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A Study on Usual and Nano Pretreated Dyeing of Cotton Knit Fabric

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Abstract

The purpose of this work is to find out a comparison between regular and nano pretreated dyeing of single jersey cotton knit fabric. The focus is on the shade difference, spectrophotometric evaluation, wash and rubbing fastness while a cotton fabric is dyed followed by both conventional and nano pretreated process. It is found that the results of this study are comparable between dyed fabrics of two processes. The nano pretreated fabric was collected from the dyeing floor of Esquire Knit Composite LTD at Kanchpur, Narayanganj. It was pretreated by Nano Dye machine (KUSTERS dye pad, Beninnger, Germany) and the rest of the works were done at the wet processing laboratory, Department of Textile Engineering in Southeast University in Bangladesh.

Keywords: Conventional Pretreatment, Nano Pretreatment, Spectrophotometric Evaluation, Nano- Dye ing Machine.

1. Introduction

An enormous amount of salt is used in the normal dyeing of cotton, which causes many sustainability problems. After the conventional dyeing of cotton the dissolved salts in the effluent are combined back into a solid by adding an additional chemical to the water treatment plant. During the binding process unintended toxic chemicals in the effluent are trapped and toxic sludge is created. The toxic sludge is then removed from the water treatment plant which results into a complex and massive solid waste problem. Many researchers are working to reduce this problem and working on the pretreatment steps of cotton knit dyeing process by cationizing the cotton fiber and dyeing it without the addition of salt [1-11].

In conventional reactive dyeing process when raw cotton is submerged in water, it takes on a negative charge. Dyestuffs have negative charges when submerged in water. Both having negative charges repel each other, making the bonding difficult. On the other hand, in nano-dye pretreatment process raw cotton is modified by cationic agents and is turned into positive charges when submerged in water.

The positive cotton charges and negative dyestuff charges attract each other, making the bonding both stronger and easier [12]. The nano-dye process makes dyeing cotton and cotton blend textiles less energy intensive. It saves both salt and fresh water with its highly efficient dyeing and bonding process. Fewer chemicals are required to recycle the effluent at a low cost. No salt technology and low pollution facilitate zero discharge in water treatment plants to open the gateway for a "closed-loop" water model for textile dye plants, saving trillions of fresh water every year. In this work, single jersey grey cotton knit fabric is pretreated in regular method and Nano pretreated method by using Nano-dye machine, then dyed with reactive dye with same recipe and compared

the color differences and quality parameters such as wash and rubbing fastness.

2. Materials and Methods

The cotton single jersey Knit fabric was pretreated by Nano dye machine (KUSTERS dye pad, Beninnger, Germany). The Chemicals used for Nano pretreatment were Rucogen WBL used as a scouring and wetting agent, NaOH solution (45%) used as scouring agent, Reagens 65 used as cationizing agent. Figure 1 shows the Nano-dye KUSTERS, Benninger, pretreatment machine.

Figure 1. Nano-dye Machine for pretreatment of cotton fabric.

2.1 Nano pretreatment procedure

In the bulk production Nano pretreatment process is like a cold pad batch dyeing system of woven fabric. There is an immersion tank and squeezing rollers for creating pressure onto the wet fabric as well as some rollers for the purpose of fabric input and output. In the immersion tank, chemicals and auxiliaries are mixed and fabric is passed through the tank and to be wetted. Then in a winder the fabric is wounded after squeezing and also covering by a plastic cover. After that the fabric is rotated continuously for 4-6 hours depending on fabric construction. The fabric is then ready for dyeing without salt.

2.2 Dyeing procedure

In this comparative study Nano pretreated and regular scoured bleached fabric samples were dyed with reactive dye (Bezaktiv Red S 3B, Bezaktiv Blue SGLD and Bezaktiv Yellow S3R). Table 1 shows the combined shade of 1%, 2% and 3%. The samples were dyed according to the dyeing recipe in the laboratory dyeing machine.

2.3 Spectrophotometric evaluation

The Spectrophotometric evaluation was done by the color measuring instrument Spectrophotometer (X-Rite) color
iMatch (Version 9.4.10, USA).

2.4 Color fastness to wash

Color fastness to wash was done by the ISO 105 C03 method. Single test of 10cm x 4cm with a 4 g/L European color fastness establishment (ECE) reference detergent and 1g/L sodium perborate solution were used in machine to wash at 40 degree Celsius.

2.5 Color fastness to rubbing

This test was designed to determine the degree of color which may be transferred from the surface of a colored fabric to a specific test cloth for rubbing (wet & dry), Method : ISO 105 x 12 and Crock meter was used for rubbing test.

Table 1. The dyes and chemicals are used in this work for various shade percentages.

	Shade 1%		Shade 2%		Shade 3%	
	Conventional Pre-treated	Nano pre-treated	Conventional Pre- treated	Nano pre-treated	Conventional Pre-treated	Nano pre-treated
Bezaktiv Red S3B	0.8%	0.8%	1.6%	1.6%	2.4%	2.4%
Bezaktiv Blue SGLD	0.1%	0.1%	0.2%	0.2%	0.4%	0.4%
Bezaktiv Yellow S3R	0.1%	0.1%	0.2%	0.2%	0.4%	0.4%
Glauber Salt (g/L)	20	N/A	40	N/A	60	N/A
Soda ash (g/L)	10	10	18	18	20	20

3. Results and Discussion

3.1 Spectrophotometric evaluation

The spectrophotometric evaluation of the color differences of the Nano pretreated dyed fabric samples were compared to the traditional pretreated dyed fabric samples which were used as the standard samples and deviations were measured by CIE L*a*b* color system with ΔE or DE values. The light sources D65, A and F02 were used.

The lightness (DL), saturation (DC) Tone (DH), CIE lab value for reference (Da and Db) and Total color deviation (DE) were evaluated among the samples of 1%, 2%, 3% for both pretreated and dyed fabric samples. The three coordinates of CIELAB represent the lightness of the color (L* = 0 point toward black and L* = 100 indicates diffuse white,Da* negative values indicate
green while positive values indicate red and Db* negative values indicate blue and positive values indicate yellow.

Table 2. The spectrophotometric evaluation of nano pretreated and dyed fabric samples.

Samples	Obs.	DL*	Da*	Db*	Dc*	DH	DE	MI
Nano 1%	D_{65}	-10.18	6.55	1.34	6.28	2.31	5.66	2.05
	A	-9.19	6.66	3.13	6.88	2.63	5.57	
	F02	-10.49	4.83	1.09	4.52	2.03	5.44	
Nano 2%	D_{65}	-7.71	3.06	3.41	2.66	3.73	4.62	1.48
	A	-7.03	3.55	4.53	4.06	4.08	4.77	
	F02	-7.97	2.03	3.02	1.51	3.48	4.66	
Nano 3%	D_{65}	-7.49	1.28	3.14	1.05	3.23	4.41	0.97
	A	-7.04	1.81	3.83	2.43	3.47	4.36	
	F02	-7.86	0.60	2.72	0.31	2.77	4.50	

It was found that with the increment of shade percentages the total DE, MI (Metamerism Index), The lightness (DL*), saturation (DC*), Hue (DH) and CIE lab value for references (Da* and Db*) are decreasing. The trend shows that in terms of deeper

shade percentages the total colour deviations (DE) and all other parameters are being nearer to the standard fabric samples under all the light sources. Table 2 shows
the spectrophotometric evaluation of Nano pretreated dyed fabric samples as compared with the regular pretreated dyed fabric samples.

Figure 2 shows the bar diagram of Nano pretreated and dyed with 1% shade as compared with the regular pretreated dyed fabric samples under different light sources such as D65, A and F02. It is seen that the DL* values are negative which indicates that the Nano pretreated and dyed fabric samples are darker than the conventional pretreated and dyed fabric samples. Similarly the other values, i.e. Da*, Db*, Dc*, DH values are all positive which mean that the samples of Nano pretreated and dyed with 1% shade are redder, yellower, more bright and yellowish in tone. The overall colour deviations are DE 5.66, 5.57 and 5.44 under D65, A and F02 light sources respectively. The metamerism index (MI) is 2.05.

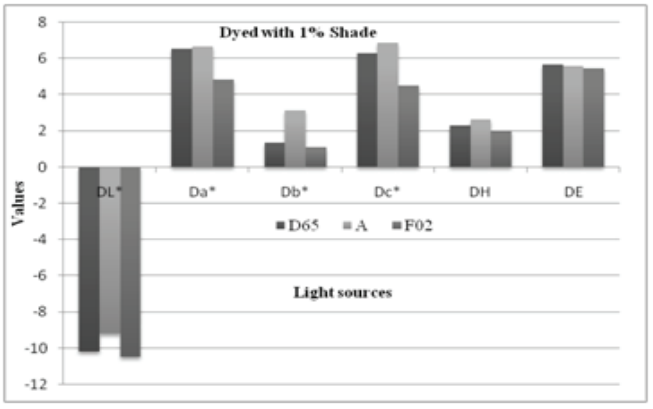

Figure 2. The bar diagram of Nano pretreated and 1% dyed fabric sample under different light sources.

Figure 3 displaysz the bar diagram of Nano pretreated and dyed with 2% shade as compared to the regular pretreated dyed fabric samples under different light sources such as D65, A and F02. It is seen that the DL* values are negative which indicates that the nano pretreated and dyed fabric samples are darker than the conventional pretreated and dyed fabric samples. Similarly the other values, i.e. Da*, Db*, Dc*, DH values are all positive which mean that the samples of Nano pretreated and dyed with 2% shade are redder, yellower, more bright and yellowish in tone. The overall colour deviations DE are 4.62, 4.77 and 4.66 under D65, A and F02 light sources respectively. The metamerism index (MI) is 1.48.

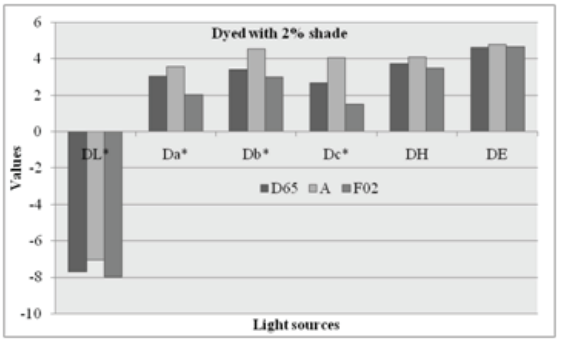

Figure 3. The bar diagram of Nano pretreated and 2% dyed fabric sample under different light sources.

Figure 4 demonstrates the bar diagram of Nano pretreated and dyed with 3% shade as

Table 3. The grey scale rating of staining of regular, Nano pretreated and dyed fabric samples.

Samples	Poly ester	Cotton	Nylon	Acrylic	Acetate	Wool
Regular 1%	5	4-5	4-5	4-5	4-5	4-5
Nano 1%	5	4-5	5	4-5	5	4-5
Regular 2%	5	4-5	4-5	4	4-5	4
Nano 2%	5	4-5	5	5	5	5
Regular 3%	5	4-5	4-5	4-5	4-5	4-5
Nano 3%	5	4-5	5	4-5	5	4-5

compared to the regular pretreated dyed fabric samples under different light sources such as D65, A and F02. It is seen that the DL* values are negative which indicates that the Nano pretreated and dyed fabric samples are darker than the conventional pretreated and dyed fabric samples. Similarly the other values , i.e. Da*, Db*, Dc*, DH values are all positive which mean that the samples of Nano pretreated and dyed with 3% shade are redder, yellower, more bright and yellowish in tone. The

overall colour deviations DE are 4.41, 4.36 and 4.50 under D65, A and F02 light sources. The metamerism index (MI) is 0.97.

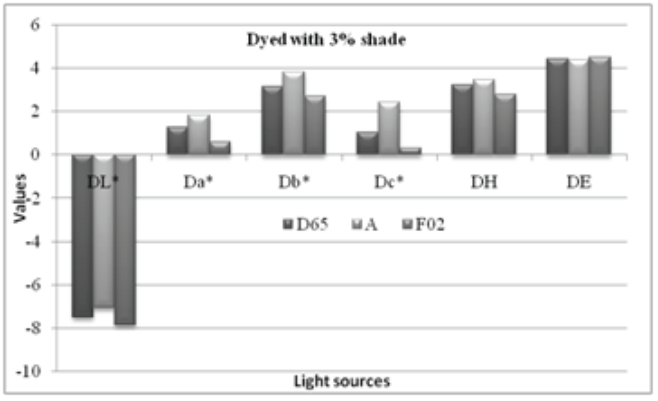

Figure 4. The bar diagram of nano pretreated and 2% dyed fabric sample under different light sources.

3.2 Color fastness to wash

Table 3 shows the grey scale rating of the color staining of multifiber fabric from both the pretreated and dyed fabric samples. The wash fastness results of different shade percentages are such as 1%, 2% and 3% dyed fabric samples followed by both regular and Nano pretreatment were observed that the difference of the both fabric samples were less and the results were very good in all the cases.

3.3 Color fastness to rubbing

Table 4 shows the grey scale rating of the color staining of on bleached fabric after rubbing of dyed samples.. The dry and wet rubbing fastness results of 1% dyed of both fabric samples were same results with values of 4-5 and 4 respectively. The dry rubbing results of 2% shade were 4-5 for regular pretreated and dyed fabric samples and 3-4 for Nano pretreated and dyed fabric samples and the wet rubbing results were 4-5 and 4 respectively. Similarly the results of 3% shade were from good to very good.

Table 4. The rubbing fastness results of regular and Nano pretreated and dyed fabric samples.

Samples	Dry Rubbing	Wet Rubbing
Regular 1%	4-5	4
Nano 1%	4-5	4
Regular 2%	4-5	4-5
Nano 2%	3-4	4
Regular 3%	4	4-5
Nano 3%	3-4	4

4. Conclusion

From the above discussions, it can be revealed that the Nano pretreated dyed fabric samples are darker than the traditional pretreated dyed fabric samples, which means that the dye uptake of the Nano pretreated samples are more than the usual pretreated samples. In all the cases, the Nano pretreated samples are redder and yellower than the conventional pretreated dyed samples. The wash and rubbing fastness of the both pretreated and dyed samples are also very good. It can be concluded that as the Nano pretreated dyed fabric samples are darker and the tone is always redder and yellower, so by decreasing the shade percentage in nano pretreated dyed fabric samples, the dye consumption can also be reduced. By implementing Nano pretreatment process salts and energy consumptions can be saved as well as the dye consumption can be less used.

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