, the influence of nano-TiO2 on compressive strength and water permeability of binary blended concrete cured in water and limewater has been investigated.

2. Materials and Methods

2.1 Materials

Commercial polyester fabrics and its blend are used**.** Polyester and polyester/cotton 40/60 and cotton/polyester 30/70 were supplied from local market in Taif Governor (K.S.A),.The selected fabrics have plain weave structure and different physical &mechanical properties .The fabrics were washed with an aqueous solution containing 2g/l nonionic detergent (Egyptol) for 45 min at 60oC, followed by thorough washing in water and air-dried.

2.2 Treatment condition

Treatment chemicals obtained from Manufacturing Company of Egypt conforming to ASTM C150 standard was used as received. The chemical and physical properties of the cement are shown in Table 1.Nano–TiO2 with average particle size of 15 nm was used as received. The properties of nano-TiO2 particles are shown in Table 2.Two series of mixtures were prepared in the laboratory trials. Series C0 mixtures were prepared as control specimens. The control mixtures were made of natural aggregates, cement and water. Series N were prepared with different contents of nano-TiO2 particles with average particle size of 15 nm. The mixtures were prepared with the cement replacement of 0.5%, 1.0%, 1.5% and 2.0% by weight. The water to binder ratio for all mixtures was set at 0.40 (Zivica V., 2009). The aggregates for the mixtures consisted of a combination of crushed basalt and of fine sand, with the sand percentage of 30% by weight. The binder content of all mixtures was 450 kg/m3. The proportions of the mixtures are presented in Table3.Series N mixtures were prepared by mixing the course aggregates, fine aggregates and powder materials (cement and nano-TiO2 particles) in a laboratory concrete drum mixer. The powder material in the series C0 mixtures was only cement. They were mixed in dry condition for two minutes, and for another three minutes after adding the water. Slumps of the fresh concrete were determined immediately to evaluate the workability following the mixing procedure (Bui DD, Hu J, Stroeven P., 2005).The moulds were covered with polyethylene sheets and moistened for 24 h. Then the specimens were demoulded and cured in water (N-W series) and saturated limewater (N-LW series) at a temperature of 20o C prior to test days. The strength and water permeability tests of the concrete samples were determined at 7, 28 and 90 days. Fabrics were treated with sodium hydroxide at 95°C for 30 min. then fabric was rinsed with water and air dried. Cotton, polyester and its blend fabric were treated with nano silicon dioxide concentration (12.5g/l) L: Raito(1:10 fabric: ethanol) the fabrics were immersed in solutions for 1hr., then pick up 100%, fixed at 130°C for 10 min., Finally the fabrics were washed thoroughly with tap water and air dried. Compressive test were done in accordance to the ASTM C293 Standard. Again, compressive tests were carried out on triplicate specimens and average compressive strength values were obtained.

2.3 Methods

The fabric characteristics were determined before and after treatment. The fabric comfort, dimensional stability, durability were determined through, electric charges, surface roughness, thickness, and drapability. Surface roughness tester Model SE 1700ἀ was used for measuring fabric surface roughness. Electricity collect type potentiometer model KS-525(Kasuga Denki, Inc., Japan) was used to evaluate the electrostatic shielding performance of the fabric. All the fabrics were tested for their dimensional stability and mechanical properties by using Fabric Assurance by Simple Testing System (FAST), (De Boos A. G., Tester D.H., (1991). It measures fabric properties which are closely related to the ease of garment making up and the effectiveness of finishing processes including the stability of finishing.

Table 1. Chemical and physical properties of Portland cement (Wt. %)

Material	SiO2	Al2O3	Fe2O3	CaO	MgO	SO3	Na2O	K2O	Loss on ignition
Cement	2 1 .89	5.3	3.34	53.27	6.45	3.67	0.18	0.98	3.21

Specific gravity: 1.7 g/cm3

Table2. The properties of nano-TiO_2

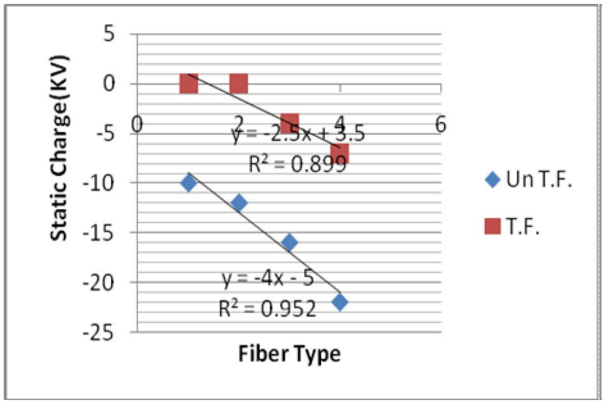
Diameter (nm)	Surface Volume ratio (m_2/g)	Density (g/cm_3)	Purity (%)
15 ± 3	155 ± 12	< 0.13	>99.9

Table 3. Mixture proportion of nano-SiO2 particles blended concretes

Sample designation	nano- SiO2 particles	Quantities (kg/m_3)	
		Cement	SiO2 nanoparticles
C0 (control)	0	450	0
N1	0.5	447.75	2.25
N2	1.0	445.50	4.50
N3	1.5	443.25	6.75
N4	2.0	441.00	9.00

3. Results and Discussion

The significant relationships between fabric characteristics and the studied parameters were determined using multi regression analysis. The percentage changes in fabric characteristics after treatment were estimated. From which the significant trends of the changes in each characteristic in relation to the parameters were investigated by applying regression analysis. Also the correlation coefficients between the change in fabric characteristics and parameters under study were obtained .The analysis of results will be discussed firstly for fabric characteristic than for the change in some of these characteristics. The regression line, regression equations and regression coefficient between fabric characteristics and the fiber type before and after treatment are presented in Figures from (1-10).



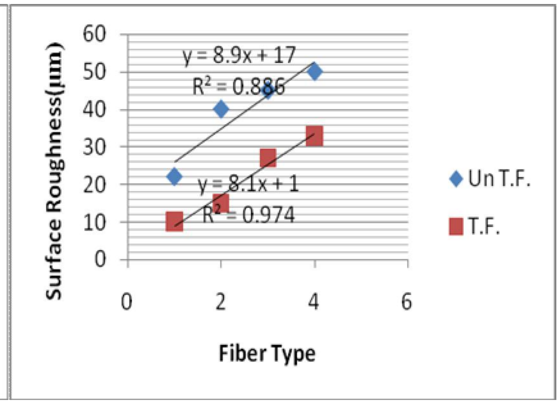
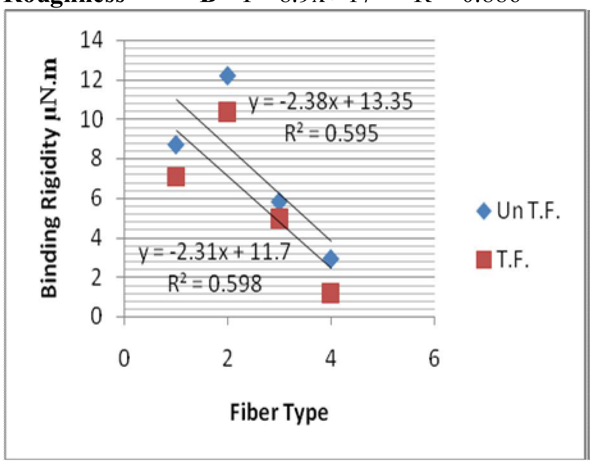


Fig.(1):Regression Line between Fiber Type& Electrostatic before and after Treatment

Fig.(2):Regression Line between FiberType& Charges Surface Roughness before and after Treatment

Electrostatic **B** Y= -4x-5 R^2= 0.952 **A** Y= -2.5x+3.5 R^2= 0.899 (A1)

Roughness **B** Y= 8.9x+ 17 R^2= 0.886 A Y= 8.1x+1 R^2= 0.974 (A2)



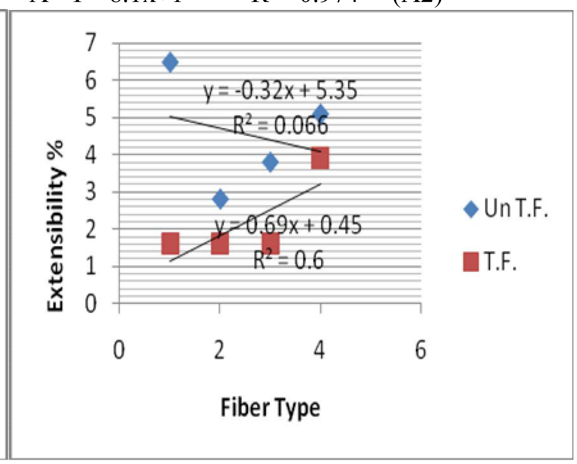
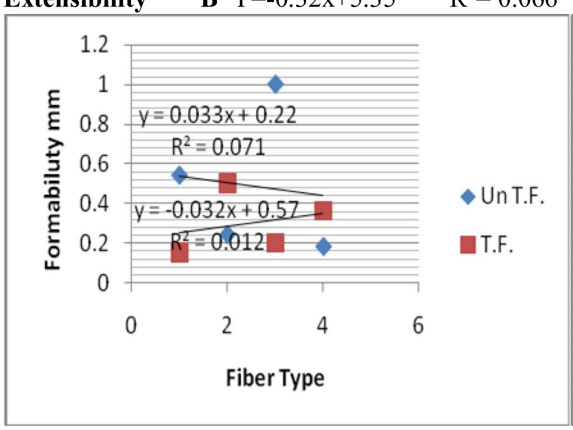


Fig.(3):Regression Line between Fiber Type& Bending Rigidity before and after Treatment

Fig.(4):Regression Line between Fiber Type& Extensibility before and after Treatment

Bending Rigidity **B** Y= -2.38x+13.35 R^2= 0.595 **A** Y= -2.31x+11.7 R^2= 0.598 (A3)

Extensibility **B** Y=-0.32x+5.35 R^2= 0.066 **A** Y= 0.69x+0.45 R^2= 0.6 (A4)



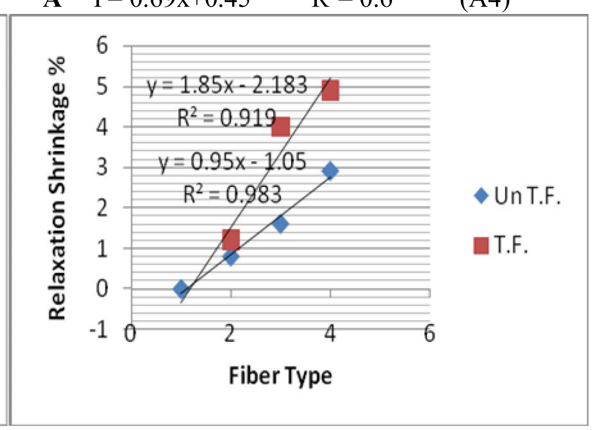


Fig.(5):Regression Line between Fiber Type& Formability before and after Treatment

Fig.(6):Regression Line between Fiber Type&Relaxation Shrinkage before and after Treatment

Formability **B** Y= 0.033x+0.22 R^2= 0.071 **A** Y=-0.032x+0.57 R^2= 0.012 (A5)

Relaxation Shrinkage **B** Y=1.85x+2.183 R^2= 0.919 **A** Y= 0.95x-1.05 R^2= 0.983 (A6)

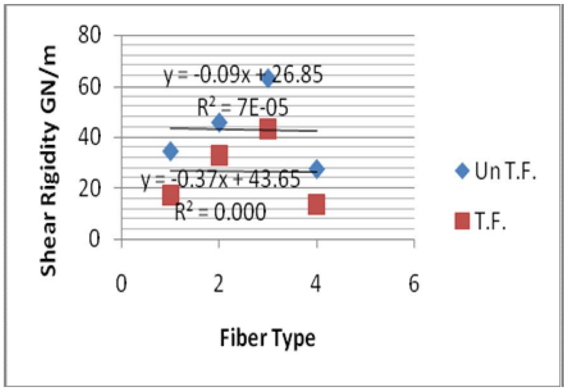


Fig.(7):Regression Line between Fiber Type&Shear Rigidity before and after Treatment

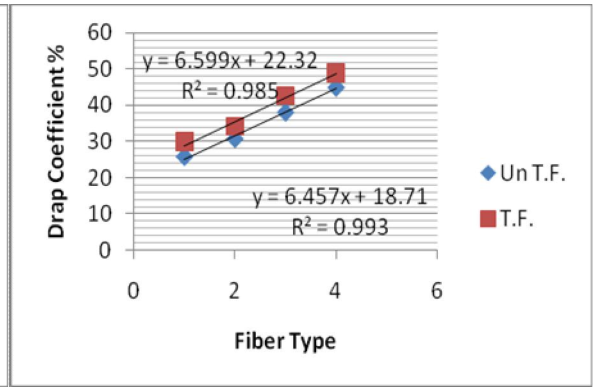


Fig.(8): Regression Line between FiberType&Drape Coefficient before and after Treatment

Shear Rigidity **B** Y=-0.09x+26.85 R^2= 7E-05 **A** Y= -0.37x+43.65 R^2= 0.000 (A7)

Drap Coefficient% **B** Y=6.599x+22.32 R^2= 0.985 **A** Y= 6.457x+18.71 R^2= 0.993 (A8)

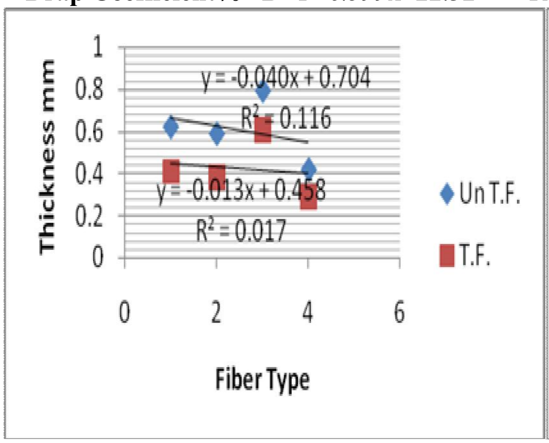


Fig.(9):Regression Line between Fiber Type& Thickness before and after Treatment

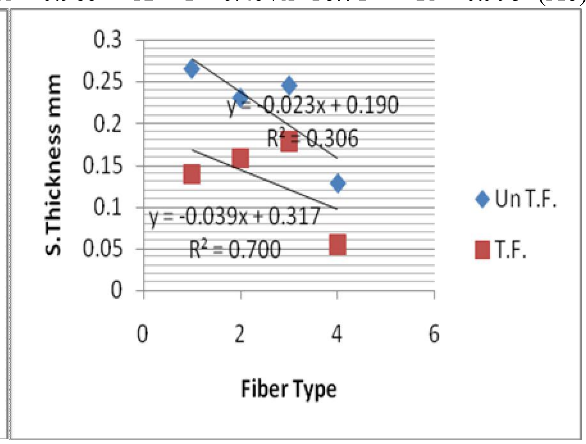


Fig.(10): Regression Line between FiberType&Surface Thickness before and after Treatment

Thickness **B** Y= -0.040x+0.704 R^2= 0.116 **A** Y= -0.013x+0.458 R^2= 0.017 (A9)

Surface Thickness **B** Y=-0.023x+0.190 R^2= 0.306 **A** Y=-0.039x+0.317 R^2= 0.700 (A10)

The previous equations demonstrate the following notes:

The electrostatic properties depend not only on the content of fibers in fabric but also on treatment in the fabric. Significant effects of treatment has determined on mostly all measured fabric characteristics. Treatment decreases bending rigidity, extensibility, formability and shear rigidity. The effect of treatment on fabric properties are presented in Figures (11-20). These results lead to increase both of fabric surface thickness and fabric thickness. Also the dimension increased when the increase percentage quantity in fabric composition decreased. At the same time, the roughness of fabric surface decreased by treatment, so the fabric will tend to be smoother and more comfort. The actual values and statistical trendiness for surface roughness (μm) are shown on Figure (12).The tendency of electrostatic charge decreased due to successive treatment. Increasing cotton fibers in fabrics increased dimension stability in width direction and that decreased dimension stability in length direction, and surface roughness, also a decrease in the accumulated static charge on surface is obtained as shown in figure (11). The use of cotton fibers in fabrics resulted in the roughest surfaces, and highest chargeability of fabrics, followed by blend of cotton /polyester**.**

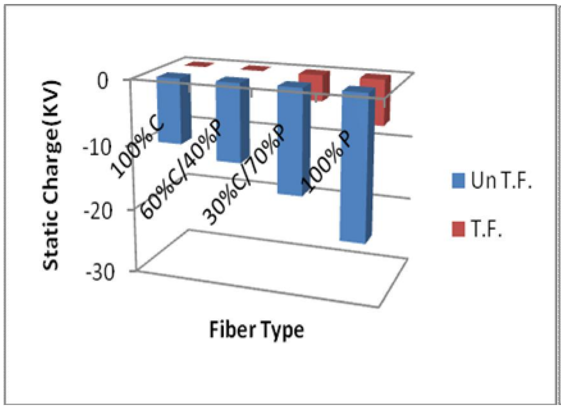


Fig.(11):The Relation between Fiber Type& Electrostatic Charges before and after Treatment

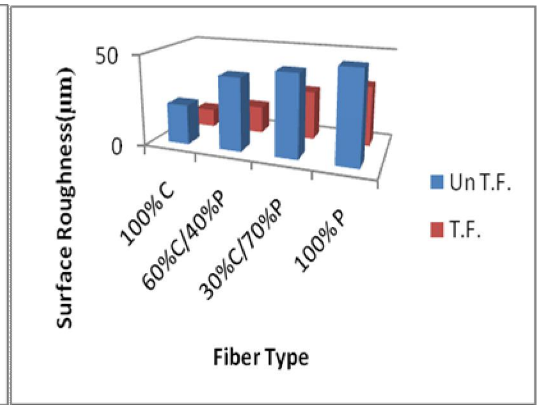


Fig.(12):The Relation between FiberType& Surface Roughness before and after Treatment

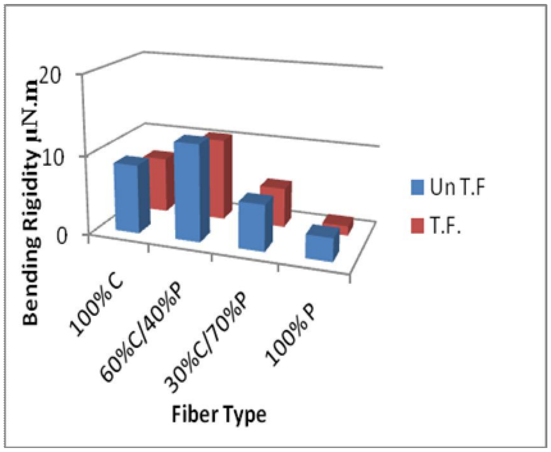


Fig.(13):The Relation between Fiber Type& Bending Rigidity before and after Treatment

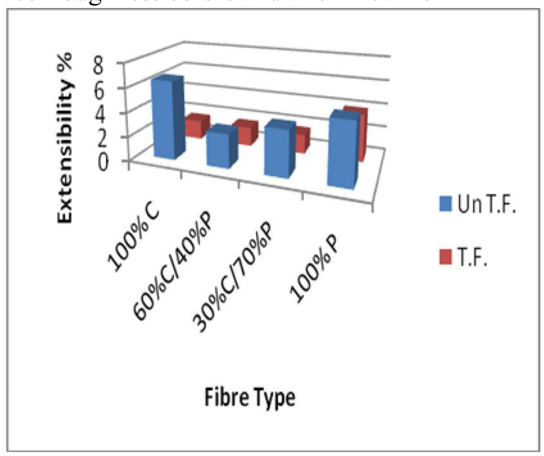


Fig.(14):The Relation between Fiber Type& Extensibility before and after Treatment

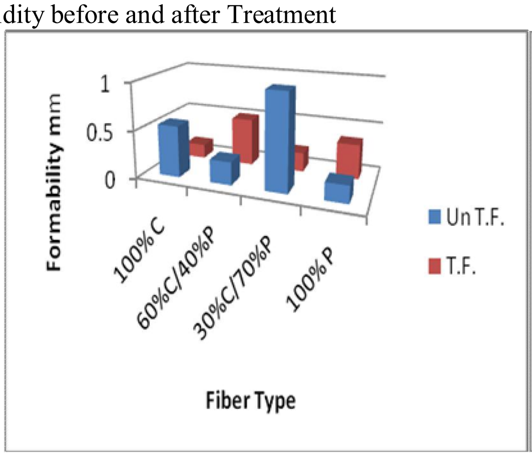


Fig.(15):The Relation between Fiber Type& Formability before and after Treatment

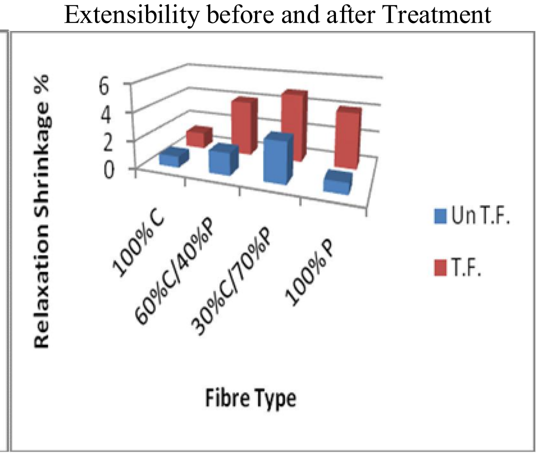


Fig.(16): The Relation between Fiber Type&Relaxation Shrinkage before and after Treatment

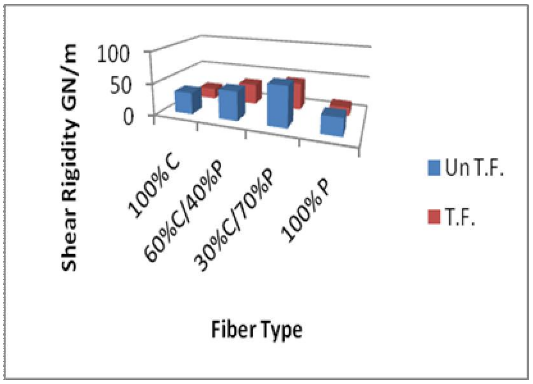


Fig.(17):The Relation between Fiber Type&Shear Rigidity before and after Treatment

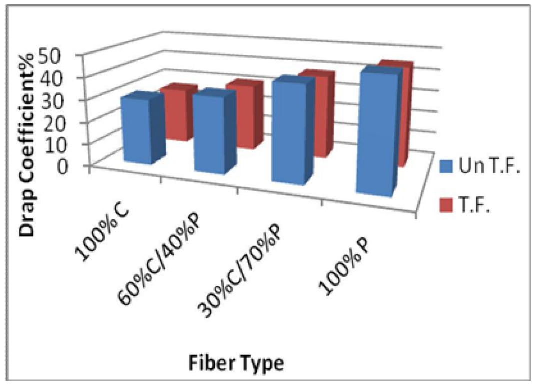


Fig.(18):The Relation between FiberType&Drape Coefficient before and after Treatment

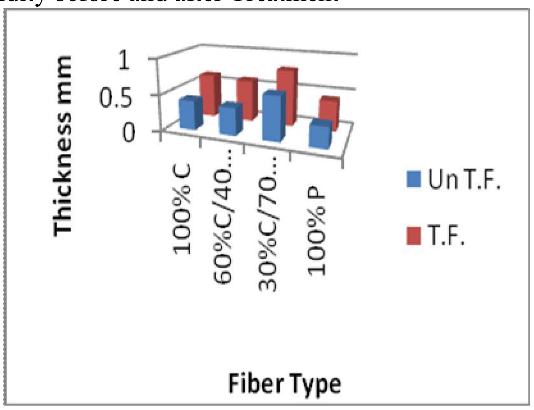


Fig. (19): The Relation between Fiber Type & Thickness before and after Treatment

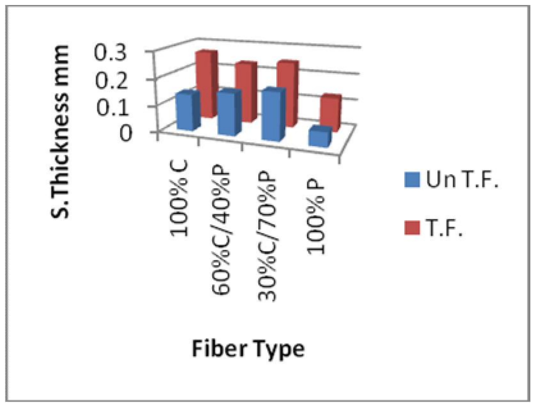


Fig.(20):The Relation between FiberType&Surface Thickness before and after Treatment

Fabric Characteristics Changes due to Treatment

The changes in fabric characteristics due to treatment were determined as presented in figures 11-20 .A multivariate analysis technique was used to determine the overall changes caused after nano treatment compared to fabric characteristics before treatment. The significant trends of the changes in each characteristic in relation to the parameters were investigated in regression equations from (A1) to (A10). As shown in the ten equations, changes in fabric characteristics due to nano treatment have affected significantly in the fabric content of fibers. The changes in roughness of fabric surface, due to nano treatment, have increased by increasing cotton fibers in fabric content .That mean cotton fabrics have significantly affected by treatment that threaten their long life.

Change in Electrostatic= -2.5 Fiber Type +3.5 R^2= 0.899 (B1)

Change in Roughness= 8.1 Fiber Type +1 R^2= 0.974 (B2)

Change in Bending rigidity = -2.31 Fiber Type +11.7 R^2= 0.598 (B3)

Change in Extensibility= 0.69 Fiber Type +0.45 R^2= 0.6 (B4)

Change in Formability=0.032 Fiber Type +0.57 R^2= 0.012 (B5)

Change in Relaxation Shrinkage=0.95 Fiber Type -1.05 R^2= 0.983 (B6)

Change in Shear rigidity=-0.37Fiber Type +43.65 R^2= 0.000 (B7)

Change in Drapability=6.457FiberType +18.71 R^2= 0.993 (B8)

Change in Thickness=-0.013 Fiber Type +0.458 R^2= 0.017 (B9)

Change in Surface Thickness=-0.039 Fiber Type +0.317 R^2= 0.700 (B10)

Changes in static charges built up on the surface of polyester fabrics have the lowest maintaining the charges on fabric surface followed by blended fabrics C/P, however treatment of cotton fabrics improved their electrostatic ability that increased the change. The correlation coefficients between changes in fabric characteristics and each other beside to the studied parameters were also given in figures from (11-20). These figures indicate that most changes in fabric characteristics is correlated significantly to each other, and correlated also to the fabric parameters. The fabric composition of fibers has a great significant effect in most changes. This phenomenon is critical to better understanding of these types of fabric characteristics in order to be able to produce fabrics fulfilling the end-user needs.

Conclusion

Due to wear, fabrics characteristics may change by several factors like nano treatment, and the application of forces in dry and wet states. The behaviors of these changes are different by changing the composition of fabrics and the construction. With respect to the experimental results, the significant regression equations indicate that both fiber type and fabric constructions have the higher effect on fabric comfort. Also treatment has a positive effect on both electrostatic and roughness. Nano treatment increased the fabric thickness and surface smoothness. The tendency of electrostatic charge decreased due to treatment. The changes in characteristics due to treatment are different by changing the composition of fabrics and its construction. Fabrics produced from cotton have less stability than polyester and blended fabrics of Cotton/Polyester. The cotton fabrics have the roughest surfaces that increased after treatment however they achieved the lowest values of static charge charges built up on the surface of polyester fabrics have the highest static charge values and increased after treatment. The surface roughness is dependent on fabric pattern, treatment and the content of fibers composed the fabrics. Aditionally, the percentages of changes in fabric characteristics due to laundering were obtained by regression equations. The correlations between these changes were meaningful. Developing products and services that include customer-specific products can be achieved by applying the obtained regression equations; also the performance of the product due to treatment can be predicted.

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