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Application of the synthesized Arylazopyrazolopyrimidine dyes in Printing Polyester and Polyamide Fabrics

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Abstract

The printing properties, colour strength, effect of particle size, and antibacterial activity of new synthesized dyes for printing of two types of polyester fabrics and polyamide fabric by the heat transfer as well as the silk screen printing techniques have been investigated. The prints obtained have good sublimation properties, high colour strength as well as very good fastness properties. Reduce the particle size of the dyes leads to increase the colour strength. The type of fabric has a great effect on the colour strength of the prints especially in screen printing technique.

Keywords: Polyester fabrics, polyamide fabrics, transfer printing, silk screen printing.

Introduction

In previous work, new series of arylazopyrazolopyrimidine dyes having bright colours were prepared. These dyes were identified and characterized for their: melting point, IR spectra, ^{1}HNMR spectra, Mass spectra and their antibacterial properties. Studies on the use of these new dyes for printing of two types of polyester fabrics and polyamide fabric by the heat transfer as well as the silk screen printing techniques were thoroughly investigated. The colour strength, the effect of dye type particle size, antibacterial properties as well as the dyes fastness properties were also investigated. Dye sublimation transfer printing technology was developed for use in textile printing. In traditional practice, the required image is first printed onto a paper carrier by conventional means – usually screen printing. The inks comprise sublimable disperse dyes, and the image can be transferred from the paper to textile by feeding the paper in contact with the textile fabric, through a heat press. The dyes sublime and diffuse into the fabric, permanently coloring it. This technique is mainly used with fibers which will readily accept the sublimed disperse dyes, most notably polyester, nylon and triacetates. This simple, flexible process offers many advantages, and low maintenance requirements, it also minimizes water and energy consumption and is an effluent-free process[1,2].

However one of the major drawbacks of heat-transfer printing was said to be the cost of the transfer paper. The latter cannot be used more than once (very seldom twice). Suggestions have been advanced to transform the used paper into carrier bags or wrapping.

It is also well known that the inks used for paper printing are quite expensive. A careful selection of materials needed to produce an ink that is suitable for a particular printing process, printing quality and other factors. It is always possible to improve the ink composition for one criterion, but at the expense of another one.

The work was conducted aiming at studying the effect of the use of the new synthesized dyes in the paper printing ink formulation, for printing the transfer paper, to be used for transfer printing PE-A, PE-B and polyamide fabrics and to study their transfer printability (ease of dyestuff release from the transfer paper) under different transfer printing conditions. This method of printing has recently been developed to a great extent and attained considerable importance[3,4].

Screen printing is an incredibly versatile, yet simple, process. A mesh is coated with a compound that seals all openings in the screen and prevents the dye paste from moving through the screen, except in the areas to be printed according to the design. One screen is used for each color. The paste is forced through the openings within the screen by a squeegee[4].

Clothing of textile can act as carrier for microorganisms such as pathogenic or odor – generating bacteria and moulds[5]. The textile material is known to be susceptible to microbial attack; in contact with the human body it offers an ideal environment for microbial growth providing oxygen, water and warmth, and nutrients from spillages and body exudates[6]. This often leads to objectionable odor, dermal infection product deterioration, allergic responses and other related diseases which necessitate the development of clothing products with antimicrobial properties[7]. The development of nanotechnologies has stimulated textile processing one possible application is to directly employ pigment nano-particles can be reduced to small enough size and the particle can be dispersed well to avoid aggregation of the nano- particles in dye bath[8].

Material and Methods

Fabrics: Polyester: Two types of polyester fabrics were used: PE-A fabric of 150g/m^2, and PE-B fabric of 250glm^2 supplied by a private sector company, which were treated with a solution containing 1g/l non-ionic detergent at 70^{0}C for 1/2 h., thoroughly washed, and air dried at room temperature. The analytical and fabric weaving properties for PE-A and PE-B were studied.

Table 1
Analytical fabric weaving properties for PE-A and PE-B

Analytical properties	PE-A	PE-B
Number of warp threads	32 warplcm	34 warplcm
Number of weft threads	23 weftlcm	26 weftlcm
yarn count of warp threads	18 Tex	43 Tex
yarn count of weft threads	43 Tex	40 Tex
Weaving Structure	Plain 1l1 (Very compact)	Twill 2l1 (containing gaps)
Number of fibersl cross section	190 fibers	288 fibers
Fiber diameter	Warp 3.9 Denier Weft 1.6 Denier	Warp 3 Denier Weft 0.9 Denier

Polyamide 6 of 212 g/m^2 supplied by El-Nasr company for spinning, weaving and knitting was treated with a solution containing 5 g/l soap at 50^{0}C for 15 minutes, then thoroughly washed and air dried at room temperature.

Thickener: Commercial synthetic thickener (leuco print) supplied by BASF company.

Dyestuffs: A series synthesized arylazopyrazolo- pyrmidine azo dyes (4a-e) as in previous work and C.I. disperse red 60 were used.

Printing methods: Transfer printing technique. Print paste recipe for printing the transfer paper:

Dye	3 g.
Synthetic thickener(leuco print)	3 g.
Water	94 g.
	100 g.

A good quality paper was manually printed with the previous formulation using silk screen and then air dried.

Transfer paper: Uncoated paper of 80 glm^2, supplied by Protucal Soporcel Company.

Transfer printing experiments: Samples of PE-A, PE-B and nylon 6 were transfer printed using the previously screen printed paper. The heat source was a 40x25 cm^2 flat-bed press. Transfer printing times and temperatures were 30, 45 seconds, and 150, 170 and 190˚C respectively.

Silk screen printing technique: Print paste recipe: (as transfer printing recipe): **Traditional (Silk screen) printing experiments:** Samples of PE-A, PE-B and nylon 6 fabrics were silk screen printed using the above printing paste recipe, the printed fabrics were dried and thermally fixed at different temperatures 160, 180 and 190^{0}C, (fixation time 3 minutes) then washed twice by cold water, then twice with hot water and finally rinsed with cold water, and air dried .

Measurements: Color strength measurement: The color strength (K/S) of each printed sample was measured using a Data Color SF 600plus Colorimeter using a measured area with diameter of 9mm.

Particle size measurement: The dye particle size was measured by using Transmission Electron Microscopy (TEM) JET 1230, JOEL LTd, Tokyo, Japan.

Filament Diameter measurement: The diameter of Polyester (PE-A) and (PE-B) fibres was measured by (Nikon profile projector Model V-12)

Antibacterial activity: The Antibacterial activity was assayed in the Micro Analytical Centre of Cairo University using Kirby-bauer disc diffusion method[8].

Fastness properties measurements: Fastness to washing, rubbing, light and perspiration were assessed according to standard methods[9-11].

Results and Discussion

Color Strength results: Heat transfer printing: Effect of heat transfer printing conditions on.

Polyester: As already known, the transfer printing conditions (temperatures and times of transfer) affect the color strength values of the prints. In this respect several transfer printing experiments were carried out .The effect of transfer printing conditions on the color strength of the transfer printed polyester (PE-A and PE-B)fabrics using screen printed transfer paper containing synthesized dyes 4a-e is represented using transfer temperatures ranging between 150˚C-190˚C and transfer times of 30 and 45 seconds, figures 1 and 2.

It can be seen that, the temperature of transfer plays a very important role in the process, as increasing the transfer temperature from 150˚C to 170˚C under any selected transfer time, increases the color strength of the polyester prints (both PE-A and PE-B) markedly, further increase in the transfer temperature up to 190˚C, causes a slight increase in the color strength of the prints, (and this applies to all dyes).

The time of transfer printing has a less marked effect on the color strength results of the PE prints. In- creasing the time of transfer from 30 to 45 seconds at lower transfer temperatures

(150˚C) had a more noticeable effect on the color strength of the PE prints as compared to the effect obtained at higher transfer temperatures for all synthesized dyes. It could be seen that, either transfer temperature of 170˚C and time of 45 sec, or transfer temperature of 190˚C and time of 30 sec could be selected as optimum transfer conditions in most cases, since at higher transfer temperature 190˚C slightly higher color strength results for the prints are obtained which could not justify the increase in the temperature, i.e increase in energy consumption. The above applies for all dyes 4a-e.

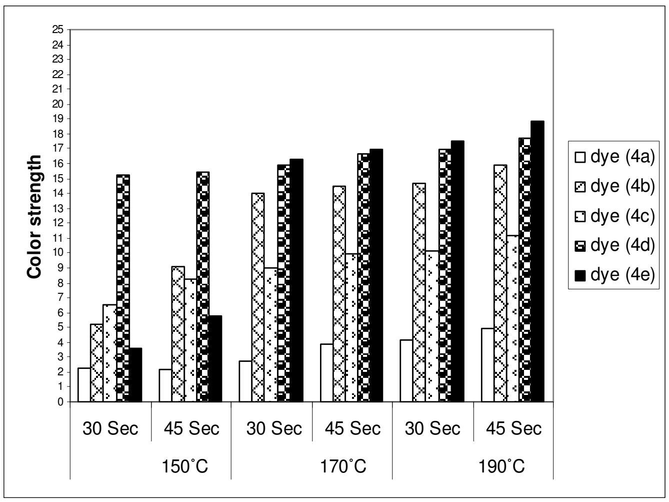


Figure -1
Effect of transfer printing conditions on the color strength of the transfer printed PE-A fabric using silk screen printed paper with synthesized dyes 4a-e

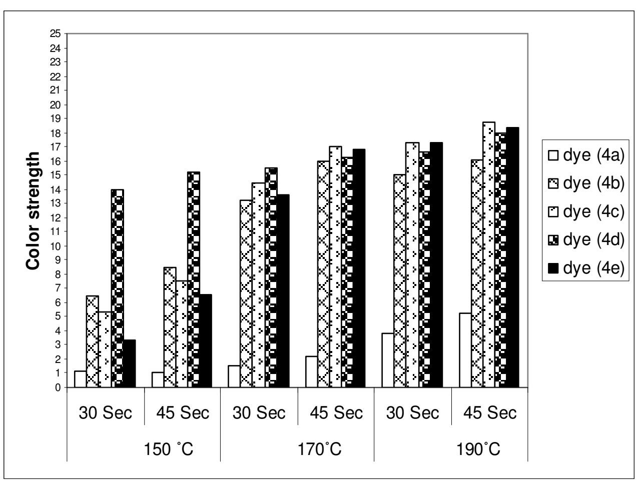


Figure -2
Effect of transfer printing conditions on the color strength of the transfer printed PE-B fabric using silk screen printed paper with synthesized dyes 4a-e

Polyamide: It is observed that a similar pattern of results is obtained in case of transfer printing polyamide fabrics using the screen printed paper containing the synthesized dyes 4a-e, the results are represented in figure 3.

Similar result trends were obtained as in case of polyester fabrics. Longer transfer times (45 sec) at higher transfer temperature of 190˚C is not recommended as the polyamide fabrics starts to soften, causing damage to the fabric handle.

Silk screen printing: Effect of silk screen printing conditions.

Polyester: The results of the effect of changing the fixation temperatures (from 150˚C to 190˚C at fixation time 3min.) on the color strength of polyesters (PE-A and PE-B) prints are shown in figures 4 and 5.

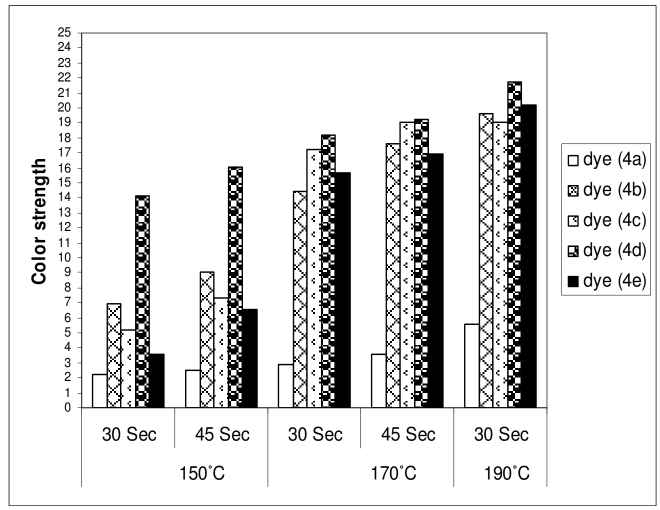


Figure -3
Effect of transfer printing conditions on the color strength of the transfer printed polyamide fabrics using silk screen printed paper with synthesized dyes 4a-e

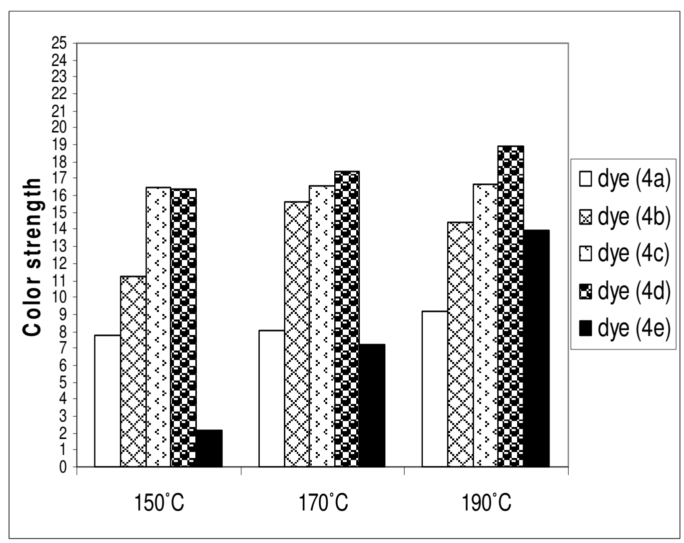


Figure -4
Effect of silk screen printing conditions on the color strength of the screen printed PE-A fabric with synthesized dyes 4a-e, Fixation time 3 min

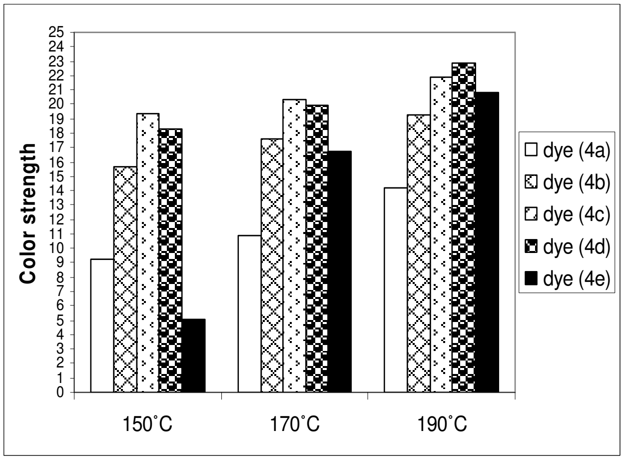


Figure -5
Effect of silk screen printing conditions on the color strength of the screen printed PE-B fabric with synthesized dyes 4a-e, Fixation time 3 min

It can be seen that all the synthesized dyes 4a-e produced successful bright prints on polyester fabrics. The increase in the temperature of fixation from 150˚C to 190˚C leads to increase in the color strength. This increase is gradual when increasing the temperature of fixation from 150 to 170˚C and 190˚C. This holds true for all the dyes. In case of dye 4e it was found that effect of increasing the fixation temperature is highly noticed as the color strength was for 2.2, 7.4, 14.5 and 5.6,17, 21.3 for PE-A and PE-B prints upon increasing the fixation temperature from 150 to 170 and 190˚C respectively. In general fixation temperatures of either 170˚C or 190˚C for 3 min could be used successfully in the above case.

Polyamide: Similar pattern and trend of results is produced with the polyamide prints as with the polyester prints. It could be safely concluded that the synthesized dyes 4a-e produced successful bright colors on PE-A, PE-B and polyamide fabrics by the screen printing technique, figure 6.

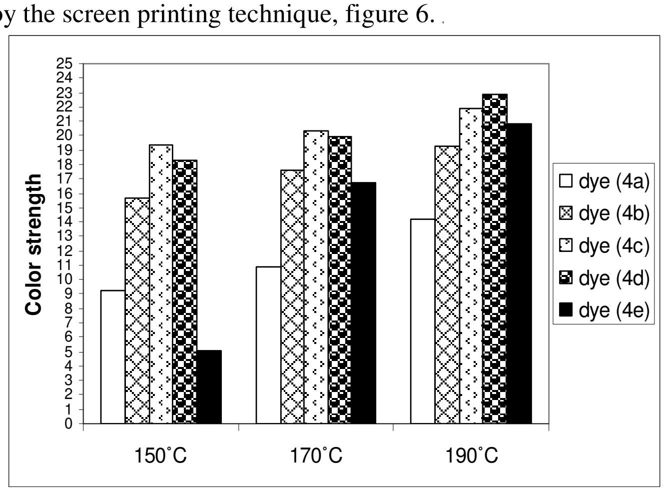


Figure -6
Effect of silk screen printing conditions on the color strength of the screen printed polyamide fabric with synthesized dyes 4a-e, Fixation time 3 min

Effect of dye type: The most important parameter for heat transfer printing is the sublimation ability of disperse dyes, which is generally associated with the relative molecular mass of the dyes, the smaller the dye molecules, the better the transferability onto the synthetic fabrics[12]. It was found that some dyes could not be used for transfer printing from paper to Polyester and polyamide fabrics meaning that its chemical structure did not allowed the dye molecule to sublime efficiently from the transfer paper and deposit on the fabric, this may be due to that, this particular dye has higher molecular weight and may be due to the presence of hindering groups in it structure. Direct dependency of the transferability of dye into fabric could be related to the molecular weight of each dye. Generally speaking, it could be concluded that, the variations obtained in the color strength results of the polyester (PE-A and PE-B) and polyamide printed fabrics upon using the different synthesized dyes 4a-e could be attributed to many factors, mainly the difference in dye structure, molecular weight, configuration and the presence of polar and non-polar groups in the dye molecule. This holds true in case of using either the transfer or silk screen printing techniques.

Effect of type of polyester fabric: It is well expected that the type of fabric used would affect the color strength results of their prints, these two kinds of polyester PE-A and PE-B were selected aiming at studying the effect of their fiber specification and weaving structure on their behavior towards printing with the new synthesized dyes. According to table 1, PE-A is very compact in structure while, PE-B contains gaps in its structure. The fiber diameters of PE-A in the warp and weft directions are 3.9 and 1.6 denier. The fiber diameters of PE-B in the warp and weft directions are 3 and 0.9 denier, which means that, the polyester filament in weft direction is in the microfiber range. PE-B fabric has a medium fine polyester constituent in the warp direction (filament diameter 3denier and microfiber polyester in the weft direction). This combination (PE-B fabric) brings about enhanced drapeability, luster, softness, smoothness and novel tactile, visual aesthetics and also is expected to have an effect on its printability. The figures 7 and 8 represent the SEM photographs of PE-A and PE-B fabrics.

Figures-7
The SEM photographs of PE-A

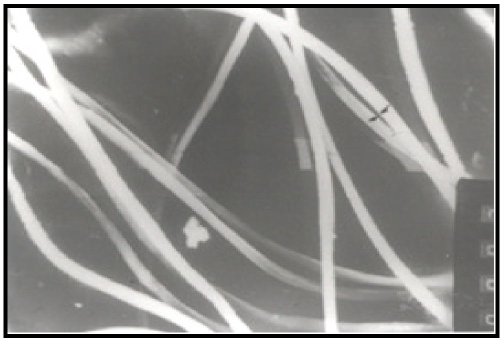


Figure -8
The SEM photographs of PE-B fabrics

The objective is to investigate the influence of fiber fineness of conventional (PE-A) and conventional micro fiber polyester (PE-B) on the color strength of the disperse dyes used. The decrease in linear density of filament is accompanied by Reduction in stiffness as well as strength of the filament .However the lowering of strength in an individual filament is compensated more by the corresponding increase in the number of individual filaments within a yarn to get the same yarn count. Collective graphs are shown in figure 9-12, representing the effect of using different type of fabrics (PE-A,PE-B and polyamide) on the color strength of their transfer printed and screen printed samples using two of the selected newly synthesized dyes (4a-4e) respectively . The results show that, the type of the selected fabric always affects the color strength of their prints, but the extent of this effect differs from one fabric to another and also from one dyestuff to another .For example, printed samples of PE-B often possessed higher color strength values when compared to those of PE-A under any selected conditions of either transfer printing or silk screen printing, and this applies for both used dyes, although this effect is much more noticeable in case of silk screen printing than in case of transfer printing. This difference in behavior is definitely attributed to the weaving structure, fiber cross section, fiber denier and the fiber specification of the two types of polyester used.

The observed differences in the color strength values of prints on conventional and conventional/microfiber polyester could also be attributed to the greater surface area of microfiber constituent of PE-B fabric. The type and chemical structure of the selected dyes as well as amount of dye on fiber have an impact on the magnitude of this difference in behavior.

Effect of dye particle size: It is a common knowledge that small particle sizes of pigments or dyes are achieved by ball milling or micro fluidization. Ball milling involves milling the pigment or dye particle in a ball mill with, typically, metal or ceramic balls, followed by size filtration, using centrifuge or appropriate screening. In this study, it is very interesting to study the effect of particle size of the prepared dyes (arylazopyrazolo- pyrmidine dyes 4a-e) on their printing behavior.

In this context, one of the newly synthesized dyes, dye (4c), was selected for the study, as well as one commercial disperse dyes C.I. Red 60 for the sake of comparison. The above two dyes were milled for 10 and 20 days in a ball mill, after that the particle size of the milled dyes together with the un milled dyes were measured using Transmission Electron Microscopy (TEM).

It was found that, milling of the mentioned three dyes for less than 10 days was not adequate and insufficient for Reducing their particle size, while dye milling for 10 days produced particle size almost the same as when milling for 20 days .Therefore dye milling for 10 days is considered adequate with the selected ball mill. Figures 13-16 represent the particle size of dye 4c, and C.I. Red 60 before and after milling for 10 days respectively.

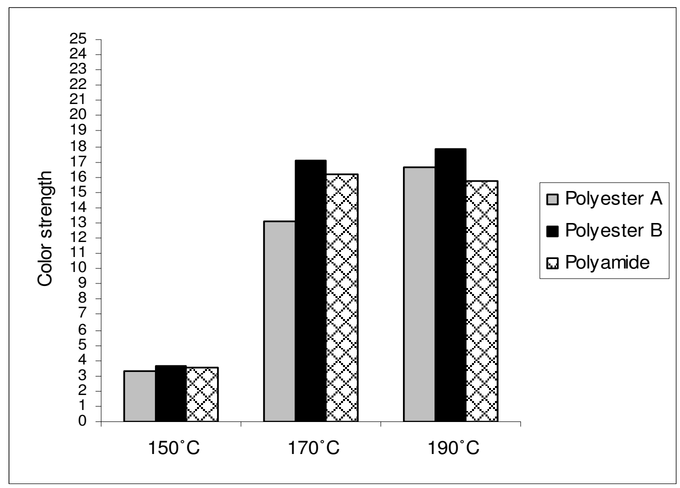


Figure-9
Effect of type of fabric on the color strength of their prints upon transfer printing with synthesized dye 4e-Transfer time 30 Sec

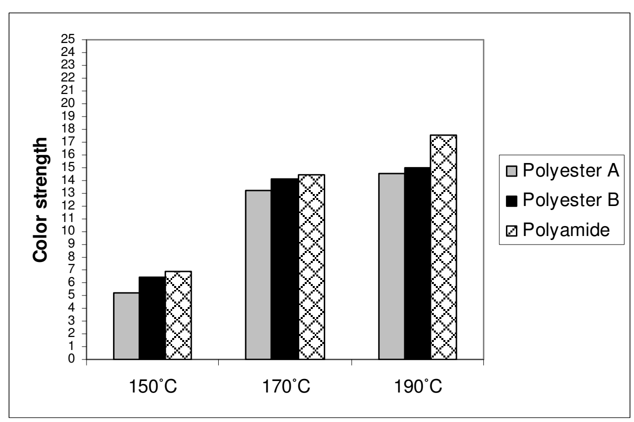


Figure-10
Effect of type of fabric on the color strength of their prints upon transfer printing with synthesized dye 4b -Transfer time 30 Sec

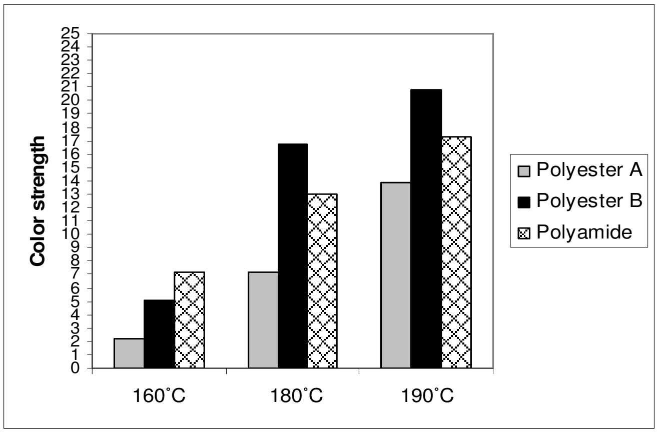


Figure-11
Effect of type of fabric on the color strength of their prints upon screen printing with synthesized dye 4e -Fixation time 3min

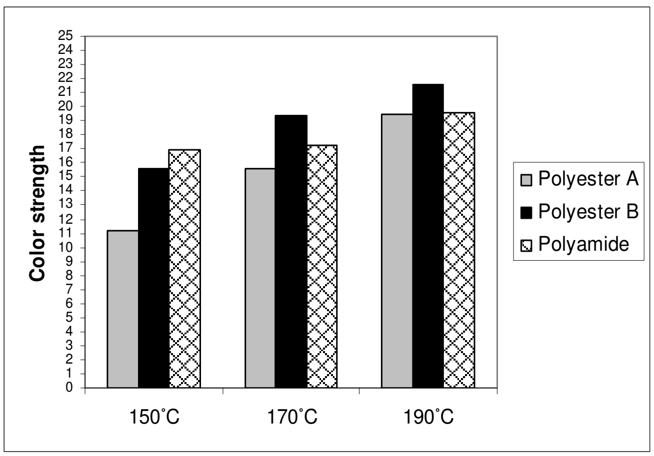


Figure-12
Effect of type of fabric on the color strength of their prints upon screen printing with synthesized dye 4b -Fixation time 3min

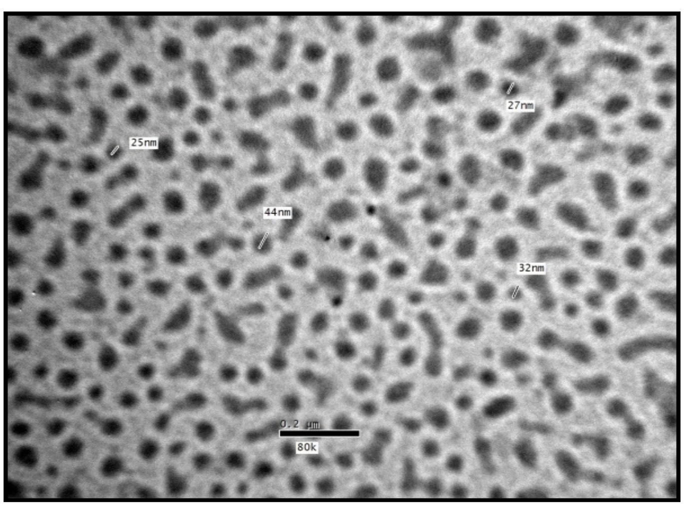


Figure-13
TEM image of synthesized dye 4c before milling

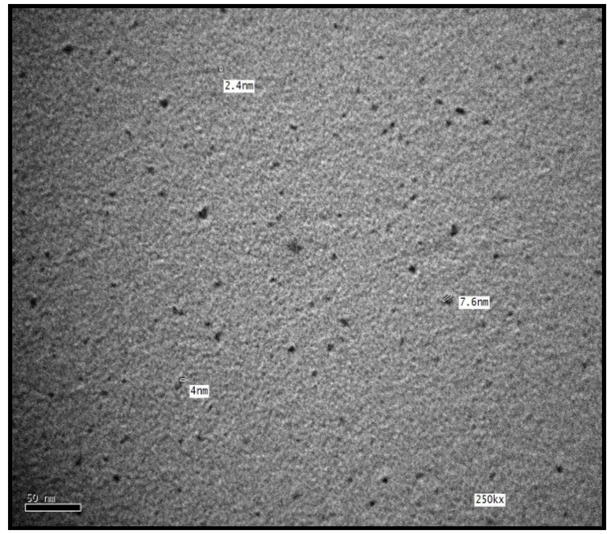


Figure -14
TEM image of synthesized dye 4c after milling

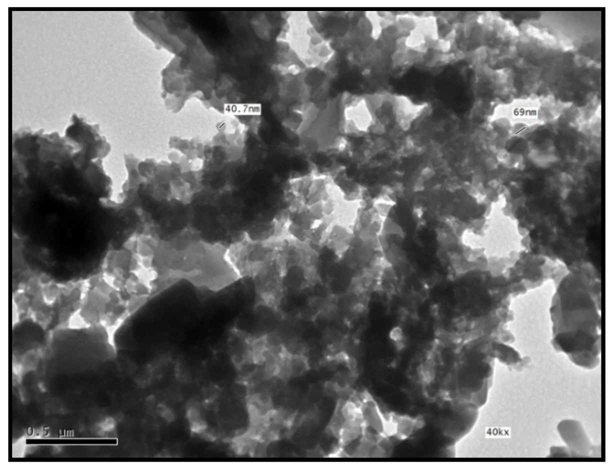


Figure-15
TEM image of Disperse C.I. Red 60 before milling

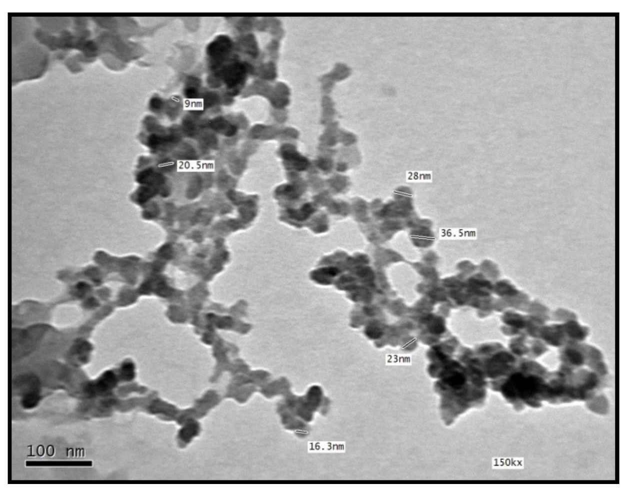
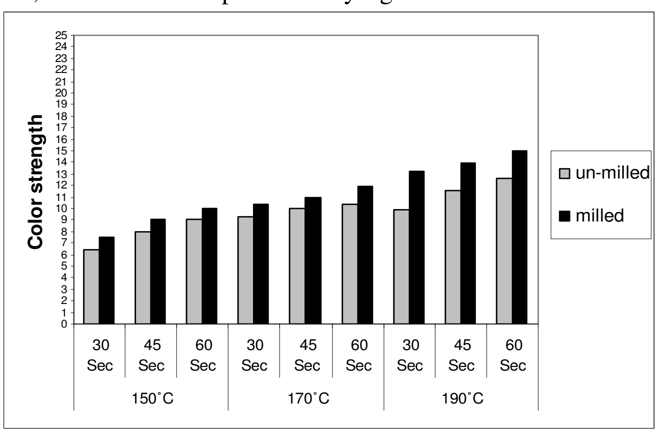


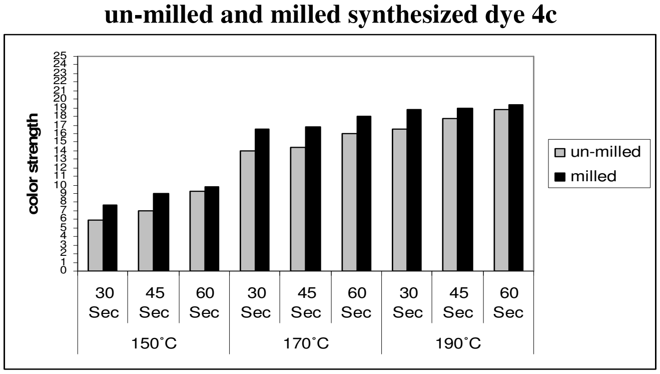
Figure-16
TEM image of Disperse C.I. Red 60 after milling

The figures 13 and 14 show that, the particle size of the dye 4c has been Reduced due to milling for 10 days from 25-44 to 2.4-7.6 mm while in case of the Red 60 dye , the dyes are present in agglomerates together with all the other ingredients usually present in the finished dye formulas which could be fillers, dispersing agents and any other unknown additives. The size of these agglomerates was also reduced by grinding, although the dye constituent is expected to be included originally in the finest form in this agglomerates, since these two dyes are in the finished form. The sizes of the C.I. disperse Red 60 agglomerates is Reduced from 40.7-69 to 2.4-36.8. The Reduction in the particle size of dye 4c and agglomerates size of dyes C.I. Red 60 would be expected to affect their color strength values on the prints which will be discussed in the following section. The previously milled dyes were used to print polyester PE-A and PE-B, as well as polyamide fabrics by the heat transfer as well as the traditional screen printing techniques.

Heat transfer printing: Polyester PE-A fabric was transfer printed under different transfer printing conditions using transfer paper containing synthesized dyes 4c and disperse Red 60 (for the sake of comparison) in the milled and un-milled state, the results are represented by figures 17 and 18.



Figures-17
Effect of transfer printing conditions on color strength of transfer printed PE-A using silk screen printed paper with un-milled and milled synthesized dye 4c

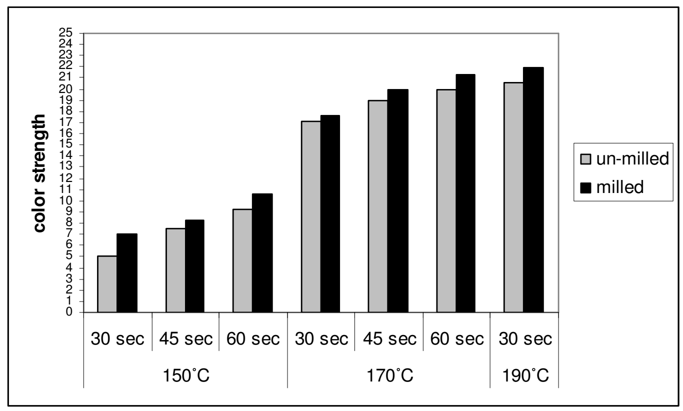


Figures-18
Effect of transfer printing conditions on color strength of transfer printed PE-A fabric using silk screen printed paper with un-milled and milled C.I. Red 60 dye

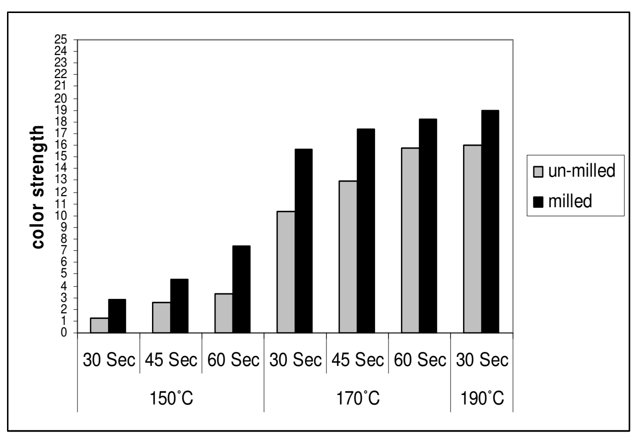
The effect of dyestuff milling is noticeable for all dyes in all cases and under any selected dye fixation conditions. The mean particle size was reduced dramatically from 35-5, 54.8-19.6 and for dyes 4c, and C.I. Red 60 respectively, figures 13-16, which was reflected on the color strength values of their prints. It can also be seen that, the effect of transfer conditions on the color strength of their printed fabrics is very clear and is expected to be as discussed earlier.

Polyamide fabrics were transfer printed with transfer paper containing the above mentioned dyes under different transfer conditions figures 19 and 20. Transfer temperature of 190˚C was not recommended as the selected polyamide fabric handle starts to deteriorate. It can be seen that similar pattern of results is expected, and the type of fabric plays also an important role.

The results show that, dyestuff milling in order to obtain smaller dye particles has certainly a clear effect since the color strength values of prints are always higher upon transfer printing with milled dyestuffs in all cases. The extent of improvement differed from one dye to another and from one fabric to another

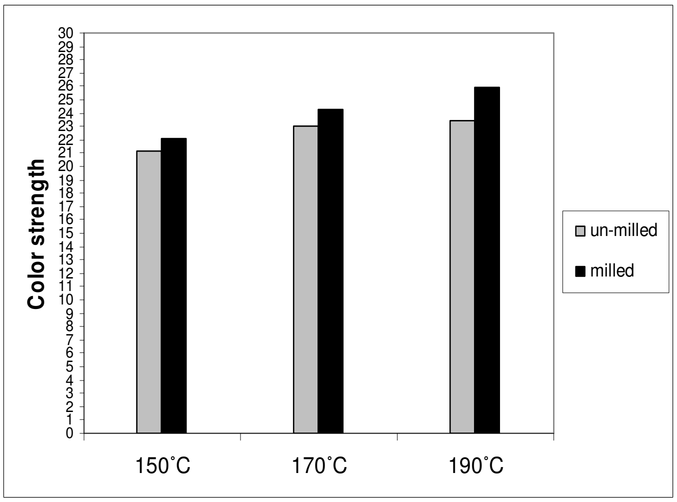


Figures-19
Effect of transfer printing conditions on color strength of transfer printed polyamide fabric using silk screen printed paper with un-milled and milled synthesized dye 4c

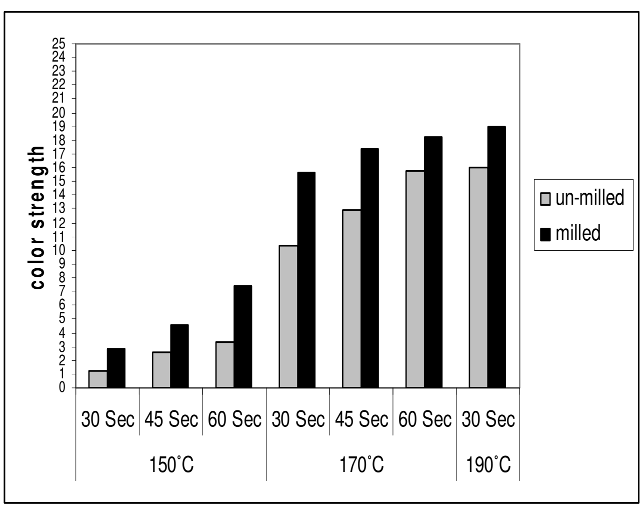


Figures-20
Effect of transfer printing conditions on color strength of transfer printed polyamide fabric using silk screen printed paper with un-milled and milled C.I. Red 60 dye

Silk Screen printing: The effect of the screen printing dye fixation conditions (fixation temperature 150, 170, and 190˚C and fixation time 3min) using un-milled and milled synthesized dye 4c as well as commercial C.I. Red 60. in the dye recipe used to print PE-A fabric is presented by figures 21 and 22. The effect of dye fixation conditions on the color strength of all prints is as discussed before. The effect of reducing the dye particle size on the color strength of the prints is noticed, but to a much less extent when compared to the results obtained in case of transfer printing the same fabrics with the same dyes. This may be attributed to that in case of transfer printing, the Reduction in the dye particle size facilitates its sublimation from the transfer paper and therefore more dye vapors transfer to the fabric which is not the case with traditional silk screen printing.

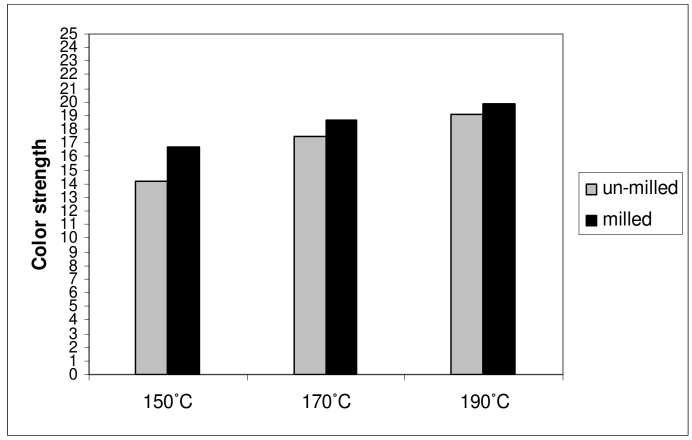


Figures-21
Effect of traditional screen printing conditions on the color strength of screen printed PE-A fabric with milled and un-milled C.I Red 60, Fixation time 3 min.

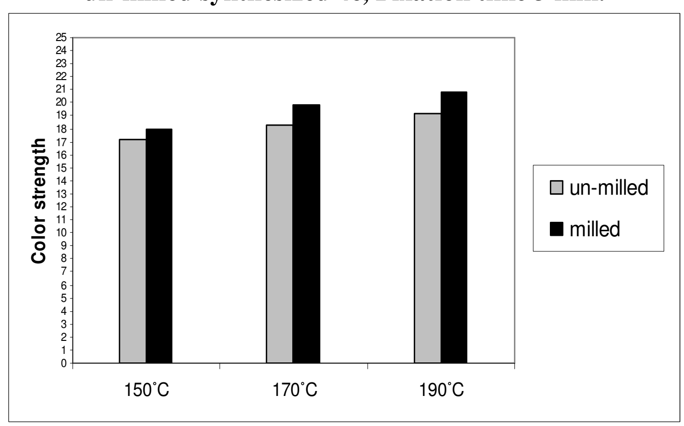


Figures-22
Effect of transfer printing conditions on color strength of transfer printed polyamide fabric using silk screen printed paper with un-milled and milled C.I. Red 60 dye

In case of screen printing polyamide fabric with the above dyes, the results are represented by figures 23-24. It can also be seen that dye milling affected the color strength values of the produced polyamide prints with all dyes used to a certain extent. As mentioned before, dyestuff milling in order to obtain smaller dye particles has also a beneficial effect on the color strength values of the screen printed fabrics. The extent of improvement differs, and depends on dye and fabric types.



Figures-23
Effect of traditional screen printing conditions on the color strength of screen printed Polyamide fabric with milled and un-milled synthesized 4c, Fixation time 3 min.



Figures-24
Effect of traditional screen printing conditions on the color strength of screen printed Polyamide fabric with milled and un-milledC.I.Red60, -Fixation time 3min

Antibacterial activity of printed fabrics: Having studied the anti-bacterial activity of the dyes (4a-e) earlier in previous work, the next step was to assess their effectiveness on the fabric.

The antibacterial activity was carried out on silk screen PE-A fabric printed with the aforementimed dyes and thermo fixed at 190˚C for 3 min. These samples were selected as examples representing the rest of the fabrics. Table 2 represents the inhibition zone diameters of PE-A screen printed fabrics with dyes 4a-e against gram positive and gram negative bacteria. The results show that, polyester PE-A screen printed samples acquired very good inhibition of the bacterial growth and the inhibition zone diameters obtained are in the range of (12-21) mm. The results also show that prints of dyes 4b and 4d having chlorine atoms in their structure possess highest antibacterial activity compared to the rest of the dyes[13-14].

The inhibition zone diameter represents the area which is not attacked by the bacteria, and as this diameter is increased, the antibacterial effect is increased. It could be safely confirmed that, the prints of newly synthesized arylazopyrazolopyrimidine dyes 4a-e possess good antibacterial properties table 2. The results indicate also that, the chemistry of the dye and the presence of certain atoms or groups have a significant influence on its antibacterial activity.

Table - 2
Inhibition zone diameter of PE-A screen printed fabrics with dyes (4a-e) against Gram positive and Gram negative bacteria

Polyester prints* with dyes	Inhibition Zone diameter (mm)	
	Esherichia coli (G-)	Staphylococcus aureus (G+)
4a	16	17
4b	21	19
4c	16	18
4d	20	18
4e	12	12

*Fixation temperature 190˚C, Fixation time 3 min.

Fastness properties: One of the main concerns of the textile dyers and printers are the fastness properties of the dyestuffs in the market. Therefore, evaluation of the fastness properties of the newly synthesized series of dyestuffs on the fabrics is of at most importance. The fastness properties and color strength values of transfer printed polyester A, polyester B and polyamide fabrics using the newly synthesized dyes (4a-e), C.I. Red 60, are represented by tables 3, 4, and 5 respectively .The data shows that excellent rubbing, washing and perspiration fastness results were obtained for prints of dyes 4a-e as compared with the results obtained with the commercial disperse dye C.I. Red 60 . The excellent rubbing fastness results indicate deeper penetration of dyes in the fabric. The light fastness results range from good to very good with the exception of dye 4a and 4e where their prints possessed moderate values in some cases. It is also clear that, fabric and dyestuff types have certain effect on the overall color strength and fastness results of all the printed fabrics.

The fastness properties and color strength values of screen printed PEA, PEB and polyamide fabrics using the newly synthesized dyes (4a-4e), C.I. Red 60 are represented by tables 6, 7 and 8 respectively. Similar trends of results were noticed as before.

Table - 3
Fastness properties and color strength of transfer printed *PE-A fabric using the newly synthesized dyes (4a-e),and Disperse Red 60

Dye No.	K/S	Rubbing		Washing		Perspiration				Light fastness
						Alkali		Acid		
		Dry	Wet	Alt.	St.	Alt.	St.	Alt.	St.	
4a	5.1	4-5	4	4-5	5	4-5	5	5	5	3-4
4b	16.1	5	4-5	5	5	5	5	5	5	4
4c	11.2	5	4-5	5	5	5	5	5	5	3-4
4d	17.9	4	4	5	5	5	5	5	5	4-5
4e	19	5	4-5	5	5	5	5	5	5	5
Red 60	19.2	5	5	5	5	5	5	5	5	5-6

*Transfer temperature 190 C, transfer time 45 sec.

Table - 4
Fastness properties and color strength of transfer printed *PE-B fabric using the newly synthesized dyes (4a-e),and Disperse Red 60

Dye No.	K/S	Rubbing		washing		perspiration				Light fastness
						Alkali		Acid		
		Dry	Wet	Alt.	St.	Alt.	St.	Alt.	St.	
4a	5.2	4-5	4	4-5	5	4-5	5	5	5	3-4
4b	16.0	5	4-5	5-4	5	5	5	5	5	5
4c	18.7	5	4-5	5	5	4-5	5	5	5	4
4d	18.0	4	4	5	5	5	5	5	5	4-5
4e	18.5	5	4-5	5	5	5	5	5	5	5
Red 60	19.0	5	5	5	5	5	5	5	5	5-6

*Transfer temperature 190 C, transfer time 45 sec.

Table – 5
Fastness properties and color strength of transfer printed *polyamide fabric using the newly synthesized dyes (4a-e), and Disperse Red 60

Dye No.	K/S	Rubbing		Washing		Perspiration				Light fastness
		Dry	Wet	Alt.	St.	Alkali		Acid		
						Alt.	St.	Alt.	St.	
4a	5.2	4-5	4	4-5	5	4-5	5	5	5	3-4
4b	16.0	5	4-5	5-4	5	5	5	5	5	5
4c	18.7	5	4-5	5	5	4-5	5	5	5	4-5
4d	18.0	4	4	5	5	5	5	5	5	4-5
4e	18.5	5	4-5	5	5	5	5	5	5	4
Red 60	19.0	5	5	5	5	5	5	5	5	5-6

*Transfer temperature 190 C, transfer time 30 sec.

Table – 6
Fastness properties and color strength of screen printed *PE-A fabric using the newly synthesized dyes (4a-e),and Disperse Red 60

Dye No.	K/S	Rubbing		washing		perspiration				Light fastness
		Dry	Wet	Alt.	St.	Alkali		Acid		
						Alt.	St.	Alt.	St.	
4a	9.18	4-5	4	4-5	5	4-5	5	5	5	3-4
4b	14.5	5	4-5	5-4	5	5	5	5	5	5
4c	16.6	5	4-5	5	5	4-5	5	5	5	4
4d	19	4	4	5	5	5	5	5	5	4-5
4e	14.5	5	4-5	5	5	5	5	5	5	5
Red 60	19.3	5	5	5	5	5	5	5	5	5-6

*Fixation temperature 190C, Fixation time 3min.

Table -7
Fastness properties and color strength of screen printed *PE-B fabric using the newly synthesized dyes (4a-e), and Disperse Red 60

Dye No.	K/S	Rubbing		Washing		Perspiration				Light fastness
		Dry	Wet	Alt.	St.	Alkali		Acid		
						Alt.	St.	Alt.	St.	
4a	14.2	4-5	4	4-5	5	4-5	5	5	5	3-4
4b	19.4	5	4-5	5-4	5	5	5	5	5	5
4c	21.7	5	4-5	5	5	4-5	5	5	5	4
4d	22.8	4	4	5	5	5	5	5	5	4-5
4e	20.8	5	4-5	5	5	5	5	5	5	5
Red 60	23.4	5	5	5	5	5	5	5	5	5-6

*Fixation temperature 190C, Fixation time 3min.

Table -8
Fastness properties and color strength of screen printed *polyamide fabric using the newly synthesized dyes (4a-e), and Disperse Red 60

Dye No.	K/S	Rubbing		Washing		Perspiration				Light fastness
		Dry	Wet	Alt.	St.	Alkali		Acid		
						Alt.	St.	Alt.	St.	
4a	15.9	4-5	4	4-5	5	4-5	5	5	5	4
4b	19.9	5	4-5	5-4	5	5	5	5	5	4
4c	19	5	4-5	5	5	4-5	5	5	5	3-4
4d	22.4	4	4	5	5	5	5	5	5	4
4e	17.6	5	4-5	5	5	5	5	5	5	3-4
Red 60	19.2	5	5	5	5	5	5	5	5	5

*Fixation temperature 190C, Fixation time 3min.

Conclusion

Both the transfer temperature and transfer time play an important role in the transfer printing process, Optimum transfer conditions of 170˚C and 45 sec could be selected for transfer printing PE fabrics (both types) using transfer paper containing the synthesized dyes 4a-e. Colour strength increase by increasing the fixation temperature in silk screen printing technique over all the fabrics using printing paste containing the synthesized dyes 4a-e. Dyestuff milling in order to obtain smaller dye particles has certainly a clear effect since the color strength values of prints are always higher upon transfer printing with milled dyestuffs in all cases. This may be attributed to that in case of transfer printing, the Reduction in the dye particle size facilitates its sublimation from the transfer paper and therefore more dye vapors transfer to the fabric which is not the case with traditional silk screen printing. Polyester PE-A screen printed samples acquired very good inhibition of the bacterial growth against the same tested bacteria and the inhibition zone diameters obtained are in the range of (12-21) mm.

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