

## Surface Modification of Polyester Fabrics with Vinyltriethoxysilane

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### Abstract

Surface modification of polyester fabrics was studied aiming at improving the water repellency property. Vinyltriethoxysilane (VTES) was employed as surface modifying agent. Prior to application, VTES was prepared in aqueous emulsion using cetyltrimethylammonium bromide (CTAB) as an emulsifying agent. The application of VTES emulsion was carried out using a padder and followed by curing at 150°C for 15 minutes. The result showed that the treated fabrics exhibited higher contact angle values when compared to untreated fabric, indicating an increase in water repellency property. It was believed that VTES was converted into silicone through siloxane network. The presence of a silicone particle on the fabric surface led to an increase in surface roughness, attributing to an increase in hydrophobicity of the treated fabric.

**Key word:** Polyester, Fabric, Water-repellent, Vinyltriethoxysilane

### Introduction

Polyester fibres are commonly used in the textile industry. Fabric of regular tenacity polyester filament yarns is very strong and durable due to its high crystallinity. It shows outstanding resistance to most common chemicals. However, a wide range of substances have little or no effect on its strength.<sup>(1)</sup>

Although polyester fabric is hydrophobic in nature, water-repellent finishes of polyester fabric are still interesting. In order to create more hydrophobic properties on the polyester fabric, the fabric was modified by using chemicals or monomers, i.e. acrylic acid (Dadashian et al., 2010; Hassan et al., 2009) 1,2-diaminoethane, and 1,6-diaminohexane.<sup>(4)</sup> Generally, commercial finishing products, i.e. antistatic, antisoil, and anticrease products, contain polysiloxanes as active ingredients. Vinyltriethoxysilane contains silicon-oxygen bonds, which indicates that it may be used as a finishing agent in textile.

In this study, surface of polyester fabric was modified with VTES at various concentrations. The characteristics and water-repellent property of the polyester fabric were investigated.

### Materials and Experimental Procedures

#### Materials

Vinyltriethoxysilane and cetyltrimethylammonium bromide were purchased from Fluka. Polyester

fabric was obtained from Thai Num Choke Textile Company Limited.

#### Surface Treatment on Polyester Fabric with VTES

The solution used for the fabric surface treatments was prepared as follows. The calculated amount of VTES was poured into 0.1%(w/v) CTAB solution. The concentration of VTES was varied from 10-40%(v/v). The solution was stirred at room temperature for 1 hour. The polyester fabric was impregnated with VTES solution by using padder (Ernst Benz AG Type KLFV) with 95% pick up. Then, the fabric was cured at 150°C for 15 minutes. After that, the sample was washed 3 times with hot water for 30 minutes, dried at 100-105°C for 2 hours, and placed in a desiccator before weight. The % increased weight was calculated by using equation (1).

$$\% \text{ increased weight} = [(W - W_0) / W_0] \times 100 \quad (1)$$

#### Characterisations

##### FTIR Measurement

The FTIR spectra of modified polyester fabric were recorded using Perkin-Elmer FTIR Spectrophotometer System 2000.

##### Surface Morphology

The surface morphology of polyester fabric was observed with a scanning electron microscope at 15 kV (SEM, JEOL JSM-5410LV).

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### Wetting Test

The wetting property of polyester fabric was tested under AATCC Test Method 43-1989. Briefly, the fabric (size 1x1 inch<sup>2</sup>) was dropped carefully onto water surface in 600 ml beaker. The time required for complete wetting of the complete surface was measured with a stop watch. The average of five determinations was recorded.

### Contact Angle

Contact angle measurements on polyester fabric were carried out by photographic method. A known amount of water was placed on the surface of the fabric and photographed. The angle between polyester/water and water/air interfaces at the point of intersection in the water phase was measured from the photographs.

## Results and Discussion

### Surface Modification of Polyester Fabric with VTES

To modify polyester fabric, VTES solution was treated onto the surface of the fabric. VTES is an organosilicon compound showing (CH<sub>3</sub>-CH<sub>2</sub>-O)<sub>3</sub>-Si-CH<sub>2</sub>=CH<sub>2</sub> structure. Alkoxide groups on the silicon are hydrolysed to silanols that condense with each other or with ethoxysilanes to give rise to siloxane bond. Subsequent drying leads to a formation of both covalent linkages with treated surface and development of a polymeric thin film of silane. The reactions are shown below.<sup>(5)</sup>

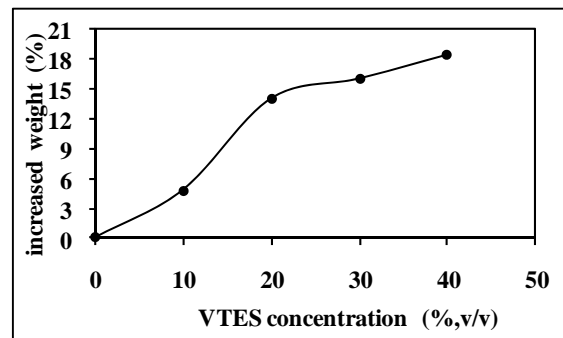
#### Hydrolysis reaction



#### Condensation reaction

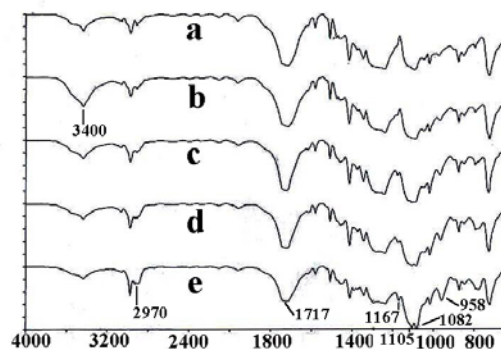


The effect of VTES concentration on the weight of polyester fabric was studied. The result obtained is shown in Figure 1. It is observed that an increase in VTES concentration also increased the weight of the samples. At higher content of VTES, a greater number of VTES molecules are available for hydrolysis and condensation. Also, VTES reacted with backbone of the polyester chain at high concentration. Thus, the concentration of VTES had an effect on increasing the weight of polyester fabric.



**Figure 1.** Weight of polyester fabric after being treated with VTES.

Figure 2 shows FTIR spectra of unmodified and modified polyester fabric with VTES. The IR spectra of the treated polyester sample show all expected characteristic peaks: the peak at 1200-1000 cm<sup>-1</sup>, attributed to asymmetrical stretching for -O-Si-O-; the peak at 2970 cm<sup>-1</sup>, attributed to -CH<sub>3</sub> stretching.<sup>(6)</sup> At a concentration of VTES 10%(v/v) (Figure 2(b)), a broad band appears at 3600-3200 cm<sup>-1</sup>. This attributed to the absorption band of silanol groups (Si-OH) formed during the hydrolysis of the alkoxide groups in VTES.

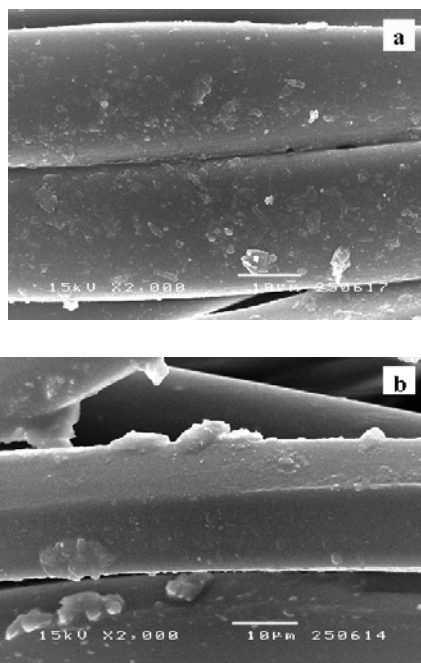


**Figure 2.** FTIR spectrum of untreated (a) and FTIR spectra of treated polyester fabric with VTES at concentrations of 10, 20, 30 and 40%(v/v) (b-e).

The intensity of the absorption band of -OH group decreased with an increase in VTES concentration. However, the intensity peak of -O-Si-O- at about 1200-1000 cm<sup>-1</sup> increased when concentration of VTES increased. This result can be explained by the fact that a polycondensation reaction between silanol groups (Si-OH) occurred. From Figure 2(e), the intensity of Si-OCH<sub>2</sub>CH<sub>3</sub> (Shieh & Liu, 1999) peaks showing at 1169, 1105, 1082, and 958 cm<sup>-1</sup> increased when concentration of VTES increased. The decrease in carbonyl absorption at 1717 cm<sup>-1</sup> may result from carboxylic

end groups of polyester reacting with VTES to form a Si-O-CO linkage. An identical observation was reported by Yin et al. (1997) who studied the reaction between poly(methyl acrylate-co-acrylic acid) and SiO<sub>2</sub>. In addition, Oyman and Tincer (Oyman & Tinçer, 2003) reported that the alkoxy groups of silane easily react with hydroxyl end groups of polyester. The reaction was generated by hydroxylation between alkoxy groups of silane and hydroxy end groups of polyester. The FTIR result can be used as an index of the silane coating onto polyester fabrics.

The surface morphology of unmodified and modified polyester fabrics was examined by using SEM analysis (see Figure 3). The result showed that modified fabric has rougher surface than unmodified resulting from converting VTES to a siloxane particle.

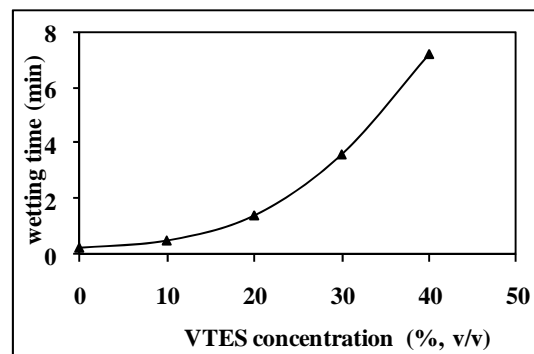


**Figure 3.** SEM micrographs of unmodified polyester fabric (a) and polyester fabric treated with VTES at a concentration of 40% (v/v).

### Wetting Measurements

The wetting on the polyester fabric by treatment with VTES was studied as a function of VTES concentration (Figure 4). For untreated fabric, overall wetting time is 0.20 minute. The wetting time of the VTES treated polyester fabric increased when increasing the concentration of VTES. This result indicated that the polyester fabric surface became more hydrophobic. Its hydrophobic

property resulted from a siloxane bond that emerged at the surface of the fabric. Also, the silicon particle increased the roughness of the polyester surface (see Figure 3). This induced the increase in the hydrophobicity of the treated fabric.



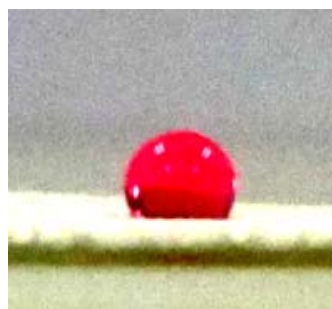
**Figure 4.** Wetting time of untreated and VTES treated polyester fabric at various concentrations.

### Contact Angle

Table 1 shows contact angle measurement of polyester fabric. Water contact angle increased gradually when increasing VTES concentration treated on polyester fabric (Figure 5). This may be due to the increasing in the number of hydrophobic groups on the treated fabric.

**Table 1.** Contact angle measurement of untreated and VTES treated polyester fabric at various concentrations.

Concentration of VTES (%v/v)	Contact angle (deg)
0	102
10	114
20	116
30	118
40	128



**Figure 5.** Water-repellent property of treated polyester fabric with VTES at a concentration of 40% (v/v).

## Conclusions

The surface of polyester fabric was modified by VTES. The hydrolysis and condensation of VTES formed siloxane onto polyester fabric surface which produced a water-repellent property of the fabric. The roughness of the silicone particle on the surface had an effect on the hydrophobicity of polyester fabric. In addition, its hydrophobic property increased together with an increase of the VTES concentration.

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