

[54] FOAM DYEING PROCESS

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[57] ABSTRACT

A process for dyeing polyester acrylic and polyamide fibers is shown. A fabric is padded with a foam formed from an aqueous solution of a dyestuff, a foaming agent and a carrier for the dyestuff and the padded fabric is maintained at elevated temperatures to fix the dye. The advantages of the process include improved dye prefixation, improved migration of the dye into the fiber, higher color yields in the fabric even after relatively short dyeing times and improved dimensional stability of the dyed fabrics.

1 Claim, No Drawings

FOAM DYEING PROCESS

This invention relates to a process for dyeing fibers. More specifically, this invention relates to a process for improving the appearance and color quality of dyed synthetic fibers by controlling the migration of dyestuff into the body of the fibers. Even more specifically, this invention relates to a process for padding polyester fibers with a foam containing dyestuffs, dyestuff carriers as well as conventional dyebath additives wherein substantially improved dyed products are obtained.

In conventional dyeing processes the fabric to be dyed is immersed in a bath containing the dyestuff and other dyebath components; over a period of time the dyestuff migrates into the fiber. The fabric is then removed from the bath and dried. In the dyeing of synthetic fabrics, notably those comprised of polyester fibers, it is necessary to include, in the dye solution, a carrier which causes the fiber surface to swell and soften and thus more readily receive the dyestuff. Typically, a fabric which has been dyed by conventional techniques with a dye solution containing a carrier must be exposed for relatively long periods, i.e., hours, to the dyestuff solution. This often results in swelling and distortion of the fibers and weakening of them. The dimensional stability of the dyed fabrics is adversely affected. Due to the time involved, processing cost is relatively high.

In the more recently developed Thermasol process the padded polyester fabric is maintained at a temperature of 350° to 450° C in a dry atmosphere. The elevated temperature, which is near the softening point of the polyester fiber, softens the surface thereof and substantially reduces the required contact time with the dye solution. The distorting effects of the carrier are thereby minimized but the elevated temperature itself adversely affects the strength and dimensional stability of the dyed fabric. The Thermasol process is expensive in that elaborate equipment for providing the elevated temperature environment is required. A further disadvantage of the Thermasol process is that only certain dyestuffs can be used, i.e., those that will migrate properly into the surface of the polyester fabric during the fixation period.

It is thus the primary purpose of this invention to provide a dyeing process for fabrics wherein the substantial disadvantages of the conventional and Thermasol processes are not encountered.

It is a further and more specific object of this invention to provide a process for dyeing fabrics consisting of polyester fibers wherein uniform and consistent color quality is obtained in the dyed fabrics.

It is still a further and related object of this invention to provide a process wherein the polyester fiber is not unduly distorted, weakened or swelled during the dyeing process and wherein the dyestuff is caused to migrate rapidly and efficiently into the fiber without damaging it.

It is still a further object of this invention to provide a continuous process which reduces the capital cost of equipment required in the dyeing process.

These and other objects of this invention are achieved in a process for dyeing fibers including synthetic fibers, for example, fibers of polyester, basic dyeable polyester, acrylics, and polyamides as well as fiber blends of these synthetics, and blends of these with natural fibers wherein the blend contains not more than 90

percent natural fiber. The several objects of this invention are achieved by forming an aqueous solution of a dyestuff and generating a foam of said solution by introducing a gas, e.g., air, into said solution while preferably mechanically agitating the solution. The foam thus generated is applied to the fabric to be dyed. The fiber is then maintained at conditions of elevated temperature to fix the dye within the fiber. Desirably, the aqueous solution of dyestuff contains a foaming agent and the solution may also contain conventional additives to control the pH of the solution, compatibilize different dyestuffs, increase the viscosity of the dye solution and change the surface active properties of the dye solution.

The process of this invention is particularly directed to a process for dyeing fabrics comprised of fibers of polyester or basic dyeable polyester or blends thereof or blends thereof with natural fibers wherein the blend contains not more than 90 percent natural fiber. An aqueous solution of a dispersed dyestuff, a carrier for the dyestuff and an effective amount of a foaming agent is formed. Air is introduced into the solution while mechanically agitating it and a foam, having specific gravity relative to water of from 0.15 to 0.5 is formed. The foam is stable under the conditions of its formation but destructible at the elevated temperatures encountered in the dye fixation step. The stable foam is then applied to the fabric and the padded fabric is steamed at an elevated temperature to break down the foam and cause the dyestuff to migrate into the fibers.

The fibers which may be dyed according to the process of this invention are broadly both natural and synthetic fibers. Advantages are obtained in the dyeing of all fibers in that the dyestuff is mechanically supported within the foam and thus is evenly distributed and held in contact with the fibers. Particularly good results are obtained, however, in the dyeing of synthetic fibers, notably those comprised of polyesters, when operating in accordance with the preferred embodiments of this invention. The latter fibers require additional equipment and processing time for dye fixation and, accordingly, the present invention is particularly directed to the dyeing of synthetic fibers.

The fibers may be presented to the foam dyeing process either singly or in multiple strands although it is contemplated that the process will find application in the dyeing of woven and knit goods as well as flat formed goods. Particularly good results are obtained in the dyeing of polyester fibers, basic dyeable polyester fibers, acrylics, polyamides, blends of these synthetic fibers and blends of any of the foregoing with natural fibers wherein the blend contains not more than 90 percent of the natural fibers.

The dyestuffs which may be used in the process of this invention are broadly any of the dispersed dyes, acid dyes, basic dyes, and direct dyes. It will be appreciated that advantages may be obtained using any of the aforementioned dyes in that they are evenly distributed and maintained in contact with the fiber during the fixation period.

In accordance with the preferred embodiment of the process, wherein polyester or basic dyeable polyester fibers are dyed, the dyestuff is a dispersed dye such as:

Disperse Yellow 42 (C.I.10338)	Disperse Blue 27 (C.I.60767)
Disperse Yellow 88	Disperse Blue 56
Disperse Yellow 54	Disperse Blue 62
Disperse Red 86	Disperse Blue 73
Disperse Red 65	Disperse Violet 26

Disperse Red 135

[All of the foregoing are color index numbers]

The concentration of the dye in the aqueous solution thereof depends upon the end color desired in the fabric and may be set by those skilled in the art. Broadly, the concentration of dispersed dyestuff in the aqueous solution is from 1 gram/liter to 50 grams/liter and preferably is 5 grams/liter to 20 grams/liter.

The aqueous solution of dyestuff includes a foaming agent which lends a foaming property such that the foam produced is stable under the conditions under which it is formed but breaks down at elevated temperatures and in the presence of a steam atmosphere. Desirably, the foaming agent is selected from the following group of surface active agents: sulfated and sulfonated alcohols, sulfated alcohol ethoxylates, sulfated alkyl phenol ethoxylates, sulfated fatty esters, phosphated alcohols, phosphated alcohol ethoxylates, phosphated alkyl phenol ethoxylates, alkanolamides, ethoxylated alcohols, ethoxylated alkyl phenols, and a mixture of the above. The foaming agent is desirably present in the aqueous solution of dyestuff in from 5 grams/liter to 20 grams/liter and satisfactory foams have been achieved with preferred foaming agents such as phosphate coesters and sulfated alkyl phenol ethoxylates in concentrations of 7 to 15 grams/liter. The actual amount of the foaming agent can be varied with practice to achieve the particular degree of foaming that is optimum for any given dye lot.

The foams suitable for padding on fibers according to the process of this invention have a density, relative to that of water, of 0.15 to 0.5; and preferably the foam density should be from 0.2 to 0.3. If the density is greater than about 0.4 to 0.5, the foam tends to run and be unstable with the same disadvantages accruing to the dyeing operation as are encountered in conventional processes. If the foam density is less than about 0.1, the foam is too dry and insufficient dyestuff is brought into contact with the fiber surface, with the result that the fiber is unevenly and inadequately dyed.

In order to create a foam having the foregoing density characteristics, air or other suitable gas such as nitrogen is introduced into the aqueous solution of dyestuff and foaming agent by means of foam generators well known in the art. The gas may be introduced beneath the surface of the dyestuff solution, as for example through a sparger of conventional design, or alternatively, the solution may be agitated and aerated by an external agitator.

In the dyeing of polyester fibers and basic dyeable polyester fibers, the aqueous solution of dyestuff must include in addition to the foaming agent, a carrier for the dyestuff. The carrier softens and swells the surface of the fiber and assists in the linkage of the dyestuff molecules thereto. It has been found that desirably the dyestuff carrier should have satisfactory foaming properties or alternatively must not adversely affect the foaming characteristics of the solution as are contributed by the foaming agent. Typically, the carrier is in two parts, namely, a solvent and an emulsifier. It has been found that satisfactory results are obtained if the emulsifier component of the carrier is inherently foaming and has sufficiently satisfactory emulsion maintaining properties to preclude the solvent from splitting out and destroying the foam. The emulsifiers which have the requisite properties are those selected from the group consisting of sulfated fatty esters, polyethylene

glycol esters, sulfated or phosphated alkyl phenol ethoxylates, sulfated or phosphated alcohol ethoxylates, ethoxylated alkyl phenols and sulfated fatty acids.

The solvents which form part of the carriers are preferably selected from the group consisting of trichlorobenzene, dichlorobenzene, dimethylphthalate, orthophenyl phenol, biphenyl, methyl naphthalate and dimethylterephthalate.

Typically, the carrier is from 10 to 50 percent by weight emulsifier and 20 to 80 percent solvent. The carrier is desirably present in the aqueous solution of dyestuff in from 20 to 60 grams/liter and good results are obtained if the carrier is present in from 10 to 80 grams/liter.

The aqueous solution of dyestuff, foaming agent and, if desired, carrier may also contain other additives which contribute various properties to the dye solution. Thus, for example, the dyestuff may contain monosodium phosphate or trisodiumphosphate in amounts to control the pH of the solution at the right level and obtain satisfactory dyeing performance.

Additives may be added to the dyestuff solution to adjust the viscosity of the mixture and lend stability to the foam. Compounds which are useful for this purpose are, for example, carboxymethylated or ethoxylated derivatives of natural gums, such as locust bean gum or guar gum. These compounds help to prevent migration of the dyestuff within the foam which is formed.

Compounds which make combinations of dyestuffs more compatible with one another and thus prevent precipitation of the reaction products of dyestuffs of opposite charge may also be added to the aqueous solution. These additives, known as compatibilizers, are added in relatively small amounts to maintain the integrity of the dyestuff mixture. Compounds which are suitable for this purpose are highly ethoxylated alcohols and alkyl phenols.

The foam process of this invention is further disclosed in the following examples.

REFERENCE EXAMPLE A

A fabric was dyed by the conventional wet dyeing process so that the results might be used as a reference for comparison with the results obtained with the process of the present invention. A solution having the following composition in grams per liter was formed:

Acetic Acid	0.04 g/l
Monosodium Phosphate	0.4 g/l
Leveling Agent	0.2 g/l
Trichlorobenzene Carrier	1.6 g/l
Disperse Blue 73	0.2 g/l
Disperse Yellow 54	0.2 g/l

Five grams of a polyester fabric were immersed into 200 milliliters of the above dye solution at 120° F. The temperature was then raised to 212° F over a period of 30 minutes. The dyeing was then continued at 212° F for 120 minutes. Thereafter, the fabric and solution were cooled to 150° F in 15 minutes. The polyester fabric was removed from the dyebath and rinsed to remove excess color.

The color of the dyed fabric was uniform and a full color shade was obtained.

REFERENCE EXAMPLE B

A dye solution having the formula set forth in Reference Example A was prepared except that the carrier concentration was reduced to 0.4 grams/liter. Five

grams of a polyester fabric were immersed into 200 milliliters of the dye solution and the temperature was raised to 250° F in 60 minutes. The dyeing was thereafter continued at 250° F for 1 hour. Thereafter, the fabric and solution were cooled to 150° F in 30 minutes.

The fabric color was uniform and a full color shade was obtained.

EXAMPLE I

A dye solution which is satisfactory when used in the foam dyeing process of this invention was formed and applied to a polyester knit fabric. The solution was not foamed however. The solution had the following composition:

Monsodium phosphate	2 ½ g/l
Compatibilizer (highly ethoxylated alcohol)	2 ½ g/l
Carboxymethyl locust bean gum	3 g/l
Phosphate coester foaming agent	7 ½ g/l
Trichlorbenzene carrier	30 g/l
Disperse Blue 73	10 g/l
Disperse Yellow 54	10 g/l

The above solution was padded on a polyester knit fabric. The padded fabric was maintained in a steam atmosphere for 8 minutes at 235° F and then was washed.

The color yield was satisfactory but the dyeing was non-uniform and blotchy.

EXAMPLE II

A dye solution having the same formula as set forth above in Example I was formed. The solution was foamed in a milkshake mixer until the foam had a density of approximately 0.25. The foam was then padded on a polyester knit fabric and the excess foam was removed. The padded fabric was steamed for eight minutes at 235° F and then was washed.

The color yield was satisfactory and the dyeing was uniform.

EXAMPLE III

The solution set forth in Example I was prepared except that the carrier was omitted. The solution was foamed and padded on the fabric as in Example II. The padded fabric was then treated at the conditions and for the time periods indicated in Example II.

The color of the dyed fabric was uniform but was weak.

EXAMPLE IV

The procedure of Example II was repeated but the steaming time was reduced to 4 minutes. The dyeing was uniform but lower in color yield.

EXAMPLE V

The procedure of Example II was again repeated, but the steam temperature was raised to 250° F. The color characteristics of the dyed fabric were satisfactory.

EXAMPLE VI

The procedure of Example II was again repeated, except that the dyestuff was Disperse Violet 26 in a concentration of 10 grams/liter. The color characteristics of the dyed fabric were satisfactory.

EXAMPLE VII

The procedure of Example II was repeated except that the dyestuff was Disperse Red 86 in a concentra-

tion of ten grams/liter. The color characteristics of the dyed fabric were satisfactory.

EXAMPLE VIII

A dye solution having the following composition was formed.

Monosodium Phosphate	25 g/l
Trisodium Phosphate	12 g/l
Carboxymethyl locust bean gum	2.25 g/l
Compatibilizer	2 g/l
Phosphate coester foaming agent	5 g/l
Dimethyl terephthalate carrier	50 g/l
Disperse Blue 56	10 g/l
Basic Yellow 11	10 g/l

The dye solution was foamed in a milkshake mixture to a density of approximately 0.25. Two fabrics were padded. The first fabric was a disperse dyeable type fabric and the second was a basic dyable polyester. After both fabrics were padded with the foamed dye solution, they were steamed for 8 minutes at 220° F and then were washed.

The disperse dyable fabric was dyed a uniform blue and the basic dyable fabric was dyed a uniform green.

As the reference examples indicate, it is possible to obtain uniform, full color dyeing with conventional processes. The disadvantages are that the fabric is weakened by exposure to carrier and/or high temperature. A further disadvantage is the length of time required for the dyeing process.

The results of Examples I and II, when compared, indicate the effectiveness of the foam process in producing a uniformly dyed fabric in substantially less time and at relatively lower temperatures than are possible with conventional processes.

Example III suggests that the carrier is essential to achieve superior results and Example IV indicates that a certain minimum steaming time is necessary to obtain satisfactory color yield. The remaining examples likewise demonstrate the effectiveness of the invention.

What is claimed is:

1. A process for dyeing fibers selected from the group consisting of synthetic fibers of polyester and basic dyable polyester, acrylics, polyamides, fiber blends thereof and blends of the foregoing with natural fibers wherein said blend contains not more than 90 percent natural fiber, comprising the steps of:
forming an aqueous solution of a dispersed dyestuff, a carrier for said dyestuff consisting essentially of a mixture of

a. a solvent selected from the group consisting of trichlorobenzene, dichlorobenzene, dimethylphthalate, ortho-phenyl phenol, biphenyl, methyl-naphthalate and dimethylterephthalate, and

b. an inherently foaming, stable emulsifier selected from the group consisting of sulfated fatty esters, polyethylene glycol esters, sulfated or phosphated alkyl phenol ethoxylates, sulfated or phosphated alcohol ethoxylates, ethoxylated alkyl phenols and sulfated fatty acids, and a foaming agent; foaming said aqueous solution in a foam forming zone and removing from said fibers, the foam being stable under the conditions of its formation and destructible at elevated temperatures and having a specific gravity of from 0.2 to 0.3; transferring the foam from said foam forming zone to a dyeing zone and applying it to said fibers out of contact with a liquid phase; and thereafter steaming said fibers to which said foam has been applied at an elevated temperature to break down said foam and fix said dye to said fiber.

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