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Modified Vegetable Oil in Textile Finishing Applications

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Abstract

Water-repellent finishing is an important process in textile industries as well as other finishing processes. Coating on the fabric can be used to achieve a substantial water-repellent effect. Using polymeric coatings, however, provided some disadvantages in air and water vapour permeability causing undesirable feelings when wearing. Besides, the fabric treated with polymeric coatings will impart a stiffening appearance, which is undesirable. In this study, water repellents have been prepared from various vegetable oils with different amounts of saturation in fatty acid moiety. Vegetable oil was transesterified with an intermediate fluorinated compound to give modified fatty esters. These fatty esters were utilized as a water repellent in the finishing process of cotton fabrics. Cotton fabrics were treated with modified fatty esters obtained from rice barn oil comparative to those obtained from sunflower oil and palm oil. Water-repellent ability, yellowing and softness of fabrics after treated were evaluated as a function of the amount of water repellant used in finishing. The results showed that the palm oil ester derivative imparted a higher water-repellency than other oils. However, finished fabrics tended to have a slightly yellowing with ester derivatives of oils.

Introduction

Textile finishing is an important process in the textile industry to obtain good properties of finished fabrics such as wrinkle resistance, flame retardant, water-and-oil repellent finishing, etc. Water-repellent finishing is the oldest repellent finish. The purpose of this finish is to prevent drops of water from spreading on the surface. The drops should stay on the surface and easily drip off.[1-3]

Water-repellent finish achieves its properties by reducing the free energy at the fiber surface. If the adhesive interactions between a fiber and a drop of water placed on the fiber are greater than the internal cohesive interactions within the water, the drop of water will spread. If the adhesive interactions between the fiber and the water are less than the internal cohesive interactions within the water, the drop of water will not spread. Surfaces exhibiting low interactions with water are referred to as low energy surfaces. Their surface tension or surface energy (γ) must be lower than the surface tension of the water (γ_w).[4]

There are different ways to achieve water-repellent finishing that can be applied to textiles. Traditional water-repellent finishing is a mechanical incorporation of paraffin waxes or paraffin emulsion onto the fabric surfaces. However, there are some disadvantages of stiff handle, lack of air and vapour permeability and consequently poor wear comfort.[5] Polydimethylsiloxane products can also be used as water-repellents for fabrics. Its unique structure of the silicone imparts the ability to form hydrogen bonds with fibers and the hydrophobic outer surface. The disadvantages of silicone repellents are increasing pilling and seam slippage. Water repellency decreased if excessive amounts are applied. Moreover, the waste water from the silicone finishing process is toxic to fish. Fluorinated coatings are another class of water-repellent finish for textiles due to their ability to provide good performance in water proofing and additional fire proofing without impairing the fabric permeability to air and vapour.[6-7]

In the urface coating area, fluorine can introduce many attributes to a low surface energy, chemical resistance, thermal resistance and low friction. Anton et.al. prepared unsaturated fluoroalkyl esters and used in conventional alkyd and uralkyd paints at very low concentration. The coated surface showed good water-repellency performance by the increasing in contact angle with water.[8]

In this work we studied the water repellent performance of fluorinated fatty acid esters on cotton fabrics. Fluorinated fatty acid esters were prepared using three different types of vegetable oils and utilized in finishing cotton fabrics. The water repellency effect of prepared fatty acid esters, finishing on the fabric surface, was investigated using the contact angle measurement and time of water penetration through the cotton fabric surfaces.

Experimental

Materials

Vegetable oils; rice barn oil, sunflower oil, and palm oil, were purchased from the Thai Vegetable Oil Co., Ltd., Thailand. Fluorinated alcohol was purchased from Dupont, USA. Phosphoric acid was purchased from Fluka, USA. Nonionic surfactant was provided by V.P.C. Co., Ltd., Thailand.

Preparation of Fatty Acid Ester

Vegetable oil (0.1 mol) was reacted with fluorinated alcohol (0.3mol) in a three necked flask equipped with a magnetic stirrer, a thermometer, a nitrogen bubbling tube and a water condenser. Reactions were carried out at 140^{o}C for 10 hours, in the presence of a catalyst, phosphorus acid (0.12g). Three different types of vegetable oils; rice barn oil, palm oil, and sunflower oil were utilized in this study.

Finishing onto Cotton Fabrics

The finishing solutions were prepared by emulsifying various levels of obtained fatty acid esters (varied from 1-6%) in water that contained 3 % of surfactant. The obtained finishing solutions were applied to cotton fabrics on a laboratory scale by the pad cure method. The padding process consisted of soaking 3x2.5 inches fabric samples in a bath containing the fluorinated fatty acid ester finishing solution, and feeding the impregnated fabric between two rollers after soaking to squeeze out the excess finishing solution and then curing at 120° C for 4 min.

Physical Testing

a) Water-repellency testing was taken by measuring the contact angle of water on the fnished cotton fabric surface, according to standard ASTM D 5725-1999.

b) The absorption of water was investigated using standard AATCC 79-2000

c) Stiffness testing was taken according to standard JIS 1096-1999 using Shirley Stiffness Tester.

d) The yellowness of cotton fabric was measured before and after finishing accordance with standard ISO 105-A02 by using a gray scale.

Results and Discussions

The water repellency of the finished cotton fabric was studied by contact angle measurements with a drop of water on the finished cotton fabric surface. Contact angle measurements with water allow detailed characterization of a surface. It is well known that surface characterization by means of contact angle measurements can be significantly affected by the nature of the physicochemical interactions between the surface and the wetting fluid.[9] The results of contact angle measurements of cotton fabric finished with all three vegetable oil fatty acid ester derivatives are showed in Figure 1. It was found that contact angles with water of fabrics finished with fatty acid ester derivatives increased in comparison with unfinished fabrics. The contact angles increased as the amount of derivative esters in finishing increased. Fabrics finished with palm oil ester derivative provided a higher contact angle than those finished with the ester derivatives of sunflower oil and rice barn oil.

However, the contact angles of fabrics finished with rice barn oil fatty ester derivative showed slightly different results in that the contact angles with water was highest when finishing with 3% of derivative fatty acid ester, and then decreased when the amount of fatty acid ester derivative was greater than 3%.

As a result, it can be concluded that palm oil fatty acid ester derivative imparted the best water repellency.

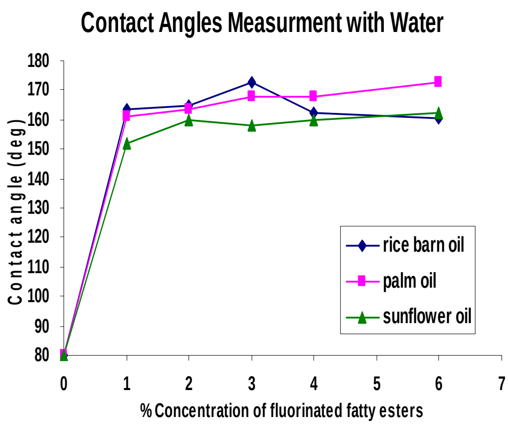

Figure 1. Contact angle measurements of finished cotton fabrics

The absorption of water on the fabric surface was investigated by measuring time used for a drop of water to be absorbed through cotton fabric. If the water repellency of the surface is high, water can stay on the surface longer or is being absorbed less. The results of water absorption evaluation can be shown in Figure 2. From the results, it was found that fabrics finished with fatty acid esters derived from all vegetable oils took longer time for a drop of water to be absorbed through the fabrics in comparison with unfinished fabrics. The results showed increment in time used in water absorption of the surfaces as the amount of ester derivatives in finishing increased.

However, the time taken in water absorption of fabrics finished with rice barn oil fatty ester was shorter when finishing with more than 3% of fatty acid ester derivative. These corresponded with the contact angle measurement results in that with over 3% of rice barn oil fatty acid esters in finishing, the contact angles of finished fabric surfaces decreased. While, fabrics finished with palm oil ester derivative showed longer time taken in water absorption as the amount of fatty acid esters increased. Fabrics finished with sunflower oil ester derivative showed only slightly increased in time taken for water absorption through the surfaces. Therefore, this can be concluded that palm oil fatty acid ester derivative provided the best water repellency.

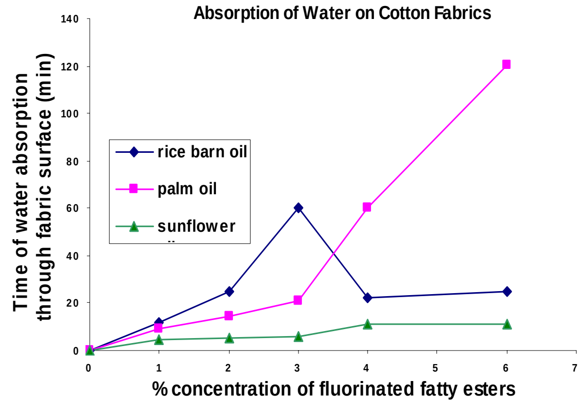

Figure 2. Water absorption of finished cotton fabric

Stiffness Testing is a test used in the valuation of finished fabrics whether the fabrics gained stiffness after finishing. Stiffness evaluation expressed as the length of fabrics that was bended after being tested. The longer the bending length of the fabrics, the stiffer the fabrics were. The results of stiffness measurements are shown in Figure 3.

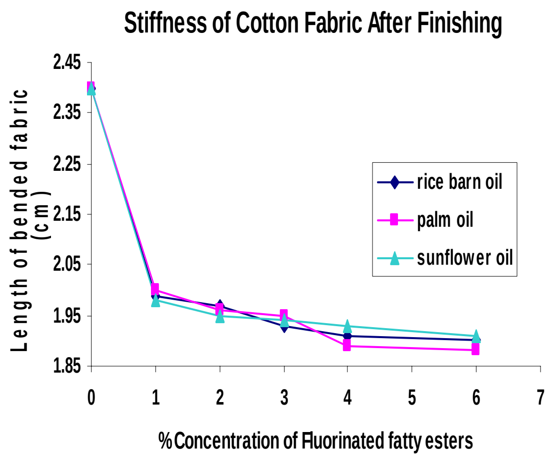

Figure 3. Stiffness of cotton fabrics after finishing

It was found that the more the amount of fatty acid esters used in finishing, the lower the bending length of finished fabrics. Lowering in bending length of finished fabrics expressed in the same fashion with all fatty acid ester derivatives from all vegetable oils. This means finishing with the fatty acid ester derivatives from all vegetable oils gave less stiffness or provided softer fabrics. This might be because the ester derivative of vegetable oil could soften the fabric and sometimes it is used as a lubricant in the textile industry.

The whiteness of finished fabrics is an important physical property in textile finishing. In this study the color measurement with the CIE system was used to evaluate the whiteness of fabrics after finishing relative to unfinished fabrics. The higher value obtained from color measurement using the CIE Ganz system meant the fabrics process more whiteness. The results of color measurement using the CIE Ganz system are shown in Figure 4.

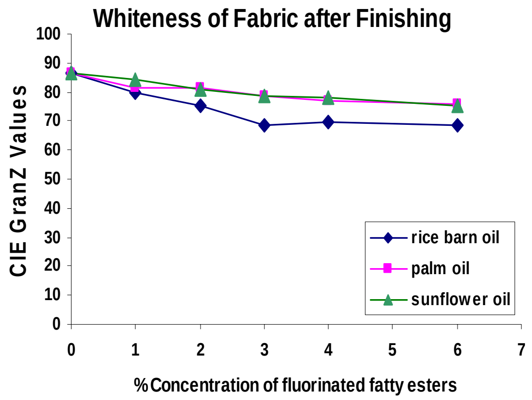

Figure 4. Whiteness of cotton fabrics after finishing

It was found that fabrics finished with fatty acid esters from vegetable oils showed a yellower in color than unfinished fabrics. However, the whiteness was slightly decreased as the amount of fatty acid ester derivatives in finishing increased. Among ester derivatives from three vegetable oils, the fabric finished with rice barn oil ester derivative showed a lowering in the whiteness of finished fabrics the most. This might be because the fatty ester derived from rice barn oil had a more yellowish color than other ester derivatives. The ester derivatives from palm oil and sunflower oil showed a slight decrease in whiteness. To take the whiteness of finished fabrics into consideration, either derivative from palm or sunflower oils could be used.

CONCLUSION

Fluorinated fatty acid esters from various vegetable oils gave water-repellent characteristics and can be used in finishing cotton fabrics. It was found, from this study, that fluorinated fatty acid ester derived from palm oil would be the best option since it gave higher water-repellency. Moreover, the time that is taken for water absorption through the finished fabric surfaces was longer and the softness of finished cotton fabrics was higher than unfinished cotton fabrics. However, there was a drawback in the whiteness of finished cotton fabrics.

ACKNOWLWDGEMENT

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