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3,350,872

PROCESS FOR YARN PRODUCTION FROM ACRYLIC FIBERS

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This invention relates to production of wool-like synthetic textile yarns from staple fibers, and more specifically to a method of preparing such yarns with high strength and uniformity.

Many attempts have been made to develop a synthetic textile yarn which would simulate the desirable quality attributes of wool. It has recently been noted that a yarn spun from a mixture of staple fibers, one component of which possessed a helical crimp or the potential to become helically crimped when heated and relaxed, and the other component of which was a relatively straight staple fiber, possessed many of the qualities of a wool yarn. However, when a good degree of helical crimp existed in the crimped staple fiber portion of the blend which was to be spun to yarn, the resulting yarn was weaker and less uniform than when the crimp was developed in the fiber after spinning. This was even more pronounced when the uncrimped staple was of lower tenacity than the crimped staple. Since fibers exist which have an inherent potential to crimp, it has been possible to blend and spin and thereafter develop the crimp in the crimpable fibers. This is of limited advantage, however, because it requires that such blends be processed without encountering crimping conditions. For example, the economically desirable process of stock dyeing, which involves exposure of the staple fibers to hot media prior to spinning, cannot be used for producing the wool-like products from such blends.

It has now been discovered that wool-like textile yarns can be made from such synthetic fibers without sacrifice of strength or yarn uniformity, or the advantage of processing in the presence of hot media prior to spinning to the yarn. These unique results are achieved by using a particular blend of staple fibers in producing spun yarns for production of wool-like textile products. The blend used in accordance with this discovery is a staple fiber blend of (A) 30 to 75 weight percent of an essentially straight monocomponent acrylic fiber having a tenacity of 0.75 to 1.40 grams per denier and (B) 70 to 25 weight percent of a bicomponent acrylic fiber having a tenacity at least equal to that of fiber (A), fiber (B) upon exposure to hot liquid media developing helical crimp to a frequency of about 10 to 18 crimps per inch and having a length, in the uncrimped state or under just enough tension to substantially eliminate crimp, of 105 to 125 percent of the length of fiber (A). Subject to the stated limitations, fiber (A) and fiber (B) each can comprise mixtures of different staple fibers. The blend can be stock dyed or otherwise treated to crimp fiber (B) and the resulting blend can then be spun to yarn with the advantageous results stated above.

The synthetic fibers that are employed in practicing the present invention are well-known, as are their methods of manufacture. The straight fiber component, fiber (A) of the blend, can be any monocomponent acrylic fiber such as a fiber formed of a homopolymer of acrylonitrile as well as copolymers such as those containing at least 85 weight percent of acrylonitrile and up to 15 weight percent of one or more monoethylenically unsaturated monomers copolymerizable with acrylonitrile. Copolymers are preferred. Fiber (B) is a bicomponent or composite acrylic fiber, by which is meant an acrylic filament spun from two different acrylic polymers or copolymers in a side-by-side or sheath-core relationship along the length of the

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fiber; the difference in shrinkability between the two components of the composite fiber causes helical crimping upon boil-off or similar treatment of the fibers. A preferred bicomponent fiber for use in this invention is a side-by-side structure, one side being of polyacrylonitrile and the other a copolymer such as indicated above for fiber (A). Such fibers are described in the patent to Breen, U.S. 3,038,236, dated June 12, 1962. The usual additives in their normal amounts can be included in one or each of the fibers making up the blends for this invention.

As noted the invention is practiced with a blend of fibers including helically crimped fibers that, but for the present discovery, would result in a non-uniform, relatively weak yarn. The present invention avoids that result by the specifications relating to the fibers making up the blend. However except for those limitations, yarn production of this invention is conventional and any desired blending, carding, drafting and spinning sequence can be used. Thus, the fibers can be blended in any of the ways staple fibers now are blended, for example by mechanically blending in a wool blender or a cotton picker followed by carding which completes the blending, by pneumatic blending or the like. The fibers used are of staple length, the exact length used depending, of course, upon the spinning system to be employed. For cotton system spinning the staple would generally be 1.2 to 3 inches, while for the worsted or woolen system lengths of 3 to 5 inches would be used. Deniers can range from about 1.5 denier to about 25 denier for the cotton, woolen or worsted systems, and normally are up to 3 denier per filament for the cotton-system and 3 to 25 denier per filament for the woolen or worsted system.

The yarns produced with the described blends are preferably produced on the woolen or worsted system in any yarn count suitable for preparation of woven, tufted or knitted textile products. A desirable yarn count for preparation of tufted carpets is 1.25 wool run singles yarn although this can be varied from about 0.5 wool run to 1.75 wool run, depending upon the style of carpet desired. The singles yarns can be 2, 3 or 4-ply for styling effects.

The crimped fibers (B) in the blend as spun have a crimp frequency of 10 to 18 crimps per inch, a crimp index of 9 to 15 percent, and a tenacity at least equal to that of fiber (A) and preferably on the order of 0.9 to 1.2 grams per denier or higher. Crimp frequency and crimp index indicate the amount and degree of crimp in a crimped fiber and are determined as follows:

To a length of the fiber to be tested is applied a tension of 2 mg. per denier and the length of the fiber (L_0) is measured while under this tension. The number of peaks protruding from one side of the helix axis of the fiber is counted (n). A 50 mg. per denier tension is substituted for the 2 mg. per denier tension and the new length of the fiber (L_x) is measured while under this tension. Crimp frequency is calculated by the formula:

$$\text{Crimp frequency} = \frac{n}{L_x \text{ (in inches)}}$$

Crimp index is calculated by the formula:

$$\text{Crimp index} = \frac{(L_x - L_0) 100\%}{L_0}$$

While the crimped fiber used in the blend is 105 to 125 percent (measured under tension to remove crimp) and preferably 106 to 120 percent of the length of the straight fiber, it is desirable that the length of the crimped fiber measured in the crimped state be the same length as the straight fiber. Accordingly, the length and crimp frequency of fiber (B) should be selected with that consideration in mind.

The quantitative strength of yarn produced is expressed in terms of its Lea Product. This is measured by determining the minimum weight, applied to the bottom of a suspended skein, required to break the skein. The Lea Product is the value obtained by multiplying that minimum weight, in pounds, by the yarn count (e.g. cotton count).

Coefficient of variation (C.V.) is a measurement of yarn evenness. It is measured on the Uster Evenness Tester, manufactured by Zellweger Company of Uster, Switzerland. A description of its operation and the treatment of data obtained is given at pages 459 et seq. of "Handbook of Textile Testing and Quality Control," by Grover & Hamby, 1960 edition.

The intrinsic viscosities stated in this specification are determined using Equation 50, page 310 of "Principles of Polymer Chemistry," by P. F. Flory, Cornell U. Press, 1953. The solvent employed is dimethylformamide.

The term straight fiber as used herein means a fiber which as produced possesses essentially no inherent ability to crimp.

The invention is illustrated by the following examples although it is not to be restricted to the details given.

Example I

This example illustrates the increased strength and uniformity of yarns obtained with the present invention.

Composite filaments characterized by having two separate and distinct polymeric species in side-by-side relationship and in intimate adherence along their longitudinal axis, similar to the composite filament disclosed in Breen U.S. 3,038,236 dated June 12, 1962, are produced by introducing a solution of 93 parts polyacrylonitrile of intrinsic viscosity of 2.0 and 7 parts tris(2,3-dibromopropyl) phosphate, into one inlet of a spinneret such as that described in Calhoun U.S. 3,006,028 dated Oct. 31, 1961, and a solution of 93 parts of a polymer consisting of 96% acrylonitrile, and 4% sodium styrene sulfonate of intrinsic viscosity 1.5 and 7 parts tris(2,3-dibromopropyl)phosphate, into the other inlet port of that spinneret and spinning the polymers into an evaporative atmosphere under conditions normally used for spinning fibers of polyacrylonitrile. The ratio by weight of polymer to copolymer components in the filaments is approximately 50:50 and the denier of the individual filaments is 12 denier per filament. The filaments are drawn to from 3.0 to 4.5 times their original length in a water/DMF solution at a temperature of between 75 and 100° C. and thereafter are cut to 3.75 inches staple. This is a commercial fiber and its tenacity is 1.1 to 1.2 grams per denier.

A copolymer of 1.5 intrinsic viscosity consisting of 93 parts of 93.6% acrylonitrile, 6% methyl acrylate and 0.4% sodium styrenesulfonate and 7 parts tris (2,3-dibromopropyl) phosphate, is spun to filaments of 17 denier per filament by standard methods used for production of polyacrylonitrile fibers. The filaments are drawn to from 1.86 to 2.50 their original length. This is a commercial fiber of about 0.9 gram per denier tenacity. These fibers are then divided into 6 separate portions and each portion is cut to staple of lengths as indicated in Table 1.

Six staple blends each composed of 50% by weight of composite filaments to copolymeric filaments are prepared by mixing the composite filament staples with each of the aforesaid six portions of the copolymeric staple fibers using wool blender. These six blends are then separately stock-dyed and dried by conventional procedures. After the staples are placed in the dye bath, the bath temperature is brought to from 98° C. to 100° C. and the staples are kept in this solution for 1.5 hours. Upon being exposed to the hot dye solution and dried, the composite staple filaments develop a crimp frequency of from 10 to 18 crimps per inch and a crimp index of from 9 to 15%.

The six blends are then separately spun on the woolen system to singles yarn of 1.25 wool run and 4.5 "Z" turns

per inch. These singles yarns are then two-ply to 3.5 "S" turns per inch. Table 1 illustrates the properties of these yarns.

TABLE 1

Item	Copolymer fiber length, inches	Lea Product (of 2-ply yarn)	C.V.
1.....	4.2	1,138	15.2
2.....	4.0	1,199	15.7
3.....	3.75	1,210	15.7
4.....	3.5	1,260	15.2
5.....	3.25	1,380	14.5
6.....	3.00	1,154	11.8

C.V. is a measure of thick and thin portions of a textile yarn and increases as the thick and thin portions become more severe. It should be noted that items 1, 2 and 3 are examples of the yarn characteristics exhibited by yarns of the prior art and items 4, 5 and 6 are examples of yarns produced in accordance with the present invention.

Example II

Two staple blends are prepared as follows: Blend 7: 50% of a composite filament staple identical to the composite filament staple of Example I with the exception that the staple is 3.90 inches long; and 50% of a copolymer staple identical to the copolymer staple of Example I with the exception that the staple is 3.65 inches long. Blend 8: Identical to blend 7 with the exception that the composite filament staple is 3.75 inches long and the copolymer staple is 4.0 inches long.

Each blend is separately dyed and spun on the woolen system as in Example I.

Table 2 shows the physical properties of the yarns of this example.

TABLE 2

Item	Lea Product (singles yarn)	C.V.
Blend 7.....	866	14.2
Blend 8.....	428	13.6

It is readily seen that the yarn of Blend 7 possesses higher strength than Blend 8.

The process of the present invention provides yarns of high strength or uniformity, or both, from mixtures of certain crimped and uncrimped staple fibers. The staple fibers may be stockdyed or exposed to heat treatment prior to spinning thus causing the crimpable staple fiber to crimp and yet surprisingly, the spun yarns resulting from these blends do not suffer from strength or uniformity defects. Yarns of the present invention may be woven or knitted into fabrics to be used for home furnishing, wearing apparel and the like. Moreover, their high degree of strength and good uniformity makes them desirable for use in pile fabrics such as carpets.

What is claimed is:

1. In the process of making yarn from fiber blends of staple length fibers of at least two different species of fibers, in which the species of fibers are thoroughly blended and then processed by being spun into a yarn, the method of providing relatively higher strength in the yarn produced comprising forming the blend from about 30 to 75 percent by weight of an essentially straight mono-component acrylic fiber, and about 70 to 25 weight percent of a helically crimpable bicomponent acrylic fiber having a tenacity at least equal to the tenacity of the straight fiber, the length of the helically crimpable fiber being 105 to 125 percent of the length of the straight fiber when measured under a tension just sufficient to remove crimp, heating the blend of fibers sufficiently to

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crimp the bicomponent fibers to 10 to 18 crimps per inch, and spinning the resulting blend of fibers to a yarn.

2. A process according to claim 1 in which the straight fiber is polyacrylonitrile, and the helically crimpable fiber is a side-by-side bicomponent having polyacrylonitrile as one of its components and a copolymer of at least 85 percent acrylonitrile and up to 15 percent of at least one monoethylenically unsaturated monomer copolymerizable therewith as the second component.

3. A process according to claim 2 in which the straight fiber has a tenacity of 0.75 to 1.40 grams per denier.

4. A process according to claim 3 in which the fibers are present in about equal amounts in the blend.

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References Cited

UNITED STATES PATENTS

3,046,724	7/1962	Ward	57—140
3,081,516	3/1963	Evans	57—140
3,161,011	12/1964	Humphreys	57—140
3,279,163	10/1966	Lulay et al.	57—140

FOREIGN PATENTS

870,017	6/1961	France.
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