# EFFECT OF THE ULTRAVIOLET IRRADIATION INTNESITY ON THE SELF-CLEANING PERFORMANCE AND PHYSICAL PROPERTIES OF COTTON FABRIC SURFACES TREATED WITH $TiO_2$ NANOSOL

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## EXTENDED ABSTRACT

The performance of cotton fabric surfaces after treatment with a $TiO_2$ nanosol, and then cured by ultraviolet irradiation (UV) at three different intensities of 294, 622 and 938 mJ/cm$^2$ for five cycles, were evaluated in terms of dye decomposition, coffee stain removal, antibacterial activity and physical properties. The titanium tetraisopropoxide (TTIP)-treated cotton fabric surfaces cured at different intensities of UV under exposure to UV lamp or Daylight 65 lamp had a similar ability to decompose the CIBACRON RED LS BHC reactive dye and coffee stain, although it was marginally better under the UV lamp. In addition, the higher UV irradiation intensity used in curing the TTIP-treated fabrics, the higher was the decomposition of reactive dye and removal of coffee stain. No significant antibacterial activity against *S. aureus* and *E. coli*, in terms of a growth-free clear zone, was noted for the untreated and treated fabrics, but the TTIP-treated cotton fabric cured at either 622 or 938 mJ/cm$^2$ showed a slight antibacterial activity in terms of no *E. coli* growth occurred underneath the fabric. With respect to the physical properties, the TTIP-treated fabrics cured at higher UV irradiation intensities showed a much higher yellow discoloration and lower tensile strength retention. The X-ray diffractometry patterns of the TTIP-treated cotton fabric surfaces cured at different intensities of UV irradiation showed the peak of anatase phase of $TiO_2$, while $TiO_2$ nano particles were observed on their surface by scanning electron microscopy analysis.

**Key Words:** Self-cleaning, Sol-gel, Ultraviolet irradiation, Titanium dioxide, Antimicrobial

## 1. INTRODUCTION

UV irradiation is another interesting way for the drying and curing steps in textile finishing and has gained in interest recently because of the increasing use of crystallite titanium dioxide nano particles ($TiO_2$NPs) in textile applications. The use of $TiO_2$NPs based photo-catalyst coatings on textile surfaces has received increasing attention due to, for example, their ability to impart self-cleaning and UV-protection properties [1-6]. In this study, different UV irradiation intensities were used to cure cotton fabric treated with a $TiO_2$ nanosol and then evaluated for the formation of $TiO_2$NPs and impact on the level of self-cleaning performance, antibacterial activity and the physical properties of the treated cotton fabrics. The efficiency of the self-cleaning performance of the treated cotton fabric surfaces was evaluated in terms of the efficacy of coffee stain removal and reactive dye decomposition. Scanning electron microscopy (SEM) and X-ray diffractometry (XRD) were used to observe the morphology of the $TiO_2$NPs on the $TiO_2$ nanosol treated cotton fabric surface.

## 2. MATERIALS AND METHODS

### 2.1 Materials

A plain weave 100% cotton fabric from a textile factory was desized, scoured and bleached. Titanium tetraisopropoxide (TTIP), nitric acid (70%) and acetic acid (99.7%) were chemicals used in this study.

## 2.2 Methods

**$TiO_2$-nanosol preparation**: An acidic aqueous solution of TTIP was prepared by mixing TTIP at 20% (v/v) in 5% (v/v) acetic acid (99.7%) and 0.1% (v/v) nitric acid (70%), and then heated to 80C with stirring and held at this temperature for 2.5 h.

**Fabric treatment**: Cotton fabric was immersed in the mixed $TiO_2$-nanosol solution for 10 min and padded through two-rollers to obtain about 80% wet pick-up. After that the padded cotton fabric was cured under UV irradiation at an intensity of 294, 622 or 938 mJ/cm$^2$ for five cycles. The cured cotton fabric was then washed with water and dried at 80C for 5 min before testing. The treated cotton fabric surface was evaluated in terms of dye decomposition efficiency, coffee stain removal efficiency, antibacterial activity, tensile strength and yellowness, X-ray diffraction and Scanning electron microscopy.

## 3. RESULTS AND DISCUSSION

### 3.1 Efficacy of dye decomposition

When irradiated under the D65 lamp (Figure 1 left), the final decomposition level of the dye solution after 8 h was 73%, 88% and 95% for those TTIP-treated fabrics cured with an UV irradiation intensity of 294, 622 and 938 mJ/cm$^2$, respectively, compared with 88%, 94% and 94%, respectively, when irradiated under the UV lamp (Figure 1 right). Nevertheless, the TTIP-treated cotton fabrics cured at higher UV intensities clearly had a much better ability to decompose the CIBACRON RED LS BHC reactive dye than those cured at a lower intensity.

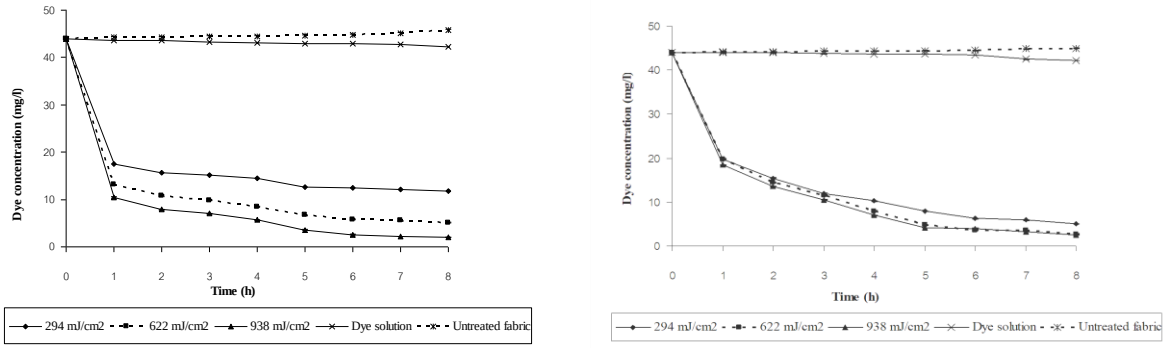


Figure 1 Decomposition rate of dye when exposed to irradiation for up to 8 h under the D65 or UV lamp

### 3.2 Coffee stain removal

The untreated cotton fabric stained with coffee did not show any stain removal after exposure to either the UV or D65 lamp, but there was a decrease in the K/S value of 78%, 73% and 69% for the TTIP-treated fabrics cured at 938, 622 and 294 mJ/cm$^2$, respectively, under the D65 lamp, and 81%, 78% and 75%, respectively, under the UV lamp.

### 3.2 Physical properties

**Table 1. Physical properties of the untreated fabric and TTIP-treated fabrics cured at different UV intensities**

| | Untreated fabric | TTIP treated fabric cured with UV intensity | | |
|---|---|---|---|---|
| | | 294 mJ/cm$^2$ | 622 mJ/cm$^2$ | 938 mJ/cm$^2$ |
| Tensile strength retention | 100% | 100% | 75.5% | 58.4% |
| Yellowness | 4.5 | 11.08 | 14.47 | 17.7 |

### 3.3 Antibacterial activity

None of the TTIP-treated cotton fabrics or the untreated fabric showed any significant ability to inhibit the growth of either *S. aureus* or *E. coli*. No clear zones appeared on any of the tested specimens, except that the TTIP-treated cotton fabric cured with UV irradiation at either 622 or 938 mJ/cm$^2$ was found to have no *E. coli* underneath the tested specimen.

### 3.4 XRD and SEM analysis

Analysis of their surface morphology by SEM revealed $TiO_2$NPs distributed over the fiber surface, while XRD analysis revealed that the UV irradiation used for curing the TTIP-treated cotton fabrics converted some of $TiO_2$ nanosol of TTIP to anatase crystalline $TiO_2$NPs.

## 4. CONCLUSIONS

The treated cotton fabrics cured at different UV intensities had a similar ability to decompose the reactive dye and coffee stain under exposure to either a UV or a D65 lamp. A higher UV irradiation had a better reactive dye decomposition and coffee stain removal. This was because more $TiO_2$NPs were formed on the surface of the TTIP-treated cotton when cured at higher intensities of UV irradiation. With respect to antibacterial activity, both *S. aureus* and *E. coli* growth were observed on the fabrics without any clear zone of growth inhibition. The TTIP-treated fabrics cured under a higher intensity of UV irradiation had a reduced tensile strength and increased degree of yellowness.

## 5. REFERENCES

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