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Changes in the Dyeing Property of Tencel Blended Fabrics as Susceptible Functional Fiber through Chitosan Finishing

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키토산 가공에 의한 감성기능소재로서의 텐셀 혼방직물의 염색성 변화

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Abstract

Cationization is effective to complement the defects of Tencel blended fabrics by introducing new functions. For this purpose, we used chitosan, which is congenial to the human body, free of pollution, and easily reacted. Then, we compared it to the Tencel single fabrics. To perform such effective cationization, the fabrics were treated with chitosan after NaOH pretreatment and enzyme treatment thereof. After that, the fabrics were treated with a crosslinking agent and a softner. The dyeing property of the cationized Tencel blended fabrics and reactive dye, which is a type of anionic dye, show a high concentration in neutral salt and excellent repulsive power between the fabrics and the decreased dyes. The dyeing property of the chitosan treated fabrics represented better performances than that of untreated fabric in the lower concentration of neutral salt. Meanwhile, when it was dyed with certain acid dyes, the dyeing property of the chitosan treated fabrics showed better results due to the reaction of an amine group, which was introduced by chitosan treatment. Thus, the verification of the cationization of the Tencel blended fabrics was performed. The washing fastness of the Tencel blended fabrics showed a little bit better than that of the Tencel single fabric, and it represented a better performance in the dye with a reactive dye than that of an acid dye.

Key words: Tencel blended fabrics, Chitosan, Susceptible functional fiber, Environment-friendly Finishing, Change of dyeing properties; 텐셀 혼방직물, 키토산, 감성기능소재, 환경친화가공, 염색성 변화

I. Introduction

Tencel is a regenerated cellulosic fabric with comfort and aesthetics. It is an eco-friendly material that satisfies the functional and sensible aspects of the fabric in demand. It is also a suitable material for the 21st century, since it does not cause any pollution and can be easily dismantled in the process of manufacture or disuse(Sonobe, 1997). The production of the Tencel has just begun since 1992. From then on, however, its usage and market share have been rapidly increased. Although a level in technical supports for the development of Tencel still remains at pri-

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mary level, it has all merits of natural fabrics. Furthermore, it represents soft touch and good drapes when it fabricated as clothes. In particular, because it shows strong cohesive power, it can be used for blended fabrics with various types of other fabrics. Thus, the Tencel can be used as economic and desired ideal product. Therefore, it is possible to improve various characteristics of the Tencel, such as drapes, comfortableness, absorption, and strength, based on its unique properties. Because it can be used as various products from casual outfits jeans and shirts to elegant outfits, it can satisfy various demands of the customers(Ahn, 2002).

In recent years, a large part of researches on the Tencel have been focused on the development of fabric production and its properties(Moon et al., 1997), changes in the finishing and dyeing property by applying pretreatment(Lee et al., 1997), and changes in hands by using crosslinking(Shin & Son, 1999) as well as the surface modification by applying enzyme treatment(Leuz & Schurg, 1990). These researches showed that the effect of such enzyme treatment for the control of fibril are continued as a long-term period relatively and does not cause serious environmental problems. However, it requires very sensitive technical supports and shows difficulties in the set-up of its process standard for a resin finishing process in order to avoid the lose of the original characteristics of Tencel. Therefore, the cationization with a functional group is the most efficient way to keep the original characteristics of Tencel during the complementation of its weak points and development of a new function. It is believed this cationization of Tencel will allow it to be used as fashion materials.

As the tendency in a preferring human body-friendly process in the fiber finishing gets higher, the demand on process methods that can satisfy certain increases in susceptible aspect. As a result, it causes an increase in the textile finishing by chitosan treatment. Chitosan is a type of finishing agent that has the affinity to the human body and can satisfy the susceptible aspect. Furthermore, the reaction process of the chitosan is fairly simple and also can achieve the cationization of Tencel without causing any pollution(Kim et al., 1997). As the various functions of chitosan as the pleasant and sanitary processing material without causing any pollution, its usage represents significances not only in terms of increasing the function of end products, but in terms of recycling the wasted natural resources.

According to wide use in textile goods, the composite fabric goods like blended fabric and mixture fabric are more preferred to single fabric. Regarding the dyeing of fabrics, various colors can be applied to the composite fabric goods. Moreover, the composite fabric goods can be used to make high value-added goods after applying the treatment that changes the characteristics of fabric. Therefore, if the Tencel blended fabric that can be easily blended with other fabrics is used without losing its original characteristics while it satisfies the blended fabric characteristics and its susceptible aspect, the Tencel blended fabric can be used in much wider ranges of products than Tencel single products.

Thus, highly sensible materials have been developed by using chitosan since it represents its own characteristics, such as biodegradability, biocompatibility, antibacterial activity, deodorant activity, and moisturized effect(Ogura et al., 1980; Samuels, 1981). In addition, the change in the dyeing property of cationized fabrics are especially expected to anionic dyes. Reactive dye, a type of anionic ion, has negative electric charges in a solution in which the dyeing property decreased by the repulsive power between dyes and fabrics(Choi & Ryu, 1995). Thus, by using cationic chitosan, it is possible to increase the dyeing property by decreasing the repulsive power between dyes and cellulose fabrics and by increasing the direct action. According to the action of an amine group introduced by chitosan treatment, it is also possible to dye the materials with acid dyes.

In this research, Tencel blended fabrics, such as Tencel/Cotton and Tencel/Cotton/PET, were treated with chitosan, which is effective to complement the defects of Tencel blended fabrics as susceptible materials and to introduce new functions. To verify the cationization of the fabrics, it was investigated the changes in the dyeing property with the anionic dyes, reactive dye, and acid dye. It was compared to the Tencel single fabric. In order to guarantee more efficient chitosan treatment, NaOH was used for the pretreatment of the fabrics. Then, an enzyme that is a type of cellulase was used to control the fibril, and glutaraldehyde, which plays a role in a crosslinking agent, was used to increase the adhesion of chitosan. Finally, it was treated using a softener. The changes in the dyeing property with the anionic dyes of the chitosan treated fabrics were compared to the effects of the cationization of Tencel blended fabrics by chitosan treatment.

II. Experimental

1. Materials

The fabrics used in this experiment were Tencel/Cotton(55/45%) and Tencel/Cotton/PET(40/35/25%) compared to Tencel 100% fabric. Chitosan(M_w 3.0×10^5, DD 95%) was received from Chembio Co.. C. I. Reactive Red 120(Synozol red HE-3BN) and C. I. Acid Red 88(Acid roccellinr NS) were used as anionic dyes. Enzyme(Denimax 991L, activity 750 ACU/g, Novo Nordisk), crosslinking agent(glutaraldehyde, 25% sol'n, Yakuri), and softener(Excellsoft 90M2, T&C Trading Co.) were used as a level of grade I or higher.

2. Methods

1) Fibrillation and Chitosan Treatment in the Fabrics

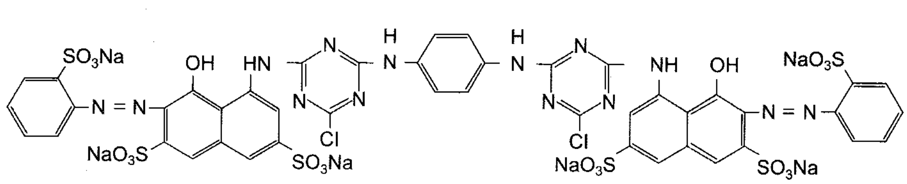
On the basis of the previous research(Park & Bae, 2006), the Tencel blended fabrics were processed in an 8% NaOH solution at room temperature for 2 minutes. It was washed and neutralized using a 5% (v/v) acetic acid aqueous solution. Also, the fabric was washed using distilled water, and dried naturally. Denimax, a sort of cellulase, was used for the enzyme treatment with the liquor ratio of 30:1, pH 5, and 3g/*l* at 55°C for 120minutes under the constant temperature in a shaking incubator(SI-600R, Jeio Tech.). To restrain the enzyme activity, the fabric was treated at 80°C for 15 minutes with 2g/*l* of Na_2CO_3 (higher than pH 10). Then, the fabric was washed and naturally dried. In this research, the control sample plays a role in an enzyme treated fabric to perform a comparison with chitosan treated fabric.

The concentration of the chitosan was set to 0.5%(w/v) in 1%(v/v) acetic acid. The fabric was soaked in a chitosan solution for 10 minutes and went through mangle with a set-up of the wet pick up for 80±2%. Furthermore, it was soaked in an 1% of NaOH solution for 5 minutes and washed using running water. In addition, it was dried at 60°C for 90 minutes and at 100°C for 3 minutes afterwards. To adhere chitosan to the fabric, the fabric was treated in 0.1mol/*l* of glutaraldehyde for 20 minutes with the liquor ratio of 50:1. Also, it was dried at 80°C for 5 minutes and at 135°C for 3 minutes, and then it was treated in an 1%(o.w.f) of softener and dried naturally.

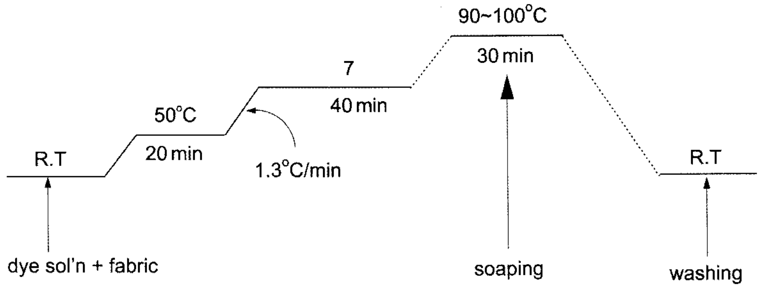
2) Dyeing with Reactive Dye

In order to investigate the dyeing property of the chitosan treated fabric with a reactive dye, C. I. Reactive Red 120(R120), a type of monochlorotriazine(MCT) was used and the structure of dye is shown in <Scheme 1>.

The dyeing solution was a 2%(o.w.f) of reactive dye with the liquor ratio of 50:1. It has no alkali, and then we changed Na_2SO_4 to 0~30g/*l* and reviewed the impact of neutral salt. Also, we compared the dyeing property because of the pH change of the dyeing solution after adding a 2%(o.w.f) of reactive dye, and 10g/*l* of Na_2SO_4 as a neutral salt. The dyeing process was conducted by <Scheme 2>. After applying



Scheme 1. Chemical structure of C. I. Reactive Red 120(R120).



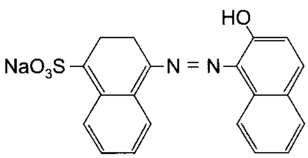
Scheme 2. Dyeing diagram of reactive dye.

a soaking process, the fabric was washed twice and dried naturally. Regarding the control of pH, the dyeing solutions for pH 3.6 and 4.5 were configured as a buffering solution that was composited by CH_3COOH and CH_3COONa. In the case of pH 7, the dyeing solution was configured as a buffering solution that was composited by KH_2PO_4 and NaOH. Also, the dyeing solution was configured as a buffering solution for pH 9 that was composited by Borax and HCl. In addition, for pH 10.8, the dyeing solution was configured as a buffering solution that was composited by Borax and NaOH(Perrin & Dempsey, 1979).

3) Dyeing with Acid Dye

In order to investigate the cationization of the chitosan treated fabric, it was examined the dyeing property of the fabrics with an acid dye, the purified C.I. Acid Red 88 was used and the structure of the acid as shown in <Scheme 3>.

The dyeing solution was a 2%(o.w.f) of acid dye, 15%(o.w.f) of Na_2SO_4, 3%(o.w.f) of H_2SO_4, and 5%(o.w.f) of CH_3COOH with the liquor ratio of 50:1. It was processed according to <Scheme 4>. After applying a soaking stage, it was washed twice and dried naturally.



Scheme 3. Chemical structure of C. I. Acid Red 88.

4) Evaluation of Dyeing Property

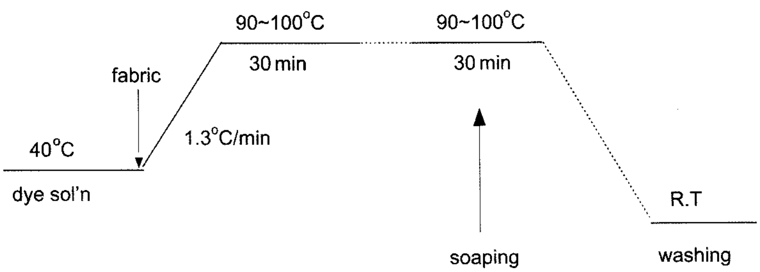
In order to exemine the dyeing property of the chitosan treated fabric, the surface reflectance at the maximum optical density was measured by using a color difference meter(Minolta Sepctrophotometer, CM-3600d), and was evaluated the dyeing property via K/S values of the Tencel blended fabrics.

$$K/S = \frac{(1-R)^2}{2R}$$

K: absorption coefficient of dyed samples
S: sacttering coefficient of dyed samples
R: spectral reflectance

5) Color Fastness in Washing

In order to examine the color fastness in washing



Scheme 4. Dyeing diagram of acid dye.

of the dyed samples, it was tested by using laundry testing machine(Launder-O-Meter, Daiei Kagaku Seiki MFG. Co., Japan) with the test method of KS K 0430-2001(A-1). Then it was measured the color difference of dyed fabrics by looking at the discoloration of the dyed fabric and the contamination level of the attached white fabric. With these results, the color difference was calculated in accordance with the following formula.

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

$$\Delta L^* = L_1 - L_2,\ \Delta a^* = a_1 - b_2,\ \Delta b^* = b_1 - b_2$$

L_1, a_1, b_1: value of CIE Lab before washing
L_2, a_2, b_2: value of CIE Lab after washing

III. Results and Discussion

For Tencel, dye that can be used to all types of cellulose fabrics including cotton, flax, and rayon can be also used. It showed no particular problems when direct, sulfur, bat, and reactive dyes were directly applied. However, the usage of reactive dye significantly increased due to its bright and wide ranged color choices as well as its easiness to use and high binding energy between fabrics and dyes(Stewart, 1989). Thus, the dyeing property of the chitosan treated Tencel blended fabric with a reactive and an acid dye were examined in this study.

1) Dyeing Property by using a Reactive Dye

Colors in a reactive dye are clear and that show an easy dyeing process. It also has high fastness and rich colors when it is used. Thus, it has been widely used compared to other dyes as cellulose fabrics because of its economic advantages. However, it has negative electric charges in a solution because the cellulose fabric has negative electric charges; electrolyte is needed to be added to aid the absorption of the dye. The added alkali to help the absorption of the dye, excels the hydrolysis of the dye, but this hydrolyzed dye causes serious environmental pollution when it is dumped in wastewater(Lewis & Lei, 1989; Vigo, 1994). Also, when using a reactive dye with a large amount of neutral salt and alkali, it requires high cost and takes quite a lot time to wash. Further, it can be easily stained by using a hydrolyzed dye and represents a possibility in the detachment of absorbed dyes. By introducing an amine group of the chitosan, however, the fabric will be cationized by the chemical attraction to the reactive dye by the replaced nucleophilic characteristic(Yuk & Bae, 2002). It is evident that the dyeing property would be outstanding even when the condition is determined as a neutral manner.

<Fig. 1> shows the dyeing property of the Tencel blended fabric dyed with a reactive dye and sodium surfate, which is a type of neutral salt with various concentration without any alkali. In <Fig. 1>, the dyeing properties of the untreated and treated fabrics were increased according to the increase in the concentration of the neutral salt. However, the chitosan treated fabric showed high dyeing property even when the neutral salt concentration was low.

Moreover, the K/S value of the chitosan treated fabric showed higher levels with a touch of neutral salt than the untreated fabric with 30g/*l* of neutral salt addition. Thus, it was proved that the dyeing property of the chitosan treated fabric increased by the chitosan treatment. Therefore, when the chitosan treated fabric is dyed with a reactive dye with no alkali and a minimum level of neutral salt, it is expected to bring an increase in the dyeing property and in a washing process that will eventually represent energy saving and wastewater from the dyeing process.

The dyeing mechanism of the reactive dye for the fabric according to the catalyst reaction of the added alkali is a type of nucleophilic displacement and nucleophilic addition reaction. The nucleophilic displacement reaction is formed as an ether bond between the dye and the hydroxyl group of the cellulous fiber. The nucleophilic addition reaction is formed as an ether bond in which the dye is changed as a vinylsulfon derivative, and then it is added to the hydroxyl group of the cellulous fiber(Sung et al., 1997). The reactive dye used in this study is the C.I. Reactive Red 120(R120) of the MCT Type, which has two reaction groups. Its chromogen is monocholorotriamine(MCT). The dyeing mechanism is processed

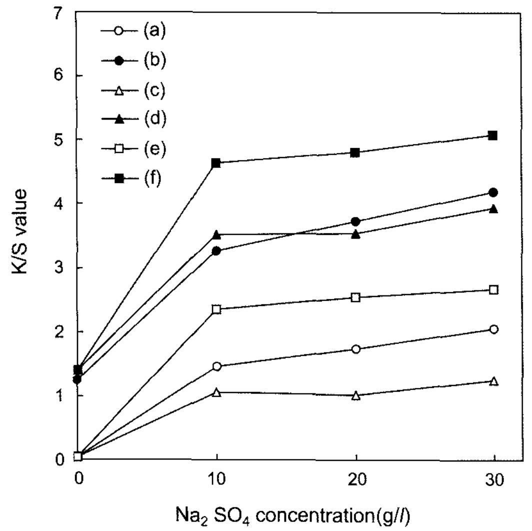


Fig. 1. Effect of salt concentration on the K/S value of the fabrics treated with chitosan(dyeing condition : C. I. Reactive Red 120, 2%(o.w.f), 70°C).
(a) control, (b) chitosan-Tencel/Cotton
(c) control, (d) chitosan-Tencel/Cotton/PET
(e) control, (f) chitosan-Tencel

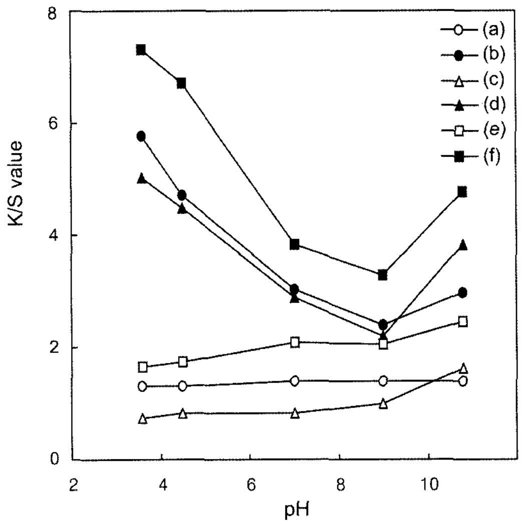


Fig. 2. Effect of pH on the K/S value of the fabrics treated with chitosan(dyeing condition: C. I. Reactive Red 120, 2%(o.w.f), Na_2SO_4 10g/l, 70°C).
(a) control, (b) chitosan-Tencel/Cotton
(c) control, (d) chitosan-Tencel/Cotton/PET
(e) control, (f) chitosan-Tencel

by the nucleophilic displacement reaction. When there are many reactive dyes, the reactive dye creates a stronger ionic bond and increases the dyeing property because it makes a covalent bond after getting close to the samples(Lee et al., 1996).

When a reactive dye is used, the added alkali places a critical role in the hydrolysis of the dye that represents a huge impact on the dyeing property, and the pH of the dyeing solution becomes a very important factor(Sung et al., 1997). Thus, the changes in the dyeing property according to the change in the pH values of the dyeing solution were investigated.

<Fig. 2> shows the dyeing property of the chitosan treated fabric caused by the change in pH values when the neutral salt concentration is fixed to 10*g/l*. According to the results of this test, the dyeing property of the untreated fabric increased according to the increase in the pH of the dyeing solution. On the other hand, the dyeing property of the chitosan treated fabric showed the best dyeing property around pH 4 and decreased according to the increase in the pH of the dyeing solution. It showed the lowest dyeing property around pH 9, and the dyeing property increased just a bit according to the increase in the pH. In all pH levels, the dyeing property of the chitosan treated fabric showed higher levels than that of the untreated fabric, and the dyeing property of the Tencel blended fabric represented higher levels than that of the Tencel single fabric. It was considered that it is due to the fact that the structure of the Tencel itself is strong. However, it showed a large scale of amorphous region where the dye can be absorbed. As shown in the above tests, the reason that the chitosan treated fabric has better dyeing property in the acid dyebath is due to the amine group of chitosan introduced into the cationized Tencel blended fabric and is activated as a positive electric charge that is combined with the dye by the ionic bond. However, when the pH in the solution represent high values by adding alkali, the dye shows a hydrolysis reaction with water, besides the reaction to the fabric in which the dye loses its activation. That is why the dyeing property is decreased(Lewis & Lei, 1989).

2) Dyeing Property by using an Acid Dye

Cellulose fabric and acid dye, which is an anionic

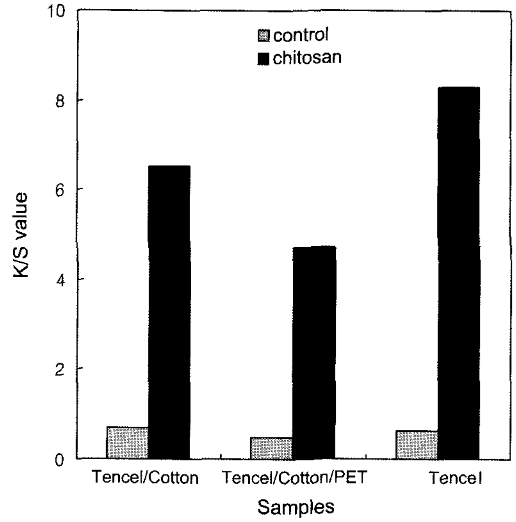


Fig. 3. Effect of chitosan treatment on the K/S value of the fabrics(dyeing condition: C. I. Acid Red 88, 2%(o.w.f), 95°C).

dye, have negative electric charges in a solution. Thus, because of the mutual repulsive power, the fabric is scarcely dyed. However, if the fabric is treated with chitosan, the surface electric charges will be changed as positive electric charges by introducing a positive ionic amine group. Now, the fabric can be dyed with an acid dye caused by the electrical attraction. Thus, in order to verify the cationization of the Tencel blended fabric, it is necessary to examine the dyeing property of the acid dye.

<Fig. 3> shows the dyeing property of the chitosan treated fabric as K/S values. For the untreated fabric, the dyeing property of the fabric exhibted very low levels compared to that of the chitosan treated fabric that proves the fabric has been cationized. In this case, an increase in the ratio of K/S values by the chitosan treatment showed differences up to the specific blend ratio of cellulose fabric. By comparing it to cotton, the Tencel shows a close inner structure and well developed orientation. Because of these factors, the absorption of the dye is not as easy as other cellulose fabrics, After applying a chitosan treatment process, however, the affinity to an acid dye represents an increase significantly. Also, for the Tencel/Cotton/PET blended fabric, the dyeing property of the fabric came out lower levels than the other two test fabrics due to the existence of polyester. However, after chitosan treatment, the dyeing property with an acid dye increased and showed almost same as the other two test fabrics. It means that the introduction of an amine group by chitosan treatment increased the affinity between the Tencel blended fabric and the acid dye.

The color differences of the Tencel blended fabric before and after dyed with a reactive dye and an acid dye are shown in <Table 1>. According to <Table 1>, the color difference of the fabric showed a large scale

Table 1. Color differences of reactive and acid dye on the fabrics treated with chitosan

Dye	Samples \ Color values		L*	a*	b*	ΔE*ab
Reactive dye	T/C	control	67.88	42.02	-4.25	21.31
		chitosan	51.27	54.14	1.36	
	T/C/P	control	72.44	35.17	-4.80	27.87
		chitosan	51.06	51.85	1.65	
	T	control	64.53	45.93	-4.38	18.30
		chitosan	49.97	54.60	2.54	
Acid dye	T/C	control	71.68	26.56	1.50	31.86
		chitosan	43.59	38.97	9.98	
	T/C/P	control	75.81	23.05	0.03	32.79
		chitosan	45.98	34.28	7.72	
	T	control	73.12	25.40	-0.64	37.51
		chitosan	39.68	38.28	10.45	

in the acid dye compared to that of the reactive dye. It is evident that the dyeing property of the untreated fabric shows a very low level when it comes to an acid dye. In the case of the use of a reactive dye, the color difference of the Tencel blended fabric represented higher levels than that of the Tencel single fabric.

3) Color Fastness in Washing

In order to examine the color fastness in washing for the chitosan treated fabric, the color difference of the samples before and after dyed with reactive and acid dyes are shown in <Table 2>. According to <Table 2>, the color fastness in washing showed higher levels when the reactive dye was used than that of the use of the acid dye. It seems that the color fastness in washing for the reactive acid shows a high level because the acid dye is dyed through electrical attraction due to the introduction of a cationic amine group when the reactive dye is absorbed to the fabric by the necleophilic displacement reaction that forms a covalent bond through the ionic bond occurred by a functional group.

The fastness of the attached white fabric demonstrated a level of 4-5 when it was dyed with a reactive dye. Also, the fastness of the attached white

Table 2. Color fastness to washing of reactive and acid dye on the fabrics treated with chitosan

Dye	Samples	Color values	washing	L*	a*	b*	ΔE*ab	wash fastness	
								A	S
Reactive dye	T/C	control	before	67.88	42.02	-4.25	1.46	4-5	4-5
			after	68.24	41.66	-5.62			
		chitosan	before	51.31	54.14	1.25	4.61	4	4
			after	54.33	54.15	-0.54			
	T/C/P	control	before	72.44	35.17	-4.80	4.61	4	4
			after	74.74	31.49	-6.34			
		chitosan	before	50.74	52.17	1.99	3.37	4	4
			after	52.97	50.13	0.49			
	T	control	before	64.53	45.93	-4.38	1.41	4-5	4-5
			after	65.08	45.30	-5.51			
		chitosan	before	49.81	54.57	2.51	3.07	4	4
			after	51.70	52.85	0.82			
Acid dye	T/C	control	before	71.68	26.56	1.50	11.63	2-3	2
			after	79.98	20.23	-3.63			
		chitosan	before	44.05	38.95	9.79	15.47	2	1
			after	55.95	29.80	6.09			
	T/C/P	control	before	75.81	23.05	0.03	9.00	3	2-3
			after	81.94	16.90	-2.33			
		chitosan	before	45.74	34.26	7.75	13.48	2-3	1
			after	57.23	27.72	5.14			
	T	control	before	73.12	25.40	-0.64	17.25	2	2-3
			after	84.29	12.74	-4.20			
		chitosan	before	39.17	38.54	10.54	14.36	2	1
			after	51.92	33.23	6.58			

A : alteration of shade
S : staining of adjacent material

fabric showed a level of 1-2 when it was dyed with an acid dye because the absorbed dye came off and contaminated the white fabric in the course of the washing. The differences of the color fastness in washing among the fabrics were insignificant. However, the color fastness in washing showed high levels when the reactive dye was used than that of the use of the acid dye.

IV. Conclusions

Tencel blended fabrics, such as Tencel/Cotton and Tencel/Cotton/PET, were treated with chitosan, which is effective to complement the defects of Tencel blended fabrics as susceptible material and to introduce new function. To verify the cationization of fabrics, the changes in the dyeing property with the anionic dyes, a reactive, and an acid dye were investigated. The results were summarized as follows:

1. In both cases of the untreated fabric and the chitosan treated fabric, their dyeing property with a reactive dye increased according to the increase in the concentration of the neutral salt. However, the chitosan treated fabric showed a high level of dyeing properties even though the neutral salt concentration showed a low value. Moreover, the K/S value of the chitosan treated fabric showed higher levels with a touch of neutral salt than the untreated fabric with 30g/*l* of neutral salt addition. Therefore, when the chitosan treated fabric is dyed with a reactive dye with no alkali and a minimum level of neutral salt, it is expected to bring an increase in the dyeing property and in a washing process that will eventually represent energy saving and wastewater from the dyeing process.

2. The dyeing property with a reactive dye in the chitosan treated fabric showed its best dyeing property around pH 4 whereas the dyeing property decreased just a bit according to the increase in pH values. In all pH levels, the dyeing property of the chitosan treated fabric showed higher levels than that of the untreated fabric, and the dyeing property of the Tencel blended fabric represented higher levels than that of the Tencel single fabric. By introducing an amine group of the chitosan, however, the fabric will be cationized by the chemical attraction to the reactive dye by the replaced nucleophilic characteristic. Also, it is evident that the dyeing property would be outstanding even when the condition is determined as a neutral manner.

3. The dyeing property of the untreated fabric with an acid dye was very insignificant during the treatment with chitosan in which its affinity for the acid dye was enhanced due to the introduction of an amine group. In addition, it showed that the dyeing property of the Tencel single fabric more increased than that of the Tencel blended fabric. This is due to the fact that the chitosan treatment occurred Tencel itself to perform greater affinity for the acid dye than cotton and polyester. In addition, the color fastness in washing showed high levels when the reactive dye was used than that of the use of the acid dye.

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요 약

텐셀 혼방직물의 단점을 보완하면서 새로운 관능기를 도입하기 위해서는 캐티온화가 효과적이다. 이를 위해 인체 친화성이 있고 공해를 유발하지 않으며 반응이 용이한 키토산을 처리하였으며, 이에 의한 캐티온화를 확인하기 위하여 음이온성 염료에 대한 염색성 변화를 살펴보았다. 먼저, 반응성 염료와의 염색성은 낮은 중성염의 농도에서도 키토산 처리 시료의 염색성이 우수하게 나타나 반응성 염료에 대한 염색 효율이 증대되었다. 이는 키토산의 아민기 도입으로 텐셀 혼방직물이 캐티온화되어 섬유에 치환된 친핵성기에 의해 반응성 염료에 대한 친화력이 향상됨으로서 중성이하의 조건에서도 염색성이 우수하게 나타난 것이다. 한편, 키토산 처리로 도입된 아민기의 작용으로 산성 염료와 친화력이 거의 없는 텐셀 혼방직물의 산성 염료에 대한 염색성이 크게 향상되었다. 또한 키토산 처리로 인하여 텐셀 혼방직물은 반응성 염료와의 친화력이 더 좋아졌고, 텐셀 단일직물의 경우 산성 염료와의 친화력이 더 좋아졌으며, 산성 염료보다 반응성 염료로 염색시 세탁견뢰도가 더 우수하였다.