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Research Article

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Improvement of Tonality in Viscose Fabric Prepared with Clay Nanoparticles to Produce Shawl

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ABSTRACT

The requirement of today industry is the production of desired product with less energy consumption. In textile industry, dyeing and finishing sectors consume the highest amounts of water and energy. Viscos yarns, which are one of the man-made fibers, have great effect of textile industry and it is widely used in clothing sector. On the other hand, in order to achieve a new method of dyeing, a new medium that could play an effective role as a cofactor in absorbing dye particles is needed. Treated clay nanoparticles are between among the mediums that poses such ability. Since, dyeing viscose fabrics have major constraints, improving the tonality of viscose fabrics which are treated with clay nanoparticles in order to be used in shawl production had been studied in the current study. For this purpose, viscose fabrics, which were washed with different values of clay nanoparticles' concentration, have been treated. Thereafter, the treated viscose fabrics were dyed under the direct reactive, sulfur and dispersants dying process. Meantime, designing the dyed fabrics for being used in shawl production was also studied. Findings of the study shows that the viscose fabrics which were treated with values more than 0/5 (o.w.b) of clay nanoparticles can improve the tonality of treated fabrics and as a consequence prevents its wastage during the Dyeing wastewater treatment.

Keywords: clay nanoparticles, viscose fabric, shawl, tonality.

INTRODUCTION

Twenty-first century, the century of nanotechnology, is the most important period in industry. Nano century is called the century of health, frugality and peace. Nano is not a matter, not an object. It is just a scale, shrinking a scale. Nano is one billionth of one meter, so small that they can not be seen. At the nanoscale, the physical, chemical and biological properties of individual atoms and molecules are different from properties of mass of material. In short nanotechnology means materials engineering at the atomic-molecular scale and construction of nano materials with very different properties at the nanoscale. Another definition of nanotechnology is "arranging and manipulation of atoms to make desired material". Nanometer (one billionths of one meter) is in size of 5 to 10 atoms together. A cube with dimensions of 2.5 nanometers approximately included 1000 atoms. Physical, chemical and biological properties of material in nanoscale are completely different from those in macro scale. Nano creates high energy in material molecules so it is called miraculous [1].

There are a number of ways for dyeing fibers, yarn or fabric. But the correct way of dyeing involves penetration of dye into the fiber and also color stability after penetration. Obviously, the dye used in the textile industry should be selected according to the type and chemical composition of the fibers. [2]

In 2013 a study as the use of nanotechnology in textile engineering was done by J. K. PATRA1 * and S. GOUDA where nanoparticles were used as materials. In this study, a better understanding of nanotechnology and nanoparticles progress in the textile industry and many of its applications were concluded.

The use of nanotechnology has quickly increased in the textile industry due to its unique and valuable properties. (2 references) There is a substantial nanotechnology program for profitable practical strategies of nanotechnology in cotton textiles. Its use can economically extend properties and the value of textile processing and its products. The use of nanotechnology allows textile be used for multifunctional fabrics and production of fabrics with special functions including antibacterial, protection against UV, easy cleaning, water and stain repellent and being anti-odor. The future success of nanotechnology lies in textile applications, for example in areas where new principles are associated with durability, and combined multi-functional textile systems without compromising the inherent properties of textile, including processing, flexibility etc. This study investigates the applications of nanotechnology in the textile industries with an emphasis on improving various properties of textiles. [3]

In 2015 a study entitled morphological and mechanical characteristics of nanoclay in covered fabric was done by A. Elamri, K. Abid, S. Dhouib, F. Sakli and clay nanoparticles were used as materials. In this study using abrasion and measuring the tensile strength, it was concluded that clay amount at most between 4% and 5% increases the mechanical performance of a fabric.

In 2015, taking into account the increase in nanotechnology during the present decade, there is an enormous potential in creating and applying new materials to improve the properties and practical programs. Many studies in improving the textiles and wear properties and implementation were conducted using nano-composite. In this work, nano-composite was prepared as a mixture of resin/clay with different percentages of clay. Then cover obtained has been deposited on cotton fabrics. Morphology and properties of nano-composite covered fabric were measured by DRX, scanning electron microscope (SEM) and mechanical tests. The results showed that despite the multi-observers on SEM images, nano-composites can be synthesized using classic clay, if they are added to PU and PAC resin. Moreover, the mechanical properties of the fabric in the world have increased in contrast the amount of clay for two resins. The clay percentage to enhance the mechanical properties of a fabric is at most between 4% and 5%. In fact, using significant amounts of more than 5% did not have the same good results. [4]

In 2015 a study entitled nanoclay was done as a new tool to change the dye of denim garment with indigo by Sadeghian Maryan1 *, M. Montazer2 and A. S. Rashidi3 where nanoclay (montmorillonite), along with co-enzymes (celluloses) were used as materials. In this study, the new method of dye changes based on the silicate nanoclay was concluded in jeans.

In 2015, nanoclay is applied in dry stone wash denim with cellulose to obtain jeans with a new look and bright wastewater. Acid and neutralized cellulose was used with nanoclay on indigo denim fabric and properties of treated sample and obtained wastewater was examined. The color change of denim fabric was evaluated using the colorimetric method. Levels of treated samples and montmorillonite in wastewater were observed using SEM and TEM. According to the results, nano-clay as a new tool with cellulose enhances the lightness, reduces coloring contact, creates a new look and reduces residual color in wastewater. [5]

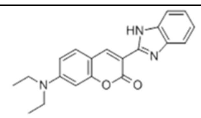
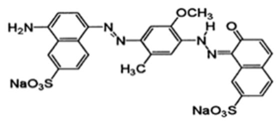
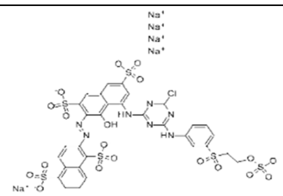
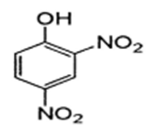
In 2015 a study entitled previous optimization of TiO_2 nanoparticles in dyeing of acid free wool using a central composite design was done by Ali Nazari a, *, Mohammad Mirjalili b, Navid Nasirizadeh b, Shahab Torabian b where nano TiO_2 and BTCA were used as materials. In this study, this nano offers a dyeing method by changing the improvement of the consistency of color samples. Meanwhile some of the benefits of this research can be the saving of dyeing energy at a lower level including temperature and improvement of the environment by reducing chemical auxiliary consumption and overall lower processing of costs.

In 2015, the aim of this study was to evaluate the nano method of acid dyeing for wool without acid auxiliary agent at a temperature lower than boiling. Initially wool fabric is treated with nano TiO_2 and BTCA at various concentrations. Then dyeing process is done on fabric with C.I, acid blue 113 and C.I acid black. Also, analysis of central composite design is applied to design the relationship between TiO_2 nano and BTCA concentration and color deterioration. Response surface methodology for finding optimal conditions is also applied for wool. Scanning electron microscope and X-ray diffraction are used to demonstrate the presence, type of crystal and size of TiO_2 nanoparticles on the surface of wool. Optimization on wool surfaces significantly increases the absorption of acidic dyes. The proposed method shows the improvement of stability properties compared to the controlled dyeing and can be introduced as a new direction. It can also disclose various and multi-functional desirable features for wool fabric. This method is also innocent of some of the chemical disadvantages of acid in dyeing including damage to dyeing of wool fabric in comparison to ordinary wool. [6]

EXPERIMENTAL SECTION

Used Materials:
In order for dyeing of viscose samples, in this study four types of chemical dyes, clay nanoparticles, other chemicals and viscose fabric with the following characteristics are used. Chemical dyes include reactive dye, direct dye, disperse dye, sulfur dye and their characteristics are given in Table 1.

Table 1: Used dye characteristics

Chemical Dye	characteristics	Chemical structure	Made in
Disperse Dye	C.I.Disperse Yellow 82,C.I. 551200,CAS 12239-58-6		India
Reactive Dye	C.I.Direct Blue 151,C.I.24175,CAS 110735-25-6,773.7,C34H25N5Na2O10S2,Copper Blue 2R,Direct Blue Light Fast R,Direct Copper Blue 2B		Iran
Direct Dye	C.I.Reactive Red 1,C.I.18158,CAS 17752-85-1,717.38,C19H9Cl2N6Na3O10S3,Reactive brilliant Red X-B		Korea
Sulfur Dye	C.I.Sulphur Black 1,C.I.53185,CAS 1326-82-5,Sulphur Black 2BR,Sulphur Black B2RN,Sulphur Black BN,Sulphur Black BRN,Sulphur Black RN,Duasyn Thiocarbon CMR,Duasyn Thiocarbon GA,Duasyn Thiocarbon LP		China

Clay nanoparticles are a product of Iranians nano-materials Pishgaman in Iran, Mashhad and their characteristics are stated in Table 2.

Table 2: Characteristics of used clay nanoparticles

Mineral type	Montmorillonite
Density	300 - 370 kg/m
Particles size	1-2 nm
Specific surface area	220-270 (m^2/gr)
Electrical conductivity	25 MV
Ion exchange coefficient	48 (meg /100 gr)
Blanking interval between particles	60 A°
Color	Yellow
Humidity	1-2%

In addition to chemical dyes, other chemicals are used in this study which are mentioned to in Table 3.

Table 3: Characteristics of used fabrics and materials

Name	Characteristics	Made in	Company
Detergent	Under the brand Rucogen DEN	Iran	Rudolf company
Acetic acid	Chemical formula: $ch^{3}cooh$, Molecular weight: 60 g/mol, Purity: 0.99% <	Germany	Merck company
Sodium Chloride	Nacl, purity: 0.99% <	Iran	Rudolf Company
100% viscose fabric	The weft yarn score 1.30 Lai, the warp yarn score 2.30 Lai, weft density 14, warp density 21	Iran	Silver weave company

Used Equipment and Devices

In order to observe the surface change of viscose fibers after dyeing operations with clay nanoparticles color guide sphere device, the light source of 65 D with the geometric measurement range of 8°/D, based on the system of CIELAB is used which is made in Germany to measure the color components.

Scanning electron microscope made in a Dutch company, model SEM PHENOM Pro X and EDS is used. Scanning electron microscope is used on fibers and in sizing of particles on the surface of the fiber. Samples prepared with clay nanoparticles have been imaged by the SEM and EDS microscope.

Operations

Washing: washing operation is used to separate the waste and external impurities of raw viscose samples weighing one gram, 1% sodium carbonate, 3% of detergent and water volume 57/8 cc that the total volume is 60 cc and it is placed on the heater for 20 min and with a temperature of 60°c. After the completion samples are dried.

Preparing with clay nanoparticles: to the suspension of clay nanoparticles in stained bath, various concentrations of clay nanoparticles (1.5, 1, 0.5%) based on the water volume (o.w.b) at 40°c and during 10 minutes were used in an ultrasonic bath for the suspension of baths containing clay nanoparticles. Each sample of washed viscose fabrics is prepared individually in baths containing various amounts of clay particles (0.5, 1, 1.5) and were under the immersion operation at 40 °c during 40 minutes, and samples were coded according to table 4.

Table 4: Viscous samples prepared with clay nanoparticles

Viscous samples	(O.w.b) clay nanoparticles (%)
V-0	0
V-1	0.5%
V-2	1%
V-3	1.5%

Washing and drying viscous samples prepared with clay nanoparticles: prepared viscous samples by immersion method has been washed several times and were dried at ambient air temperature.

Dyeing: in this stage, one-gram samples of viscose fabric are prepared and then pre-washing is done in order to remove fat and starch on fabric. In this study, four types of chemical dyes were used with varying amounts of clay nanoparticles. However, due to the similarity of baths the dyeing test was conducted, and baths conditions are described in table 5:

Table 5: Conditions of dyeing bath

Required dye concentration	2% (o.w.f)
Sodium Chloride	10 g/L
Temperature	100 °c
Water	50 cc
L:R	70:1
Period of time	30 min

RESULTS AND DISCUSSION

Spectrophotometric Results

What is obtained from reflective spectrophotometry on colored samples are information that states not only the color rendering index, but also color depth and lightness and color difference of colored samples in comparison to control sample of the same product.

Here explanation of a few points is needed:

L* = lightness

a* = redness-greenness

b* = yellowness-blueness

and

ΔE = Color difference between the test sample and the standard sample

+ΔL* = ΔL * = L * sample - L * standard, that means the test sample is lighter than standard

- ΔL* = that means the test sample is darker than the standard

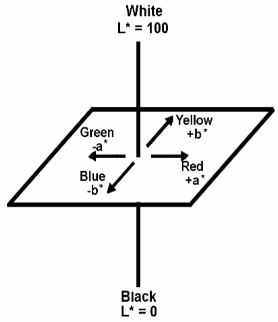


Figure 1. The assessment of colorful components

In tables 6, 7, 8 and 9 the results of the colorful components of viscous samples dyed with reactive, direct, disperse and sulfur chemical dyes are respectively shown.

Table 6: Colorful components of viscous samples prepared with different concentrations of clay nanoparticles with reactive dyes

Different Samples	L*	a*	b*	c*	K/S	E*Δ	L*Δ	a*Δ	b*Δ
V-0	66.818	41.971	-8.425	42.808	9.8867	0	0	0	0
V-1	66.573	40.547	-8.354	41.399	11.1584	1.447	-0.245	-1.424	0.071
V-2	66.365	37.164	-7.374	37.889	9.0756	4.941	-0.453	-4.807	1.051
V-3	66.653	40.018	-7.702	40.752	11.5635	2.089	-0.165	-1.953	0.723

The results of the colorful components of the dyeing with Direct Blue 151 reactive dye related to the samples of viscose fabrics prepared with different concentrations of clay nanoparticles are shown in table 6. The lightness (L*) of the prepared samples with clay nanoparticles compared to control sample has been slightly lower. In other words samples compared to control sample have been a little darker. But this decline of lightness was very small and compared to control sample its lightness is reduced less than one unit. The redness (a*) of the prepared samples with clay nanoparticles compared to control sample has been fallen too. The greatest reduction of redness is related to the viscose sample prepared with 1% of clay nanoparticles. The blueness (b*) of prepared samples compared to control sample is also less. But these amounts are small about one unit. (ΔE*) value for sample prepared with 1% clay nanoparticles compared to control sample has the highest value of color difference. Moreover, (ΔL*) for the prepared sample with 1% clay nanoparticles compared to control sample has the greatest decrease of lightness.

Table 7: Colorful components of viscous samples prepared with different concentrations of clay nanoparticles with direct dyes

Different Samples	L*	a*	b*	c*	K/S	E*Δ	L*Δ	a*Δ	b*Δ
V-0	48.556	-7.003	-25.762	26.697	36.3016	0	0	0	0
V-1	48.522	-6.870	-25.845	26.742	36.2821	0.160	-0.034	0.133	-0.083
V-2	48.452	-7.160	-24.801	25.814	35.2425	0.979	-0.104	-0.157	0.961
V-3	48.494	-7.141	-25.133	26.128	40.3041	0.647	-0.062	-0.138	0.629

The results of the colorful components of the dyeing with Reactive Red 1 direct dye related to the samples of viscose fabrics prepared with different concentrations of clay nanoparticles are shown in table 7. The lightness (L*) of the prepared samples with clay nanoparticles compared to control sample has been slightly lower. In other words samples compared to control sample have been a little darker. The redness (a*) of the prepared samples with clay nanoparticles compared to control sample have been increased and the greatest reduction is related to the viscose sample prepared with 0.5% of clay nanoparticles too. The blueness (b*) of prepared samples compared to control samples is also less and the most reduction of blueness is for the viscose sample prepared with 1% of clay nanoparticles. (ΔE*) value for sample prepared with 1% clay nanoparticles compared to control sample has the highest value of color difference. Moreover, (ΔL*) like reactive dye for the prepared sample with 1% clay nanoparticles compared to control sample has the greatest decrease of lightness.

Table 8: Colorful components of viscous samples prepared with different concentrations of clay nanoparticles with disperse dyes

Different Samples	L*	a*	b*	c*	K/S	E*Δ	L*Δ	a*Δ	b*Δ
V-0	92.694	-4.126	12.115	12.798	0.7695	0	0	0	0
V-1	93.681	4.156	15.193	15.751	4.9566	8.890	0.987	8.282	3.078
V-2	90.744	9.035	6.958	11.404	3.8882	14.269	-1.950	13.161	-5.157
V-3	90.569	4.373	3.651	5.697	2.4409	12.181	-2.125	8.499	-8.464

The results of the colorful components of the dyeing with Disperse Yellow 82 disperse dye related to the sample of viscose fabrics prepared with different concentrations of clay nanoparticles are shown in table 8. The lightness (L*) of the prepared samples with clay nanoparticles compared to control sample has been slightly increased. In other words samples compared to control sample have been a little lighter. Moreover, the prepared samples with clay nanoparticles compared to control sample, with their amount of redness (a*) denote greenness and prepared samples denote redness that the viscose sample prepared with 0.5% of clay nanoparticles has the most reduction of redness. The yellowness (b*) of prepared samples compared to control sample is also more and the most reduction of yellowness is for the viscose sample prepared with 1.5% of clay nanoparticles. (ΔE*) value for sample prepared with 1% clay nanoparticles compared to control sample has the highest value of color difference. Moreover, (ΔL*) like reactive dye for the prepared sample with 0.5% clay nanoparticles compared to control sample has the greatest lightness.

Table 9: Colorful components of viscous samples prepared with different concentrations of clay nanoparticles with sulfur dyes

Different Samples	L*	a*	b*	c*	K/S	E*Δ	L*Δ	a*Δ	b*Δ
V-0	79.968	-1.034	-2.204	2.434	2.8383	0	0	0	0
V-1	79.848	-1.034	-2.470	2.534	5.1752	0.553	-0.120	0.470	-0.266
V-2	79.964	-0.564	-1.980	2.117	7.8584	0.363	-0.004	0.285	0.224
V-3	80.045	-0.749	-1.500	1.674	7.4209	0.766	0.077	0.291	0.704

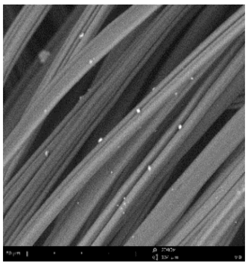
The results of the colorful components of the dyeing with Sulphur, black 521 sulfur dye related to the sample of viscose fabrics prepared with different concentrations of clay nanoparticles are shown in table 9. The lightness (L*) of the prepared samples with clay nanoparticles compared to control sample has been slightly less. In other words samples compared to control sample have been a little darker. But this decline of lightness was very small and compared to control sample its lightness is reduced less than one unit. Moreover, the redness (a*) of the prepared samples with clay nanoparticles compared to control sample have been fallen. The greatest reduction is related to the viscose sample prepared with 1% of clay nanoparticles. The blueness (b*) of prepared samples compared to control sample is also less. But this reduction is little and it is just about one unit. (ΔE*) value for sample prepared with 1% clay nanoparticles compared to control sample has the highest value of color difference. Moreover, (ΔL*) for the prepared sample with 1% clay nanoparticles compared to control sample has the greatest lightness.

3.1. The Results of Scanning Electron Microscope (SEM) and Energy-Dispersive X-Ray (EDX)

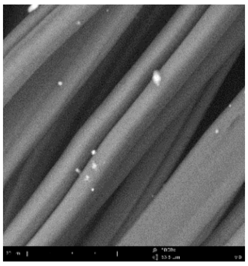
To investigate the uniformity and to show the dispersion in different forms of clay nanoparticles in the structure of viscose fabrics, sem analysis is used. To determine the amounts of penetration, clay nanoparticles were studied by sem and samples were analyzed with x2000, x5000, x10000, x20000 magnification. As can be seen by changing the percentage of clay nanoparticles and changing the focus of microscope, particles size has changed. It seems that increasing the amount of clay nanoparticles means there are too nanoparticles.

Sem image shows the prepared clay nanoparticles which indicates the formation of clay nanoparticles with sizes between 52.4 to 83.8 nanometer that have the highest percentage of frequency.

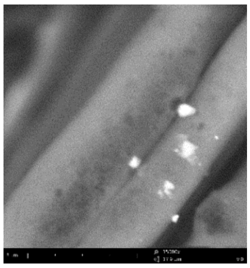
Figures 2-A, 3-B, 4-C, 5-D, 6-E, 7-F, 8-G, 9-H, 10-I, 11-J, 12-K, 13-L, 14-M, 15-N, 16-O and 17-P represent sem images.



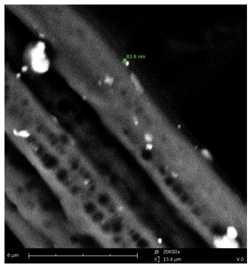
(Figure 5-D)



(Figure 4-C)

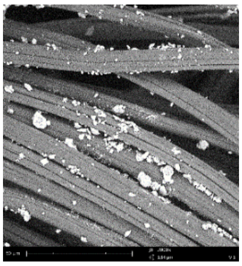
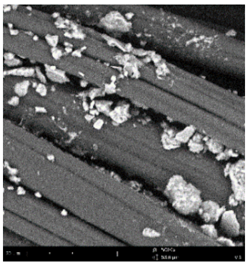
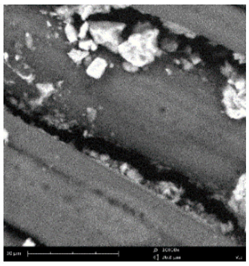
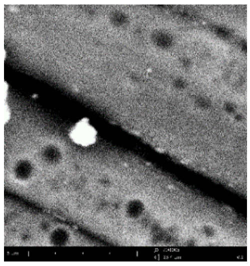


(Figure 3-B)



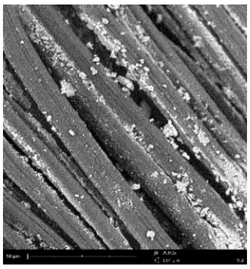
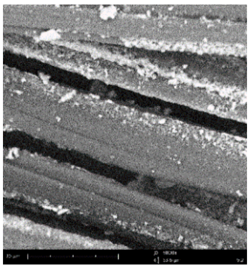
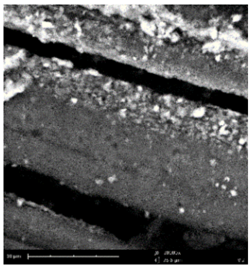
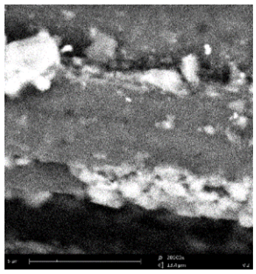
(Figure 2-A)

Figures (2-A), (3-B), (4-C) and (5-D) are raw sample to compare with prepared samples. As can be seen the raw sample contains no nanoclay. Scanning electron microscopic images of V-0 with a resolution of x2000 (figure 2-A) and x5000 (figure 3-B) and x10000 (figure 4-C) and x20000 (figure 5-D) are displayed.

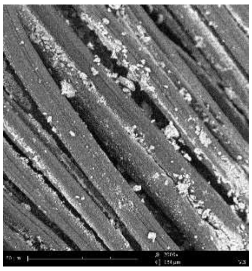
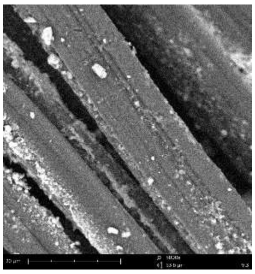
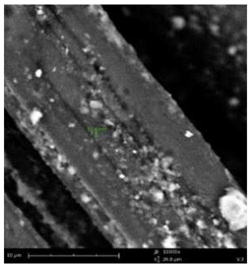
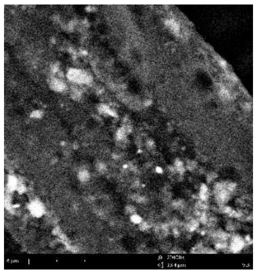
(Figure 9-H) **(Figure 8-G)** **(Figure 7-F)** **(Figure 6-E)**

The sample (figure 6-E) in figure (figure 2-A) has nanoclay in comparison to the raw sample so the latency operations of fabric and fiber were done by clay nanoparticles. Scanning electron microscopic images of V-1 with a resolution of x2000 (figure 6-E) and x5000 (figure 7-F) and x10000 (figure 8-G) and x20000 (figure 9-H) are displayed.

(Figure 13-L) **(Figure 12-K)** **(Figure 11-J)** **(Figure 10-I)**

The sample (figure 10-I) in figure (figure 2-A) has nanoclay in comparison to the raw sample so the latency operations of fabric and fiber were done by clay nanoparticles. Scanning electron microscopic images of V-2 with a resolution of x2000 (figure 10-I) and x5000 (figure 11-J) and x10000 (figure 12-K) and x20000 (figure 13-L) are displayed.

(Figure 17-P) **Figure 16-O)** **(Figure 15-N)** **(Figure 14-M)**

The sample (figure 14-M) in figure (figure 2-A) has nanoclay in comparison to the raw sample so the latency operations of fabric and fiber were done by clay nanoparticles. Scanning electron microscopic images of V-3 with a resolution of x2000 (figure 14-M) and x5000 (figure 15-N) and x10000 (figure 16-O) and x20000 (figure 17-P) are displayed.

The Results of Energy-Dispersive X-Ray EDX Images

In EDX images to ensure the presence of clay nanoparticles on viscose fabric, energy dispersive X-ray spectroscopy EDX is used that in prepared samples confirmed the presence of nanoparticles; because there are particles of silicon, aluminum and so on in the structure of clay nanoparticles and with this study, these particles are determined on fabric.

Figure 17-X-ray dispersion EDX image-clay nanoparticles, figure 18-X-ray dispersion EDX image-sample V-0, figure 19-X-ray dispersion EDX image-sample V-1, figure 20-X-ray dispersion EDX image-sample V-2, figure 21-X-ray dispersion EDX image-sample V-3 represent EDX image.

Elements of clay nanoparticles in EDX images:

C	Carbon
O	Oxygen
Si	Silicon
Fe	Iron
Na	Sodium
Al	Aluminium
Mg	Magnesium
Ca	Calcium
K	Potassium

Figure 17 shows the clay nanoparticles

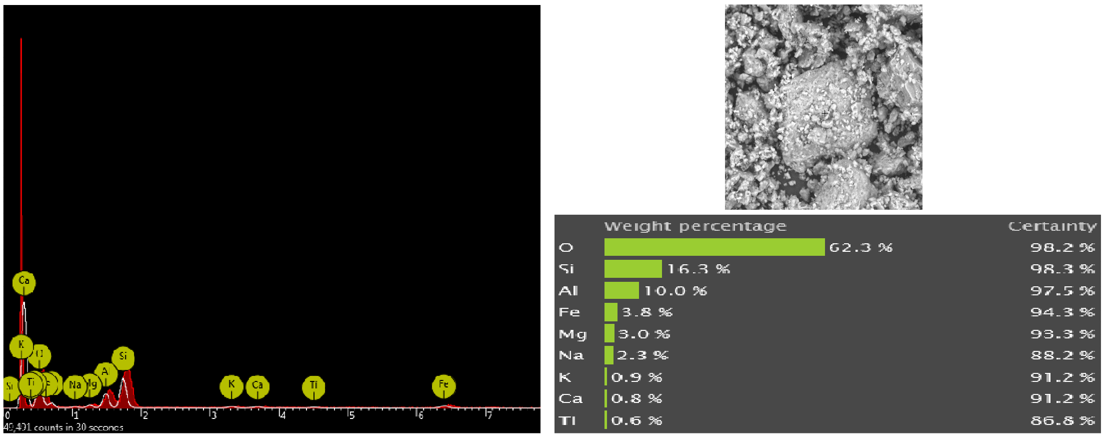


Figure 17: X-ray dispersion EDX image-clay nanoparticles

Figure 18 represents viscose fabric which has no clay nanoparticles.

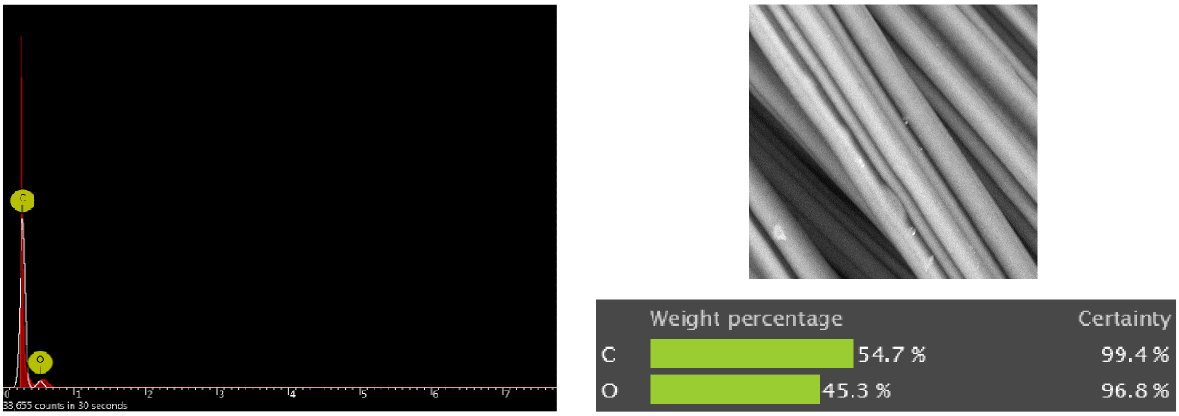


Figure 18: X-ray dispersion EDX image-sample V-0

In Figures 19, 20 and 21 nanoclay materials and their ingredients which were described above can be seen. Therefore it can be concluded that there is nanoclay in the tested samples.

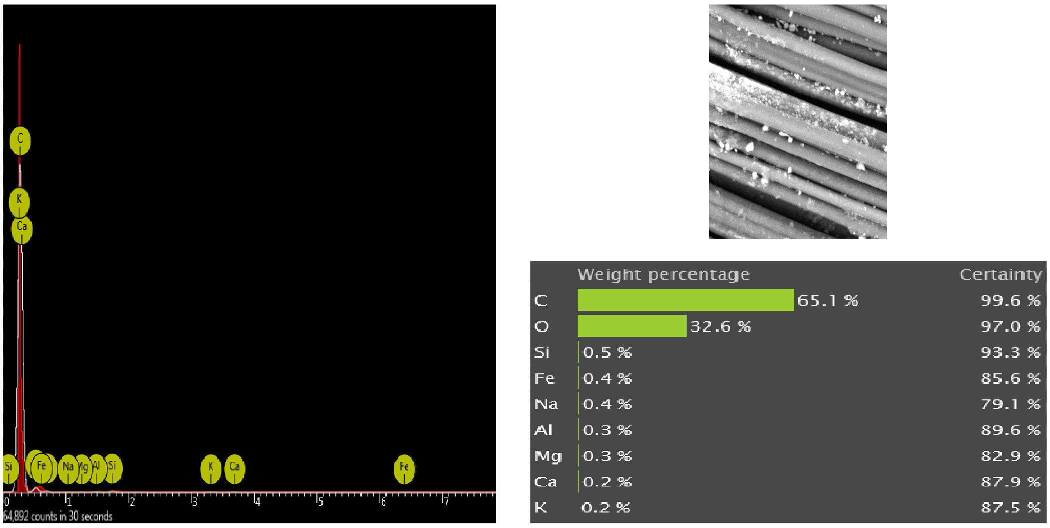


Figure 19: X-ray dispersion EDX image-sample V-1

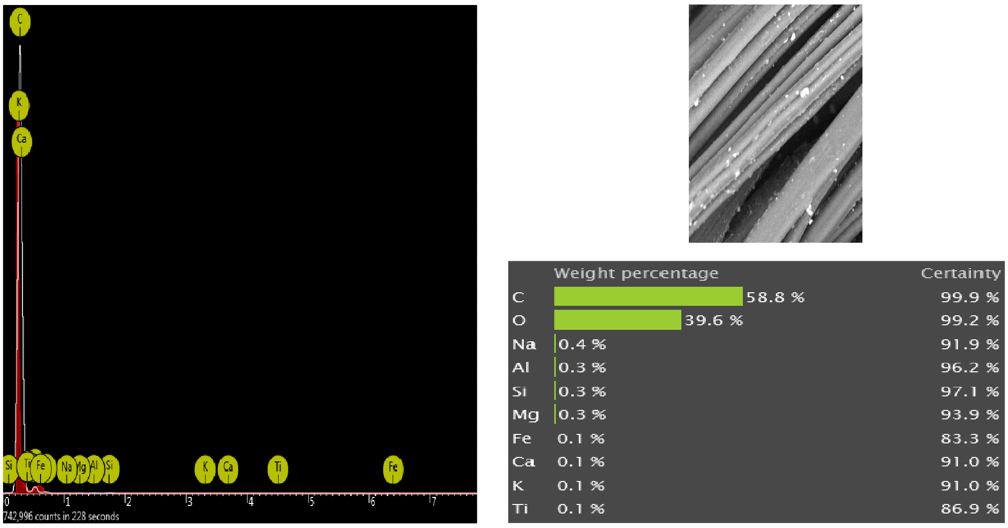


Figure 20: X-ray dispersion EDX image-sample V-2

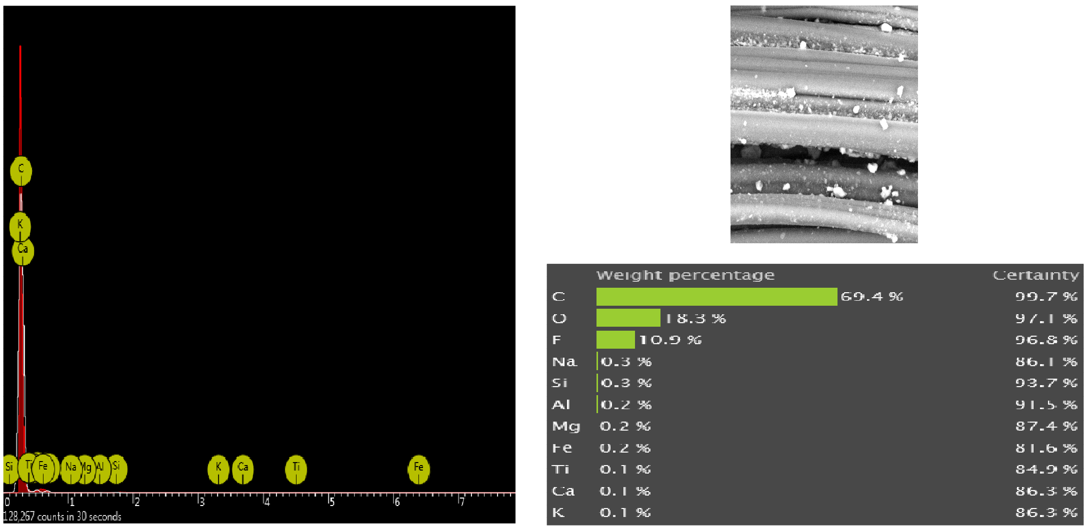


Figure 21: X-ray dispersion EDX image-sample V-3

To investigate the uniformity and to show the dispersion in different forms of clay nanoparticles in the structure of viscose fabric, sem analysis is used. To determine the amounts of penetration, clay nanoparticles were studied by sem and samples were analyzed with x2000, x5000, x10000, x20000 magnification. As can be seen by changing the percentage of clay nanoparticles and changing the focus of microscope, particles size has changed. It seems that increasing the amount of clay nanoparticles means there are too nanoparticles.

CONCLUSION

Investigating the coverage by SEM showed the sample fabrics that are prepared have clay nanoparticles which are uniformly scattered on the fabric.

EDX images are used to ensure the presence of clay nanoparticles on viscose fabric that in prepared samples the presence of nanoparticles is confirmed; because there are particles of silicon, aluminum and so on in the structure of clay nanoparticles.

In investigating the improvement of viscose fabric dyeing with prepared sample with clay nanoparticles and dyeing with four different types of chemical dyes (reactive dye, direct dye, disperse dye, sulfur dye) compared to the raw sample, samples which are prepared with 1% clay nanoparticles compared to control sample have the greatest amount of color difference and lightness.

It is suggested that in future research other nanoparticles should be used instead of clay nanoparticles. It is also recommended that researchers to continue their research in the field of dyeing and to improve it use different dyes and fabrics.

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