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(54) Acrylic fibers for low pill fabrics.

(57) Acrylic fibers from which low pill woven or knitted spun fabrics can be made are described. The fibers are characterized in having low elongation-to-break and low knot tenacity values.

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BACKGROUND OF THE INVENTION

This invention relates to acrylic fibers from which low pill fabrics can be made. By "acrylic fibers" is meant manufactured fibers in which the fiber-forming substance is any long chain synthetic polymer composed of at least 85% by weight of acrylonitrile units [-$CH_2CH(CN)$-]. The term "fibers" includes fibers of extreme or indefinite length (filaments) and fibers of short length (staple).

In commercial practice, acrylic fibers, after being manufactured in filament form (e.g. tow) by either wet-spinning or dry-spinning processes, are either converted to a strand of loosely assembled staple (sliver) by stretch breaking of the tow or to individual staple by cutting of the tow. The staple, with or without blending with other staple, and the sliver, with or without combining with other sliver, is processed in a conventional manner into spun yarn. The spun yarns are then used in a conventional manner to make knitted or woven fabrics. A major problem associated with these fabrics is that of pilling. Pilling is the formation of small pills on the surface of the fabrics. The pills, i.e., bunches or balls of tangled fibers, are held to the surface of a fabric by one or more fibers. The pills are normally produced when the fabric is rubbed (abraded) at wear areas, e.g., the elbow and collar areas of a shirt or the pocket area of a pair of trousers. Pilling is especially a problem with sweaters due to their bulky knit construction. Pills greatly distract from the appearance of garments. Although considerable effort has been expended in the past to solve the pilling problem, a satisfactory solution has not heretofore been found.

SUMMARY OF THE INVENTION

The present invention provides acrylic fibers having a denier fiber (dpf) in the range of 0.5 to 6.0 and being characterized in having an elongation-to-break of no greater than 35% and a knot tenacity no greater than 1.7 grams per denier. Elongation-to-break and knot tenacities given herein are determined according to ASTM tests designations D 2101-82 and D 3217-79, respectively. The fibers are further characterized in that the elongation and knot tenacity are selected such that when a test fabric is made from yarn consisting of the fibers in 2-inch (5.08-cm) staple form and tested for pilling according to Test A, hereinafter defined, the test fabric on a scale of 1 to 5 has a Pilling Value of at least 3.5 and preferably at least 4.0 and most preferably at least 4.5. (A Pilling Value of 5 represents no pilling and a Pilling Value of 1 represents very severe pilling.) Typically, woven or knitted fabrics made from conventional acrylic staple have a Pilling Value in the range of 1 to 2.

Fabrics made from spun yarn consisting of acrylic staple of the present invention are unique in that pills which form on the surface of such fabrics break off and become separated from the fabric, thereby reducing the pilling characteristics of the fabric. The loss of this small amount of fiber from the fabric is insignificant and, as compared to the unsightly appearance otherwise caused by the pills, is highly beneficial.

PREFERRED EMBODIMENTS OF THE INVENTION

According to the preferred embodiment, the acrylic fibers of the invention are prepared by the modified wet-spinning process disclosed in Example 1 given hereinafter. This process differs from the conventional wet-spinning process in that (1) the wet-stretch orientation taken is in the range of 1.5 to 4.5 with a range of 2.5 to 4.5 being preferred, whereas conventionally the range is from 4.75 to 6.5, (2) the concentration of dimethlyacetamide (DMAc) in the aqueous spin bath is in the range of 35 to 45% by weight with a range of 37 to 43% by weight being preferred, whereas in the conventional process the range is from 45 to 62% by weight and (3) the autoclave relaxation (annealing pressure) used is in the range of 10 to 20 psig (0.70 to 1.40 Kg/cm^2) with a pressure of 13 to 18 psig (0.91 to 1.27 Kg/cm^2) being preferred, whereas in the conventional process the range is from 30 to 37 psig (2.11 to 2.60 Kg/cm^2). In using the modified wet-spinning process to prepare acrylic tow of the invention, the wet-stretch, DMAc spin bath concentration and annealing pressure are correlated within the modified ranges just given to provide tow such that when a test fabric is made from yarn consisting of 2-inch (5.08-cm) staple cut from the tow and tested for pilling according to Test A, the test fabric has a Pilling Value of at least 3.5.

According to one embodiment of the invention the fibers are modacrylic fibers instead of acrylic fibers. Modacrylic fibers differ from acrylic fibers in that they are composed of less than 85% but at least 35% by weight of acrylonitrile units.

Preferably, the acrylic and modacrylic fibers of the invention are composed of a fiber-forming copolymer formed by reacting acrylonitrile with one or more vinyl monomers copolymerizable therewith. Such monomers are well-known in the art and include by way of example vinyl acetate, vinylidene chloride, methylacrylate, methylmethacrylate, vinyl bromide, styrene, sodium styrene sulfonate, 2-methyl-2-acrylamidosulfonic acid, and sodium sulphophenyl methallyl ether.

TEST A

Pilling Performance Values for acrylic fibers having a dpf in the range of 0.5 to 6.0 are determined as follows:

The fibers in filament for (e.g. tow), are cut to 2-inch (5.08-cm) staple and then processed into sliver

and spun into 16 cotton count spun yarn having 11 turns per inch (4.33 turns per cm) in the Z-direction on a conventional short staple ring spinning frame. Two of these yarns are plied with 5 turns per inch (1.97 turns per cm) of twist in the S-direction. The resulting 16/2-ply cotton count yarn is knitted into a 7 cut jersey fabric and tested for pilling according to ASTM Test designation D 3512 - 82. A rating (Pilling Value) of 5 is the best rating (no pilling) while a rating (Pilling Value) of 1 is the worst rating (very severe pilling). When the appearance of the test fabric is between two ratings (e.g. between 2 and 3) a half value is assigned (e.g. 2.5).

The following examples are given to further illustrate the invention. In the examples, percentages are by weight unless otherwise specified.

EXAMPLE 1

This example illustrates a wet-spinning process for producing the acrylic fibers of the present invention.

A copolymer comprising 92.5% acrylonitrile and 7.5% vinylacetate was dissolved in DMAc in an amount sufficient to provide a 25% polymer solution. This polymer solution, at a temperature of 105 degrees C., was extruded through 12 spinnerets, each having 60,000 circular orifices of a diameter of 3.0 mils (0.076 mm) at the rate of 2459 grams of polymer solution per spinneret per minute. Each spinneret was immersed in an aqueous DMAc spin bath having a DMAc concentration of 40% and a temperature of 41 degrees C. Water was added during spinning to maintain this concentration and temperature. The rate of fiber production was 975 pounds (442 Kg) per hour. Each resulting filament bundle (tow) was withdrawn from the spin bath by means of rolls at a linear speed of 36 ft. (10.97 m.) per minute, washed with water to remove DMAc and wet-stretched 3.5 times in a series of mass transfer units at 70 to 97 degrees C. as described in U.S. patent 4,059,668. An aqueous finish comprising an emulsifier, a wetting agent and a lubricant and antistatic agent for the tow was applied to each tow and the tows were dried and collapsed by being passed under tension, first, over rolls heated internally to a surface temperature of about 160 degrees C. by means of steam and, then, over rolls cooled to a surface temperature of about 55 degrees C. by means chilled water. The peripheral speed of both the heated and cooled rolls was 127 ft. (38.71 meters) per minute. The tow was then crimped by being passing through a conventional stuffer box crimper using pressurized steam. From the crimper, the tow was piddled into a can and annealed by placing the can in an autoclave and subjecting the tow to 20 steam treatment cycles where each cycle consisted of pressurizing the autoclave with steam to a pressure of 15 psig (1.05 Kg/cm^2) then venting the autoclave to reduce the pressure to atmospheric pressure. After annealing, the final dpf of each tow was 3.0. The 3.0 dpf tows were cut to 2.0-inch (5.08-cm) staple. A knit test fabric was made from 16/2-ply cotton count yarn consisting of the staple and tested according to Test A. The fabric had a Pilling Value of 4.0.

COMPARATIVE EXAMPLE

In this example, a test fabric was made and tested as described in Example 1, except in this instance the DMAc spin bath concentration was 51%, the wet-stretch orientation was 6.02 times, and the annealing pressure was 33.8 psig (3.38 Kg/cm^2). In this instance, the test fabric had a Pilling Performance Value of 1.5.

EXAMPLE 2

This example illustrates the blending of acrylic staple of the invention with commercially available acrylic staple having a higher than normal boiling water shrinkage (BWS) value, i.e., a value of 18 to 20% BWS instead of the normal 0 to 3%.

Three (3) dpf staple tow was made as described in the Comparative Example, except that an annealing pressure of 44 psig (3.09 Kg/cm^2) was used. The tow was hot-stretched under conditions to provide a final dpf of 2.5 and a BWS value of 18 to 20% and then cut to 2-inch (5.08 cm) staple. This staple was then blended with staple made as described in Example 1 in an amount sufficient to provide a blend consisting of 60% by weight of the staple of Example 1 and 40% by weight of the high shrinkage staple. A knit test fabric was made from 16/2-ply cotton count yarn consisting of the staple blend and tested according to Test A. This fabric also had a Pilling Value of 4.5.

Claims

1. Acrylic or modacrylic fibers having a denier in the range of 0.5 to 6.0, said fibers being characterized in having an elongation-to-break of no greater than 35% and a knot tenacity no greater than 1.7 grams per denier.

2. The fibers of claim 1, wherein said fibers are acrylic fibers.

3. The fibers of claim 2 further characterized in that said elongation and said knot tenacity are selected such that when a test fabric is made from yarn consisting of said fibers in 2-inch (5.08-cm) staple form and tested for pilling according to Test A, said fabric has a Pilling Value of at least 3.5.

4. The fibers of claim 3, wherein said fibers are wet-

spun fibers.

5. The fibers of claim 4 comprising a copolymer of acrylonitrile and vinyl acetate.

6. The fibers of claim 5, wherein said copolymer comprises from 88% to 95% by weight of units of the formula $-CH_2-CH(CN)-$.

7. The fibers of claim 1, wherein said fibers are in filament form.

8. The fibers of claim 1, wherein said fibers are in staple form.

9. The fibers of claim 3, wherein said test fabric has a Pilling Value of at least 4.0.

10. The fibers of claim 3, wherein said test fabric has a Pilling Value of at least 4.5.

11. The fibers of claim 1, wherein said fibers are modacrylic fibers.