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The Color Fading and Staining of Fabrics by Drum-type Washer

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드럼세탁기 사용시 세탁물의 변·퇴색 방지에 관한 연구

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Abstract

To study the effect of a washing machine with silver nano technology on its detergency, the discoloring of the dyed clothes and the staining of standards adjacent fabrics were examined. As the laundry specimen, cotton fabric dyed with reactive dyes and Polyester fabric dyed with disperse dyes were chosen; and as the adjacent fabrics, undyed cotton, polyester and nylon fabrics were chosen. The colorfastness was evaluated after washing under conditions that those washing temperature, liquor ratio, detergency concentration and the type of water were varied. When the clothes were washed with the tap water contains silver ion, the deposition of silver compounds into the washed clothes was measured. As a results, after the washing in the various conditions, discoloring of the dyed clothes was not intense. The higher the washing temperature and the lower the liquor ratio, the larger the staining appeared on the white fabrics; especially for the white nylon fabrics. The concentration of detergent and the type of water affected hardly the colorfastness. After the repeated washing with the water contains silver, whiteness of the cotton and the nylon fabrics were lower than the result after the washing with the tap water, and a quantity of silver ions was found on the washed clothes.

Key wards: Drum-type washing machine, Discoloring, Staining, Silver ion; 드럼타입세탁기, 변퇴색, 오염, 은이온

I. Introduction

In comparison with the washing machine with the agitator and the impeller which is popular in America and Asia, the rotary drum-type washing machine is generally used in Europe and the middle east because of the high water efficiency, easy use of hot water and the fact that it gives clothes less damage and entanglement(Kim, 2000). For these properties, despite of the longer washing hours, the market share of rotary drum-type washing machine are increasing in Korea. But with the spread of this type washing machine, problems such as discoloring of the dyed clothes and staining on the white clothes were arouse.

The discoloring of dyed clothes and the staining on the white clothes can be resulted from the bond of dye molecules with detached fibers during the washing process and dispersed in washing bath(Yang & Rhee, 1998). These problem might become prominent under the washing condition as follows: low

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liquor ratio, high temperature, long washing time. It is possible that the metal ions in water associate with the detached dye molecules and the components of detergents to provoke discoloring and staining.

For a long time, silver has known to be antibiosis and have a sterilizing ability(Oh, 2006). Antibiotic and sterilizing effects of silver are produced in two ways, from solid silver and from silver ions. The oxygen molecules can dissolve into metal silver, because the silver molecules in a solid phase have a similar atomic distance to oxygen molecules. Therefore, silver can contain oxygen as much as 10 times of its own volume, and the oxygen molecules contained in the metal silver can be degraded to oxygen atoms by silver itself. It has been known that oxygen atoms oxidize and kill the bacteria.

Most of the virus and the bacteria that are found up to now, have the materials that can strongly bind with the silver ion(Lee et al., 2005). When the silver ions meet the bacteria or virus, they strongly combine with the latter to produce a compound and this compound kills the bacteria and the virus that are hindering the delivery of hydrogen to metabolize cells (Baker et al., 2005). Thus, silver nano technology has wide range of application to such as nursing bottles, food container, and electric home appliances.

The application of the silver nano technology to a washing machine is available in two methods; first, coat the drum of the washing machine with silver, second, produce the silver ions by electrolysis of 99.9% silver metal.

However, silver ions in the washing water can bind to a fiber or a detached dye molecules, or an anion in the detergent solution, and or chemically produce a silver compound by corrosion and cause a deposition of silver compounds on the clothes during the washing process.

In this study, we have tested the washing condition of a drum-type washing machine, examined the discoloring and the staining of clothes, investigated the possibility of discoloring that the silver ion can cause. As the washing conditions, liquor ratio, washing temperature, detergent concentration, and the type of washing water were varied and colorfastness after the washing were evaluated. To check the deposition of silver compound on the clothes washed with the water contains silver ion, a quantitative analysis were implemented.

II. Experimental

1. Materials

Test fabrics based on KS K ISO 105 were used for dyed fabrics and the adjacent fabrics. The characteristics of fabrics are as summarized in <Table 1>.

The dyes were supplied by Oh-Young Chemicals. As a Reactive dyes, Sunfix Supra Orange S2R(C.I. Reactive orange 127: RO), Sunzol Brill Blue RS (C.I. Reactive blue 19: RB), as a disperse dyes, Suncron Blue R-DE(C.I. disperse blue: DB), Suncron Red F3BS 150(C.I. disperse red 343: DR) were chosen in the form of commercials without any purification.

A commercial detergent, "Perfect" for the drum-type washing machine(Ae-kyoung), a neutral detergent (wool-shampoo, Ae-kyoung), Sodium Carbonate, Sodium Sulfate, Sodium Hydroxide, and Sodium Hydrosulfite were also used.

2. Methods

1) Dyeing

Reactive dyes: Cotton fabric specimens were dyed in a bath which contains the 3% dye owf, Na_2CO_3

Table 1. Characteristics of test fabrics

	yarn count (tex)		density (warp × filling/cm)	weight (g/m^2)	thickness (mm)
	warp	filling			
cotton	16.5	14	35 × 31	115 ± 5	0.23
polyester	7.5/2	20	23.5 × 20.5	130 ± 5	0.32
nylon	10/2	20	17.5 × 20	130 ± 5	0.34

20g/L, and Na_2SO_4 50g/L at 60°C and place for 70 minutes; then soaped with a neutral detergent solution at 90°C during 10 minutes, and then dried at a room temperature.

Disperse dyes: Polyester fabrics were dyed in a bath includes dye 3% owf at 130°C, placed for 60 minutes and cooled down to 80°C still in the dye bath; then dried after the reduction cleaning.

2) Washing

Washings were carried by Launder-o-meter and commercial drum-type washing machine produced by SilverCare technology. Most of the tests were carried out by Launder-o-meter, which has a similar mechanic system to a drum type washing machine, because it is difficult to control the washing conditions such as temperature, the liquor ratio and the component of water by commercial washing machine precisely.

As the washing water, distilled water, tap water and water with silver ions were prepared. The water with the silver ions was obtained from a commercial drum-type washing machine produced by SilverCare technology: the machine was operated for 3 minutes, then water was collected.

Below is the description of test equipments: Launder-o-meter(Model no. LM-8, Toyo Rika Instruments Inc.); the standard adjacent fabrics were attached on the both side of dyed clothes, and these samples were washed under the prescribed condition, rinsed and dried. Size of samples were 4cm×10 cm.

Drum-type washing machine produced by silver nano technology("Hauzen" SEW-5HW164A, Samsung): 2 x two pieces of fabrics reactive dyed and two pieces of disperse dyed fabrics of a same size(30×30cm), total 8 pieces of dyed fabrics were attached to the standard adjacent fabrics made of cotton, polyester and nylon of a same size. Total 3 kgs of clothes including a dummy load was put to the designated washing course and dried.

3) Colorfastness to Washing

In case of the staining into the adjacent fabrics, the color difference between the untreated fabrics and the standard adjacent fabrics after the washing, were measured by Spectrophotometer(CM-2600d, Minolta). And the degree of staining were evaluated by <Table 2> according to ISO 105.

Table 2. Staining-Scale-Rating(from ISO 105/A04)

calculated SSR	Reported SSR
5.00 to 4.75	5
4.74 to 4.25	4-5
4.24 to 3.75	4
3.74 to 3.25	3-5
3.24 to 2.75	3
2.74 to 2.25	2-3
2.24 to 1.75	2
1.74 to 1.25	1-2
<1.25	1

In case of the discoloring of the dyed fabrics, after and before the washing, the Hunter's a and b value of the dyed fabrics were measured by Spectrophotometer(CM-2600d, Minolta).

III. Results and Discussion

1. Effect of the Washing Temperature on the Staining on the Adjacent Fabrics

<Fig. 1> shows the degree of staining on the adjacent fabrics from the dyed fabrics by washing temperature.

In case of washing at 40°C, staining on the adjacent fabrics from reactive and disperse dyes did not appear. The higher washing temperature, the higher the tendency of staining was shown to the adjacent fabrics.

After washing the clothes dyed with reactive dyes, the amount of stains on the adjacent cotton fabrics has increased following the increase in the washing temperature. However, the adjacent polyester fabrics were not affected. In case of the adjacent nylon fabrics, the degree of staining showed a difference by dyes; RO, which showed severe staining on cotton, did not provoked much staining, and RB showed heavier staining tendency by the increasement in the washing temperature.

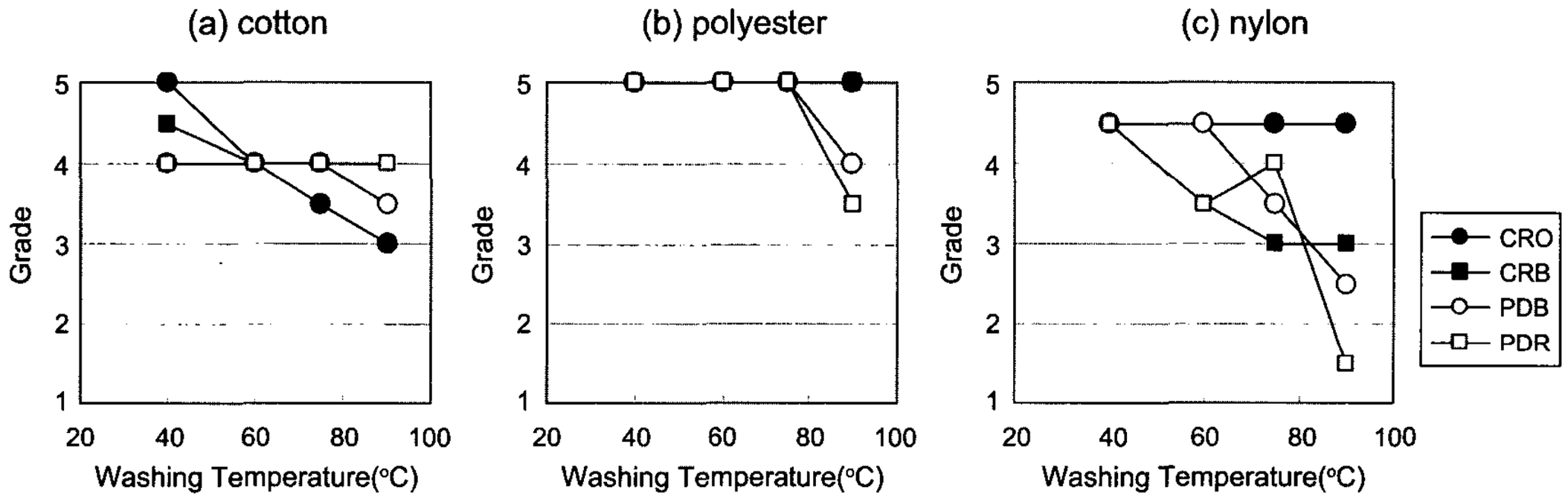
In case of the clothes dyed with disperse dyes, the

adjacent cotton and the polyester fabrics were hardly stained until the washing temperature increased up to 75°C, and slightly start to get stained at 90°C. The adjacent nylon fabrics were stained differently by dyes. And when the washing temperature was increased, the staining on the nylon fabrics has increased more than on the cotton and the polyester fabrics.

The differences among staining on the cotton, polyester and nylon fabrics were examined as well; the staining on the cotton fabrics from reactive dyes were more severe than on the polyester fabrics, and the staining on the cotton fabrics from disperse dyes were less severe than on the polyesters. In addition, the staining was the most prominent in the nylon fabrics. It is possibly because nylon can have both anion and cation in the water, and is more hydrophobic than natural fibers, and has more allowance in the internal structure than polyester(Burkinshaw & Son, 2008; Kim, 2002) so that the dye molecules eluted during the washing process can easily penetrates into nylon fibers.

2. Effect of the Liquor Ratio on the Staining on the Adjacent Fabrics

<Table 3> shows the effect of the liquor ratio on the colorfastness to washing. To make the simulation similar to commercial washing machines, the water-detergent ratio was set to 50:1 for the impeller-type



CRO: cotton fabric dyed with RO
CRB: cotton fabric dyed with RB
PDB: polyester fabric dyed with DB
PDR: polyester fabric dyed with DR

Fig. 1. The effect of washing temperature on staining on the standard adjacent fabrics(washing machine: Launder-o-meter).

Table 3. Effect of the liquor ratio on the staining on the standard adjacent fabrics(washing machine: Launder-o-meter)

		dyed fabrics			
adjacent fabric	liquor ratio	CRO	CRB	PDB	PDR
cotton	50:1	4	5	4-5	5
	10:1	4	4	4-5	4-5
polyester	50:1	4-5	5	4	4-5
	10:1	4-5	4-5	4	4-5
nylon	50:1	4-5	4-5	4	4
	10:1	4-5	3	2	2-3

CRO: cotton fabric dyed with RO CRB: cotton fabric dyed with RB
PDB: polyester fabric dyed with DB PDR: polyester fabric dyed with DR

Table 4. Effect of the detergent concentration on the staining on the standard adjacent fabrics(washing machine: Launder-o-meter)

		Dyed fabrics			
Adjacent Fabric	Detergent Concentration	CRO	CRB	PDB	PDR
cotton	2g/L	3	3	4-5	4-5
	4g/L	3-4	3-4	4-5	4-5
polyester	2g/L	4	4-5	3-4	4
	4g/L	4-5	4-5	4	4
nylon	2g/L	4-5	3	2	1-2
	4g/L	4-5	3	2-3	1-2

CRO: cotton fabric dyed with RO CRB: cotton fabric dyed with RB
PDB: polyester fabric dyed with DB PDR: polyester fabric dyed with DR

washing machine and 10:1 for the drum-type washing machine in Launder-o-meter.

In case of the clothes dyed with reactive dyes, staining on the adjacent fabrics increased in the order of cotton, polyester and nylon, when the liquor ratio was reduced. The clothes dyed with disperse dyes stained the adjacent nylon fabric much more heavily than the cotton and the polyester fabrics.

During the washing process, some of the dye molecules might be able to bleed out into the washing bath from the clothes(Anonymous, 1987). At a low liquor ratio, the same result was appeared with the increase of dye concentration in the washing bath, and the staining on the adjacent fabrics was increased as well.

3. EfFect of the Detergent Concentration on the Staining on the Adjacent Fabrics

To examine the effect of the detergent concentration on staining, the specimens were washed in the washing water of 2g/L of detergent concentration, which was recommended by the Manufacturer, and 4g/L concentration as a comparison. The results are shown in <Table 4>.

Although the detergent concentration has increased, the staining on the adjacent fabrics not increased in both dyes. In the presence of detergent, the soils and the dye molecules can be easily removed from the fabrics, but the surfactant included in detergent makes the dispersion of these stable to prevent the reattachment(Akcakoca et al., 2007). As the surfactant concentration increased with the detergent concentration, the soils and the dye molecules were dispersed in more stable manner, and the staining on the adjacent fabrics were decreased.

Although the reactive dyes become hydrolyzed under the alkali condition(Johnson, 1989; Kim, 1992; Waring & Hallars, 1990), there are buffer materials included in the detergent to prevent the washing bath to go through a drastic change of pH. Even when the detergent concentration has increased, the pH value of the detergent solution did not change that much. It seemed that the high concentration of the detergent did not affect the detachment of the dye molecules from the dyed clothes and the staining on the adjacent fabrics.

4. Effect of the Components of Water on the Staining on the Adjacent Fabrics

After the samples were washed with the distilled water, the tap water and the tap water contains silver ions that are prepared at 40°C and at 90°C, the staining on the adjacent fabrics were measured. The results are summarized in <Table 5>. The hardness of the tap water was about 60ppm and the concentration of the silver ions was about 75ppb.

From both type of dyes, the adjacent fabrics were stained more visibly at 90°C than at 40°C, and the staining on the nylon adjacent fabrics were the most prominent. In the effect of the washing waters, hardness of the tap water did not seem to reduce the function of the detergent. In case of the tap water that

Table 5. Effect of water used for detergency on staining on the standard adjacent fabric(washing machine: Launder-o-meter)

Adjacent Fabrics	Dyed Fabrics	Temperature	Water used for detergency		
			Distilled water	Tap water	Tap water to contain Ag ion
Cotton	CRO	40°C	4-5	5	4-5
		90°C	4	4	4
	CRB	40°C	4	4-5	4-5
		90°C	4	4	4
	PDB	40°C	5	5	5
		90°C	4-5	4-5	4-5
	PDR	40°C	5	5	5
		90°C	4-5	4-5	4-5
Polyester	CRO	40°C	4-5	5	5
		90°C	5	5	5
	CRB	40°C	5	5	5
		90°C	5	5	5
	PDB	40°C	5	5	5
		90°C	4	4	4
	PDR	40°C	5	5	5
		90°C	3-4	4-5	3-4
Nylon	CRO	40°C	5	4-5	5
		90°C	4-5	4-5	4-5
	CRB	40°C	4-5	4-5	4-5
		90°C	3	3	3
	PDB	40°C	5	4-5	4-5
		90°C	2-3	2.5	2-3
	PDR	40°C	4-5	4-5	5
		90°C	1-2	1-2	1-2

CRO: cotton fabric dyed with RO CRB: cotton fabric dyed with RB
PDB: polyester fabric dyed with DB PDR: polyester fabric dyed with DR

contains silver ions, silver ions contained in water were very small, and did not affect on the staining on the adjacent fabrics.

Unlike a soap, a synthetic detergent includes a sequestrating agent to avoid the effect of the metal ion during the washing process. It is probably because of a commercial detergent was used, so that metal ions such as Ca, Mg ions and Ag ions could combine with the sequestrating agent and could hardly affect the washing function of the detergent.

5. Discoloring of the Dyed Clothes After Washing

1) Discoloring according to the Washing Condition

<Fig. 2> shows the discoloring after washing of the cotton fabrics dyed with the reactive dyes and the polyester fabrics dyed with the disperse dyes.

The polyester fabrics dyed with the disperse dyes hardly shows the discoloring after the washing process, but the cotton fabrics were slightly discolored. The cotton fabrics dyed with RO showed more discoloring than the fabrics dyed with RB. The discoloring of fabrics did not get much affected by the variance of washing conditions such as detergent concentration, liquor ratio and washing temperature. Thus it can be said that the washing condition does not affect much on the detachment of the dye molecules from dyed fabrics, but on the re-soiling of dye molecules on the white adjacent fabrics.

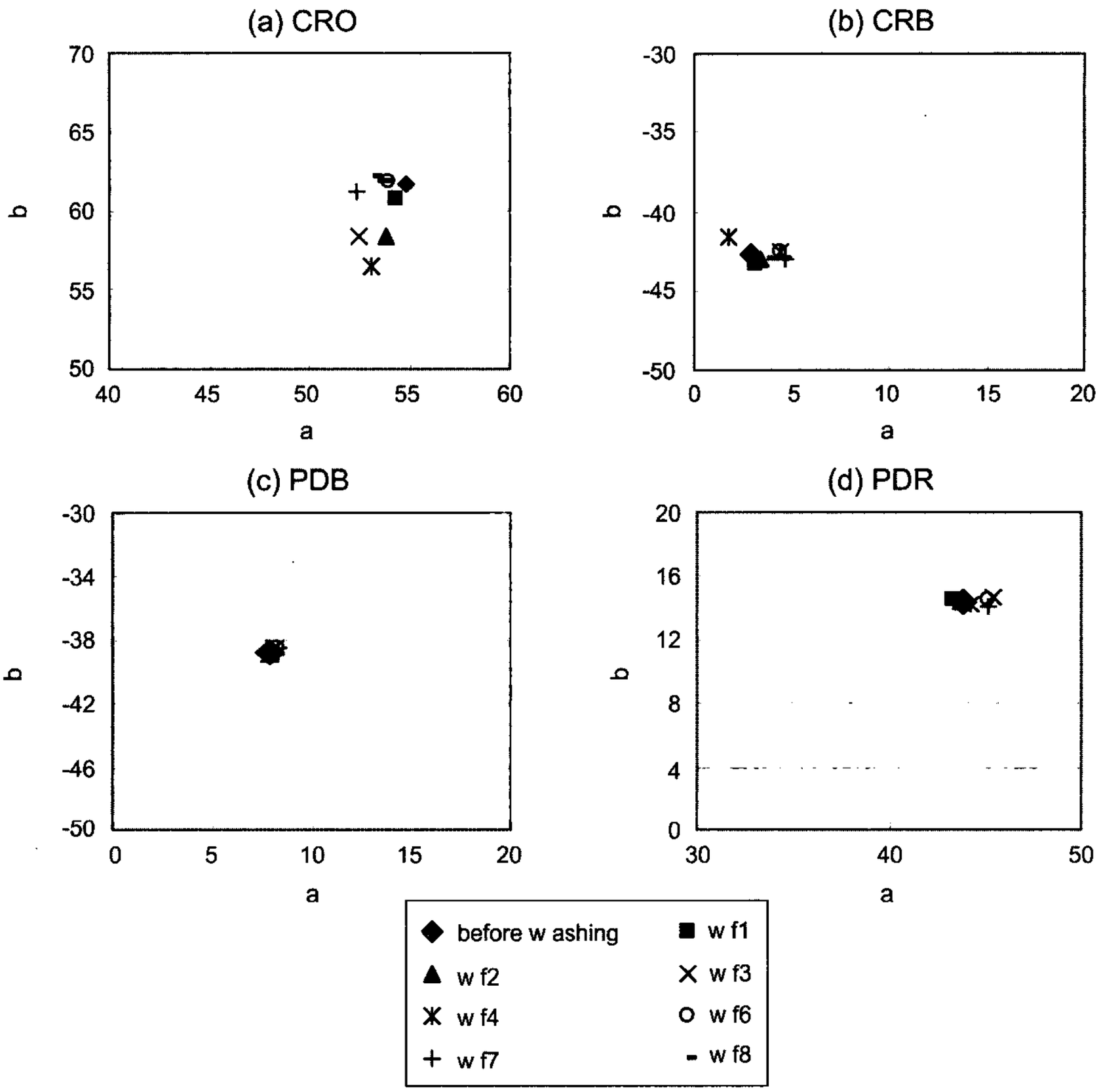


Fig. 2. Discoloring of Dyed Fabrics after the Washing with various condition(washing machine: Launder-o-meter).

conditions	detergent	detergent concentration	liquor ratio	washing temperature	washing time
wf1	standard soap	5g/L	50:1	60°C	30 min.
wf2	standard soap	5g/L	50:1	90°C	30 min.
wf3	standard soap	5g/L	10:1	90°C	30 min.
wf4	standard soap	25g/L	10:1	90°C	30 min.
wf5	Perfect for Drum	2g/L	10:1	40°C	30 min.
wf6	Perfect for Drum	4g/L	10:1	40°C	30 min.
wf7	Perfect for Drum	2g/L	10:1	90°C	30 min.
wf8	Perfect for Drum	4g/L	10:1	90°C	30 min.

CRO: cotton fabric dyed with RO
CRB: cotton fabric dyed with RB
PDB: polyester fabric dyed with DB
PDR: polyester fabric dyed with DR

2) Discoloring according to the Components Included in Water

<Fig. 3> shows the results from the washing of dyed cotton fabrics and polyester fabrics with the distilled water, the tap water and the tap water with silver ions.

After the washing process, the cotton fabrics dyed with the reactive dyes discolored a little, and the fab-

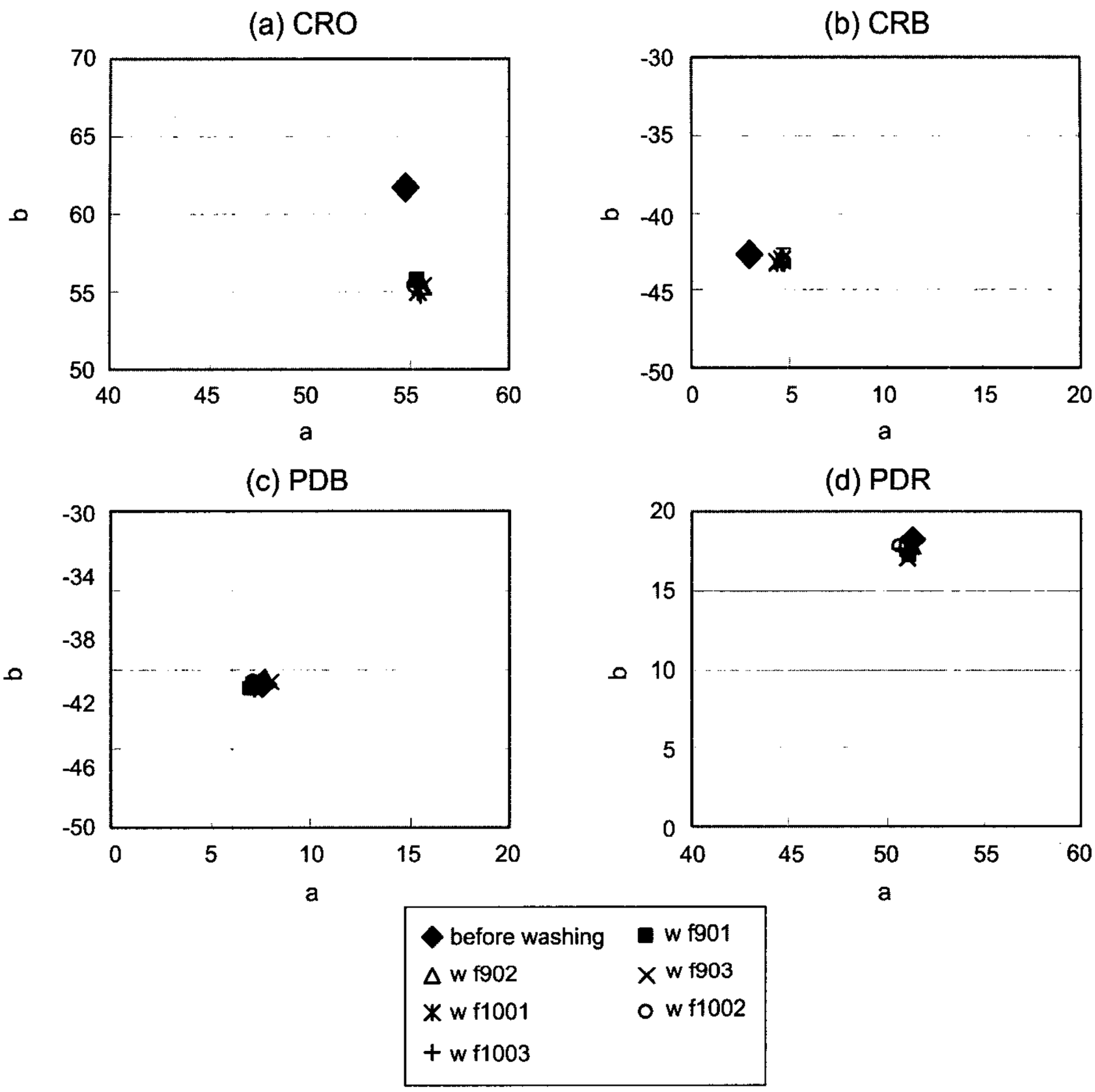


Fig. 3. Discoloring of dyed fabrics after the washing with the water contained different components(washing machine: Launder-o-meter).

conditions	detergent	water	liquor ratio	washing temperature	washing time
wf901	Perfect for Drum	D	10:1	40°C	30 min.
wf902	Perfect for Drum	T	10:1	40°C	30 min.
wf903	Perfect for Drum	S	10:1	40°C	30 min.
wf1001	Perfect for Drum	D	10:1	90°C	30 min.
wf1002	Perfect for Drum	T	10:1	90°C	30 min.
wf1003	Perfect for Drum	S	10:1	90°C	30 min.

D: distilled water
T: Tap water
S: Tap water containing silver ions
PDR: polyester fabric dyed with D
CRO: cotton fabric dyed with RO
CRB: cotton fabric dyed with RB
PDB: polyester fabric dyed with DB

rics dyed with dye RO, which have showed more staining result in the cotton adjacent fabrics in the test above, were discolored more than the fabrics dyed with RB. Polyester fabrics dyed with disperse dyes discolored hardly. The components included in the water did not affect the discoloring of the dyed fabrics. It seemed that the metal ions in water can effectively bind with the sequestrating agent in detergent, and does not affect the discoloring of dyed fabrics.

6. The Effect of the Repeated Washing on the Whiteness of Fabrics

To examine the precipitation of silver compounds on the fabric when the clothes were washed with the tap water that contains silver ions, the specimens of white cotton, polyester and nylon fabrics were prepared and washed with/without detergent. After the fabrics were washed by 1, 2, 3, 4, 5, 10, 20, 30, 40, 50 times, and the water was replaced for each load, and then the whiteness of fabrics were measured. <Fig. 4> shows the results.

In case of washing with detergent, whiteness of cotton fabrics increased with increasing washing cycles, because of the effect of the bleach and fluorescent agent included in detergent. Whiteness did not showed a large differences between tap water and tap water to contain silver ions. Whiteness of polyester fabrics changed scarcely. On the other hand, whiteness of nylon fabric increased until washed 5 time, after that started to decrease and levelled off.

As the polyester fibers have low absorptiveness and low reactivity, they were not affected by the bleach and fluorescent agent; and the whiteness was also scarcely changed. Nylon is a synthetic fiber, same as polyester, that has a relatively higher reactivity, and reacts more easily with the reagents and the external factors. Under the low washing cycles, nylon fabrics were affected by the bleach and fluorescent agent; when the washing cycle was repeated, the nylon fabrics were turned into yellow by the damage of the fibers and the reac-

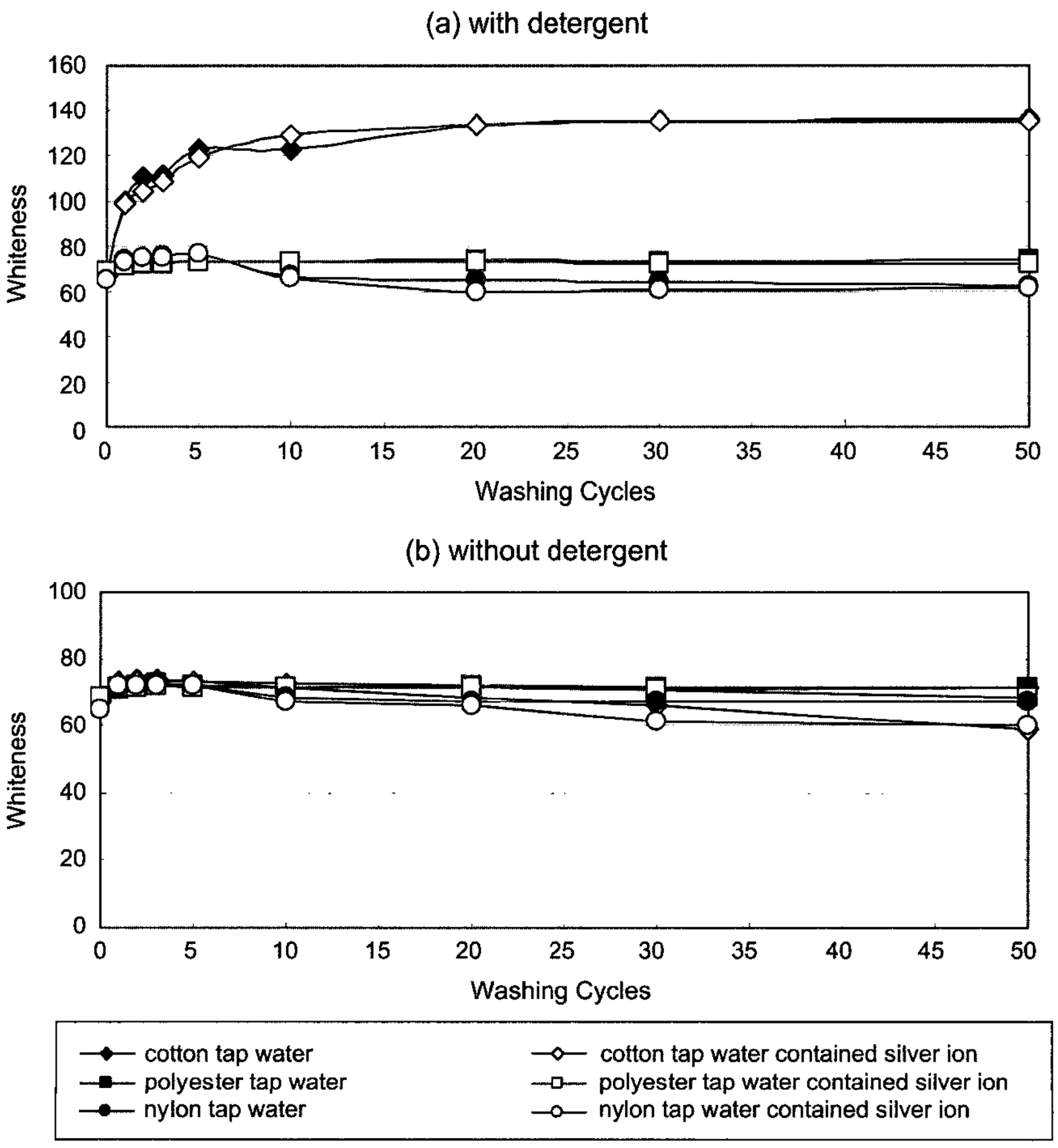


Fig. 4. Whiteness of the fabrics according to washing cycles.

tion between fibers and the components of the detergent.

In case of the washing without detergent and the washing with tap water, the change in the whiteness of cotton and polyester fabrics was not visible; but the whiteness of the nylon fabrics decreased because of yellowing. When washed with tap water to contain silver ions, whiteness of fabrics decreased with increasing the washing cycles. The differences of whiteness between the washed fabrics with tap water and with tap water contains silver ions were visible in the order of cotton, nylon, polyester. It was assumed that, the lower reactivity and the tighter internal structure the fibers have, the smaller the differences

Table 6. Silver content of the fabrics washed 50 times

Substrates	Content of silver (μg/g fiber)	Substrates	Content of silver (μg/g fiber)
untreated cotton	5.877	untreated nylon	1.640
washed cotton with silver without detergent	40.664	washed nylon with silver without detergent	29.280
washed cotton without detergent and silver	7.000	washed nylon without detergent and silver	1.716
washed cotton with silver and detergent	10.660	washed nylon with silver and detergent	11.040
washed cotton with detergent without silver	1.388	washed nylon with detergent without silver	1.800

Table 7. Staining of the standard adjacent fabrics according to washing temperature on drum type washing machine

Adjacent fabrics	water	Dyed fabrics	cold water	40°C	60°C	75°C	boiling water
cotton	tap water	CRO	4-5	4-5	4-5	4-5	4-5
		CRB	4-5	4-5	4-5	4-5	4-5
		PDB	4-5	4-5	4-5	4-5	4-5
		PDR	4-5	4-5	4-5	4-5	4-5
	tap water containing silver ions	CRO	4-5	4-5	4-5	4-5	4-5
		CRB	4-5	4-5	4-5	4-5	4-5
		PDB	4-5	4-5	4-5	4-5	4-5
		PDR	4-5	4-5	4-5	4-5	4-5
polyester	tap water	CRO	5	5	5	5	5
		CRB	5	5	5	5	4-5
		DB	5	5	5	5	4-5
		DR	5	5	5	5	4-5
	tap water containing silver ions	CRO	5	5	5	5	5
		CRB	5	5	5	5	5
		PDB	5	5	5	5	4-5
		PDR	5	5	5	4.5	4-5
nylon	tap water	CRO	4-5	4-5	4-5	3-4	3
		CRB	4-5	4-5	4-5	3-4	3
		PDB	4-5	4-5	4-5	3-4	2-3
		PDR	4-5	4-5	4-5	3	2
	tap water containing silver ions	CRO	4-5	4-5	4-5	4	3
		CRB	4-5	4-5	4-5	3-4	3
		PDB	4-5	4-5	4-5	3-4	2-3
		PDR	4-5	4-5	4	3	2

of whiteness were.

When washed with detergent, silver ions did not affect on the whiteness. It was seemed that detergent treated the silver compounds as the particulate soils and removed the compounds during washing.

To know that the silver compounds were deposited on the fabrics, cotton and nylon fabrics washed 50 times were dissolved in nitric acid solution and the concentration of silver ions in nitric acid solution were measured. The results were shown in <Table 6>.

The concentration of silver included in the fabrics washed with the tap water was higher than that in the fabrics washed with the tap water with silver ions. Though the whiteness of fabrics washed with the tap water did not differ from that of those washed with the tap water contains the silver ions, the real silver contents in the fabrics washed with the tap water contains the silver ions were larger. In case of the cotton fabrics, because of the effect of the bleach and the fluorescent agent, the deposition of the silver compounds could not be distinguished and in case of nylon fabrics, the components of detergent accelerated yellowing and the whiteness of fabrics were reduced than those washed without detergent. Detergent helped the removal of silver compound, but did not remove completely.

7. Staining on the Adjacent Fabrics When Washed in Drum-type Washing Machine at the Designated Courses

Because the above results were obtained by Launder-o-meter, it is difficult to compare these with the results of the home washing processes. Therefore, the staining on the adjacent fabrics were retested by using a commercial drum-type washing machine. The specimens were washed in the standard courses at a room temperature, 40°C, 60°C and 75°C, and in the boiling course. <Table 7> shows the degree of staining at each courses.

The degree of staining on the cotton adjacent fabrics were 4.5 through the whole range of washing temperature. But the staining on the fabrics could not be observed with eyes. Since the increase of whiteness of the fabric was caused by detergent, and the color differences between reference and samples occurred and staining grade was evaluated low.

The polyester adjacent fabrics was not stained from the clothes dyed with the reactive dyes even in the boiling wash course, but the clothes dyed with the dispersed dye made them stained in the boiling course.

The nylon adjacent fabrics had the grade below 4-5. at the room temperature and the stains were increased from 75°C.

The silver ions in the water did not seem to have much influence on the staining effect.

IV. Conclusions

The washing conditions of drum-type washing machine that are thought to affect the colorfastness were investigated and the staining on the adjacent fabrics, and the discoloring of the dyed clothes were examined. From the results, we have concluded as follows:

1. The staining of the reactive dyes were increased in an order of polyester, cotton, and nylon, and the staining of the disperse dyes came in an order of cotton, polyester and nylon.

2. The staining on the adjacent fabrics was enhanced at a higher washing temperature.

3. The staining on the adjacent fabrics was enhanced at a lower liquor ratio.

4. The hardness and the concentration of silver ions of water were not high enough to affect the colorfastness of washing.

5. After washing, although the discoloring of the dyed fabrics were not remarkable, the staining on the adjacent fabrics could observed.

6. When the washing with detergent has done repeatedly, the whiteness of cotton and polyester fabrics did not decreased; however, those of nylon fabrics were decreased by increase of the washing cycles. Without the detergent, the whiteness of the cotton and the nylon fabrics that are washed with the tap water contains the silver ions was lower than those of washed with the tap water.

7. When the washing with the tap water contains the silver ion has done repeatedly, some silver com-

pounds were found on the washed fabrics.

8. When the washing process was implemented by the drum-type washing machine, the nylon adjacent fabrics started to get stains from 75°C.

9. Repeated washing with the tap water that contains silver ion provoked the staining on the test fabrics.

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요 약

은나노를 이용한 드럼식 세탁기로 세탁한 경우 발생되는 세탁물의 변퇴색 및 오염현상을 관찰 하기위해 이와 유사한 세탁원리를 갖는 론더로메타를 이용하여 그 결과를 알아보았다. 반응성염료로 염색한 면직물과 분산염료로 염색한 폴리에스터 직물을 세탁포로 하고, 첨부 백포로 면, 폴리에스테르, 나일론을 이용하여, 세탁온도, 세탁액비, 세제 농도, 세탁용수를 변화시켜 세탁물의 염색견뢰도를 관찰하였고, 은물로 세탁한 경우 세탁물로의 은침착 여부를 관찰하였다. 그 결과, 세탁조건에 따른 염색포의 변색은 크지 않았으나, 세탁온도가 높고, 세탁 액비가 낮은 조건에서 첨부 백포로의 오염이 크게 나타났고, 특히 나일론 첨부 백포로의 오염이 컸다. 세제농도와 세탁용수는 염색견뢰도에 큰 영향을 미치지 않았다. 세탁용수를 달리하여 세제없이 백포만 반복 세탁한 경우, 은물로 세탁한 면, 나일론은 수돗물로 세탁한 경우보다 백도가 약간 낮게 나타났으며, 정량분석 결과 세탁물에 은화합물이 침착되었음이 확인되었다.