Southeast University Journal of Textile Engineering, Vol. 2, No. 1, January 2022,
ISSN 2709-9598 (Print), 2790-6337 (Online)

The Usage of Egg White instead of Common Salt for Reactive Dyeing of Silk Fabric

Syed Atiqur Rahman[1*], Md. Atiqur Rahman Munna[2] and Md. Nesar Khan[1]
[1]Department of Textile Engineering, Southeast University, Dhaka, Bangladesh
[2]Zaber & Zubair Fabrics Ltd., Noman Group, Tongi, Gazipur, Bangladesh
Corresponding Author: atiqur.rahman@seu.edu.bd

Abstract
This paper describes the coloring method of Mulberry silk fabric with reactive color using egg white as an absorbing agent for 0.5, 1, 2, 3, and 4 shade%. We have also described here the dyeing method of the same Mulberry silk fabric using sodium chloride salt as an absorbing agent for the same shade%. Comparison among samples of corresponding shade% revealed that the samples colored with egg white (as an absorbing agent) are much deeper in color. The tests of wash fastness showed that the silk samples dyed with sodium chloride salt as an absorbing agent are better in (wash) fastness than the fabric samples dyed with egg white as an absorbing agent. The tests of rubbing fastness, however, revealed that the (rubbing) fastness of both varieties of samples is fairly good and comparable to one another.

Keywords: Silk Fabric, Reactive Color, Egg White, Sodium Chloride Salt, Spectrophotometry, Wash Fastness, Rubbing Fastness.

1. Introduction

Silk is a very fine, regular, and translucent natural protein filament extruded from the silkworm. Due to its luster, handle, and draping qualities, silk is known as the Queen of all textile fibers. Silk can be dyed with acid, basic and direct dyes. However, these dyes give poor wash fastness due to the formation of secondary bonds with dye molecules [l]. Recently, different initiatives have been taken to dye silk with reactive colors [2]-[8].

However, similar to cotton coloring with reactive color, a huge quantity of salts is used as an absorbing agent for silk dyeing because silk gains negative charges in water that repel the anionic reactive colors. The salts are still present in the released dye fluid which generates major environmental issues [9].

Several researchers in the world are working to reduce or remove the usage of electrolytes for reactive dyeing. In cellulose, cationic sites are added to raise the dye absorption [10]-[15]. Cationization of cotton and silk by adding polyacrylamide is also presented in different papers [9], [16]-[17]. Like polyacrylamide, egg white protein contains the amide group (- CO-NH-), amino group ($-NH_3^+$), and carboxylate group ($-COO^-$) in the polymer chain structure. Silk also contains these chemical groups in the polymer chain structure. The cationic amino groups, as well as the anionic carboxylate groups, might be engaged in the absorption of anionic reactive colors, thus giving a probability of reactive coloring of silk with egg white as an absorbing agent. Due to this contention, we have accomplished different experiments to identify the coloring probability of silk with reactive color adding egg white as an absorbing matter for several shade%. The outcomes are also contrasted with reactive coloring of silk using sodium chloride salt as an absorbing agent.

2. Materials and Methods

Silk fabric degumming

Degumming was done with the recipe shown below in Table 1. The silk samples were then rinsed and dried.

Table 1. The recipe for degumming silk cloth.

Auxiliaries	Quantity
Sodium carbonate	2.0 g/L

Detergent	2.0 g/L
Temperature	87 ^{o}C
pH	10.6
Time	45 min.
M:L	1:28

Coloring of silk

Silk fabric samples (five) were colored with reactive dye (Remazol Red RR-DyStar) for 0.5, 1, 2, 3, 4 shade%. 30 g/L egg white solution was made in a conical flask. 5% glacial acetic acid was added to the egg solution for proper dissolution. 15%, 20%, 25%, 30%, and 35% egg white solutions (of fabric weight) were utilized as an absorbing reagent. Henceforth, this process will be illustrated as the egg white absorption method. Table 2 shows the dyeing recipe.

Table 2. The recipe for silk fabric dyeing with egg white absorption method.

Shade (%)	0.5	1.0	2.0	3.0	4.0
Egg white %	15	20	25	30	35
EDTA (g/L)	1.0	1.0	1.0	1.0	1.0
Retarding reagent (g/L)	1.0	1.0	1.0	1.0	1.0
Surfactant (g/L)	1.0	1.0	1.0	1.0	1.0
Sodium carbonate (g/L)	7.5	10	12.5	15	17.5
M:L	1:28	1:28	1:28	1:28	1:28
Fixation Temperature (^{o}C)	60	60	60	60	60
Time (min.) (Absorption + Fixation)	35+60	35+60	35+60	35+60	35+60

The process of dyeing: Necessary quantity of water was poured in the pots of the Laboratory dyeing machine. The necessary quantity of egg solution was poured into the pots. Silk samples (1 g) were put in each pot and soaked. Then the necessary quantity of EDTA, retarding reagent, surfactant, and the anti-creasing agent were poured and stirred. The stock solution of Remazol Red RR (1%) was prepared in a conical flask. The necessary quantity of stock solution for each shade% was poured into the pots. The samples were shaken at ambient temperature for 35 minutes for absorption. Then the necessary quantity of sodium chloride was filled to each pot, and heated to 60oC and colored for 60 minutes. After being dyed, the samples were rinsed and dried.

To compare the shade change of samples colored with egg white absorption method with silk samples colored with sodium chloride as absorbing agent (henceforth referred to as sodium chloride absorption method), five samples were once more colored with the same dye for the same shade% of 0.5, 1, 2, 3 and 4. The EDTA, retarding agent, surfactant, sodium carbonate, M: L, absorption, fixation temperature, and needed time were kept the same as for the egg white absorption method. The quantities of sodium chloride salt taken are exhibited in table 3.

Table 3. Quantity of sodium chloride in the salt absorption method.

Shade%	Sodium chloride(g/L)
0.5	30
1.0	40
2.0	50
3.0	60
4.0	70

Spectrophotometry

Color variations between samples dyed with egg white absorption method and sodium chloride absorption method were measured by X-Rite Spectrophotometer (USA).

3. Results and Discussion

Spectrophotometric results of five (0.5, 1, 2, 3, and 4) shade% of silk samples are shown in Table 4. We take fabric samples dyed with the sodium chloride absorption method as the standard. From the table, we can see that all lightness difference, DL* values are negative which indicate that samples dyed with the egg white absorption method are deeper than the standards. The CMC DE values also imply that the samples of the egg white absorption method are much deeper than the standards as shown in Fig. 1.

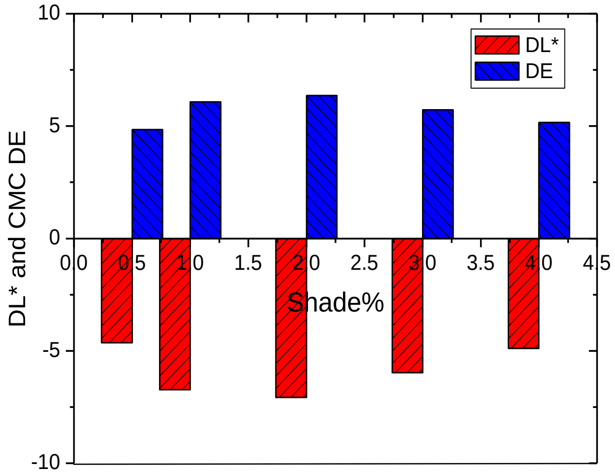

Figure 1. Change of DL* and CMC DE values with the increment of shade (%).

Change of K/S (color strength) values with the change of shade (%) are shown in Figure 2 for both the sodium chloride absorption method and the egg white absorption method. In 530 nm wavelength, the highest K/S values are found. These values are displayed against various shade% for both varieties of samples as shown in Figure 2. For every shade%, samples from the egg white absorption method showed higher K/S values.

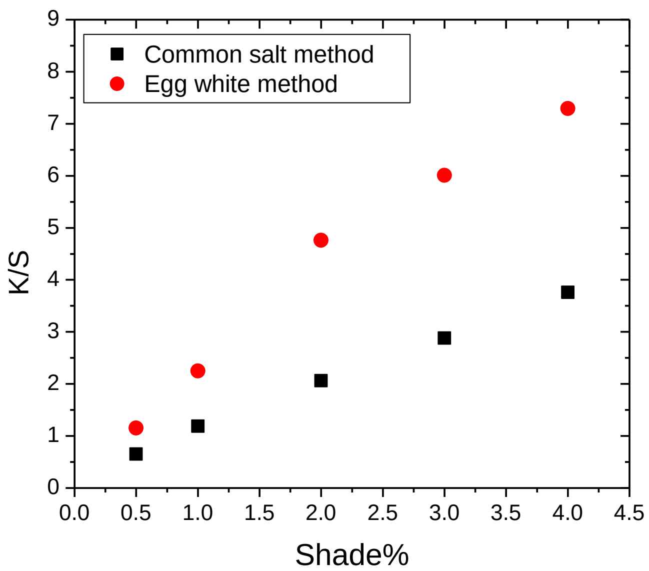

Figure 2. Change of K/S with the increment of shade (%).

Table 4. Spectrophotometric results of several shade%.

Shade%	Illuminant	DL*	Da*	Db*	DC*	DH*	CMC DE
0.5	D65	-4.64	8.49	1.52	8.02	3.17	4.84
1.0	D65	-6.73	10.69	3.41	10.05	5.00	6.08
2.0	D65	-7.07	11.10	4.99	10.49	6.16	6.36
3.0	D65	-5.98	8.85	6.15	8.28	6.90	5.73
4.0	D65	-4.89	8.04	5.96	7.59	6.53	5.16
0.5	F02	-4.08	6.52	1.98	5.78	3.61	4.50
1.0	F02	-6.13	8.06	3.72	7.07	5.37	5.69
2.0	F02	-6.60	8.48	4.97	7.50	6.35	6.05
3.0	F02	-5.56	6.69	6.11	5.68	7.06	5.65
4.0	F02	-4.52	6.26	5.83	5.39	6.64	5.14

The protonated amino ($-NH_3^+$) group of amino acids of egg white form ionic bonds as they appear close to the carboxylate group ($-COO^-$) of silk in the aqueous medium (as shown in Figure 3), thus drawing the negative ions of dye molecules and make a covalent bond with silk at 60^{o}C as shown in Figure 4. Again, the ionic bonds between different amino acids within egg white protein may also react with anions of dye molecules and make a covalent bond in an alkali medium at 60^{o}C. These colored amino acids form hydrogen bonds through polar peptide groups (-CO-NH-) with other peptide groups of silk [18]. Thus, the silk samples dyed with the egg white absorption method looked deeper in comparison with that of silk dyed with the sodium chloride absorption method.

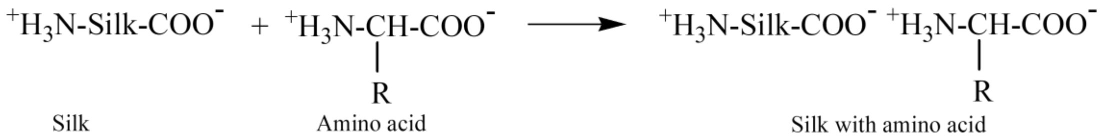

Fig 3: Reaction between silk and amino acid

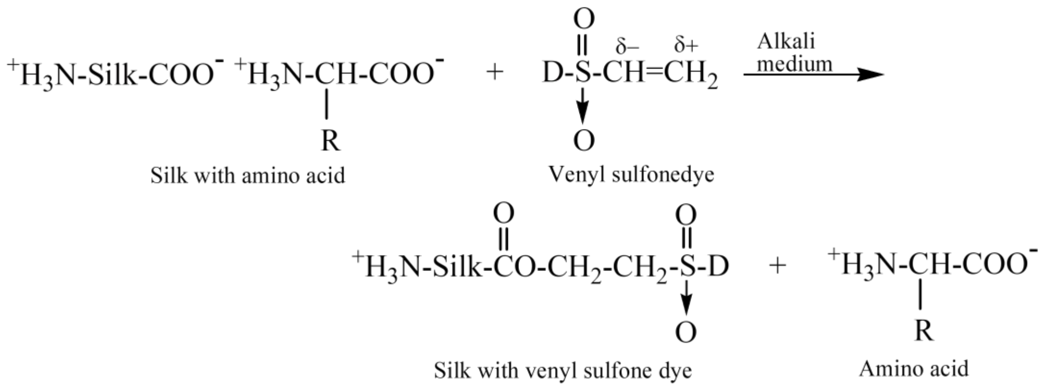

Fig 4: Reaction possibility between amino acid added silk and vinyl sulfone dye

Table 5. Wash fastness results.

	For samples of the sodium		For samples of the Egg white absorption method	
	3% depth	**4% depth**	**3% depth**	**4% depth**
Color change	4	4	2-3	2
Staining (di-acetate)	4-5	4-5	4	4
Staining (cotton)	3-4	3-4	3	3
Staining (polyamide)	4-5	4-5	4-5	4-5
Staining (polyester)	5	5	5	5
Staining (acrylic)	4-5	4-5	4-5	4-5
Staining (wool)	4-5	4-5	4-5	4-5

Wash Fastness Test

The wash fastness of the silk samples dyed with the egg white absorption method and the sodium chloride absorption method are shown in Table 5 for comparison. The silk samples colored with 3% and 4% shades were assessed (ISO 105 C60:1994 process) for the wash fastness test. ECE (4 g/L) reference detergent and sodium perborate (1 g/L) solution were used to test this. The grey scale rating shows 4 for both 3% and 4% shades for samples dyed with the sodium chloride absorption method. The grey scale rating shows 2-3 for 3% shade and 2 for 4% shade for samples dyed with the egg white absorption method. These results also implicate that the colored amino acids form hydrogen bonds through polar peptide groups with other peptide groups of silk amino acids. The color staining on multifiber has also been assessed. The grey scale rating results are found to be nearly identical for both varieties of samples (Table 5).

Table 6. Rubbing fastness results.

Shade%	**For samples of the sodium chloride absorption method**		**For samples of the Egg white absorption method**	
	Dry	Wet	Dry	Wet
3	4-5	4	4-5	4
4	4-5	4-5	4-5	4

Rubbing Fastness Test

The rubbing fastness of the silk samples dyed with the egg white absorption method and the sodium chloride absorption method are shown in Table 6.

Here both dry and wet fastness of rubbing is shown. 3% and 4% shade samples were measured (ISO 105x12:1993 process) to test the rubbing fastness. The dry rubbing fastness is rated as being pretty good (grey scale rating 4-5) for both 3% and 4% shades. The wet fastness test also yielded good results (grey scale rating of 4) for both 3% and 4% shades.

4. Conclusion

We have successfully dyed the silk fabrics with vinyl sulfone reactive dye using egg white as the absorbing agent. The comparison showed that silk samples dyed with the egg white absorbing agent are much deeper than the corresponding shade% of the sodium chloride salt absorbing agent. Thus, we can readily dye the silk fabric using egg white as an absorbing agent except using sodium chloride salt because sodium chloride salt increases the salinity of water and soil as it is harmful to the environment. However, the wash fastness of the sodium chloride absorption method is better than the egg white absorption method. The rubbing fastness for both the sodium chloride absorption method and the egg white absorption method are found quite good and comparable to each other.

REFERENCES

[1] I. A. Bello, A.-R.A. Giwa, A. A. Olajire, and M. A. Oladipo, Correlation between thermodynamic parameters and % exhaustions of some carboxylated reactive dyes on silk, Chemistry and Materials Research. 3(9),pp 1-5,2013.

[2] D. Agarwal, K. Sen, and M. L. Gulrajani, Application of heterobifunctional reactive dyes on silk," Coloration Technology. 112,pp 10-16, 1996, doi:10.1111/j.1478-4408.1996.tb01748.x

[3] D. Agarwal, K. Sen, and M. L. Gulrajani, Dyeing of silk with bifunctional reactive dyes: the relationship between exhaustion and fixation, Coloration Technology. 113,pp 174-178,1997, doi:10.1111/j.1478-4408.1997.tb01893.x

[4] P. G. H. Barker and A. Johnson, The application of monochlorotriazinyl reactive dyes to silk, Coloration Technology. 89,pp 203-208,1973, doi:10.1111/j.1478-4408.1973.tb03148.x

[5] S. M. Burkinshaw and M. Paraskevas, The dyeing of silk: Part 3 the application and wash-off of modified vinyl sulfone dyes, Dyes and Pigments. 88,pp 212-219,2011, doi:10.1016/j.dyepig.2010.06.010

[6] S. M. Burkinshaw and M. Paraskevas, The dyeing of silk: Part 4 heterobifunctional dyes, Dyes and Pigments. 88,pp 396-402,2011, doi:10.1016/j.dyepig.2010.08.018

[7] D. M. Lewis, Developments in the chemistry of reactive dyes and their application processes, Coloration Technology. 130(6),pp 382-412, 2014, doi:10.1111/cote.12114

[8] R. Rehman, S. Mahmud, M. A. Habib and A. Islam, A revolution of silk dyeing with FL based cotton- reactive dyes, International Journal of Textile Science. 4(2),pp 42-52,2015, doi: 10.5923/j.textile.20150402.03

[9] S. A. Rahman, Dyeing of silk fabric with reactive dye using polyacrylamide as exhausting agent, SSRG International Journal of Polymer and Textile Engineering. 7(1),pp 1-5,2020, https://doi.org/10.14445/23942592/IJPTE-V7I1P101

[10] G. E. Evans, J. Shore, and C. V. Stead, Dyeing behavior of cotton after pretreatment with reactive quaternary compounds, Coloration Technology. 100, pp 304-315,1984, doi:10.1111/j.1478-4408.1984.tb00946.x

[11] P. J. Hauser and A. H. Tabba, Improving the environmental and economic aspects of cotton dyeing using a cationised cotton, Coloration Technology. 117,pp 282-288,2001, doi:10.1111/j.1478-

4408.2001.tb00076.x

[12] Y. A. Youssef, Direct dyeing of cotton fabrics pre-treated with cationising agents, Coloration Technology. 116(10),pp316-322,2006, doi:10.1111/j.1478-4408.2000.tb00008.x

[13] X. P. Lei and D. M. Lewis. Modification of cotton to improve its dyeability. Part3 – polyamide-epichlorohydrin resins and their ethylenediamine reaction products, Coloration Technology. 106,pp 352-356, 1990, doi:10.1111/j.1478-4408.1990.tb01231.x

[14] M. N. Micheal, F. M. Tera, and S. F. Ibrahim, Effect of chemical modification of cotton fabrics on dyeing properties, Journal of Applied Polymer Science. 85, pp 1897-1903,2002, doi:10.1002/app.10740.

[15] T. S. Wu and K. M. Chen, New cationic agents for improving the dyeability of cellulose fibers. Part 2-pretreating cotton with polyepichlorohydrin-amine polymers for improving dyeability with reactive dyes, J. Soc. Dyers Colourists. 109,pp 153-158,1993, doi:10.1111/j.1478-4408.1993.tb01547.x

[16] R. Nithyanandan and M. S. S. Kannan, Salt & alkali free reactive dyeing on cotton, Fibre2fashion.com. 2007, Avaible From: https://www.fibre2fashion.com/industry-article/1661/salt--alkali-free-reactive

[17] S. A. Rahman, A.B.M. Foisal, and A. Sarker, Treatment of cotton fabric with cationic polyacrylamide – an initiative to salt free reactive dyeing, SEU Journal of Science and Engineering. 9(1-2),pp 18-22,2015.

[18] E. P. G. Gohl, and L. D. Vilensky,The protein fibers, Textile science. pp 77,1987.