Finishing terry towel with softeners

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Processing terry towel is a great challenge. The dyed and finished towel should have excellent wash fastness, absorbtion and softness whilst the pile fibres must have the desired abrasion resistance. Processing must avoid both pressure on the pile surface, and degradation of the pile fibre, to get a proper pile height and performance. Similarly, machinery must avoid unnecessary abrasion and crack marks during scouring and bleaching.

Terry towel has to be quite soft, absorbent and if coloured, should have good fastness properties. The absorbency of the terry towel should be estimated in several ways-water uptake, sinking time, wicking height, etc. A number of companies offers various softeners for finishing terry towel fabrics. However, it is often the case that the application of a softener impairs the absorbency and the fastness properties of the coloured towel. It is also possible that the meterial is quite absorbent but the softness imparted does not show durability. Finally, a significant proportion of all towels are white. This whiteness has to be of high order and should be of permanent nature.

This article describes the results of experiments with four softeners: Sarasoft DP - a hydrophilic lubricant-cum-softener, light cream coloured paste, cationic in nature; Supercone-2300-an elastomeric softener nearly neutral in character; Terrysoft-478 - a nonionic new generation modified silicone softener; and Terrysoft-TC-a substantive, non-yellowing rewetting softener, cationic in nature. All softeners supplied by Texchem Ltd., Mumbai, India.

Each of the softeners was applied in a laboratory HT/HP machine at various temperatures - 40, 50 and 60°C at a concentration of 2% for 60 min. to establish the optimum temperature for application. Fabric was subsequently hydroextracted, dried and tested for water uptake, sinking time, bending lenght, wicking height and feel (Table 1). In each case the optimum temperature seems to be 40°C, as this corresponds to maximum water uptake, least bending lenght, (warp as well as weft) and the maximum wicking height.

The next step involved keeping the temperature fixed at 40°C whilst the treatment time and concentration of the softeners were varied as 20, 40, 60 min. and 2, 3 and 4%, respectively. Results are shown in Tables 2 - 5.

With Sarasoft-DP, a cationic softener, as concentration increases so the water uptake drastically reduces. However, the concentration of 2% seems to be the optimum one giving maximum water uptake at 2% concentration.

The maximum value of water uptake i.e. 11.65 gm/100 cm^2 (at 2% concentration and 60 min.) could be due to the negatively charged fabric utilising the substantivity offered by the cationic softener to a maximum extent when used in aqueous solution. Since, the fabric was found to be "not sinking" after the treatment of cationic softener, it is clear that the cationic softener is responsible for decreasing the absorbency of the fabric. Such things are likely to result when a softener contains a hydrophobic fatty acid part. The control sample gave water uptake of the level of 20.22 gm/100 cm^2, which reduced to 11.65 gm/100 cm^2 at 2% concentration of the softener treatment.

As far as bending length measurements were concerned, they were found to vary as the concentration and time varied and at 4% concentration these

Table 1: Optimisation of temperature

Time of Treatment : 60 min. **Concentration : 2%**
Machine : HTHP **L : M** :: 15 : 1, **pH** : 4-5

Softener	SARASOFT-DP			SUPERCONE-2300			TERRYSOFT-478			TERRYSOFT-TC		
Temperature, (°C)	40	50	60	40	50	60	40	50	60	40	50	60
Water uptake, (gm/100cm^2)	9.25	9.00	8.95	23.00	19.75	19.75	27.20	26.35	26.50	27.15	26.00	26.15
Sinking Time, (sec.)	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking	4.00	4.05	4.10	4.60	4.70	4.75
Bending Length, (cm) Warp	2.25	2.28	2.28	2.20	2.25	2.25	2.40	2.35	2.40	2.15	2.25	2.25
Weft	1.80	1.92	1.95	2.00	1.85	1.85	2.20	2.10	2.10	1.85	1.88	1.90
Wicking Height, (cm) After ( ) min. (1)	2.55	2.40	2.25	1.75	1.65	1.60	4.95	4.90	4.85	2.95	2.90	2.90
(2)	2.80	2.60	2.50	2.55	2.45	2.45	5.60	5.55	5.55	3.25	3.00	3.00
(5)	3.00	2.95	2.65	3.80	3.65	3.65	6.65	6.50	6.50	3.65	3.20	3.20
(10)	3.95	3.45	3.00	4.85	4.30	4.30	7.65	7.45	7.45	4.05	3.70	3.65
Whiteness, % (Hunter)	77.65	75.64	74.35	78.94	76.95	79.72	86.00	85.05	85.19	83.54	82.17	82.65
Yellowness, % (ASTM)	14.38	15.44	15.66	13.55	14.53	14.35	10.63	11.32	10.56	11.32	11.35	12.05

values were, in general, found to be the least. In the case of wicking height, it was found to be drastically reduced as a result of treatment with cationic softener, however, at the lowest concentration studied (2%), the wicking height was found to be maximum and that too, for the longest time of treatment. Wicking height was studied after 1, 2, 5 and 10 min. and the trend remained the same. At 3% and 4% concentration of the softener, wicking height was almost insignificant and one could see that the fabric sample turned out to be soft but not absorbant.

With increase in the concentration, results with respect to feel, analysed by subjective test were also found to be running parallel with those of the bending length. The whiteness of the control sample was maximum and the yellowness was minimum and it was found that on finishing, this whiteness did decrease; however maximum retention in whiteness was found in case of the sample treated with Sarasoft-DP for 60 min. at 2% concentration at 40°C.

In case of softener treatment, especially on terry towel fabrics, a lot of importance is given to absorbency and it is measured in terms of water uptake and more so in terms of wicking height. Softness naturally was found to be improved with increase in the concentration of the cationic softener; however, because of Sarasoft-DP being a lubricant-cum-softener, it did hamper the absorbency of the fabric and the best balance was achieved in the case of process parameters such as temperature 40°C, time 60 min. and concentration 2%.

Similar experiments with Supercone-2300, an elastomeric softener of microemulsion type, also found that a 2% concentration offered the maximum water uptake, wicking height and least bending length values were lowest at about 2% concentration. This may be attributed to microemulsion type of elastomeric softener, which penetrates in the fibre interstices, decreasing the friction between fibre and increasing its softness. Thus it could be considered as optimum one.

Among the three time periods studied, 40 min. time seemed to have been optimum one wherein the maximum improvement in the desirable properties was obtained. The whiteness index, 72.58% observed here was not the maximum, although it did exhibit minimum yellowness index. From all the results it was concluded that the optimum condition for supercone-2300 could be considered as, temperaure 40°C, time 40 min and concentration 2%.

With Terrysoft-478, a modified silicon type, the water uptake level in almost all

Table 2: Optimisation of treatment time and concentration

Softener : Sarasoft-DP
Machine : HTHP
Temperature : 40°C
L : M :: 15 : 1, **pH** : 4-5

Treatment Time	Control sample	20 minutes			40 minutes			60 minutes		
Softener %		**2%**	**3%**	**4%**	**2%**	**3%**	**4%**	**2%**	**3%**	**4%**
Water uptake, (gm/100cm²)	20.22	10.05	2.00	1.45	7.75	1.94	1.46	11.65	1.46	2.25
Sinking Time, (sec.)	5.05	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking
Bending Length, (cm) Warp	2.35	2.10	2.00	2.07	2.27	2.40	2.45	2.22	2.18	2.00
Weft	2.00	1.77	1.60	1.65	1.81	1.92	1.95	1.80	1.75	1.57
Wicking Height, (cm) After ( ) min. (1)	3.20	1.20	0.40	0.20	0.45	0.20	0.20	2.45	0.10	0.10
(2)	3.90	1.30	0.35	0.20	0.75	0.20	0.40	2.75	0.10	0.10
(5)	4.60	1.70	0.35	0.20	1.10	0.30	0.40	3.15	0.10	0.10
(10)	5.40	2.05	0.35	0.20	1.70	0.30	0.40	3.90	0.10	0.10
Feel, (Subjective Test)	2.5	2.75	3.00	3.25	2.58	2.75	3.16	2.30	2.90	3.25
Whiteness, % (Hunter)	84.13	76.95	74.80	72.49	76.55	74.47	75.61	77.42	77.13	77.38
Yellowness, % (ASTM)	4.52	14.53	15.66	17.14	14.56	15.55	15.47	14.28	13.75	14.00

Subjective test was done by 10 different person at different time average ratings are given in table: 1-poor, 2-average 3-fair, 4-good, 5-excellent.

Table 3: Optimisation of treatment time and concentration

Softener : Supercone-2300
Machine : HTHP
Temperature : 40°C
L : M :: 15 : 1, **pH** : 4-5

Treatment Time	Control sample	20 minutes			40 minutes			60 minutes		
Softener %		**2%**	**3%**	**4%**	**2%**	**3%**	**4%**	**2%**	**3%**	**4%**
Water uptake, (gm/100cm²)	20.22	19.75	12.40	11.43	24.45	18.10	6.80	23.82	18.57	22.90
Sinking Time, (sec.)	5.05	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking	Not sinking
Bending Length, (cm) Warp	2.35	2.13	2.40	2.40	2.13	2.00	2.50	2.20	2.20	2.50
Weft	2.00	1.70	1.92	1.96	1.68	1.62	2.01	1.73	1.76	2.00
Wicking Height, (cm) After ( ) min. (1)	3.20	2.05	0.90	0.90	3.05	1.45	0.90	1.70	1.85	1.45
(2)	3.90	3.05	2.05	1.70	4.00	2.10	1.45	2.50	3.05	2.50
(5)	4.60	4.15	4.00	3.10	5.45	3.20	2.90	3.90	4.75	4.20
(10)	5.40	4.80	5.60	4.50	6.55	4.10	4.05	4.50	5.80	5.60
Feel, (Subjective Test)	2.5	3.16	3.08	3.08	3.41	3.50	3.41	4.00	3.33	3.41
Whiteness, % (Hunter)	84.13	80.75	79.70	75.78	72.58	79.61	76.36	79.84	79.97	78.81
Yellowness, % (ASTM)	4.52	12.90	14.72	15.61	11.61	13.36	15.00	13.34	13.46	13.12

Table 4: Optimisation of treatment time and concentration

Softener : Terrysoft-478
Machine : HTHP
Temperature : 40°C
L : M :: 15 : 1, **pH** : 4-5

Treatment Time	Control sample	20 minutes			40 minutes			60 minutes		
Softener %		**2%**	**3%**	**4%**	**2%**	**3%**	**4%**	**2%**	**3%**	**4%**
Water uptake, (gm/100cm²)	20.22	26.30	26.00	26.35	25.60	26.65	26.19	26.90	27.60	27.66
Sinking Time, (sec.)	5.05	4.05	4.75	4.00	4.25	3.80	4.50	4.00	4.00	4.00
Bending Length, (cm) Warp	2.35	2.33	2.28	2.23	2.43	2.30	2.30	2.48	2.30	2.34
Weft	2.00	1.90	1.83	1.70	1.84	1.86	1.88	1.99	1.89	1.93
Wicking Height, (cm) After ( ) min. (1)	3.20	4.90	4.70	4.85	4.85	4.95	4.85	4.90	4.85	4.83
(2)	3.90	5.55	5.50	5.50	5.60	5.60	5.30	5.60	5.65	5.60
(5)	4.60	6.50	6.70	6.55	6.50	6.60	6.50	6.60	6.55	6.65
(10)	5.40	7.30	7.30	7.30	7.35	7.60	7.60	7.45	7.30	7.35
Feel, (Subjective Test)	2.5	2.00	2.00	2.15	2.65	2.88	2.10	2.50	2.55	2.89
Whiteness, % (Hunter)	84.13	83.71	83.06	82.45	85.19	85.22	84.70	85.02	83.94	82.45
Yellowness, % (ASTM)	4.52	10.30	11.33	11.38	10.52	10.63	10.50	10.32	11.02	11.56

Table 5: Optimisation of treatment time and concentration

Softener : Terrysoft-TC
Machine : HTHP
Temperature : 40°C
L : M :: 15 : 1, **pH** : 4-5

Treatment Time	Control sample	20 minutes			40 minutes			60 minutes		
Softener %		2%	3%	4%	2%	3%	4%	2%	3%	4%
Water uptake, (gm/100cm²)	20.22	27.07	25.40	25.36	26.10	25.40	25.07	26.50	27.05	26.01
Sinking Time, (sec.)	5.05	3.50	4.00	3.75	3.25	4.25	4.25	4.75	4.75	4.75
Bending Length, (cm) Warp	2.35	2.20	2.75	2.89	2.80	2.15	2.25	2.05	2.23	2.23
Weft	2.00	1.76	2.20	2.20	2.24	1.72	1.77	1.60	1.88	1.77
Wicking Height, (cm) After ( ) min. (1)	3.20	3.10	3.20	3.15	2.95	2.85	2.90	2.85	2.90	2.90
(2)	3.90	3.55	3.55	3.50	3.00	3.00	3.05	3.15	3.15	3.15
(5)	4.60	3.75	3.85	3.65	3.50	3.25	3.45	3.35	3.40	3.40
(10)	5.40	4.05	4.15	4.20	3.90	3.35	3.65	3.70	3.55	3.70
Feel, (Subjective Test)	2.3	3.85	3.16	3.50	3.50	3.66	3.41	3.00	3.33	3.41
Whiteness, % (Hunter)	84.13	82.02	80.44	79.50	83.84	82.17	79.90	83.56	82.24	75.25
Yellowness, % (ASTM)	4.52	11.77	12.38	13.68	10.59	11.46	12.76	11.29	11.59	15.08

the cases of the finished sample seemed to be higher than that of control. This is due to the fact that this finishing agent is basically hydrophilic silicon. Looking at the water uptake and wicking height values, a 40 min time of treatment and 3% concentration of the softener seemed to be optimum at 40°C temperature.

Sinking time in this case was also found to be lower than that of control, indicating thereby the improvement in the water absorbency of the fabric. The whiteness index at these conditions was also found to be maximum, so was the case with the subjective feel and the minimum bending length. In other words, from the point of view of softness, whiteness and absorbency, these conditions were the optimum.

In case of Terrysoft-TC, water uptake values of the finished sample were again found to be much higher than those of the control. Terrysoft-TC a cationic, non-yellowing, rewetting type, based on quaternary compounds gave good water absorbency. The sample after the treatment showed distinct decrease in sinking time. Hence, minimum sinking time of 3.5 sec., maximum water uptake level 27.07 gm/100 cm² and also highest wicking height were observed in the case of sample treated for 20 min. at 2% concentration at 40°C. The whiteness observed was also of a higher order, so was the case with the feel, measured by the subjective method and also indicated by bending length measurement.

Table 6 gives a summary of the performance properties of the softeners at respective optimised conditions. Taking into consideration, the wicking height and water uptake as most important properties as well as the whiteness of the terry towel fabric sample, it is clear from these results that Terrysoft-478 performs the best as it gave maximum wicking height as well as whiteness and the lowest yellowness values. From the point of view of finishing of terry towel fabric, where absorbency, softness, wicking height and whiteness are of utmost important, one could put these four softeners with respect to cumulative performance properties in following decreasing order of performance: Terrysoft-478 > Terrysoft-TC > Supercone-2300 > Sarasoft-DP.

Looking at the nature of these softeners, Terrysoft-478 seemed to be a hydrophilic new generation silicon softener, distinguished for its whiteness and also said to be non-yellowing type. The second in order of performance is Terrysoft-TC, which is also claimed to be non-yellowing rewetting softener based

Fig 2: Comparative performance properties of softeners (at optimised conditions)

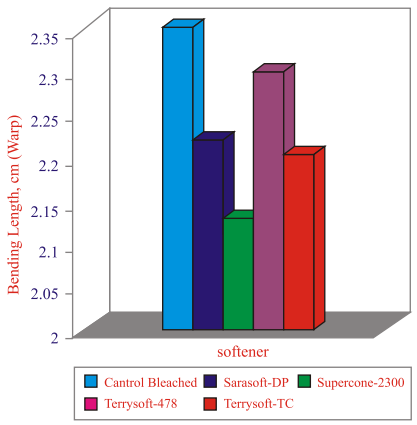

Fig 1: Comparative performance properties of softeners (at optimised conditions)

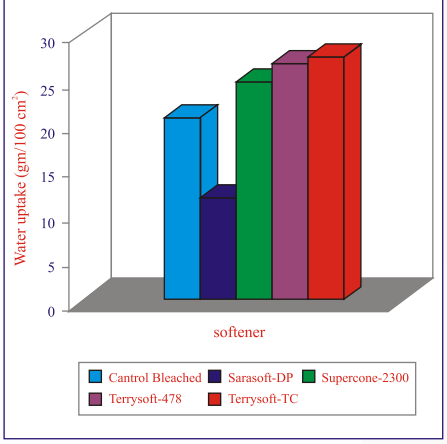

Table 6: Comparative performance properties of softeners (At respective optimised conditions)

Softener	Control Bleached	SARASOFT-DP	SUPERCONE-2300	TERRYSOFT-478	TERRYSOFT-TC
Optimised Conditions		(2%, 40°C, 60 min)	(2%, 40°C, 40 min)	(3%, 40°C, 40 min)	(2%, 40°C, 20 min)
Water uptake, (gm/100cm²)	20.22	11.65	24.45	26.65	27.07
Sinking Time, (sec.)	5.05	Not Sinking	Not Sinking	3.80	3.50
Bending Length, (cm) Warp	2.35	2.22	2.13	2.30	2.20
Weft	2.00	1.80	1.68	1.86	1.76
Wicking Height, (cm) After ( ) min. (1)	3.20	2.45	3.05	4.95	3.10
(2)	3.90	2.75	4.00	5.60	3.55
(5)	4.60	3.15	5.45	6.60	3.75
(10)	5.40	3.90	6.55	7.60	4.06
Feel, (Subjective Test)	2.50	2.30	3.41	2.88	2.85
Whiteness, % (Hunter)	84.13	77.42	72.58	85.22	82.02
Yellowness, % (ASTM)	4.52	14.28	11.61	10.63	11.77

on modified quaternary compounds, since it basically passessed highter wetting power. Samples treated with it gave the least sinking time, its water uptake was also higher than that of Terrysoft-478. However, its wicking height is not as good as that of Terrysoft-478, not only that, in that respect Supercone-2300 behaved much better.

In a terry towel fabric, there are two important factors; one is the absorbency of the fabric towards water and the second important factor is wicking height. If the terry towel fabric is highly absorbent but has poor wicking height, then the fabric is likely to pick up the water fast in the first wipe, but at the same time will get saturated with the water as transport of water from the capillary would not take place. If the wicking height is better, not only will the fabric absorb the water from the body but will transport it to the other end of the pile and terry towel as a whole will not appear as a wet cloth.

From this respect, Terrysoft-478 having the best wicking height with good degree of absorbency, sinking time and whiteness is said to be the best performing softener for terry towels.

The fabric finished with Terrysoft-TC is likely to give feeling of wet cloth because of the limited wicking height, although it did have the best water uptake and sinking time values.

In the case of Supercone-2300, an elastomeric softener of micro-emulsion type, it penetrates to the interstices of the fabric. However, in this case too, the wicking height did show slight improvement but this improvement was not sufficient to cause sinking to the sample even after 20 min. It is also to be noted that the softness observed in this sample in terms of bending length was found to be minimum and that may be attributed to micro-emulsion used for this elastomeric softener which pentrates into the fabric interstices and lowe the inter fibre friction. Wicking height in this case was quite appreciable (second order among the four studied).

Sarasoft-DP is a cationic softener supposedly hydrophilic lubricant. However, it brought down the water uptake values almost 50%. Being basically cationic in nature, it shown improved performance at 2%.

Table 7: Effect of different parameterson performance properties (pilot scale)

Time of Treatment : 30 min **Machine : Softflow** **Temperature :** 40°C **pH** : 4-5

Softener	Control sample	Sarasoft-DP		Supercone-2300		Terrysoft-478				Terrysoft-TC			
Concentration (%)		2%		2%		3%		4%		2%		3%	
Liquor : Material		10.1	15.1	10.1	15.1	10.1	15.1	10.1	15.1	10.1	15.1	10.1	15.1
Water uptake, (gm/100cm^2)	21.22	1.62	1.51	0.88	0.41	22.92	24.07	22.98	24.12	22.66	21.83	25.38	24.61
Sinking Time, (sec.)	5.05	Not sinking	Not sinking	Not sinking	Not sinking	3.80	4.00	4.75	4.85	4.20	4.20	4.00	4.20
Bending Length, (cm) Warp	2.35	1.90	1.95	1.95	1.95	2.15	2.20	2.25	2.20	2.20	2.10	2.05	2.00
Weft	1.90	1.80	1.92	1.95	2.00	1.85	1.85	2.20	2.10	1.75	1.85	1.95	1.85
Wicking Height, (cm) After ( ) min. (1)	3.20	0.30	0.10	0.10	0.10	4.85	4.75	4.65	4.55	3.81	3.60	3.05	3.05
(2)	3.90	0.90	0.60	0.30	0.30	5.50	5.35	5.60	5.40	4.65	4.50	3.35	3.25
(5)	4.60	1.50	1.00	0.90	0.70	6.55	6.45	6.25	6.15	5.20	4.95	3.75	3.60
(10)	5.40	2.00	1.40	1.10	1.00	7.50	7.30	7.00	6.90	5.95	5.60	4.10	4.00
Feel, (Subjective Test)	2.50	2.89	2.80	3.26	3.20	2.90	2.95	3.05	3.00	3.11	3.00	3.10	3.00
Whiteness, % (Hunter)	84.97	79.33	80.25	81.24	81.26	84.38	83.64	83.41	83.55	82.72	82.56	82.48	82.40
Yellowness, % (ASTM)	4.61	8.27	7.15	9.31	8.27	3.61	3.61	4.11	4.42	4.17	4.39	4.07	4.31

Fig 3: Comparative performance properties of softeners (at optimised conditions)

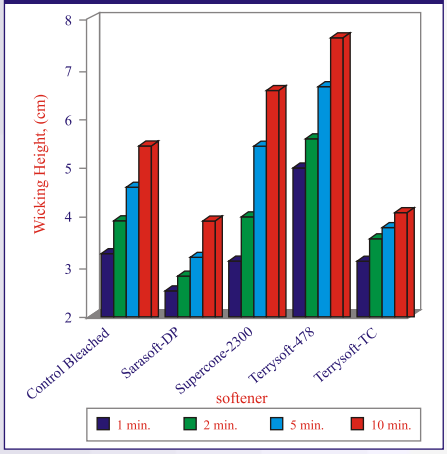

Fig 4: Comparative performance properties of softeners (at optimised conditions)

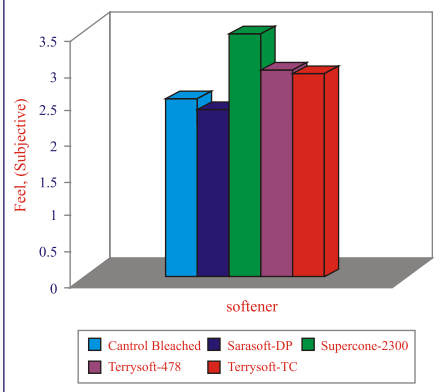

Table 8: Effect of different parameterson performance properties (pilot scale)

Time of Treatment : 30 min **Machine : Softflow** **Temperature :** 40°C **pH** : 4-5

Softener	Control sample	Sarasoft-DP		Supercone-2300		Terrysoft-478				Terrysoft-TC			
Concentration (%)		2%		2%		3%		4%		2%		3%	
Liquor : Marterial		10.1	15.1	10.1	15.1	10.1	15.1	10.1	15.1	10.1	15.1	10.1	15.1
Water uptake, (gm/100cm^2)	21.22	0.17	0.17	0.14	0.13	26.55	24.40	24.04	23.88	26.53	25.98	24.73	22.98
Sinking Time, (sec.)	5.05	Not Sinking	Not Sinking	Not Sinking	Not Sinking	4.00	4.20	4.80	5.00	4.20	4.25	4.60	4.60
Bending Length, (cm) Warp	2.35	2.05	1.95	2.05	1.85	2.10	2.05	1.95	2.25	2.10	2.00	2.05	1.95
Weft	1.90	1.80	1.92	1.95	2.00	1.85	1.85	2.20	2.10	1.10	1.85	1.88	1.90
Wicking Height, (cm) After ( ) min. (1)	3.20	0.20	0.10	0.10	0.10	4.80	4.85	4.65	4.50	2.90	2.85	2.85	2.95
(2)	3.90	0.50	0.20	0.30	0.20	5.40	5.40	5.50	5.45	3.10	3.10	3.10	3.15
(5)	4.60	0.90	0.40	0.30	0.20	6.35	6.35	6.20	6.20	3.50	3.45	3.35	3.40
(10)	5.40	1.10	0.60	0.30	0.30	7.30	7.25	7.00	6.95	3.95	3.65	3.70	3.65
Feel, (Subjective Test)	2.50	2.80	2.70	3.18	3.00	3.00	3.00	3.05	3.00	3.05	3.10	3.21	3.20
Whiteness, % (Hunter)	84.97	79.91	79.85	80.73	81.46	84.65	84.64	83.91	83.40	82.48	82.72	83.53	82.41
Yellowness, % (ASTM)	4.61	11.34	8.95	8.27	7.56	3.07	3.79	3.49	3.31	4.01	3.90	4.15	5.10