

## Effects of Various Buffers and Salt on Color Strength of Reactive Dye Sumifix 3RF

<sup>1</sup>MUHAMMAD ABDUL QADIR, <sup>1</sup>MUHAMMAD RAMZAN ADIL  
AND <sup>2</sup>KARAMAT MAHMOOD\*

<sup>1</sup>Institute of Chemistry, University of the Punjab, Lahore-54590, Pakistan.

<sup>2</sup>Department of Chemistry, Islaymia University, Bahawalpur, Pakistan.

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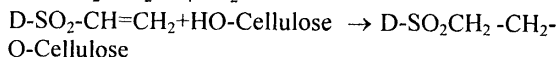
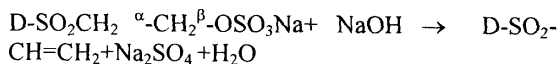
**Summary:** In order to optimize the conditions for reactive dyeing, some variations in the procedure adopted by the industry were taken into consideration. In the present work the effect of buffers like 25 % K<sub>2</sub>HPO<sub>4</sub>, NaHCO<sub>3</sub> + NaOH, KCl + NaOH and Borax + NaOH was studied on the color strength by using Sumifix 3RF yellow (Trichloropyrimidine (TCP) available from Sandoz Corp.) and the results were compared to that of soda ash under the same identical conditions as being employed in textile industry. The effect of salt addition on the fastness of dyes was also studied and is reported in this paper in detail.

### Introduction

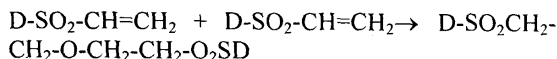
Reactive dyes are colored compounds that contain functional groups capable of forming covalent bonds with active sites in fibers such as hydroxyl groups in cellulose, amino, thiol and hydroxyl groups in wool or amino groups in polyamides. Bond formation between the functional groups and substrate; result in high wet fastness properties. These dyes fundamentally differ from the others that owe to their wet fastness to physical adsorption or mechanical retention. The principal commercial application of reactive dyes is in the dyeing of cellulose, wool and nylon, either individually or compounds of fiber blends. These dyes also have their application in dyeing silk, hair and leather.

The dyeing with reactive dyes is performed in the presence of an alkali such as Na<sub>2</sub>CO<sub>3</sub> and caustic soda. The ionization of OH group in cellulose fibers is accelerated with an increase in pH value, which facilitates their reaction with reactive dyes. On the other hand, reactive dyes also react with water and are increasingly hydrolyzed, which is unfavorable for dyeing. In practical dyeing, therefore it is necessary to adopt proper dyeing condition e.g. the kind and amount of alkali, temperature and time, so that to minimize the hydrolysis of dyes and maximize the reaction of reactive dyes with cellulose fibers and water taking place in the presence of alkali [1].

#### Reaction with Cellulose (Main Reaction)



#### Reaction with Water (Side Reaction)



The main reaction is higher than that of side reaction by several hundred to several thousand times. The presence of reactive dyes in exhaust dye bath waste waters is not good from the economic and environmental point of view. Several workers work on the recovery of these dyes from exhaust solutions, where as our point of view is to utilize as much dye as possible from economic point of view.

Koyuncu, Topacil and Wiesner [2] investigated the factors influencing the flux decline of nanofiltration membranes for the treatment of dye bath wastewaters. Ismail Koyuncu [3] studied on the Comparative Evaluation of the results for the Synthetic and Actual Reactive Dye Bath Effluent Treatment by Nano-filtration Membranes. The experiments were performed using lab-scale membrane system. Permeate quality was appropriate

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\*To whom all correspondence should be addressed.

to reuse permeate in dyeing process again. Pretreatment and neutralization were the parameters which are very important for the recovery of high amounts of salt and water at the permeate stream. Chiou and Li [4] reported that the use of HCl instead of H<sub>2</sub>SO<sub>4</sub> for neutralization increased the NaCl recovery. A batch system was applied to study the adsorption of reactive dye (reactive red 189) from aqueous solutions.

Excess use of salt may possibly cause dye aggregation and lower migration, which leads to un-level dyeing. Insufficient use of salts may cause insufficient color yield to poor fixation. Fujimura [5] and his co-followers in 1997 described the effect of adding methods of neutral and alkali salts on concentration change of dye-bath and dyeing efficiency in dyeing cotton fabric with reactive dyes. This study was with real time dyeing bath detection system. Not only the adding methods, but also the nature of dye used gave big effect on dyeing. Similarly in 1998, Yamaguchi [6] and co-workers introduced the methodology of the dyeing of cross-spun cotton and wool fabric with reactive dyes. Xie [7] and co-workers studied the property of bifunctional reactive dyes with sulfato ethyl sulfone group and monofluorotriazine group for the cellulose of whole-cotton poplin. The dye had better dyeing property for cellulose than that of conventional reactive dyes having only one reactive group. The property applying conditions of the bifunctional reactive dyes for cellulose were, temperature of fixing the dye 50-60°C, dosing of Na<sub>2</sub>CO<sub>3</sub>, 3g/L and 50-60g/L NaCl. The use of sodium edate in dyeing of cotton/wool blend with hetero bi-functional reactive dyes was studied by Reda M. El-Shishtawy [8] *et al.* They reported that the compounds of the present invention exhibit increased Exhaustion (E), Fixation (F) and Efficiency (T) values and provide improvements in terms of reducing spent dyestuff in effluent, increasing dye affinity to the substrate, increasing the efficiency of the dye-substrate covalent reaction, ability to carry out the long-liquor dyeing process at room temperature as well as at elevated temperatures, and simplifying the post dyeing "soaping off process" traditionally associated with fiber reactive dyes. In addition, the compounds of the present invention provide significantly more intense dyeings, *i. e.* greater colour intensity in the dyed substrate, without compromising levelness. Typical Exhaustion Values for the compounds and products herein are greater than 95 %. Typical

Fixation Values for the compounds and products herein are greater than 95 %.

Bredereck *et al.* [9, 10] have shown that bulky molecules and dyes better diffuse into fibers. It is believed that this higher proportion of larger pores and greater longitudinal extent of pores between the microfibrils is responsible for this phenomenon [11].

Some workers [12] applied reactive dyes on various fibres by an exhaustion process, which showed the order of color yield of the order of viscose > Tencel > cotton, although for the smaller reactive dye molecules, the difference between the regenerated fibres was marginal. However under printing conditions, with different series of reactive dyes, the order of color yield was Tencel > viscose > cotton [13].

The present work deals with the study of the effect of exhaustion of Sumifix 3RF yellow on cotton by applying different buffers and salt. The absorption measurements were carried out of the exhaust solution and at the same time color strength was monitored which indicate a direct relationship *i. e.* less absorption of exhaust solution more color strength of the cotton and *vice versa* and discussed in details in this paper.

## Results and Discussion

The results from the tabulated data (Table-1) indicate that with the increase in pH there is an increase in color strength, but this relation is not directly proportional. As a general rule, color strength increases with increase in pH up to some level, after that by increasing further pH, there is no appreciable change in shade-depth. There is an inverse relation between the color strength and the absorbance of exhaust solution at 516 nm. The reason for this is obvious and indicates that the equilibrium between the exhaust solution dye and the color strength is forward.

Every buffer has its own nature and the results of pH of one buffer does not co-inside with the other buffer at the same pH. Most of our developed buffers bring the color strength equal to or above to that of standard soda ash which is generally considered as a standard procedure in our textile industry. Soda ash shows its standard color strength of 1.34 at a pH of 9.98, while a color strength of 1.59

Table-1: Effect of volume change of buffer on color strength.

S. No.	Vol. Of Buffer Used	Absorbance of Exhaust Solution at 516 nm	pH	Color Strength
<i>A. Buffer <math>K_2HPO_4</math></i>				
1	0.1	0.267	8.80	1.12
2	0.2	0.261	9.10	1.40
3	0.3	0.259	9.23	1.43
4	0.4	0.252	9.45	1.50
5	0.5	0.243	9.90	1.52
6	0.6	0.241	10.60	1.55
7	0.7	0.236	10.85	1.59
	Ref Soda	0.235	9.98	1.34
<i>B. Buffer <math>NaHCO_3 + NaOH</math></i>				
1	0.6	0.290	9.36	0.94
2	0.8	0.285	9.66	1.24
3	1.2	0.281	10.20	1.40
4	1.5	0.274	10.79	1.63
5	Ref Soda	0.235	9.98	1.34
<i>C. Buffer <math>KCl + NaOH</math></i>				
1	0.7	0.275	10.13	1.14
2	1.0	0.263	10.47	1.2
3	1.3	0.257	10.83	1.33
4	1.6	0.241	11.07	1.34
5	Ref Soda	0.235	9.98	1.34
<i>D. Buffer Borax + NaOH</i>				
1	0.7	0.288	9.70	1.02
2	0.9	0.287	9.82	1.22
3	1.2	0.276	10.07	1.5
4	1.4	0.271	10.21	1.59
5	1.6	0.265	10.37	1.64
	Ref Soda	0.235	9.98	1.34

was achieved by  $K_2HPO_4$  at a pH of 10.85.  $NaHCO_3 + NaOH$  buffer have best color strength of 1.63 at pH of 10.79. By using buffer of  $KCl + NaOH$ , the maximum color strength of 1.34 was achieved at a pH of 11.07, similarly borax +  $NaOH$  buffer indicate best color strength of 1.64 at 10.37 pH.

An interesting relation was obtained when the amount of salt was increased at the best above mentioned pH of different buffers. A color strength of 2.06 was achieved by using 15 gm of  $NaCl$  and  $K_2HPO_4$  at a pH of 9.10 by  $K_2HPO_4$ , Similarly  $NaHCO_3$  and  $NaOH$  buffer at pH 8.0 represent a shade dept of 2.34, while that of soda ash reference had a maximum color strength of 1.34 by using 15 gm of  $NaCl$  at a pH of 9.98.  $KCl$  and  $NaOH$  buffer at the same  $NaCl$  and pH of 9.40 had a color strength of 1.60 which is considerably lower than that of above sited buffers. Interesting results were obtained by using 15gm of  $NaCl$  at a pH of 8.70 using borax and  $Na_2CO_3$ , had a color strength of 2.29.

## Experimental

### *Effect of Buffers on Color Strength*

5 grams of the half bleached fabric along with 100ml of distilled water was taken in 500 ml

Table-2: Effect of  $NaCl$  on color strength at constant buffer concentration.

S. No.	Amount of $NaCl$ used in gr	Absorbance of Exhaust Solution at 516 nm	pH	Color Strength
<i>A. Buffer <math>K_2HPO_4</math></i>				
1	0.0	0.293	9.10	0.08
2	3.0	0.287	9.10	0.79
3	6.0	0.274	9.10	1.03
4	9.0	0.269	9.10	1.49
5	12.0	0.258	9.10	1.54
6	15.0	0.239	9.10	2.06
	Ref Soda ash	0.235	9.98	1.34
<i>B. Buffer <math>NaHCO_3 + NaOH</math></i>				
1	0.0	0.289	8.90	0.74
2	3.0	0.285	8.90	0.96
3	6.0	0.277	8.90	1.29
4	9.0	0.264	8.90	1.77
5	12.0	0.260	8.90	1.88
6	15.0	0.253	8.90	2.34
	Ref Soda ash	0.235	9.98	1.34
<i>C. Buffer <math>KCl + NaOH</math></i>				
1	0.0	0.289	9.40	0.71
2	3.0	0.286	9.40	0.95
3	6.0	0.281	9.40	1.36
4	9.0	0.269	9.40	1.38
5	12.0	0.260	9.40	1.40
6	15.0	0.239	9.40	1.60
	Ref Soda ash	0.235	9.98	1.34
<i>D. Buffer Borax + NaOH</i>				
1	0.0	0.279	8.70	0.12
2	3.0	0.275	8.70	0.97
3	6.0	0.271	8.70	1.23
4	9.0	0.266	8.70	1.60
5	12.0	0.257	8.70	1.70
6	15.0	0.254	8.70	2.29
	Ref. Soda ash	0.235	9.98	1.34
<i>E. Ref 2 g Soda Ash</i>				
1	0.0	0.238	9.80	0.74
2	5.0	0.235	9.80	1.33
3	10.0	0.232	9.80	1.59
4	15.0	0.211	9.80	1.60
5	20.0	0.196	9.80	1.78

beaker. 10 ml of 1 % Sumifix 3RF Yellow was then added and the contents were heated. 5 g of common salt was added into it at 40°C. The temperature was raised to 60°C in 10-15 min. At 60°C, 2gm of soda ash was added in to the reaction mixture and temperature was maintained at 70-75°C for one hour. After an hour exhaust dyed solution was separated in another beaker for further analysis.

The dyed fabric was rinsed thoroughly with tap water and neutralized with 1 % acetic acid. Neutralized fabric was washed with water at 80-85°C for 10 minutes and finally washed with cold water. The fabric was dried at room temperature and its color strength was noted by using Data Color model SF-600 spectrometer. This fabric was then used for the comparison of color strength (Ref. Soda ash) against various buffers dyed fabric.

The above procedure was then repeated by using following buffers, instead of 2 g soda ash.

- Buffer 1. 25 %  $K_2HPO_4$
- Buffer 2. 2.20 %  $NaHCO_3$ , 4.6 %  $NaOH$  (Mix 20ml  $NaHCO_3$  and 30 ml  $NaOH$  buffer of pH 14).
- Buffer 3. 3.72 %  $KCl$ , 4.45 %  $NaOH$  (Mix 10 ml  $KCl$  and 20 ml  $NaOH$  buffer of pH 14).
- Buffer 4. 2.91 % Borax, 4.45 %  $Na_2OH$  (Mix 10 ml Borax and 10 ml  $NaOH$  buffer of pH 14).

The results obtained by using various amounts of buffers (0.1-1.6 ml) in place of 2 g of soda ash are reported in Table-1.

#### *Effect of Salt addition on Color Strength*

In order to study the effect of salt  $NaCl$  of the color strength the pH of the reaction mixture was held constant by using above sited buffers and the amount of salt was then varied (0-20 g/500 ml), the results thus obtained are reported in Table-2.

#### **Conclusion**

We therefore recommend textile industry to use  $K_2HPO_4$ ,  $NaHCO_3+NaOH$ , or use Borax+ $Na_2CO_3$  and 15 gm of  $NaCl$  at their respective pH. By replacing buffers instead of soda ash they may save 50 % of their reactive dyes and improve their cost of production. In the present work the fixation of the dye with cellulose was excellent. The

homogeneity of the dye on various textile products in real baths needs further studies.

#### **References**

1. A. K. Samanta and D. N. Sharma, Indian Journal of Fibre and Textile Research, **20**, 4, (1995).
2. I. Koyuncu, D. Topacik and M. R. Wiesner, *J. Water Res.*, **38**, 2, (2004).
3. I. Koyuncu, D. Topacik and E. Yuruk, *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances & Environmental Engineering*, **38**, 10, (2003).
4. M. S. Chiou and H. Y. Li, *J. Chemosphere*, **50**, 8 (2003).
5. H. Fujimura, K. Kenkyu, *Senshoku*, **41**, 1, (1997).
6. Yamaguchi, Kazushi (Tech; Cent;Mitsui BASF Dyestuff Co; Ltd; Japan), *Kako Gijutsu (Osaka)*, **998**, **33**, 4 (1998).
7. Xie, F. Xuebao, **17**, 1 (1996).
8. M. Reda, El-Shishtawy, Y. A. Youssef, S. Nahed, E. Ahmed and A. A. Mousa, *J. Dyes and Pigments*, **72**, 1, (2007).
9. K. Bredereck and M. Gruber, *Melliand Textilber.*, **76**, 1 (1995).
10. K. Bredereck and M Gruber, A Utterbach and F Schulz, *Textilveredlung*, **31**, 1, (1996).
11. J. Schurz, *Lenzinger Ber.*, **74**, 37, (1994).
12. S. M. Burkinshaw and N J Willmott, *Dyes Pigm.*, **26**, 129, (1994).
13. J. M Taylor and P. Mears, *Journal of the Society of Dyers and Colourists*, **107**, 64 (1991).