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Effect of Operational Parameters on Water-repellent Properties of Woven Cotton Fabric

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ABSTRACT

This study was mainly focused on the effect of operational parameters (temperature and concentration of finishing agents) on the properties of water repellent finishes of plain woven cotton fabric. The samples were treated with fluorocarbon based water repellent chemicals by RUDOLF with three different concentrations and three different curing temperatures while keeping with the other parameters at the same conditions. The water repellency of the treated samples were evaluated with ASTM D 583-54 (Spray Test) with spray test rating. The whiteness index test was also done for the treated samples in order to determine the effect of finishes on other subsequent process, i.e., especially dyeing process which partially depends on the condition of yellowness or whiteness of the cotton fabric which can give changes in final colour of the dyed fabric. It was noticed that both the curing temperature and concentration of water repellent agents was the critical factor for the evaluation of water repellency and whiteness index of treated fabrics.

Keywords: water repellent finishes, concentrations, curing temperatures, spray test, whiteness index

1. Introduction

In recent years clothing are needed not only for just wearing but also for having functional properties depending on the wearers for their intended condition e.g., sport wear, and also depending on the weather. Water repellent finishes is one of the desired functional finishes for clothing and apparels in nowadays. Generally, water repellency effect can be achieved by modification of the surface energy of textiles fibres [1]. There are some chemicals used for water repellent finishes such as wax dispersions free of metal ions, metallic salts and soaps, wax dispersions containing zirconium salt and prydinium compounds, silicones, organo chromium compounds and fluorochemicals products [2]. Cotton is a hygroscopic nature due to the presence of hydroxyl group in the cellulosic backbone. The way to convert the hygroscopic to hydrophobic nature is formation of the thin layer which has the hydrophobic properties . By using fluorochemical based finishing, hydrophobic effect can be obtained because of the replacing of fluorine with other elements such as H and C, in the order – CF3< CF2H< CF2< CH3< CH2, which result in increasing of surface free energy. Therefore, more hydrophobicity effect can be achieved with decreasing surface energy by increasing the number of fluorine-carbon bonds in the functional structure [3]. Pad-dry-cure method is generally used for water-repellent finishes [4]. Mostly, the nature of the water repellent finishing with fluorochemicals for textile materials is cationic condition and so the suitable pH condition of the finishing bath is around 5. Water repellent properties of textile materials can be expressed in terms of repellency and contact angle. Water repellency means properties of the fabric i.e., resistance to absorption, adsorption and penetration of water on a fabric. Wettability is one of the most important properties of a solid surface and the contact angle has been commonly used to characterize the surface wettability. Spray test is also used for determination of resistance to external (surface) wetting [5].

2. Materials and Methods

In this study, the bleached cotton fabric (59 ends per inch × 48 picks per inch), plain weave design is used to treat with water-repellent finishes. The fabric are cut into nine sample pieces of (8 × 8) inches in order to use for treating with different concentrations of finishing agents and temperatures. After getting the samples, they are conditioned in the room with the standard conditions 20 C± 2 and 65 % R.H for about 1 hour and weighed.

2.1. Technical Data used for Water-Repellent Finishes

In the application of water-repellent treatment, the RUCO-DRY ECO combining with RUCO-LINK RCX (supported by RUDOLF GROUP) are used. In the treatment, three different concentrations (35g/L, 45g/L, 55g/L) of RUCO-DRY ECO are applied in the preparation of water-repellent finishing solution. The concentration of crosslinking agent RUCO-LINK RCX is the same (15g/L) for all this treatments. The necessary data for finishing agent of RUCO-DRY ECO and RUCO-LINK RCX used are calculated depending on the material to liquor ratio of 1:20. Table 2.1 describes the designation of samples with the technical parameters used in the water-repellent treatments.

Table 2.1. Designation of Samples with Technical Data

Sr. No.	Sample Code	Wt. of sample (gm)	Concentration of RUCO-DRY ECO(gm/L)	Amount of RUCO-DRY ECO (gm)	Concentration of RUCO-LINK RCX (gm/L)	Amount of RUCO-LINK RCX (gm)
1	A	5.6	35	3.92	15	1.68
2	B	5.7	45	5.13	15	1.71
3	C	5.7	55	6.27	15	1.71
4	D	5.9	35	4.13	15	1.77
5	E	5.5	45	4.95	15	1.65
6	F	5.9	55	6.49	15	1.77
7	G	6.0	35	3.93	15	1.68
8	H	6.0	45	5.06	15	1.69
9	I	5.9	55	6.36	15	1.73

2.2. Treating the Samples with Pad-Dry-Cure Method

The samples are treated with the prepared solution using pad-dry-cure machine. Three different curing temperatures are applied in this process. Padding pressure is maintained at 4 bar of nip pressure to keep the pick-up percent approximately equal during the operation and three different curing temperatures are used during the operation to examine the effect of temperature on the water-repellent treatment. Table 2.2 shows the treated samples with their corresponding different curing temperatures.

Table 2.2. Designation of Samples with Technical Data

Sr No.	Samples	Pick-up Percent	Curing Time (minute)	Curing Temperature (˚C)
1	A	82	3	130
2	B	83	3	130
3	C	83	3	130
4	D	82	3	140
5	E	83	3	140
6	F	82	3	140
7	G	81	3	150
8	H	81	3	150
9	I	81	3	150

2.3 Evaluation the Whiteness Index of Treated Samples

After treating the samples, the whiteness index of the samples are determined using the X- Rite Spectrophotometer. In order to compare the effect of water-repellent treatment on whiteness index, untreated sample is also examined. The results of whiteness index related with concentration of RUCO-DRY ECO and curing temperature for untreated and treated samples are shown in Table 2.3 .

Table 2.3. Results of Whiteness-index of Treated Samples

Sr. No.	Sample	Concentration of RUCO-DRY ECO (gm/L)	Curing Temperature (˚C)	WI-ASTM (Whiteness Index)
1	Untreated(U)	-	-	193.29
2	A	35	130	180.83
3	B	45	130	183.03
4	C	55	130	178.11
5	D	35	140	182.12
6	E	45	140	178.24
7	F	55	140	178.14
8	G	35	150	186.88
9	H	45	150	186.99
10	I	55	150	181.54

2.4. Evaluation of the Water-Repellent Test on Treated Samples

Spray rating test is used according to ASTM D583-54 to evaluate the effect of different concentrations of the solution and different temperatures on water repellency of samples. All the samples are tested under the standard conditions i.e., relative humidity (65% ±2) and temperature (20 ˚C ±2). The results of the water-repellent tests of the treated samples are shown in Table 2.4.

Table 2.4. Results of Spray Rating on Treated Samples

Sr. No.	Sample	Concentration of RUCO-DRY ECO(gm/L)	Curing Temperature (˚C)	Spraying Rating
1	A	35	130	50
2	B	45	130	70
3	C	55	130	90
4	D	35	140	70
5	E	45	140	70
6	F	55	140	80
7	G	35	150	80
8	H	45	150	70
9	I	55	150	70

3. Results and Discussion

The effect of water-repellent properties are examined by changing the parameters i.e., concentration of solution used and temperature. In the treatment, the highest temperature is considered as 150˚C because the properties of cotton can be degraded over 150˚C. All the treated samples attain water-repellent effect after testing by spray test method. Considering the temperature as a constant, it is observed that the better water-repellent effect is obtained with increasing in concentration of RUCO-DRY ECO used for 130˚C and 140˚C but there is poor water-repellent effect with increasing in concentration of RUCO-DRY ECO used for 150˚C. Considering the concentration of solution used as a constant (35 and 45 g/L), it is seen that the temperature of 150˚C gives better water-repellent effect but, when increasing the concentration of the chemical used to 55g/L, the better water-repellent effect can be obtained with the temperature of 130˚C. Figure 3.1 shows the effect of concentration used and temperature on water-repellent properties of the treated samples.

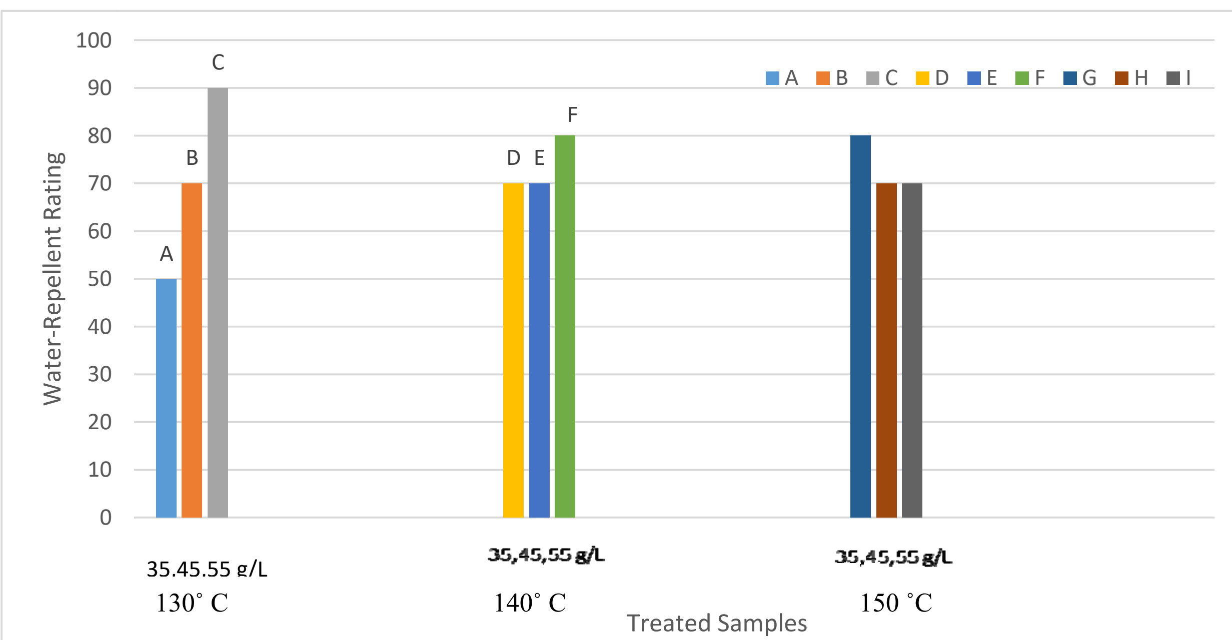

Figure 3.1. Results of Concentration and Temperature on Water-Repellent Properties

The effect of water-repellent finish on the whiteness index of samples is also examined. It is seen that the whiteness index of all treated samples are more reduced than untreated samples. When the temperature is considered as a constant, it is observed that 45g/L concentration gives the maximum whiteness index for 130 ˚C and 150 ˚C, whereas 35g/L concentration gives the maximum whiteness index for 140 ˚C. Figure 3.2 shows the effect of concentration and temperature used in water-repellent finishes on the whiteness index of samples.

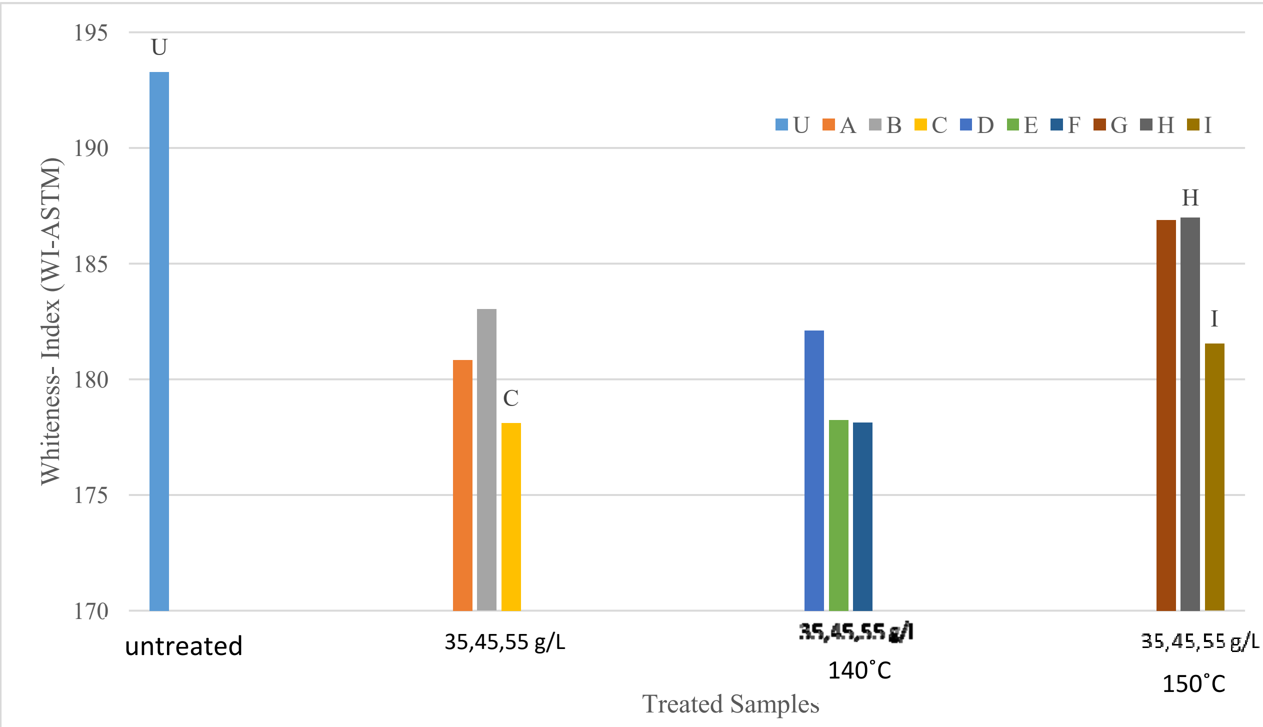

Figure 3.2. Results of Water-repellent Finish on Whiteness-Index

4. Conclusions

The evaluation of water repellency and whiteness index properties of plain woven cotton fabric are determined by changing the concentration of solution used and temperature. It is seen that both parameters are important factor for water repellency and whiteness index properties of cotton fabric. However, there is no directly proportional relation of concentration and temperature with water repellency and whiteness index properties. The best water repellency is obtained with the highest concentration (55g/L) and the lowest temperature (130˚C), and the best whiteness index is obtained with the medium concentration (45g/L) and the highest temperature (150˚C). Therefore, the parameters used in water-repellent finish should be used considering the desired properties and also the economical point of view; the lowest temperature for saving energy and amount of concentration used for commercial production.

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