MODIFICATION OF COTTON FABRIC HYDROPHOBICITY BY FUNCTIONALIZED POLYSILOXANE

Marcin Przybylak¹, Hieronim Maciejewski¹,²
¹ Poznań Science and Technology Park, Rubież 46, 61-612 Poznań, Poland
² Faculty of Chemistry, Adam Mickiewicz University, Grunwaldzka 6, 60-780 Poznań, Poland
marcin.przybylak@ppnt.poznan.pl

ABSTRACT

The surface modification of cotton textiles was carried out using two types of bifunctional, fluorinated polysiloxanes with different ratios of functional groups. The modification was performed by either a one or two step process. Both methods, a sol-gel and a dip coating process were used in different configurations. The heat treatment and the washing process were applied after modification. The water contact angles were also measured. Highly hydrophobic textiles were obtained in all studied cases. Impregnated textiles were hydrophobic even after the washing process showing that the investigated modification is durable.

Key Words: hydrophobic surface, cotton, polysiloxane, sol-gel, dip coating

1. INTRODUCTION

In recent years, interest in the investigation and production of highly hydrophobic natural textiles has increased considerably. Waterproof properties are important for different purposes, such as protective clothing, stain-resistant fabric, and clothing for medical personnel. Several challenges must be addressed when developing waterproof coatings: the texture, mechanical properties, density, flexibility and coloring of the basic fabric must all be retained, and the coating must survive the washing process. There are currently many methods and compounds for textile modification that impart hydrophobicity, but many of them have disadvantages such as leachability, roughness, decrease mechanical properties stiffness [1-6].

We investigated the influence of fluorinated polysiloxanes on the hydrophobicity of cotton textiles.

To obtain water repellent fabric, two types of difunctional polysiloxanes with different ratios of functional groups, were used. The fluorinated groups are responsible for the hydrophobic effect and lowering of the surface’s free energy. The presence of the alkoxy groups enable polysiloxanes to covalently bond to the modified surface. Polysiloxane forms a silica layer on the surface of textile which further increases hydrophobicity.

2. EXPERIMENTAL

2.1. Materials

A cotton fabric with an areal density of 145g/m² was purchased from Textile Factory in Lodz.

Two types of difunctional polysiloxanes with different ratios of functional groups, were used. Reagents were synthesized at the Science and Technology Park in Poznan.

- poly[dimethyl-co-(octafluoropentyloxypropyl)methyl-co-(trimethoxysilylethyl)methyl]siloxane 9:9
• poly[dimethyl-co-(octafluoropentyloxypropyl)methyl-co-(trimethoxysilylethyl) methyl]siloxane 12:6

The tetraethoxysilane was purchased from Unisil company. Isopropanol and acetic acid were purchased from Sigma-Aldrich.

2.2. Modification process

A cotton fabric was bleached using the pad-batch process. The modification was performed by either a one or two step process. In both processes polysiloxane was hydrolysed in aqueous isopropanol over one hour and the cotton samples were immersed in a siloxane solution by a dip coating method. Coating was carried out for 15, 30 or 60 minutes at room temperature or 80°C. All samples were then dried at 80°C and cured at 130°C. In the two step process, pure silica phases were synthesized on the cotton fabric by a sol-gel method before the hydrolysis and dip coating step. The silica sol was produced by stirring tetraethoxysilane aqueous acetic acid for 16 hours and then the fabric was immersed for 40 minutes.

The durability of the modification was assessed by washing the samples with distilled water at 60°C for 1 hour.

2.3. Characterization

The water contact angles were measured using an automatic video contact-angle testing apparatus Krüss model DSA 100 Expert. 10 μL of the water was applied on to the treated cotton fabrics, and the contact angle was determined by the video camera images of the drop in the course of its formation. Each measurement was repeated 5 times and then the average was taken.

3. RESULTS AND DISCUSSION

The water contact angles were measured directly after modification the first and second time after washing process. The effect of modification time on the water contact angle (WCA) of cotton fabrics before and after washing is shown in Fig1. and Fig 2., respectively. The results are shown for the textiles treated with poly[dimethyl-co-(octafluoropentyloxypropyl)methyl-co-(trimethoxysilylethyl) methyl]siloxane 12:6

Figure 1. Modified samples before washing

Figure 2. Modified samples after washing

Analysis of the water contact angles showed that all methods of modification increased the hydrophobic character of cotton fabric. One step modification at 80ºC (after washing process) gave the best results with a dip coating period of 30 minutes (WCA 145º). For the two step modification, we can clearly see that the water contact angle grows as the time of modification increases.

It should be noted that the water contact angles after the washing period did not diminish, which demonstrates the strength of impregnation and formation of covalent bonds between hydroxyl groups of the fabric and the modifying agent. Contact angles after washing are even higher than for treated samples before this process, it can be caused by leaching unabsorbed modifiers during washing process.

Fig 3. and Fig 4. show the effect of modification time on the water contact angle (WCA) of cotton fabrics before and after washing, respectively. Analyzed textiles were treated with poly[dimethyl-co-(octafluoropentyl oxypropyl)methyl-co-(trimethoxysilyl ethyl)]methyl]siloxane 9:9

**Figure 3. Modified samples before washing**

**Figure 4. Modified samples after washing**

RTe – two step process (sol-gel + chemical modification), OW9:9 poly[dimethyl-co-(octafluoropentyl oxypropyl)methyl-co-(trimethoxysilyl ethyl) methyl]siloxane 9:9, DiK – dip coating process, T – reaction at 80ºC, P – washing process

Polysiloxane 9:9 is giving similar results in comparison with polysiloxane 12:6. The best results were obtained for one step modification at 80ºC (after washing) with a dip coating period of 30 minutes (WCA 145º). It should be also mentioned that the wetting angles after washing period did not diminish but were even higher

4. CONCLUSIONS

The highly hydrophobic textiles were obtained in all studied cases. One step modification at 80ºC with a dip coating period of 30 minutes was found to be the most effective method of modification. The modified textiles are resistant for washing process due to the formation of covalent bonds between hydroxyl groups of the fabric and the modifying...
Better results were achieved for poly[dimethyl-co-(octafluoropentylxyloxypropyl)methyl-co-(trimethoxysilylethyl) methyl]siloxane 9:9. After the modification process, the fabric remained elastic, with the same texture and color.

The authors gratefully acknowledge on financial support from the National Centre for Resorts and Development. Project “Novel organosilicon compounds for gentrify natural fibers and textiles” No. 180 480. And from The National Centre of Science, project “Technologies of synthesis of highly hydrophobic materials on the based of fluorofunctional organosilicon compounds” No. N N209 765640

REFERENCES