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Impact of nano-clay on improving the properties of cotton / nylon fabric

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ABSTRACT

The opaque cotton / nylon fabric that is often used in military clothing should have unique properties to enhance the efficiency and ability of individuals. Therefore, creating properties such as waterproof, antimicrobial, fire retardant, etc. on the product is considered, which can be achieved by using nanoparticles on the product in small quantities. As a cheap mineral, with thermal and optical stability, clay nanoparticles have many absorption properties and can be used to complete textile goods. In this paper, a 5% solution of montmorillonite nano-clay was applied on a cotton / nylon cloth (50/50) by pad-dry-curing method (at 160 ° C for 10 minutes) and then the product properties included The bleaching, dyeing, fire retardant, wash stability, optical stability and UV resistance properties were investigated.

The results of dyeing test using two dyes of methylene blue (cationic) and direct dye class B (Blue218) (anionic) and performing uv-vis test on their effluent showed that the use of nano-clay on cotton / nylon fabric It can create more space for dye adsorption and allows more dye to be involved in the nanoclay layers, thus increasing the dye adsorption by the fabric and, consequently, increasing the decolorization capacity in the effluent. Also, the presence of nano-clay on this fabric increases the washing stability, optical stability, fire resistance and UV protection.

Keywords

Nano-clay, Cotton / nylon fabric, Increased lubrication, Wash and optical stability, Wastewater treatment.

1. Introduction

Given that the importance of the high position of the Armed Forces in maintaining and independence and territorial integrity and ensuring the security and comfort of the people is not hidden from anyone, so improving the quality of military textiles is very important and always many researchers to produce safe and at the same time military textiles[1]. Now they have worked hard for the military and law enforcement forces[2]. Therefore, in order to provide simultaneous protection and comfort in the textile, a mixture of natural and synthetic fibers has been used to prepare the fabric, in addition to strength, resistance to stress, comfort and lightness[3,4]. But because garments made from a mixture of natural and synthetic fibers have undesirable properties such as low water absorption, hard dyeability and low comfort, the researchers used a powerful cotton / nylon blend to solve other problems, in addition to other unique features such as Provide abrasion stability and sunlight in the fabric[5]. It is obvious that the use of suitable nanoparticles can also give special properties to the fabric. Fire also provides UV protection, increased washing and light stability in the fabric[6].

Today, clays are perhaps the most well-known materials that have a large market in the field of nanotechnology. These materials are of natural origin and because they are so abundant in nature, they can be industrialized at much lower costs than other nanomaterials[7]. Clay nanocomposites use micrometer particles of nanometer clay layers as

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fillers. But it may be a small fraction of the hundreds of nanomaterials hidden in the earth. Clay is a clear indication that the earth has properties whose value can not be determined except by careful examination and combination with other materials. Modified clays have realized the first applications of nanotechnology in nanocomposites [8].

In fact, nanoclays fall into different categories depending on the composition and morphology of the nanoparticles (appearance, for example, being spherical or cubic, two different morphologies)[9]. Montmorillonite or MMT (the most important nanoclay in the smectite group) is a nanostructure for nanocomposite applications. This substance is a very soft mineral of aluminosilicates with the following formula [10].

Montmorillonite silicate sheets have a nanometer distance and are comprehensive of very desirable properties not found in any other natural product. These properties include high aspect ratio (length to thickness ratio) and highly ionic structure. High contact surface means that each particle has a high surface area, which leads to higher reactivity with resins and polymers MMT Connected to an ionic network[11]. Polar compounds like MMT tend to bind to polar materials. Some polymers, such as nylon, are completely polar, so threads such as MMT bond strongly to them. MMT filaments are usually surface-modified with four-factor ammonium salts, and are thus associated with non-polar polymers such as polypropylene and polyethylene [12].

Nanoclays are minerals that have at least one nanometer in size. Due to their cheapness and availability, nanoclay has been considered by many researchers in addition to having properties such as: high specific surface area, high adsorption capacity, mechanical and chemical stability, cation exchange capacity and swelling capability. Due to its unique structure and having functional groups, it can also act as an adsorbent [13]. In this paper, Montmorillonite nanoclay is used in which two thirds of its octagonal regions are occupied by trivalent positive ions (such as Al_3 $^+$), some of which have been replaced by ions such as Fe_3 $^+$ and Mg_2 $^+$. The quadrilateral montmorillonite regions are also usually composed of Si_4 $^+$ ions as central atoms with some Al_3 $^+$ substituents [14]. Quadrilateral (T) (Si_4 $^+$ in quadrilateral coordinates with O_2^-) and octahedral alumina (O) (Al_3 $^+$ in octahedral coordinates with O_2^-) by sharing O_2^- ions at polygonal corners and edges[15]. A sheet of octagonal aluminum is placed between two sheets of quadrilateral silica. In this way, a three-layer ross mineral with a structural unit consisting of T-O-T is obtained [16].

Existence of these structural characteristics which include active sites and functional groups such as: hydroxyl groups, Lewis and Brunsted acidity, interchangeable cations, SiO_4 quadrilateral sheet and Al_2 (OH) $_6$ octahedral sheet under chemical stability, nano Has introduced clay as a good adsorbent in the textile industry [17,18].

2. Experimental

2.1. Materials

In this research, modified montmorillonite cation nanoclay and 50/50 cotton / nylon fabric have been used, the specifications of which are as follows.The specifications of the nanoclay used are shown in Table 1.

Table 1. Technical specifications of used nano-clay

Cloisite®15A	Nano clay
Weight	1Kg
Organic Modifer	2M2HT
Modifer concentration	125meq/100g
Moisture	<2%
Weight loss on Ignition	43%
Anion	Chloride
Density	1/66g/ml
Dool	31/5°A

The technical specifications of the cotton / nylon fabric used are as follows:

50% nylon - 50% cotton

Yarn density 5/25 - Weft density 5/20

2.2. Methods

In order to investigate the effect of nanoclay on the properties and characteristics of cotton / nylon fabric, nanoparticle particles are applied as a solution on cotton / nylon fabric by pad-dry-curing method, so that first the solution We prepare some of the modified cation nanoclay with a weight percentage of 5% and then cut the samples of cotton / nylon fabric in the dimensions of 15 x 10 and after the initial washing, each of the samples was padded several times. Until the nanoclay particles are placed on the fabric and then we put the samples inside the oven so that the baking step is done and the nanoclay is fixed on the fabric and can show the desired properties.

The pads were repeated up to 12 times and the oven temperature was 160 ° C for 10 minutes.

Washing of produced samples:

The produced samples are then washed at 60 ℃ with 1 g / l of detergent for 30 minutes and then weighed.

First, FESEM and EDX tests were performed to prove the presence of nanoclay on the fabric, and then to test the adsorption capacity of the processed fabric, bleaching test using two methylene blue (cationic) dyes and direct class B dye (Blue218 (anionic) and uv-vis were taken. In the end, the results of optical stability test and washing stability of nanoclay processed fabric also showed the improvement of these properties.

3. Results and Discussion

3.1. FESEM and EDX tests

FESEM test was performed on the morphology of the samples and the placement and opening rate of the nanoclay layers on the cotton / nylon fabric. Also, spectroscopy was performed to analyze the structure or chemical properties of the samples. X-ray diffraction (EDX) energy was also taken from the samples.

Device specifications

FESEM device model: Sigma model of German manufacturer Zeiss

EDS and Map Detector Specifications: Oxford Instruments UK

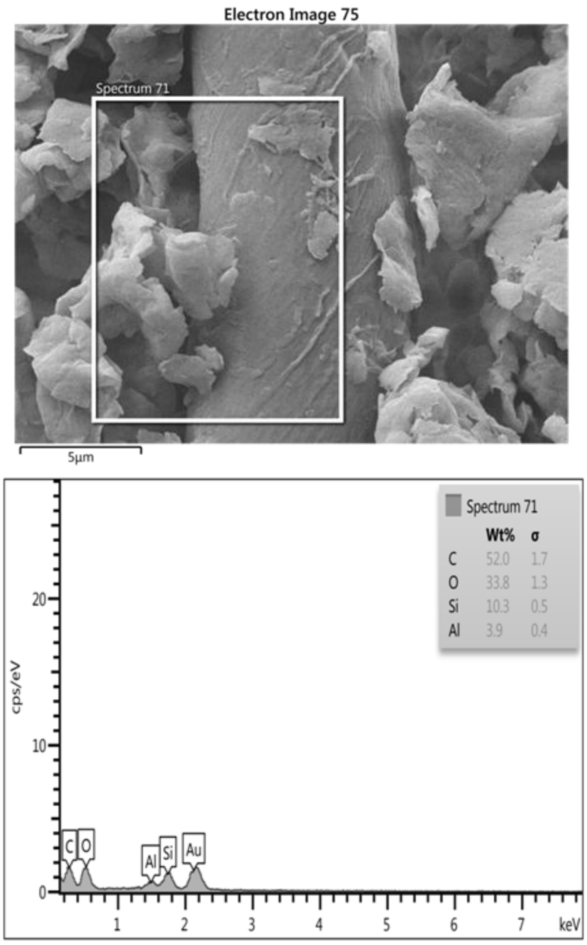

Fig1. FESEM image and EDX test for nano-clay processed cotton / nylon fabric

Fig2. FESEM image of nano-clay processed cotton / nylon fabric in different zooms

EDX and FESEM experiments at different scales show that the nanoclay is placed on the surface of the product and also shows that using the pad-dry-baking method, the nanoclay layers can be said to be almost well separated and They are placed on the surface of the product, so it can be expected that the processed fabric has desirable properties and characteristics due to the presence of nano-clay.

FESEM and EDX test results confirm the presence of nanoclay on cotton / nylon fabric.

3.2. Dyeing and bleaching test

Dyeing of samples and uv-vis test:

Using a solution of 0.001% of methylene blue (cationic) dyes and direct class B (Blue218) (anionic) dyes, we apply the nanoclay-treated cotton / nylon fabric and then after passing For one hour, two hours, 24 hours and 72 hours, the effluent from each sample is subjected to a uv-vis test at a wavelength of 660 nm to obtain the amount of uv uptake from the effluents. Lower UV absorption means that the effluent is clearer and less pigmented.

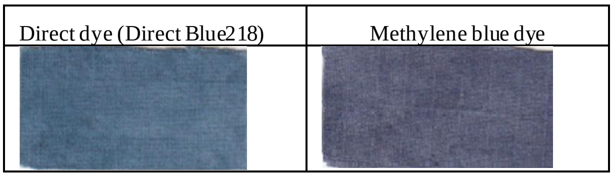

Fig3. Picture of cotton / nylon fabric dyed with methylene blue dye and direct dye (Direct Blue218).

As can be seen in Figure 3, dyeing with direct dye is more uniform than dyeing with methylene blue dye, and the reason for this can be attributed to the negative charge of this dye (Direct Blue218) because the nanoclay used It is a cationic type and the surface of the fabric has a positive charge, so dyeing operations have been performed against a dye with a more uniform negative charge.

3.3. uv-vis test

After dyeing, uv-vis test was performed on nanoclay-treated cotton / nylon fabric at different times, which shows the effect of time on the amount of effluent decolorization (Figure 4).

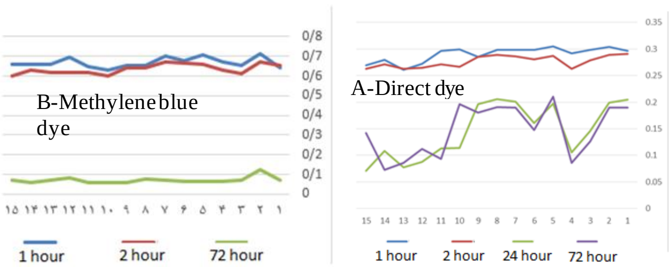

Fig 4. The effect of time on the amount of effluent decolorization

As it is known, over time, the concentration of dye in the effluent decreases and as a result, we have less effluent and less pollution enters the environment, so according to the results obtained, we can use nanoclay as a cheap adsorbent in Use for bleaching and finally treatment of dye factory effluents[19].

In the past, many researchers have conducted studies on the surface of nanoclay to determine the adsorption mechanism of nanoclay[20]. This study clarifies the role of nanoclay surface as adsorption sites on the adsorbent and the effect of other surface factors. Nanoclays generally have attractive structural properties[21]. These structural properties include active sites such as hydroxyl groups, Lewis and Brunsted acidity, interchangeable cations, quadrilateral SiO_4, and octahedral $Al_2(OH)_6$ under chemical stability[22]. The existence of these active sites and functional groups of nanoclay has been suggested as a good adsorbent in the textile industry[23].

Therefore, it can be expected that the higher the percentage of nanoclay, the higher the dye absorption rate, and the results confirm this, because the higher the percentage of nanoclay, the more active sites and functional groups. The dye is provided for absorption in the fabric and the absorption of the dye of the fabric is increased. As a result, by increasing the percentage of nanoclay, the number of pads and increasing the absorption of dye by the resulting fabric, the uv-vis test shows a smaller value. Give.

As shown in Figure 4, time has a significant effect on the amount of bleach because the longer the time, the longer it takes for the dye to be absorbed by the cotton / nylon fabric, and the dye can work well in the spaces in The fabric penetrates and is absorbed due to the presence of functional groups and active places, which causes us to have less effluent and increase the amount of bleaching.

3.4. Optical reflection test

This experiment was performed by examining the samples to determine the extent to which they absorb UV in the zero to 2000 nm wavelength range.

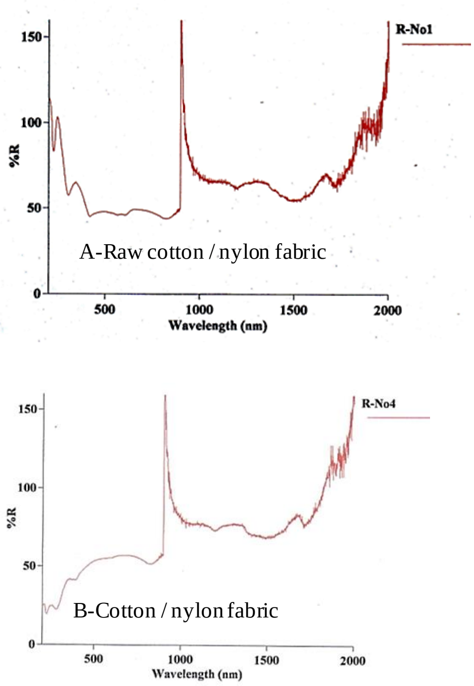

Fig 5. Comparison between samples in the amount of UV absorption in the range of zero to 2000 nm

Considering the results obtained from the light reflection experiment, it can be concluded that the presence of nanoclay increases the absorption rate in the uv region and the fabric has uv absorption property. The reason for this can be the presence of metal compounds such as SiO4 and Al2 (OH) 6 in the structure of nanoclay because these metal compounds have the ability to absorb in the uv region and it is obvious that increasing the percentage of nanoclay on the fabric increases these metal compounds and consequently the fabric has the ability to resist uv turns.

3.5. Water droplet absorption test

In this experiment, it shows how long it takes for a drop of water to drip from a distance of one centimeter onto the fabric.

Table 2 . Results of water droplet adsorption test

Absorption time (seconds)	
14	Samples processed with nanoclay
2	Unprocessed samples

According to the results of droplet adsorption test, it can be concluded that with the presence of nanoclay on the fabric, more time is needed to absorb water droplets, so it can be concluded that the use of nanoclay on cotton / nylon fabric Due to the structure of the shaped sheets, it causes water repellency on the fabric.

3.6. Flame test

In this experiment, cotton / nylon cloth samples were placed at a certain distance (10 cm) from the flame and then the time to start burning in these fabrics was recorded.

According to the results obtained from Table 3, it can be seen that the presence of nanoclay on the fabric causes more time to burn and the reason for this can be attributed to the structure of nanoclay because the sheet structure The nano-clay form can act as a suitable barrier against fire and cause the fire to burn the fabric for a longer period of time[24]. In addition, it should be noted that nanoclay itself as a mineral compound has a high thermal resistance and is always considered as a suitable thermal insulation, so nanoclay can be used for fire resistance [25].

Table 3. Flame test results

Duration (seconds)	
72	Samples processed with nanoclay
3	Unprocessed samples

3.7. Wash stability test

In this experiment, raw and dyeed samples with methylene blue dye and direct dye were washed at 60 ° C with 1% detergent for 30 minutes in the same washing process.

As shown in Figure 6, the presence of nano-clay has increased the washing stability of the product and the fabric has shown less color change because the colors are better absorbed by the product and have a better penetration into the fabric, so less Detergents are available. According to this, it can be concluded that the presence of nanoclay increases the washing stability of the fabric.

Before washing	After washing	
		A-Samples processed with nanoclay
		B-Unprocessed samples

Fig 6. Examination of raw cotton / nylon fabric processed with nano-clay for washing stability

3.8. Optical stability

In this experiment, the samples were exposed to direct sunlight for three days (72 hours) in the same conditions and then the samples were compared with each other for color changes.

Obviously, when the fabric is exposed to sunlight, it changes color slightly and loses some of its color and fades, as shown in Figure 7, the presence of nanoclay can be It shows good resistance to this color change and the fabrics on which the nano-clay is padded have less color change, as a result of which the presence of nano-clay on the cotton / nylon fabric increases the optical stability.

prototype	Sample after 72 hours in sunlight	
		A-Samples processed with nanoclay
		B-Unprocessed samples

Fig 7 . Examination of raw cotton / nylon fabric processed with nanoclay for optical stability

4. Conclusions

Nano-clay as a cheap mineral, with high thermal, optical and absorption properties, can be a good option to complete the textile product, in order to create and improve properties such as waterproof, fireproof and so on. In this article, we examined the properties and characteristics of finishing cotton / nylon goods with nano-clay, and according to the results of various experiments, we can conclude that the presence of nano-clay on cotton / nylon goods can in addition It also plays a major role in improving washing stability, light stability, heat resistance, fabric dyeing and effluent bleaching, also protects the fabric from UV rays. Due to the high use of cotton / nylon fabric in military textiles, creating and improving the mentioned features in this fabric is of great importance.

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