Study on fluorescent and non-fluorescent pigments dyeing of different fabrics by both exhaust and padding methods.

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Abstract—Normally dye-stuffs are used to make colored textile substrates but pigments can also be used and will be able to reduce problems which are faced using dye-stuffs. In this research work, some textile substrates such as cotton, polyester and nylon fabrics were dyed using fluorescent and non-fluorescent pigments and some color fastness properties of that dyed materials were evaluated. First cotton polo pique and plain nylon fabrics were dyed with fluorescent and non-fluorescent pigments in exhaust method. These dyed nylon showed better wash fastness to color and rubbing fastness, poor light fastness compared to cotton. Later, cotton and polyester fabrics were dyed with non-fluorescent pigment in both padding and exhaust methods. Dyed polyester fabric showed better pigment build up, levelness, perspiration fastness, rubbing fastness compare to cotton fabric in padding method. However in exhaust method both cotton and polyester dyed fabrics showed poor pigment build-up and levelness. Again different structured cotton knitted fabrics, plain polyester and nylon fabrics were dyed with fluorescent and non-fluorescent pigments in exhaust method and dyed nylon with fluorescent pigment showed better pigment buildup and levelness compared to others.

Keywords—Fluorescent pigment, Non-fluorescent pigment, Exhaust method, Padding method.

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1 INTRODUCTION

TO make colored fabrics we need colorants which are water soluble, partially water soluble or insoluble to water.

Pigments can be inorganic or organic, white or colored, opaque or transparent in polymer binders, fluorescent or non-fluorescent and almost water insoluble, less toxic, particle size are larger and have no substanivity to textile materials and usually present on the surface of the materials [4], [5]. Discharge of pigment is a suspension (a dispersion in a liquid of insoluble particles that slowly settle on standing), no need any washing off after applying into textile materials, so pigment has less environmental and toxicological impact. Non-fluorescent pigment is used for the safety clothes which are worn by the stuff of emergency services, where higher visibility garments are essential. This type of pigment is able to absorb near ultra violet light and reflects larger quantity of visible lights results in brighter substrates [1].

Thousand tons of dye-stuffs are produced and used per year in the world. Dye-stuffs are not hundred percent consumed during dyeing of textile materials and even small amount of colored waste can create an environmental and toxicological hazard and due to their high solubility they can be distributed through the environment, via rivers and can be accumulated by particular plant and animal organisms [1].Photosynthesis of phytoplankton is interrupted the colored discharge from the textile dyeing house because light transmission does not occurred properly [2].

So the aim of this research work to develop some colored textile materials such as cotton, nylon and polyester fabrics using fluorescent and non-fluorescent pigments.

In general cotton, nylon and polyester fabrics are dyed with reactive, acid and disperse dye-stuffs where hundred percent dye-stuffs are not consumed by textile materials. It is found that commonly 7-20% Acid dyes, 2-3% Cationic dyes, 5-20% Direct dyes, 1-20% Disperse dyes, 2-5% Premetallised dyes and 5-20% Reactive dyes, 30-40% Sulpher dyes and 5-20% Vat dyes are generally lost in effluent [1]. Instead of reactive, acid and disperse dyes, cotton, nylon and polyester fabrics can be dyed using only pigments.

Actually dye-stuffs diffuses into the interior of substrates such as textile fiber but pigments are not, they are applied into a medium by a dispersion process, which reduces the cluster of solid particles into a more finely divided form and remain as solid particles held in place mechanically, usually in a matrix of a solid polymer [1].

So in this research work cotton, nylon and polyester were dyed with fluorescent and non-fluorescent pigments and were evaluated their fastness properties as washing fastness to color, perspiration, rubbing and light fastness.

2 Materials and Methods

2.1 Raw Materials

2.1.1. Fabrics

Sheeting (100% cotton fabric of plain construction EPI 60, PPI 48, warp count 22Ne, weft count 20Ne),Poplin(100% cotton fabric of plain construction EPI 120, PPI 80, warp count 40Ne, weft count 40Ne), Nylon(Lycra attached nylon interlock knitted fabric), Polyester(100% polyester fabric of plain construction EPI 100, PPI 50, warp count 135 denier), Rib (Knit Cotton fabric of 2/2 rib construction WPI 68, CPI 52, yarn count 34 Ne) Polo pique (knit Cotton fabric of polo pique construction WPI 25, CPI 80, yarn count 20 Ne) were used .

2.2 Pigments and Chemicals

2.2.1 Pigments

Printofix Blue H-BK (non-fluorescent pigment, Archroma), Forneon Flavine E-17W (fluorescent pigment, Orient chem tex).

2.2.2 Chemicals

Indosol E-50 (cationizing agent used for non-fluorescent pigmentation in exhaust method, aliphatic polyamine in aqueous solution, Archroma), RACFIX- HM 38-M(cationizing agent used for fluorescent pigment in exhaust method, Orient chem tex), Printofix binder 77N , binder for non-fluorescent pigment, Archroma), RAC 201-HK 200M (binder for fluorescent pigment, Orient chem tex), Lyocol O powder(dispersing agent, Dinapthylmethane sulphonate, anion, Archroma).

2.3 Procedures

2.3.1 Recipes and Procedure of Exhaust Method

Recipes: Cotton polo pique and plain nylon fabrics were colored with both non-fluorescent and fluorescent pigments for 5% and 10% shades in exhaust method. Again different structured knitted cotton fabrics, plain polyester and nylon fabrics were colored with using same pigments for 1%, 5%, 20% and 40% shades. Later plain cotton and polyester fabrics were colored with only using non-fluorescent pigments for 8%, 1.6% and 3.2% shades. Following procedures was maintained in dyeing with each recipe & each sample.

Preparation of samples: Dry fabric was immersed into water to make it capable of getting an anionic charge on to the fabric surface.

Cationization: For cationization required amount (5%) of cationizing agent was taken into the dye bath of sample dyeing machine. Then rest amount of liquor (m: l = 1:10) is added into the dye bath according to the calculation. Bath pH was kept at 4.5-5.5 by using acetic acid and treated the fabric at 70° c for 10 minute. After cationization, the bath was dropped & the fabric was rinsed properly with a warm water of temperature at 60°c.

Pigment Application: Required amount of pigment, dispersing agent (1 g/l) and rest amount of liquor following same liquor ratio were taken into the pigmentation bath. After squeezing cationized fabric was treated in the pigment bath at 80°C for 10 min. After 10 min at 80°c, 1cc Acetic Acid (80%) was added to the bath and then again continue the pigmentation for more 10 min at the same temperature. After pigmentation, the bath was dropped and the fabric was rinsed with cold water.

Binder Application: Required amount of binder (5%) was taken into the bath. After adding the rest amount of liquor following same liquor ratio, the fabric was then added to the binder liquor and treated the fabric at 40°c for 10 minute. After this application fabric was squeezed and dried and cured at 150°c for 5 min.

2.4.1 Recipes and Procedure of Padding Method

Padding recipe: Cotton and polyester fabrics were colored following below given recipes.

Used pigment & chemicals	Unit	1	2	3
Printofix Blue H-BK	g/l	10	20	40
Printofix Binder 77N	g/l	100	150	200
Solidokoll N	g/l	20	20	20
Lyocol O powder	g/l	15	15	15
Diammonium Phosphate	g/l	4	4	4
Water	ml/l	Y	Y	Y

The required quantity of binder was diluted in water at room temperature. The Printofix Blue H-BK pigment was added and the mixture was stirred. The rest of the products were then added and the mixture topped up to 1 liter with water. After preparation the liquor was then filtered. It was impregnated with a pickup of 70% and dried at 80-100°C in a pin stenter frame. The quantity of Printofix Binder Liq. in the padding recipe depends mainly on the concentration of the pigment. After padding and drying, the fabric was placed in a pin stenter frame at 150°C for 5 minutes.

3 Results and Discussion

3.1 Evaluation of wash fastness to color of cotton polo-pique and nylon fabrics colored with fluorescent and non-fluorescent pigments in exhaust method.

Table.1
Color fastness to washing test 3 (ISO 105-C03): For 5% shade

F	P	SC GSV, N	Staining on multifibre, Gray Scale Value					
			TC	CO	PA	PES	PAC	VS
CP	FLR	3.0	4.8	4.6	4.7	4.6	4.7	4.8
	NFLR	4.5	4.6	3.7	3.2	3.5	4.0	4.2
NY	FLR	4.8	4.8	4.7	3.8	4.6	4.9	4.9
	NFLR	3.8	4.6	4.2	3.5	3.5	4.2	4.5

F= Fabric, P= Pigment, SC= Shade change, GSV= Grey scale value, CP= Cotton pique, NY= Nylon, FLR= Fluorescent, NFLR= Non-fluorescent.

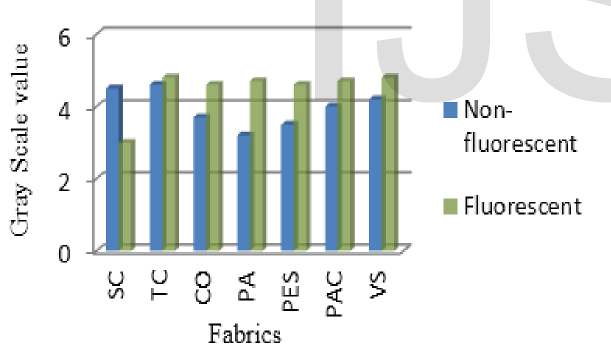

Fig.1 (a). Shade change and staining on multi-fiber of cotton fabric colored with non-fluorescent and fluorescent pigments by exhaust method.

From this figure it is found that staining on multi-fiber of cotton fabric colored with fluorescent pigment shows good and better than non-fluorescent pigment but shade change

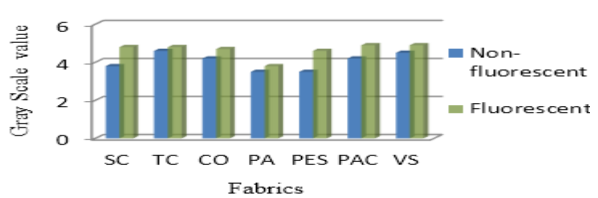

Fig.1 (b). Shade change and staining on multi-fiber of nylon fabric colored with non-fluorescent and fluorescent pigments by exhaust method.

From the above figure it is seen that both shade change and staining on multi-fiber of nylon fabric colored with fluorescent pigment show good and better results than non-fluorescent pigment.

3.2 Evaluation of rubbing fastness of cotton and nylon fabrics colored with non-fluorescent and fluorescent pigments in exhaust method.

Table.2
Rubbing Fastness for 5% shade (ISO CO6 X 12)

Fabric	Pigments	Dry rubbing	Wet rubbing
Cotton	Non-fluorescent	3.6	2.7
	Fluorescent	4.8	4.6
Nylon	Non-fluorescent	3.2	2.6
	Fluorescent	4.9	4.8

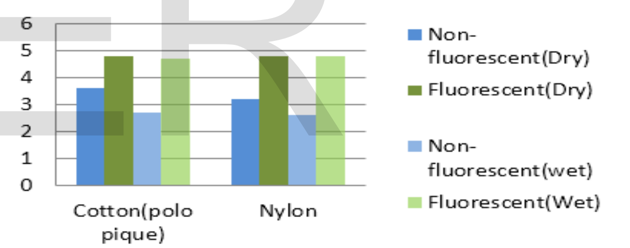

Fig.2: Dry and wet rubbing fastness of cotton and nylon fabrics colored with non-fluorescent and fluorescent pigments.

From this figure it is clearly seen that rubbing fastness (dry and wet) of cotton and nylon fabrics colored with fluorescent pigment is better than non-fluorescent.

3.3 Evaluation of light fastness of cotton and nylon fabrics colored with fluorescent and non-fluorescent pigments in exhaust method.

Table 3
For 10 % shade (ISO105 D02)

Pigments	Fabrics	Fastness rating
Fluorescent	Cotton Polo pique	6
	Plain nylon	2
Non-Fluorescent	Cotton Polo pique	7
	Plain nylon	2

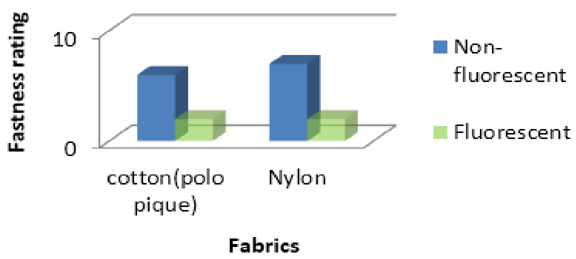

Fig. 3. Light fastness of cotton and nylon fabrics colored with non-fluorescent and fluorescent pigments by exhaust method.

From this figure it is found that light fastness of cotton and nylon fabrics colored with non-fluorescent pigment is very good and better compared to fluorescent pigment.

3.4 Evaluation of pigment build–up (K/S) and levelness (DE CMC) values of Cotton and polyester fabrics colored with non-fluorescent pigment in both padding and exhaust methods.

Table.4
To evaluate pigment build up property (K/S), same strength liquor is applied in both padding and exhaust methods.

Shade	Fabrics	Method	K/s values
10g/1 ≈0.8%	Cotton	Padding	2.9
		Exhaust	2.05
	Polyester	Padding	5.15
		Exhaust	3.7
20g/1 ≈1.6%	Cotton	Padding	5.5
		Exhaust	3.65
	Polyester	Padding	10.3
		Exhaust	3.8
40g/l≈ 3.2%	Cotton	Padding	8.0
		Exhaust	6.8
	Polyester	Padding	11.4
		Exhaust	4.0

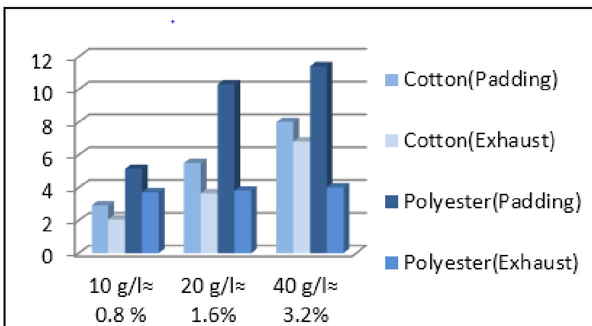

Fig.4: K/S values (pigment build-up) of cotton and polyester fabrics dyed with non-fluorescent pigment in both exhaust and padding methods.

From above table and figure, it is seen that build up values of all concentrations of shades of cotton and polyester fabrics
From above table and figure, it is seen that build up values of all concentrations of shades of cotton and polyester fabrics dyed with non-fluorescent pigment in padding method is higher than exhaust method. Build up values of polyester are higher than cotton in both methods. (The greater the K/S value, the greater the pigment build-up)

3.5. Levelness is evaluated for 20g/l ≈1.6% shade for both cotton and polyester fabrics.

Table.5
Levelness (CMC DE Values, D65, 10 degree)

Fabrics	Method	Levelness 1st Reading	2nd Reading	3rd Reading
Cotton	Padding	0.27	0.26	0.29
	Exhaust	0.37	0.99	0.59
Polyester	Padding	0.13	0.12	0.18
	Exhaust	0.36	0.15	0.63

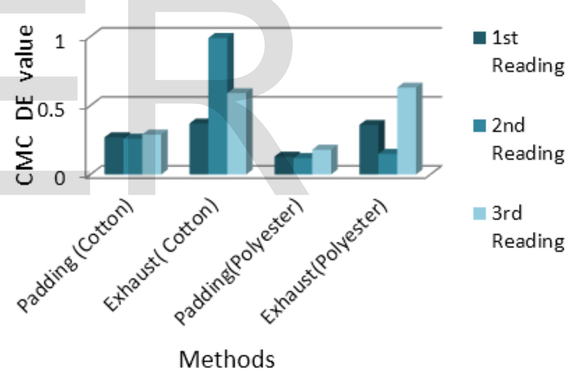

Fig.5. Levelness of cotton and polyester fabrics dyed with non-fluorescent pigment in exhaust and padding methods.

From above table and figure it is clearly understood that, both cotton and polyester fabrics dyed with non-fluorescent pigment in padding method show better levelness than exhaust method. (If the difference between three readings is less than 0.5, then it is level dyeing).

3.6. Evaluation of Wash fastness to color of cotton fabric colored with non-fluorescent pigment in both padding and exhaust methods.

Table.6
Color fastness to washing test 3(ISO 105-C03, 60° C) for 20g/l ≈1.6% shade of cotton.

F	Methods	SC, N	Staining on Multifibre					
			TC	CO	PA	PES	PAC	VS
C	Padding	4.8	4.8	4.6	4.7	4.6	4.7	4.8
	Exhaust	3.0	4.6	4.7	3.8	3.6	4.6	4.8
P	Padding	4.2	4.8	4.7	4.4	4.6	4.8	4.9
	Exhaust	3.0	4.6	4.8	3.5	3.6	4.7	4.8

F= Fabric, M= Methods, SC= Shade change, C= Cotton, P= Polyester

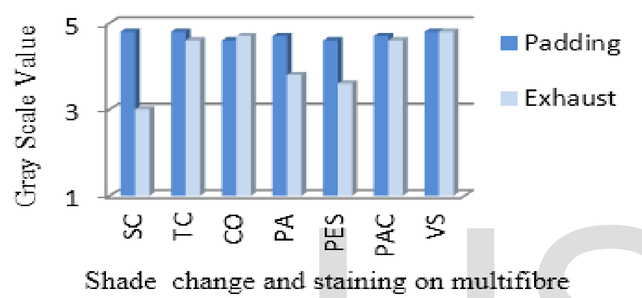

Fig.6 (a). Shade change and staining on multifibre of cotton fabric colored with non-fluorescent pigment in both exhaust and padding methods.

From this figure it is clearly seen that the shade change and staining on multi fiber of cotton fabric colored with non-fluorescent pigment in padding method are better compared to exhaust.

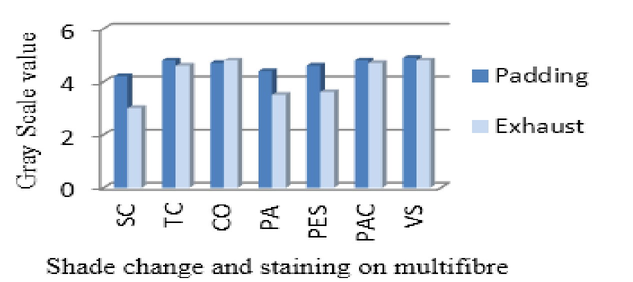

Fig.6 (b): Shade change and staining on multifibre of polyester fabric colored with non-fluorescent pigment in both exhaust and padding methods.

From this figure it is clearly seen that shade change and staining on multifibre of polyester fabric colored with non-fluorescent pigment in padding method are better compared to exhaust.

3.7. Evaluation of perspiration fastness of cotton and polyester fabric colored with non-fluorescent pigment in both padding and exhaust methods.

Table 7
Acidic perspiration fastness is evaluated for 20g/l ≈1.6% shade of cotton and polyester fabrics coloured with non-fluorescent pigment in both exhaust and padding methods.

F	Method	SC, N	Staining on multifibre					
			TC	CO	PA	PES	PAC	VS
C	Padding	4.9	4.7	4.6	4.6	4.8	4.7	4.6
	Exhaust	4.7	4.7	4.6	4.8	4,9	4.6	4.7
P	Padding	4.8	4.7	4.8	4.6	4.7	4.8	4.7
	Exhaust	4.6	4.6	4.7	4.8	4.7	4.6	4.8

F = Fabric, SC=Shade change, C = Cotton, P = Polyester

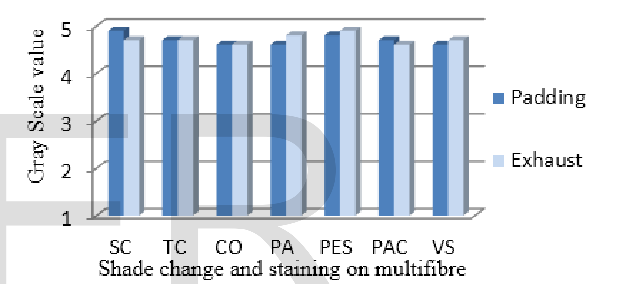

Fig.7 (a). Shade change and staining on multifibre of cotton after perspiration fastness dyed with non-fluorescent pigment by exhaust and padding methods

From above table and figure it is seen that the color change and staining on multifibre are similar of cotton fabric dyed with non-fluorescent pigment in both padding and exhaust methods.

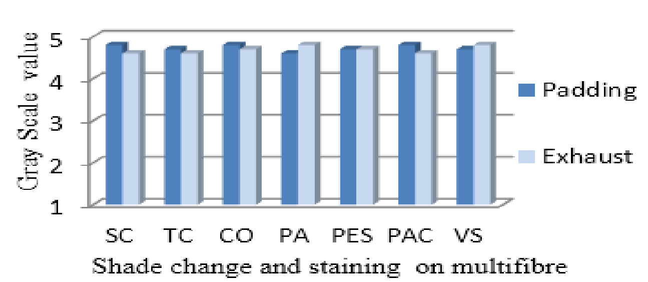

Fig.7 (b): Shade change and staining on multifibre of polyester after acidic perspiration fastness dyed with non-fluorescent pigment by both exhaust and padding methods.

From above table and figure it is clearly understood that the shade change and staining on multifibre of polyester fabric dyed with non-fluorescent pigment are similar in both padding and exhaust methods.

3.8. Evaluation of Perspiration (alkaline) fastness of cotton and polyester fabrics dyed with non-fluorescent pigment in both padding and exhaust methods.

Table.8
Alkaline perspiration fastness is evaluated for 20g/l ≈1.6% shade of cotton and polyester fabrics in both padding and exhaust methods.

F	Method	SC, N	Staining on multifibre					
			TC	CO	PA	PES	PAC	VS
C	Padding	4.8	4.7	4.8	4.6	4.9	4.7	4.6
	Exhaust	4.7	4.8	4.9	4.6	4.6	4.8	4.7
P	Padding	4.9	4.7	4.8	4.6	4.6	4.7	4.8
	Exhaust	4.8	4.7	4.9	4.7	4.7	4.6	4.6

F= Fabric, C= Cotton, P= Polyester, SC= Shade change

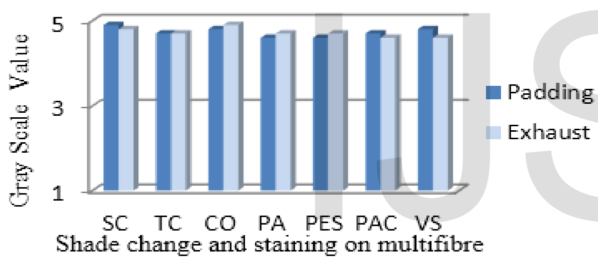

Fig.8 (a). Shade change and staining on multifibre of cotton fabric after alkaline perspiration fastness colored with non-fluorescent pigment by both

From above table and figure it is clearly seen that the shade change and staining on multifibre of cotton fabric dyed with non – fluorescent pigment are good and similar results in both padding and exhaust methods.

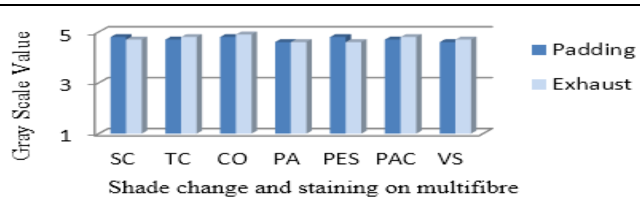

Fig.8 (b). Shade change and staining on multifibre of polyester after alkaline perspiration fastness dyed with non-fluorescent pigment by both exhaust and padding methods.

change and staining on multifibre of polyester fabric dyed with non – fluorescent pigments are good and similar in both padding and exhaust methods.

3.9. Evaluation of Rubbing Fastness of cotton and polyester fabric dyed with non-fluorescent pigment in both padding and exhaust methods.

Table.9
Dry and wet rubbing fastness is evaluated for 20g/l ≈1.6% shade of cotton and polyester fabrics dyed with non-fluorescent pigment by both exhaust and padding methods.

Fabrics	Methods	Dry Rubbing	Wet Rubbing
Cotton	Padding	4.8	3.8
	Exhaust	3.6	3.0
Polyester	Padding	2.5	2.5
	Exhaust	4	3

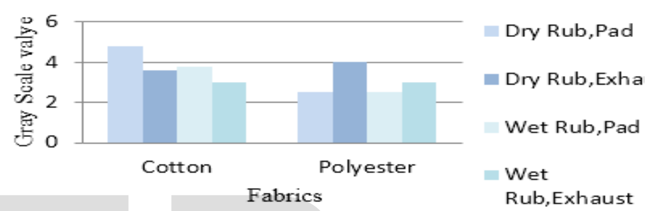

Fig.9: Dry and wet rubbing of cotton and polyester fabric dyed with non-fluorescent pigment in both exhaust and padding methods.

From this figure, we can say that in padding method dry and wet rubbing fastness of cotton fabric is better than exhaust. But in case of polyester dry and wet rubbing in exhaust is better than padding.

3.10. Evaluation of dye build –up (K/S value) of cotton, polyester and nylon fabrics dyed with non –fluorescent pigment in exhaust method.

Table.10
Evaluation of K/S values of cotton, nylon and polyester fabrics for 1%, 5%, 10% and 20% shades dyed with non-fluorescent pigment in exhaust method.

Fabrics	1% Shade K/S	5% Shade K/S	10% Shade K/S	20% Shade K/S
Cotton Poplin	2.05	6.6	6.7	6.4
Cotton Sheeting	3.4	7.0	6.6	5.8
Cotton Rib	2.3	7.5	6.55	6.0
Nylon Interlock	2.6	0.6	1.4	0.8

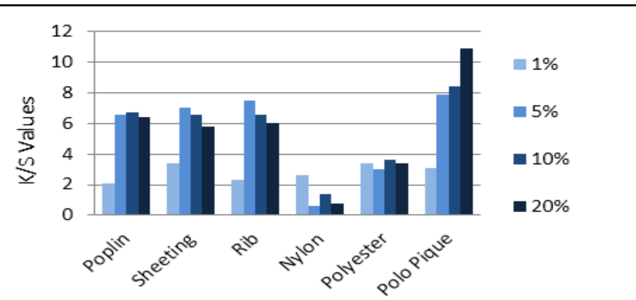

Fig.10: Pigment build-up of different cotton, nylon and polyester fabrics colored with non-fluorescent

From above graph it is clearly understood that pigment build- up of cotton polo pique gradually increases, its build–up by increasing shade % but nylon has poor build - up property. Polyester is suitable for light shade and cotton poplin, sheeting and rib fabrics show maximum build-up of 5% shade.

3.10. Evaluation of Levelness of different fabrics dyed with 5% non-fluorescent pigment in exhaust method.

Table.11
Levelness (CMC DE Values, D65, 10 degree) of different fabrics dyed with 5% non-fluorescent pigment by exhaust method.

Fibers	1st Reading CMC DE	2nd Reading CMC DE	3rd Reading CMC DE
Cotton Poplin	0.37	1.5	0.2
Cotton Sheeting	0.42	0.89	0.19
Cotton Rib	1.34	0.3	0.5
Nylon plain	0.28	0.8	0.66
Polyester plain	0.36	0.15	0.63
Cotton Polo Pique	1.06	1.65	0.9

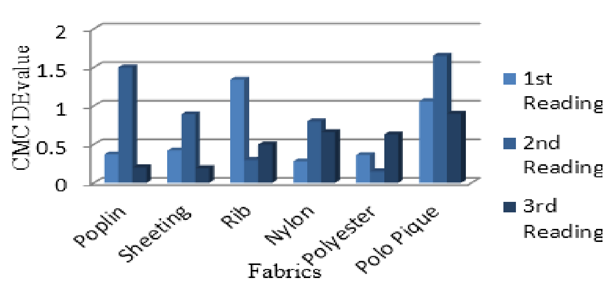

Fig.11. Levelness of different fabrics dyed with 5% non-fluorescent pigment in exhaust method.

From above table and figure it is clearly seen that all fabrics dyed with non-fluorescent pigment in exhaust method show unevenness. (If the difference between three readings is less than 0.2, then it is level dyeing).

3.12. Evaluation of pigment build – up and levelness of cotton, polyester and nylon fabrics dyed with fluorescent pigment in exhaust method.

Table.12
Evaluation of K/S values of cotton, nylon and polyester fabrics for 1%, 5%, 10% and 20% shade of non-fluorescent pigment by exhaust method.

Fabrics	1% Shade K/S	5% Shade K/S	10% Shade K/S	20% Shade K/S
Poplin	0.15	0.26	0.29	0.27
Sheeting	0.23	0.49	0.65	0.27
Rib	0.18	0.38	0.70	0.35
Nylon	0.55	1.35	2.30	2.40
Polyester	0.49	1.44	1.75	0.75
Polo Pique	0.21	0.58	1.05	0.46

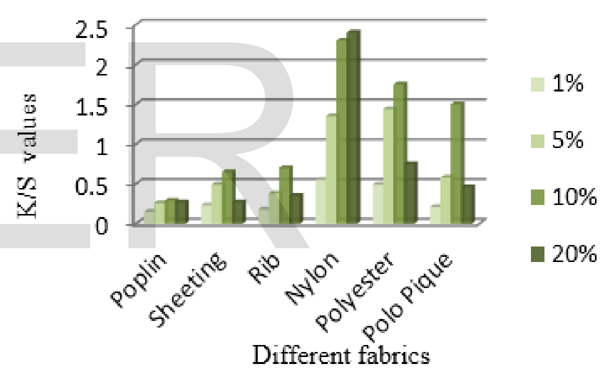

Fig.12. Dye build-up of different cotton fabrics, nylon and polyester fabrics with fluorescent pigment in exhaust method.

From the above table and figure it is seen that nylon fabric dyed with fluorescent pigment show good pigment build-up compared to others but here K/S values of fluorescent pigment are less because their reflectance curves are different to non-fluorescent pigment. Except nylon Polyester is better than others.

Table.13
Evaluation of Levelness (CMC DE Values, D65, 10 degree) of different fabrics dyed with 5% fluorescent pigment in exhaust method.

Fibres	1st Reading CMC DE	2nd Reading CMC DE	3rd Reading CMC DE
Poplin	0.2	0.9	1.5
Sheeting	1.5	0.5	1.0
Rib	0.1	1.7	1.0
Polo pique	0.75	0.5	0.2
Nylon	0.19	0.24	0.21

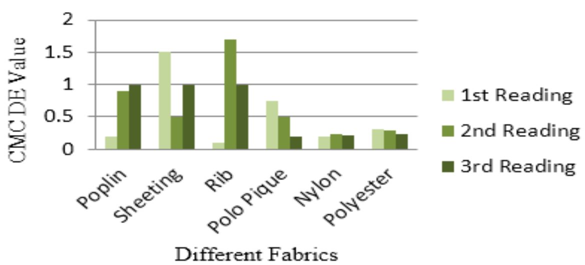

Fig.13. Levelness of different cotton fabrics, nylon and polyester fabrics dyed with fluorescent pigment in exhaust method.

From figure it is found that nylon and polyester fabrics dyed with fluorescent pigment show good levelness compared to others. (If the difference between three readings is less than 0.2, then it is level dyeing).

Conclusion

Cotton polo pique and nylon plain fabrics were colored with fluorescent and non-fluorescent pigments for light to deep shade percentages in exhaust method and these colored fabrics were evaluated through the following tests - wash fastness to color, rubbing fastness, light fastness build-up and levelness. Nylon fabrics colored with fluorescent pigment showed good wash fatness to color, rubbing fastness, poor light fastness and good levelness compared to non-fluorescent pigment. Again build-up and levelness of different structured cotton knitted fabrics, polyester and nylon colored dyed with non-fluorescent and fluorescent pigments were evaluated and polyester colored with fluorescent pigment showed moderate build-up and levelness compared to non-fluorescent pigment. Cotton polo pique colored with fluorescent pigment showed less build-up, less levelness, good wash fastness, good rubbing fastness and poor light fastness compared to non-fluorescent pigment. Samples of cotton and polyester fabrics were colored with non-flourescent pigment by both padding and exhaust methods and evaluated through the following tests – build-up, levelness, wash fastness, perspiration fastness, rubbing fastness. Colored polyester by padding method showed the highest build-up and levelness, good to moderate wash and perspiration fastness and poor rubbing fastness compared to exhaust method. Colored cotton by padding method showed the highest build-up and levelness, good to moderate wash fastness and perspiration fastness and rubbing fastness compared to exhaust method. From this research work we have deduced that pigments can be used for coloring different textile materials with good to moderate color fastness results. Different fabrics may also be colored using pigments for combination shades by same process.

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