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Application of TiO_2 Nano-particles to incorporate Self- Cleaning in Polyester Fabric with the Help of Binder and to Study Changes in Physical Properties

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ABSTRACT

The study aims at application of Nano scaled titanium dioxide nanoparticles with photocatalytic activity. The titanium dioxide nanoparticles were applied by a dip-pad–dry-cure process with the help of binders to textile materials for producing photocatalytic self-cleaning thin films. The study was focused on the application and characterization of titanium dioxide. The photocatalytic activity of TiO_2 nanoparticles was studied against Methyl Orange degradation test in solar box test instrument by dissolving TiO_2 nano-composites in an aqueous solution at low temperature. Polyester is most widely used synthetic fibre in textile and clothing. In this study, Anatase TiO_2 nanoparticles are dispersed at room temperature via Sonication and treated polyester fabrics exhibit significant photocatalytic self-cleaning properties of degradation of coffee stains. The mechanical properties like bending length, breaking strength, air permeability and durability of TiO_2 treated polyester fabrics were accessed. The study discovered that anatase TiO_2 based self-cleaning system shows potential systems for self-cleaning textiles having high potential in commercialization being environmentally affable, energy and water saving, low cost as of reduced laundry cycles of the finished textiles.

KEYWORDS: *Self-cleaning textile, mechanism, TiO_2 binder, coffee stains, polyester fabric*

INTRODUCTION

In today's modern era of time shortage and fast life apparel products with functional surface finishing treatment are of high demand [1]. Functionality of textiles can improve their applications, to meet consumer demands in the form of stability, ease etc. ensuring their constancy against chemical, photochemical thermal or mechanical damage. In this context, need of developing self-cleaning textiles is an aim required by the apparel industry as per new generation customer needs [2]. The self-cleaning textiles will add the cost saving on cleaning along with improved life of apparels due to continuous self-cleaning of the fabric surface under sunlight irradiation e.g. application of nanocrystallineTiO_2 thin films on the textile surface. The sol-gel process of applying nanofinish to textile substrates is a well known technique. It is beneficial as it can produce films of homogeneity, high purity which involve lower operating temperatures for producing particles which can be controlled [3,4]. The titanium dioxide nanoscaled photocatalytic films have taken research attention for their wide uses like anti-fouling [5,6], environmental purification [7,8], sterilization [9], deodorizing [10,11] and self-cleaning glass [12,13]. The literature reports numerous types of sol-gel metal oxide films with photocatalytic activities, but a few are aimed at the photocatalytic uses of sol-gel nanoscaled metal oxide films for textile finishing. As reported inorganic metal-oxide sol films applied via sol-gel hydrolysis of metal alkoxide precursors give the demanding opportunity of producing films on textiles with photo catalytic self-cleaning finish [14,15]. The present work aims to further study the photocatalytic activities of nanoscaled titanium oxide films on textiles via sol-gel process and their assessment in terms of mechanical and functionality of finish.

MATERIALS AND METHODS:

Trevira CS (100 gsm) polyester which is an inherently flame retardant fabric manufactured by Hoechst AG, Germany was used for the research and marketed and promoted by Reliance Industries, India. The fabrication process of TiO_2 based self-cleaning films on inherent flame retardant polyester fabric is attractive and challenging at a low temperature. A systematic nanocrystalline Titania preparation via sol-gel process at a low temperature was applied for obtaining highly photoactive single-phase anatase on textile surfaces.

2.1 Sample preparation: The inherent flame retardant polyester fabric was first washed with 2 grams per litre non-ionic detergent solution for 30 min in hot water in order to minimize degree of contamination.

2.2 Application of nanoparticles with binders

Chemicals: TiO_2 Nanoparticles (<100 nm), emulsifier (sodium dodecyl sulphate solution) purchased from Sigma Aldrich, USA, Trevira CS. Required amount of TiO_2 nanoparticles was sonicated with DI water (1:4) in addition to acrylic binder (1%) and emulsifier (sodium dodecyl sulphate solution, 0.5%) for 30 min. The substrate was immersed for 2 min in the suspension solution of nano-particles and following padding mangle to remove the excess solution. Afterwards, the fabric was dried for 4 min at 80 ^{0}C with curing for 3 min at 1400 ^{0}C. Effects of concentration of nanoparticles on the photo catalytic activity, the coatings were prepared in concentration (0.5, 1.0, and 1.5%) on the weight of fabric.

Recipe: using 0.5 % TiO_2 Nanoparticles
Fabric weight – 32.7 gm
DI water – 1:4 (130 ml)
Binder – 1%
Emulsifier – 0.5 %
TiO_2 – 0.5 %

Recipe: using 1 % TiO_2 Nanoparticles
Fabric weight – 32.7 gm
DI water – 1:4 (130 ml)
Binder – 1%
Emulsifier – 0.5 %
TiO_2 – 1 %

Recipe: using 1.5 % TiO_2 Nanoparticles
Fabric weight – 32.7 gm
DI water – 1:4 (130 ml)
Binder – 1%
Emulsifier – 0.5 %
TiO_2 – 1.5 %

2.3 Dye Degradation study

Chemicals: Methyl orange (Indikrom, Qualigen fine chemicals) was used for dye degradation study. Deionized water was used for whole reasearch. TiO_2 (particle size <100nm) nanoparticles were purchased from Sigma Aldrich, USA.

Equipments: Solar box (1500E, 550 W/m^2), Sonicator (Elmasonic S40H), UV-VIS (Win Aspect Plus, Specord 200 Plus) were used for different assessments.

The 0.02 gpl methyl orange solution with TiO_2 nano-particles was studied for dye degradation. Sonication process was used for 0.5 gpl dispersion in DI water of each of above nanoparticles by adding 40cc of Methyl Orange solution in 40 cc of nanoparticles dispersion. The resultant solution was exposed to ultraviolet by dye degradation taking sample from that solution at each half an hour interval.

2.4 Preparation of TiO_2 sols and finishing process:

The TiO_2 sols were produced via sol- gel process in aqueous solution at low temperatures using titanium tetra-isopropoxide as the precursor taking nitric acid and acetic acid as catalysts.

2.5 Assessment of degradation activities of coffee stains

The degradation activities of coffee stain for nestle, 1.0g 100% pure soluble coffee power added in 100 ml boiling water were assessed. Finished inherent polyester fabric was cut and dipped in coffee solution. The coffee stained fabrics were irradiated with predefined durations. One sample was cut from that dipped fabric and covered in black paper to remain unexposed to UV light. The irradiation of all samples was carried out in Solar box (irradiance 550 W/m^2 at 300-400 nm Wavelength).

2.6 Evaluation of physical properties of treated samples

Physical properties of the fabric were evaluated for flame Retardancy (Vertical flame retardancy test and 45^0 Angle flame Retardancy test), air permeability, breaking strength and bending length,

2.7 Durability of coated samples

The durability of TiO_2 layers on inherent flame retardant polyester fabric was studied with comparison of stain decomposition of treated fabrics before and after repeated washing as per IS Test method 687 using Launderometer.

2.8 Self-Cleaning performance by K/S: An average of these K/S values was taken to get the average K/S of the stain before and after the exposure. The % decrease in K/S was calculated.

RESULTS AND DISCUSSIONS:

3.1 Dye Degradation study

Figure 1 shows the degradation of Methyl Orange aqueous solution by TiO_2 nanoparticles which shows that the absorbance peak of the solution decreases continuously on exposure to UV light. The absorbance peak of the solution at zero h containing methyl orange and TiO_2 nanoparticles, before exposure to UV was shown at 464nm and decreases after irradiation and completely degrades after 3 h irradiation. This shows that TiO_2 nanoparticles have good photocatalytic properties.

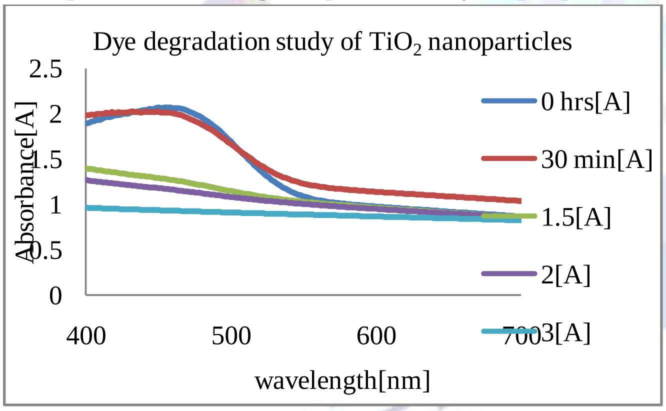

Figure 1. Dye degradation study TiO_2 nanoparticles

3.2 Self-cleaning Performance (Degradation of coffee stains)

3.2.1 TiO_2 nanoparticles with binder

Table1. unexposed and exposed samples

S. No	TiO_2 nano-particles with binder Conc (%)	Time of exposure	
		Unexposed	4h
1	0.5		
2	1.0		
3	1.5		

Table 1 presents the degradation of coffee stains on TiO_2 coated inherent flame retardant polyester fabric before and after light irradiation in solar box light exposure instrument. It can be seen that coffee stain on TiO_2 coated original inherent flame retardant polyester fabric with conc.1.5% were discolored significantly after 4h of light irradiation.

3.3 Assessment of Physical properties

3.3.1 Breaking Strength: The Breaking Strength of TiO_2 coated sample is shown in Figure 2. It can be seen from figure that there is a slight decrease in breaking strength in both direction, warp as well as in weft direction.

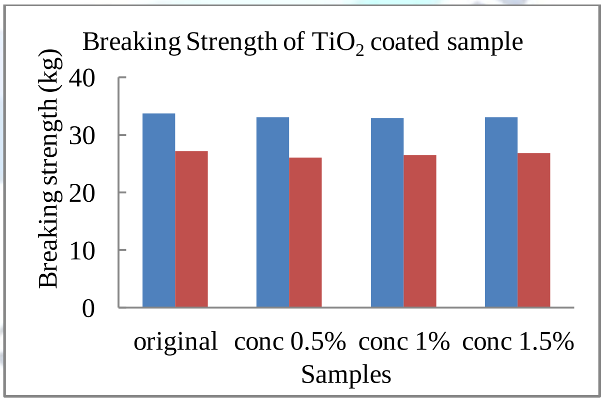

Figure 2. Breaking strength of TiO_2 Coated sample

3.3.2 Bending Length: Figure 3 shows that TiO_2 nanoparticles treatment of inherent flame retardant fabric with binder has increased the stiffness of fabric. The increased bending length of fabric is due to the presence of binder.

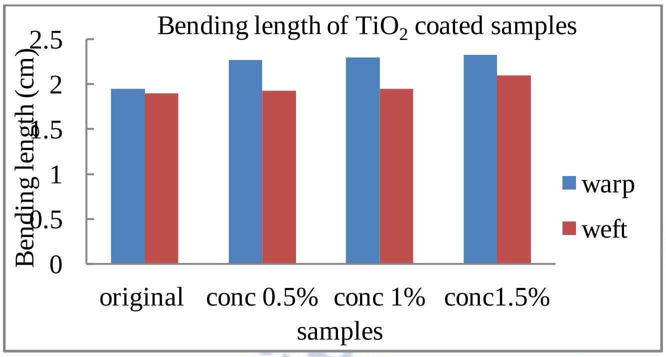

Figure 3. Bending lengths of TiO_2Coated samples

3.3.3 Air Permeability: Figure 4 shows that air permeability of scoured inherent flame retardant polyester fabric and TiO_2 treated polyester. It can be seen from the figure that the decrease in air permeability is higher in this case than with nanosols application because of presence of binder along with TiO_2 nanoparticles. The results indicate that there are no remarkable changes on increasing the con of nanoparticles.

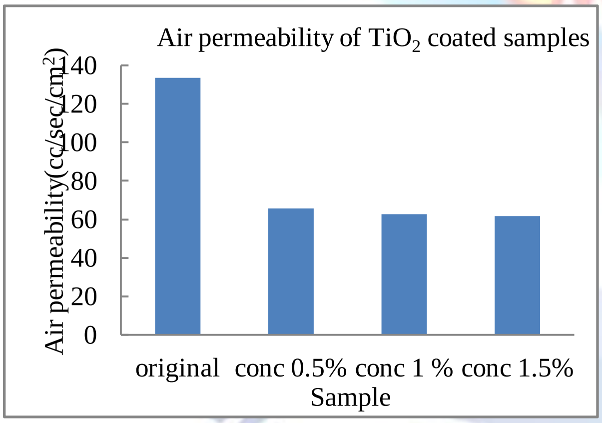

Figure4. Air Permeability of TiO_2 sol coated sample

3.3.4 Flame Retardancy: Table2 and 3 shows the flame retardancy test study of scoured IFR polyester fabric and TiO_2 coated fabric. The results indicate that TiO_2 treatment does not affect flame retardant properties of fabric.

Table 2. Flame Retardancy test

*DNI (Did not ignite)

45⁰ Flame Retardancy Test of TiO_2 solution coated samples

Table 3 Vertical Flammability Test: (BS:3119)

3.4 Self-Cleaning performance by K/S:

Table 5 Self-cleaning performance decreasing % of K/S value

Samples	Flame Retardancy	
	Warp	Weft
Original inherent flame retardant polyester fabric	DNI	DNI
TiO_2 coated polyester	DNI	DNI

Samples	Flame Retardancy					
	Warp Direction			Weft Direction		
	After fire (sec)	After glow (sec)	Flame Debrish	After fire (sec)	After glow (sec)	Flame Debrish
Original inherent flame retardant polyester fabric	Nil	Nil	No	Nil	Nil	No
	Nil	Nil	No	Nil	Nil	No
	Nil	Nil	No	Nil	Nil	No
TiO_2 coated polyester	Nil	Nil	No	Nil	Nil	No
	Nil	Nil	No	Nil	Nil	No
	Nil	Nil	No	Nil	Nil	No

Sample	Unexposed	4 wash cycles	8 wash cycles	Reduction (%)
0.5% TiO_2 nanoparticle with binder	32.80	1.36	1.18	96.3 %
1% TiO_2 nanoparticle with binder	1.67	1.23	1.28	23.5 %
1.5% TiO_2 nanoparticle with binder	1.77	1.21	1.07	31.2 %

The self cleaning performance of the fabric is also evaluated by the decreases percentages of the K/S value of the stain degradation of the TiO_2 coated inherent PET fabric as shown in table 5. The K/S value is decreased before and after washing of the fabric. It shows the fabric has good self cleaning performance.

CONCLUSION

• Nanocrystalline films using TiO_2 were prepared on inherent polyester fabrics with the help of binder and emulsifiers.

• The anatase nano-crystallite coated fabrics showed significant self-cleaning performance against coffee stains.

• TiO_2 nanoparticles with three different concentrations (0.5%, 1.0% and 1.5%) were applied to inherent flame retardant polyester fabric by using binder.

• No significant effect on bending length was found on the fabrics by using binder as it imparts stiffness to fabric.

• No effect on Flame Retardancy of inherent flame retardant polyester was found after coating.

• Durability of finish up to 8 washes indicates that there are no significant changes in photocatalytic activity of all coated samples on washing.

• Research estimates that photo-catalysis self-cleaning function can provide high added value apparels helping in greener and cleaner environment with the reduced needs for laundering.

• Thus, application of TiO_2 nanoparticles to apparels also beneficial for high-end applications as TiO_2 has good anti-odor, anti-bacterial and UV protective characteristics.

REFERENCES:

1. Ritika Sharma and Neetu Rani, Development of self cleaning textile with TiO -SiO binder, Asian dyer, Feb-March, 2020, 44-50.
2. Chengjiao Zhang, The Swedish School of Textiles, Report No.: 2013.14.3.
3. A.L. Linsebigler, G.Q. Lu, J.T. Yates Jr., (1995). Chem. Rev. 95, 735–758.
4. M.R. Hoffman, S.T. Martin. Choi,W, (1995). Chem. Rev. 95, 69–96.
5. Marius stamate, gabriel lazar, (2007). Mocm 13 – Volume 3 – Romanian Technical Sciences Academy –282-283.
6. Kamal K Gupta, Manjeet Jassal, Ashwini K Agrawal, IJFTR, 2008. Vol. 33, pp 443-450.
7. C.C. Chen, C.S. Lu, Y.C. Chung, J.L. Jan, (2007). Journal of Hazardous Materials 141,520–528.
8. Penwisa Pisitsak1, Arnon Samootsoot1 and Nassarin Chokpanich1. KKU Res. J. 2013; 18(2), 200-211.
9. Dr. A. Ahmad, Gul Hameed Awan, Salman Aziz. Paper No. 676, 404-412., Linsebigler, A. L., Lu, G., & Yates, J. T., Jr, (1995). Chemical Reviews, 95(3), 735-758.
10. T. Yuranova , R. Mosteo , J. Bandara , D. Laubb, J. Kiwi, (2006). Journal of Molecular Catalysis A: Chemical 244, 160–167.
11. K.T. Meilert , D. Laubb, J. Kiwi, (2005).Journal of Molecular Catalysis A: Chemical 237,101–108.
12. Mills, A., & Le Hunte, S. (1997).Journal of photochemistry and photochemistry and photobiology A: Chemistry, 108(1), 1-35.
13. Kim, S., Park, H., & Choi, W. (2004).). Journal of Physical Chemistry B, 108(20), 6402-6411.
14. Mills, A., Lepre, A., Elliott, N., Bhopal, S., Parkin, I. P., & O'Neill, S. A. (2003). Journal of photochemistry and photobiology A: Chemistry. 160(3), 213-224.
15. Karakitsou, K. E., & Verykios, X. E. (1993). Journal of Physical Chemistry, 97(6), 1184-1189.