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(57) Abstract: The present disclosure provides a process for preparing hydrophilic polyester fibers, said process comprising the steps of treating polyester fibers with a mixture comprising pre-determined weight proportions of at least one alkali and at least one hydrophilic polymer for a pre-determined period of time to obtain treated polyester fibers and curing the treated polyester fibers in an heated environment to obtain hydrophilic polyester fibers. The hydrophilic polyester fibers thus prepared demonstrate a wicking height of at least 2 cm in 30 minutes.



WO 2014/207760 A2

Title: HYDROPHILIC POLYESTER FIBERS**FIELD OF THE DISCLOSURE:**

The present disclosure relates to hydrophilic polyester fibers and a process for the preparation thereof.

BACKGROUND:

Synthetic fibers, for example, polyester fibers are always competing with cellulose fibers such as cotton and viscose on their hydrophilic nature and comfort properties. Polyester fibers are used in various areas but the hydrophobic nature of the polyester fibers restricts their use in several applications where hydrophilic properties of polyester fibers are particularly desired. Therefore, various routes are being explored to create hydrophilic polyester fibers in order to meet the market needs.

United States Patent Document 3400187 suggests a process for improving the surface characteristics such as hydrophilicity and antistatic property of shaped polyester structures such as films, filaments or fibers. The aforementioned US patent document recites the use of polyethylene glycol and an alkali hydroxide solution to induce hydrophilicity in polyester material, particularly at the fabric stage. Further, both the components are applied separately one after another using an applicator wheel.

Great Britain Patent document 786153 suggests a process for inducing hydrophilicity in polyester materials, particularly at the fabric stage by boiling the polyester material with an aqueous solution of sodium/potassium hydroxide and polyethylene glycol at 98°C to 100°C temperature. In the process as disclosed in the aforementioned GB patent, fabrics are dipped in large quantities of KOH and polyethylene glycol mixture. The application of the hydrophilic mixture to the processed fabric further involves additional process steps such as wetting and washing with large amounts of water, and drying.

Chinese patent document 102182063 suggests a method for the preparation of hydrophilic polyester fibers comprising uniform coating of a photosensitive polymer solution with a hydrophilic group on the surface of oil-removed polyester fibers. The coating of the hydrophilic solution is done by dipping or spraying method, under irradiation of ultraviolet light for solidification of the coating so that the hydrophilic group is fixed on the surface of the polyester fibers.

PCT publication WO1993/006269 discloses water-dispersible polyester fibers and precursor filament tow whose surface is modified and water dispersibility is improved by treating undrawn polyester filaments with a very small amount of caustic, when freshly extruded, preferably in spin-finish so as to become hydrophilic.

In spite of the various methods known for topical treatment, there is still felt a need to provide an improved method for imparting hydrophilicity to hydrophobic polymer materials so that the disadvantages allied with these known processes, such as long reaction time, additional process steps, weight reduction of polymer materials or expensive finishing agents are successfully solved.

OBJECTS:

Some of the objects of the present disclosure which at least one embodiment satisfies are described herein below:

It is an object of the present disclosure to ameliorate one or more problems of the prior art or to at least provide a useful alternative.

Another object of the present disclosure is to provide a simple and an economic process of the preparation of hydrophilic polyester fibers.

Still another object of the present disclosure is to provide a process for the preparation of hydrophilic polyester fibers that requires a considerably reduced process time as compared to the conventional processes.

Yet another object of the present disclosure is to provide a process for the preparation of hydrophilic polyester fibers where hydrophilicity to the hydrophobic polyester fibers is imparted at the final stages of fiber processing as compared to the existing processes where a hydrophilic mixture is added upstream thereby exposing the downstream equipment to alkali which causes corrosion.

Other objects and advantages of the present invention will be more apparent from the following description, which are not intended to limit the scope of the present invention.

DEFINITIONS:

As used herein, the term “hydrophobic polymer” refers to a polymer which is resistant to wetting or lacks affinity for water or tends to repel and not absorb water.

As used herein, the term, “hydrophilicity” refers to a tendency of a material which has a strong affinity for water, or readily absorbs water or is readily wetted by water. The hydrophilicity of polyester fibers in accordance with the present disclosure is measured by sinking time.

As used herein, the term “sinking time” refers to the time required to sink the compact mass of fiber completely at the surface of the water.

As used herein, the term “wicking height” refers to the level of water that rises in a given fabric in a specified time via capillary action.

As used herein, the term “durable” refers to a fiber which sustains hydrophilicity after several detergent washes and after several months of storage.

As used herein, the term “fiber” refers to a generic term for any one of the various types of matters that form the basic elements of a textile and is characterized by having a length of at least 100 times of its diameter.

As used herein, the term “yarn” refers to a bundle of continuous fibers or strands of fibers used in fabric or other textile fabrication.

Throughout this specification the word “comprise”, or variations such as “comprises” or “comprising”, will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

The use of the expression “at least” or “at least one” suggests the use of one or more elements or ingredients or quantities, as the use may be in the embodiment of the invention to achieve one or more of the desired objects or results.

SUMMARY

In accordance with the present disclosure, there is provided a process for preparing hydrophilic polyester fibers, said process comprising the following steps:

treating drawn and annealed polyester fibers with a mixture comprising pre-determined weight proportions of at least one alkali and at least one hydrophilic polymer for a pre-determined period of time to obtain treated polyester fibers; and curing the treated polyester fibers in a heated environment at a temperature varying between 80 °C and 160 °C for a time period varying between 6 and 15 minutes to obtain hydrophilic polyester fibers.

The method step of treating the polyester fibers comprises applying the mixture uniformly on the surface of said polyester fibers by at least one of a spraying method and a dipping method.

The mixture can be in the form of a solution or dispersion.

The individual weight proportion of the alkali and the hydrophilic polymer applied on the surface of the polyester fibers can vary between 0.02 and 1.0 %, based on the fiber weight.

The alkali can be at least one of potassium hydroxide and sodium hydroxide

The hydrophilic polymer can be at least one selected from the group of polymers consisting of polyethylene glycol, polyethylene oxide, polyethylene glycol diglycidyl ether and polyethylene glycol dimethyl ether.

In accordance with another aspect, the present disclosure provides a hydrophilic polyester fiber characterized by a sinking time ranging between 1 second to 5 minutes.

In accordance with still another aspect, the present disclosure provides a yarn comprising the hydrophilic polyester fibers of the present disclosure.

In accordance with yet another aspect, the present disclosure provides a fabric comprising the yarns of the present disclosure, said fabric being characterized by a wicking height of at least 2 cm in 30 minutes.

DETAILED DESCRIPTION:

The present disclosure overcomes the disadvantages of the earlier known processes by providing a method for producing hydrophilic polyester fibers, wherein the hydrophobic polyester fibers, at specific fiber forming stages, are treated with a mixture comprising an alkali and a hydrophilic polymer.

In accordance with one aspect, the present disclosure provides a process for preparing hydrophilic polyester fibers, said process comprises treating hydrophobic polyester fibers with a mixture comprising pre-determined weight proportions of at least one alkali and at least one hydrophilic polymer for a pre-determined period of time to

obtain treated polyester fibers; and curing the treated polyester fibers to obtain hydrophilic polyester fibers.

The hydrophobic polyester fibers according to the process of the present disclosure can include any polyester polymers or copolymers known to be used in textile industries, for example, polyethylene terephthalate. The hydrophobic polyester fibers according to the process of the present disclosure are treated with a mixture comprising pre-determined weight proportions of at least one alkali and at least one hydrophilic polymer for a pre-determined period of time. The concentration of the mixture, treatment time and conditions of treatment to a great extent depend on the degree of hydrophilicity desired to be imparted to the hydrophobic polyester fibers.

The treatment of the hydrophobic polyester fibers, according to the process of the present disclosure, includes the application of the mixture uniformly on the surface of the fibers so as to form a layer or a coating thereof on the surface of the fibers. The mixture can be applied on the surface of the polyester fibers by employing conventional application methods, for example, dipping, spraying and the like. In accordance with one of the preferred embodiments of the present disclosure, the mixture is applied on the surface of the polyester fibers by a spraying method.

The mixture used for the purpose of the present disclosure is a mixture that comprises at least one alkali and at least one hydrophilic polymer. The alkali used for the purpose of present disclosure is at least one of KOH and NaOH. The hydrophilic polymer used for the purpose of the present disclosure is at least one polymer selected from the group consisting of polyethylene glycol, polyethylene oxide, polyethylene glycol diglycidyl ether and polyethylene glycol dimethyl ether. The preferred hydrophilic polymer for the purpose of the present disclosure is polyethylene glycol polymer with an average molecular weight ranging between 100 and 10,000. The alkali and the hydrophilic polymer are mixed in excess of water to obtain the mixture. The obtained mixture is either in the form of a solution or dispersion.

The treatment of the hydrophobic polyester fibers, in accordance with the process of the present disclosure, is carried out during fiber forming stages, particularly during drawline or annealing of the fibers whereas in the existing processes the treatment is usually carried out either at an early stage i.e. during polymer preparation or melt spinning, or at a later stage during fabric manufacturing.

In accordance with the process of present disclosure, the polyester fiber (undrawn tow received from spinning) is passed through a draw zone to form drawn crimped polyester fibers. The mixture is then sprayed through nozzles on the drawn polyester fibers in a drawline as a Post Annealer Finish Application. The concentration of the mixture, treatment time and conditions of treatment depend on the degree of hydrophilicity desired in the polyester fibers. The mixture used for the purpose of the present disclosure comprises the alkali and the hydrophilic polymer in pre-determined weight proportions so as to form a uniform layer thereof on the surface of the polyester fiber. The individual weight proportions of the alkali and the hydrophilic polymer are in the range of 0.02 to 1.0 wt%, based on the fiber weight. The mixture is typically sprayed on the surface of the polyester fiber for a time period varying between 6 minutes and 15 minutes. The treated polyester fibers, thus obtained, are then passed through a crimper to impart crimps (waviness) to the treated polyester fibers.

The treated polyester fibers are then dried and cured to remove excess of water and to durably fix the mixture composition on the surface of the hydrophobic polyester fibers. The curing of the treated polyester fibers is typically accomplished at a temperature varying between 80 °C and 160 °C and for a time period varying between 6 minutes and 15 minutes.

In order to confirm the hydrophilic nature of the polyester fibers prepared in accordance with the process of the present disclosure, the hydrophilic polyester fibers are subjected to a sink time measurement. For this, the present hydrophilic polyester fibers are washed with AATCC detergent WOB 1993 (without optical brightener and

without phosphate) at 40°C for 10 min and rinsed in flowing water. Afterwards, the washed fibers are dried in an oven at 75 °C for 1 hour. The dried fibers are then opened by hand and made into a ball of about 1.5" diameter. The ball is conditioned at 23 °C at RH = 65% for 24 hours. The ball is then dropped from 1 cm height into a water filled beaker. The time period till the ball is completely immersed into water is measured. The sinking time of the hydrophilic polyester fibers in accordance with the process of the present disclosure ranges between 1 second to 5 minutes.

The hydrophilic polyester fibers prepared in accordance with the present disclosure are used further in the preparation of yarns and fabrics.

In another aspect, the present disclosure also provides a hydrophilic yarn comprising the hydrophilic polyester fibers of the present disclosure.

In still another aspect, the present disclosure provides a hydrophilic fabric comprising the yarns of the present disclosure. The hydrophilic fabric, in accordance with the present disclosure is characterized by a wicking height of at least 2 cm in 30 minutes. The wicking height the hydrophilic fabric of the present disclosure clearly shows its excellent hydrophilic nature. Further, the hydrophilicity imparted to the polyester fibers and yarns and fabrics of the present disclosure is durable and able to withstand washing or laundering.

The embodiments herein and the various features and advantageous details thereof are explained with reference to the non-limiting embodiments in the following description. Descriptions of well-known components and processing techniques are omitted so as to not unnecessarily obscure the embodiments herein. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments herein may be practiced and to further enable those of skill in the art to practice the embodiments herein. Accordingly, the examples should not be construed as limiting the scope of the embodiments herein.

Example 1:**Preparation of hydrophilic polyester fibers:**

Polyethylene glycol 1500 (0.4 parts) and potassium hydroxide (0.2 parts) were mixed in 100 parts of water. The solution thus prepared was sprayed through nozzles on drawn polyester fibers (50 % on the weight of fiber) which were taken post annealer from the drawline. The treated polyester fibers thus obtained were kept in an oven at temperatures gradually increasing from 110°C to 140°C with a gradient of 3°C per minute.

Example 2:

The same procedure as in example 1 was followed except that polyethylene glycol 1500 was not added to the composition.

Example 3:

The same procedure as in example 1 was followed except that potassium hydroxide was not added to the composition.

Example 4:

The same procedure as in example 1 was followed except that polyethylene glycol of molecular weight 400 was taken instead of 1500.

Example 5:

The same procedure as in example 1 was followed except that polyethylene glycol of molecular weight 4000 was taken instead of 1500.

Sinking Time Measurement:

The fibers prepared in accordance with the above described examples were subjected to a sinking time measurement in order to evaluate their hydrophilic nature.

1 g of each the fibers, prepared in accordance with the above described examples, were individually washed with AATCC detergent WOB 1993 (without optical

brightener and without phosphate) (1 gpl) at 40°C for 10 min and rinsed in flowing water. Afterwards, the washed fibers were dried in an oven at 75 °C for 1 hour.

The dried fibers were then opened by hand and made into individual balls of about 1.5" diameter. The balls were conditioned at 23 °C at RH = 65% for 24 hours. The balls were then dropped from 1 cm height into a water filled beaker. The time period till the balls were completely immersed into water was measured, as shown in **Table-1**.

Table-1: Sinking time test results

Fiber type	Sinking time
Polyester fibre (Example 1)	Less than 20 seconds
Polyester fiber (Example 2)	> 24 hours*
Polyester fiber (Example 3)	> 24 hours*
Polyester fiber Example 4)	Less than 20 seconds
Polyester fiber Example 5)	Less than 20 seconds

- Sample was observed for 24 hours

Examples 1 to 5 were accomplished in a laboratory to optimize the process conditions and the solution composition. From the data provided in Table-1, it is evident that the combination of polyethylene glycol and potassium hydroxide furnishes excellent results in terms of imparting the hydrophilic nature to the hydrophobic polyester fibers. The individual use of polyethylene glycol and potassium hydroxide does not provide any satisfactory results (see data in Table-1 corresponding to example-2 and example-3). Further it was demonstrated that the optimized combination of polyethylene glycol and potassium hydroxide with different molecular weights of

polyethylene glycol also provides excellent results in terms of imparting the hydrophilic nature to the hydrophobic polyester fibers.

Based on the aforementioned results, plant trials were also conducted which are explained herein below in the following examples.

Example-6:

Preparation of hydrophilic polyester fibers:

Polyethylene glycol 1500 (1.84 parts) and Potassium hydroxide (0.95 parts) were mixed together. Subsequently, water was added to make up 100 parts. The solution thus obtained was sprayed through nozzles on the drawn polyester fibers running at 45 kg/min and 180 m/min in drawline at 6.5 l/min flow rate to obtain treated polyester fibers. The treated polyester fibers were passed through a crimper, to impart crimps (waviness) to the fibers, and were then passed through a relaxer where heat-setting /curing took place at 150°C for 7 minutes. The hydrophilic polyester fibers, thus obtained, were cut into staple length of 38 mm.

Example 7:

Preparation of polyester fiber (Control):

The same procedure as in example 6 was followed except that polyethylene glycol 1500 and potassium hydroxide were not added to the composition.

Sinking time was measured for these samples and the results are provided in Table-2 as follows:

Table-2: Sinking time test results

Fiber type	Sinking time
Polyester fibre (Example 6)	Less than 20 seconds
Polyester fiber (Example 7)	> 24 hours*

- Sample was observed for 24 hours

Example 8:

2/30s yarn was spun individually from the hydrophilic polyester fibers of example-6 and the controlled polyester fibers of example 7 using a ring spinning machine with a twist multiplier of 2.9. Afterwards, fabrics were individually manufactured from the yarns using 62 ends per inch and 52 picks per inch on CCI sample loom.

Example 9:

This example describes a process for dyeing fabric samples prepared in accordance with example-8.

Fabric samples prepared in example-8 were dyed in high temperature and high pressure dyeing machine (HTHP), at a shade depth of 1% at 130°C and holding of 30 min. Afterwards, reduction clearing was done using 2 g/l NaOH and 2 g/l Na₂S₂O₄ at 80°C for 20 min. These dyed fabric samples were then dried at 75°C.

The wicking height of the fabrics of example-8 (referred to as grey fabric) and the fabrics of example-9 (referred to as dyed fabrics) was measured using AATCC 79 in which strips of size 9x1 inch were marked 1 inch above the bottom edge and 1 inch below the upper edge. The strips were clamped so that they hang vertically. The strips were then lowered in the beaker containing 300 ml distilled water up to the mark. The wicking height was measured in cm (the height to which the water rises in 30 minutes). Wicking height test results of the hydrophilic polyester fabrics both grey and dyed are displayed in Table-3.

Table-3: Wicking height test results

No of Washes	Wicking height of hydrophilic grey fabric, cm	Wicking height of hydrophilic dyed fabric, cm
1 wash	10	15
10 wash	8.5	13
20 wash	7.5	13

It is clearly understood from Table-3, that the hydrophilic polyester fabrics, both grey and dyed, prepared from the yarns comprising the hydrophilic polyester fibers of example-6 demonstrate a wicking height in the range of 7.5 cm to 13 cm in 30 minutes. Whereas, the fabrics prepared from the yarns comprising the controlled polyester fibers of example-7, demonstrate a wicking height of < 1 cm even after 1 detergent wash. Washing was done with AATCC detergent WOB 1993 (without optical brightener and without phosphate) (1 gpl) at 40°C for 10 min (per wash), rinsed in flowing water, and dried in an oven at 75 °C.

TECHNICAL ADVANCEMENT:

The present disclosure, related to a process for preparing hydrophilic polyester fibers, has the following technical advancements:

- Less reaction time, as the process involves
 - (i) rapid application of a mixture comprising an alkali and a hydrophilic polymer to the surface of the hydrophobic polyester fibers at the fiber stage, particularly after annealing zone; and
 - (ii) treated polyester fibers are exposed to high temperature for considerably short time period,
- Durable hydrophilicity,
- Simple and economic process for producing durable hydrophilic polyester fibers, and
- Use of excess amount water is alleviated.

The numerical values mentioned for the various physical parameters, dimensions or quantities are only approximations and it is envisaged that the values higher/lower than the numerical values assigned to the parameters, dimensions or quantities fall within the scope of the invention, unless there is a statement in the specification specific to the contrary

The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the embodiments as described herein.

CLAIMS:

1. A process for preparing hydrophilic polyester fibers, said process comprising the following steps:
 - i. treating drawn and annealed polyester fibers with a mixture comprising pre-determined weight proportions of at least one alkali and at least one hydrophilic polymer for a pre-determined period of time to obtain treated polyester fibers; and
 - ii. curing said treated polyester fibers in a heated environment at a temperature varying between 80 °C and 160 °C for a time period varying between 6 and 15 minutes to obtain hydrophilic polyester fibers.
2. The process as claimed in claim 1, wherein the process step of treating the polyester fibers comprises applying the mixture uniformly on the surface of the polyester fibers by at least one of a spraying method and a dipping method.
3. The process as claimed in claim 1, wherein said mixture is in the form of a solution or dispersion.
4. The process as claimed in claim 1, wherein the individual weight proportion of the alkali and the hydrophilic polymer applied on the surface of the polyester fibers varies between 0.02 and 1.0 %, based on the fiber weight.
5. The process as claimed in claim 1, wherein the alkali is at least one of potassium hydroxide and sodium hydroxide.
6. The process as claimed in claim 1, wherein the hydrophilic polymer is at least one selected from the group consisting of polyethylene glycol, polyethylene oxide, polyethylene glycol diglycidyl ether and polyethylene glycol dimethyl ether.

7. A hydrophilic polyester fiber prepared in accordance with the process as claimed in any of the preceding claims, wherein said fiber is characterized by a sinking time varying between 1 sec and 5 minutes.
8. A yarn comprising hydrophilic polyester fibers as claimed in claim 7.
9. A fabric comprising yarns as claimed in claim 8, wherein said fabric is characterized by a wicking height of at least 2 cm in 30 minutes.