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Semi-Industrial Preparation of Biologically Active dyed fabrics Treated with Nano-metal oxides Impart them Multiple Functions for use in Potential Medical Approaches: Chemical and Bio-Treatment of Wastewater of Dyeing baths Effluents in an Environmentally Safe Manner

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Abstract

The enhancement of the production of garments designed to safeguard individuals employed in the healthcare sector from harmful pathogens has not only become more convenient and feasible but has also extended its applicability to encompass clothing for the general populace. Within the scope of our ongoing research endeavors, we are actively engaged in conducting a preliminary investigation, with the anticipation that it will be executed in manufacturing facilities in the near future. The procedural framework of our study entails the treatment of both cotton and polyester textiles with nanometal oxides, subsequent to which they undergo a dyeing process. Following this, an assessment of these treated fabrics is conducted to evaluate the acquired characteristics, which have exhibited highly encouraging outcomes. Simultaneously, measures are put in place to manage the wastewater generated during the dyeing phase in an ecologically responsible manner, ensuring the mitigation of any potential risks of environmental contamination.

Keywords:*Biotechnology ; Nanotechnology ; Antibacterial ; Dye Removal. Smart textiles*

1. Introduction

Individuals working within the medical field operating in environments where contagion is prevalent or attending to patients who harbor infectious diseases, germs, and microbes exhibit a rather intriguing lack of concern regarding the potential transmission of said diseases or microbes [1]. This phenomenon can be attributed to a multitude of factors, one of which pertains to the attire worn by medical personnel and the specific textiles utilized within medical facilities [2-6]. In the contemporary aria, a diverse range of innovative technologies are harnessed with the primary goal of enhancing, streamlining, and fortifying human existence. Among these advanced technologies are biotechnology and nanotechnology, the latter of which is increasingly pervasive across various spheres of human activity, alongside the burgeoning field of smart textiles. Smart textile technology stands out as a particularly novel and promising innovation due to its ability to interact with the wearer and the surrounding environment in response to external stimuli [7]. The amalgamation of nanotechnology and biotechnology within the textile industry has engendered a wave of innovative initiatives that have swiftly become integral components of our day-to-day routines, manifesting in the development of numerous high-tech fabrics designed for diverse purposes such as wound treatment, medicated bandages, and textiles imbued with fragrances, antiviral, antibacterial, and antifungal properties. Furthermore, it is worth noting that synthetic fibers have the capacity to be engineered to possess qualities akin to the softness and comfort traditionally associated with cotton fabric [8-12]. The integration of reagents, both inorganic and organic compounds, into the material of textiles has been a subject of interest. Among these, inorganic compounds, particularly metal oxides, have garnered more attention compared to their organic counterparts due to their superior ability to endure harsh environmental conditions and provide enhanced safety for human use. It is worth noting that most organic materials exhibit biocompatibility and biodegradability, thus highlighting the significance of incorporating nanostructures composed of inorganic compounds into textile materials, thereby presenting various advantages for the smart textile industry [9]. Diverse textile materials, such as cotton, polyester, and silk, serve as excellent substrates for the embedding of smart and efficient nanoparticles. Recent research indicates a prevalent utilization of TiO_2, ZnO, and MgO nanoparticles in functionalizing substrates owing to their numerous physiochemical and biological attributes, such as UV protection, antimicrobial efficacy, non-toxicity, and self-cleaning properties. In addition to enhancing the properties of textile materials concerning exposure to light, durability during washing, mechanical strength, and thermal resistance, the development of antimicrobial textiles necessitates the incorporation of active nanomaterials into fabrics, either through

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chemical bonding or physical means. Nanoparticles like Zn and Ti have demonstrated antimicrobial characteristics akin to those of antimicrobial agents. Although the precise mechanism behind their antimicrobial activity remains incompletely understood [1,2], one of the most recognized mechanisms involves the generation of reactive oxygen species (ROS) upon exposure to light. Subsequently, these ROS penetrate microorganisms, inducing oxidative harm to cellular components like carbohydrates, lipids, and proteins, eventually culminating in cell demise. On the nanoparticle surface, at least two photochemical processes take place concurrently when oxygen and water are present. Photo-induced negative electrons are engaged in reduction, while photo-induced positive holes are involved in the first process, oxidation. Highly reactive oxygen species (ROS), such as ($HO^{\bullet}$) and ($O_2^{\bullet-}$), are produced in these reactions and are essential to the photocatalytic effectiveness of TiO_2 and ZnO [3]. For UV protection, nanoparticles possessing UV-blocking capabilities, such as titanium dioxide and zinc oxide, can be seamlessly integrated into textiles to offer amplified defense against hazardous ultraviolet (UV) rays. These nanoparticles either absorb or reflect UV radiation, diminishing its permeation through the fabric and safeguarding the wearer's skin against sunburn and UV-induced damage or illnesses. Because of its exceptional chemical stability when exposed to UV radiation and its great efficacy at blocking UV-A and UV-B radiation, zinc oxide has UV protection qualities. ZnO high refractive index facilitates both absorption and refraction of UV radiation, preventing UV rays from diffusing or directly penetrating textile materials and reaching the skin. This is the process by which ZnO is thought to provide UV protection [4]. TiO_2 holds a significant place in the market because of its superior UVA and UVB radiation-blocking capabilities. Both TiO_2's chemical and physical characteristics are responsible for its UV protection, although the exact mechanisms are still up for debate [5]. ZnO and TiO_2 nanoparticle concentration, size, and crystalline structure all have a direct impact on their antibacterial and UV-protective properties on textile fibers. Moreover, nanoparticles like titanium dioxide can facilitate self-cleaning attributes in textiles by decomposing organic compounds upon exposure to light, thereby eliminating them from textile fibers, thereby ensuring the cleanliness and aesthetic appeal of the fabrics. Furthermore, this process results in super hydrophobicity, where water droplets effortlessly roll off the fabric's surface, carrying away any contaminants present. This phenomenon, known as the superhydrophobic self-cleaning effect, the physical self-cleaning effect, or simply the lotus effect, underscores the remarkable potential of nanoparticles in enhancing the functionality of textiles [6]. In the research conducted by our team, polyester and cotton were chosen as the primary substrates due to their status as archetypal representatives of synthetic and natural origins, respectively. Initially, the fabrics underwent a treatment process involving the application of nanometal oxides such as TiO_2 and ZnO, each at varying concentrations tailored to the specific substrate. Subsequently, the cotton fabric was subjected to dyeing with reactive blue 19 dye, while the polyester fabric underwent a dyeing process utilizing disperse red 60 dye. The subsequent phase involved the evaluation of the fabrics to ascertain the presence of the intended characteristics, with appropriate control samples utilized to discern any variations. The intricate processes of dyeing and treating the fabrics are known to be laborious endeavors that necessitate a considerable volume of water. The disposal of such wastewater without appropriate processing is not just harmful to the environment because of resource depletion but also represents a significant risk of environmental damage (13-21). A tiny stabilizing effect is produced by the reactive dye's distinctive chemical structure, which makes it resistant to chemical attack. This is because hydrolysis reactions compete with the reactive dye's creation of its reactive state, vinyl sulfone. Because they hinder photosynthesis and reduce light penetration, they may have a detrimental effect on the ecosystem. The textile industries employ Reactive Blue 19 (RB19), sometimes referred to as Remazol Brilliant Blue, which is an anthraquinone dye. Consequently, it is imperative that dye be removed from wastewater. Color can be eliminated by a variety of physical, chemical, biological, or hybrid techniques [7]. Consequently, the treatment of wastewater has emerged as a prominent, indispensable, and highly beneficial sector in contemporary society. Our study adopted diverse approaches, encompassing chemical methods employing MgO nanoparticles in conjunction with ultraviolet (UV) radiation. Such a method is referred to as the advanced oxidation process (AOP). The great efficiency and high oxidation potential of AOP make it a highly effective method for removing organic molecules. Under general terms, the AOP describes a procedure wherein an ultraviolet light source is present or not, along with a powerful oxidizing agent and catalyst like magnesium oxide and ozone [8, 9]. In addition to biological techniques involving the enzymatic activity of bacteria, the ultimate aim is to optimize outcomes, yielding reusable water resources that can be effectively repurposed across various domains.

2. Materials and Methods

2.1. Treatment process: In our study, metal oxide nanoparticles, specifically ZnO and TiO_2, were applied to two distinct substrates, cotton and polyester, at varying concentrations of 1%, 2%, and 3%. Both ZnO and TiO_2 underwent identical treatment processes. To begin, fabric samples of cotton and polyester were immersed in a 10 g/l solution of nonionic detergent (Hostapal, Clariant) for 10 minutes. Following this, a gentle stirring period of 15 minutes was employed to ensure the dispersion of nanoparticles. Any excess dispersion was eliminated thorough pressing of the textiles. Subsequently, the treated fabrics were subjected to a baking process at 70°C for 10 minutes, followed by a query at 140°C for 3 minutes. Following the thermal treatment, the textiles underwent a cleaning phase. This involved immersing the fabrics in an aqueous solution containing a liquor ratio of 1:50 and 3 g/l of nonionic detergent solution (Hosta pal, Clariant). The cleaning process was conducted for 15 minutes at a temperature of 60°C.Through this meticulous methodology, we aimed to investigate the effects of metal oxide nanoparticles on both natural (cotton) and manufactured (polyester) substrates. [10]

2.2 Dyeing process. The several types of treated textiles underwent dyeing using distinct dye varieties; specifically, reactive blue 19 was applied to the cotton specimens, while disperse red 60 was utilized for the polyester counterparts.

2.2.1 Dyeing of Cotton: Fabric specimens, each with a weight of 2 grams, were carefully placed into a specialized vessel that had been filled with a meticulously prepared dyebath solution containing a specific dye shade concentration of 2% (o.w. f). The experimental process of applying reactive blue 19 dye in the context of this particular research endeavor entailed the precise utilization of a solution composed of 60 grams per liter of sodium sulfate in conjunction with 20 grams per liter of

sodium carbonate. The initial stages of the dyeing procedure entailed subjecting the fabric material to the sodium sulfate solution at a controlled temperature of 60 degrees Celsius for a specified duration of 30 minutes. This was then followed by a subsequent fixation stage involving immersion in a sodium carbonate solution for the same period of time (30 minutes) at the same temperature of 60 degrees Celsius. Following these meticulous treatment steps, the dyed fabric specimen underwent a thorough rinsing process for 30 minutes at 60 degrees Celsius in a vessel containing a detergent solution with a concentration of 3 g/L to eliminate any residual dye or chemicals, after which it was carefully transferred for drying under controlled ambient room temperature conditions, ensuring optimal drying outcomes.

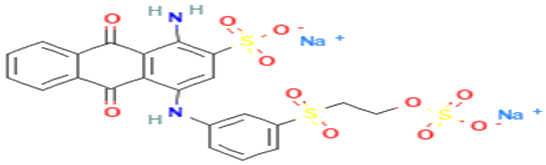

Figure 1: Chemical Structure of Reactive Blue 19

2.2.2. Dyeing of Polyester: The dyes were utilized in their pure powder state, in an unaltered manner without undergoing any milling process. Fabric specimens weighing 2 g were placed into a vessel filled with a dyebath containing a dye shade of 2% (O.W.F) and Matexil DA-N (provided by ICI Company, UK) acting as a dispersing agent at a temperature of 130 °C with a liquor ratio of 1:50. To prepare the dyebath, the dye was initially combined with 10 drops of DMF, followed by mixing with the dispersing agent, and eventually water was added to create a uniform dispersion of the dye. The pH level was regulated to 4.5 using acetic acid. Following the dyeing procedure, the dyed test specimens were extracted, cleansed in warm water, and exposed to reduction clearing in a solution comprising 2 g/L of sodium hydrosulphite and 2g/L of sodium hydroxide (caustic soda) for 10 minutes at a temperature of 60 °C, with a liquor ratio of 1:40; subsequently, the reduction-cleared specimen was thoroughly rinsed inwater. The dyed specimens were then taken out, washed in tap water, and left in the air to dry. [12]

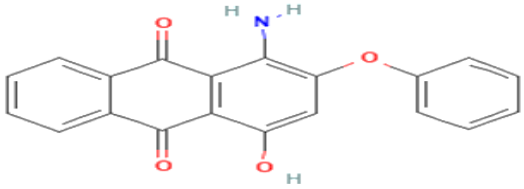

Figure 2: Chemical Structure of disperse Red 60.

2.3. Fastness Properties: The American Association of Textile Chemists and Colorists conducted assessments to gauge the fastness properties of colored specimens across various scenarios. These assessments encompassed evaluations under conditions like rubbing, washing, and perspiration, employing a gray scale with grades spanning from 1 to 5. Moreover, the assessment included the evaluation of light fastness, utilizing a blue wool scale with grades ranging from 1 to 8. In these evaluations, the specimens underwent rigorous testing to find their resistance to fading or alteration in color when subjected to different environmental conditions or external factors. The grading systems provided a standardized method for quantifying the degree of color retention or stability exhibited by the materials under examination. By utilizing these established scales, textile chemists and colorists could effectively compare and analyze the performance of various materials, aiding in the development of products with enhanced durability and colorfastness. This systematic approach to assessing fastness properties is crucial for ensuring the quality and longevity of colored textiles in real-world usage scenarios. [13]

2.3.1. Washing Fastness: After sandwiching the composite samples between two colored pieces of cotton and wool, they were immersed in an aqueous solution containing 5 g/L of nonionic detergents for 30 minutes at 60 °C for Cotton and 50 °C for Polyester. The samples were removed and then dried. The wash fastness for color change was evaluated using the grey scale. [13]

2.3.2. Rubbing Fastness: The method used to determine color fastness to rubbing was ISO 105-X12:1987. The goal of the test is to ascertain the amount of color that may transfer from the colored material's surface to another surface. In the current test, materials can be employed either dry or wet. [13]

2.3.2.1. Dry Rubbing: A white testing cloth was fastened once the test specimen was leveled on the base of the crock meter. The test subject was made to move a covered finger twenty times back and forth. The white test sample was eliminated, then stained, and the grayscale was used for investigation. [13]

2.3.2.2.Wet Rubbing: Water covered 65% of the white test sample's surface. The same approach was followed. The white test samples were allowed to air dry before being evaluated. [13]

2.3.3. Light Fastness: Light fastness testing in compliance with ISO 105-B02. A carbon arc lamp is used in the test, running continuously for 35 hours. In the end, it can be concluded that the type of cloth the dye has been applied to determines the color of the colored cloth, which gets more intense as the dye concentration rises. This is because distinct chemical groups found in various textiles may significantly impact a dye's light fastness index when applied to a certain cloth. the distribution

of wavelengths in the incoming light; not every absorption initiates the bleaching process equally. The surrounding air's chemistry and humidity can significantly affect how quickly some colorants fade. We used the blue scale to measure the color variations of the items. [13]

2.3.4. Perspiration Fastness:

The perspiration test was conducted according to our previous work [12, 13].

2.4. Ultraviolet Protection Factor : We utilized the advanced ultraviolet visible spectrophotometer 3101, which is recognized as a sophisticated and meticulously accurate scientific device, in order to conduct a quantitative evaluation of the quantities of ultraviolet radiation that have been either absorbed or permitted to transmit through the dyed and chemically processed textiles, irrespective of whether they were constructed from natural cotton fibers or artificial polyester materials.[13]

2.5. Antibacterial Activity Measurement:

Upon subjecting the fabrics to a series of treatments involving different concentrations of ZnO and TiO_2 ranging from 1% to 3%, two distinct categories of dyes, namely reactive Blue19 for the cotton samples and dispersed Red60 for the polyester ones, were meticulously administered, and two different tests were conducted to evaluate the antibacterial activity of the fabrics as a result of the treatment.

2.5.1 Inhibition Zone:

This meticulous approach was adopted to assess and evaluate the antibacterial properties exhibited by the treated fabrics. The evaluation process involved the implementation of various experimental methodologies, including, but not limited to, the examination of inhibition zones as a key indicator of antibacterial efficacy within the fabrics. In a particular scientific investigation. The antimicrobial potential of the investigated compounds was assessed via the agar disk diffusion method on a nutrient agar medium. All the compounds have been checked in vitro for antibacterial activity against Escherichia coli, Salmonella enterica, and Klebsiella pneumonia (gram-negative bacteria), with additional testing against Staphylococcus aureus, Bacillus subtilis, and Streptococcus mutans (gram-positive bacteria). Ampicillin and Gentamicin were standard antibiotics for Gram-positive and Gram-negative bacteria, respectively. Dimethyl sulfoxide (DMSO) was employed as the negative control solvent in the experiment. The efficacy of the compounds was evaluated against bacterial strains at a concentration of 15 mg/ml. The sterilized Petri dishes were filled with sterilized media (20–25 mL per dish) and allowed to solidify at room temperature. A bacterial suspension was prepared in a sterile saline solution with the same concentration as the McFarland 0.5 standard solution (1.5 x 105 CFU/mL). Ideally, within 15 minutes after generating the inoculum solution, a sterile cotton swab was immersed into the adjusted solution, overwhelmed on the dried agar surface, and subsequently allowed to dry for 15 minutes with the cover kept on. Samples were sliced into 10 mm-diameter discs and deposited on the agar medium. The plates were incubated at 37°C for 24 hours to assess antibacterial activity. This experiment was performed three times, and the inhibition zones have been documented on a millimeter scale. [14]

2.5.2Colony Forming Unit (CFU) :

To verify the antibacterial activity of the given treatment, an additional laboratory test was performed (CFU colony-forming unit). We chose some bacterial strains that the samples showed the best activity against; the gram-positive one is Bacillus subtilis, while E. coli and Staphylococcus aureus were used as gram-negative bacteria, and the test was applied to the cotton and polyester samples. Using the agar-plating method, the previous bacterial strains were used to assess the antibacterial activity of the nanoparticles. The bacterial suspension (McFarland standard 0.5) was made and cultured in Mueller-Hinton broth medium to measure the antibacterial ratio of the samples. The tested samples and control sample (DMSO) were then placed into a 96-well plate, and 200 µl of the produced bacterial suspension was added. The well plate was then incubated for 24 hours at 37 °C.Subsequently,dried nutrient agar plates were covered with a 20 µl bacterial solution and cultivated. The plates were incubated for twenty-four hours at 37°C. Using a digital camera, the bacterial colony on the plates was examined & the number of colonies was counted. This is how the antibacterial efficacy was measured. [15]

$$\text{Antibacterial Ratio} = \frac{X - Y}{X} \text{ x } 100$$

Where (X = No. of Colonies in Control) , (Y = No. of Colonies in Experimental)

2.6. Chemical removal of Reactive Blue19 using MgO NPs and UV:

In all trials, a volume of 20 mL of dye solution was utilized with a specified initial concentration and pH through the process of diluting the dye stock solution (0.1 g/L) of reactive blue 19 with distilled water while ensuring constant stirring. The pH levels in the trials were regulated by employing a mixture of diluted acetic acid and sodium carbonate. A specific quantity of MgO nanoparticles was introduced into the solution, which encompassed various concentrations of H_2O_2. Following this, the amalgam was agitated for a duration of 180 minutes under a UV lamp emitting a wavelength of 365 nm. After the completion of the irradiation period, the decolorization rate was quantified, and subsequently, all trials were left undisturbed for 24 hours under daylight before reevaluating the decolorization rate. All procedures were conducted at room temperature. The experimentation was replicated multiple times, with the alteration of one variable during each iteration in order to ascertain the optimal conditions for the experiment. [16]

3. Results and Discussion.

3.1. Fastness Properties &Color Strength :

The research findings demonstrate that the utilization of titanium dioxide (TiO_2) and zinc oxide (ZnO) nanoparticles (NPs) contributed to an improvement in fabric characteristics, notably reducing the rate of fading under diverse conditions including washing, rubbing, perspiration, and exposure to light. The fabrics showcased commendable resistance to light fading, as evaluated on the blue scale, alongside satisfactory outcomes in both washing and perspiration assessments. Furthermore, while the rubbing test results were moderate according to the gray scale, the overall performance of the fabrics was notably enhanced by the incorporation of TiO2 and ZnO NPs. These nanoparticles effectively bolstered the fabric's ability to withstand various environmental stressors, thus prolonging its lifespan and enhancing its aesthetic appeal. The study underscores the potential of TiO_2 and ZnO NPs as valuable additives in textile production, offering manufacturers a means to enhance fabric durability and maintain visual integrity amidst frequent use and exposure to external elements.

Table 1: Perspiration Fastness for Polyester.

Sample No.	ST	ST*	ST**	ALT	ST	ST*	ST**	ALT
	Acid				Base			
1	4	4	4	4	4	4	4	4
2	4	4	4	4	4	4	4	4
3	4	4	4	4	4	4	4	4
4	4	4	4	4	4	4	4	4
5	4	4	4	4	4	4	4	4
6	4	4	4	4	4	4	4	4
7	4	4	4	4	4	4	4	4

*** Polyester: [1 : 3 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [4 : 6 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)] [7 Blank (Untreated)]**

Table 2: Perspiration Fastness for Cotton

Sample No.	ST	ST*	ST**	ALT	ST	ST*	ST**	ALT
	Acid				Base			
8	4	4	4	4	4	4	4	4
9	4	4	4	4	4	4	4	4
10	4	4	4	4	4	4	4	4
11	4	4	4	4	4	4	4	4
12	4	4	4	4	4	4	4	4
13	4	4	4	4	4	4	4	4
14	4	4	4	4	4	4	4	4

*** Cotton: [8 : 10 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [11 : 13 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)] [14 Blank (Untreated)]**

3.1.1. Perspiration Fastness:

The results indicate a consistent outcome across all samples, regardless of the treatment applied. This uniformity suggests that the variations in nanoparticle concentration did not significantly impact the perspiration resistance of the fabrics. Such findings could have implications for the practical application of these treatments in textile engineering, indicating that the effectiveness of the treatments might plateau beyond a certain concentration threshold. Further investigation could delve into the underlying mechanisms behind this saturation effect and explore alternative strategies for enhancing fabric properties. (Table 1&2)

3.1.2. Light Fastness:

The light test using a carbon arc lamp assessed polyester and cotton fabrics treated with TiO_2 and ZnO nanoparticles, alongside ablank sample, revealing a uniform blue scale rating of 6, indicating moderate color change postexposure,and in table no. 3, the untreated polyester sample (blank) gave a lower value than the treated ones. Furtherinvestigation intoNanoparticle concentrations and fabric composition is suggested to understand their specific effects on color retention. Despite this, a rating of 6 falls within acceptable limits for many applications, highlighting the study's relevance in optimizing fabric treatments and guiding material selection in contexts prioritizing color
longevity. (Table 3)

3.1.3. Rubbing Fastness :

Using both cotton and polyester fabrics and treating them with different percentages of TiO_2 and ZnO nanoparticles allows for a comprehensive examination of how these treatments affect the fabric's properties. The use of a gray scale to evaluate the results adds a quantitative aspect to your findings, providing a clear indication of the level of color transfer or retention after

rubbing.The fact that most of the results fall within the range of 3 to 4 suggests a moderate degree of color transferor alteration,which can be further analyzed and compared to assess the effectiveness of each treatment.(Table 4)

3.1.4. Washing fastness:

The utilization of various concentrations (1%, 2%, and 3%) of TiO_2 and ZnO nanoparticles facilitates a comprehensive examination of how different treatment levels affect the performance of the fabric. This methodology aids in the identification of the most effective concentration levels to improve the fabric's resilience and color retention. The consistent observation of a gray scale value of 4 in all samples indicates The successful preservation of color vibrancy and fabric quality post laundering. This homogeneity suggests that both TiO_2 and ZnO nanoparticles present feasible options for augmenting the durability and colorfastness of polyester and cotton textiles, although further investigation is necessary to ascertain the nanoparticle variety and concentration that offer the greatest advantages.

Table 3: Light Fastness for Polyester and Cotton.

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Result	6	6	6	6	6	6	5-6	6	6	6	6	6	6	6

*** Polyester: [1 : 3 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [4 : 6 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)] [7 Blank (Untreated)]**
*** Cotton: [8 : 10 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [11 : 13 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)] [14 Blank (Untreated)]**

Table 4: Rubbing Fastness for Polyester and Cotton.

Sample No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Result	Dry	3-4	4	4	4-5	4-5	4-5	4-5	4	3-4	4	4	3-4	4	4
	Wet	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	3-4	4	3-4	4	3-4

*** Polyester: [1 : 3 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [4 : 6 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)] [7 Blank (Untreated)**
*** Cotton: [8 : 10 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [11 : 13 (1% (ZnO) , 2% (ZnO) ,3% (ZnO)] [14 Blank (Untreated)**

Table 5: Washing Fastness for Polyester.

Sample No.	ST	ST*	ST**	ALT
1	4	4	4	4
2	4	4	4	4
3	4	4	4	4
4	4	4	4	4
5	4	4	4	4
6	4	4	4	4
7	4	3-4	4	4

*** Polyester: [1 : 3 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)][4 : 6 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)] [7 Blank (Untreated)]**

Table 6: Washing Fastness for Cotton

Sample No.	ST	ST*	ST**	ALT
8	4	4	4	4
9	4	4	4	4
10	4	4	4	4
11	4	4	4	4
12	4	4	4	4
13	4	4	4	4
14	4	4	4	4

*** Cotton: [8 : 10 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [11 : 13 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)][14 Blank (Untreated)]**

3.2.1.Color Strength of Polyester:

The data different samples. The measurements include L*,a*,b*,and **Δ**E values, providing insights into the colorimetric properties of the dyed polyester. Overall, the colour strength appears to vary slightly among the samples, with differences in L* values indicating variations in lightness, and variations in a* and b* values indicating differences in chromaticity. The addition of different percentages of TiO_2 and ZnO to the polyester demonstrates potential treatments that could influence colour strength.

Table 7: Color Strength of dyed Polyester.

Sample No.	K/S	L	a	b	Δ E
1	11.69	55.50	-5.28	-21.46	35.91
2	12.50	54.67	-4.27	-22.37	36.91
3	12.96	56.63	-4.29	-23.67	36.25
4	13.27	55.28	-4.28	-24.32	37.66
5	13.20	55.91	-4.10	-24.21	37.13
6	13.20	55.48	-.4.08	-24.34	37.50
7	13.43	55.41	-4.10	-24.56	37.70
*** Polyester: [1 : 3 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)][4 : 6 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)] [7 Blank (Untreated)]**					

3.2.2.Color Strength of Cotton: The data presented in Table 8 illustrates the colour strength of cotton dyed with Reactive Blue 19 under various conditions, including different concentrations of titanium dioxide (TiO_2) and zinc oxide (ZnO), as well as untreated (blank) cotton. Across the samples, there is a noticeable variation in colour strength, it appears that the presence and concentration of both TiO_2 and ZnO impact the colour strength of the dyed cotton, with some variations observed between different concentrations. These findings suggest that the choice and concentration of dyeing agents play a crucial role in determining the colour strength of dyed cotton, which is essential information for optimizing dyeing

Table 8: Color Strength of dyed Cotton.

Sample No.	K/S	L	a	b	Δ E
8	2.75	55.50	-5.28	-31.64	-21.46
9	2.86	54.67	-4.27	-32.56	-22.37
10	2.61	56.63	-4.29	-33.86	-23.67
11	2.68	55.28	-4.26	-34.50	-24.32
12	2.76	55.91	-4.28	-34.39	-24.21
13	2.85	55.48	-.4.10	-35.56	-24.34
14	2.89	55.41	-4.8	-34.76	-24.57
*** Cotton: [8 : 10 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [11 : 13 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)] [14 Blank (Untreated)]**					

3.3. Ultraviolet Protection Factor (UPF): The correlation between the increasing ultraviolet protection factor and the blocking of various UV radiation types by polyester and cotton fabrics is found to be directly linked to the concentration of treatment applied to the dyed samples, as evidenced by the results obtained from sample no. 14 (3% ZnO) cotton and sample no. 6 (3% ZnO) polyester. Moreover, the effectiveness of ZnO in comparison toTiO_2 in providing protection against ultraviolet radiation is notably more pronounced in polyester samples than in cotton ones. Subsequent to the analysis of the dyed samples, it is commonly presumed that the UV protection values of 32.8 (sample no. 7) for polyester and 4.3 (sample no. 15) for cotton fabrics indicate very good to outstanding levels of UV protection even in the absence of treatment. Furthermore, the data illustrated in Table 9 serves to demonstrate that the control fabrics composed of polyester (sample no. 8) and cotton (sample no. 16) display the lowest UV protection factor when compared to the other samples, registering values of 0.7 for cotton and 23.0 for polyester, respectively. The discoveries highlighted in the research emphasize the significant potential of utilizing TiO_2 and ZnO treatments for enhancing ultraviolet (UV) protection, with a specific focus on their efficacy in polyester fabrics. This indicates a promising avenue for the implementation of these treatments in UV-protective textiles, showcasing their beneficial impact on overall UV protection levels within the textile industry.

Table 9: Ultraviolet Protection Factor Measurement

Sample No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Result	**UPF**	30	34.9	32.2	36.4	26.1	37.8	32.8	23	5.4	5.7	5.7	5.7	5.9	7.3	4.3	0.7
	UVA	6.8	5.4	5.7	5.7	7.3	4.9	5.0	25.5	20.7	19.3	19.8	19.3	19.2	15.6	12.6	88.4
	UVB	3	2.6	2.9	2.4	3.5	2.5	2.9	2.2	18.7	17.8	17.6	17.8	17.3	14.1	24.3	158.5
*** Polyester: [1 : 3 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [4 : 6 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)] [7 (Dyed & Not Treated)] [8 Blank (Not Dyed & Not Treated)] * Cotton: [9 : 11 (1%(TiO_2) , 2%(TiO_2) , 3%(TiO_2)] [12 : 14 (1%(ZnO) , 2%(ZnO) , 3%(ZnO)] [15 (Dyed & Not Treated)] [16 Blank (Not Dyed & Not Treated)]**																	

3.4. Inhibition Zone Measurement: Presentation of polyester specimens is outlined in Table 10, denoted by the numbers 1 through 7, while the cotton specimens are delineated in Table 11, represented by the numbers 8 through 14. Table 10 outlines the quantity of polyester samples that proved biological efficacy towards certain relevant bacterial strains. The group of gram-negative bacteria was subjected to samples numbered 1, 2, 3, and 4, revealing an absence of any discernible activity against the bacterial strain. Conversely, samples 5, 6, and 7 exhibited a notable inhibitory effect on this particular strain with inhibition zones = 12.0±1mm, 14.0±1mm and 12.3±0.6mm respectively. Notably, sample number 6 demonstrated the most potent inhibitory activity among all the tested samples. Moving on to bacterial strain b, it was observed that all samples

induced an equivalent inhibitory effect, resulting in an inhibition zone with a maximum diameter of approximately 11.3± 0.6 millimeters. In the case of bacterial strain c, the majority of samples did not exhibit any activity against it, except for samples 5 and 7 which demonstrated a similar inhibitory effect., they produced inhibition zones measuring 13.0±1 millimeters and 13.3±0.6 millimeters respectively. In relation to gram-positive bacteria, the majority of the samples exhibited notable antimicrobial activity against this type of bacteria. In the case of bacterial strain D, it was observed that sample number 2 did not demonstrate any activity, in contrast to the other samples which resulted in inhibition zones with values ranging from a minimum of 11.3±.6mm produced by sample number 7 to a maximum of 13.3±0.6mm caused by sample number 5. Proceeding to evaluate bacterial strain E, it was determined that every single sample exhibited remarkable antibacterial efficacy against the specific microorganism under scrutiny. Samples denoted as numbers 3, 5, and 7 manifested an inhibitory region measuring at 10.7±0.6mm, while conversely, samples labeled as numbers 1, 2, 4, and 6 showcased broader inhibitory regions spanning from 11.0±1mm in the case of sample number 2 to 11.3±0.6mm for the remaining samples. Finally, with regards to bacterial strain F, samples number 2, 5, and 6 did not exhibit any activity, while the rest of the samples showed substantial antimicrobial effects. Notably, sample number 1 resulted in an inhibition zone of 18.3±.6mm, while samples number 3 and 4 showed approximate values of 16.0±1mm and 16.3±.6mm respectively. Sample number 7 displayed the lowest value of antimicrobial activity among the samples tested. Regarding the cotton samples in Table11 according to the findings regarding the gram-negative bacteria, it was observed that all analyzed samples exhibited significant antibacterial activity against bacterial strain A, The inhibition zone values were found to be quite consistent across samples 8, 10, 11, and 14, with a measurement of 11.0 ±1mm. Interestingly, sample numbers 12 and 13 displayed a slightly wider inhibition zone of 11.3±.6mm, while the most substantial inhibition zone was recorded for sample number 9, measuring at 12.3±.6mm. Moving on to strain B, it was noted that samples 9, 10, 11, 12, and 13 did not demonstrate any antibacterial activity. In contrast, sample 8 exhibited an inhibition zone of 11.3 ± 0.6 mm, while sample 14 showcased the widest inhibition zone at 14.0 ± 1 mm. Shifting the focus to bacterial strain C, samples 9, 11, 12, and 13 did not exhibit any activity. On the other hand, samples 8, 10, and 14 displayed significant antibacterial activity, with values of 11.0 ± 1 mm for sample 8, and 15.0 ± 1 mm, 15.3 ± 0.6 mm for samples 10 and 14, respectively. Regarding the gram-positive bacteria, sample number 12 did not show any activity against bacterial strain D. However, the remaining samples displayed varying levels of activity with distinct inhibition zones. Samples 9, 11, and 13showed inhibition zone values of 11.0 ± 1 mm, while samples 8, 10, and 14 exhibited inhibition zones of 12.3 ± 0.6 mm. Sample number 13 showed an inhibition zone of 13.0 ± 1 mm. Across the board, all samples demonstrated moderate activity against strain E. Sample 11 showed an inhibition zone of 10.7 ± 0.6 mm, sample 10 had a value of 11.0 ± 1.0 mm, and samples 9, 12, and 14 displayed inhibition zones with a value of 11.3 ± 0.6 mm. The widest observed inhibition zones were 12.3 ± 0.6 mm and 13.3 ± 0.6 mm, caused by samples 8 and 13, respectively. Notably, no activity was observed against strain F by samples 9, 10, 11, and 12. Conversely, samples 8, 13, and 14 showcased varying levels of activity with inhibition zones measuring at 12.7 ± 0.6 mm, 15.3 ± 0.6 mm, and 12.0 ± 1 mm, respectively. The treatment's biological efficacy demonstrated a more pronounced impact on gram-positive bacteria in comparison to gram-negative bacteria, irrespective of whether the samples were composed of polyester or cotton. In the case of polyester samples, the most effective antibacterial properties were demonstrated by TiO_2 at concentrations of 2% and 3%, resulting in the widest zones of inhibition. Moreover, a considerable zone of inhibition was observed with 2% ZnO, closely mirroring the earlier data. The most evident inhibitory zones in the cotton samples were generated by ZnO at concentrations of 2% and 3%, confirming more powerful antibacterial activity.

Table 10: The Antibacterial Activity of The Treated Polyester Against Different Bacterial Strains. confirming more powerful antibacterial activit

Sample No.	1	2	3	4	5	6	7	Standard Antibiotic
Gram Negative Bacteria	**Clear Zone (mm)**							**Gentamicin**
(a) *Escherichia coli (ATCC:10536)*	NA	NA	NA	NA	12.0 ± 1.0	14.0 ± 1.0	12.3 ± 0.6	27.0 ± 1.0
(b) *Klebsiella pneumonia (ATCC:10031)*	11.0 ± 1.0	11.0 ± 1.0	11.3 ± 0.6	11.0 ± 1.0	11.3 ± 0.6	11.0 ± 1.0	11.3 ± 0.6	25.3 ± 0.6
(c) *Salmonella enterica (ATCC:14028)*	NA	NA	NA	NA	13.0 ± 1.0	NA	13.3 ± 0.6	18.3 ± 0.6
Gram Positive Bacteria	**Clear Zone (mm)**							**Ampicillin**
(d) *Staphylococcus aureus (ATCC:13565)*	12.0 ± 1.0	NA	12.0 ± 1.0	12.3 ± 0.6	13.3 ± 0.6	12.0 ± 1.0	11.3 ± 0.6	22.0 ± 1.0
(e) *Streptococcus mutans (ATCC:25175)*	11.3 ± 0.6	11.0 ± 1.0	10.7 ± 0.6	11.3 ± 0.6	10.7 ± 0.6	11.3 ± 0.6	10.7 ± 0.6	20.3 ± 0.6
(f) *Bacillus subtilis (DSM:1088)*	18.3 ± 0.6	NA	16.0 ± 1.0	16.3 ± 0.6	NA	NA	13.0 ± 1.0	21.0 ± 1.0

*** Polyester: [2 : 4 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [5 : 7 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)] [1: Blank (Untreated)]**

Table 11:Antibacterial Activity of The Treated Cotton Against Different Bacterial Strains.

Sample No.	8	9	10	11	12	13	14	Standard antibiotic
Gram Negative Bacteria	**Clear Zone (mm)**							**Gentamicin**
(a) *Escherichia coli* *(ATCC:10536)*	11.0 ± 1.0	12.3 ± 0.6	11.0 ± 1.0	11.0 ± 1.0	11.3 ± 0.6	11.3 ± 0.6	11.0 ± 1.0	27.0±1.0
(b) *Klebsiella pneumonia* *(ATCC:10031)*	11.3± 0.6	NA	NA	NA	NA	NA	14.0 ± 1.0	25.3±0.6
(c) *Salmonella enterica* *(ATCC: 14028)*	11.0 ± 1.0	NA	15.0 ± 1.0	NA	NA	NA	15.3 ± 0.6	18.3±0.6
Gram Positive Bacteria	**Clear Zone (mm)**							**Ampicillin**
(d) *Staphylococcus aureus* *(ATCC:13565)*	12.3 ± 0.6	11.0 ± 1.0	12.3 ± 0.6	11.0 ± 1.0	NA	13.0 ± 1.0	12.3 ± 0.6	22.0±1.0
(e) *Streptococcus mutans* *(ATCC:25175)*	13.3 ± 0.6	11.3 ± 0.6	11.0 ± 1.0	10.7 ± 0.6	11.3 ± 0.6	12.3 ± 0.6	11.3 ± 0.6	20.3±0.6
(f) *Bacillus subtilis* *(DSM: 1088)*	12.7± 0.6	NA	NA	NA	NA	15.3 ± 0.6	12.0 ± 1.0	21.0±1.0

*** Cotton: [8 Blank (Untreated)] [9 : 11 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2))] [12 : 14 (1% (ZnO) , 2% (ZnO) , 3% (ZnO))]**

3.5. Colony Forming Unit (CFU):

In the examination of the polyester samples, each individual sample underwent rigorous testing against the bacterium known as *Bacillus subtilis* a gram-positive strain the samples showed good antibacterial activity against. The inhibition percentage resulting from this testing was meticulously calculated for every single sample in the study. Specifically, sample number 6, containing 2% ZnO, exhibited the least activity with an inhibition percentage of 11.1%. Conversely, the highest level of activity was observed in sample numbers 7 (featuring 3% ZnO) and 2 (containing 1% TiO_2). The remaining samples displayed moderate levels of activity, showcasing a range of inhibitionpercentages including 36.0%, 38.5%, 18.5%, and 37.04% for samples 1, 3, 4, and 5 respectively. Upon further analysis involving the application of E. Coli, a Gram-negative bacterium, onto the samples, a distinct pattern emerged. Sample number 7, with 3% ZnO, detrated and cotton sample no.8 against B. subtilis, **(b):**cotton samples no.13&no.14against *B. subtilis*, **(c):**polyester samples no.5&no.6&no.7and cotton sample no.8 against E. coli, cotton samples no.13 and no.14 against K. pneumonia. **(d):**cotton samples no.11&no.12&no.13&no.14 against *S. aureus*The confirmation of the numerical data mentioned previously was achieved through the analysis of visual data. It was observed in figure 3a that polyester samples 1, 3, and 4 exhibited notably wide inhibition zones against B. subtilis, in contrast to sample numbers 2, 5, and 6 which showed no activity, with only a weak activity detected in sample numbers 7 and 8. Furthermore, the examination of the cotton samples, specifically sample number 13 as depicted in figure 3b, revealed a significantly wide inhibition zone against B. subtilis, while sample number 14 exhibited a weaker activity. Moving on to figure 3c, it was evident that sample number 6 caused the most prominent inhibition zone against E. coli, whereas the other samples displayed negligible effects. Subsequently, in figure 3d, the biological activity of certain cotton samples against S. aureus was assessed, with sample numbers 13 and 14 showcasing noticeable inhibition zones, while the remaining samples exhibited weak or almost imperceptible activity.

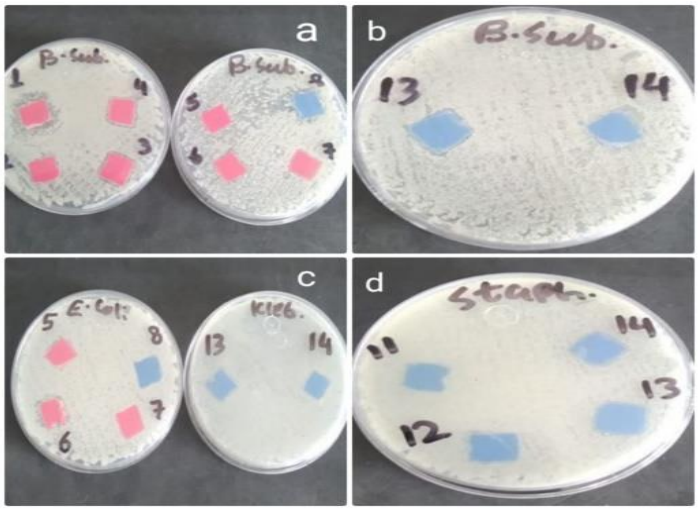

Figure3: the photographs show the inhibition zones caused by some samples of the treated fabrics**(a):**polyester samples (1-7)

most favorable outcome with an inhibition percentage of 48.8%. Following closely behind was sample number 3 (featuring 2% TiO_2) with an inhibition percentage of 46.0%. On the other end of the spectrum, sample number 6 displayed the lowest inhibition percentage at 18.0%. The remaining samples showed relatively similar inhibition percentages, hovering around 20.8%, 30.0%, 20.0%, and 26.0% for samples 1, 2, 4, and 5 respectively. In relation to the cotton samples, each individual sample underwenttesting against the bacterium Staphylococcus aureus, characterized as a gram-negative organism, and subsequently the inhibition percentage was meticulously calculated for every single one of these samples.Sample number 14

containing 3% Zinc Oxide exhibited the most remarkable activity with an inhibition percentage reaching an impressive 98.8%, whereas sample number 13 comprising 2% Zinc Oxide displayed the least inhibition percentage of a mere 11%. Furthermore, the remaining samples showcased varying degrees of activity, such as samples number 8 and 9 both reflecting inhibition percentages of 96.3%, sample number 10 exhibiting a value of 90.2%, sample number 11 demonstrating 64.6%, and sample number12 revealing 59.8%. Upon closer examination, it is evident that the cotton samples exhibited dissimilar levels of activity against the gram-positive bacteria known as Bacillus subtilis. Notably, the highest inhibition percentages were noted in samples 8, 9, and 11, recording values 96.4%, 95.8%, and 96.7% respectively. Conversely, the remaining samples presented a spectrum of inhibition values, with samples 10, 12, and 14 displaying figures of 74.3%, 92% and 89.2% respectively. Remarkably, the sample with the lowest inhibition percentage was identified as samplenumber13, registering an inhibition percentage67.4%.

Table 12: CFU results of Polyester against (*Bacillus subtilis*&*Escherichia coli*) showing the inhibition percentage.

Sample No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Ctrl**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Ctrl.**
Bacterial Strain	***Bacillus Subtilis***								***E. coli***							
Dil. Factor	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}
Plated Broth Vol (µl)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
CFU Diluted	173	160	166	220	170	240	160	270	198	157	135	200	185	205	129	250
Total CFU /ml (10^6)	8.65	8	8.3	11	8.5	12	8	13.5	9.9	8.75	6.75	10	9.25	12.25	6.45	12.5
Log Total CFU	6.94	6.91	6.92	7.04	6.93	7.08	6.91	7.31	7	6.94	6.83	7	6.97	7.01	6.81	7.1
Inhibition Percentage	36.0	40.7	38.5	18.5	37.04	11.1	40.7	-	20.8	30	46	20	26	18	48.8	-

*** Polyester: [1 Blank (Untreated)][2 : 4 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [5 : 7 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)]**

Table 13: CFU results of Cotton against (*Bacillus subtilis*&*Staphylococcus aureus*) showing the inhibition percentage.

Sample No.	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Ctrl**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Ctrl.**
Bacterial Strain	***Bacillus Subtilis***								***Staphylococcus aureus***							
Dil. Factor	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-4}
Plated Broth Vol (µl)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
CFU Diluted	12	14	86	11	27	109	36	250	3	3	8	29	33	73	1	82
Total CFU /ml (10^6)	0.45	0.525	3.225	0.412	1.012	4.087	1.35	12.53	0.15	0.15	0.4	1.45	1.65	3.65	0.05	4.1
Log Total CFU	5.66	5.72	6.51	5.62	6.01	6.61	6.18	7.10	5.18	5.18	5.60	6.16	6.22	6.56	4.70	6.61
Inhibition Percentage	96.4	95.8	74.3	96.7	92	67.4	89.2	-	96.3	96.3	90.2	64.6	59.8	11	98.8	-

*** Cotton:[8 Blank (Untreated)] [9 : 11 (1% (TiO_2) , 2% (TiO_2) , 3% (TiO_2)] [12: 14 (1% (ZnO) , 2% (ZnO) , 3% (ZnO)]**

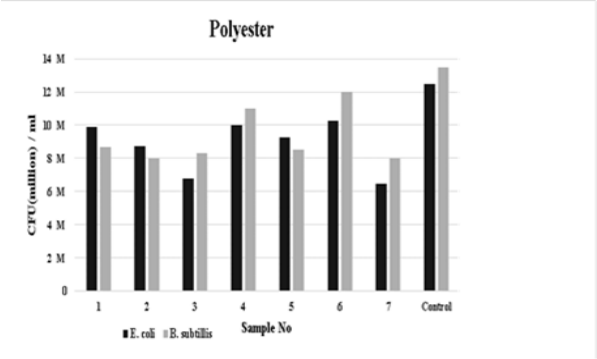

Figure 4:Graph Show the CFU Results of Treated Polyester Against E. coli and B. subtills

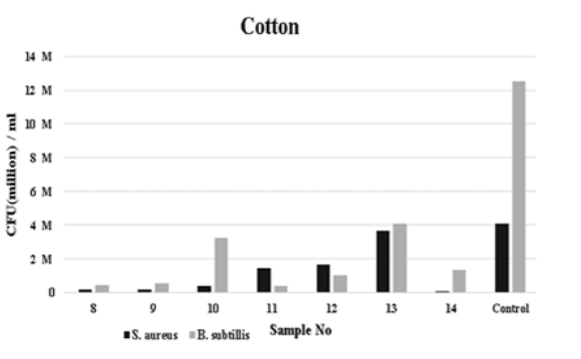

Figure 5: Graph Show the CFU Results of Treated Cotton Against S. aureus and B. subtills

3.6. Chemical Removal of Reactive Blue19 Using MgO NPs and UV:

The outcomes indicated in table15 demonstrate that the optimal pH employed was 9, and the alkaline conditions impact the rate of decolorization positively, leading to a reduction in absorbance values of 0.21 after 180 minutes and 0.1 after 24 hours. Moreover, as illustrated in table 14, it was noted that the most effective concentration of MgO was 0.5g/L, resulting in a reduction in absorbance values of 0.25 after 180 minutes and 0.11 after 24 hours. In table 16, the concentration of 1gm/L was the optimum concentration for H_2O_2.Once all other variables were meticulously controlled and maintained at their optimal levels within the experimental parameters, it was determined that the concentration of 0.1 gm/L emerged as the most efficacious and influential factor for the dye under investigation When we bio-treated the wastewater coming out of dyeing bath effluents after the dyeing process using two different types of bacteria, *Escherichia coli* (Gram-negative bacteria) and *Staphylococcus aureus* (Gram-positive bacteria), we did not get satisfactory results. Bio-treatment of wastewater of dyeing baths effluents using different species of fungi is now under investigations as illustrated in table 17.

Table 14: Effect of MgO NPs Conc. on the decolorization

MgO Conc. (gm / L)	Abs. 180 Min	Abs. 24 H	Decolorization percentage
Blank	0.8	0.8	0
0.5	0.25	0.11	86.25
1	0.22	0.19	76.25
2	0.22	0.21	73.75
3	0.23	0.20	75

Table 15: Effect of pH on the decolorization efficiency

PH	Abs. 180 Min	Abs. 24 H	Decolorization Percentage
Blank	0.8	0.8	0
3	0.38	0.18	77.5
5	0.31	0.13	83.75
7	0.30	0.15	81.25
9	0.21	0.10	87.5
10.5	0.24	0.11	86.25

Table16: Effect of H_2O_2 Conc. On theDecolorization.

H_2O_2 Conc. (gm / L)	Abs. 180 Min	Abs. 24 H	Decolorization Percentage
Blank	0.8	0.8	0
0.5	0.38	0.23	71.25
1	0.31	0.13	83.75
2	0.30	0.17	78.75
3	0.29	0.16	80

Table 17: Effect of Dye Conc.On the Decolorization.

Dye Conc (gm/L)	Abs. 0 Time	Abs. 180 Min	Abs. 24 H	Decolrization Percentage
0.1	0.8	0.07	0.04	95
0.15	1.21	0.1	0.08	93.38
0.2	1.55	0.15	0.099	93.6
0.25	1.76	0.21	0.11	93.75

When we bio-treated the wastewater coming out of dyeing bath effluents after the dyeing process using two different types of bacteria, *Escherichia coli* (Gram-negative bacteria) and *Staphylococcus aureus* (Gram-positive bacteria), we did not get satisfactory results. Bio-treatment of wastewater of dyeing baths effluents using different species of fungi is now under investigations

4. Conclusion

In the current research, our focus was centered on the investigation of two distinct categories of textiles, namely cotton and polyester. The fabrics underwent a series of treatments involving various nanometal oxides, specifically Zinc Oxide (ZnO) and Titanium Dioxide (TiO_2), followed by subsequent dyeing processes using Reactive Blue 19 for cotton and Dispersed Red 60 for polyester. It was observed that these treatments resulted in the enhancement of the fabrics' properties to a significant extent, albeit at varying degrees. Notably, the treated fabrics exhibited remarkable attributes in terms of fastness, with commendable outcomes recorded across lightfastness, washing fastness, and perspiration resistance tests, while displaying moderate performance in terms of rubbing fastness.The inclusion of treatments, either ZnO or TiO_2, in both fabrics exhibited minimal impact on the dyeing process, as evidenced by the color intensity of the treated textiles; the observed values did not significantly vary from those of the untreated samples.Furthermore, the treated textiles demonstrated a notable degree of protection against harmful ultraviolet (UV) rays, a characteristic that was particularly prominent in the polyester samples as opposed to the cotton counterparts, especially in instances where the ZnO concentration was at 1% and 3% with values of 36.4 % and 37.8 respectively. Of utmost significance was the fabrics' newfound ability to resist diverse types of bacteria, encompassing both gram-positive and gram-negative strains. The efficacy of this antibacterial property was validated through the execution of various tests such as Colony Forming Units (CFU) and Inhibition Zone assays, affirming the treated fabrics' resilience against microbial threats, regardless of whether they were cotton-based or polyester-based. Overall, the optimal outcomes were obtained when employing ZnO or TiO_2 at concentrations of 2% and 3%, underscoring the efficacy of these treatments in augmenting the fabrics' performance characteristics. And in our experimentation aimed at eliminating dye color using MgO nanoparticles, it was observed that various factors exert influence on the process. For instance, the duration of time plays a crucial role as decolorization diminishes over time. upon completion of the optimization process pertaining to various influencing factors, it was determinedthat the most optimal decolorization percentage, amounting to 95%, was achieved when utilizing a dye concentration of 0.1 g/L in conjunction with a pH value of 9. Additionally, the incorporation of a MgO NPs concentration of 0.5 g/L and a H_2O_2 concentration of 1 g/L also played a substantial role in the above-mentioned outcome. After the dyeing process, we bio-treated the wastewater exiting the dyeing bath effluents using two distinct types of bacteria: Gram-negative *Escherichia coli* and Gram-positive *Staphylococcus aureus*. However, the results were not adequate.

We can use cotton and polyester fabrics treated with metal oxide NPs for potential medical purposes, such as bed sheets, curtains, masks, medical gowns, and bandages based on the promising satisfactory results**.**

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