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Effects of Different Soaping and Fixing Agents on Washing Fastness of Reactive Dyed Cotton Fabric

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***Abstract*—Reactive dyes are the dominant choice of colorants in wet processing industries for coloration purposes of cotton goods due to some technical advantages. These dyes make co-valent bonds with the fiber molecules for which color fastness characteristics become greater. But after dyeing the substrate contains unfixed hydrolyzed dyes and usually some residual active dyes. The dyeing does not show optimal wash fastness properties until such dyes are removed insignificant in amount. So, effective washing and after-treatment after reactive dyeing are crucially important. Formation of the insoluble dye–agent complex on goods that have not been thoroughly washed leads to unacceptable color fastness to wash. The aim of this paper is to study the effects of different soaping and fixing agents on the color fastness to wash of the reactive dyed cotton fabric. For the determination of these effects, fastness has been measured in case of dyed cotton fabric before and after using both soaping and fixing chemicals. It has been observed that use of soaping agent on the reactive dyed cotton fabrics improved the color fastness to wash ratings than that of the dyed fabrics. Better color fastness to wash effects was found using 0.5g/l soaping in comparison to 1.0g/l soaping agent for the three different types of soaping agents. Use of different types of fixing agents also increased the fastness ratings.**

Keywords—Soaping agents, fixing agents, reactive dyes, cotton fabric, washing fastness.

1. Introduction

Reactive dyes have better property in terms of fastness. They contain reactive groups which react with the hydroxyl groups in cellulose under alkaline condition to form covalent bonds [1, 2]. But this alkaline condition also facilitates the reaction of reactive group with the water, resulting in deactivation or hydrolysis of the dye. Approximately 3/4th of the dyes get fixed while remaining 1/4th gets hydrolyzed [3]. After dyeing the substrate contains unfixed hydrolyzed dyes and usually some residual active dyes. This hydrolyzed dye adheres onto the substrate and keep on getting removed during washing treatments causing poor wash fastness. So besides taking steps to reduce the hydrolysis as much as possible, this hydrolyzed dye must be removed by rinsing and using an appropriate washing-off agent in order to retain the fastness properties. Effective washing after reactive dyeing is crucially important [4, 5]. The dyeing does not show optimal wash fastness properties until this loose color is removed or rendered insignificant in amount. It is remarkable that, on an average, only about 0.003% dye on weight of substrate will produce a stain equivalent to a grey scale rating of 4. The amount remaining after washing must be sufficiently small to ensure that after migration the fibers on the surface of the material still exhibit acceptable fastness. During washing the rate of diffusion out of the fiber is retarded by the substantivity forces between dye and cellulose molecules. The smaller the proportion of unfixed dye and the weaker these substantivity forces, the easier is the removal of the unfixed hydrolyzed dye remaining. Especially when applying reactive dyes in full depths, difficulties may arise in removing the unfixed dyes. In these circumstances it may be found necessary to after-treat the dyeing with a cationic fixing agent. Treatment with a cationic agent is not a substitute here for thorough washing to remove unfixed dye. Formation of the insoluble dye–agent complex on goods that have not been thoroughly washed will lead to unacceptable color fastness to wash and rub [6, 7].

2. Materials and Methods

2.1. Materials

2.1.1. Fabric

The grey 100% cotton knit fabric (Single Jersey) of about 164 g/m2, procured from GMS Composite Industries Ltd. Bangladesh was used in the study.

2.1.2. Dyes

Medium brand reactive dye- Remazol Red RGB procured from Huntsman, Bangladesh was used for this study.

2.1.3. Dyeing Chemicals and Auxiliaries

Glauber's salt (99%), caustic soda (50%) and soda ash (98%) were used as dyeing chemicals. Sequestering agent (Lufibrol MSD) and wetting agent (Kieralon oil) was used as dyeing auxiliaries.

2.1.4. Soaping and Fixing agents

Dekol SN (BASF), Ladipur RSK (Clarichem) and Easy Soap R (Intersac) were used as soaping agents and Cyclanon FIX (BASF), Optifix EC (Clarichem) and Huefix R (Intersac) were used as fixing agents for this study.

2.2. Methods

2.2.1. Preparatory Process

For scouring and bleaching purposes, grey fabric was prewashed with the bath liquor containing 4 ml/l hydrogen peroxide (35%), 3g/l caustic soda, 1.25g/l sodium silicate as stabilizer, 1g/l wetting agent and 1g/l sequestering agent at pH 10.5, material to liquor ratio 1:50, temperature 90^{0}C for 60 minutes, then washed thoroughly with 2g/l detergent followed by neutralization with 1 g/l acetic acid.

2.2.2. Dyeing

Dyeing was carried out in isothermal method with the five shade% (0.5%, 1%, 3%, 5% and 8%) of Remazol Red RGB dyes at 60^{0}C for 60 minutes, keeping material to liquor ratio 1:10 in the laboratory IR sample dyeing machine. Dyeing recipes for different shades of reactive dyes are shown Table 1.

Table 1. Dyeing recipes of reactive dyes

Remazol Red RGB	0.5%	1%	3%	5%	8%
Glauber's salt (g/l)	20	40	60	80	100
Soda ash (g/l)	5	5	5	5	5
Caustic soda 50% (ml/l)	0 .75	0 .9	1.5	2	2
1st Alkali addition	Soda ash		Soda ash + 1/3 Caustic soda		
2nd Alkali addition	Caustic soda		2/3 Caustic soda		
Sequestering agent (g/l)	1	1	1	1	1
Wetting agent (g/l)	1	1	1	1	1
Temperature, °C	60	60	60	60	60
Fixing time, min	15	15	30	30	30
Material to liquor ratio	1:30	1:30	1:30	1:30	1:30

Then dyed fabric was washed with water at 60°C, followed by neutralization with 1% acetic acid at room temperature for 10 min.

2.2.3. Soaping and Fixing Process

0.5g/l and 1g/l of each soaping agent were used on the neutralized fabric at 95^{0}C temperature for 15 minutes followed by hot and cold rinsing of fabrics. After that, fixing was carried out using 0.5% and 1% (O.w.f.) of fixing agent at room temperature for 10 minutes.

2.2.4. Color Fastness to Wash

Color fastness to wash was determined of each dyed, soaped, and fixed fabric by ISO 105 C06 method [8, 9].

Table 2. Effects of soaping (Dekol SN) and fixing (Cyclanon FIX) on washing fastness

Fabric type	Shade	Color change ratings	Ratings for degree of staining					
			Di-acetate	Bleached cotton	Polyamide	Polyester	Acrylic	Wool
Dyed fabric	0.5%	3	3/4	4/5	4	4/5	4/5	4/5
	1%	3	3/4	3/4	4	4/5	4/5	4/5
	3%	3	3/4	3	4	4/5	4/5	4/5
	5%	3	3/4	3	3/4	4/5	4/5	4/5
	8%	2/3	3/4	2/3	3/4	4/5	4/5	4/5
Dyed fabric treated with 0.5g/l soaping agent (Dekol SN)	0.5%	4/5	4	5	4/5	5	5	5
	1%	4	3/4	4/5	3/4	4/5	4/5	4/5
	3%	4	4	4/5	4/5	5	5	5
	5%	4	4	4/5	5	5	5	5
	8%	4	4	4	4	4/5	5	5
Dyed fabric treated with 1.0g/l soaping agent (Dekol SN)	0.5%	4	3/4	5	4	5	5	5
	1%	3	3	4/5	3/4	4/5	4/5	4/5
	3%	3/4	4	5	4/5	5	5	5
	5%	3/4	4	4/5	4/5	5	5	5
	8%	3/4	4	4/5	4/5	5	5	5
Dyed fabric treated with 0.5g/l soaping agent (Dekol SN) and 0.5% fixing agent (Cyclanon FIX)	0.5%	4/5	4	5	4	5	5	5
	1%	4/5	4	4/5	4	5	5	5
	3%	4	4	4	4/5	5	5	5
	5%	4/5	4	4/5	4/5	5	5	5
	8%	4	4	4/5	4/5	5	5	5
Dyed fabric treated with 1.0g/l soaping agent (Dekol SN) and 1.0% fixing agent (Cyclanon FIX)	0.5%	4/5	5	4/5	4/5	5	5	5
	1%	4/5	4	5	4	4/5	4/5	4/5
	3%	4	4	4/5	4	5	5	5
	5%	4/5	4/5	4/5	4/5	5	5	5
	8%	4/5	4	4	4/5	5	5	5

3. Results and Discussion

3.1. Effects of Soaping (Dekol SN) and Fixing (Cyclanon FIX) on Washing Fastness of Dyed Cotton

Effects of Dekol SN and Cyclanon FIX on washing fastness were shown in Table 2.

From Table 2, it was found that the color fastness to wash ratings was improved after soaping. When 0.5g/l Dekol SN was used for soaping, better results were achieved than using 1.0g/l Dekol SN. Again, in case of fixing of soaped samples (0.5g/l Dekol SN) with 0.5% Cyclanon FIX, better fastness results were found in case of 1% and 5% shades, before fixing the color change ratings were 4 while after fixing the ratings found 4/5.

When the concentration of Cyclanon FIX was increased from 0.5% to 1.0% and applied on to soaped samples (1g/l Dekol SN), fastness was also found improved. For example, before fixing the color change fastness ratings were 4 (0.5% shade), 3 (1.0% shade), and 3/4 (3.0%, 5.0% and 8% shades), but after fixing with 1.0% Cyclanon FIX, the ratings was improved to 4/5 (For 0.5%, 1.0%, 5.0% and 8.0% shades) and to 4 (For 3.0% shade).

On the other hand, the color staining ratings were found within 4/5 to 5 and almost unchanged in case of acrylic, polyester and wool of the multifiber fabrics for the entire range of shade%. In case of di-acetate, bleached cotton and polyamide, color staining ratings were improved due to soaping and fixing. For light shade (0.5% shade) the rating on the bleached cotton was found 5 while it was 4 for 8.0%shade). Overall, for most of the shades and various concentrations of Dekol SN and Cyclanon FIX, the staining ratings were found 4/5.

3.2. Effects of Soaping (Ladipur RSK) and Fixing (Optifix EC) on Washing Fastness of Dyed Cotton

Effects of Ladipur RSK and Optifix EC on washing fastness were shown in Table 3.From Table 3, it was noticed that, when soaping was carried out with 0.5g/l Ladipur RSK the color change ratings were found improved than that of dyed untreated samples. But in case of using 1.0g/l of RSK when compared to 0.5g/l RSK, fastness to wash (Color change) remain unchanged for 0.5% and 3% shades (Rating was 3/4), also in some cases it decreased (For 1.0% and 5.0% shades). Rating improved from 3 to 3/4 using 1g/l RSK for only 8% shade.

Table 3. Effects of soaping (Ladipur RSK) and fixing (Optifix EC) on washing fastness

Fabric type	Shade	Color change ratings	Ratings for degree of staining					
			Di-acetate	Bleached cotton	Polyamide	Polyester	Acrylic	Wool
Dyed fabric	0.5%	3	3/4	4/5	4	4/5	4/5	4/5
	1%	3	3/4	3/4	4	4/5	4/5	4/5
	3%	3	3/4	3	4	4/5	4/5	4/5
	5%	3	3/4	3	3/4	4/5	4/5	4/5
	8%	2/3	3/4	2/3	3/4	4/5	4/5	4/5
Dyed fabric treated with 0.5g/l soaping agent (Ladipur RSK)	0.5%	3/4	3/4	4/5	3/4	4/5	4/5	5
	1%	3/4	3	4/5	3/4	4/5	4/5	5
	3%	3/4	3	4/5	3/4	4/5	4/5	4/5
	5%	4	3/4	4	4	4/5	4/5	5
	8%	3	3/4	3/4	4/5	4/5	4/5	5
Dyed fabric treated with 1.0g/l soaping agent (Ladipur RSK)	0.5%	3/4	4	4/5	4	5	5	5
	1%	3	3/4	4/5	4	4/5	4/5	5
	3%	3/4	3/4	4/5	4	4/5	5	5
	5%	3/4	3	4	4	4/5	4/5	5
	8%	3/4	3	3/4	4	4/5	4/5	5
Dyed fabric treated with 0.5g/l soaping agent (Ladipur RSK) and 0.5% fixing agent (Optifix EC)	0.5%	4	3	4/5	4	4/5	5	5
	1%	4/5	4	4/5	4	4/5	5	5
	3%	4	4	4/5	4	5	5	5
	5%	4/5	3/4	4/5	4	4/5	5	5
	8%	3/4	3/4	4	4/5	5	5	5
Dyed fabric treated with 1.0g/l soaping agent (Ladipur RSK) and 1.0% fixing agent (Optifix EC)	0.5%	4	3/4	4/5	4	4/5	5	5
	1%	4	3/4	4/5	4	4/5	4/5	5
	3%	4	3/4	4/5	4	4/5	4/5	5
	5%	4/5	4	4/5	4	4/5	5	5
	8%	4	3/4	4/5	4	4/5	5	5

After fixing of soaped samples (0.5g/l Ladipur RSK) with 0.5% Optifix EC, the washing fastness (Color change) rating was found improved. For example, in this case, after soaping the color change ratings of 0.5%, 1.0% and 3% shades were 3/4 and after fixing the rating improved to 4/5 (For 1% shade) and to 4 (For 0.5% and 3% shades). In addition, the rating improved from 4 to 4/5 (For 5% shade) and 3 to 3/4 (For 8% shade).

Moreover, when the concentration of Optifix EC was increased from 0.5% to 1.0% and applied on to soaped samples (1g/l Ladipur RSK), fastness was also found improved. For example, before fixing the color change fastness ratings were 3/4 (0.5%,3.0%, 5.0% and 8% shades), and 3(1.0% shade), but after fixing with 1.0% Optifix EC, the ratings were improved to 4/5 (For 5.0% shade) and to 4 (For 0.5%, 1.0%, 3.0% and 8.0% shades).

In terms of degree of staining ratings, here also di-acetate, bleached cotton and polyamide fiber of multifiber fabrics are affected. In other three fibers rating were within 4/5 to 5 for dyed fabrics and treated fabrics. In case of bleached cotton, staining ratings were improved due to soaping. For 1% shade after dyeing the rating for staining on the bleached cotton was 3/4 while after soaping with 0.5g/l RSK the rating improved to 4/5, similarly for 3% shade rating improved from 3 to 4/5, for 5% shade rating improved from 3 to 4, and finally for 8% shade rating improved from 2/3 to 3/4. Using 1.0% Optifix EC, in all shades staining ratings were found 4/5 on bleached cotton.

3.3. Effects of Soaping (Easy Soap R) and Fixing (Huefix R) on Washing Fastness of Dyed Cotton

The Table 4 showed the effects of Easy Soap R as a soaping agent and Huefix R as a fixing agent on the washing fastness of reactive dyed cotton fabric.

Table 4 also showed the general trend that use of 0.5g/l soaping chemical improved the color change ratings. Using 0.5g/l Easy Soap R on the dyed fabric improved the ratings. But when the concentration of Easy Soap R was increased, the fastness to wash was either decreased or remain same compared to previous (0.5g/l). For example, the fastness rating to wash after dyeing for 8% shade was 2/3, after soaping with0.5g/l Easy Soap R rating was 3/4 but after soaping with 1.0g/l Easy Soap R rating was 2/3.

Table 4. Effects of soaping (Easy Soap R) and fixing (Huefix R) on washing fastness

Fabric type	Shade	Color change ratings	Ratings for degree of staining					
			Di-acetate	Bleached cotton	Polyamide	Polyester	Acrylic	Wool
Dyed fabric	0.5%	3	3/4	4/5	4	4/5	4/5	4/5
	1%	3	3/4	3/4	4	4/5	4/5	4/5
	3%	3	3/4	3	4	4/5	4/5	4/5
	5%	3	3/4	3	3/4	4/5	4/5	4/5
	8%	2/3	3/4	2/3	3/4	4/5	4/5	4/5
Dyed fabric treated with 0.5g/l soaping agent (Easy Soap R)	0.5%	3/4	3	4	3/4	4/5	4/5	5
	1%	3/4	3/4	4/5	4	4/5	4/5	5
	3%	3/4	3	3/4	4	5	4/5	5
	5%	3	3	3/4	3/4	4/5	4/5	5
	8%	3/4	3/4	3/4	4	4/5	4/5	4/5
Dyed fabric treated with 1.0g/l soaping agent (Easy Soap R)	0.5%	3	3/4	4	4	4/5	4/5	4/5
	1%	3/4	3/4	4	3/4	4/5	5	5
	3%	3	3	3/4	4	4/5	4/5	5
	5%	3	3/4	3/4	4	4/5	4/5	5
	8%	2/3	3/4	3/4	4	4/5	4/5	5
Dyed fabric treated with 0.5g/l soaping agent (Easy Soap R) and 0.5% fixing agent (Huefix R)	0.5%	4	3	4/5	4	4/5	4/5	5
	1%	3/4	3/4	4/5	4	4/5	4/5	5
	3%	3/4	3/4	4	4	5	5	5
	5%	3/4	3/4	4	3/4	4/5	4/5	5
	8%	4	3/4	3/4	4	4/5	4/5	5
Dyed fabric treated with 1.0g/l soaping agent (Easy Soap R) and 1.0% fixing agent (Huefix R)	0.5%	4	3/4	4	3/4	4/5	5	5
	1%	3/4	3/4	4	3/4	4/5	5	5
	3%	3/4	4	4	4	4/5	5	5
	5%	4	4	4	4/5	5	5	5
	8%	4	3/4	3/4	4	4/5	5	5

Here in case of Intersac Company, fixing after soaping improved the color change rating of washing except 1% and 3% shades. Fixing with 0.5% Huefix R which was previously soaped with 0.5g/l Easy Soap R, showed the color change rating to wash improved from 3/4 to 4 (For 0.5% and 8% shades) and 3 to 3/4 (5.0% shade). No benefit was found using 1% Huefix R instead of 0.5%.Like other soaping and fixing chemicals, the staining ratings were slightly affected by Easy Soap R and Huefix R in case of di-acetate, bleached cotton and polyamide, ratings for wool, acrylic and polyester almost unaffected.

4. Conclusion

After the completion of this investigation it has been observed that use of soaping agent on the reactive dyed cotton fabrics improved the color fastness to wash ratings than that of the dyed fabrics. Overall, better color fastness to wash effects was found using 0.5g/l soaping in comparison to 1.0g/l soaping agent for the three different type soaping agents (Dekol SN, Ladipur RSK, and Easy Soap R). Use of increased amount of fixing agent increased the color fastness to wash. The improvement of color fastness to wash was found more in darker shades than lighter shade using soaping and fixing chemicals. Dekol SN as a soaping agent and Cyclanon FIX as a fixing agent showed slightly better results than the other chemicals used. This paper was confined to dyeing with one kind of reactive dyes in five different shades to be washed off and fixed with three pairs of soaping and fixing chemicals of three manufacturers. However, investigations with other type of reactive dyestuffs and other washing and fixing agents are necessary before making any generalized statement. As washing plays key role in reactive dyeing, detailed knowledge of their chemical composition is also essential to understand and explain all the facts. Similarly, chemical constitution of fixer also should be known to comprehend their effects.

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