Causticization and Anticrease finish in Continuous Process

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Abstract

The adsorption of cotton fabric is improved by treatment with sodium hydroxide, which is called causticization method. In the method, it is necessary to wash off unreacted sodium hydroxide from the fabric and then neutralize with some acids, such as acetic acid and sulphuric acid. In this research, citric acid was used to neutralize causticized fabric and anticrease finish on cotton fabric. The citric acid is non-formaldehyde anticrease finishing agent. So that the two processes, i.e. causticization and anticrease finish, could be combined into one continuous process. And it was found that the causticization would improve some properties of anticrease fabric with citric acid.

From the result, it showed that the anticrease fabric had lower tensile strength than untreated fabric. The anticrease finish with 6% w/v citric acid had higher tensile strength than 8 and 10 % w/v, respectively. When concentration of acid, curing temperature and time were higher, wrinkle recovery angle would be increased. The effect of catalyst showed that anticrease finish using sodium hypophosphite as catalyst was higher wrinkle recovery angle and tensile strength than non-catalyst finish.

The causticization before anticrease finish would increase tensile strength and whiteness of fabric when compared to only anticrease finish. The effect of catalyst showed that at low acid concentration, increasing of catalyst didn't have effect on tensile strength and wrinkle recovery angle value. At higher acid concentration, trend of tensile strength was decreased whereas wrinkle recovery angle increased and slightly effect on whiteness.

Keywords : Anticrease finish, Causticization, Citric acid, Non-formaldehyde finish

1. Introduction

Easy-care and durable press finishes are generally applied to cellulose and cellulose blend fabrics. An unavoidable side effect of the cellulosic crosslinking finishes is a reduction in the elasticity and flexibility of the cellulose fibers. This produces a considerable decrease in abrasion resistance and tear and tensile strengths on natural cellulose fibers[1]. Citric acid was found to be the most effective polycarboxylic acid in the absence of added catalyst by pad-dry-cure treatment, although it produced more fabric discoloration than the other agents. The crosslinks were formed in cellulose by acid-catalyzed esterification with citric acid and cellulose[2-3]. Several researchers studied the way to give the high efficiency of non-formaldehyde durable press finishes of cotton by mixing citric acid with other agents [4-7].

In this study, the causticization process was applied to improve the absorption of citric acid. That should give more effective of anticrease finish with citric acid. It is due to the degradation of citric acid at high temperature. It will generate aconitic acid and itaconic acid that cause the yellowish of cotton fabric. So that if we can improve the absorption of finishing agent such as citric acid, the crosslinking reaction should be increased and the amount of unreacted citric acid, that causes the yellowish and degrade the fabric, was decreased.

2. Experimental

2.1 Materials and Chemicals

Grey cotton woven fabric was purchased from the textile mill, Thailand. The chemical used in this research are listed in the Table 1.

2.2 Equipment

1. Padding laboratory machine: Tsujii Dyeing Machine MFG Co.,Ltd.
2. Oven : K+Z Corporation Co.,Ltd.
3. Tensile Strength Tester : Intro Enterprise Co.,Ltd.
4. Wrinkle Recovery Tester : Daiei Kagaku Seiki MFG Co.,Ltd.
5. Spectrophotometer Spectraflash 500 : Datacolour International Co.,Ltd.

Table 1 Chemical used in this study

Chemicals	Grade	Supplier
Sodium persulphate	Commercial	Sahaworakit (Thailand)
Sodium hydroxide	Commercial	Sahaworakit (Thailand)
Hydrogen peroxide	Commercial	Thaiperoxide (Thailand)
Sodium silicate	Commercial	Sahaworakit (Thailand)
Barium hydroxide	Analytical	Ajax Finechem
Potassium hydrogen phthalate	Analytical	BDH
Phenolphthalein	Analytical	Fluka
Sodium carbonate	Analytical	Carlo Erba
Hydrochloric acid	Analytical	Merck
Citric acid	Analytical	Ajax Finechem
Sodium phosphate monohydrate	Analytical	Ajax Finechem
Petroleum ether	Analytical	BDH
Acetic acid	Analytical	Merck
Ethanol	Analytical	BDH

2.3 Preparation of Fabric

Desizing

Grey cotton fabric was desized following exhaustion method. The desizing bath contained with 5g/l of Sodium persulphate, 4 g/l of sodium hydroxide and 2 g/l of soaping agent. The desizing was carried out at 100^{o}C for 1 hour.

Bleaching

The desized cotton fabric was bleached in the bleaching bath containing with 8 g/l of hydrogen peroxide, 5 g/l of sodium hydroxide, 4 g/l of sodium silicate and 2 g/l of soaping agent. The bleaching was carried out at 100°C for 1 hour.

2.4 Causticization

The bleached cotton fabric was causticized in 20, 25 and 30% w/w of sodium hydroxide without tension. This method was compared between room temperature and 20°C. The treated fabric was soaked in hot water for 3 minutes and then cold water for 3 minutes. After that, it was dried in Oven at 100°C for 3 minutes.

2.5 Barium Number Analysis

The analytical method was followed by AATCC Test Method 89-2003 - Mercerization in cotton [8].

2.6 Anticrease finish with Citric Acid

In this study, the Pad-dry-cure technique was used for anticreasing finish. The bleached fabric was immersed in various finishing bath containing 6, 8 and 10% w/v of citric acid with and without 4% w/v of sodium hypophosphite monohydrate as catalyst. And then padded with Padder Laboratory Machine at 70% pick up. The fabric was dried at 100°C for 3 minutes and then cured at various temperature, 160 170 and 180°C, and various time for 60 90 and 120 seconds. The finished cotton fabric was boiled in 1 g/l sodium carbonate solution at 50°C for 10 minutes.

2.7 Causticization and Anticrease finish in Continuous Process

The bleached cotton fabric was causticized in 20% w/w of sodium hydroxide solution at 20°C and then immersed in hot water for 3 minutes and then cold water for 3 minutes. After that, the causticized fabric was treated with various concentrations of citric acid at 2, 4, 6, 8 and 10% w/v with 4 and 6% w/v of sodium hypophosphite as catalyst. The treated fabric was dried at 100°C for 3 minutes. The curing temperature and time were varied at 160, 170 and 180°C for 60, 90 and 120 seconds. The final step, it was boiled in 1 g/l sodium carbonate at 50°C for 10 minutes for washing-off excess NaOH from the fabric.

2.8 Testing Methods

Tensile Strength test was followed by TISI standard 121 No 9-2518. And wrinkle recovery angle test was followed by AATCC standard 66-1998. The whiteness of fabric was characterized by Spectrophotometer Spectraflash 500.

3. Results and Discussion

3.1 Mercerization in Cotton fabric.

The degree of mercerization of cotton fabric was indicated with barium number. They show in Table 2.

Table 2 Barium number of causticized fabric

Temperature	NaOH Concentration (%)	Barium number
Room temp.(25°C)	20	157
	25	171
	30	192
20°C	20	161
	25	182
	30	200

A barium activity number in the range of 100-105 indicates no mercerization. A barium activity number above 150 indicates substantially complete reaction between the cotton and the mercerizing bath [8]. From the result indicated that the causticization at 20°C showed higher barium number than at room temperature. At higher concentration of NaOH, the barium number was increased.

From the AATCC standard, barium number is above 150 indicates the complete mercerization. So that condition at 20°C using 20% w/w of NaOH was used in this study.

The comparison between causticization at 20°C using 20% w/w of NaOH with and without washing-off excess NaOH on the fabric shows in Table 3.

Table 3 pH values of the fabric after causticization at 20°C using 20% w/w of NaOH

Process	pH of fabric	NaOH concentration on fabric (F)
Causticization without washing-off	11.95	0.04480
Causticization with washing-off	9.21	0.00003

3.2 Anticrease finish of bleached cotton fabric

Table 4 Properties of cotton fabric after anticrease finish with 8 % w/v of citric acid without catalyst

Temp (°C)	Time (Sec)	Tensile strength				Wrinkle recovery angle (°)	Whiteness	
		Warp		Weft				
		Load (N)	Extension (mm)	Load (N)	Extension (mm)		Before	After
Bleached fabric		368.7	47.6	385.7	37.6	134	104.1	-
160	60	339.6	42.3	341.2	34.6	180	106.2	66.7
160	90	337.9	43.1	342.0	34.2	181	105.7	65.8
160	120	337.8	42.5	340.1	32.6	181	104.9	66.0
170	60	339.1	43.6	342.1	33.9	180	106.1	65.8
170	90	338.2	43.5	340.9	34.8	182	107.2	65.1
170	120	338.0	42.9	339.5	33.6	182	104.3	64.9
180	60	339.0	42.8	339.7	34.1	183	104.1	63.8
180	90	337.2	42.1	339.9	32.1	184	103.9	62.0
180	120	336.5	43.0	337.1	32.5	184	103.5	63.1

Table 5 Properties of cotton fabric after anticrease finish with 8 % w/v of citric acid with 4% w/v of sodium hypophosphite

Temp (°C)	Time (Sec)	Tensile strength				Wrinkle recovery angle (°)	Whiteness	
		Warp		Weft			Before	After
		Load (N)	Extension (mm)	Load (N)	Extension (mm)			
Bleached fabric		368.7	47.6	385.7	37.6	134	104.1	-
160	60	350.6	44.8	357.4	36.4	186	109.1	67.3
160	90	348.1	44.5	352.2	35.0	185	109.0	66.5
160	120	352.7	44.1	354.5	35.6	185	107.9	65.0
170	60	348.5	43.2	351.5	36.9	188	108.7	67.0
170	90	347.4	45.1	349.4	37.0	187	106.3	64.1
170	120	342.3	44.4	345.8	35.1	187	108.9	64.0
180	60	347.4	44.1	350.1	35.5	190	109.6	65.1
180	90	346.9	44.5	350.2	35.2	192	106.7	63.0
180	120	350.6	44.8	357.4	36.4	186	109.1	67.3

The result indicated that the anticrease fabric showed lower tensile strength than bleached fabric. This may due to the acid degradation of cotton fabric causes from citric acid. The amount of citric acid and curing temperature affected on the tensile strength properties. It was found that the higher concentration of citric acid and curing temperature, the tensile strength would be decreased. But the wrinkle recovery angle was increased at higher acid concentration. That means the anticrease property of cotton fabric was better. The whiteness usually decreases after anticrease finish with citric acid. The catalyst will affect on the properties of cotton fabric. Because of the catalyst activates the crosslinking reaction between cotton fabric and citric acid, the higher amount of citric acid would be reacted in curing process.

For the results in Table 6 and 7 showed that the causticization process can improve the absorption of citric acid. The causticization before anticrease finish would increase tensile strength and whiteness of fabric when compared to only anticrease finish. And the effect of catalyst showed that increasing of catalyst did not effect on tensile strength and wrinkle recovery angle value.

Table 6 Properties of cotton fabric after causticization and anticrease finish with 8 % w/v of citric acid with 4% w/v of sodium hypophosphite

Temp (°C)	Time (Sec)	Tensile strength				Wrinkle recovery angle (°)	Whiteness	
		Warp		Weft				
		Load (N)	Extension (mm)	Load (N)	Extension (mm)		Before	After
Causticized fabric		375.3	57.3	390.1	48.3	165	108.7	-
160	60	361.6	44.4	364.1	46.8	172	107.9	110.1
160	90	359.6	44.1	365.7	46.8	174	105.4	109.9
160	120	359.4	44.9	365.3	46.6	173	111.0	108.6
170	60	359.4	44.9	362.9	45.0	174	109.1	107.2
170	90	362.0	44.3	367.5	47.1	174	108.7	107.9
170	120	359.4	44.3	362.5	46.1	175	111.0	107.8
180	60	360.7	45.0	363.7	46.3	173	106.3	109.2
180	90	362.2	45.8	364.1	45.7	174	108.9	107.1
180	120	360.0	44.6	366.4	46.1	175	109.6	107.1

Table 7 Properties of cotton fabric after causticization and anticrease finish with 8 % w/v of citric acid with 6% w/v of sodium hypophosphite

Temp (°C)	Time (Sec)	Tensile strength				Wrinkle recovery angle (°)	Whiteness	
		Warp		Weft				
		Load (N)	Extension (mm)	Load (N)	Extension (mm)		Before	After
Causticized fabric		375.3	57.3	390.1	48.3	165	108.7	-
160	60	361.3	45.1	361.1	45.0	174	111.7	108.7
160	90	362.2	45.7	363.3	45.6	175	110.6	109.8
160	120	361.0	45.0	356.6	45.7	175	109.2	109.0
170	60	358.8	43.8	365.3	45.5	177	110.1	107.6
170	90	359.9	44.7	368.1	45.7	179	108.2	108.7
170	120	361.9	45.8	367.7	45.8	175	108.0	108.7
180	60	361.8	46.8	366.1	45.6	176	109.3	112.0
180	90	361.8	45.3	364.9	45.2	179	106.7	106.0
180	120	361.5	45.1	363.3	45.3	179	109.1	106.6

4. Conclusion

From the result, they show that the anticrease fabric had lower tensile strength than untreated fabric. The anticrease finish with 6% w/v citric acid had higher tensile strength than 8 and 10 % w/v, respectively. And when concentration of acid, curing temperature and time were higher, wrinkle recovery angle would be increased. The effect of catalyst showed that anticrease finish using sodium hypophosphite as catalyst was higher wrinkle recovery angle and tensile strength than non-catalyst finish.

The causticization before anticrease finish would increase tensile strength and whiteness of fabric when compared to only anticrease finish. And the effect of catalyst showed that at low acid concentration, increasing of catalyst didn't have effect on tensile strength and wrinkle recovery angle value. At higher acid concentration, trend of tensile strength was decreased whereas wrinkle recovery angle increased and slightly effect on whiteness.

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