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Effect of TiO_2 Nanoparticles on Aluminium Effect Pigment Coated Fabric-Application of Reflection and Transmission of Light through Fabric

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Abstract

Cotton and polyester plain woven fabric have been incorporated with two coats: basecoat with/without TiO_2 nanoparticles and topcoat prepared with aluminium effect pigment. After pigmenting and drying, the reflection and transmission characteristics were measured through UV-Vis spectrophotometry. The reflection and transmission properties of the coated textile were investigated as a function of wavelength ranging from 220 nm to 1400 nm. Using TiO_2 nanoparticle as coating in combination with aluminium effect pigment can be used to develop optical protection of textile- will be discussed in this work.

Keywords: TiO_2 Nanoparticles; Special effect pigments; Aluminium pigment; Textile coating; Textile functionalization

Introduction

Aluminium pigments are mainly used in coatings to achieve a silvery lusture on textile surface. Aluminium reacts with water which leads to aluminium oxide and aluminium hydroxide formation. Surface modification of aluminium is important to prevent these reactions [1]. Silica is the dominating inorganic way of coating with silica.

The surface modification of textile materials with nanoparticles has been investigated through several studies aimed at producing finished fabrics with different performances [2-6]. Good optical properties, water repellent antistatic textiles, photo catalytic coating have been developed through different experiments [7-9]. To get antimicrobial effect on modified surface is one of the biggest fields of research [10-18]. Surface modification has been done using different material following different process.

To get special optical effects of color, special effect like aluminium pigments are used [19]. Optical property of the fabric depends on the fundamental parameters of textiles [20-24]. Silver-doped Titanium Oxide coatings has been developed to get UV protection of cotton fabrics [25]. Fabric after being dyed shows more protection in compared to bleached fabric. Normally unbleached cotton shows more sun protection than bleached cotton [20,22-27]. In this circumstance, different solution can be followed to reduce transmission or increase reflection. ZnO nanoparticles can be used as absorber efficiently on the surface of cotton [28-32].

The modified textile surface with different properties like antibacterial, self-cleaning, ultraviolet-protection, antistatic properties are being obtained [33-42]. By finishing with nano-TiO_2 sols, cotton fabrics prevent ultraviolet ray [43,44]. Silver improves the performance of TiO_2 photo catalyst in visual region spectrum [45,46]. Silver/TiO_2 is used to get the photo catalytic, self-cleaning and antibacterial properties of textile materials [47-54].

Cotton is the most important natural and cellulosic textile fiber. The cotton fibre contains 88 to 96.5% of cellulose and after scouring and bleaching, cotton possesses 99% cellulosic [54]. On the other hand, 100% polyester textile was used as well. The polyester is of at least 85% by weight of an ester.

In this work, textile surface has been treated with two coats: basecoat and topcoat. Considering the presence of the TiO_2 on the basecoat, the transmission % and the reflection % of the aluminium effect pigment coated textile were measured and they will be compared with each other to show the developed optical properties.

Materials and Methods

Materials

Woven cotton and polyester fabrics are composed of two sets of warp and weft yarns interlacing at right angles. Cotton fabric is very durable, absorbent and comfortable which make its appeal in application directly to skin. It helps the body to keep warm in winter and cool during summer. Plain-weaved 100% cotton woven fabric was used in the experiments.

On the other hand, the polyester fabric though is produced in same technique; it shows different properties than cotton. Being a man-made fabric, it does not give same advantages like natural cotton fiber. The fabric made from polyester fibers is extremely strong in structure and durable in nature. Resistance to most chemicals make it difference than any other fiber in textile processing from dyeing to finishing.

Shinedecor 3500 and Shinedecor 5000

Eckert pigment Shinedecor 3500 and Shinedecor 5000 are white aluminium pigments which have been developed for the development of transmission or reflection properties. Shinedecor 3500 shows ‘brilliant silver bright’ color and Shinedecor 5000 shows silver extra brilliant color. Non-volatile pigment concentrations % of Shinedecor 3500 and Shinedecor 5000 are 32% and 26% respectively [55]. These pigments comply with REACH regulation. The pigments are widely used in coating, plastic and painting industry. In coating technology the coated surface shows the highest possible amount of reflection with excellent corrosion resistance by maintaining excellent whiteness color.

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Preparation of basecoat1 and basecoat2

Two different basecoats were applied on the fabric surfaces. Basecoat1 contains no TiO_2 compound, on the other hand basecoat2 contains TiO_2 compound as 30% Helizarin White RTU was added additionally. In both coatings, 3% of Lutexal Thickener HIT PLUS was added as thickener and rest amount to 100% was water. Edulan GS was used to disperse the chemicals uniformly, acting as foam coating agent. Edulan XCL is anionic mixture of aliphatic polyisocyanates. 1.5% of it was used. It improves technical properties of coating like solvent, UV etc and it have no effect on the light fastness of the coating (Figure 1).

Preparation of topcoat

Topcoat was prepared by using 30% Edulan CA, 1.5% Edulan XCL and 2.5% Lutexal Thickener HIT PLUS. 2.5% and 10% pigments were used for both shinetor 5000 and shinetor 3500 pigments (Supplied by Eckert GmbH). Like basecoat, the rest amount to be 100% was water.

Methods

Sample specimens were taken which are already been ironed to get the perfect result to absorb the stuffs. Samples were set on strand to be hold up. Prepared solutions are poured on fabric. By the help of squeezing roller, coating for basecoat1, basecoat2 and topcoat was done. Samples were then dried for 2 minutes at 130-degree temperature. After 2 minutes, samples were brought out and kept in open air for 24 hours. The structure of the final deposited film depends on the evaporation condensation reactions and shear-induced ordering [56]. Eight samples, four for cotton and four for polyester, have been treated with two aluminium effect pigments. The samples were then investigated to measure the transmission and reflection in UV-vis spectrophotometer.

Results and Discussion

UV spectrum, visible spectrum and infrared spectrum range respectively 10 nm-400 nm, 400 nm-800 nm and 800nm-1mm. Ultraviolet spectrum is further subdivided in UV-A, UV-B and UV-C ranges and infrared spectrum is subdivided in IR-A, IR-B and IR-C ranges. Due to the structure of effect pigment, the transmission % is decreased while it was being applied on textile as coating. Higher reflection % has been achieved due to coating of effect pigment on textile surface as a comparison with non-coated textile. Thus, these coats provide better optical protection. We examined aluminium pigment coated cotton reflection % and transmission%.

Special effect pigment like aluminium consists of small metal platelets. These platelets operate like small mirrors and make it hard to permit the light through textile. By the application of TiO_2 on basecoat makes the permit of light harder. So that the reflection % is more while using TiO_2 on basecoat than the basecoat without TiO_2 (Figures 2a and 2b).

Same phenomenon has been found in case of transmission. An increase of reflection means the decrease of transmission and the addition of an extra layer on textile substrate decreased transmission of coated surface. So, that the transmission percentage is decreased while using TiO_2 on basecoat than the basecoat without TiO_2 (Figure 3a and 3b).

As the surface of pigment particles influences the optical properties of textile. For all the cases, the topcoat compositions were same. Only

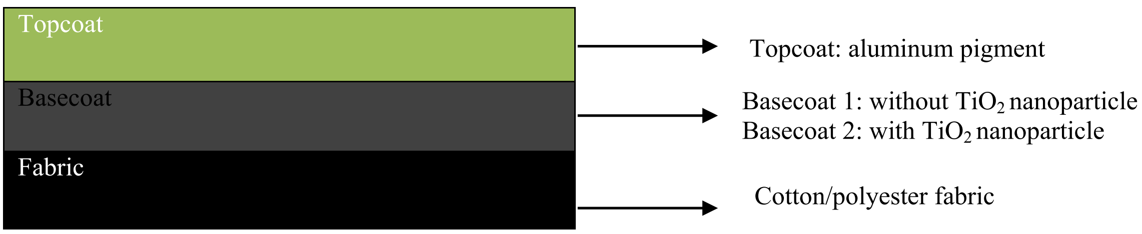


Figure 1: Schematic views of coating process of basecoat 1, basecoat 2 and topcoat.

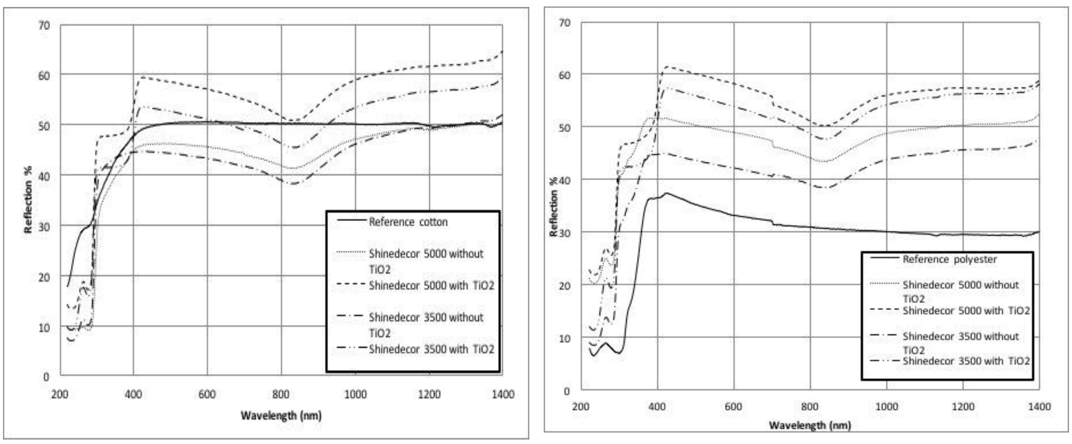


Figure 2a Figure 2b

Figure 2: Reflection % of coated 2a cotton and 2b polyester textile treated with 10% pigment on topcoat and with/ without TiO_2 on basecoat.

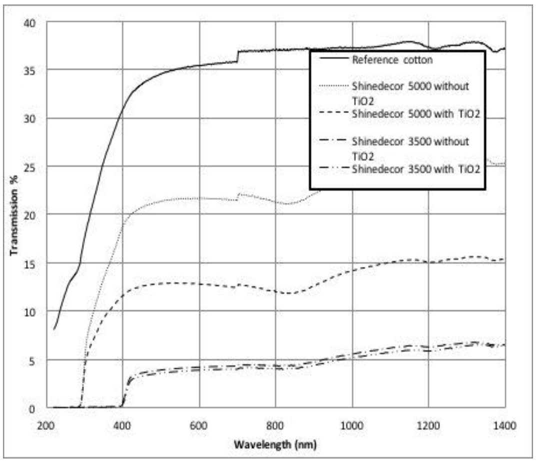


Figure 3a

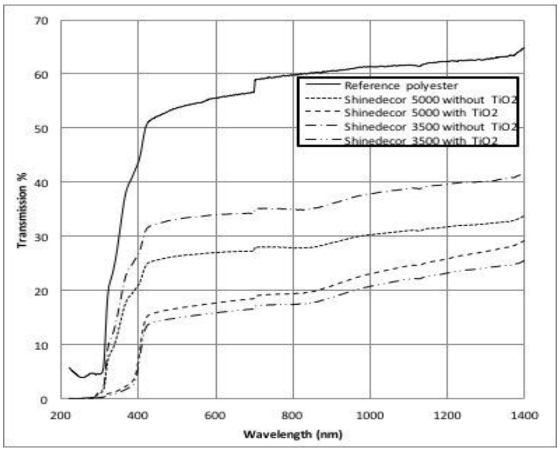
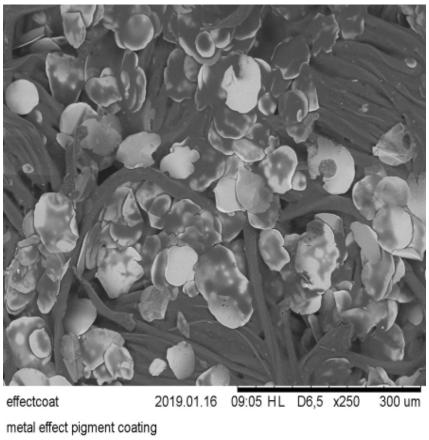
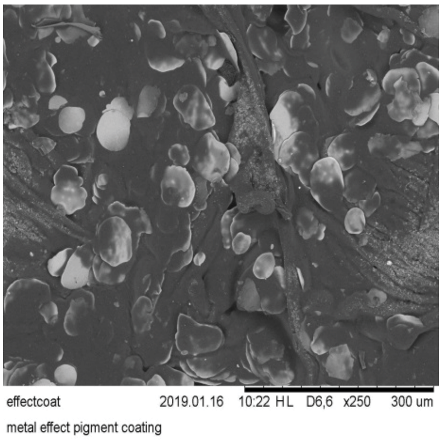


Figure 3b

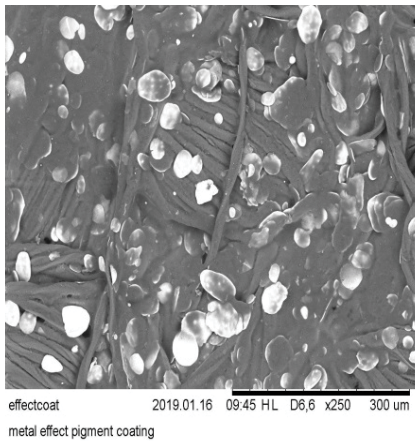
Figure 3: Transmission % of coated 3a cotton and 3b polyester textile treated with 10% pigment on topcoat and with/ without TiO_2 on basecoat.



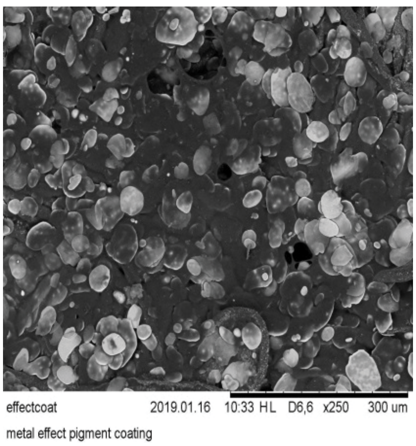
4a) 10% shinedecor 5000 without TiO_2



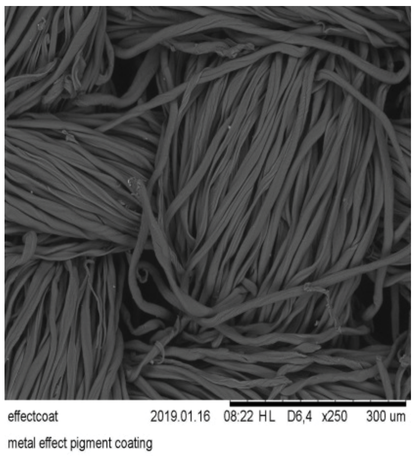
4b) 10% shinedecor 5000 with TiO_2



4c) 10% shinedecor 3500 without TiO_2

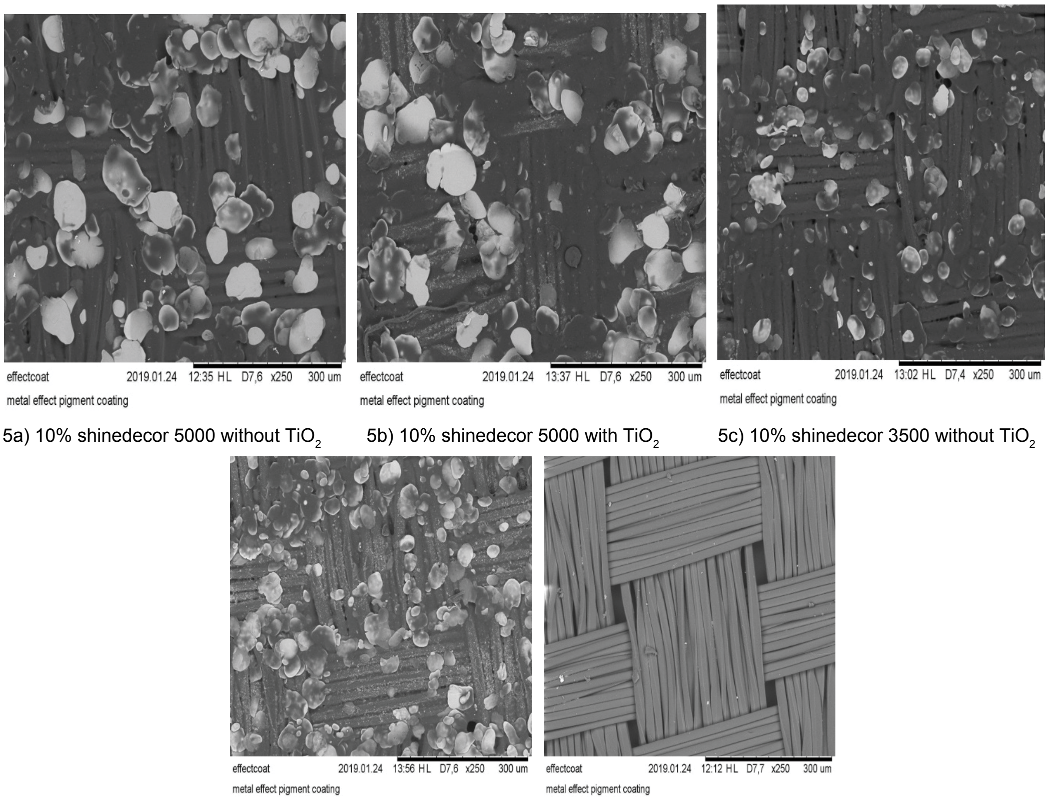


4d) 10% shinedecor 3500 with TiO_2



4e) Reference cotton

Figure 4: SEM images of various aluminium effect pigment coated cotton with/ without TiO_2 nanoparticle on basecoat and reference cotton (250 times magnification).



5a) 10% shinedecor 5000 without TiO_2 5b) 10% shinedecor 5000 with TiO_2 5c) 10% shinedecor 3500 without TiO_2

5d) 10% shinedecor 3500 without TiO_2 5e) Reference polyester

Figure 5: SEM images of various aluminium effect pigment coated cotton with/ without TiO_2 nanoparticle on basecoat and reference cotton (250 times magnification).

different was the basecoat compositions, as one basecoat contains TiO_2 and other does not. So, the presence of TiO_2 on basecoat increases the optical textile properties significantly.

SEM images help to understand the microscopic view pigment coating mechanism of reference samples and the coated samples. Images show the metal platelets of the aluminium pigments which reflect the incident light in coated cotton (Figure 4a-d) and polyester samples (Figure 5a-d). On the other hand, these platelets are absence in untreated reference cotton (Figure 4e) and polyester (Figure 5e).

Conclusion

TiO_2 Nanoparticles have been used for multi-functional material along with optical functionalization. TiO_2 has been the focus of research efforts due to its improved chemical stability. Aluminium pigments are commonly used in coatings to give a silvery and shiny lustre to the substrate. It increases the optical performance of textile. Using TiO_2 basecoat increases the performance dramatically. As TiO_2 materials are more promising than metal doped counterparts, the combination of TiO_2 as basecoat and aluminium pigment as topcoat for better silvery effect ensuring improved light reflection and transmission properties.

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