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THE EFFECTS OF NANOPARTICLES AND UV ON SOME PROPERTIES OF FABRICS

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ABSTRACT

Nanotechnology has been playing an important role in recent textile applications. Nano materials have attracted much of attentions due to their unique properties demanded in various applications .Their use in textile finishing for imparting advanced functions for textile fabrics attracted many scientists. Sudan is a country that enjoys sunshine all the year .It lies between latitude 4^o and 22^o north the equator and longitude 22^o and 38^o in the tropical region. In this paper, different fabrics of plain design are exposed to uv rays for different periods of time and the effects on the properties of fabrics are studied. The amounts of nanodiamond suitable for the treatment of each type of fabrics are determined.

Keywords: Nanodiamond; ultraviolet rays; plain and ultraviolet protection factor

1. INTRODUCTION

Ultraviolet radiation (UV) is an electromagnetic radiation that means "beyond violet" (from Latin ultra, “beyond"). UV light has a shorter wavelength than violet light. Nine percentage of the energy of the sun is in the form of ultraviolet rays. UV radiation has both positive and negative health effects on human beings. These uv rays are invisible to humans, but visible to a number of insects as bumblebees and birds.

The regions of ultraviolet radiation are divided into three zones A, B, and C

Ultraviolet A	315-400
Ultraviolet B	280-315
Ultraviolet C	100-280

UV radiation is one of the major causes of degradation of textile materials which is due to excitations in some parts of the polymer molecule and a gradual loss of integrity, depending on the nature of the fibers [1, 2 and 3].

The Ultraviolet Protection Factor (UPF) rating system measures the UV protection provided by fabric.

$$UPF = \frac{\sum_{290\,nm}^{400\,nm} E\lambda \times S\lambda \times \Delta\lambda}{\sum_{290\,nm}^{400\,nm} E\lambda \times S\lambda \times T\lambda \times \Delta\lambda} \quad \ldots\ldots\ldots\ldots (1)$$

Where:

$E\lambda$ = erythemal spectral effectiveness

$S\lambda$ = solar spectral irradiance in Wm-2nm-1

$T\lambda$ = spectral transmittance of fabric

$\Delta\lambda$ = the bandwidth in nm

λ = the wavelength in nm

The numerator of equation (1) described the quantity of the uv radiation that reach the skin when it is unprotected and the denominator described the quantity of the uv radiation that reach the skin when it is protected by the garment [4, 5].

Nanodiamonds

Nanodiamonds are diamonds with a size below 1 micrometer. They can be produced by impact events such as an explosion or meteoritic impacts. [6, 7]

Diamond nanoparticles, or nanodiamonds, have the most disparate origins. They are found in crude oil at concentrations up to thousands of parts per million, in meteorites, interstellar dust and protoplanetary nebulae, as well as in certain sediment layers on Earth. They can also be produced in the laboratory by chemical vapor deposition or by detonating high explosive materials.

Nanodiamond particles are another form of carbon materials with promising properties and applications.

The application of nanodiamond in textiles for protection from uv will help in finding ways of protection from the risks of these rays.

2. MATERIALS and METHODS

Three fabrics were used viscose (v), polyester (p) and cotton(c), of the same plain design, number of ends /cm and number of picks/cm. Tests are conducted before and after exposing them to UV. All fabrics are produced in Helwan University in Egypt; their specifications are given in table (1).

Table (1): Specifications of fabrics used

No of warp(count) Ne	40/2 Ne for all designs
No of weft (count)	Viscose 30/2 Ne Polyester 300/1 Denier Cotton 40/2 Ne
Structure	Plain weave
No of ends/cm	36
No of picks /cm	21

3. Experimental Work

3.1 Mass per Unit Area (weight) of Fabric

The test was carried a according to the Standard test methods for mass per unit area (Weight) of fabric (ASTM D3776 / D3776M – 09) as described in the international recognized test standards (ASTM D 661)

3.2 Ultraviolet Protection Factor (UPF)

The Spectrophotometer device is used in measuring ultraviolet protection factor. The test is run according to the standards (ASTM 6544-12)

3.3 Breaking Force and Elongation

The determination of the maximum force and elongation at maximum force using the strip method is performed in this work by using the device Tinius olsen

Uv Source

The uv source used in this work is an arc lamp .The irradiance level of the mercury –ARC lamp have been measured using the NIS reference radiometers 268 UVA whose maximum response is located at 365 nm and 268 UVC whose maximum response is located at 254 nm .

The distance between the middle point at surface of the lamb blub and the detector was 20 cm (as requested).

The average reading at UVA is 5.5616 mw/cm2and the average reading at UVC is 3.0782 mw/cm2

The estimated expanded uncertainty for the above mentioned irradiance value is ±8.05 % (k=2)

The test is run according to the standards (ASTM 6544-12)

Nano Material

Nano-materials used in this work have been brought from China (Nanodiamond). Nanodiamond (ND) are of particle size of around 10 nm of 99% purity was obtained from Hongwu International Group LTD, trend Centre, 29-31 Cheung Lee Stree Chai Wan, Hong Kong.

In a beaker containing 48 ml of acetone 2 vol% of binder (B) was dissolved. Then variable masses (2, 3, 4, 5 wt. %) of ND based on the final weight of B-ND composite are dispersed. Then the amount of nanodiamond suitable for the type of fabric was determined.

4. Results

4.1 Weight

Table (2) Weight of Fabric used

Specification of samples	Weight (g)
Viscose /plain 2/2 (VP)	1.995133
Polyester /plain 2/2(PP)	1.892867
cotton /plain 2/2 (CP)	2.206333

All the 3 samples were weighed on an analytical balance. Readings were taken and weights /unit area were determined.
The breaking force and elongation results for the three specimens tested are obtained by using the grab test method. The breaking force (maximum force) is marked for all specimens. Examination of the specimens after being tested shows that the tests were Successful in determining the breaking force and the percentage elongation of the fabric. Specimen preparation is extremely important in acquiring accurate results. A single fiber can significantly affect the reliability and repeatability of the results. As shown on table (3).

4.2 Breaking force and elongation

Table (3) breaking force of fabrics used and the effect of exposure time on the breaking force

The Sample	Breaking Force zero time	After 1.5hour	After 2.5hour	After 3.5hour
VP	52.10	47.00	44.00	40.00
PP	124.60	120.00	112.00	110.23
CP	54.00	48.60	46.90	43.50

Table (4) elongation of fabrics used and the effect of exposure time on breaking force

No of sample	Elongati on % zero time	After 1.5hour	After 2.5hour	After 3.5hour
VP	7.68	7.30	7.01	6.00
PP	21.26	21.01	20.65	20.00
CP	16.70	16.00	15.60	15.01

The tested samples become more solid, rough and brittle as a consequence of exposure to uv .Table (3) shows that the rate of loss in the breaking force increases by increasing the exposure time. This amount of energy absorbed was enough to break the links between the atoms making up the molecules of cellulose and leading to a decrease in breaking force. The Plain polyester fabrics got the highest breaking force, followed by cotton and then viscose.

4.3 UPF

Table (5) UPF of Textile Fabrics used after being exposed to uv rays

samples	Upf zero time	After 1hour	After 2 hour	After 3 hour
VP	70.31	65	63	60.35
PP	71.74	70	65	63.01
CP	43.08	43.00	41.01	40.64

A natural fibre like cotton has lower degree of absorption of ultraviolet radiation than synthetic fibres [8]. In figure (3) Polyester has high ultraviolet protection value followed by cotton and viscose .The upf dropped in all samples after exposure to uv radiation.
Processing Using Nanotechnology (After Treatment with Nanodiamond Material)

After using Nanodiamond (40, 60,80 and 100mg);(N1,N2,N3,N4) Breaking force and elongation of textile fabrics (strip method) are tested .The results are shown below on table (6) and drawn in figures(1),(2) and (3) as shown for each material.

Table (6) the effect of adding nano (mg) to fabrics samples on the properties of the breaking force and elongation

Samples	weave	Elongation %	Maximum force (kgf)
VP-N1	Plain	4.080	48.45
VP-N2	Plain	4.405	59.20
VP-N3	Plain	3.995	63.00
VP-N4	Plain	4.300	66.00
PP-N1	Plain	13.600	137.50
PP-N2	Plain	16.060	127.60
PP-N3	Plain	14.950	132.80
PP-N4	Plain	15.000	135.00
CP-N1	Plain	3.972	48.85
CP-N2	Plain	4.395	53.90
CP-N3	Plain	9.930	97.30
CP-N4	Plain	9.940	99.51

Mass per Unit Area (Weight) of Fabric used before and after treated by nanodiamond by different weight (40, 80 and 100mg)

Samples	Weight (before) in grams	Weight (after) in grams
VP-N1	8.261	8.6586
VP-N2	8.2512	8.6228
VP-N3	7.8506	8.0476
PP-N1	8.5442	9.0717
PP-N2	8.6978	9.2568
PP-N3	8.7207	9.0096
CP-N1	8.4718	8.7548
CP-N2	8.0371	8.6601
CP-N3	7.8891	8.4066

The breaking force and elongation properties of treated and untreated textile fabrics were investigated .Tables (6) shows gradual increase in the breaking force after being treated with nanodiamond (ND) as shown and drawn in figure(4) .

The breaking force of virgin viscose was 48 and when NDs incorporated the breaking force was firstly decreased, but when mass NDs was added, the breaking force reached 66.

Table (7) Ultraviolet protection factor (Upf)

Samples	upf	UV-B	UV-A
VP-N1	64	1.2	4.19
VP-N2	107.06	0.72	2.56
VP-N3	100.66	0.83	2.26
PP-N1	135.02	0.48	3.26
PP-N2	126.46	0.54	5.3
PP-N3	136.76	0.51	2.85
CP-N1	63.1	1.26	3.82
CP-N2	56.39	1.5	3.61
CP-N3	142.52	0.55	1.87

The upf untreated and treated textiles were evaluated. The effect of the coating layer on the absorption of the harmful ultraviolet rays was studied and the results are tabulated on table (7) .From this table it was shown that the upf values of viscose was 51 .When nano diamonds were Incorporated in the coating layer, the upf values increased to 64and 107 respectively .The upf values increased with the increase of NDs.

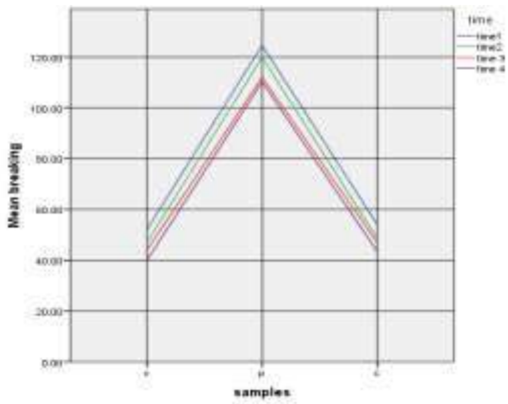

Fig (1) Effect of uv radiation on the breaking force with the change of exposure time (plain design).

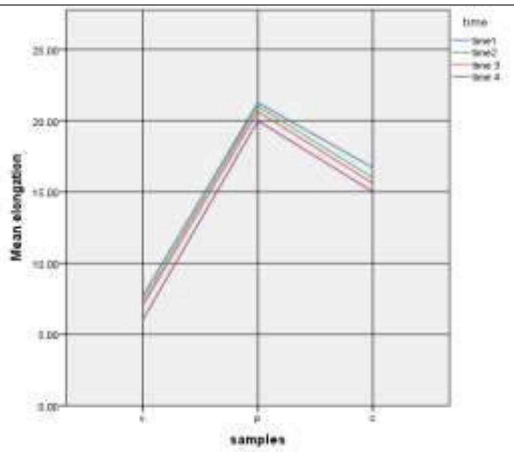

Fig (2) relationship between elongation and time of exposure to uv (plain design)

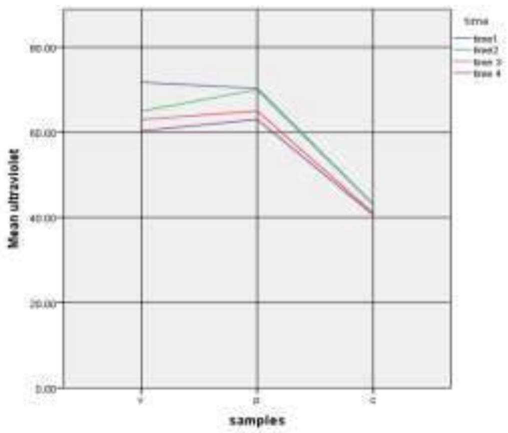

Fig (3) Effect of uv radiation on the upf with the change of exposure time (plain design)

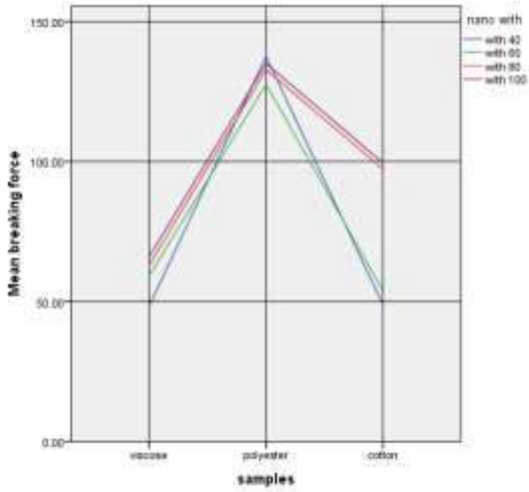

Fig (4) the effect of nano particles on breaking force

Table (8) Simple correlation and simple regression (breaking force)

samples	R2	Equation
viscose	0.904	Y =0.16-6.975x
polyester	0.005	Y=5.377-0.022x
cotton	0.857	Y=0.044x-0.785

Y is breaking force and x was the quantity of nano. Viscose is treated with 80mg ND, polyester with 40 mg ND and cotton with 100 mg and then exposed to ultrasonication at 50 % output for 1, and 2h.When ultrasonication time increased to 2 hours the upf values were significantly enhanced recording 91 for viscose, 116 for polyester and 216 for cotton and the the breaking force recorded 114.9 for viscose, 144.6 for polyester and 121.3 for cotton as clear from table (9).

Table (9) the breaking force, elongation and upf after treating with ND and using ultrasonication time(2hour)

Samples	Elongation %	Maximum force (kgf)	UPF
Viscose (80mg)	17.68	114.9	90.63
Polyester (40mg)	15.20	144.6	115.87
Cotton (100mg)	11.83	121.3	216.37

4. CONCOLUSION

UV radiation causes degradation of textile materials, due to excitations in some parts of the polymer molecule and a gradual loss of integrity.

All the samples showed a decrease in breaking force and UPF after exposure to uv.

The mass loading of nanodimond and ultrsonication time played significant role in uv protection and breaking force properties.

5. ACKNOWLEDGMENTS

Our thanks to the experts who have contributed towards development of the template.

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