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Research paper

Treatment of nylon garment to improve its properties

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Abstract

Nanotechnology is extensively used in textile industries because it confers unique properties on fabrics.In this study, using nano silicon dioxide (SiO2)-coated nylon fabrics have created a lot of awareness appropriate to improve their functional properties. Using deferent construction of nano silicon dioxide (SiO2), the optimization construction are used to carry out treatments impart to improve the roughness, antistatic charge, sew ability, thickness; weight and UPF measurement are investigated. The study evaluates the possibility of using the scanning electron microscope (SEM) to show optimize the effect of treatment of nylon fabrics with nano silicon dioxide not only on the effect of treatment of nylon fabrics with nano silicon dioxide not only on their performance and appearance but also in garment manufacturing.

Keywords: *Nylon Fabrics; Mechanical Properties; UPF; Sewability and SEM.*

1. Introduction

Nanotechnology is extensively used in textile industries because it confers unique properties on fabrics such as ultraviolet (UV) protection, antibacterial activity, fire resistance, and high durability [1]. The large surface-to-volume ratio of the nano particles is effectively interacted with fabric surface due to the Van der Waals forces involved in both [2]. The inorganic materials like metals and metal oxide-coated fabrics have created a lot of awareness appropriate to improve their functional properties [3]. Owing to their cost consideration, a small amount of metal nanoparticles,compared with the usage of metal oxide nanoparticles, are used in textile industry. The metal oxide nanoparticles, like Al2O3, SiO2, MgO, ZnO, TiO_2 [4], etc., 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.[5,6] 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. [7], [8]Treatments with different softeners on nylon fabrics enhancement anti pilling.[9]In the synthetic component provides crease recovery, dimensional stability, tensile strength, abrasion, resistance and easy care properties, but low in moisture absorption, antistatic characteristics and reduced pilling. [10] Some fabrics – particularly synthetics such as polyester and nylon – tend to gather static charge. Whisk a top over your head and your hair stands on end. But nanoparticles that conduct electricity, such as zinc oxide, titanium dioxide and antimony-doped tin oxide, can help disperse this charge.
At the moment, clothes featuring nanotechnology are largely made from standard fabrics upon which a nano-coating has been applied. But in the future we're likely to see more fabrics made from nanofibres, with nanoparticles and nanofilaments an integral part of the weave. A new era of "smart" fabrics, for example, could automatically respond to your body and the environment around you. [11], [12]
A high penetration force means a high resistance of fabric. Sewing needle penetration force is one of the most significant technical parameters in the sewing process which affected by various factors such as type of layers of the sewing material, needle size, needle point shape, speed of the sewing machine, fabric design, finish of fabric, type of sewing machine used, stitching conditions and the behavior of the sewing thread.. The sewing needle penetration force is the quantitative measure of the damage which appears in agreement as the result of the sewing process [13], [14], [15] [16], [17], [18]
In this study, surface treatments of nylon knitted fabrics with using nano silicon dioxide (SiO_2) are carried out to improve some of their mechanical properties such as antistatic charge, roughness, weight,sewability, thickness surface and UPF. 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

Nylon 6.6 weft knitted fabrics were supplied by jockey Co Cairo, Egypt, for Spinning, knitting and dyeing . The fabrics were soaped with (2 g/L) nonionic detergent solution (Hostapal C .V., from Clariant Co, Egypt) with a liquor ratio 1 : 25, at 45ºC, for30 min, then rinsed twice in cold tap water, and dried at room temperature. Show Table 1.

Table 1: Show Specifications of Samples.

Samples	Nylon		Nylon	
Fabric types	Weft knitted		Weft knitted	
Composition	100%		100%	
Yarn number	96\60 denier		80\60 denier	
Construction	Single jersey		Single jersey	
Density	Wales\cm	courses\cm	Wales\cm	courses\cm
	14	14	13	13

2.2. Chemical

The nanoparticle used in this study is SiO2, obtained from Sigma – Aldrich, Germany. Potassium hydroxide and Methyl alcohol are of laboratory grade.

2.3. Alkaline pretreatment of nylon

To improve the adhesion of SiO_2 nanoparticle to the smooth surface of nylon 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.

2.4. Treatment

The nylon fabrics were immersed in solutions of (5 g/l)and(10 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 80ºC for 5min. The samples were rinsed with cold water then rinsed with tap water, and finally air dried.

2.5. Measurements

2.5.1. Roughness [15], [20]

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).

2.5.2. Antistatic property measurement [15], [20]

Antistatic property measurement Static electricity of treated and untreated nylon fabrics was measured using electricity collect type FMX-003TM Electrostatic Field meter (Simco- Japan). The antistatic property measurements were carried out according to ASTM D 4238.

Table 2: The Results of Fabrics Properties

samples	Roughness μm	Thickness (mm)	Weight (g/m^2)	Antistatic Kv after	Antistatic Kv before	Sewability
Untreatment A	17.96	0.65	2.0991	0	0	105
Treatment A 5gm\l sio_2	22.59	0.68	2.144	0.02	0	210
Treatment A 10gm\l sio_2	34.75	0.72	2.1860	0.02	0	160
Untreatment B	16.58	0.68	1.5139	0.01	0	166
Treatment B 5gm\l sio_2	20.56	0.78	2.3516	0.03	0	216
Treatment B 10gm\l sio_2	30.28	0.81	2.3783	0.03	0	175

2.5.3. UPF measurement [15], [20]

Standard practice for preparation of textiles prior to ultraviolet (UV) transmission testing spectrophotometer for treated and untreated nylon fabrics measurements were carried out according to ASTM D 6544-12.

2.5.4. Weight. [15], [20]

Weight of treated and untreated nylon fabrics was measured using the weight measurements were carried out according to ASTM Standards. D1910-64 (1970).

2.5.5. Thickness. [15], [20]

Thickness of treated and untreated nylon fabrics was measured using the thickness measurements were carried out according to ISO 5084.

2.5.6. Sewability. [22]

Using the sewability tester (based on US patent 3979951, 1976), a device used in many studies on the needle penetration force. This equipment simulates a sewing machine by penetrating the tested fabric with an unthreaded needle, at a rate of 100 penetrations per min., with needle count 18\ 110.

2.5.7. Scanning electron microscope (SEM). [15], [20]

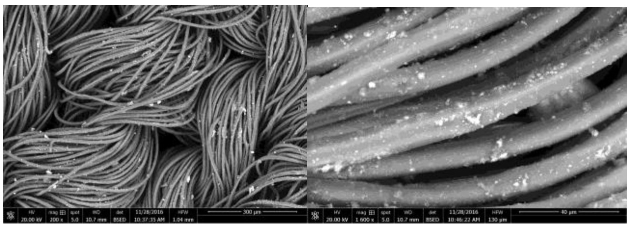
The untreated and treated ultrasonic nylon fabrics were examined using a SEM Model Philips XL 30 with an EDX Unit attached, with accelerating voltage of 30 kV and magnification between 10 and 400.000. All the samples were coated with gold before SEM testing.
All tests were carried out in National Institute for Standards after the samples were conditioned under standard atmospheric conditions(temperature 20 ± 2°C, 65 ± 2% (relative humidity), according to standard ISO 139:1973. An exploratory data analysis containing central tendency and dispersion statistics was performed with the purpose of identifying outliers, normal behavior of the measured properties and also the homogeneity of variances. Then, univariate analysis of variance by using ANOVA procedure.

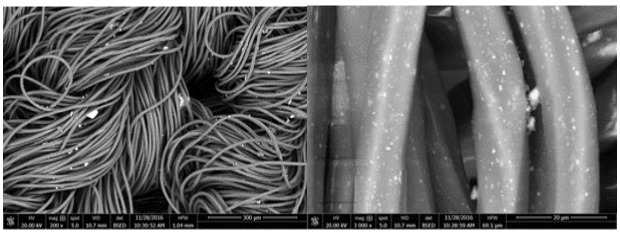
3. Results and discussion

In this study, surface treatments of nylon knitted fabrics A&B with using nano silicon dioxide(SiO_2) concentration 5&10gm\l are carried out to improve some of their properties such as antistatic charge, roughness, sewability,weight, thickness surface and UPF(ultraviolet protection factor). The obtained results will surely help to identify the design criteria for clothing so as to produce high quality garments, and the average value of fabrics are given in Table2.

3.1. Scanning electron microscope (SEM)

Changes of the surface morphology of Nylon fibers after treatment with Nano Silicon dioxide (sio_2). Were investigated using SEM as shown in figure 1. The SEM analysis of surface morphology reveals changes which occur on the surface of nylon fibers as a result of modification with Nano Silicon dioxide (sio_2). The treatment make then cover and penetration the treated nylon fabric, the more effect happens with increasing the concentration Nano Silicon dioxide (sio_2)5&10gm\l. This result illustrates the effect in properties of treated nylon fabrics as compared with untreated one.


Treated nylon A 5 gm\l sio_2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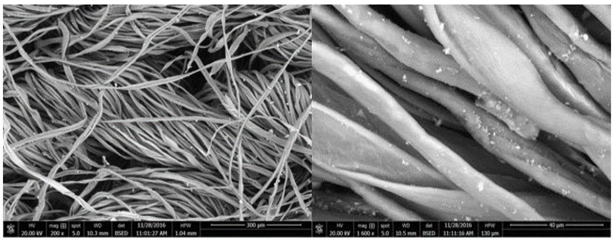
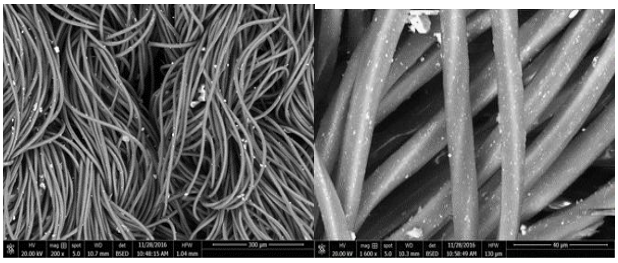


Treated nylon B 5 gm\l sio_2



Treated nylon B 10 gm\l sio_2

Fig .1: Surface Morphology of Untreated and Treated Nylon Fibers with Nano Silicon Dioxide (Sio_2).

3.2. Antistatic charge KV

Figure 2 and table 2 show the antistatic charge of untreated and treated Nylon fabrics 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. The increase of moisture regain for the treated fabrics could be attributed to the opening of the fiber structure with the aid of SiO_2 nanoparticle, which allowed more water vapor molecules to penetrate the fiber structure. Improving antistatic property all samples after treatment when compare the sample after and before treatment.

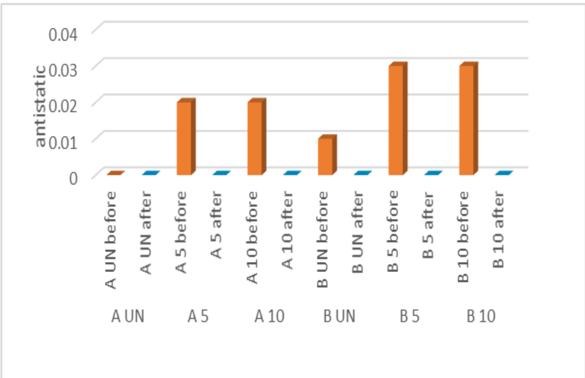


Fig. 2: The Relation between Antistatic Charge and Concentration of Nano Silicon Dioxide (Sio_2).

3.3. Roughness property

The treated fabrics are tested for roughness. Results of this analysis are tabulated in figure 3. The results show that, there are increases in the treated fabrics. In the roughness data show some change for treated fabrics than untreated one. Treated Nylon A&B fabrics with 10 gm\l nano silicon dioxide improve the roughness when compare treated Nylon A&B fabrics with 5 gm\l nano silicon dioxide. This may be attributed to the treatment make then cover and penetration the treated nylon fabric, the more effect happens with increasing the concentration Nano Silicon dioxide (sio_2) 5&10gm\l. figure 1.

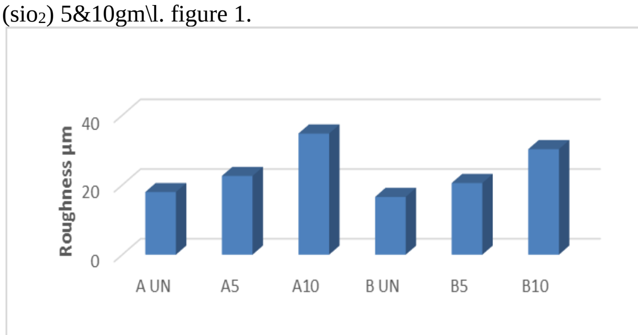


Fig. 3: The Relation between Roughness Property and Concentration of Nano Silicon Dioxide (Sio_2).

3.4. Surface thickness

Figure 4 shows surface thickness of untreated and treated fabrics. Surface thickness does not themselves have any great impact upon the tailoring performance of a fabric but are useful indicators of any change or variation in fabric handle [9]. The treatment improved surface thickness samples values which indicating the finish on the fabric is unstable.

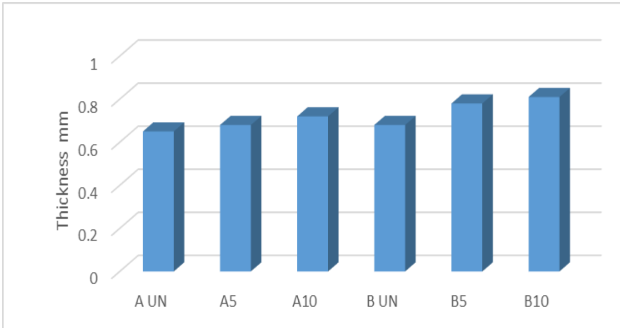


Fig. 4: The Relation between Surface Thickness and Concentration of Nano Silicon Dioxide (Sio_2).

3.5. Weight

Figure 5 shows weight of untreated and treated fabrics. The results show that, there are increases in the treated fabrics. In the weight data show change for treated fabrics than untreated one. Treated Nylon A&B fabrics with 10 gm\l nano silicon dioxide improve the weight when compare treated Nylon A&B fabrics with 5 gm\l nano silicon dioxide. This may be attributed to the treatment make then cover and penetration the treated nylon fabric, the more effect happens with increasing the concentration Nano Silicon dioxide (sio_2) 5&10gm\l. figure 1.

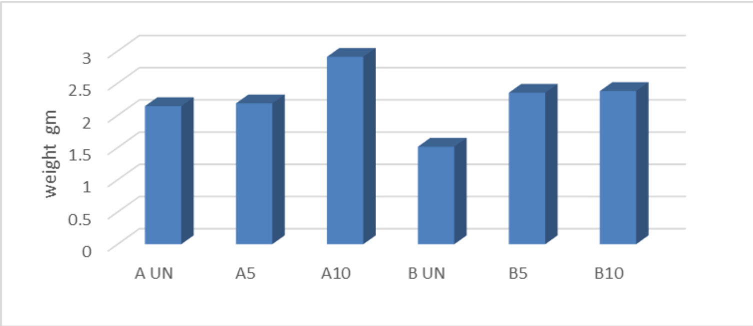


Fig. 5: The Relation between Weight and Concentration of Nano Silicon Dioxide (Sio_2).

Table 3: The Results of UPF Measurement. Where: L = Wave Length. DT = Diffuse Transmittance.

A-UN		A-5		A-10		B-Un		B-5		B-10	
W L (nm)	D T %	W L (nm)	D T %	W L (nm)	D T %	W L (nm)	D T %	W L (nm)	D T %	W L (nm)	D T %
400	15.719	400	11.417	400	11.116	400	12.458	400	9.035	400	8.540
395	14.878	395	10.614	395	10.308	395	11.811	395	8.470	395	7.958
390	13.734	390	9.500	390	9.232	390	11.089	390	7.770	390	7.287
385	12.024	385	7.968	385	7.729	385	10.192	385	6.990	385	6.444
380	9.484	380	5.753	380	5.603	380	9.002	380	5.909	380	5.364
375	6.248	375	3.217	375	3.138	375	7.353	375	4.467	375	3.955
370	3.378	370	1.379	370	1.311	370	5.389	370	2.976	370	2.542
365	1.812	365	0.567	365	0.528	365	3.805	365	1.907	365	1.578
360	1.132	360	0.298	360	0.261	360	2.792	360	1.325	360	1.084
355	0.855	355	0.196	355	0.171	355	2.271	355	1.055	355	0.859
350	0.728	350	0.156	350	0.130	350	1.968	350	0.916	350	0.757
345	0.609	345	0.144	345	0.111	345	1.828	345	0.857	345	0.718
340	0.575	340	0.129	340	0.096	340	1.680	340	0.805	340	0.651
335	0.549	335	0.121	335	0.083	335	1.591	335	0.754	335	0.629
330	0.550	330	0.122	330	0.088	330	1.520	330	0.725	330	0.601
325	0.541	325	0.120	325	0.088	325	1.520	325	0.710	325	0.579
320	0.543	320	0.123	320	0.090	320	1.509	320	0.720	320	0.588
315	0.554	315	0.122	315	0.085	315	1.453	315	0.678	315	0.562
310	0.553	310	0.127	310	0.094	310	1.389	310	0.667	310	0.544
305	0.556	305	0.127	305	0.093	305	1.371	305	0.656	305	0.550
300	0.572	300	0.130	300	0.098	300	1.371	300	0.682	300	0.559
295	0.571	295	0.142	295	0.102	295	1.379	295	0.692	295	0.568
290	0.568	290	0.148	290	0.110	290	1.338	290	0.713	290	0.603

3.6. UPF measurement

The measured transmittance data for the untreated and treated fabrics. showFigures6&7can also be converted to UPF values: The increase in UPF offered by the treated fabrics additive is apparent from Table 3. The same advantage applies to the total Blocking (100%-T%) for either UVA (315 nm - 400 nm) or UVB (280 nm - 315 nm). Treated Nylon A&B fabrics with 10 gm\l nano silicon dioxide improved sun protection when compare treated Nylon A&B fabrics with 5 gm\l nano silicon dioxide. Emission spectrum in Figures 6&7 was isolated by the measured difference between the treated and untreated fabrics. The increased absorption at UV wavelengths is also evident. The relative strengths of both the absorption and the emission spectra are proportional to the concentration of the Treated Nylon A&B fabrics with10 gm\l nano silicon dioxide. Quantitative analysis is possible by devising a calibration curve using a sample set of known10 gm\l concentration. The application Is uniquely supported by the design of the UV -1000F due to its use of polychromatic illumination, diffuse Transmittance geometry and spectral range of 250 nm to 450 nm. Optical brightening agents are often applied to enhance the whiteness of textiles by inducing fluorescence by UV excitation and visible blue emission. 10 gm\l concentration has the added benefit of increasing the UV absorption and hence a textile's sun protective ability.

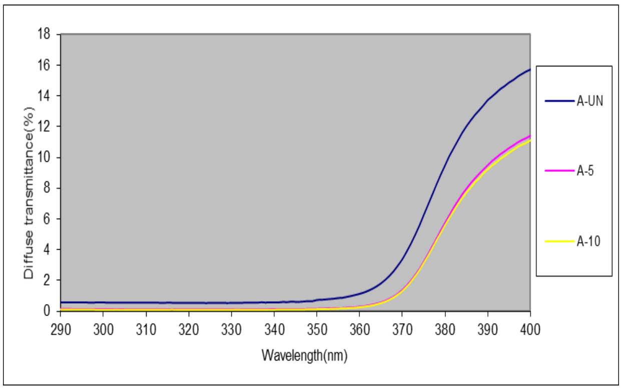


Fig. 6: The Relation between UPF Measurements and Concentration of Nano Silicon Dioxide (Sio2) Nylon.

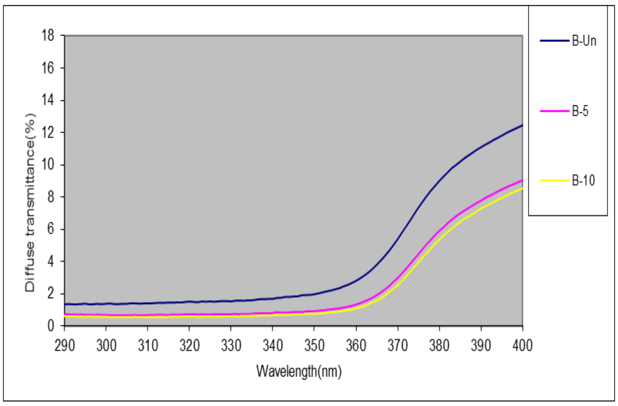


Fig. 7: The Relation between UPF Measurements and Concentration of Nano Silicon Dioxide (Sio_2) Nylon.

3.7. Sewability (sewing needle penetrations force)

The figure 8, illustrated the sewing needle Penetration force, which have been calculated, the untreated and treated fabrics. It can see that needle penetrations force increase for treated fabrics than others. Sewing needle penetrations force increase for samples A_5 and B_5 (treated with 5 g/l SIO_2), but Penetrations force decrease for samples A_{10} and B_{10} (treated with 10 g/l SIO_2). The results show that treatment improves sewing needle penetration force property.

Table 4: One-Way ANOVA of the Untreated and Treated Fabrics Properties

property	Source of Variation	df	F	P-value	F critical
Weight (g/m2)	AUN,Bun,A5,B5,A10,B10	5	5390397.746	1.14E-37	3.105875
Thickness (mm)	AUN,Bun,A5,B5,A10,B10	5	338.2666667	1.78E-12	3.105875
antistatic charge Kv	AUN,Bun,A5,B5,A10,B10	5	65535	1.82E-30	2.066608
Roughness µm	AUN,Bun,A5,B5,A10,B10	5	3513444.6	1.49E-36	3.105875
Sewability (Sewing needle penetrations force)	AUN,Bun,A5,B5,A10,B10	5	10850.025	1.71E-21	3.105875
UPF	AUN,Bun,A5,B5,A10,B10	5	0.176699149	0.967867	2.772853

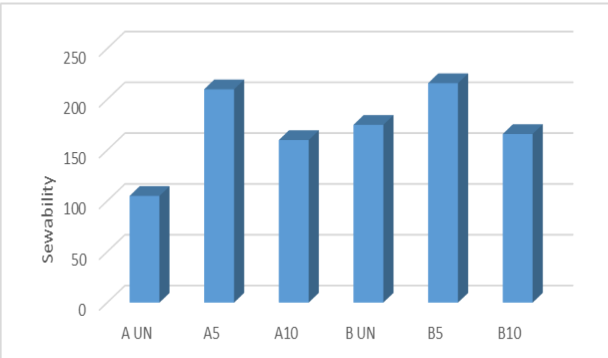


Fig. 8: The Relation between Sewing Needle Penetrations Force and Concentration of Nano Silicon Dioxide (Sio_2).

Statically evaluation

The above-mentioned results are confirmed by analysis of variance (ANOVA), and the result is significant influence of the untreated and treated fabrics properties.

Note: ANOVA: analysis of variance.

The ANOVA confirmed that there are different properties between untreated and treated fabrics proved the significant difference among all the groups. By considering all the above cases,the results of the ANOVA are listed in Table 4, which analyses the effect of groups of fabrics samples with respect to Weight, Thickness, antistatic charge, Roughness, Sewing needle penetrations force, UPF.

Proves that the changes in properties of fabrics results is highly significant differences.

Show table 4, there are significant differences between weight of fabrics A_{UN},B_{un},A_5,B_5,A_{10},B_{10}indication this P-value=1.14E-37, where fabric A_{10} is highest weight and then B_{10} and then $B_5$and A_5finally A_{un} and B_{un}. Treated Nylon A&B fabrics with 10 gm\l nano silicon dioxide improve the weight when compare treated Nylon A&B fabrics with 5 gm\l nano silicon dioxide.

There are significant differences between thickness of fabrics A_{UN},B_{un},A_5,B_5,A_{10},B_{10} indication this P-value=1.78E-12, where fabric A_{10} is highest weight and then B_{10} and then $B_5$and A_5finally A_{un} and B_{un}. Treated Nylon A&B fabrics with 10 gm\l nano silicon dioxide improve the weight when compare treated Nylon A&B fabrics with 5 gm\l nano silicon dioxide.

There are significant differences between antistatic charge of fabrics A_{UN},B_{un},A_5,B_5,A_{10},B_{10} indication this P-value=1.82E-30, where treated fabrics Treated with5 gm\l and 10 gm\l nano silicon dioxide improve the antistatic charge when compare untreated Nylon fabrics.

There are significant differences between Roughness of fabrics A_{UN},B_{un},A_5,B_5,A_{10},B_{10} indication this P-value=1.49E-36, where treated fabrics Treated with5 gm\l and 10 gm\l nano silicon dioxide improve the Roughness of fabrics when compare untreated Nylon fabrics.

There are significant differences between Sewability(Sewing needle penetrations force)of fabrics A_{UN},B_{un},A_5,B_5,A_{10},B_{10} indication this P-value=1.71E-21, where treated fabrics Treated with5 gm\l and 10 gm\l nano silicon dioxide improve the Sewability(Sewing needle penetrations force)of fabrics when compare untreated Nylon fabrics.

There are significant differences between UPF(ultraviolet protection factor) of fabrics A_{UN},B_{un},A_5,B_5,A_{10},B_{10} indication this P-value=0.967867, where treated fabrics Treated with5 gm\l and 10 gm\l nano silicon dioxide improve the UPF of fabrics when compare untreated Nylon fabrics.

The ANOVA confirmed that there are the treatments with nano silicon dioxide significant improve some of their properties than untreated fabrics.

4. Conclusion

The treatments with nano silicon dioxide significant improve some of their properties such as antistatic charge, roughness, sew ability (Sewing needle penetrations force), weight, thickness surface and UPF(ultraviolet protection factor) than untreated fabrics . The obtained results will surely help to identify the design criteria for clothing so as to produce high quality garments.

Treated Nylon A&B fabrics with 10 gm\l nano silicon dioxide improve the their properties when compare treated Nylon A&B fabrics with 5 gm\l nano silicon dioxide, but Sewing needle penetrations force increase for samples A_5 and B_5 (treated with 5 g/l SIO_2), but Penetrations force decrease for samples A_{10} and B_{10} (treated with 10 g/l SIO_2).

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