A COMPARATIVE STUDY BETWEEN ONE BATH DYEING METHOD FOR POLYESTER COTTON (PC) BLENDED FABRIC OVER CONVENTIONAL TWO BATH DYEING METHOD

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Abstract

Dyeing of Polyester Cotton (PC) blended knit fabrics is done by two different types of dyestuff namely reactive dyes for cotton part and disperse dyes for polyester part in conventional two bath method where after polyester part dyeing the liquor is drained and then cotton part is dyeing. This research work has been carried out on finding the possibility of dyeing this type of fabric in single bath method without drain the liquor after enzyme bio-polishing and polyester part dyeing. No extra chemicals are needed in one bath dyeing method. There is in significant change of fastness properties than conventional two bath method. This one bath dyeing method saves the consumption of water with energy and time. In this research work, it was found that in one dyeing method cost and time are saved to conventional two bath dyeing method.

Keywords: PC blend fabric, one bath dyeing, two bath dyeing, CMC value, color fastness, cost analysis

Introduction

In worldwide polyester cotton (PC) blended knit fabric is widely used due to their good aesthetic properties. 100% cotton knit fabric shows lower strength and crease resistance with higher absorbency where as 100% polyester fabric shows lower absorbency with higher strength and crease resistance. But PC blended fabric shows moderate strength and moderate crease resistance with an average absorbency. However, there are some requirements when dyeing is carried out of this type of fabric as the two fibres show two different types of characteristics. Cotton fibres show hydrophilic characteristics where as polyester fibres show hydrophobic characteristics. For this reason, it is impossible to dyeing polyester cotton blended fabric by using same dyestuffs. Conventionally polyester cotton blended fabric dyeing was carried out in separately using disperse and reactive dye with adequate control of temperature. In HT dyeing method polyester part is dyeing at 130^0C temperature and cotton part is dyeing at 60^0C-80^0C temperature. But it has been needed to drain the liquor of disperse dye after polyester part dyeing. Then in new liquor cotton part is dyeing by using reactive dye. It is possible to dyeing the cotton parts in the same liquor of disperse dyes as the polyester part absorbs most of the dye molecules from the liquor and there is no affinity of cotton fibres to disperse dyes. The one-bath dyeing process uses a separated high P^H and low temperature reactive fixation step after the high temperature, low P^H disperse dyeing to avoid a high rate of hydrolysis of both disperse and reactive dyes under high temperature, or high P^H dyeing environment. This one bath dyeing method requires shorter time period and less consumption of water compared to conventional two bath method. One bath dyeing process is eco-friendly process than two bath process as the water consumption is less means less waste water.

Materials and Methodology

- **PC blended knit fabric**: PC is blended fabric made of both synthetic polyester and natural cotton where polyester percentage is higher than cotton percentage with a blend ratio of 2:1, 3:2 or 4:1. In this research 2:1 blending ratio of PC fabric is used having 160 GSM of plain single jersey structure.
- **Disperse dye**: Normally disperse dyes are low molecular weight, non-ionic mono azo and anthraquinone derivatives. Hydroxyethylamino groups (NH-CH_2-CH_2-OH) and their substitute is present in disperse dyes. Mechanically bonding is created between disperse dyes and polyester fibres.
- **Reactive dye**: The molecular structures of reactive dyes resemble those of acid and simple direct cotton dyes, but with an added reactive group. Typical structures include the azo (a), anthraquinone (b), triphenodioxazine. The key structural features of a reactive dye are the chromophoric system, the sulphonate groups for water solubility, the reactive group, and the bridging group that attaches the reactive group either directly to the

chromophore or to some other part of the dye molecule. The chromophoric system consist of azo, quinoid carbonyl, nitroso, nitro-group, carbonyl, vinyl group (-N=N-, C=O, -NO, -NO2, >C=O, -C=C-) etc unsaturated group. Each of these structural features can influence the dyeing and fastness properties.

- Anti creasing agent
- Detergent
- Sequestering agent
- Antifoaming agent
- Stabilizer
- Hydrogen peroxide
- Peroxide killer
- Enzyme
- Buffer solution
- Dispersing agent
- Leveling agent
- Softener
- Gluber salt
- Soda ash
- Acetic acid

Scouring & Bleaching Combined Process:

Scouring is done to remove impurities present on the fabric such as oil, wax, lubricants, dirt, surfactents, residual tints etc. where as bleaching is done to remove the natural color from the fibres. Typically NaOH is used at high temperatures for saponify and emulsify impurities in scouring process. For bleaching H_2O_2 and stabilizer are used to remove the natural color from fibres. H_2O_2 produces per hydroxil ions with the help of stabilizer which can remove the natural color from the fibre.

Reciepe:

Table 1: Reciepe of Scouring & Bleaching, Hot wash and Neutralization

Scouring & bleaching		**Hot wash**		**Neutralization**	
Detergent	1 gm/l	Peroxide killer	0.5 gm/l	Acetic acid	1 gm/l
Anti creasing agent	1 gm/l				
Sequestering agent	1 gm/l	M:L	1:8	M:L	1:8
Wetting agent	1 gm/l				
Antifoaming agent	1 gm/l				
NaOH	5 gm/l				
H_2O_2	2.5 gm/l				
Stabilizer	1 gm/l				
M:L	1:8				

Process

Scouring and bleaching is done combindly in 98^{0}C for 1 hour with the necessary chemicals menthioned in the table 1. The process for scouring and bleaching is shown in figure 1.

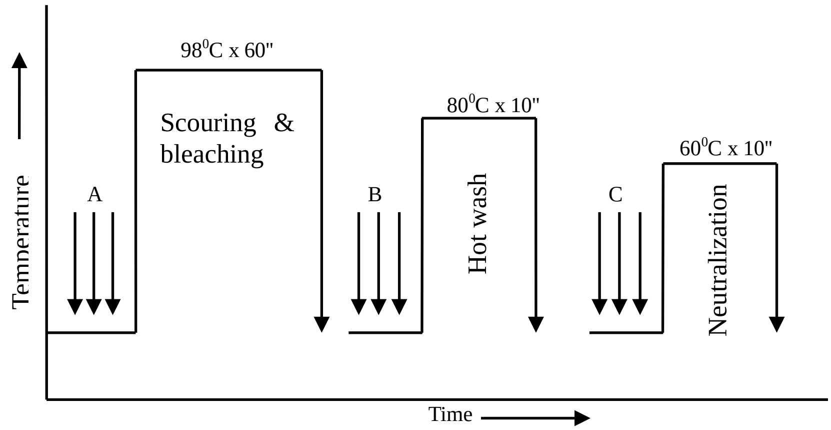

Figure 1: Scouring & bleaching combined process curve
A = All chemicals of scouring bleaching dosing at room temperature
B = Peroxide killer dosing at room temperature
C = Acetic acid dosing at room temperature

Enzyme Bio-polishing and Dyeing Process

Scoured and bleached fabric is subjected to enzyme to remove the fuzzy or projecting from fabric surface. After enzyme bio-polishing polyester part of PC blend fabric is dyeing with disperse dye by the help of dispersing agent at 130^{0}C temperature. After polyester part dyeing cotton part of PC blend fabric is dyeing with reactive dye by the help of salt and soda at 60^{0}C-80^{0}C temperature.

Recipe

Table 2: Recipe for enzyme wash, Polyester & cotton dyeing, Soaping

Enzyme wash		Polyester part dyeing	
Enzyme	0.5 gm/l	Disperse dye	As per shade %
Buffer	0.5 gm/l	Dispersing agent	1gm/l
Acetic acid	For pH 4.5	Sequestering agent	1gm/l
M:L	1:8	M:L	1:8

Cotton part dyeing		Soaping	
Reactive dye	As per shade%	Detergent	1 gm/l
Sequestering agent	1 gm/l	Acetic acid	1gm/l
Anti creasing agent	1 gm/l	M:L	1:8
Labelling agent	1 gm/l		
Acetic acid	For pH 6		
Gluber salt	Depends on shade%		
Soda ash	Depends on shade%		
M:L	1:8		

Conventional Two Bath Process

In conventional process of PC blend fabric dyeing, liquor is drained after enzyme bio polishing. Then polyester part dyeing of PC fabric is done and the liquor is drained again. Cotton part is dyeing after the polyester part dyeing. The above process for conventional two bath method is shown in the figure 2 with the help of chemicals listed in the table 2.

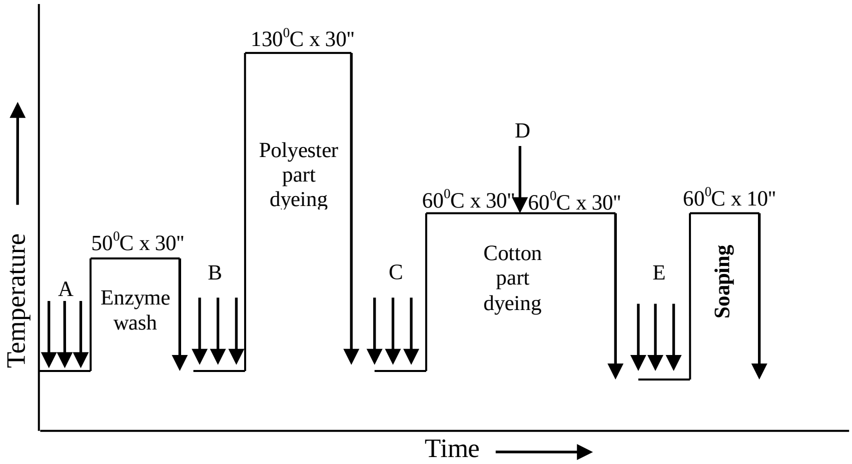

Figure 2: Two bath PC fabric dyeing method with enzyme wash

A = Enzyme and buffer dosing at room temperature
B = Dye and all chemicals dosing at room temperature
C = Dye and all chemicals without soda dosing at room temperature
D = Soda dosing at 60^{0}C temperature
E = Detergent and acetic acid dosing at room temperature

One Bath Dyeing Process

In one bath process of polyester part dyeing all the existing chemicals are used as like two bath method mentioned in table 2. The problems of draining the liquor after enzyme wash and polyester part dyeing is removed by one bath dyeing method. The process is run by follow the figure 3.

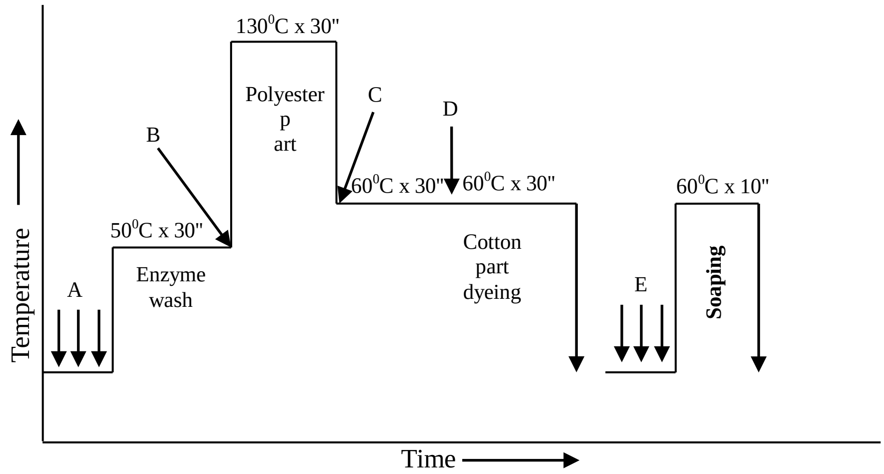

Figure 3: One bath dyeing method with enzyme wash

A = Enzyme and buffer dosing at room temperature

B = Dye and all chemicals dosing at 50^0C temperature

C = Dye and all chemicals dosing without soda at 60^0C temperature

D = Soda dosing at 60^0C temperature

E = Detergent and acetic acid dosing at room temperature

CMC Value Measurement

Color Measurement Committee (CMC) value is measured for determining pass or failure of a sample. The color of an object depends on the relative quantity of the light reflected or transmitted at different wavelengths within the visible range (400-700 nm). Spectrophotometric measurements provide the numerical description of the reflection or transmission of light by an object.

The result was analyzed by a CIELAB color system. CIE (Commission Internationale de I'Eclairage) color coordinates include color qualities in terms of L* (lightness and darkness), a* (redness and greenness), b* (yellowness and blueness), C* (chroma) and H (hue angle, the angle of the anticlockwise movement from an axis of +a* direction, that is, +a*=00, +b*=900, -a*=1800, and –b*= 2700). The ΔE values of differently dyed fabrics. ΔE value contains the information of color depth, shade, and the hue of a sample. ΔE value is calculated by using the CIE L*, a*, and b* values with the equation;

ΔE = (ΔL*2 + Δa*2 + Δb*2)1/2

Where ΔL*, Δa*, and Δb* values were the difference between L*, a*, and b* values of a pair of color standard and sample.

The values of C* and H are calculated from a* and b* as;

C* = (a*2 + b*2)1/2

H = tan-1(b*/a*)

The larger the ΔE value, the greater would be the color difference between this pair of color standard and sample. The experiment was carried out under light source of D 65 at 100 and the outputs showed satisfactory results remarked as "pass" for pairs of samples having a value of CMC DE value less than 1.00 will be an acceptable match.

Testing of Color Fastness to Wash

The resistance of a colored materials to change its color against wash is called color fastness to wash. Color fastness to wash of different sample has been done by following the method ISO 105 C03. This process is carried out in a stainless steel container putting on a Wash-wheel with a thermostatically controlled water bath and rating speed of 40±2 rpm. SDC multifibre DW is used to measure the color staining of sample. D 65 light source is used to evaluation of result with using color change grey scale and color staining grey scale.

Testing of Color Fastness to Rubbing

Rubbing fastness is the resistance of fading of dyed textiles when rubbed against a rough surface. This test is designed to determine the degree of color which may be transferred from the surface of a colored fabric to a specify test cloth for rubbing (which could be dry and wet). EN ISO 105×12 method is followed for testing color fastness to rubbing. In this test the dyed specimens are rubbed 10 times using crockmeter which has a weighted finger covered with piece of desized and undyed cotton cloth. For wet rubbing the cotton cloth is wetted out by distilled water before being rubbed on the dyed sample. Evaluation has been done under D 65 light source with using color change grey scale.

Testing of Color Fastness to Perspiration:

Continuous contact with the human perspiration also affects the fastness of some the dyed fabrics. In fact the perspiration is found to be either slightly alkaline or acidic in nature. ISO 105 E02 method is followed to conducting this test in alkaline solution. SDC DW multifibre is used for measuring color staining. Thoroughly wetting one composite specimen in the solution at pH 8 at liquor ratio 50:1 and allowing it to remaining in the solution for 30 minute at room temperature. Wiping of excess liquid from the specimen placed it between two plates of the perspirometer under a pressure 12.5 KPa. Then the perspirometer is placed in an oven at 37ºC for 4 hours. Evaluation is done by color change grey scale and color staining scale in a light box under D65 light source and rated from 1 to 5.

Results & Discussion

CMC Pass/Fail Values

CMC pass/fail values can be determined by spectrophotometer. If the CMC DE value is 1 or greater than the sample is failed. CMC DE values of the one bath dyeing method is calculated with respect to the two bath dyeing method sample. The CMC DE values for each color are shown in the table 3.

Table 3: CMC pass/fail values

Color	**Shade%**	**CMC DE**	**Comments**
Red	0.5	0.11	Pass
	1	0.27	Pass
	1.5	0.38	Pass
	2	0.23	Pass
Blue	0.5	0.12	Pass
	1	0.23	Pass
	1.5	0.20	Pass
	2	0.13	Pass
Yellow	0.5	0.36	Pass
	1	0.25	Pass
	1.5	0.10	Pass
	2	0.15	Pass
Combined	R=0.5, B=0.5	0.18	Pass
Combined	R=0.5, Y=0.5	0.35	Pass

Rating of Color Fastness to Wash

There is slight difference in color fastness to wash ratting of one bath method sample over two dyeing method sample. Only the slight difference is found in nylon and wool part staining. The other parts staining are same or better than two bath method. No difference is found in color change ratting. Ratting of color fastness for two bath dyeing method sample and one bath dyeing method sample are shown in the table 4.

Table 4: Rating of color change and color staining to wash

Rating of color staining							**Rating of color change**
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool	
Sample of two bath method	4.5	4.5	5	4.5	4.5	5	4.5
Sample of one bath method	4.5	4.5	4.5	4.5	5	4.5	4.5

Rating of Color Fastness to Rubbing

The dry rubbing and wet rubbing are found same for one bath method sample and two bath method samples. Rating of color fastness to rubbing test for two bath dyeing method sample and one bath dyeing method sample are shown in table 5.

Table 5: Rating of color fastness to rubbing

Rating		
	Dry rubbing	Wet rubbing
Sample of two bath method	5	4
Sample of one bath method	5	4

Rating of Color Fastness to Perspiration

Only a slight difference is found in acrylic part staining and the other part staining results are found same in color fastness to perspiration test results. No difference is found for color change rating of one bath method sample with two bath method sample. Rating of color fastness to perspiration is shown in table 6.

Table 6: Rating of color fastness to perspiration

Rating of color staining							**Rating of color change**
	Acetate	Cotton	Nylon	Polyester	Acrylic	Wool	
Sample of two bath method	5	4.5	5	5	5	4.5	4.5
Sample of one bath method	5	4.5	5	5	4.5	4.5	4.5

Cost Analysis

Due to the savings of time and water the one bath PC blend dyeing process reduces the total cost. The savings of cost is calculated in perspective of Bangladesh.

Amount of Time Required

As in one bath method no draining is done, so it saves time. Here the required time is calculated by assuming the temperature grading 2^0C/min. The time required for one bath method and two bath methods are shown in the table 7.

Table 7: Amount of time required

Process name	Two bath method	One bath method
Time required in minute	1100	1010

So, the one bath dyeing method saves 90 minutes (1.5 hours) of time.

Cost Saves for Extra Time:

- Per KW hour electricity cost = $ 0.07 (Approximately)
- Dyeing machine capacity = 60 KW
- Total electricity cost per hour = $ 4.2 (Approximately)
- One bath method saves = $ 6.3 (Approximately)

Amount of Water Required

One bath dyeing method saves two bath of water due to no draining. Amount of water required is calculated for 1000 kg fabric and is shown in the table 8.

Table 8: Amount of water required

Process name	Two bath	One bath
Water required in liter for 1000 Kg fabric	64000	48000

So, the one bath dyeing method saves 16000 liters water.

Cost Saves for Extra Water:

Cost in WTP (Water Treatment Plant):

16000 liters water saved in one bath method of PC blended fabric dyeing. No water treatment is needed for this 16000 liters water. The savings of cost due to no water treatment is shown in table 9.

Table 9: Cost saves in WTP

Cost name	Dip cost	Salt cost	Power cost		Man power	Total Cost
			Surface	Under ground		
Amount/1000 ltr.	$0.02	$0.04	$0.008	$0.007	$0.005	$0.08

So, 16000 liter of water saves = $ 1.28 (Approximately).

Cost in ETP (Effluent Treatment Plant):

No effluent treatment is needed for 16000 liters water in one bath method due to saving 16000 liters of water. Savings of cost due to no effluent treatment is shown in table 10.

Table 10: Cost saves in ETP

Cost name	Power	Chemical	Installation	Man power	Total
Amount/1000 ltr.	$0.033	$0.122	$0.083	$0.005	$0.243

So, 16000 liter of water saves = $ 3.89 (Approximately)

Total Savings in Cost:

Savings of total cost due to energy saving, no water treatment and effluent treatment are shown in the table 11.

Table 11: Total savings in cost

Cost name	Energy	WTP	ETP	Total
Amount/1000 ltr.	$ 6.3	$ 1.28	$ 3.89	$ 11.47

So, one bath dyeing method saves $11.47 per 1000 Kg fabric with 90 minutes time.

Conclusion

Dyeing of PC blended fabric was successfully completed by one bath dyeing method. The one bath dyeing method was not cumbersome as other process because here no new chemicals have been used. The process has not needed any special requirements. The process is able to given the correct shade% by maintaining the process rightly. The process is also able to saves $11.47 per 1000 kg fabric with 90 minutes time. The one bath dyeing method for PC blended fabric is a cost effective and eco friendly method compared to conventional two bath dyeing method. Commercially it will be profitable if the process is accepted.

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