

Colorimetric Properties of Disperse-dyed Polyester Fabrics Treated with Nano TiO₂

Jantip Setthayanond^{1,*}, Potjanart Suwanruji²,
Porntip Tooptompong¹ and Sinee Tungtriratanakul¹

¹Department of Textile Science, Faculty of Agro-Industry, Kasetsart University, Bangkok 10900, Thailand

²Department of Chemistry, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand

(*Corresponding author's e-mail: jantip.s@ku.ac.th)

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Abstract

In this work, the influence of nano titanium dioxide (TiO₂) finishing on colorimetric properties of polyester fabrics dyed with mono-azo disperse dyes was examined in terms of the degree of shade change, color strength reduction and the percentage of dye lost from the fabrics and color fastness to washing. A self-cleaning effect imparted by nano TiO₂ not only removes unwanted stains from polyester fabrics but also the dye molecules situated in the area nearby the fiber surface. Changes in colorimetric properties of the fabrics dyed with Disperse Violet 33, Disperse Red 167.1 and Disperse Blue 79.1 dyes were, therefore, examined. Shade change and reduction in color strength were observed, in addition, the dye quantity within the fiber decreased as a result of nano TiO₂ treatment. Higher amount of nano TiO₂ brought about a stronger effect on changes in colorimetric values, quantity of lost dye and color fastness to washing of the dyed polyester fabrics. A similar tendency was observed on these 3 mono-azo dyes. A way to achieve optimal functional performance of nano TiO₂ finishing with minimal effect on colorimetric properties of the disperse dyes on polyester is by employing low nano TiO₂ content and 0.05 % nano TiO₂ is recommended in this work. Under such conditions, the color properties of the dyed fabrics were less influenced and in acceptable level, moreover, the resulting color fastness to washing was not affected and comparable to those exposed to reduction clearing process.

Keywords: Nano titanium dioxide, Disperse dye, Polyester, Decolorization

Introduction

Nanomaterials, e.g. titanium dioxide (TiO₂) silicon dioxide (SiO₂), zinc oxide (ZnO) and silver, have been extensively studied for various textile functionalization. Textile functionalities created by titanium dioxide nano particles (nano TiO₂) are mainly in the fields of easy-care and protection finishing, including photocatalytic self-cleaning, antimicrobial activity, ultraviolet (UV) protection and flame retardancy [1,2]. Apart from application on textiles, nano TiO₂ has also been researched in use for wastewater treatment. Decolorization of dyehouse wastewater has been studied and it is confirmed that the presence of nano TiO₂ helps remove contaminated dyes in water and wastewater remedy [3-6].

Poly (ethylene terephthalate) or PET is the polyester fiber commonly used for production of textile commodities. PET fiber (or commonly called polyester fiber) possesses good mechanical properties, good dimensional retention and cost effectiveness. Hence, it has been widely used for both apparel and non-apparel products. Coloration to attain a desirable shade on polyester textiles is normally by dyeing with disperse dye. A subsequent finishing process is typically conducted on the dyed textiles to create or improved textile functionalities. Nano TiO₂ has been introduced as a self-cleaning agent, providing stain removal ability, for easy-care polyester products, such as upholstery and home textiles that are occasionally laundered. Nano TiO₂, as a photocatalyst, is activated by UV irradiation and accelerates the photocatalytic reaction that results in degradation of organic compounds, including stains. Studies on self-cleaning of nano TiO₂-treated textiles have been reported on several types of textile fiber substrates e.g. cotton, wool and polyesters [7-12]. Moreover, nano TiO₂ also provides antimicrobial properties and UV protection to textiles. Photocatalytic activity induced by nano TiO₂ can also cause destruction of dye molecules present in dyehouse wastewater, leading to a further development of wastewater treatment process. Degradation of various azo-based dyes in solution have been researched [13-15]. However, in the light of photocatalytic

activity, there may be a concern regarding stability of the dyes present on textiles treated with nano TiO₂ for finishing purpose. The dyes within the fiber interior, in particular those situated nearby the fiber surface, could be risked by photocatalytic degradation induced by nano TiO₂ adhered as well on the fiber surface. This is likely to cause a destructive effect on the dye molecules and may lead to commercially unacceptable shade stability and consistency of the dyed textile products. To dates, such issue has not been intensively investigated and examined quantitatively to evaluate its influence on the quality of the dyed-textile products.

Therefore, in the present work, the effect of nano TiO₂ finishing on colorimetric properties of the dyed polyester fabrics was studied. The fabrics were first dyed with mono-azo disperse dyes, viz. Disperse Violet 33, Disperse Red 167.1 and Disperse Blue 79.1 and subsequently treated with nano TiO₂ in the finishing process. The influence of nano TiO₂ on shade of the dyed fabrics was evaluated by monitoring change in colorimetric values of the dyed fabrics after the designated exposure times of UV irradiation in comparison with the untreated counterparts. The color strength reduction, amount of lost dye and color fastness to washing were also examined to quantify the influence of nano TiO₂ on colorimetric properties of disperse-dyed polyester fabric.

Materials and methods

Materials

The 90 % Anatase and 90 % Rutile TiO₂ nano particles with the average size of 30 nm were purchased from US nano, USA. Knitted polyester fabric with 40 - Ne yarn count was purchased from Far East knitting & Spinning Co., Ltd, Thailand. Mono-azo disperse dyes (**Table 1**), i.e. Dianix Rubine SE-B, Dianix Navy S-2G and Dianix Rubine S - 2G, were supplied by DyStar, Thailand. Chemical structures of the dyes are depicted in **Figure 1**. Dypidol 101B, a nonionic/anionic wetting agent, was obtained from Brenntag, Co. Acrylic binder was provided by Thai Mitsui Specialty Chemicals Co, Ltd. Mono-chlorobenzene and potassium hydroxide were purchased from Ajax Finechem.

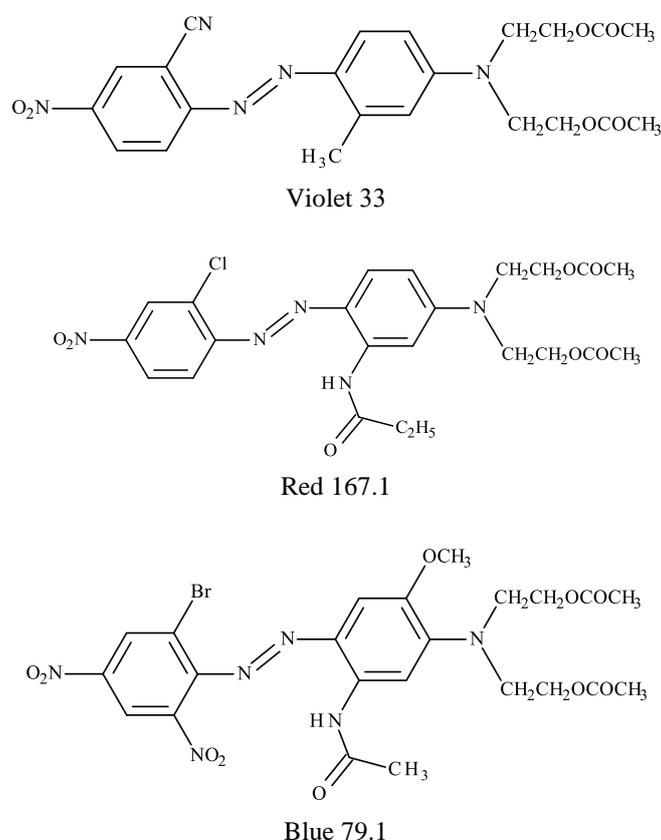


Figure 1 Chemical structures of disperse dyes used.

Table 1 Mono-azo disperse dyes used.

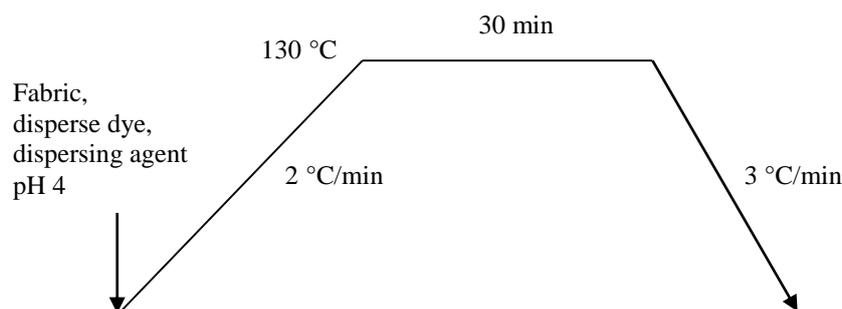
Disperse dye class	Commercial name	C.I. generic name	Molecular weight
Medium energy	Dianix Rubine SE - B	Disperse Violet 33	453.45
High energy	Dianix Rubine S - 2G	Disperse Red 167.1	505.91
	Dianix Navy S - 2G	Disperse Blue 79.1	625.38

Fabric pretreatment

The fabric was scoured before use with 1 g/L sodium carbonate and 1 g/L wetting agent, with 30:1 liquor ratio for 15 min at 70 °C. The scoured fabrics were then treated in 5 g/L potassium hydroxide solution at 100 °C for 30 min and then rinsed with water and air dried.

Dyeing process

The pretreated polyester fabrics were dyed with the selected azo-based disperse dyes, namely Violet 33, Red 167.1 and Blue 79.1, at varying applied concentrations of 0.5, 1, 2, 3 and 5 % owf. High-temperature dyeing process was performed as shown in **Figure 2**.

**Figure 2** Disperse dyeing procedure for polyester.

The dyed fabrics were rinsed with running water and air dried at room temperature. Without passing through the reduction clearing (RC) process, the dyed fabrics were determined for their reflectance values with a Macbeth ColorEye 7000 spectrophotometer and the color strength (K/S values) of the dyed fabrics were calculated according to Kubelka-Munk Equation as shown in Eq. (1);

$$K/S = \frac{(1-R)^2}{2R} \quad (1)$$

where K is the absorption coefficient, S is the scattering coefficient and R is the observed reflectance values at λ_{\max} = 520, 530 and 620 nm for Violet 33, Red 167.1 and Blue 79.1, respectively.

Relationship between the applied dye concentrations and the obtained K/S values was established and the appropriate dye concentrations to achieve K/S of 10 ± 1 were figured out for each dye. Then the fabrics were dyed to attain the K/S value of 10 ± 1 in order to achieve the same level of visual color strength and these fabrics were later used in the next experiment. Another set of dyed fabrics that passed through RC process in order to eliminate surface dye, was kept for comparison with those undergoing nano TiO₂ treatment.

Nano TiO₂ finishing

Nano TiO₂ mixture (80:20 anatase:rutile) was prepared into a colloidal suspension in water at concentrations of 0.05, 0.1 and 0.5 % w/v with 0.25 % w/v ethylene glycol as a dispersing aid. The mixtures were homogenized at 15,000 rpm for 15 min. After that, the freshly prepared nano TiO₂ colloids were applied onto polyester fabric via a padding process by impregnating the fabrics in the nano TiO₂ colloids for 5 min and squeezed through a pad mangle at 110 % wet pick-up and then dried at 120 °C for 3 min. Acrylic binder was subsequently applied to the fabrics at 20 g/L by padding. The treated fabrics were air dried followed by curing at 150 °C for 3 min. The obtained fabrics were washed in 1 g/L wetting agent solution at 60 °C for 15 min to remove the loosely bound TiO₂ particles on the fiber surface, followed by rinsing and air drying. Amount of titanium on the fabrics was analyzed by Perkin Elmer inductively coupled plasma optical emission spectrophotometer (ICP-OES) and the surface characteristics of the fabrics were monitored by JEOL scanning electron microscope (SEM).

Effect of UV irradiation on shade and color strength of the treated polyester fabric

The untreated and nano TiO₂-treated dyed fabrics were UV irradiated at the wavelength of 365 nm for 0.5, 1, 2 and 4 h. The fabrics were hung vertically towards the dual arranged UV lamps as illustrated in **Figure 2**. Distance between the fabrics and UV lamps was set at 10 cm. After each irradiation time, the K/S values of the fabrics were recorded and compared with their initial values. The percentage of color strength reduction (K/S reduction) was calculated from Eq. (2);

$$\%K/S \text{ reduction} = \frac{(K/S_0 - K/S_t)}{K/S_0} \times 100 \quad (2)$$

where K/S_0 is initial color strength of the fabric and K/S_t is color strength of the fabric after each UV-irradiation time.

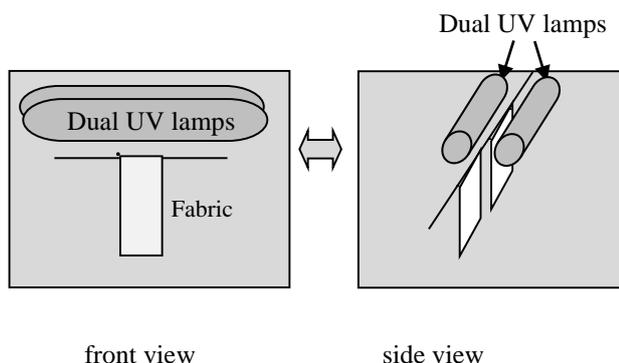


Figure 2 UV irradiation experiment set up.

The colorimetric properties including lightness (L^*), red-green color coordinate (a^*), yellow-blue color coordinate (b^*) and the color differences (ΔL^* , Δa^* , Δb^* and ΔE_{cmc}) of the dyed fabrics treated with nano TiO₂ were also compared with those of the untreated, dyed fabrics after each irradiation time.

Quantitative dye loss analysis

The influence of nano TiO₂ finishing on the dye loss from the dyed polyester fabrics was investigated quantitatively by dye extraction method. The dyed polyester fabrics (0.3 g), both nano TiO₂-treated and untreated ones, were extracted with mono-chlorobenzene (250 mL) in a Soxhlet extractor repeatedly until all the dyes within the fabric were extracted into the solution. Absorbance values of the extracted solutions were examined by Specord UV/vis spectrophotometer and later, amount (mg) of dyes in the solutions was calculated from calibration graphs of each dye in mono-chlorobenzene. Amount of the extracted dyes from the treated fabrics after each irradiation times was compared against the untreated, UV irradiated and untreated, RC counterparts. Percentage of dye lost due to UV irradiation was calculated from the amount of dye extracted from the UV-irradiated fabrics against those of non-irradiated fabrics. The results were compared with the percentage of dye eliminated by RC process.

Color fastness to washing of the nano TiO₂-treated fabrics against the untreated fabrics

Color fastness to washing of the dyed fabrics was assessed to evaluate the degree of color change and staining due to laundering according to ISO 105/C06 standard method with the test no. C2S (60 °C). Degrees of shade change and staining of the tested samples were evaluated with grey scales.

Results and discussion

Characterization of nano TiO₂-treated polyester fabrics

Titanium content in the untreated and nano TiO₂-treated fabrics was analyzed by ICP-OES technique (Table 2). Titanium found in case of the untreated polyester fabric was from the TiO₂ delustrant, formerly incorporated during the fiber production process. By finishing the fabrics with nano TiO₂, amount of titanium was increased with increasing nano TiO₂ applied concentrations. The surface morphology of polyester fibers with and without nano TiO₂ treatment by SEM is depicted in Figure 3. Nano TiO₂ particles were found attaching on the fiber surface. Larger amount of the attached nano TiO₂ was recorded when higher nano TiO₂ concentration was applied. This result agrees with the titanium content analysis and confirms existence of nano TiO₂ on treated polyester fibers.

Table 2 Titanium content in the nano TiO₂-treated and untreated polyester fabrics.

TiO ₂ (%w/v)	Titanium content (%)
untreated	0.2626 ± 0.0030
0.05	0.5527 ± 0.0036
0.1	0.9629 ± 0.0021
0.5	2.0357 ± 0.0171

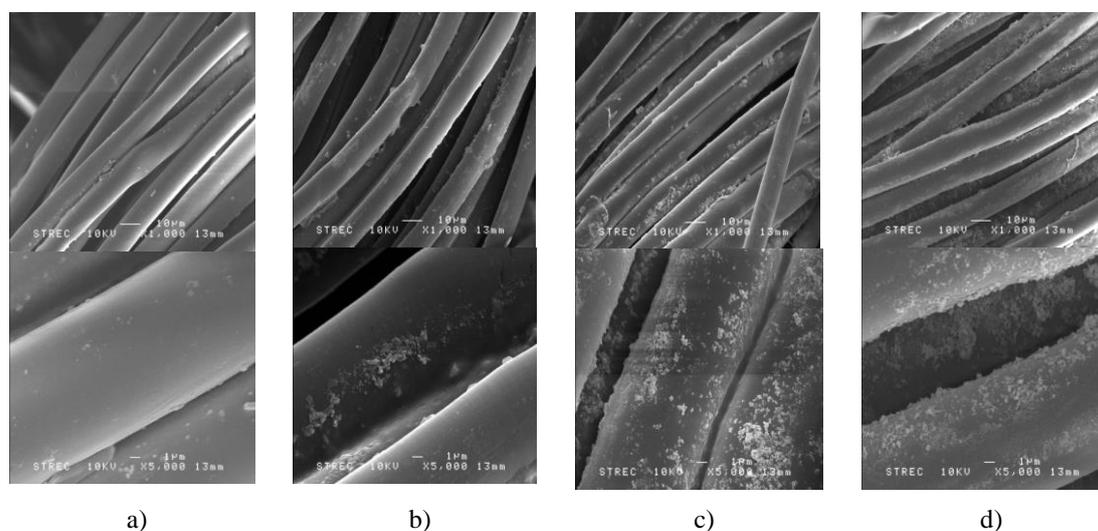


Figure 3 SEM photographs of the polyester fabrics dyed with Blue 79.1 and subsequent finished with nano TiO₂, a) untreated; b) 0.05 % nano TiO₂; c) 0.1 % nano TiO₂; d) 0.5 % nano TiO₂.

Effect of nano TiO₂ on colorimetric properties of the dyed polyester fabrics

At the same level of color strength (K/S 10 ± 1), the colorimetric properties of the dyed polyester fabrics seemed to influence by nano TiO₂ finishing (Table 3). Shade of the dyed fabrics became slightly lighter and bluer with increasing nano TiO₂ content. The color difference values (ΔE_{cmc}) informed the total color difference of the treated fabrics against the untreated counterparts. The results elucidate that finishing the fabrics with nano TiO₂ caused shade alteration to the dyed fabrics. Shade difference was marginal when low nano TiO₂ concentration (0.05 % w/v) was employed; the ΔE_{cmc} values were about 1 or less. However, when the amount of applied nano TiO₂ was increased to 0.1 and 0.5 % w/v, shade change was beyond

industrially acceptable level ($\Delta E_{cmc} > 1$). Similar effect of nano TiO_2 on causing color change was reported by Abbasipour & Mehrizi [16] but on the printed cotton/polyester fabric with pigment and vat dye.

Table 3 Effect of nano TiO_2 finishing on the colorimetric properties of the dyed fabrics at the same color strength level ($K/S 10 \pm 1$).

Dye	TiO_2 (%w/v)	Color			Color difference			
		L^*	a^*	b^*	ΔL^*	Δa^*	Δb^*	ΔE_{cmc}
Violet 33	untreated	40.61	47.89	2.53	0	0	0	-
	0.05	41.39	48.28	2.57	0.78	0.39	0.04	0.87
	0.1	42.02	48.45	1.77	1.41	0.56	-0.76	1.70
	0.5	43.23	47.04	-2.48	2.62	-0.85	-5.01	5.72
Red 167.1	untreated	43.64	52.76	4.32	0	0	0	0.00
	0.05	44.25	53.17	3.79	0.61	0.41	-0.53	0.91
	0.1	45.08	53.58	3.19	1.44	0.82	-1.13	2.01
	0.5	45.73	52.83	0.23	2.09	0.07	-4.09	4.59
Blue 79.1	untreated	30.49	-0.84	-23.67	0	0	0	-
	0.05	31.4	-1.01	-24.2	0.91	-0.17	-0.53	1.07
	0.1	33.74	-0.92	-24.82	3.25	-0.08	-1.15	3.45
	0.5	35.83	-0.9	-26.28	5.34	-0.06	-2.61	5.94

This result indicates that finishing polyester fabric, aiming for self-cleaning functionality, with nano TiO_2 , has an influence on shade of the disperse dyes formerly applied on polyester. This could be problematic for shade accuracy of the dyed fabrics and in addition, the extent of shade change relates to the amount of applied nano TiO_2 . The higher the concentration of nano TiO_2 is, the larger the shade difference is attained. Therefore, finishing polyester with nano TiO_2 could bring an unacceptable adverse effect to the final shade of the dyed fabrics when high nano TiO_2 content (> 0.05 % w/v) was employed.

Effect of UV irradiation on shade and color strength of the treated polyester fabric

Being a photocatalyst, nano TiO_2 accelerates degradation of organic compounds, giving a stain removal property to textiles. By applying nano TiO_2 onto the dyed polyester fabric, there is a question whether this nano TiO_2 could destroy the dye molecules formerly applied on the fiber when it is triggered with UV irradiation. If so, not only stain but also dye molecules on the fiber may be removed. In this study, the color strengths of the dyed and nano TiO_2 -treated fabrics were measured after exposure to UV irradiation for varying times and compared with the untreated, dyed ones. In **Figure 4**, the K/S reduction of the fabrics dyed with Violet 33, Red 167.1 and Blue 79.1, after each UV irradiation times is reported. UV irradiation caused color fading (K/S reduction) to all cases, including the untreated fabrics. This may be explained by UV sensitivity of the dye's chromophore (azo). Azo-based dyes can be photolyzed by UV irradiation [17]. In the presence of nano TiO_2 , more pronounced K/S reduction was observed, especially those applied at high amount of nano TiO_2 . Decolorization occurred quite rapidly in the first 30 min of irradiation and reached a plateau within 1 h. Highest degree of K/S reduction was observed on the fabric dyed with Blue 79.1 followed by finishing with 0.5 % w/v nano TiO_2 . While those Violet 33 and Red 167.1 dyes displayed maximally about 5 - 6 % reduction. This result infers that when nano TiO_2 catalyzes degradation reaction of stains so as to impart self-cleaning ability, it may also stimulate degradation of the dye molecules on the fabrics. Therefore, color fading on the dyed fabrics was observed and more significantly on those finished with high nano TiO_2 content.

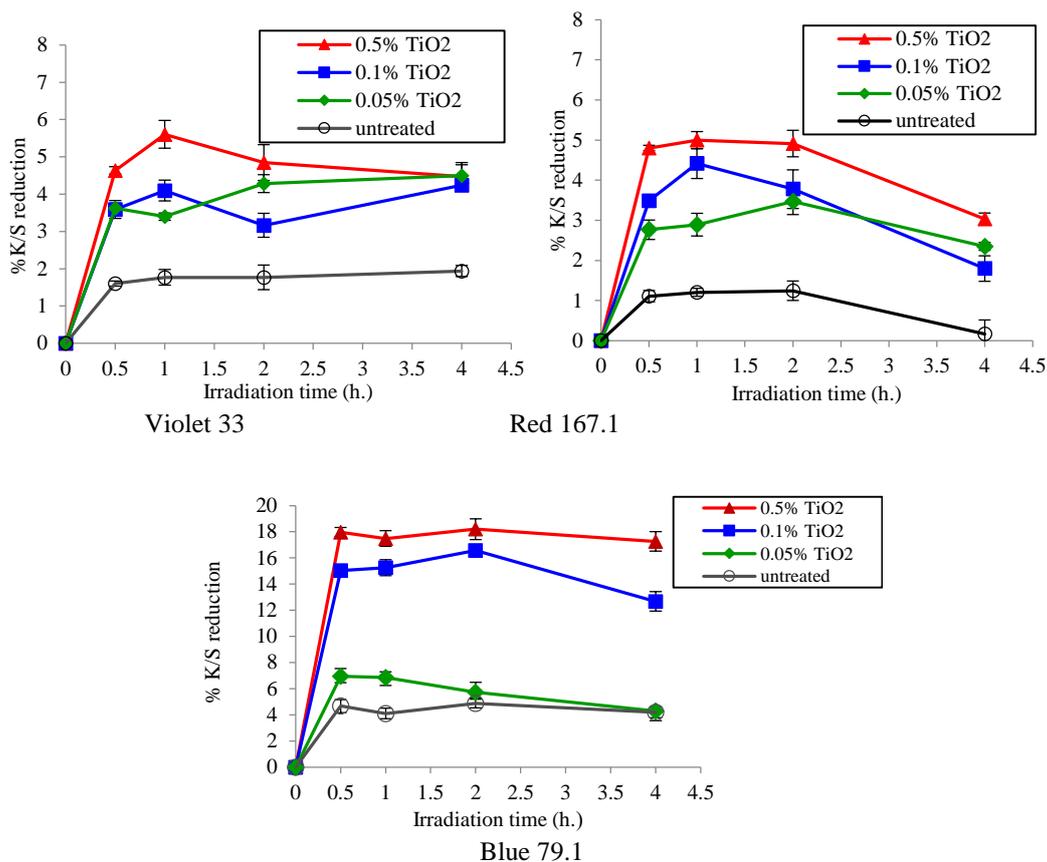


Figure 4 K/S reduction of the dyed fabrics finished with nano TiO₂ after UV irradiation for 0.5, 1, 2 and 4 h in comparison with the untreated fabrics.

Apart from visual observation on change in K/S values, the direct method, i.e. dye extraction, was used to confirm the effect of nano TiO₂. The dyed fabrics were extracted with mono-chlorobenzene and the amount of dye in the solution was analyzed. In **Table 5**, amount of lost dye was noticed on the treated fabrics even before UV irradiation as compared with the untreated, dyed ones. This is presumably due to detachment of loosely bound dyes from the fibers during finishing and washing processes. However, this loss seemed to increase with increasing applied nano TiO₂ even before UV irradiation. This may be explained by a result of nano TiO₂ on dye degradation when the dyed fabrics are exposed to UV-containing lights during the experiment and more nano TiO₂ stimulating stronger effect. After 30-min UV irradiation, the amount of dye in the fabrics decreased apparently. Moreover, higher nano TiO₂ concentration seems to give stronger degree of dye removal. The 3 dyes showed about 18 - 19.5 % maximal amount of lost dye at 0.5 % nano TiO₂ although a drastic reduction in visual color strength of Blue 79.1 at 0.1 and 0.5 % applied nano TiO₂ was observed (as shown in the previous section). Mono-azo dyes are quite susceptible to photodegradation and have been reported to exhibit higher photodegradation rate than anthraquinone dyes. The substituted groups on the dye structure also take part in manipulating the photodegradation reaction in the presence of nano TiO₂ [14], however, in this study, about the same quantities of dye lost was observed for these 3 mono-azo disperse dyes. A substantial amount of dye lost from the fabrics as a result of high nano TiO₂ could deteriorate shade stability and consistence of disperse-dyed polyester fabrics.

Table 5 Amount of dyes extracted from the fabrics applied with nano TiO₂ before and after UV irradiation, compared with the untreated fabrics.

Dye	Treatment	Irradiation time (min)	Avg. amount of lost dye ($\times 10^{-4}$ mg)	%Dye loss	
Violet 33	Dyed	0	0	0	
	Dyed and RC	0	0.421	1.34	
	Dyed and finished with TiO ₂ 0.05 %	0	2.444	7.79	
		30	3.408	10.86	
	Dyed and finished with TiO ₂ 0.1 %	0	3.235	10.31	
		30	5.321	16.96	
	Dyed and finished with TiO ₂ 0.5 %	0	3.540	11.28	
		30	6.097	19.43	
	Red 167.1	Dyed	0	0	0
		Dyed and RC	0	0.449	0.96
Dyed and finished with TiO ₂ 0.05 %		0	5.465	11.69	
		30	7.619	16.30	
Dyed and finished with TiO ₂ 0.1 %		0	5.648	12.08	
		30	7.325	15.67	
Dyed and finished with TiO ₂ 0.5 %		0	8.954	19.15	
		30	10.528	22.52	
Blue 79.1		Dyed	0	0	0
		Dyed and RC	0	1.557	3.23
	Dyed and finished with TiO ₂ 0.05 %	0	4.088	8.47	
		30	4.955	10.27	
	Dyed and finished with TiO ₂ 0.1 %	0	7.277	15.08	
		30	8.778	18.19	
	Dyed and finished with TiO ₂ 0.5 %	0	6.730	13.95	
		30	8.828	18.30	

When only the effect of UV irradiation was considered, it was found out that the dyes were lost or destroyed further as expected by nano TiO₂-induced photodegradation. The results in **Figure 5** illustrate the percentages of dye lost from the treated fabrics as a result of UV irradiation for 30 min. The percentages of lost dyes were the differences of dye quantities before and after irradiation on the treated fabrics.

RC is a typical after-treatment process for eliminating surface dye, especially for medium-deep shade disperse dyeing to improve the wet fastness performance of the dyed fabrics. The percentage of dye elimination as a result of RC for these disperse dyes was in the range of 1 - 3 % with Blue 79.1 exhibiting the highest dye loss. Nano TiO₂ treatment showed a significant effect on dye removal from polyester fibers. The dyed fabrics without subjecting to RC process exhibited an increase in % dye lost due to UV irradiation with increasing applied nano TiO₂. More pronounced effect was observed in the case of medium-energy dye i.e. Violet 33, indicating higher photodegradation tendency in the presence of nano TiO₂. As compared with the RC fabrics, most of the treated fabrics lost much more dyes with nano TiO₂-induced photodegradation. This elucidates a strong influence of nano TiO₂ finishing on dye removal from polyester fabric. Only 30 - min irradiation as high as 9 % dye loss could reach in the case of Violet 33 with 0.5 % nano TiO₂ with overall maximum dye loss of about 18 - 19.5 % for these 3 dyes. Therefore, this nano TiO₂ finishing typically applied to add functional properties to polyester, could also bring about a negative effect on the colorimetric properties by destroying the dyes present on the fabrics.

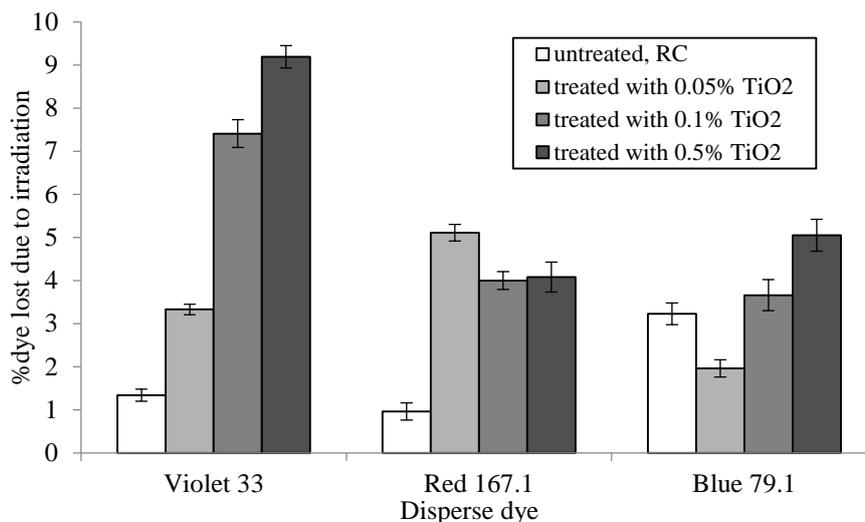


Figure 5 % Dye lost as a result of 30-min UV irradiation from nano TiO₂ treated fabrics as compared with untreated, dyed fabrics with RC process.

Table 6 Color fastness to washing of the dyed fabrics with nano TiO₂ treatment, UV irradiated for 30 min against the untreated dyed fabrics.

Dye	Treatment	Irradiation time (min)	Shade change	Staining	
				Nylon	Polyester
Violet 33	dyed	0	4/5	3/4	4/5
	dyed and RC	0	4/5	3/4	4/5
	dyed, 0.05 % TiO ₂ finished	30	4/5	3/4	4/5
	dyed, 0.1 % TiO ₂ finished	30	4/5	3/4	4/5
	dyed, 0.5% TiO ₂ finished	30	4/5	3/4	4/5
Red 167.1	dyed	0	5	4	4/5
	dyed and RC	0	5	4	4/5
	dyed, 0.05 % TiO ₂ finished	30	5	4	4/5
	dyed, 0.1 % TiO ₂ finished	30	5	4	4/5
	dyed, 0.5 % TiO ₂ finished	30	4/5	3/4	4
Blue 79.1	dyed	0	5	4	4/5
	dyed and RC	0	5	4/5	4/5
	dyed, 0.05 % TiO ₂ finished	30	5	4/5	4/5
	dyed, 0.1 % TiO ₂ finished	30	5	4/5	4/5
	dyed, 0.5 % TiO ₂ finished	30	5	4	4/5

Effect of nano TiO₂ finishing on wash fastness properties

Basically, fabric with less surface dye would show better wash fastness properties. In this study, after subjecting to RC process, the color fastness to washing of the dyed fabrics remained at the same level, excepted for blue 79.1, a slightly less dye staining on nylon adjacent fabric (higher grey scale rating) was noticed (**Table 6**). The nano TiO₂-treated, dyed fabric also showed a similar level of color fastness to washing to the RC fabrics. However, when higher nano TiO₂ was employed (0.5 % w/v), the wash fastness properties were slightly poorer than those subjected to RC in cases of Red 167.1 and Blue 79.1. Although an obvious loss of dye quantity and reduction of color strength were observed for 0.5 % w/v applied nano TiO₂ content, the wash fastness performance was reduced. This could be a result of nano TiO₂ on shade intensity of the dyed fabrics, bluer shade causes more noticeable staining on multifiber adjacent fabrics. However, it was not affected when lower nano TiO₂ contents (0.05 and 0.1 % w/v) were applied.

In this research, nano TiO₂ applied in a finishing process has shown the effect on colorimetric properties of the disperse dyed-fabrics. Photocatalytic degradation induced by nano TiO₂ to impart functional properties such as self-cleaning to polyester, can cause destruction of mono-azo disperse dyes on polyester fibers and this is more pronounced with increased nano TiO₂ content. Therefore, it is suggested from this study that the amount of nano TiO₂ for finishing should be well controlled to achieve an intended fabric functionality with minimizing effect on shade stability and consistency of disperse dyes on polyester. Low % applied nano TiO₂ (0.05 %) would be recommended in order to maintain shade stability of the dyed polyester fabrics with good color fastness to washing with no need of RC after-treatment. This also indicates an ability of nano TiO₂ treatment, if a proper amount is applied, in helping eliminate surface dye on polyester fiber and has a potential to replace RC process that consumes unpleasant reducing agent, like sodium hydrosulfite. Therefore, a study would be conducted further to examine the optimal elimination process of surface dye on polyester by nano TiO₂ treatment as an alternative to RC process.

Conclusions

Nano TiO₂ finishing, typically applied to create functional properties, i.e. self-cleaning and anti-microbial activity for textiles, shows an influence on shade, color strength, dye removal and color fastness to washing of polyester fabrics dyed with mono-azo disperse dyes. The degree of change in colorimetric properties depends on the amount of applied nano TiO₂. The color change was more pronounced for high applied nano TiO₂ content. Nano TiO₂ not only induces removal of unwanted stains from polyester fabrics but also the dyes situated in the area nearby the fiber surface. Therefore, amount of nano TiO₂ for finishing should be well controlled in order to obtain both satisfactory fabric functionality and acceptable colorimetric properties on polyester. From this study, it is suggested that low nano TiO₂ (0.05 %) could be considered for rendering efficient finishing properties and shade stability of the dyed polyester fabrics, in addition, good color fastness to washing could also attained without RC after-treatment.

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