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Dyeing with reactive dyes by the combination of different functional groups and evaluation of color fastness to wash on cotton knitted fabric

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Abstract

In this colorful world, the beauty of dreams is effervesced by hundreds of man-made dyes on which Reactive dyes is in crest position. Maximum natural textile substrates are wafted by this pukka reaction-based dye. The exercise of this dye is progressed in an elevated celerity for its moderate to good light fastness, simple and variant dyeing methods and apparition of many bright colors. Over and above, Reactive dyes inflict good wash fastness at wet processing. Still sometimes buyers make assertions about bad wash fastness of reactive dyes for inadequate removal of unreacted and hydrolyzed dyes from surface of the substrates. The volition of dyes in this case is very important. A trichromatic mixture of dyes of same reactive group is always preferred. But recently metamerism becomes a big prerequisite for many renowned buyers to maintain. In those cases, dyes of same reactive group cannot be conserved. Therefore outcome on color fastness to wash, tonally change and color strength during washing becomes unknown. In this paper, this incognito effect is tried to be investigated a little. Dyeing is performed by mixing dyes of same functional group and different functional groups. Then color fastness to wash at different stages is observed.

Keywords: Color fastness to wash, Metamerism, Reactive dyes, its Structure and prominent figure

Introduction

Reactive dye is the flourishing class of dyes that was started on cellulosic materials in 1954. In 1956 Procion dye was introduced as Reactive dye with great popularity by ICI in England. History was created at that time in the story of dyes. Today the use reaches to 50% on cellulosic fibers. Gradually it is increasing and also applying on wool and polyamide fibers. In the world now use of reactive dye is 29% that is 2nd whereas 1st is use of Disperse dye (32%). Popularity has been established due to easy application; availability of different kind of methods as discontinuous, semi-continuous, continuous etc.; possibility of applying both in old and modern machines; different spreading power; application for dull to bright shades. People like it against sulphur and Azoic dyes for environment issue, against vat dyes for pricing, against direct dyes for fastness.

Contrarily it pollutes the environment much (mainly water). [1]

Structure:

Reactive dye makes co-valent bond with the fiber and turns out a part of it. A relation can be derived as-

Reactive dyes+Fiber=Reactive dye-Fiber
(Covalent bonding)

If a general structure of Reactive dye can be shown as-'R-B-X', we can write:

R-B-X +Fiber= R-B-X-fiber (Dyed fiber)

Where,

R= Chromophore Group

B=Bridging Group (Imino, Ethyl & Methyl, Oxide, Suphide group)

X=Reactive Group [2]

Prominent Figure:

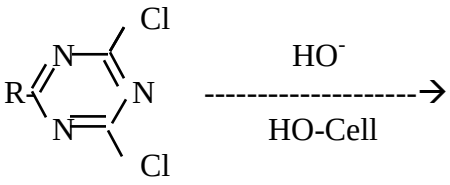
Trichloroazines are the one of the most important functional groups in Reactive dyes. Amine functional group makes a chromophore that is attached to the triazine. This chromophore displaces one chloride:

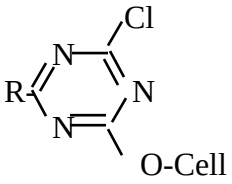
$(NCCl)_3$ + dye-NH_2 → $N_3C_3Cl_2$(NHdye) + HCl

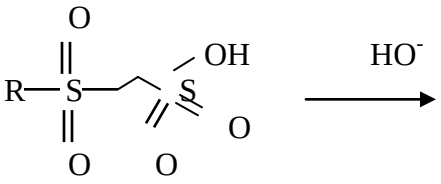
A dichlorotriazine is produced here. It is sticked to cellulose fiber by replacing one of the two chloride groups:

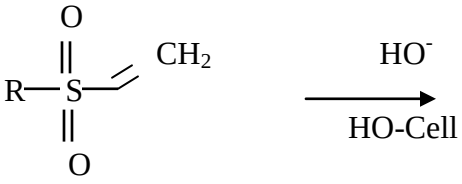
$N_3C_3Cl_2$ (NH dye) + HO-cellulose → N_3C_3Cl (NHdye) (O-cellulose) + HCl

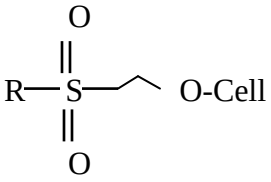
A buffered alkaline dye bath fixes the dyes in the fabric. Commercially vinylsulfonyl group is a dominant figure in fixation. Hydroxyl group of cellulose is attracted by this functional group. Remazol is a very popular brand of this functionality. First fixation is done to the ethylsulfonyl group.











Here Cell refers cellulose and R refers chromophore.

Categories of functional groups of reactive dyes used here:

Functionality	Functional group Type	Brands having
Chloropyrimidine	Mono	Drimarine
Vinyle sulphone	Mono	Remazol RR
Monoflurotriazine-vinyle sulphone	Bi	Novacron FN

[3]

Selection of colors:
Normally selection of dyes is an important factor for perfect performing of dyeing. It is better to use dyes of same functional group as well as exhaustion of dyes should be same. Otherwise perfect shade cannot be achieved as dyes are washed off. Dyes can also be hydrolyzed. Very high reaction based and very low reaction based dyes should not be in a same recipe.[4]

A recent trend (Metamerism):
Recently another issue has been originated i.e. metamerism. Not matching of the colors of different spectral power distribution is called metamerism. It is a common phenomenon in near neutral or dark colors. Neutral means grayed or whitish colors. For the bright colors, different combinations of light wavelengths become smaller. Images produced in photography, television, printing, digital imaging etc. produce this metamerism. As the spectral emittance curve is created by a light source, metamerism depends on light sources. Another way, metamerism is defined as difference of views of same material sample under two light sources. Metamerm can also be produced for geometric angle, change of wavelength, light sensitivity of eye etc. This metamerism creates a huge problem in dyeing industry. [5] Lab people, dyeing people, quality people and all check persons in Apparel Industry have to match shades under same light source. Otherwise for this, shade cannot be matched consummately.

Datacolor (U.S.A.) has invented a scientific instrument named Spectrophotometer for transmitting and reading the intensity of the light wavelengths that is used now all over the world. It has given two softwares named as Datacolor Tools and Datacolor Match. It can perform operations such as taking main recipe, correction recipe, costing and Metamerism Index also. [6] If we combine 3 colors of different functional groups, Datacolor Spectrophotometer can give a best recipe for considering metamerism.

Buyer Requirements:
Therefore it has been ended in to use of different functional groups at one recipe in the industries to prevent metamerism for fulfilling the demand of buyers.

Here it is seen that for taking the recipe of the color of 13-0550 TCX, among two trichromatic dyes, one individual combination is not able to give a recipe of good metamerism. Here the 4^{th} recipe is being shown by one combination which has metamerism of 0.60 at A and 0.42 at F11. But the best recipe is combined with two dyes of Sunjol and one of Remazol.

Therefore it is understood that a good recipe with less metamerism needs combination of dyes of different functional groups. This is the present scenario of recipe for dyeing in Textile sector according to the demand of buyers.

Problem created:
This practice of mixing dyes of different functional groups can create some problems in dyeing. For instance, shades cannot be harmonized easily; bad impact can be created on color fastness or color strength can be affected badly. In this paper, some of these effects will be analyzed.

Color fastness to wash:
Color fastness is defined as the resistance of dyed substrate against loosing color from its body during washing.

For testing color fastness to wash, a sample is kept inside of one or two specified adjacent fabrics and then mechanically agitated, rinsed & dried. The color lost by the sample and the staining absorbed by the adjacent fabric are then assessed by grey scale or by spectrophotometer.

An example of recipe is exposed below from Datacolor Spectrophotometer having amount of metamerism.

Standard		13-0550 TCX			
Quality/style		100%cotton			
Substrate(factor)		160GSM S/J(1.00)			
Process(factor)		(1.00)			
Formula		Cielab Default[D65]			
dE*D65	1	0.01	0.00	0.01	0.01
Metamerism A	0.7	0.33	0.34	0.53	0.60
Metamerism F11	0	1.23	0.45	0.48	0.42
Total concentration %	0	1.4252	1.4372	1.4376	1.4416
Dyestuff		1(3)	2(3)	3(3)	4(3)
Remazol Yellow 3GL					
Remazol Yellow RR		0.0073			
Remazol Red RR			0.0005		
Remazol Blue RR					
Sunzol T.Blue G(266%)		0.0155	0.0152		
Sunzol Blue R(spl)					
Sunzol Blue BB					
Sunfix Yellow S-4GL(200%)		1.4023	1.4216	1.4234	1.4257

Another example is shown below:

Standard		193920 TPX					
Quality/style		100% cotton					
Substrate(factor)							
Process(factor)							
Formula							
dE*D65	1	0.01	0.00	0.00	0.01	0.01	0.00
Metamerism A	0.7	0.15	0.23	0.24	0.23	0.24	0.26
Metamerism F11	0	0.73	1.67	0.80	1.66	0.76	0.75
Total concentration %		2.109	3.8664	1.9404	3.8073	2.1231	1.6736
Remazol Yellow 3GL			0.2578				
Remazol Yellow RR							
Remazol Red RR				0.6943			
Sunzol T.Blue G		0.5225		0.5387		0.5504	0.5600
Sunzol Blue R(spl)			2.5337		2.5370		
Sunfix B.Red BB							
Sunfix Red MF-2BD							0.4195
Sunfix Red S2B		0.8586				0.8777	
Sunfix Yellow S-4GL					0.1933		
Everzol Yellow 3RS							
Everzol Red 3BS							
Sunzol Black SG						0.6930	
Novacron S Black G		0.7279		0.7075			0.6940

Generally Color fastness to wash is the most important requirement for the most of the buyers among all the color fastness tests. There are many renowned color fastnesses to wash done for the buyers in the market. Here followings are applied:

1. IS:687:79
2. IS:3361:79
3. IS:764:79
4. IS:765:79
5. IS:3417:79

Instruments:

1. Rotawash/Gyrowash
2. Stainless still ball
3. Multi-fiber fabric
4. Grey scale
5. Sewing machine
6. Thermometer
7. Color matching cabinet
8. Soap & Soda: ECE Phosphate is used here as soap that is without optical brightener

Sample Preparation:

- Sample fabric: 10X4 cm
- Multifiber: Same size

Working procedure:

1. Collection of sample
2. Conditioning(4 hours 30 min to 6 hours)
3. Making a specimen having size of 4cmX10 cm
4. Sewing the specimen with multifiber of same size at one corner
5. Making solution as shown in the table one by one
6. In one beaker M:L ratio is=1:50
7. Covering the lid tightly.
8. Setting in Rotawash/Gyrowash
9. Running the machine according to the following table one by one
10. Rinsing with hot water
11. Squeezing with cold water
12. Drying with maximum 60 degree Celsius
13. Assessing shade change and staining

Methodology

Dyes are mixed in three different ways:

1. Dyes of same functional groups are combined together.
2. Two dyes of one functional group is combined with one dye of another functional group
3. Dyes of three functional groups are combined together

This will be applied in following ways:

1. 1st process will be applied on three different shades (typical red, blue and green).

Recipe of red is:
Red: 2.1%
Yellow: 0.5%
Blue: 0.1%

Recipe of Blue is:
Blue: 2.5%
Red: 0.2%
Yellow: 0.3%

Recipe of green is:
Blue: 1.3%
Yellow: 1.3%
Red: 0.1%

Here, red is dyed with Remazol RR brand, blue is dyed with Novacron FN brand and green by Drimarine CL brand.

Sl.No.	Method	Washing severity	Soap+Soda (gm/lt)	Time (min)	Temp. (^{0}C)	Steel balls
1	IS:687:79	Very mild like hand wash	5	30	40±2	0
2	IS:3361:79	5 times severe than method 1	5	45	50±2	0
3	IS:764:79	Mild washing	5+2	30	60±2	0
4	IS:765:79	Severe washing	5+2	30	95±2	10
5	IS:3417:79	Severe washing	5+2	4 hrs	95±2	10

[7]

2. 2nd process will be applied for those shades of same recipe where two dyes of same functional group is mixed with one dye of another functional group. Here the recipe are as follows:

Recipe of red is:
Remazol Red RR: 2.1%
Remazol Blue RR: 0.1%
Novacron Yellow FN2R: 0.5%

Recipe of Blue is:
Drimarine Navy CLR: 2.5%
Novacron Red FN3GL: 0.2%
Novacron Yellow FN2R: 0.3%

Recipe of green is:
Drimarine Navy CLR: 1.3%
Drimarine Yellow Cl: 1.3%
Remazol Red: 0.1%

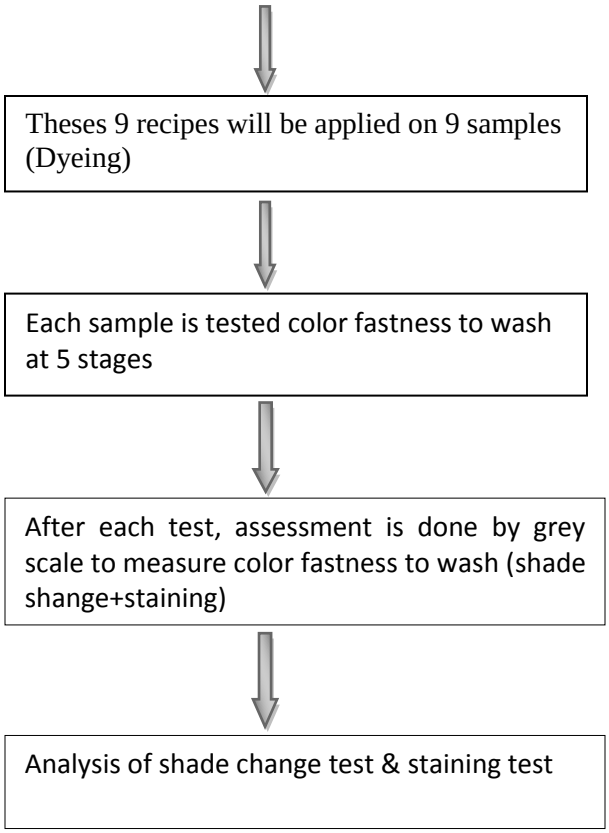
3. 3rd process will be applied again for those 3 colors by 3 dyes of different functional groups.

Recipe of red is:
Remazol Red RR: 2.1%
Drimarine Navy CLR: 0.1%
Novacron Yellow FN2R: 0.5%

Recipe of Blue is:
Remazol Blue RR: 2.5%
Novacron Red FN3GL: 0.2%
Drimarine Yellow CLHB: 0.3%

Recipe of green is:
Novacron Blue FNR: 1.3%
Remazol Yellow RR: 1.3%
Drimarine Red CLHB: 0.1%

4. Here, we will have total 9 recipes for dyeing; those will be applied for 9 batches.



Result found in the test:

Dyes Combination	Very Mild		5 times stronger than very Mild		Mild		Severe Washing		Long Severe Washing	
	Shade	Staining	Shade	Staining	Shade	Staining	Shade	Staining	Shade	Staining
vsR+vsY+vsB	4/5	2/5	4/5	2	4	2	2	2	1	1/2
vsR+biY+vsB	3/4	2	3/4	2	3/4	2	3	1/2	2/3	1/2
vsR+biY+cpB	4	2	4	2	4	2	3	1/2	2	1/2

Dyes Combination	Very Mild		5 times stronger than very Mild		Mild		Severe Washing		Long Severe Washing	
	Shade	Staining	Shade	Staining	Shade	Staining	Shade	Staining	Shade	Staining
biR+biY+biB	4/5	3/4	4/5	3/4	4	2/3	3/4	2	2	2
biR+biY+cpB	4/5	4/5	4/5	4	4/5	4	4	2/3	2	2
biR+cpY+vsB	5	4/5	4/5	4	4/5	3/4	3/4	3	2	2/3

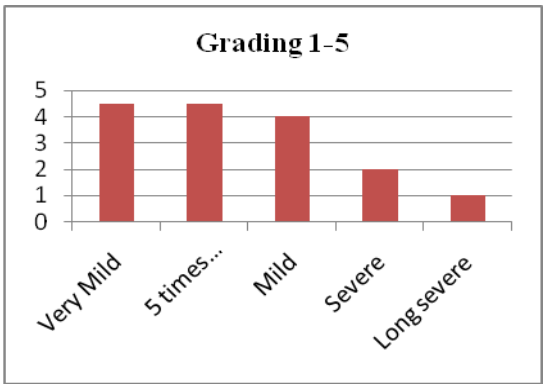
Dyes Combination	Very Mild		5 times stronger than very Mild		Mild		Severe Washing		Long Severe Washing	
	Shade	Staining	Shade	Staining	Shade	Staining	Shade	Staining	Shade	Staining
cpR+cpY+cpB	5	4/5	4/5	4/5	4/5	4	4	2	1	2
vsR+cpY+cpB	5	5	5	4/5	4/5	4	4	2	1	1/2
cpR+vsY+biB	4/5	4	4/5	4	4	4	3/4	3	2	2/3

Note: cp= Chloropyrimidine, vs= vinyle sulphone, bi= bi-functional

ANALYSIS:

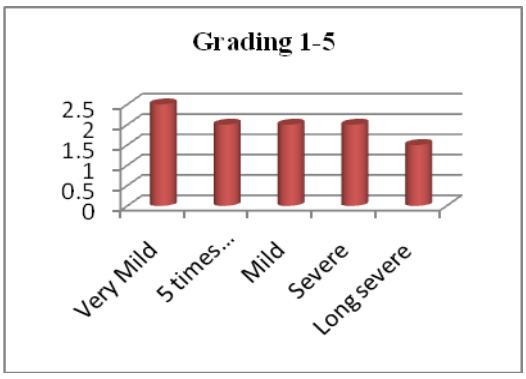
1.1 Combination:

a. Color: Red
b. (Red+blue+yellow) from Remazol (vinyle sulphone)+ Yellow from Novacron (bi-functional)
c. For shade change:



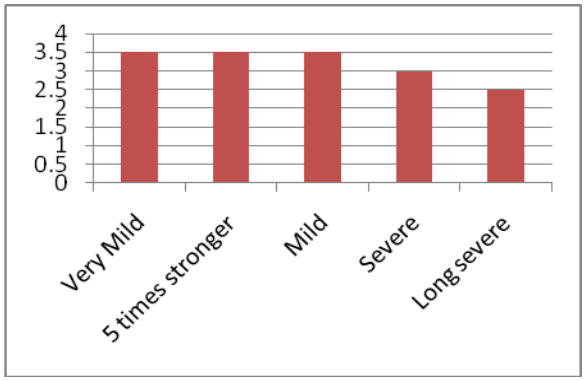
1.2 Combination:

a. Color: Red
b. (Red+blue+yellow) from Remazol (vinyle sulphone)+ Yellow from Novacron (bi-functional)
c. For staining:



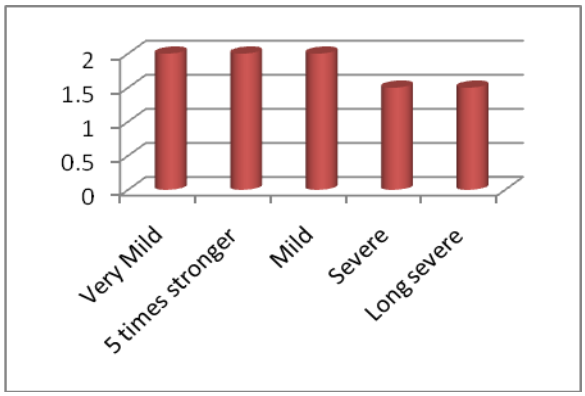
2.1 Combination:

a. Color: Red
b. (Red+blue) from Remazol (vinyle sulphone)+ Yellow from Novacron (bi-functional)
c. For shade change:



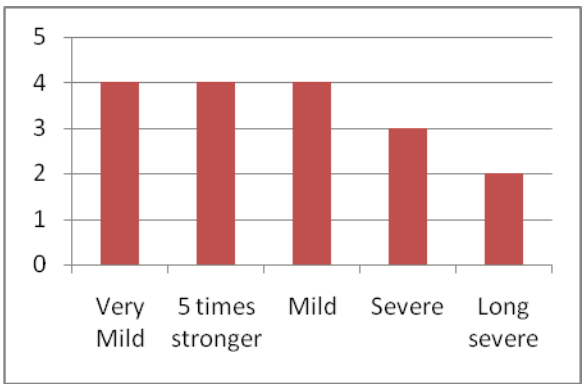
2.2 Combination:

a. Color: Red
b. (Red+blue) from Remazol (vinyle sulphone)+ Yellow from Novacron (bi-functional)
c. For staining:

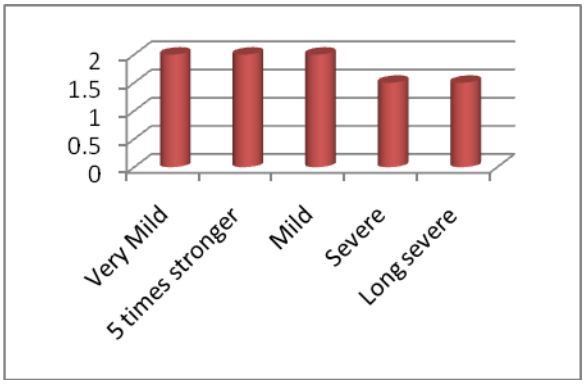


Result (1.1, 1.2, 2.1, 2.2):
When 3 dyes of vinyle sulphone are mixed, result is found good (considered as case1). But result is found bad when 2 vinyle sulphones are mixed with 1 bifunctional (considered as case2).

3.1 Combination:
a. Color: Red
b. Red from Remazol (vinyle sulphone)+ Yellow from Novacron (bi-functional) + Blue from Drimarine (Chloropyrimidine)
c. For shade change:



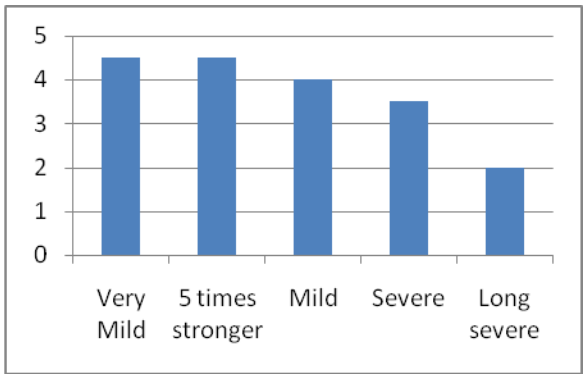
3.2 Combination:
a. Color: Red
b. Red from Remazol(vinyle sulphone)+ Yellow from Novacron(bi-functional) + Blue from Drimarine (Chloropyrimidine) **{**case3**}**
c. For staining:



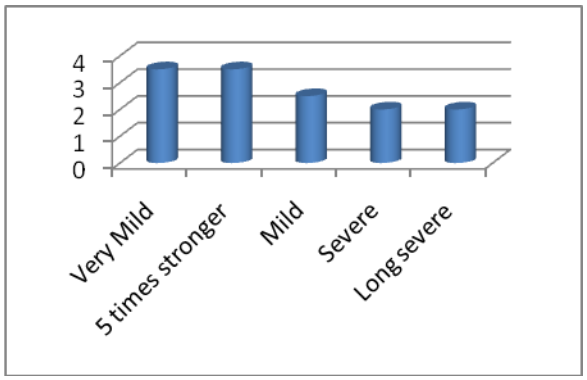
Result (1.1-3.2):
For staining test, result is same as case2 i.e. result is bad. For shade change test, result is comparatively good.

Explanation of the result (1.1-3.2)
For red shade, strength of vinyle sulphone is comparatively bad when mixing with another or other functional groups. In case 3, 1 vinyle sulphone is mixed with 2 other functional groups; so result is found comparatively good.

4.1 Combination:
a. Color: Blue
b. Red, yellow and blue from Novacron series(bi-functional) {case 4}
c. For shade change:

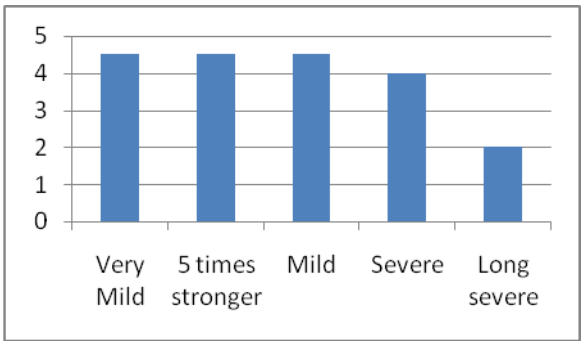


4.2 Combination:
a. Color: Blue
b. Red, yellow and blue from Novacron series(bi-functional)
c. For staining:

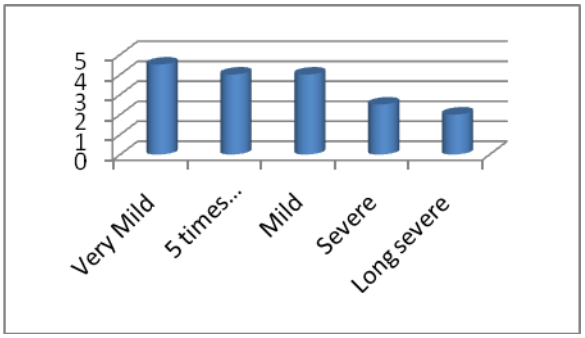


Result (1.1-4.2):
Result is better than case1 both for shade change and staining i.e. very good. It can be said that bi-functional group is stronger than vinyle sulphone in case of color fastness to wash.

5.1 Combination:
a. Color: Blue
b. (Red and yellow) from Novacron series (bi-functional) + blue from drimarine (chlopyrimidine)
c. For shade change:



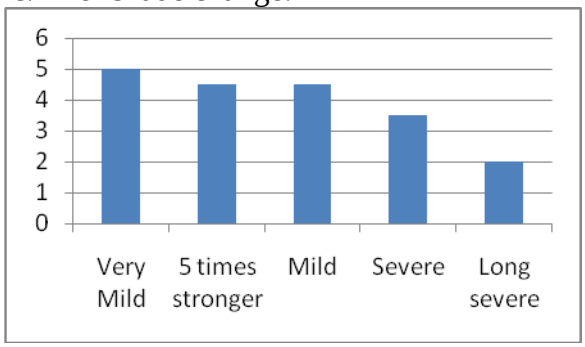
5.2 Combination:
a. Color: Blue
b. (Red and yellow) from Novacron series (bi-functional) + blue from drimarine (chlopyrimidine)
c. For staining:



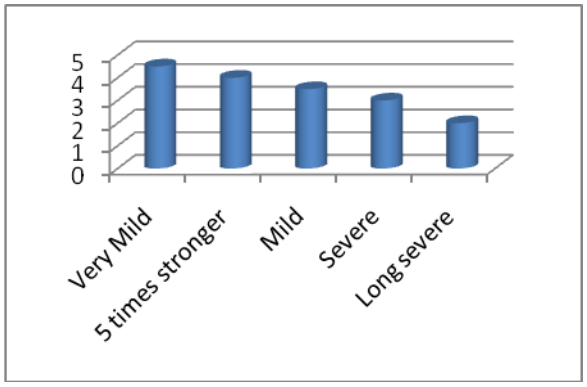
Result (1.1-5.2):
Result is much better than case2. Result is also little better than case4.

Explanation (1.1-5.2):
Here no vinyle sulphone is used in the combination. Therefore result is much better than case 2 that we have found in the previous time. Again as result is little better than case4, it refers that chloropyrimidine is little stronger than byfunctional in case of fastness to wash.

6.1 Combination:
a. Color: Blue
b. Red from Novacron series(bi-functional) + blue from remazol(vinyle sulphone)+ Yellow from drimarine(chloropyrimidine) (chlopyrimidine)
c. For shade change:

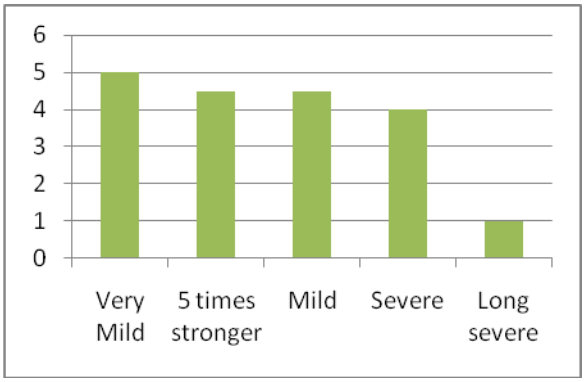


6.2 Combination:
a. Color: Blue
b. Red from Novacron series (bi-functional) + blue from remazol(vinyle sulphone)+ Yellow from drimarine (chloropyrimidine) (chlopyrimidine)
c. For staining:

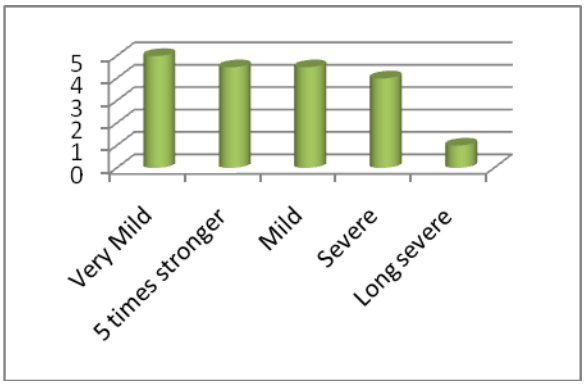


Result (1.1-6.2):
For both shade change and staining, best result is being found though 3 dyes are mixed from 3 functional groups. In combination 3 also, 3 functional groups are used. The probable cause is color fastness to wash shows better result for blue color than red color.

7.1 Combination:
a. Color: Green
b. Red, yellow and blue from Drimarine series (chlopyrimidine)
c. c. For shade change:

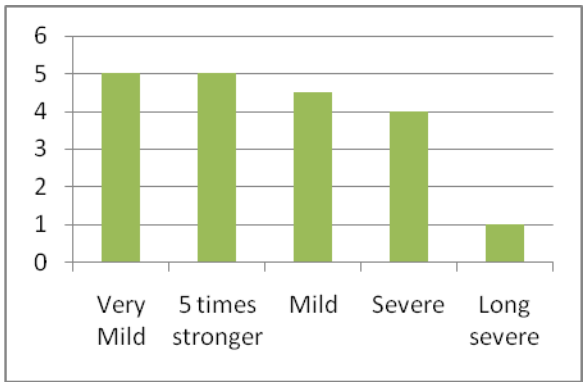


7.2 Combination:
a. Color: Green
b. Red, yellow and blue from Drimarine series (chlopyrimidine)
c. For staining:

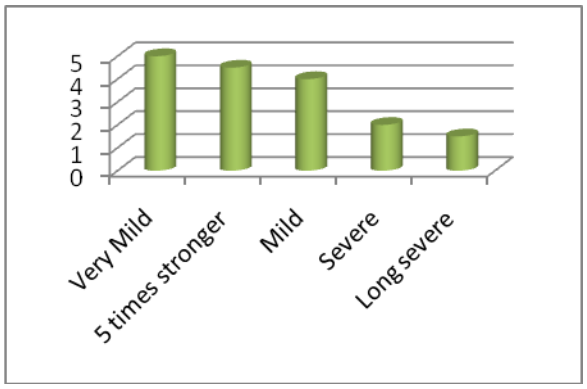


Result (1.1-7.2):
Except severe washings, result is very good. Already it is seen that chlopyrimidine shows best result. That is reflected here.

8.1 Combination:
a. Color: Green
b. (Yellow and blue) from Drimarine series
(chlopyrimidine) + Red from remazol(vinyle sulphone)
c. For shade change:



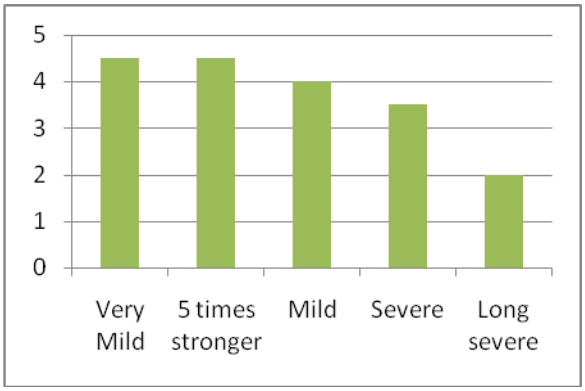
8.2 Combination:
a. Color: Green
b. (Yellow and blue) from Drimarine series
(chlopyrimidine) + Red from remazol(vinyle sulphone)
c. For staining:



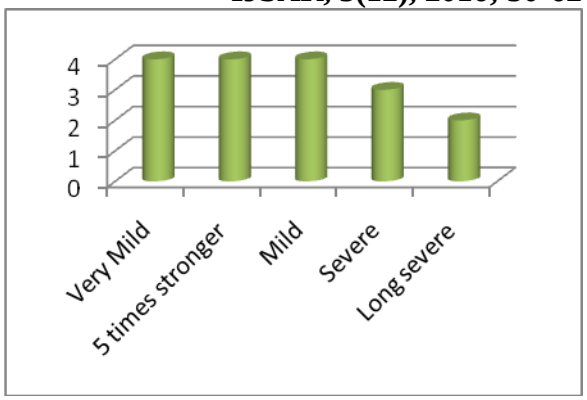
Result (1.1-8.2):
Almost same as result of combination 7 and combination 5. These results are better than those of combination 2.

Explanation (1.1-8.2):
As it is seen that color strength of vinyle sulphone is comparatively low, result is found bad for combination 2 where 2 vinyle sulphones are mixed with one bi-functional. For combination 5 and 8, results are comparatively good as these have 1 vinyle sulphone or not. Result is little better for combination 5 than that of combination 8 as combination 5 has no vinyle sulphone.

9.1 Combination:
a. Color: Green
b. Red from Drimarine series (chlopyrimidine) + yellow from remazol (vinyle sulphone) +
blue from novacron(bi-functional)
c. For shade change:



9.2 Combination:
a. Color: Green
b. Red from Drimarine series (chlopyrimidine) + yellow from remazol(vinyle sulphone) + blue from novacron(bi-functional)
c. For staining:



Result (1.1-9.2):
For combination 6 and 9; results are almost same i.e. good though these have 3 functional groups.

Executive Summary of all Result:
When vinyle sulphones are mixed with each other, it can give a good color fastness which is found in test of combination 1. But when it is mixed with other functional groups, result is found very bad when 2 vinyle sulphones are mixed with 1 other functional group which is found in the test of combination 2. When 1 vinyle sulphone is mixed with 2 other functional groups, result is found good (even better) which is found in the test of combination 3, 6, 8 and 9. For red color the last mentioned combination shows worse result than that of blue color. Color fastness for bi-functional group and chloropyrimidine is almost found same.
So, vinyle sulphone shows poor fastness property with others.

Materials and methods
For Dyeing the fabric has been collected from Rupa Knitwear, Gazipur, Bangladesh.
The entire chemicals are collected from local market of Bangladesh. Process is carried at 98 degree Celsius for 30 min. Enzyme wash is carried for 40 min.

The recipe for scouring and bleaching is as follows:

Function	Chemical Name	Dosing
Detergent	Marla OLS	0.40 g/L
Sequestering Agent	Invatex CS	0.50 g/L
Anti Creasing Agent	Jeosoft HG	1.00 g/L
Alkali	Soda Ash	1.00 g/L
Alkali	Caustic Soda	0.50 g/L
Stabilizer	Staper pH	0.20 g/L
Bleaching Agent	H2O2 (50%)	2.00 g/L
Acid	Acetic Acid	0.50 g/L 0.0….5
Peroxide Killer	Inazyme CAT	0.10 g/L
Acid	Acetic Acid	0.50 g/L
Enzyme	Cellusoft 1001	0.25%

The materials used in dyeing process are as follows-

Name	Use	Brand	Source
Levelling agent	Dyeing	M.S.Trades	Local market(china)
Remazol dyes	Dyeing	Dystar	Local agent
Novacron dyes	Dyeing	Huntsman	Local agent
Drimarine dyes	Dyeing	Drimarine	Local market
Detergent	Pretreatment	M.S.Trades	Local market(china)
Glauber salt	Dyeing	M.S.Trades	Local market(china)
Alkali	Dyeing	M.S.Trades	Local market(china)
Acid	Aftertreatment	M.S.Trades	Local market(china)
Soaping agent	Aftertreatment	M.S.Trades	Local market(china)
Softening agent	Aftertreatment	M.S.Trades	Local market(china)
Fixing agent	Aftertreatment	FDR	Local market(china)

For dyeing following parameters have been initiated-

-M: L ratio= 1:7

-The recipe of chemical is kept as follows:

1. Leveling agent: 1.5 gm/lt
2. Acid:0.7 gm/lt, hand stirring for 60 sec
3. Soap: 1.5 gm/lt, hand stirring for 60 sec
4. Fixing agent: 1gm/lt, hand stirring for 60 sec
5. Salt: 45 gm/lt
6. Soda: 14 gm/lt

-Dyeing is done for 1 hour 20 min in the machine named Mathis (china).

-Aftertreatment is done as follows:

Hot wash (hand stirring for 60 sec) [65^0C-70^0C]

↓

Cold wash (hand stirring for 60 sec)

↓

Acid (hand stirring for 60 sec) [55^0C-60^0C]

↓

Soap (hand stirring for 60 sec) [90^0C]

↓

Hot wash (hand stirring for 60 sec) [65^0C-70^0C]

↓

Cold wash (hand stirring for 60 sec)

Softening (hand stirring for 60 sec)

All the result of color fastness is assessed by AATCC grey scale.

Acknowledgement

We would like to thank Mr. Shimul Kumar Banik (Dyeing Manager, Rupa Fabrics Ltd.) and Mr.Asif Reza (Head of Quality Control, Tex Europe Bd ltd.) for technical assistance.

Reference

[1] 'Golden Jubilee of Reactive Dyes-Future Trends'—SDC conference organized by Mumbai region; 'Cellulosic Dyeing', Edited by John Shore; SDC, 1995

[2] International Journal of Engineering and Management Science: Technical Facts & Figures of Reactive Dyes used in Textiles

[3] Horst Tappe, Walter Helmling, Peter Mischke, Karl Rebsamen, Uwe Reiher, Werner Russ, Ludwig Schlafer and Petra Vermehren "Reactive Dyes" in Ullmann's Encyclopedia of Industrial Chemistry 2000, Wiley-VCH, Weinheim. Doi: 10.1002/14356007.a22_651; Stig Hjortshoj(1999), pp. 44-45

[4] I.J.E.M.S., Vol.4 (3) 2013: 308-312 ISSN 2229-600X

[5] Wyszecki, Gunter & Stiles, W.S.(2000). Color Science- Concepts and Methods, Quantitative Data and Formulae (2nd ed.). New York: Wiley-Interscience. ISBN 0-471-39918-3; R.W.G Hunt. The Reproduction of Color (2nd ed.). Chichester: John Wiley & Sons, 2004; Mark D.Fairchild. Color Appearance Models Addison Wesley Longman, 1998.

[6] Scribd

[7] http://textilelearner.blogspot.com