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A Study on Cleaning Finishing Process of Cotton Fabric with Water and Oil Repellent

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Abstract

Water and oil repellent finishing is done on cotton fabric by pad-dry baking process. The influences of baking temperature, baking time, pH value and concentration of finishing liquid on water and oil contact angle of fabric are analyzed. The result shows that the optimized water/oil repellent finishing process of cotton fabrics is as follows: The concentration of finishing agent is 30 g/L, pH value is 6.67, pick up rate is 80%, and the baking time is 8 minutes under 140. After finishing, the oil and water contact angle of the cotton fabrics can reach up to 143.33 degrees and 134 degrees respectively and at this time the finishing effect is the best. Scanning Electron Microscopy (SEM) reveals that after water and oil repellent finishing, the surface of the cotton fiber becomes smooth, the finishing agent has good film-forming ability and it has better water and oil repellent performance.

Keywords: Cotton fabric • Water proof • Oil repellent treatment • Finishing process

Introduction

The main component of cotton fiber is cellulose, which has good hydrophilic property, is easily wetted by water and is easily stained by oil. In order to make the fabric have certain water and oil repellency, the fabric is subjected to water and oil repellent finishing. Fluorine-containing finishing agent is currently the main water and oil repellent finishing agent due to the fluorine atom has a small diameter, a large electronegativity, and a high C-F bond energy. The immersion process is used to adhere the fluorine containing compound to the surface of the fabric, which can significantly reduce the surface tension of the fabric and impart good water and oil repellency to the fabric [1]. The surface morphology of the cotton fabric before and after finishing was observed using a Scanning Electron Microscope (SEM).

Materials and Methods

Test material

Plain weave bleached cotton fabric: 21 tex × 21 tex, 108/10 cm × 58/10 cm, fabrics were collected from the chemistry and chemical engineering lab. The waterproof and oil repellent finishing chemical Swiss Cariant three anti-finishing agent. All the, dyestuffs, basic chemicals etc. (hydrochloric acid-analytical grade, sodium hydroxide-analytical grade), received from the chemistry and chemical engineering examination center for clean production of textile dyeing and printing, ministry of education lab [2].

Fabric preparation

Plain weave bleached cotton fabric roll were collected from the chemical lab. To inspect the fabric cleanliness and to check the hole mark, crease mark, GSM cut in to many pieces as A 4 size (8 × 11 inch).

Experimental equipment

Scissors, beakers, dropper, petridis, glass rods, electrical balances, safety glass, mask, apron, hand gloves, padding machine, small dryer machine, curing machine, washing machine, contact angle instrument [3].

Test methods

Bleached cotton fabric → two-dip two-pad (pick up rate of 80%) → pre-baking (80°C, 5 min) → baking (160°C, 3 min) → washing (60°C × 15 min) → dry (75°C-80°C) naturally 4-5 min → Measurement of Contact Angle (CA).

Measurement of contact angle

The name of the instrument KRUSS easy Drop Shape Analyzer-(DSA) and software was DSA 20 contact angle measuring instrument

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was used, and deionized water and oil were used as water and oil test liquid. Tested 3 times in different parts of the same sample, the average value of CA is the contact angle of the sample. The surface morphology of the fabric was observed-the finished fabric was sprayed with gold by a gold-plated instrument, and its surface morphology was observed by a field emission scanning electron microscope [4].

Results and Discussion

The effect of the pH value of the finishing liquid on the water and oil repellent finishing effect of the fabric. Prepare 30 g/L finishing solution and measure the pH value of 6.67. Adjust with 6 mol/L HCl and 2 g/L NaOH to adjust the pH value (Table 1 and Figure 1). Change the pH vale at 2, 4, 6, 8 and 10, the cotton fabric was finished according to the finishing process; the water-oil contact angle of the fabric was tested. The results which are stated below in Table 2 and Figure 2.

pH	Water contact angle (°)
2	136.33
4	138.33
6	140
6.67	143.67
8	140.67
10	98.67

Table 1. Effect of pH value of finishing liquid on water repellency of fabric.

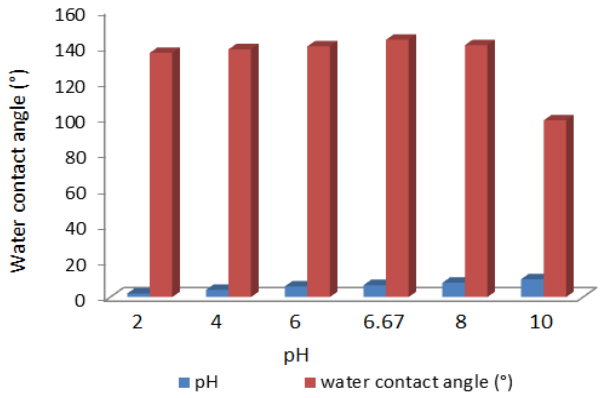

Figure 1. A graphical representation of the effect of pH value of finishing liquid on water repellency of fabric.

pH	Oil contact angle (°)
2	116.67
4	136.67
6	132
6.67	129
8	113.33
10	52.67

Table 2. Effect of pH value of finishing liquid on oil repellency of fabric.

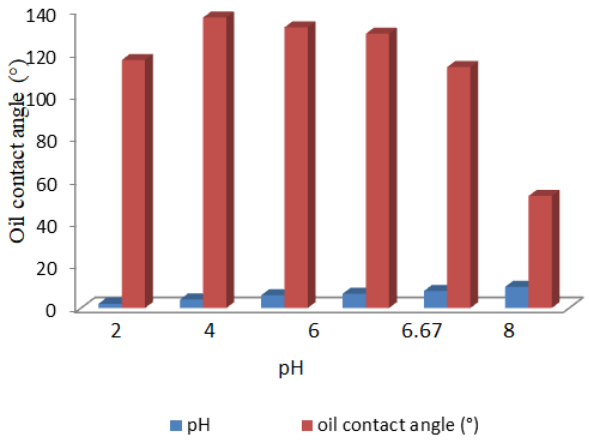

Figure 2. A graphical representation of the effect of pH value of finishing liquid on oil repellency of fabric.

It can be seen from Table 2 that, as the pH value of the finishing liquid increases, the water-oil contact angle of the cotton fabric first increases and then decreases. When the pH is 4~6, the water-oil contact angle of the cotton fabric after finishing is about 140°, which has good water and oil repellent effect; at pH=10, the oil-water contact angle is small, especially the oil contact angle. Only 52.67°, indicating that the fabric after alkaline finishing has basically no water and oil repellency. Considering the high temperature baking after acid treatment, the cotton fiber is damaged, and the test results of water and oil contact angle are taken into consideration Tables 3 and 4 [5]. When the finishing liquid is not adjusted by acid and alkali, the cotton fabric has the best water and oil repellent finishing effect, and the pH is 6.67. Effect of baking temperature on water and oil repellent finishing effect of fabrics 30 g/L finishing liquid, pH value of 6.67, changing baking temperature, finishing cotton fabric according to the finishing process and testing the water and oil of fabric contact angle, the results are shown in Figures 3 and 4.

Temperature (°C)	Water contact angle (°)
120	144
130	138.33
140	138.67
150	139.67
160	143.67

Table 3. Effect of baking temperature on water repellency of fabric.

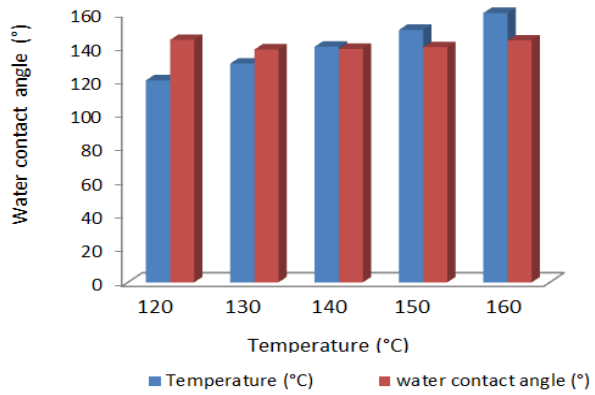

Figure 3. A graphical representation of the effect of baking temperature on water repellency of fabric.

Temperature (°C)	Oil contact angle (°)
120	123.33
130	131
140	132
150	129
160	129

Table 4. Effect of baking temperature on oil repellency of fabric.

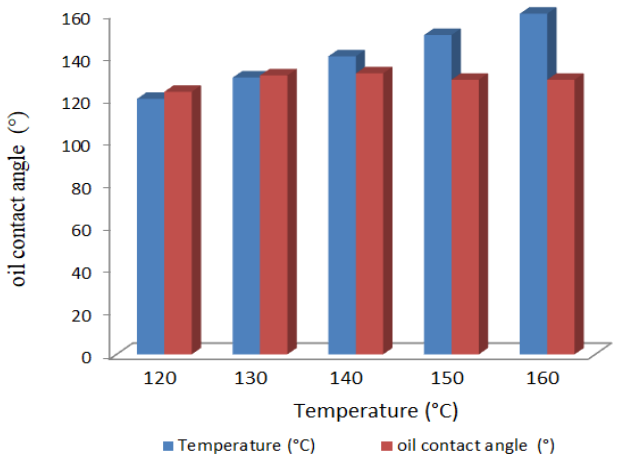

Figure 4. A graphical representation of the effect of baking temperature on oil repellency of fabric.

According to Tables 5 and 6, when the baking temperature is 120°C-160°C, the water contact angle of the cotton fabric after inishing is about 140°C, and the oil contact angle is about 130°C. Considering the excessive baking temperature, the fabric is yellowed, the iber is damaged, and the test results of the water-oil contact angle are taken into consideration. The baking temperature with good water and oil repellency is 140°C. Effect of baking time on water and oil repellent inishing effect of fabrics 30 g/L inishing liquid, pH value 6.67, baking temperature 140°C, changing baking time, inishing cotton fabric according to the inishing process and the water-oil contact angle of the fabric was tested and the results are shown in Figures 5 and 6.

Time/min	Water contact angle (°)
3	138.67
5	139.67
8	145
10	137

Table 5. Effect of baking time on water repellency of fabric.

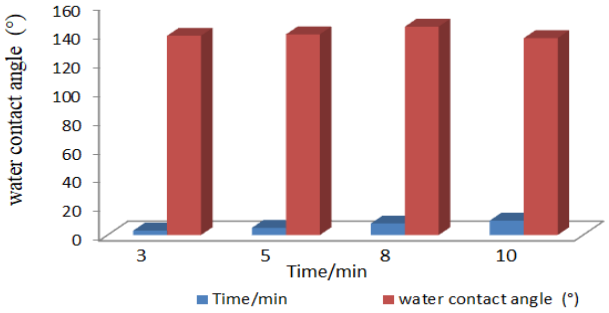

Figure 5. A graphical representation of the effect of baking time on water repellency of fabric.

Time/min	Oil contact angle (°)
3	132.33
5	130.33
8	141.67
10	128.33

Table 6. Effect of baking time on oil repellency of fabric.

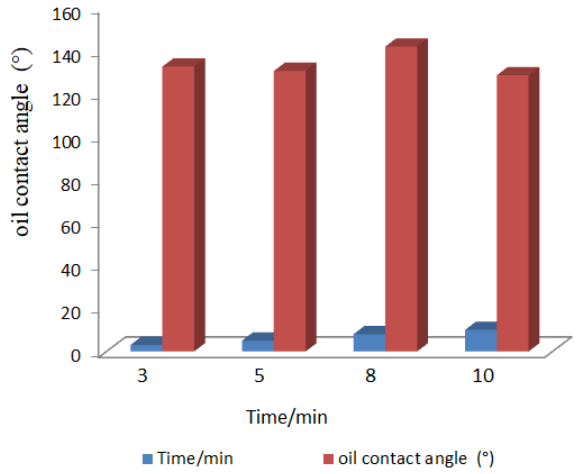

Figure 6. A graphical representation of the effect of baking time on oil repellency of fabric.

The degree of polymerization or film formation of the fluoro finish on the fabric is directly affected by the baking time. The baking time is too short, the polymerization or crosslinking of the organic fluoride is insufficient; the baking time is not too long, and the time is too long, which affects the whiteness, strength and process progress of the fabric. It can be seen from Tables 7 and 8 that, as the baking time is extended, the water-oil contact angle of the cotton fabric after finishing is first increased and then decreased. When the baking time is at 10 min, the water contact angle of the cotton fabric after finishing was significantly reduced, and the oil repellency was deteriorated [6]. When the baking time was 8 min, the water-oil contact angle of the cotton fabric after finishing was the largest, and the water-repellent and oil-repellent effect was the best. Therefore, the preferred baking time of the cotton fabric for water and oil repellent finishing is 8 min. The effect of finishing agent concentration on the water and oil repellent finishing effect of the fabric When the pH value is 6.67, the baking temperature is 140°C, and the baking time is 8 min, the concentration of the finishing agent is changed, and the cotton fabric is finished according to the finishing process. The water-oil contact angle of the fabric was tested and the results are shown in Figures 7 and 8.

Concentration (g/L)	Water contact angle (°)
1	0
5	0
10	129.33
20	137.33
30	143.33
40	136.33
50	137.67
60	132.33

Table 7. Effect of inishing agent concentration on water repellency of fabric.

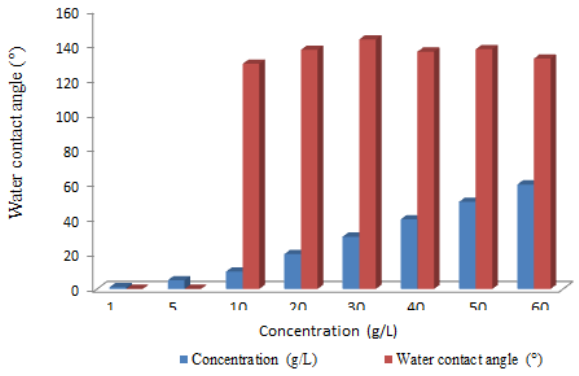

Figure 7. Effect of inishing agent concentration on oil repellency of fabric.

Concentration (g/L)	Oil contact angle (°)
1	0

Concentration (g/L)	Oil contact angle (°)
1	0
5	0
10	124.33
20	129
30	134
40	131.67
50	132.33
60	132

Table 8. Effect of inishing agent concentration on oil repellency of fabric.

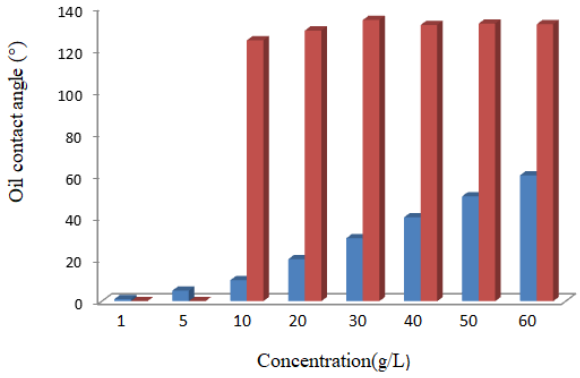

Figure 8. A graphical representation of the effect of finishing agent concentration on oil repellency of fabric.

The water and oil repellency of the fabric is achieved by a layer of material with low surface energy adsorbed on the surface of the fabric. The effective component in the finishing liquid is an organic fluorine compound and the alignment of the organic fluorine molecules on the surface of the fiber reduces the surface tension of the fiber, thereby imparting a water and oil repellency effect to the fabric. Therefore, the content of organic fluorine in the finishing liquid determines whether the organic fluorine molecules on the surface of the fiber can be closely aligned, that is, the concentration of the finishing liquid can affect the water and oil repellency of the fabric after finishing [7]. It can be seen from Figure 9 that, when the finishing agent concentration is 1 g/L and 5 g/L, the water oil contact angle of the fabric is zero. When measuring, the water droplets and oil droplets will be on the surface of the finished cotton fabric in a short time. Completely spread. With the increase of the concentration of the finishing liquid, the water-oil contact angle of the cotton fabric after finishing has a tendency to increase first and then decrease. According to the Cassie-Wenzel transition state mode, the state of the droplet in contact with the solid depends on the relative size of the critical contact angle between the Wenzel state and the Cassie-Baxter mode Figures 9-11.

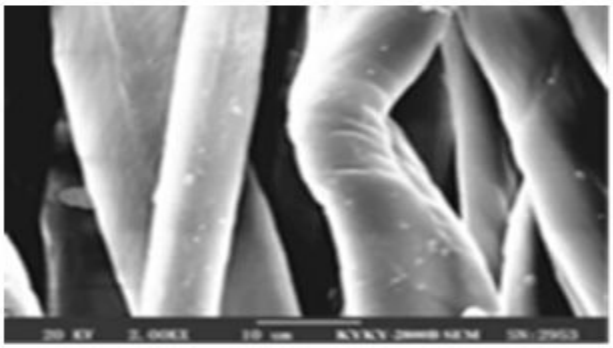

Figure 9. Unfinished cotton fabric SEM image.

The surface should have a certain rough structure, and when the concentration of the finishing agent is too high, the film is uniformly formed on the surface of the fabric, and the surface is too smooth, thereby reducing the water and oil repellency [8]. When the concentration of the finishing liquid is 30 g/L, the water-oil contact angle of the cotton fabric after finishing is the largest, so the optimum finishing liquid concentration is 30 g/L.

Water and oil repellency test of cotton fabric after finishing

The concentration of water and oil repellent finishing agent is 30 g/L, the pick-up rate is 80% (two dip two pad), pre-bake at 80°C for 5 min, and baking at 140°C. The finishing process of min is used for water and oil repellent finishing of cotton fabrics. The water and oil contact angles of cotton fabrics after finishing are shown in Figures 10 and 11.

Figure 10. Water contact angle of cotton fabric after finishing.

Figure 11. Oil contact angle of cotton fabric after finishing.

It can be seen that, the cotton fabric has good water and oil repellency after finishing, and the best water-oil contact angle

reaches 143.33°C and 134°C. From the above results, it is known that the measured oil contact angle is always smaller than the water contact angle. According to Young's equation, $\gamma SL-\gamma S+\gamma L \cos\theta=0$, where γSL is the interface tension between solid and gas, γS is the interfacial tension between liquid and gas, and γL is the interfacial tension between liquid and solid. When γS is constant, the smaller γL is, the smaller θ is, and the liquid is more likely to wet the solid. The surface tension of oil is 32.95 ($mN.m^{-1}$), while the surface tension of water is 71.79 ($mN.m^{-1}$). The surface tension of oil is much smaller than the surface tension of water, so water contact angle is also larger than the contact angle of the oil, but both water repellent and oil repellent can achieve better results [9,10].

Observation of surface morphology before and after finishing

Observing the scanning electron micrographs before and after finishing the cotton fabric, it can be seen that after the water and oil repellent finishing, the surface of the cotton fiber is smooth, the film forming property of the finishing agent is good, and a uniform organic fluoride film can be formed on the surface of the fibere [11-14]. Has good water and oil repellency which is shown below in Figure 12.

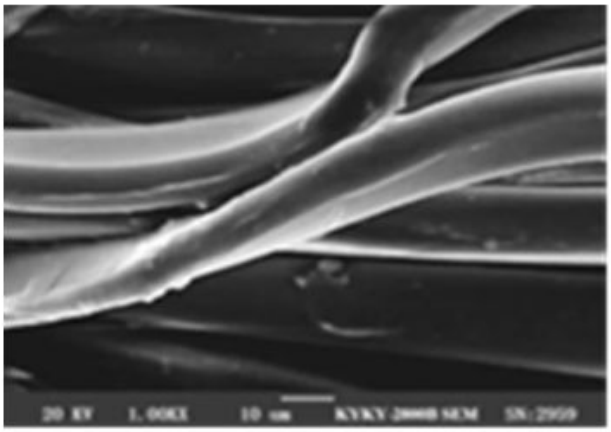

Figure 12. SEM image of cotton fabric after water and oil repellent finishing.

Conclusion

Water and oil repellent treatment of plain weave bleached cotton fabric was treated with Swiss Clariant three anti-finishing agent. Fluorocarbons free finishing which are applied on cotton fabrics by two dip two pad process. Applying water and oil repellent finishing chemicals, the surface of the hydrophobicity of cloth was investigated. When a water and oil finishing chemical was used, then the best water and oil finishing is obtained by evaluating especially contact angle test and the optimized condition was concentration 30 g/L, backing temperature 140°C, backing time 8 min and pick up-rate 80%. The finishing agent has the function of changing the surface properties of the fiber, so that the surface of the fiber variations from hydrophilic to hydrophobic.

References

1. Nguyen, Son T, Jingduo Feng, Nhat T Le and Ai TT Le, et al. "Cellulose Aerogel from Paper Waste for Crude Oil Spill Cleaning." *Ind Eng Chem Res* 52 (2013): 18386-18391.
2. Hiyama, Tamejiro, Tamejiro Hiyama and Hisashi Yamamoto. "Fluorine-Containing Materials." *J Fluor Chem* (2000): 183-233.
3. Xiong, Dean, Guojun Liu EJ Scott Duncan "Diblock-Copolymer-Coated Water and Oil Repellent Cotton Fabrics." *Langmuir* 28 (2012): 6911-6918.
4. Wang, Chuanxi, Tongjie Yao, Jie Wu and Cheng Ma, et al. "Facile Approach in Fabricating Superhydrophobic and Superoleophilic Surface for Water and oil Mixture Separation." *ACS Appl Mater Interfaces* 1 (2009): 2613-2617.
5. Landolt, D. "Electrodeposition Science and Technology in the Last Quarter of the twentieth Century." *J Electrochem* 149 (2002): 1-9.
6. Bormashenko, Edward, Roman Pogreb, Gene Whyman and Mordehai Erlich. "Cassie-Wenzel Wetting Tansition in Vibrating Drops Deposited on Rough Surfaces: Is the Dynamic Cassie-Wenzel Wetting Transition a 2d or 1d Affair? " *Langmuir* 23 (2007): 6501-6503.
7. Zhang, Xi, Feng Shi, Jia Niu, and Yugui Jiang, et al. "Superhydrophobic Surfaces: From Structural Control to Functional Application." *J Mater Chem A* 18 (2008): 621-633.
8. Thomas, SPS Thomas, R Abraham and S Bandyopadhyay "Polystyrene/ Calcium Phosphate Nanocomposites: Contact Angle Studies Based on Water and Methylene Iodide." *Express Polym Lett* 2 (2008): 528-538.
9. Gao, Qinwen, Quan Zhu, Yuliang Guo and Charles Q Yang et al. "Formation of Highly Hydrophobic Surfaces on Cotton and Polyester Fabrics Using Silica Sol Nanoparticles and Nonfluorinated Alkylsilane." *Ind Eng Chem Res* 48 (2009): 9797-9803.
10. Ibrahim, NA, A Amr, BM Eid and AA Almetwally, et al. "Functional Finishes of Stretch Cotton Fabrics." *Carbohydr Polym* 98 (2013): 1603-1609.
11. Onar, Nurhan and Gulfem Mete "Development of Water-Oil-Repellent and Flame-Retardant Cotton Fabrics by Organic-Inorganic Hybrid Materials." *J Text Inst* 107 (2016): 1463-1477.
12. Yeh, Jen-Taut, Chin-Lai Chen, Kuo-Shien Huang. "Preparation and Application of Fluorocarbon Polymer/SiO2 Hybrid Materials, part 2: Water and Oil Repellent Processing for Cotton Fabrics by Sol-Gel Method." *J Appl Polym Sci* 103 (2007): 3019-3024.
13. Ferrero, Franco and Monica Periolatto. "Application of Fluorinated Compounds to Cotton Fabrics *via Sol-Gel*." *Appl Surf Sci* 275 (2013): 201-207.
14. Li, Guoqing, Zhonghua Mai, Xin Shu and Dongzhi Chen, et al. "Superhydrophobic/Superoleophilic Cotton Fabrics Treated With Hybrid Coatings for Oil/Water Separation." *Adv Compos Hybrid Mater* 2 (2019): 254-265.

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