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ORIGINAL RESEARCH

Reactive Blue-25 dye/TiO_2 coated cotton fabrics with self-cleaning and UV blocking properties

Ishaq Ahmad · Chi-wai Kan · Zhongping Yao

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Abstract Cotton fabrics have been used in a variety of applications due to its attractive properties of softness, comfort, warmth, biodegradability and breathability. Coating cotton fabrics with photocatalytic materials can extend their use as self-cleaning and other practical applications. In this study, coating of cotton fabrics with dye sensitized/TiO_2 for self-cleaning and UV blocking properties has been reported. Phthalocyanine based reactive dye, Reactive Blue-25 (RB-25), has been used as a visible light scavenger for TiO_2. RB-25/TiO_2 hybrid sol was prepared by sol–gel method and coated on the cotton fabrics via dip-pad-dry-cure method. The coated cotton fabric was characterized by FTIR-ATR, UV–Visible absorption, XRD, SEM and reflectance measurements. The surface studies confirmed the stable attachment of RB-25/TiO_2 on the cotton fabric while photocatalytic and UV absorption studies shown that the RB-25/TiO_2 coated cotton fabric exhibit substantial visible light driven self-cleaning and UV blocking properties. Rhodamine B (RhB) dye was used as to examine the photocatalytic efficiency of the coated cotton fabric. 91% RhB was degraded in 180 min when exposed to visible light in the presence of RB-25/TiO_2 coated cotton fabric.

Keywords Reactive Blue 25 · Cotton · Self-cleaning · UV blocking · TiO_2 coating

I. Ahmad · C. Kan (✉)
Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong
e-mail: tccwk@polyu.edu.hk

I. Ahmad
e-mail: ahmadrai621@gmail.com

Z. Yao
Department of Applied Biology and Chemical Technology, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong
e-mail: zhongping.yao@polyu.edu.hk

Introduction

In recent years, effort has been made to bring innovations in the fabrication of textile materials. Along with growth of conventional textiles, the market growth of multifunctional textiles in last few years has opened new gateways of research and development in the textile industry. Among all textile materials, cotton has been preferred over other textile materials due to its porosity, absorbency, biodegradability and wear comfort. The surface functionalization of cotton fabrics with nano materials is an emerging research field to develop functional cotton fabrics with multiple functionalities and wide ranges of practical applications (Ahmad and Kan 2016; Li et al. 2017). Functional coatings on the cotton fabrics impart tailored properties to the cotton regarding performance and durability. Self-cleaning (Zhu et al. 2017a), antibacterial (Xu et al. 2018), antifouling (Zhang et al. 2018), UV-blocking (Chen et al. 2018; Gao et al. 2017), biosensing (Malon et al. 2014), oil–water separation (Huang et al. 2015) and many more smart cotton fabrics have been developed by coating with metals, non-metals, metal oxides, and some organic compounds (Afzal et al. 2013a, b). Imparting self-cleaning properties to cotton fabrics by coating with anatase TiO_2 was reported for the first time in 2004 (Daoud and Xin 2004). Strong oxidizing power, chemical and photostability, cost-effective and environmentally friendly nature are the inherent characteristics of TiO_2 which extend its versatile applications when coated on cotton fabrics. However, limited light absorption in the UV region of solar spectrum and short life of electron hole pair in the excited state of TiO_2 due to high recombination rate of electron hole pair reduce its practical applications as a photocatalyst for self-cleaning coating on cotton fabrics (Zhang and Yates 2010). To overcome these limitations, TiO_2 has been doped with metals (Wang et al. 2009), non-metals (Wu and Long 2011) and metal oxides (Pakdel and Daoud 2013). This doping technique enhances the photocatalytic properties of TiO_2 under visible light, however, the coating stability of these doped TiO_2 sols on cotton fabrics remains an issue. It has been reported (Afzal et al. 2012) that the problem can be overcome by attachment of some visible light scavengers on the TiO_2 surface which can inject electrons into the conduction band of TiO_2 after excitation with visible light. Porphyrin, a structural analogue of chlorophyll, has been used as a visible light scavenger for TiO_2 (Afzal et al. 2012). The synthesis and purification process of porphyrin is an expensive and complex process which reduces its practical industrial applications. In this study, we report the coating of cotton fabric with a visible light active dye/TiO_2 hybrid to impart self-cleaning and UV blocking properties. A phthalocyanine dye, Reactive Blue-25 (RB-25), has been used as a visible light scavenger for TiO_2. This dye is commercially available and has been used in the dyeing of textiles on industrial scale.

Experimental

Materials

Plain woven cotton fabric (100% scoured and bleached) having areal density of 119 g/m^2 with 40/1 yarn in both warp and weft direction was used. The warp and weft density of cotton fabric was 52 cm^{-1} and 28 cm^{-1} respectively. Titanium tetraisopropoxide (TTIP, Aldrich 97%) was used as precursor for TiO_2. All other chemicals such as hydrochloric acid, absolute ethanol and glacial acetic acid were used as received from the suppliers to prepare TiO_2 nano-sol. A phthalocyanine-based reactive dye, C.I. Reactive Blue 25 (RB-25) dye was provided by Avani Dye Chem Industries, India. It was used without further purification. The chemical structure of RB-25 is given in the Fig. 1.

Preparation of RB-25/TiO_2 nano-sol

TiO_2 nano-sol with composition H_2O (70%), absolute ethanol (20%), TTIP (5%), glacial acetic acid (4%) and hydrochloric acid (1%) was prepared. To prepare the TiO_2 nano-sol, the precursor TTIP (15 mL) was dissolved in absolute ethanol (60 mL). This TTIP solution was added dropwise to the acidified water (225 mL). The mixture was stirred at 70 °C for 16 h. To prepare the RB-25/TiO_2 nano-sol, 3 mL, 5 mL and 7 mL of RB-25 solution (0.05 g/100 mL) were added separately during the TiO_2 nano-sol preparation.

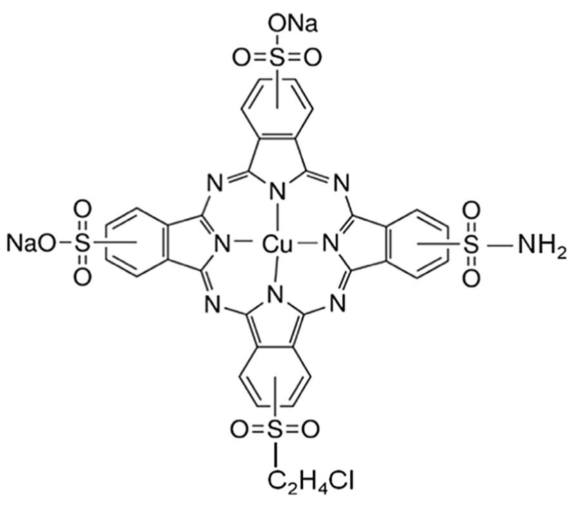


Fig. 1 Chemical structure of RB-25

Coating of cotton fabric with RB-25/TiO_2 nano-sol

The cotton fabric, before coating process, was completely washed with non-ionic detergent, C-13 oxoalcoholethoxylate (1 g/L) to remove the impurities and dried at 80 °C for 30 min. The dried cotton fabrics were coated with already prepared TiO_2 and RB-25/TiO_2 sols by dip-pad-dry-cure method as reported in previous study (Ahmad and Kan 2017). In detail, the pre-cleaned cotton fabrics were dipped in the TiO_2 and RB-25/TiO_2 sols for 5 min and pressed with a padding machine (Rapid Labortex Co., Ltd., Taipei, Taiwan). The nip pressure of the padder was kept at 2.5 kg/cm^2 to get the homogeneous coating of TiO_2 and RB-25/TiO_2 on each of the cotton fabric pieces. The wet pick up of TiO_2 and RB-25/TiO_2 sol was measured by weighing the cotton fabric pieces before and after padding. The wet pick up of all padded samples was about 77–80%. Aqueous solution of Na_2CO_3 was sprayed thoroughly by conventional spraying method to neutralize the fabric to pH 7. The TiO_2 coated and RB-25/TiO_2 coated cotton fabrics were dried in a preheated oven at 80 °C for 5–8 min and finally cured at 120 °C in a preheated curing machine (Mathis Lab dryer Labor-Trockner Type LTE, Werner Mathis AG Co., Oberhasli, Switzerland) for 5 min.

The resulting RB-25/TiO_2 coated fabrics were washed with de-ionized water to remove the unattached TiO_2 and RB-25 dye molecules. The coated fabric samples were dried at standard atmospheric conditions for further characterization. The coating process is summarized in the Fig. 2.

Fourier transform infrared spectroscopy analysis

Fourier transform infrared (FTIR) spectrophotometer equipped with an attenuated total reflection (ATR) accessory (Spectrum 100, Perkin Elmer Ltd., Thane, India) was used to get transmittance spectra of pristine cotton fabric and RB-25/TiO_2 coated cotton fabrics. The FTIT-ATR spectra were obtained in the scanning range of 650–4000 cm^{-1} with an average of 64 scans of each fabric at 16 cm^{-1} resolution.

UV–visible absorption studies

The UV–visible absorption of RB-25 dissolved in water was measured by using a UV–visible UH5300 spectrophotometer (Hitachi, Tokyo, Japan). The UV–visible absorption of pristine cotton fabric, TiO_2 coated and RB-25/TiO_2 coated cotton fabrics were measured with Cary 300 spectrophotometer.

Color yield measurements

Reflectance studies of coated fabrics were conducted by a reflectance spectrophotometer (Macbeth Color-Eye 7000A, Grand Rapids, Michigan, USA) by using a D65 illuminant and 10° standard observer. The reflectance measurements were taken for each sample three times from 400 to 700 nm with 10 nm intervals. K/S values were obtained by using the Kubelka–Munk equation (Eq. 1).

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

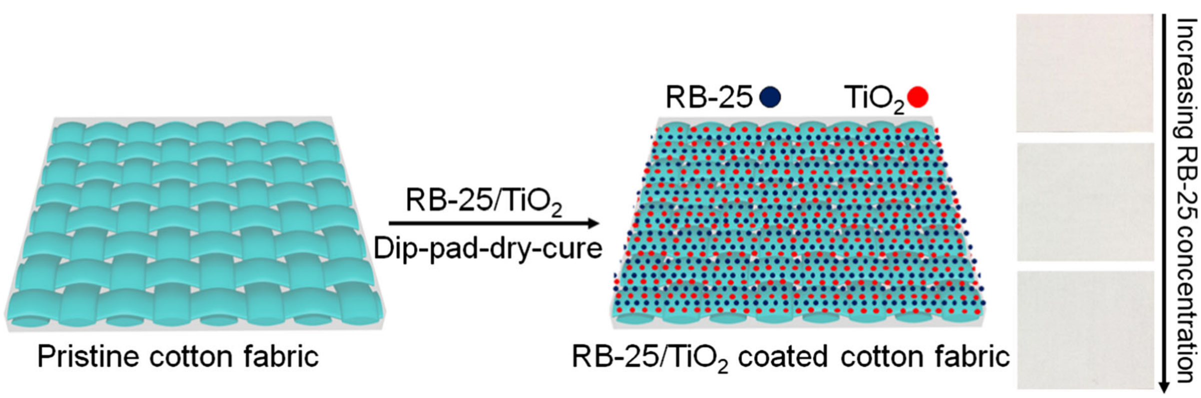


Fig. 2 The coating process of cotton fabrics with RB-25/TiO_2

where K is the absorption coefficient of the colorant, S is the scattering coefficient of the colored substrate and R is the reflectance of the colored sample. The higher the K/S value, the greater the dye uptake is, resulting in a better color yield.

XRD and SEM analysis

Crystal structures of pristine cotton fabric, TiO_2 coated and RB-25/TiO_2 coated cotton fabric were examined by high power X-ray diffractometer (Rigaku Smartlab, USA). SEM images were recorded by Scanning Electron Microscope (Tescan VEGA3, Czech Republic) to observe the surface morphologies of the pristine cotton fabric, TiO_2 coated and RB-25/TiO_2 coated cotton fabrics.

Photocatalytic activity measurements

Rhodamine B (RhB) was selected as probe dye to evaluate the photocatalytic efficiency of TiO_2 coated and RB-25/TiO_2 coated cotton fabrics. 3 g of the cotton fabric (each from pristine cotton, TiO_2 coated and RB-25/TiO_2 coated cotton fabrics) were cut into pieces of 1 cm × 1 cm dimension. The pristine and coated cotton fabric pieces were soaked in 100 mL of the RhB dye aqueous solution (18 mg/L) in a 250 mL glass beaker. The cotton fabric pieces were shaken well in the dye solution and kept in the dark for 2 h to achieve the absorption–desorption equilibrium. The beakers with a test specimen were exposed to visible light under Philip fluorescent lamps with light intensity of 5.2–5.3 mW cm^{-2} on the top of samples while vigorously shaking. To measure the concentration of RhB in the presence of pristine and coated cotton fabrics, a total of 10 mL of the target dye solution was taken out from each beaker after regular time intervals for 3 h and the UV–Visible absorption spectra were recorded on a UV–Visible UH5300 spectrophotometer (Hitachi, Tokyo, Japan). The concentration of RhB, at 555 nm (λ_{max} of RhB), after visible light irradiation at regular time intervals was compared with the initial concentration of RhB. The relative decrease in the concentration of RhB was examined by plotting C/C_o where C is concentration of RhB at any specific time and C_o is initial concentration of RhB. The dye degradation efficiency was calculated by using Eq. 2.

$$\text{Degradation efficiency } (\%) = 100 \times \frac{Co - C}{Co} \quad (2)$$

UV-protection factor analysis

UV-protection factor of the RB-25/TiO_2 coated cotton fabric was evaluated by Cary 300 spectrophotometer at wavelength range of 280–400 nm with scanning speed of 300 nm/min. The results were calculated by Cary 300 using the methods described in the Australian/New Zealand Standard AS/NZS 4399:1996). The coated cotton fabrics were washed five times at room temperature in a laundry machine for 40 min without any detergent and UV protection factor was also measured after five washings.

Self-cleaning study

For self-cleaning studies, the RB-25/TiO_2 coated cotton fabric (5 × 2.5 cm) was dipped in aqueous solution of Rhodamine B (RhB) (7.5 mg/L). The stained fabric samples were dried in dark and the stained fabrics were exposed to light (8 W lamp) for 6 h. Also, these stained samples were placed in open environment under sunlight.

Results and discussion

Fourier transform infrared spectroscopy

To study the surface modifications of the cotton fabric by the coating with RB-25/TiO_2, the FTIR-ATR transmittance spectra of pristine cotton fabric and RB-25/TiO_2 coated cotton fabrics were recorded as shown in the Fig. 3. Figure 3a represents the FTIR transmittance spectrum of pristine cotton fabric. The broad peak at around 3300 cm^{-1} is due to the surface hydroxyl groups (–OH) present on the cellulose chains of the cotton fabrics. The peaks at 2900 cm^{-1}, 1320 cm^{-1} and 1038 cm^{-1} are due to C–H stretching vibrations of the cellulose alkyl chains, C–O, C–H bending vibrations, and C–O, O–H stretching vibrations of the polysaccharide in the cotton fabrics respectively. The peak at 1638 cm^{-1} is associated with the water adsorbed in the cellulose chains.

Figure 3b spectrum represents the RB-25/TiO_2 coated cotton fabric. The peak intensity at 3300 cm^{-1} and 1038 cm^{-1} has decreased with the

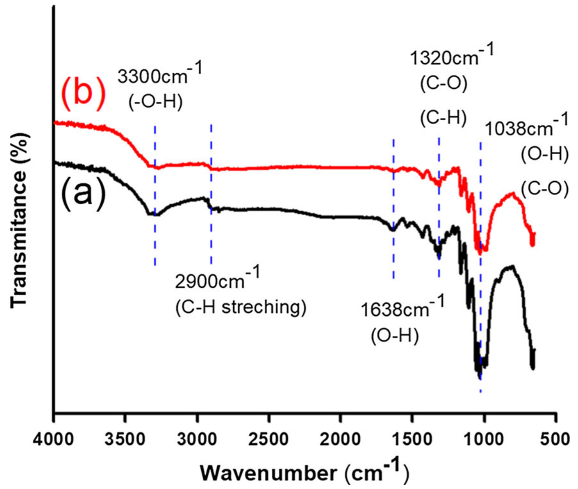


Fig. 3 FTIR-ATR spectra of pristine cotton (**a**) and RB-25/TiO_2 coated cotton fabrics (**b**)

coating of RB-25/TiO_2 on the surface of cotton fabric which confirms the chemical attachment of the RB-25/TiO_2 via surface hydroxyl groups (–OH) of the cotton fabric. Peak at 1638 cm^{-1} has disappeared after coating with the photocatalyst which also indicates that the adsorbed water molecules are removed by the attachment of RB-25/TiO_2. TiO_2 has strong electrostatic attachment with RB-25 and cotton fabrics. The schematic diagram of attachment of RB-25/TiO_2 on the cotton fabric is given in the Fig. 4.

UV–visible absorption measurements

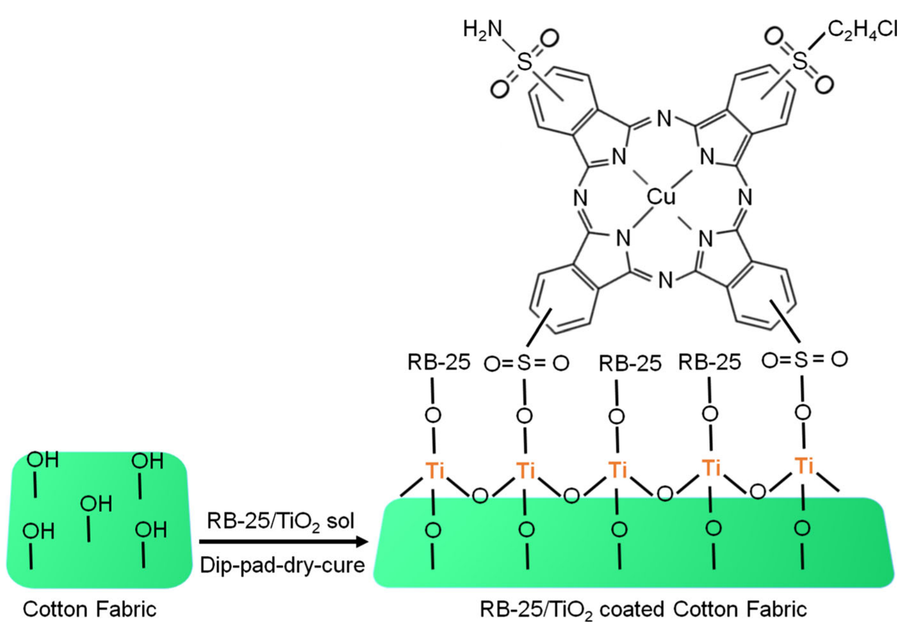
Binding of RB-25/TiO_2 with the cotton fabric was studied by UV–visible absorption measurements. Figure 5 presents the UV–visible absorption spectra of RB-25 in water, TiO_2 coated, and RB-25/TiO_2 coated cotton fabric. The absorption peak at 662 nm shown in the spectrum of RB-25 in water belongs to inherent Q band of the phthalocyanine core structures. When RB-25/TiO_2 was coated on the cotton fabric, this absorption peak (Q band) shifted to 675 nm as shown in Fig. 5b. This bathochromic shift (red shift) of 13 nm can be attributed to the strong binding of RB-25/TiO_2 with the fabric (Afzal et al. 2013a, b).

The Fig. 6 presents the UV–visible absorption spectrum of RB-25/TiO_2 coated cotton fabric with different concentrations of RB-25. 3 mL of RB-solution (0.05 mg/100 mL), 5 mL of RB-solution and 7 mL of RB-25 solution were added in the TiO_2 mixture during sol preparation in sample 1, 2 and 3 respectively. The Q-band peak intensity is higher in the sample 3 representing the higher uptake of the dye by the fabric.

Color yield measurements

To confirm the presence of RB-25 on the coated cotton fabric, color yield measurements were done by reflectance spectrophotometer. The K/S values of the

Fig. 4 Schematic diagram of attachment of RB-25/TiO_2 on the cotton fabric



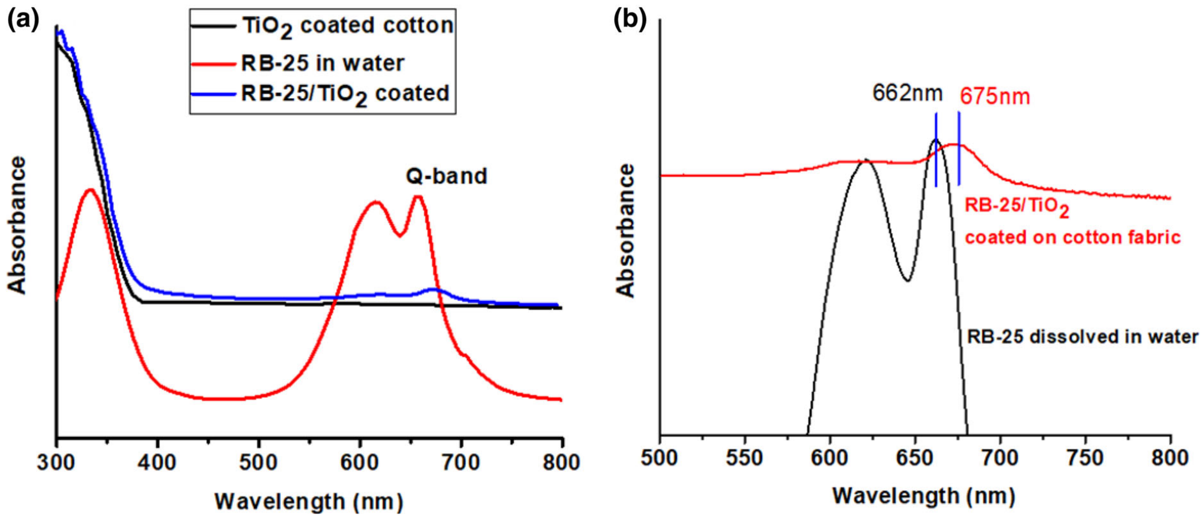


Fig. 5 **a** UV–visible absorption spectra of RB-25 in water, TiO_2 coated cotton and RB-25/TiO_2 coated cotton fabric and **b** UV–visible absorption spectra of RB-25 dissolved in water and RB-25/TiO_2 coated on cotton fabric

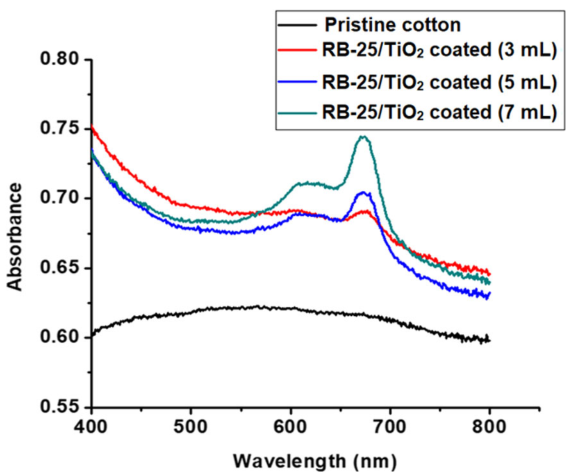


Fig. 6 UV-visible absorption spectra of pristine cotton and RB-25/TiO_2 coated cotton fabric

Table 1 K/S values of RB-25/TiO_2 coated cotton fabrics

Specimen	Description	K/S value
1	RB-25/TiO_2 (3 mL) coated	2.667
2	RB-25/TiO_2 (5 mL) coated	2.779
3	RB-25/TiO_2 (7 mL) coated	2.972

RB-25/TiO_2 coated cotton fabrics calculated by using the Kubelka–Munk equation are given in the Table 1. The sum of K/S values are according to the dye concentration in each of the coated samples. The K/S values increased as the dye amount increased within

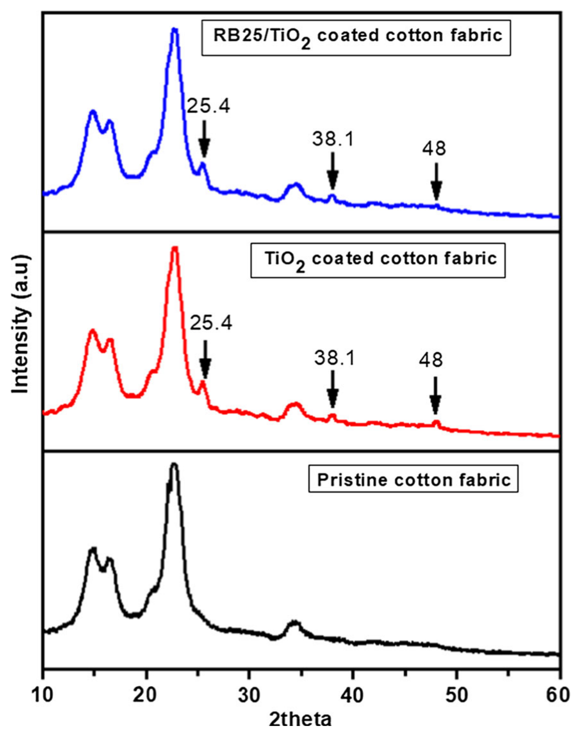


Fig. 7 XRD pattern of pristine cotton, TiO_2 coated cotton and RB-25/TiO_2 coated cotton fabric

the photocatalyst hybrid sols. The increasing value of K/S by increasing dye concentration in the RB-25/TiO_2 sol indicates the greater uptake of the dye on the cotton fabric during the coating process. This can also be confirmed from the UV visible absorption spectrum given in the Fig. 5.

X-ray diffraction analysis

Crystal structures of pristine cotton fabric, TiO_2 coated and RB-25/TiO_2 coated cotton fabric were studied by high power X-ray diffractometer. XRD pattern of pristine cotton, TiO_2 coated cotton and RB-25/TiO_2 coated cotton are given in the Fig. 7. The sharp diffraction peaks at 14.7°, 16.4°, 22.6° and 34.4° shown in the XRD pattern of pristine cotton fabric are characteristics peaks for cellulose I crystalline structure (Kafle et al. 2014). After coating with TiO_2 and RB-25/TiO_2, the characteristic peaks intensity of the cellulose substrate structure is not changed which confirms that the crystalline phase of cellulose I does not alter with TiO_2 and RB-25/TiO_2 coating. However, sharp diffraction peaks at 25.4°, 38.1° and 48° appeared in XRD pattern of TiO_2 coated and RB-25/TiO_2 coated cotton fabrics. These characteristic peaks correspond the crystalline anatase phase of TiO_2 which confirm the successful coating of anatase TiO_2 on the fabrics (Afzal et al. 2014). Moreover, the peaks of anatase TiO_2 do not change in RB-25/TiO_2 coated cotton fabrics which indicates that RB-25 has no effect on the crystalline structure of the TiO_2.

Scanning electron microscope (SEM) analysis

The deposition of the RB-25/TiO_2 coating on the surface of cotton fabric was confirm by the scanning electron microscopic (SEM) analysis of the coated cotton fabrics. SEM images of pristine cotton fabric and RB-25/TiO_2 coated cotton fabric are given in the Fig. 8.

The smooth surface has been observed for the pristine fabric as shown in the image 8a. However, the deposition of RB-25/TiO_2 on the cotton fabric can easily be seen in the image 8b. In addition, surface elemental analysis was conducted by EDX data. The EDX data has been given in the Table 2 and the EDX spectrum is given in the Fig. 9.

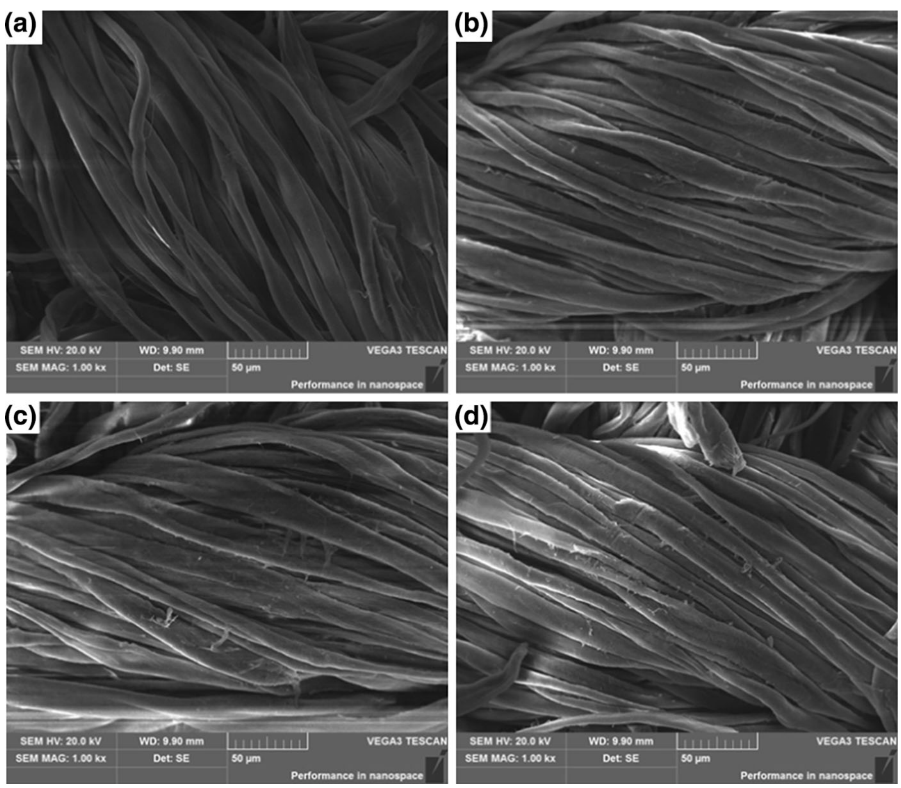


Fig. 8 SEM images of **a** pristine cotton; **b** RB-25/TiO_2 coated cotton with 3 mL of RB-25; **c** RB-25/TiO_2 coated cotton with 5 mL of RB-25 and **d** RB-25/TiO_2 coated cotton with 5 mL of RB-25

Photocatalytic activity measurements

RhB ($C_{28}H_{31}N_2O_3Cl$) is a toxic dye which have hazardous effects on human and animal skin. It is widely used as a basic dye in textile industries and its large amount is being released to the waste water resulting in the water pollution. To evaluate the photocatalytic efficiency of RB-25/TiO_2 coated cotton fabric, this dye was used as a target probe. The degradation curves (C/C_o plots) of the RhB with pristine cotton, TiO_2-coated and RB-25/TiO_2 coated cotton fabrics are presented in Fig. 10. The curve 10a represent the degradation of RhB when only pristine cotton was used and the curve 10b corresponds to the degradation of RhB by the TiO_2 coated fabric as a photocatalyst. The degradation of RhB was 25% and 30% for pristine cotton fabric and TiO_2 coated cotton fabric after 180 min of light irradiation. However, the RhB degradation efficiency for RB-25/TiO_2 coated cotton was 91% after 180 mint of light irradiation. The degradation curves 10c–e correspond to RB-25/TiO_2 coated cotton fabrics when 3 mL, 5 mL and 7 mL of the dye solution of RB-25 were used respectively. The degradation curves show that the photocatalytic activity of RB-25/TiO_2 coated cotton fabric increased as the dye concentration was increased in the TiO_2 nano-sol. The degradation efficiency increased from 52 to 91% as the dye concentration was increased from 3 to 7 mL in the photocatalyst hybrid. This indicates that the ratio of RB-25 and TiO_2 plays an important role in the photocatalytic efficacy of the RB-25/TiO_2 photocatalyst.

The mechanism for the visible light driven photocatalytic efficiency of the RB-25/TiO_2 hybrid can be attributed to the electron injection from excited state

Table 2 The EDX data of RB-25/TiO_2 coated cotton fabric with 5 mL of RB-25

Element	Weight (%)	Atomic (%)
Carbon (C)	39.40	53.55
Oxygen (O)	42.54	43.41
Titanium (Ti)	5.98	2.04
Gold (Au)	12.08	1.00

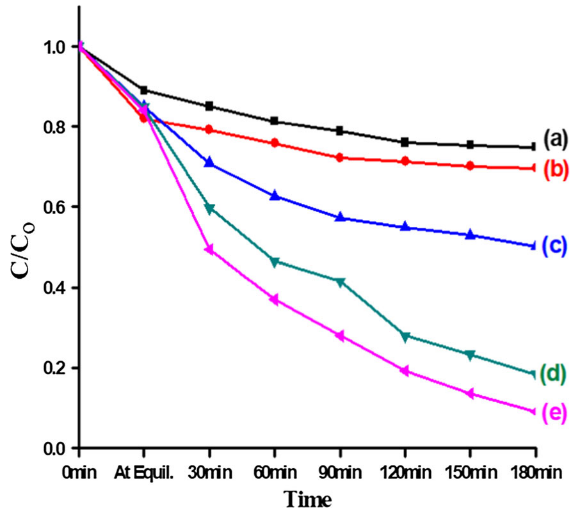


Fig. 10 The degradation curves of the RhB: **a** degradation of RhB in the presence of pristine cotton; **b** degradation of RhB in the presence of TiO_2 coated cotton, **c** degradation of RhB in the presence of RB-25/TiO_2 coated cotton with 3 mL of RB-25; **d** with 5 mL of RB-25 and **e** with 7 mL of RB-25

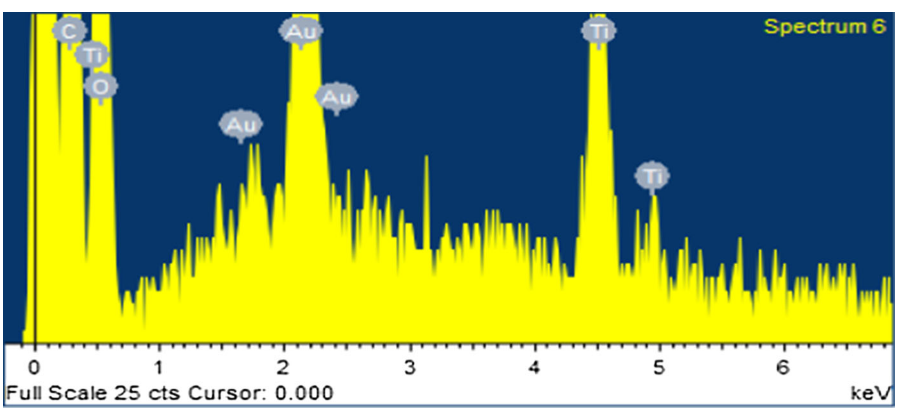


Fig. 9 EDX spectrum of RB-25/TiO_2 coated cotton fabrics

of the dye molecule to the conduction band of the TiO_2. Thus, electron density in the conduction band of TiO_2 increases which results in increase in the photocatalytic performance of TiO_2 under visible light source. The schematic explanation of photocatalytic phenomenon of RB-25/TiO_2 is given in the Fig. 11.

The energy gaps were measured from the absorption wavelength using a simple energy equation as given in the Table 3.

UV-protection factor analysis

UV-protection factor (UPF) is the measure of how much of the UV radiations coming from the sun are absorbed by the fabric. UPF measurements of the RB-25/TiO_2 coated cotton fabrics were tested by Cary 300 spectrophotometer at wavelength range of 280–400 nm with scanning speed of 300 nm/min. UPF values and average (%) transmission of UV-A (315–400 nm) and UV-B (290–315 nm) radiations for the RB-25/TiO_2 coated cotton fabric are presented in the Table 4.

According to the Australian/New Zealand Standard AS/NZS 4399:1996, the fabrics having the value of UPF above 50 show excellent protection against UV light coming from sun (Mishra and Butola 2018). The RB-25/TiO_2 coated cotton fabrics have shown the UPF values more than 100 which reflects excellent UV protection. The high energy UV radiations, UV-B ranging 290–315 nm are more than 99% absorbed by the fabric. The graphical representation of UV transmission from the coated fabric is given in the Fig. 12.

It can be observed from the UV transmittance spectra that all the UV region of radiations has been absorbed by the coated fabrics with negligible transmittance which shows that the RB-25/TiO_2 coated cotton fabrics possess excellent UV protective properties (Zhu et al. 2017b).

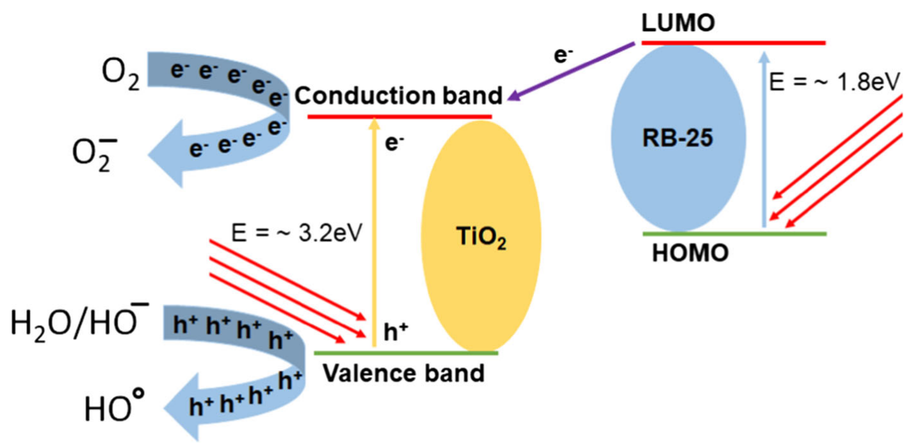


Fig. 11 The schematic explanation of photocatalytic phenomenon of RB-25/TiO_2

Table 3 Calculations of energy gap

Band gap energy (E) = hc/λ
h = Planks constant = 6.626×10^{-34} J s
c = speed of light = 3.0×10^{8} m/s
λ = cut off absorption wavelength
Conversion factor: 1 eV = 1.6×10^{-19} J

Sr. no.	Sample	λ (m)	Energy (J)	eV
1	TiO_2	3.90×10^{-7}	5.1×10^{-19}	3.18
2	RB-25	7.04×10^{-7}	2.82×10^{-19}	1.78

Table 4 UPF values and average (%) transmission of UV-A and UV-B radiations for the RB-25/TiO_2 coated cotton fabric

Sample name	UPF value	UV-A (%)	UV-B (%)	Status
RB-25/TiO_2 coated (3 mL)	139.833	6.360	0.222	1st measurement
RB-25/TiO_2 coated (3 mL)	137.336	6.994	0.267	After 5 washings
RB-25/TiO_2 coated (5 mL)	155.668	5.221	0.181	1st measurement
RB-25/TiO_2 coated (5 mL)	152.925	5.485	0 272	After 5 washings
RB-25/TiO_2 coated (7 mL)	101.196	7.894	0.348	1st measurement
RB-25/TiO_2 coated (7 mL)	98.842	7.947	0.367	After 5 washings

Data was calculated with 95% signifiance level

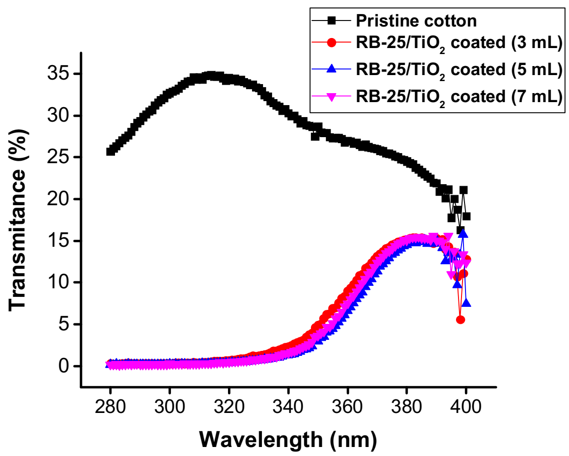


Fig. 12 UV transmittance spectra of pristine and RB-25/TiO_2 coated cotton fabrics

Self-cleaning studies

For self-cleaning studies, the RB-25/TiO_2 coated cotton fabric was dipped in aqueous solution of Rhodamine B (RhB) (7.5 mg/L). The stained fabric samples were dried in dark and the stained fabrics were exposed to light (8 W lamp = 464 lm) for 4 h. Also, these stained samples were placed in open environment under sunlight for 1 h. The stains of RhB were removed from the RB-25/TiO_2 coated cotton fabrics in 4 h under lamp exposure and in open environment sunlight exposure the stains were removed in 1 h. However, the stains of RhB remained same on the pristine cotton fabric. The stained pristine cotton fabric and RB-25/TiO_2 coated cotton fabrics before and after light irradiation are shown in the Fig. 13.

Conclusions

In this study, preparation and coating of RB-25/TiO_2 nano-sol on the cotton fabric and structural, morphological and photocatalytic studies of the coated cotton fabric have been reported. In detail, TiO_2 and RB-25/

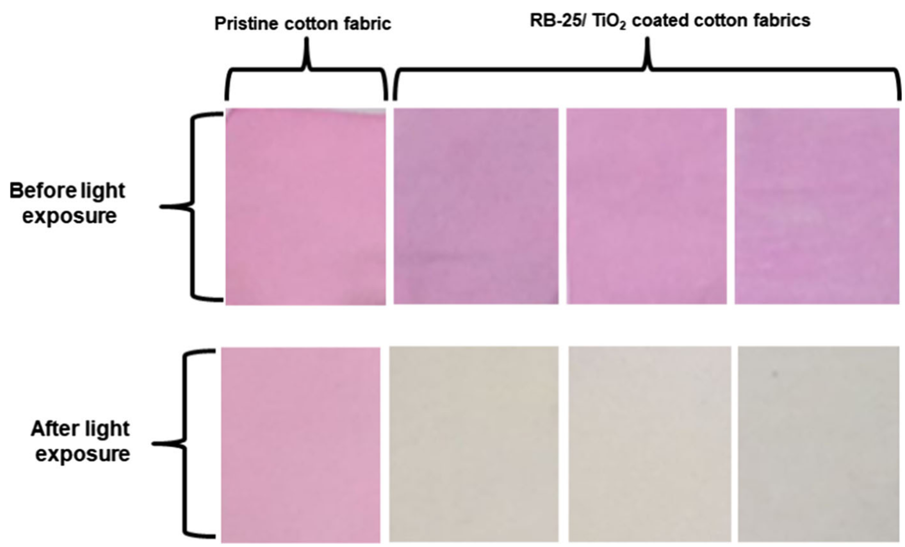


Fig. 13 The stained pristine cotton fabric and RB-25/TiO_2 coated cotton fabrics before and after light irradiation

TiO_2 sols were prepared by the sol–gel method. The TiO_2 and RB-25/TiO_2 sols were coated on the pre-cleaned cotton fabric by dip-pad-cure-dry method. The wet pick up of TiO_2 and RB-25/TiO_2 on the cotton fabric was measured by weighing the cotton fabric before and after padding. It was calculated from the weight gain of cotton fabric which was about 77%. After coating the cotton fabrics were washed with deionized water to completely remove the unattached TiO_2 and RB-25 molecules from the fabric. The resulting coated cotton fabrics were dried at standard atmospheric conditions for structural, morphological and photocatalytic evaluations. Studies of structural properties of the coated cotton fabric were conducted by FTIR and UV–visible absorption measurements. FTIR and UV–visible absorption spectra confirmed the attachment of RB-25/TiO_2 on the cotton fabric. The maximum absorption peak of the RB-25 had a red shift of 13 nm by after coating on the cotton fabric which indicates its strong binding.

Morphological studies were conducted by the XRD, SEM and EDX analysis. XRD, SEM and EDX studies confirmed the deposition of RB-25 and anatase TiO_2 layer on the cotton fabric surface. Photocatalytic efficiency of the resulting cotton fabric was evaluated by the degradation of RhB dye. The coated cotton fabrics shown remarkable photocatalytic and self-cleaning properties. The UV transmittance spectra of the coated fabrics shown the remarkable UV blocking properties.

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