IOSR Journal of Polymer and Textile Engineering (IOSR-JPTE)
e-ISSN: 2348-019X, p-ISSN: 2348-0181, Volume 2, Issue 1 (Jan - Feb. 2015), PP 01-05
www.iosrjournals.org

Self-Cleaning Finish on Cotton Textile Using Sol-Gel Derived Tio2 Nano Finish

Dr.B.Senthil kumar ,Asst.Professor
Gandhigram Rural Institute-Deemed University,Tamil Nadu.

Abstract: *TiO2 Nano Particles have been synthesized using titanium tetrachloride as precursor through Sol-gel technique. The characterization of synthesized particles was done in XRD and FTIR analysis. It is revealed from XRD and FTIT spectroscopy that the TiO2 nano particle formation. Subsequently the synthesized particles were applied on the Cotton textile plan woven fabrics using pad patch method using 1 wt% of acrylic binder. While coating three different contraction of TiO2 Nano particles were maintained. The self cleaning action of nano coated fabric has been quantified by measuring photo catalytic degradation of stain due to visible light irradiation. %of Decrease in K/S value is increased with respect to increase in TiO2 concentration as well as duration of visible light irradiation.*
Keywords: *TiO2 Nano particls, Self-cleaning property, Nano-Sol, Photocatalysis*

I. Introduction

Functional textiles are generally classified in functions related to basic properties, comfort properties,safety and new functions. The functional application oriented textile products can be further classified in to two types such as general apparels and special apparels (Chi-Chung,2002) .Sensitivity /appearance functions and health /cleanliness functions are further divided as branch of comfort functions. Textile finishing has always led to introduction of new technical properties,which are useful in diversified end uses. Technological diversification in finishing decides the performance domain of fabrics and renders it special functional properties. There has been a continuous improvement and innovation in the area of chemistry related to textile finishing. Recently high demand has created among the customer about the high technology textile products.

Ever since the introduction of Nano particles in textiles,efforts were on to produce finished fabrics with multiple functional performances. It was demonstrated in recent years that Nano technology can be used to enhance textile attributes, such as fabric softness, durability, and breathability, water repellency, fire retardancy, anti-microbial properties, and the like in fibers, yarns, andfabrics(Sawhney A P S et al,2008).Lee et al (2003) reported the use of nano sliver particles for imparting antimicrobial properties .Yadav et al(2006) reported that use of ZnOnano particles the antimicrobial as well as UV protection can be achieved. Photocatalysis have gained higher attention in recent years because these materials enablelow energy and low cost (Herrmann,J,M,2005&Karuanakaran ,C etal,2008).The Catalytic activity of TiO2 is based on the electron/hole pair information due to photo excitation (Kamal K Gupta etal ,2008). More over Nano level TiO2 exhibits higher photo-catalytic properties behave of having large surface area. In addition to that photo catalytic activity of TiO2 Nano particle coating depends strongly on the phase ,the crystallite size, porosity of the coatings and the particles size are formed during synthesis(Kamal K Gupta etal ,2008).Among the photocatalysts ,Tio2 Nano particles are widely used in air and water purification and self-cleaning process(Laoufi,N.A etal,2008).TiO2 coating attempts on surfaces such as glass,textile,cement and plastics was done in various places (Coronado ,J,M. etal.2008). Colemanaetal(2005) reported that TiO2 has three types of crystal structures in nano level called anatase,rutile and brookite. Anatase types of TiO2 nano particles are generally having high photo catalysis. Several techniques

As reported by Chen,X et al(2007) major efforts have been devoted to the development of methods for their synthesis, and numerous, fundamentally different ways of preparation have been postulated some of them being sol-gel, sol, hydrothermal and solvothermal methods , micelle and inverse micelle methods, direct oxidation methods , chemical and physical vapour deposition methods and also electrodeposition , sonochemical and microwave deposition methods . However, when we take into consideration the application of TiO2 nanoparticles on textile substrates it should be kept in mind that the low-temperature methods for the synthesis is highly preferable. Therefore, the wet chemistry methods such as solgelor hydrothermal methods are used to obtain textiles withself-decontaminating properties. As these methods are most promising ones. The sol-gel method (Andersson etal,1995) is performed bythe hydrolysis of a titanium precursor, usuallytitanium(IV)chloride or titaniumtetraisopropoxide (TIP) ina mixture of water and alcohol in acidic conditions. Itinvolves the reaction of hydrolysis of a corresponding Tiprecursor and a subsequent polymerization reaction leading to the formation of the liquid sol phase.

This paper titanium tetrachloride has been utilized as precursor for TiO2 nano particles using sol-gel techniques. The synthesized nanoparticle are then characterized using XRD,FTIR and SEM. Then Nano particle then applied on the fabric by pad –dry cure method in different concentration. The self cleaning action of TiO2 studied.

II. Experimental

2.1Photocatalytic Mechanism of TiO2

The development of nano technology, used to get self-cleaning fabrics is to apply photocatalytic materials on the textile substrate. By utilizing the photoreaction induced by photocatalytic material, when the textile substrate expose to certain irradiations, irradiations with higher energy than the band gap of the photocatalytic material, the organic contaminants will be degraded into air and water on the photocatalytic material surface. (Malik T. et al., 2013) Titanium dioxide gets a lot attention during past decades and is taken as one of the most promising photocatalytic materials that could be used in textile industry for many advantages such as low band gap, UV protection. (Hashimoto ,k et al., 2005)

The mechanism of photoreaction induced by TiO2 was extensively studied and explained by many researchers, some of them are Dastjerdi R. and Montazer M.(2010), Yuranova T. et al (2007) and Chen X. and Mao S.(2007), when TiO2 nanoparticles are irradiated by light, usually ultraviolet light (UV), with energy equal to or higher than its band gap (>3.0 eV), electrons on the TiO2 surface are excited and will escape from valence band to the conduction band, leading to formation of electron- hole pairs on the surface – excited negative charged electrons in the conduction band and positive charged holes in the valence band. The created pairs can recombine, radiatively or get trapped and react with other materials absorbed on the photocatalyst. The pairs will cause redox reactions at the surface, the negative electrons (e-) will combine oxygen to produce super oxide radical anions (O2 -), the positive electric holes (h+) will act with water to generate hydroxyl radicals. Ultimately, all the formed highly active oxygen species will oxidize organic compounds to carbon dioxide (CO2) and water (H2O). Hence, titanium dioxide can decompose common organic matters in the air such as odour molecules, bacteria and viruses. However, it has been demonstrated that the intensity of photocatalytic activity of titanium dioxide is affected by its physical and chemical properties such as crystallinity, shape, size of the particles and surface area. The mechanism of generation of oxidative radicals and photodecomposition of organic compounds could be seen in below figure.

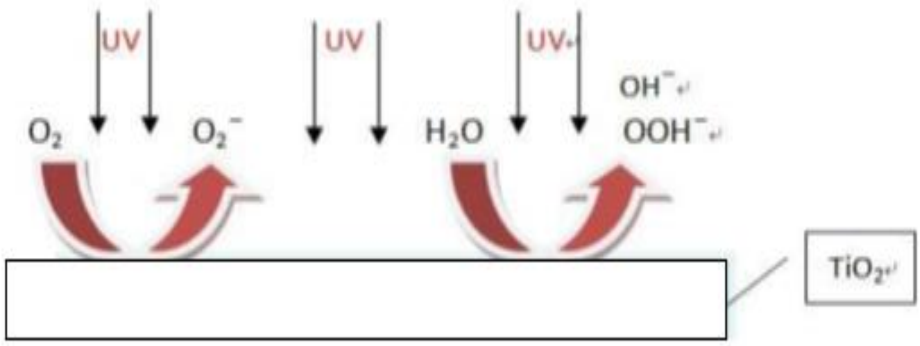

Fig.1- shows the highly oxidative radicals produced under UV light by TiO2

III. Materials

The cotton plan woven fabric with well bleached. The construction parameters are as follows ,ends per inch 96 and pick /inch is 75 .Warp and weft counts are 40s Ne .The cloth GSM is 135.The titanium tetrachloride precursor were procured from Raj enterprises ,Mumbai. Lissapol-N surfactant was used as capping agent during the sonication process.

IV. Methods

4.1Synthesis of TiO2 Nano particle using titanium tetrachloride

As per the procedure reported by Parthasarathi(2009) titanium tetrachloride (TiCl4)was taken as a precursor .The said chemical was hydrolyzed by adding 1.0 M ammonia drop-wise to prepare a stock solution, in which the concentration of titanium was 5.45M.During the reaction ,the yellow cakes of TiO(OH)2 were formed first, which was then dissolved with added ammonia solution to form an aqueous TiCl4 solutions. This stock solutions remained in a stable state without precipitation even after 5 months at room temperature. Finally ,ammonia solution with a concentration of 4.5M HNO3 was added to the stock solutions with various concentrations of Ti 4+ for precipitation. This solution was poured into reactor and placed in oven at 90^0cfor precipitation.TiO2 precipitates were repeatedly cleaned by distilled water and dried at 80 ^{0}c for 6 h.

4.2 Tio2 Nano coating on fabric

Nano –particle were applied on the fabric using pad-dry-cure method.Before initiating the coating process, the fabric samples were dried at 100 °C for 5 min. in oven to remove the moisture content .. The coating were prepared 1.0Wt% of TiO2 nano particles and 1.0% acrylic binder on weight of the solutions. Subsequently sonication process was initiated for 30 min in the solution bath to ensure the even application on the fabric. The surfactant of 0.5% Lissapol-N is added in the bath as a capping agent. The cotton fabric was immersed for 1-2 min in aqueous nano solution then passed over the padding mangle to remove the excess amount solution.A100% wet pick up maintained for all the samples. After the padding the fabric was dried for 4 min at 80°C and then cured for 30 min at 100 °C. Similarly 2% nano particle coating is also done

V. Characterization of Nanoparticles

The nano-particles size, shape, chemical and physical structures were characterized through the following procedures

5.1 X-Ray Diffraction (XRD)

The Crystallinity of the nanostructures was done by XRD spectrum using SHIMADZU-XRD 6000 advanced X-rays Diffractometer equipped with a Cu Kα radiation ,λ=1.5406A^0,applied voltage 30kV and current 30 mA.The dried nanoparticles deposited as randomly oriented power onto a plexiglass sample container, and the XRD patterns were recorded at angle 10^0-80^{0}c,with a scan speed of 5^0/min,sampling pitch of 0.02^0 ND PRESET TIME OF 0.24 S.The crystallite domain diameters(D) were obtained from XRD using the Debye-Scherrer's equation ,as shown below

$$D=\frac{0.89X\lambda}{\Delta WXCos\theta}$$

Where λ is wave length of the incident X beam (1.5406 Å for Cu kα);θ is bragg;s diffraction angle;and**Δ**W is the full width of the X-ray pattern line at half peak –height in radians

The XRD Spectra of TiO2 Nano-particle is shown in figure no.2 .It shows the well defined peak of TiO2 Nano particles presence.The XRD spectra of TiO2 Nano-particles synthesized using TiCl4 shows distinctive peaks at 29.9,38,47.8,57,64.5 and 74.6 respectively

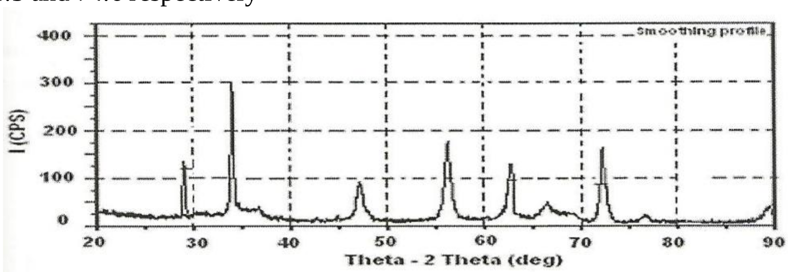

Fig.2-XRD Pattern of TiO2 nano particle synthesized by TiCl4

5.2 FTIR Spectroscopy

SHIMADZU-FTIR 8400S with a spectral range of 4000-400 $cm^{-1}$was utilized to study the nano particle presence.Spectra with resolution of 0.9 -1.0 $cm^{-1}$and given as ratio of 200 single bean scans to the same of background scans in pure KBr.KBr was grounded to fine power and mxed with samples[2% w/w].

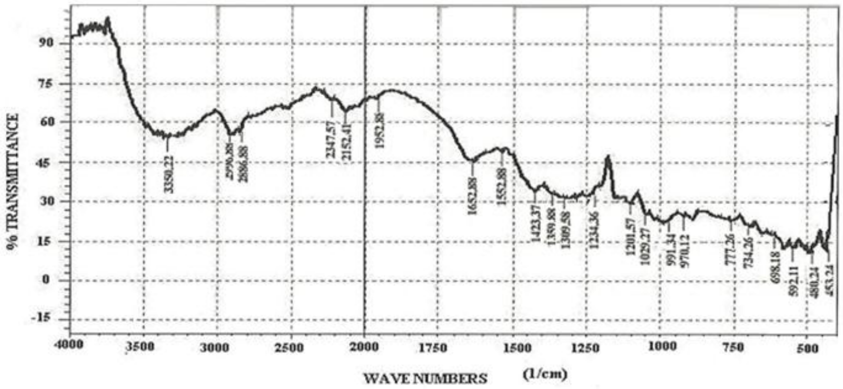

Fig.3-FTIR Spectrogram of TiO2 nano-particle synthesized using TiCl4

The above FTIR spectra for TiO2 coated cotton fabrics.The diffraction spectrogram of TiO2 nano particles synthesized shows absorption band of TiO2 near 482 cm^{-1} .The peak at 3000 and 1200 cm^{-1} indicate the presence of –OH and C=O residues due to atmospheric moisture and CO2 respectively.

5.3 SEM Analysis

JEOL-JSM-6360 –SEM analyzer was used to predict the samples. The treated fabric samples were mounted on a specimen stub with double sided adhesive tape,coated with gold in a sputter coater and examined.

Figure 2 shows the SEM image of TiO2 nano particle coated cotton plain woven textile fabrics.The diagram proved that nano particles are well dispersed and embedded on the surface of the fibre. Some places in the diagram (a) shows the uneven and agglomerated patch coating ,which is due to larger nano particle size. More over the particle size place an important role in determining their adhesion on the fabric.

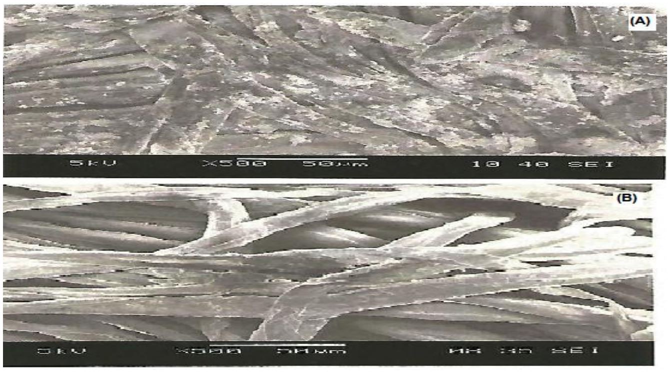

Fig.4-SEM image of Tio2 n Nano particle coated fabric produced from Sol-gel technique.

5.4 Evaluation of Self-cleaning action

As reported by (Kamal, K .etal 2008)The self-cleaning activity was assessed for the Nano coated textile fabric is by exposing the samples containing adsorbed coffee stain to visible irradiation .The measured quality of 6% coffee solution was introduced on the fabric and was allowed to spread.One half of each stain on the fabric was exposed to sunlight for 12-48 h,while the other half was covered with a black paper to prevent its irradiation from sun light.The exposed part of the stain was compared with that of covered part for self-cleaning action.Premier Color scan SS5100$\dot{A}$ Spectrophotometer was used to measure the change in K/S value.

The K/S value of exposed part= $\frac{\left(\frac{K}{s}\right)un\ expected-\left(\frac{k}{s}\right)expected}{\left(\frac{k}{s}\right)unexpected} X100$

Where K is the absorption;and S is scattering.

The self-cleaning property of TiO2 Nano coated textile fabric is analysed and reported in graphical form shown as fig.5.The K/S value of coffee stained cotton fabrics were measured in various Nano-TiO2 coated structures in different duration of 12.24 and 48h.The percentage of decrease in K/S value for the exposed samples in higher concentration of TiO2 Nano coating.The rate of change in deterioration is also depends upon the duration as well.Higher the duration the percentage of decrease in K/S value is increased.

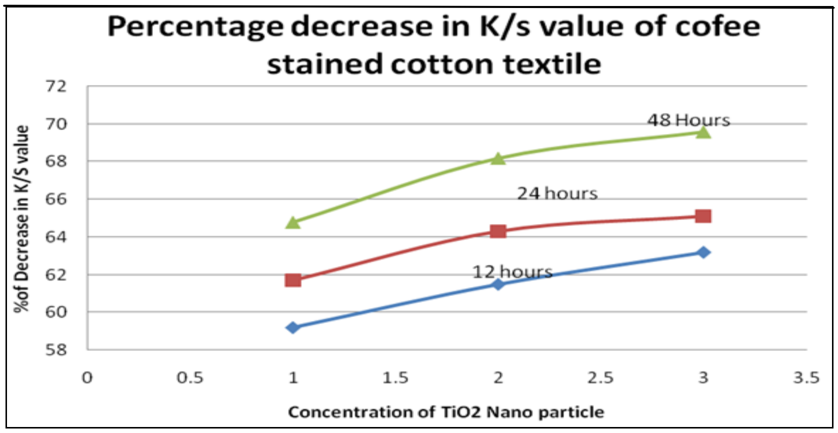

Fig.5-percentage of decrease in K/S Value of Coffee stained cotton fabric in various Nano TiO2 concentrated coating

VI. Conclusion

- TiO2 Nano particle were synthesized through Sol-gel technique. The XRD spectra analysis indicated the presence of Nano particle and then FTIR analysis again conformed the TiO2 Nano particle formation.
- Coating of TiO2 Nano particles were done well through Pad-Batch technique .
- SEM Image demonstrated that the even coating of TiO2 Nano particle over the surface of the cotton textile.
- The coated Textile structure demonstrates the significant self –cleaning activity when exposing under UV light spectrum.
- It is also confirmed that the percentage of TiO2 Nano particle increases with increase in Self-cleaning activity and the High duration of exposing under UV light will also accelerate the Self-cleaning action.

References

[1]. Anderson, C., & Bard, A. J. (1995). An improved photocatalyst of TiO2/SiO2 prepared by a sol-gel synthesis. The Journal of Physical Chemistry, 99(24), 9882-9885.

[2]. A.P.S.Sawhney1 and B. Condon, K.V. Singh, S.S. Pang and G. Li ,"Application of nano technology in Textiles", Textile Research Journal,2008, Vol 78(8) 731-739 DOt 10.1177/0040517508091066.

[3]. Beringer, J., and Hofer, D.(2004), Melliand Jut., 10, 295.

[4]. Chen Xiaobo and Mao Samuel S., 2007, Titanium Dioxide Nanomaterials: Synthesis, Properties, Modifications, and Applications, Chem. Rev., 107 (7), pp.2891-2959

[5]. Coleman HM; Marquis CP; Scott JA; Chin S-S; Amal R, (2005), ' Bactericidal effects of titanium dioxide-based photocatalysts', Chemical Engineering Journal, vol. 113, no. 1, 55 – 63.

[6]. Daoud and J.H. Xin, (2004).Nucleation and Growth of Anatase Crystallites on Cotton Fabrics at Low Temperatures", J. Amer. Ceram. Soc., 87 (5), 953-955.

[7]. DastjerdiRoya and MontazerMajid, (2010), A review on the application of inorganic nano-structured materials in the modification of textiles: Focus on anti-microbial properties, Colloids and Surfaces B: Biointerfaces,79, pp. 5-18.

[8]. J.M.Coronado.B,Sanchez,R,Portela,S.Suarez,(2008) J.Solar energy engineering trans.130(1) 115-120.

[9]. Kamal K Guptha ,ManjeetJassal&AshwinK.Agrawal(2008).Sol gel Derived titianum dioxide finishing of cotton fabric for self cleaning ", Indian J. of Fibre and Textile research,Vol 33, 443-450

[10]. Karunakaran, C., &Anilkumar, P. (2008). Photooxidation of iodide ion on immobilized semiconductor powders. Solar Energy Materials and Solar Cells, 92(4), 490-494.

[11]. Hashimoto Kazuhito, IRIE Hiroshi and FUJISHIMA Akira, 2005, TiO2 Photocatalysis: A Historical Overview and Future Prospects, Japanese Journal of Applied Physics, 44(12), pp. 8269-8285.

[12]. Herrmann, J. M. (2005). Heterogeneous photocatalysis: state of the art and present applications In honor of Pr. RL Burwell Jr.(1912–2003), Former Head of Ipatieff Laboratories, Northwestern University, Evanston (Ill). Topics in Catalysis, 34(1-4), 49-65.

[13]. J.Zhao,V,Krishna,B.HUa,B.Moudgit,Bkoopman,(2009).J.Photochemical.Photobiot,A94(2)(2009)96-100

[14]. Laoufi, N. A., Tassalit, D., &Bentahar, F. (2008). The degradation of phenol in water solution by TiO2 photocatalysis in a helical reactor. Global NEST Journal, 10(3), 404-418.

[15]. L. Haixia, D. Hua, and Z. Jing, "Performance research of polyester fabric treated by nano titanium dioxide (N ano-TiO2) anti-ultraviolet finishing," International Journal of Chemistry, vol. 1, p. 57, 2009.

[16]. Lee HJ, Yeo SY, Jeong SH (2003) Antibacterial effect of nanosized silver colloidal solution on textile fabrics.J Mater Sci 38:2199–2204.

[17]. Malik Tanveer, NogjaShriraj and GoyalPurva, (2013), Self-cleaning textile - an overview, available at : <http://www.fibre2fashion.com/industry-article/4/389/self-cleaning-textile-an-overview1.

[18]. Sivakumar,A, Murugan,R, Sundaresan,K&Periyasamy, S.(2013).UV protection and self-cleaning finish for cotton fabric using metal oxide nanoparticles", Indian Journal of Fibre& Textile Research,Vo. No. 38, 285-292.

[19]. V. Parthasarathi and G. Thilagavathi, "Synthesis and characterization of titanium dioxide nano-particles and their applications to textiles for microbe resistance," Journal of Textile and Apparel, Technology and Management, vol. 6, no.2, 2009.

[20]. Yadav A, Prasad V, Kathe AA, Raj S, Yadav D, Sundaramoorthy C, Vigneshwaran N (2006) Functional finishing in cotton fabrics using zinc oxide nanoparticles. Bull Mater Sci 29:641–645

[21]. Yuranova T., Laub D. and Kiwi J., 2007, Synthesis, activity and characterization of textiles showing self-cleaning activity under daylight irradiation, Catalysis Today, 122 (2007), pp.109-117