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Comparison between the two treated methods of polyester fabrics with TiO_2 or ZnO nanoparticles

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Abstract

We treated dyed polyester fabric with disperse dyes that we have been prepared with TiO_2 or ZnO NPs to increase self-cleaning and light fastness, and we noticed that these attributes were greatly improved. The effectiveness of the polyester fabric to block UV radiation has been tested. Also, the comparisons between the two treated methods were discussed.

Keywords: Polyester fabrics, self cleaning, ultraviolet protection factor UPF, light fastness.

1. Introduction

Azo dyes are the most widely used synthetic dyes in the recent years because they are easy to manufacture and have a wide range of industrial applications such as textile dyeing and bioactivity [1-15]. Polyethylene terephthalate (polyester) is a semi-aromatic thermoplastic fiber that has a variety of uses as a fiber in the textile industry [16]. Permanent functional activation of polyester surfaces is a difficult task due to the need of functional groups and inadequate wettability. Various modification methods have been used to improve polymers, including plasma treatment, grafting, metalic nanoparticles, alkaline hydrolysis, and UV irradiation. Plasma treatment improves the surface properties of polyester fabrics through increasing surface roughness and polar functional groups. Metal nanoparticles have a significant impact on the improved surface of polyester fabrics. The alkaline medium enhances the surface activity of polyester fibers, improves the absorption of nanoparticles and provides the alcohol needed to reduce the precursor to metal nanoparticles. The use of nanoparticles, like semiconductor nanoparticles, over the last decade has increased due to their electrical, mechanical and optical properties [17]. ZnO NPs and TiO_2 NPs are widely used due to their wide band gap. ZnO NPs and TiO_2 NPs have been used as pretreatment for polyester fabrics [1, 2]. ZnO and TiO_2 are non-toxic and chemically stable at high temperatures. Polyester fabric is treated with TiO_2 or ZnO nanoparticles to improve self-cleaning ability and light fastness. In this work, we present in details the comparison between nano zinc oxide and nano titanium dioxide when they are used to treat polyester fabrics before and after the dyeing process in order to give these

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fabrics multiple properties, including improving the light fastness, self-cleaning and ultraviolet resistance properties..

2. Materials and Methods

General method for synthesis of disperse dyes **1-6** which applied in this survey had been annotated in our published study [1, 2].

Dyeing procedure

El-Mahalla El-Kobra Company, Egypt, provided scoured and bleached 100% polyester fabric. The disperse dyes **1-6**, a dispersion of the dyes were produced by dissolution of the appropriate amount of dyes (3% shades) in 2 ml DMF and then added drop wise with stirring to the dye bath (liquor ration 1:30) containing dispersing agent. The pH of the dye bath was adjusted to 5.5, and the wetted-out polyester fabrics were added. We performed dyeing by raising the dye bath temperature to 130°C at and holding it at this temperature for 60 min. After they were cooled to 50°C, the dyed fibers were rinsed with cold water and reduction-cleared (1 g/L sodium hydroxide, 1 g/L sodium hydrosulfite, 10 min, 80°C). The samples were rinsed with hot and cold water and, finally, air dried [4].

Photo-Stimulated Color Removal on Polyester

A total of 0.01 g/L of methylene blue was marked on both the treated TiO_2 NPs or ZnO NPs (1–3%) treated polyester and the untreated fabrics. The polyester fabrics were illuminated through exposure to an ultraviolet lamp for 12 hours [1].

Ultraviolet Protection Factor Measurement

It is worth noting that the ultraviolet protection factor is the capability of dyed polyester fabric to block ultraviolet, which was conducted in an ultraviolet visible spectrophotometer 3101[2].

Light fastness

The light fastness test was performed using a carbon arc lamp and continuous illumination for 35 hours in line with ISO 105-B02:1988 test method 9. The influence on the colour of the examined samples was measured using the blue scale

Treatment of fabrics

Pre-treatment

Fabric samples were soaked in a 10 g/l nonionic detergent solution (Hostapal, Clariant) for 10 minutes before being dispersed with TiO_2 NPs or ZnO NPs (1-3 %) for 15 minutes with gentle stirring. The materials were squeezed to eliminate excess dispersion before being dried in a 70°C oven for 10 minutes. The fabrics were queried for 3 minutes at 140 °C. The fabrics were washed at 60 ºC for 15 minutes in an aqueous solution with a liquor ratio of 1:50 containing 3 g/l nonionic detergent solution (Hostapal, Clariant) [1].

Post-treatment

After dyeing, the fabric samples were soaked in a 10 g/l nonionic detergent solution (Hostapal, Clariant) for 10 minutes before being dispersed with TiO_2 NPs or ZnO NPs (1-3 %) under gentle stirring for 15 minutes. The materials were squeezed to eliminate excess dispersion before being dried in a 70°C oven for 10 minutes. The fabrics were queried for 3 minutes at 140 °C . The fabrics were washed at 60 ºC for 15 minutes in an aqueous solution with a liquor ratio of 1:50 containing 3 g/l nonionic detergent solution (Hostapal, Clariant) [2].

3. Results and Discussion

It is a great value to mention here that scheme 1 shows the chemical structure of the disperse dyes **1-6** used to dye the polyester fabrics [1, 2].

3.1. Self Cleaning.

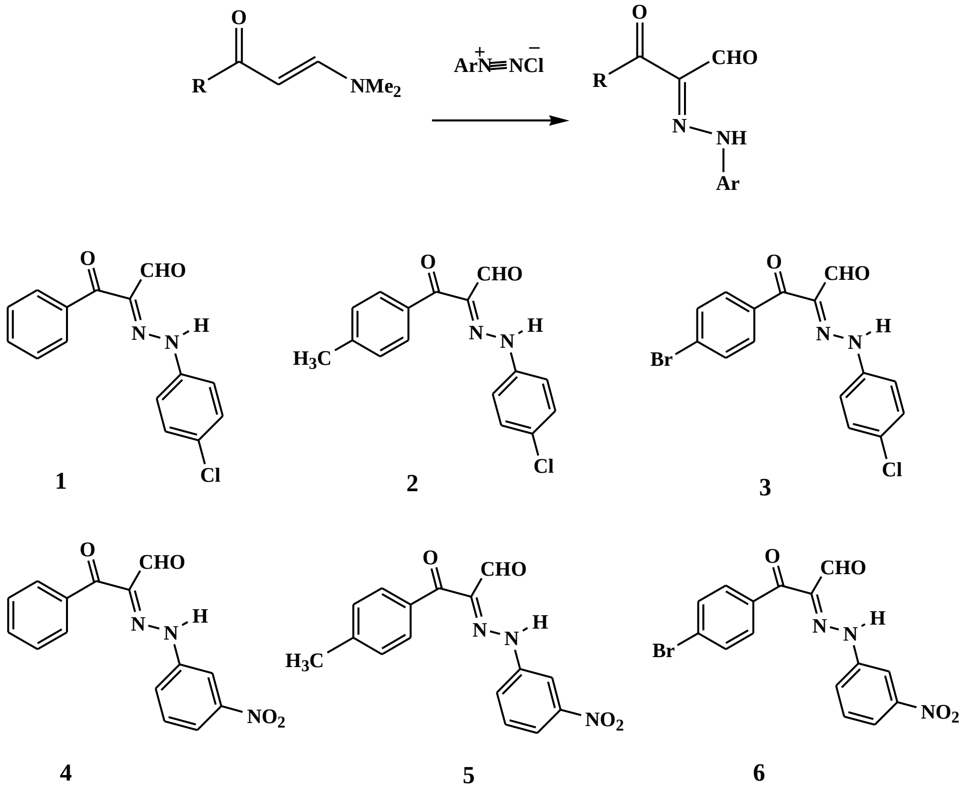
It is clear from Table 1, regarding the removal of colours that treating polyester fabrics after the dyeing process (post-treatment) with nano-particles of zinc oxide ZnO NPs or nano-particles of titanium dioxide TiO_2 NPs were better than treating polyester fabrics before the dyeing process (pre-treatment), for all dyes **1-6**, except dye **3** when treated with TiO_2 NPs. The values of dye removal for untreated dyed fabrics were always lower than values of dye removal for treated dyed fabrics for all prepared dyes **1-6.** In general, when referring to the self-cleaning values when comparing both methods of treating dyed polyester fabrics with dyes **1-6**, we can say that treatment with TiO_2 NPs is better than treatment with ZnO NPs.

3.2. Ultraviolet protection factor UPF.

It is clear from Table 2 that pretreatment of polyester fabrics before the dyeing process (pre-treatment) with zinc oxide nanoparticles or with titanium dioxide nanoparticles TiO_2 NPs was better than pre-treatment of polyester fabrics after the dyeing process (post-treatment), for all dyes **1-6** except for dyes **4** and **6**, which were the opposite, and the UPF values of untreated fabrics were always lower than the UPF values of treated dyed fabrics for all prepared dyes **1-6** except for dye **2** when treated with titanium dioxide nanoparticles. Table 2 shows that when making a comparison between the two methods of treating polyester fabrics dyed with dyes **2**, **3**, **5** and **6**, we find that the values of treatment with titanium dioxide nanoparticles TiO_2 NPs are the best for all dyes except for dye **2**, which was treated with nanoparticles of zinc oxide ZnO NPs is the best. While the two treatment methods for dyes **1** and **4** are the same effect. In general, when comparing the two methods of treating polyester fabrics with dyes **1-6**, we can say that treatment with TiO_2 NPs is better than treatment with ZnO NPs.

3.3. Light fastness enhancement

It is clear from the table 3, the dyeing treatment before the dyeing process (pre-treatment) with ZnO NPs or TiO_2 NPs was better than the treatment for polyester fabrics after the dyeing process (post-treatment) for all dyes **1-6**. In general, when referring to the light fastness values when comparing both methods of treating dyed polyester fabrics with dyes **1-6**, we can say that treatment with TiO_2 NPs is better than treatment with ZnO NPs



Scheme 1. Chemical structures of the disperse dyes 1-6

Table 1. Dye removal

Dye No	Treatment	TiO_2 Or ZnO %	Dye Removal of treated fabrics with TiO_2	Dye Removal of treated fabrics with ZnO	Dye No	Treatment	TiO_2 Or ZnO %	Dye Removal of treated fabrics with TiO_2	Dye Removal of treated fabrics with ZnO
1	Untreated		50		**4**	Untreated		50	
	Pre-treated	1	30	60		Pre-treated	1	40	40
		2	30	50			2	50	60
		3	50	50			3	70	50
	Post-treated	1	50	70		Post-treated	1	60	60
		2	60	40			2	60	60
		3	60	50			3	50	60
2	Untreated		50		**5**	Untreated		50	
	Pre-treated	1	40	-		Pre-treated	1	60	60
		2	50	50			2	50	60
		3	50	50			3	70	50
	Post-treated	1	50	50		Post-treated	1	60	50
		2	60	60			2	50	60
		3	60	50			3	60	70
3	Untreated		50		**6**	Untreated		50	
	Pre-treated	1	50	50		Pre-treated	1	40	40
		2	60	40			2	50	50
		3	60	50			3	60	50
	Post-treated	1	40	50		Post-treated	1	60	60
		2	40	50			2	70	50
		3	50	60			3	60	50

Table 2. UPF of treated polyester fabrics

Dye No	Treatment	TiO_2 Or ZnO %	UPF of treated fabrics with TiO_2	UPF of treated fabrics with ZnO	Dye No	Treatment	TiO_2 Or ZnO %	UPF of treated fabrics with TiO_2	UPF of treated fabrics with ZnO
1	Untreated		738.4		4	Untreated		277.8	
	Pre-treated	1	836.0	817.4		Pre-treated	1	316.9	435.7
		2	452.8	476.5			2	281.4	186.5
		3	773.5	369.8			3	261.4	164.7
	Post-treated	1	329.5	452.2		Post-treated	1	410.2	602.7
		2	308.3	707.9			2	366.3	564.1
		3	393.5	372.5			3	384.3	271.8
2	Untreated		396.0		5	Untreated		380.4	
	Pre-treated	1	377.3			Pre-treated	1	1240.1	413.4
		2	394.1	394.6			2	595.7	692.5
		3	346.6	368.7			3	700.9	523.0
	Post-treated	1	285.7	414.1		Post-treated	1	1214.3	472.7
		2	324.5	379.2			2	708.1	341.0
		3	259.5	326.5			3	667.2	425.4
3	Untreated		308.7		6	Untreated		220.1	
	Pre-treated	1	420.1	402.8		Pre-treated	1	430.9	252.7
		2	340.8	335.6			2	313.6	344.0
		3	366.0	278.1			3	355.8	277.8
	Post-treated	1	353.6	313.8		Post-treated	1	448.9	337.9
		2	280.7	258.9			2	166.1	509.1
		3	375.4	295.5			3	447.9	284.8

Table 3. Light fastness treated polyester fabrics.

Dye No	Treatment	TiO_2 Or ZnO %	Light Fastness of treated fabrics with TiO_2	Light Fastness of treated fabrics with ZnO	Dye No	Treatment	TiO_2 Or ZnO %	Light Fastness of treated fabrics with TiO_2	Light Fastness of treated fabrics with ZnO
1	Untreated		3-4		4	Untreated		3	
	Pre-treated	1	4	3-4		Pre-treated	1	3-4	3
		2	2-3	4			2	3-4	4
		3	4	3			3	3-4	4
	Post-treated	1	3-4	3		Post-treated	1	4	3
		2	3-4	3			2	4	3
		3	3-4	3			3	4	3
2	Untreated		5		5	Untreated		3	
	Pre-treated	1	3-4	-		Pre-treated	1	4-5	3
		2	3	3-4			2	4-5	2-3
		3	2-3	5			3	4-5	4
	Post-treated	1	2-3	3		Post-treated	1	3-4	3
		2	4	3			2	3	3
		3	4	3			3	3-4	3
3	Untreated		3		6	Untreated		2-3	
	Pre-treated	1	2-3	3		Pre-treated	1	2-3	3
		2	3	4			2	2	2-3
		3	2-3	2			3	2	4
	Post-treated	1	2	3		Post-treated	1	4	2-3
		2	2	3			2	4	2-3
		3	2-3	3			3	3-4	2-3

4. Conclusions

We can summarize the results we obtained in some points, the first is that the disperse dyes that we have prepared have been used in dyeing polyester fabrics, and secondly, the treatment of polyester fabrics with ZnO NPs or TiO_2 NPs has given these fabrics several properties like good ultraviolet protection values, improves light fastness and has the ability to self-clean. When comparing both methods, we found that treating fabrics with TiO_2 NPs is better than treating fabrics with ZnO NPs.

5. Conflicts of interest

There are no conflicts to declare.

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