American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-3, Issue-9, pp-87-90
www.ajer.org
Research Paper Open Access

Effect of Titanium Dioxide Treatment on the Properties of 100% Cotton Knitted Fabric

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ABSTRACT : *Titanium dioxide (TiO_2) is a white, water insoluble pigment. It is used in paints, plastics, foods, pharmaceuticals and cosmetics. Its main application on textile materials as an ultraviolet ray protecting agents. Titanium dioxide can reflect, scatter or absorb ultraviolet ray. Besides Titanium dioxide also modify the properties of fabrics. In previous research, titanium dioxide was applied mainly by padding mangle method. This paper presents an approach to observe the effect of titanium dioxide treatment 100% cotton knitted (plain jersey) fabric applied by exhaustion method followed by curing and washing. The treated fabrics were then analyzed by Scanning Electron Microscope (SEM) and the tensile strength, p^H value and absorbency of the treated and untreated fabrics were checked. It is found that titanium dioxide impairs the better hand feel and absorbency (wetting time) of all treated fabrics increased gradually than untreated fabrics. The treatment increases the strength and keeps the p^H of the fabric in acidic medium.*

KEYWORDS:*Bursting strength, Cotton fiber, Knitted fabric, Exhaustion method, Titanium dioxide (TiO_2)*

I. INTRODUCTION

The history of clothing is the history of civilization. By the development of science and technology, peoples begin to use cloth in the form of garments. The development of clothing was depended on the development of fiber, which is the only one raw material of making fabric. Natural fibers such as cotton, silk, wool etc. was the major natural sources for making cloth. Among different types of fibers, cotton receives the supreme places by considering different factors of various fibers. Today, cotton is the most used textile fiber in the world. At present, current market share of cotton fiber is 56 percent for all fibers used for garments and home furnishing. It is generally recognized that most consumers prefer cotton personal care items to those containing synthetic fibers. Today, the world's cotton fiber production is around 90 million bales per year. Cotton is a natural fiber that comes from the seed pod of the cotton plant and is used to make many fabric types. The fiber is hollow in the center and under the microscope, resembles a twisted ribbon [1]. Cotton can be knit or woven into cloth. A plain weave or jersey fabric is used to make a wide range of wearing apparel including blouses, shirts, T shirts, children's wear, swimwear, skirts, ladies hosiery etc.

Cotton fabric is popular because it's easy to care and comfortable year round. In hot, humid weather, cotton breathes. Cotton fibers can absorb up to 27 times its own weight in water [2]. As the body perspires, cotton fibers absorb the moisture and release it on the surface of the fabric, so it evaporates. In cold weather, if the fabric remains dry, the fibers retain body heat, especially napped fabrics. Another characteristic of cotton fiber is that it can be blended with synthetic fibers such as cotton/polyester, cotton/nylon, cotton/acrylic, cotton/wool blends etc. Cotton/polyester blend are the most common. By blending with polyester wrinkles and shrinkage problem of cotton fibers can be reduced. Functional finishes such as mildew, flame and stain resistance have added to cottons appeal. Another functional finish, anti-ultraviolet finish is also demanded properties on cotton fabric. Too much ultraviolet (UV) ray of sunlight is harmful to human being, especially for human skin. Exposing of UV ray causes sun burn, suntan, skin ageing, eye inflammation and cataract. Excessive exposures of ultraviolet ray damage the DNA of skin cell and results malignant skin cancers. So, to protect the human skin from the excessive exposure of UV ray, anti UV ray finish is necessary on cotton fabric. Titanium dioxide (TiO_2) and zinc oxide (ZnO) is widely used as ultraviolet protecting agent [3-4]. Because both of these chemicals can effectively absorb, reflect and scatter the UV ray from the exposing sunlight. These particles not only rendering the UV protecting function on cotton fabrics but also affect their properties. Especially cotton fabrics absorbency, pH, hand feel and strength are important requirements for wet processing treatment and in normal uses. But the performance of titanium dioxide treatment on absorbency, pH and strength of 100% cotton fabrics are not yet studied in versatile range. The present investigation deals with the treatment of 100% cotton knitted fabric with titanium dioxide and followed by checking the properties of it. In this work normal plain jersey was used as a knitted fabric. A chemical can be applied on fabric by either exhaustion method or padding method. Already many research of titanium dioxide treatment have done by padding method. In this investigation, titanium dioxide was applied by exhaustion method by following a recipe to find out effectiveness of exhaustion method for penetration of titanium dioxide particles through fiber chain. After treatment, properties were checked to found the effect of titanium dioxide on cotton fabric. Properties mean surface investigation by Scanning Electron Microscopy (SEM), hand feel, strength and elongation at break, pH and absorbency of knitted fabrics were checked.

II. MATERIALS AND METHODS

2.1 Raw materials: In this experimental exertion, plain jersey fabric was used as knit fabric. The fabric was 140 GSM (Gram per Square Meter) and made from 100% cotton 30's yarn.

2.2 Chemical: The major chemical in this work is titanium dioxide (TiO_2, Merck Specialties Private Ltd, Mumbai). Besides this, wetting agent (Kieralon XC-J) sequestering agent (Lufibrol MSD) and distilled water are also used in this experiment.

2.3 Machines and Instruments: The following machines and instruments were used in this experimental work

a. High temperature high pressure (HT/HP) sample dyeing machine
b. Electrical oven
c. Hand dryer
d. James heal pneumatic bursting strength tester
e. Scanning electron microscope
f. p^H Universal indicator

2.4 Application of titanium dioxide: In exhaustion method, knitted fabrics were treated with three different quantities of titanium dioxide at 80°C for 20 min in the presence of wetting agent and sequestering agent in a HT/HP sample dyeing machine. The liquor ratio of exhaustion bath was 1:10. After 20 min of exhaustion, the titanium dioxide contained fabric was cured at 140°C for 10 min in an electrical oven. Finally treated fabrics were washed at 60°C for 20 min followed by drying. Three different quantities (0.5%, 1% and 2%) of titanium dioxide were used to treat the fabric. As a result, three fabric samples were obtained which was treated with different quantities of titanium dioxide.

2.5 Measurement of bursting strength: Bursting strength and Elongation at break of every knitted fabric samples were measured with James-Heal Pneumatic Bursting strength tester by following the method of ISO – 13938-2. Five readings were taken for each sample and the average was taken as the final value [5].

2.5 Surface investigation by Scanning Electron Microscope (SEM): The basic function of SEM is to produce an image of three dimensional appearance of any surface structure at micro meter to nanometer scale. In this experimental work, the surface analysis of titanium dioxide treated knitted fabric was done by InspectTM scanning electron microscope.

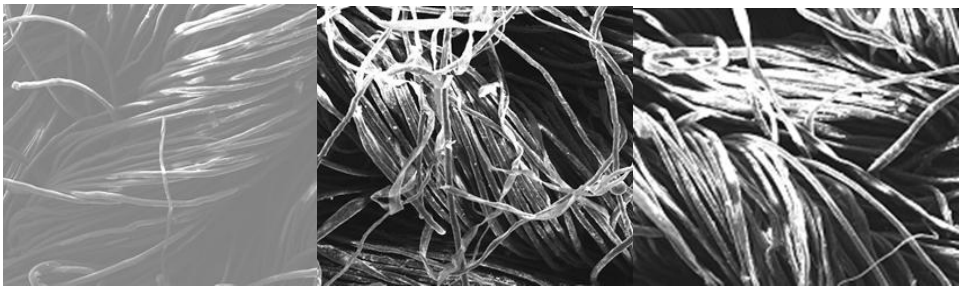
2.6 Measurement of absorbency: Absorbency is one of several factors that influence textile processing such as fabric preparation, dyeing and the application of finishes. In this thesis work, absorbency of the treated and untreated fabric samples was measured by the AATCC test method 79-2007. In the test method of AATCC 79-2007, a drop of water is allowed to fall from a fixed height onto the taut surface of the test specimen. The time required for the water drop to disappear is measured and recorded as wetting time. In this experimental work, the testing temperature was 22°C to 24°C. Five time readings were taken for each sample and the average was considered for the final wetting time of the tested specimen. The shorter the average time, the more absorbent the fabric [6].

2.7 Measurement of fabric p^H: p^H is a dominant factor to determine the use of a fabric material in daily life. Extreme acidity or basicity is not accepted. To make a quantitative determination of textile fabric p^H, the chemicals which influence p^H must be removed from the textile specimen, collected as water extract and then accurately measured by a p^H indicator. In this experimental work, p^H of the titanium dioxide treated and untreated fabrics were measured by AATCC test method 81-2006. In the test method of AATCC 81-2006, the textile specimen (10 gm) is boiled in distilled water. The water extract is cooled to room temperature and the p^H is determined by p^H Universal Indicator. In this experimental work, the testing temperature was 22°C to 24°C. Three readings were taken for each sample and the average was considered for the final p^H of the tested specimen [7].

III. RESULTS AND DISCUSSION

3.1 Observation of fabric appearance: After visual investigation the surface of the treated fabrics, it is obvious that the surface is rough and not smooth than the untreated fabric. Fabric surface becomes harsh and powdery in compared with original untreated fabric samples. The harshness and powdery affect are increased with the increases of amount of titanium dioxide.

3.2 Surface investigation by SEM: The SEM images of knit fabric treated with different concentration of $TiO_2$are given below

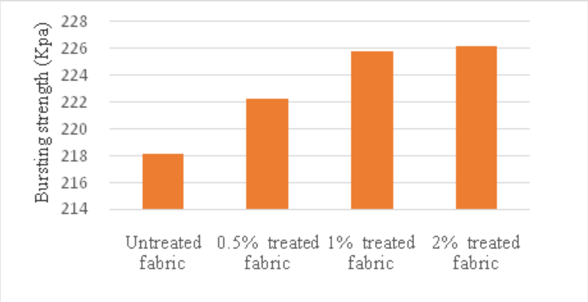


(a) (b) (c)

Fig. 1: SEM (Scanning Electron Microscope) image of untreated (a) treated with 0.5% TiO_2 (b) and treated with 1% TiO_2 (c) knit fabric.

Figure 1 shows the fiber surface topography of the knitted fabric samples after 500 times of magnification. By comparing the three images we can see that the untreated fiber surface (in figure, a) is smooth and delicate. But in treated fabric (in figure, b and c) it is thoroughly possible to recognize the TiO_2 particles on the surface of all samples. The TiO_2 particles are well dispersed on the fiber surface of the treated fabric and in some areas some aggregated TiO_2 particles are still visible. From the images of treated knit fabric (in figure, b and c), it is also observed that TiO_2 deposited on fiber surface in a consecutive way i.e. the amount of TiO_2 particles on fiber surface increases with the increasing of amount of TiO_2 in treatment time. The white and bright appearance of the treated fabric SEM images, proven the presence of white TiO_2 particles on the fabric surface.

3.3 Effect on burstingstrength: Comparative values of bursting strength are shown in figure 2 and elongations at breaking point are shows in figure 3. The data express that bursting strength of treated knitted fabric is more than the untreated fabric. Bursting strength increased rapidly in case of 0.5% and 1% treated fabric. In case of 2.0% treated fabric, bursting strength increased slightly than previous two. So it can be concluded that treatment of 100% cotton knitted fabric with TiO_2 will enhance the bursting strength of fabric. From the figure 3, it reveals that, elongation of the treated fabric at breaking point decreased gradually than the untreated fabric



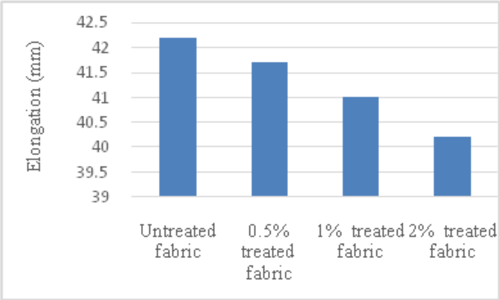
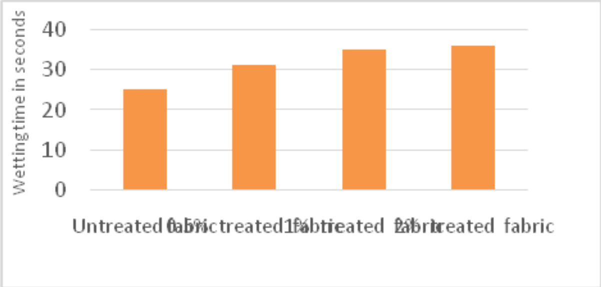


Fig. 2: Effect of TiO_2 on bursting strength of the treated anduntreated fabric samples

Fig. 3: Effect of TiO_2 on elongation of the treatedand untreated fabric samples

3.4 Observation of absorbency: The figure 4 represents the comparative study of wetting time of TiO_2 treated and untreated knit fabrics. The graph reveals that, titanium dioxide impaired the absorbency of knit fabric. Wetting time of all samples increases gradually with the increasing amount of TiO_2.

3.5 Observation of p^H of the fabric: From the figure 5, it is obvious that presence of titanium dioxide makes the fabrics slightly acidic. In the case of untreated fabric the p^H was 7 i.e. very much neutral. But treatment with TiO_2shifts the p^H to the slightly acidic condition and it reaches to the p^H value 6 in fabrics treated with 1.0% and 2.0% TiO_2.



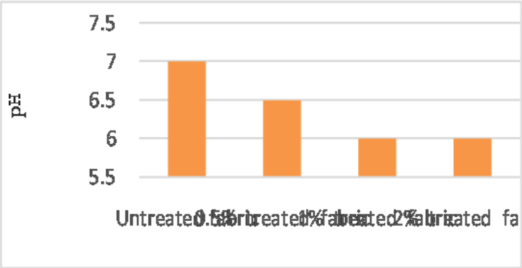


Fig. 4: Effect of TiO_2 on absorbency of the treated and untreated fabric samples

Fig. 5: Effect of TiO_2 on pH of the treated and untreated fabric samples

IV. CONCLUSION

By analyzing the test results, it is found that treated fabric surfaces become harsh and powdery due to the presence of titanium dioxide. Fabrics surfaces lose its smoothness in compared with untreated fabric. From scanning electron microscopy (SEM), it is obvious that titanium dioxide particles remain on treated fabric polymer chain. It clarifies that treatment by exhaustion method at 80°C capable of penetrating titanium dioxide particles through polymer chains of cotton fiber. Tensile strength (bursting strength) of fabric is increased while elongation at breaking point decreased. It is also observed that treatment with titanium dioxide impaired the absorbency of fabric and the p^H of the treated fabric is found in slightly acidic.

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