Dec. 15, 1964 C. R. HUMPHREYS 3,161,011

BULKY TEXTILE YARN AND PROCESS FOR PREPARING SAME

Filed Nov. 5, 1962

FIG. 1

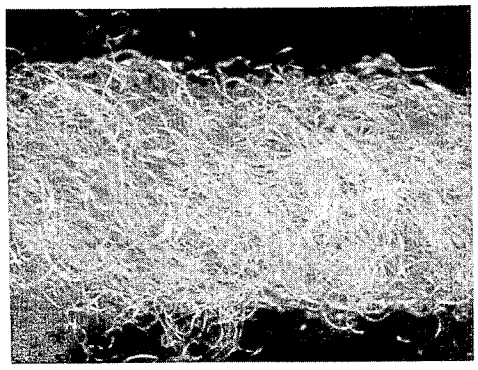
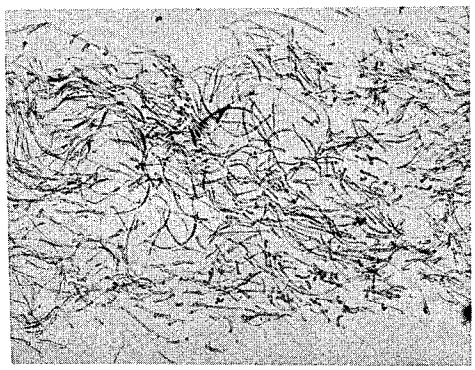


FIG. 2



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BULKY TEXTILE YARN AND PROCESS FOR PREPARING SAME

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This invention relates to bulky yarns and, more particularly, to high bulk yarns having a substantially uniform cross-sectional structure which are prepared from synthetic fibers of staple length.

The utility of textiles generally lies in a combination of their pleasing appearance or ability to adorn, their warmth or insulating value, or their covering power. Weight is usually not a desirable quality of a fabric and constant efforts have been made to obtain lighter fabrics having higher insulating and covering power. One approach has been preparation of bulky yarns, i.e., yarns having a high volume-to-weight ratio.

A great variety of bulky yarn structures are known. For example, such yarns have been prepared from staple fiber blends having differential shrinkage characteristics as described in U.S. Patents 2,810,281 and 2,985,940. The fibers are crimped and blended together, and subsequently treated to shrink one of the components. While the shrinking of the one component results in a contraction or bulking of the yarn with the formation of loops and arches in the low-shrinkage fibers, the high-shrinkage fibers tend to be drawn towards the center of the yarn, forming a relatively dense core. In addition, the ends of the looped and arched fibers tend to protrude from the surface of the yarn, presenting a fuzzy or hairy surface. In other attempts to prepare bulky yarns, difficulty has been experienced in obtaining adequate strength which will permit the weaving of the yarn into fabrics. In order to provide sufficient strength, it has been necessary to use a relatively high degree of twist which obviously reduces the bulky quality of the yarn.

It is, therefore, an object of this invention to provide yarns from staple length fibers having a high volume-to-weight ratio. Another object of this invention is to provide bulky yarns which have a uniform, core-free, cross-sectional structure. A further object of this invention is to provide low twist, bulky yarns having sufficient strength for processing and a minimum of surface fuzz. Other objects will be apparent from the following description of the invention.

The objects of this invention are accomplished by critical selection and processing of two different types of fibers which are blended together to provide a bulky, low twist textile yarn. In general, the objects of this invention are accomplished by blending two groups of staple length textile fibers in which one group is comprised of highly crimped, dimensionally stable fibers, and the other group is comprised of essentially straight fibers which shrink and develop a high crimp when treated under shrinking conditions. As the fibers in the second group shrink, the crimp develops and the two groups of fibers in the blend interlace with each other to provide a highly bulked structure having a uniform, core-free cross section. Surprisingly, the yarn has sufficient strength for further processing into fabric without introducing substantial twist.

Selection of the two groups of fibers is critical in preparing the bulky yarns of the present invention. The dimensionally stable fibers must have a crimp frequency from about 15 to about 40, a crimp index from about 15 to about 40, and a crimp product from about 225 to about 1600. It is essential that these fibers remain dimensionally stable during the preparation of the yarn and in subsequent textile processing; however, slight shrinkage, e.g., up to about 4%, presents no problem. The other group of fibers must be essentially straight and be capable of shrinking from about 25% to 40% and developing a crimp frequency of at least 15, a crimp index from about 15 to about 40, and a crimp product from about 225 to about 1600 when treated under shrinking conditions. In order to provide the high bulk yarns of the present invention it is necessary that at least 15% of the fibers in the initial fiber blend be high shrinkage fibers. Optimum bulk is obtained by using fine denier fibers, e.g., 3 to 15 denier, when about 30% of the fibers in the blend are high shrinkage fibers. Preferably, 30% to 40% of the high shrinkage fibers are used; however, amounts up to about 70% provide bulky yarn structures. The remaining fibers in the blend, i.e., the highly crimped fibers, are used in amounts from 30% to 85% with from about 60% to about 70% being preferred.

In a preferred embodiment, the low twist yarns of the present invention have twist multipliers in the range from about 0.9 to about 1.1; however, bulk is still retained at twist multiplier levels as high as 2.0. The twist multiplier values referred to are those determined before shrinkage of the yarn. It will, of course, be readily understood that as the amount of twist is increased, bulk is sacrificed. The fibers comprising the preferred yarns have a crimp frequency from about 25 to 30, a crimp index from about 25 to 35, and a crimp product from about 625 to 1050.

Throughout the specification and in the claims, by the term "crimp frequency" it is meant the number of crimps per inch along the length of the staple fiber; the "crimp index" is defined as the

$$\frac{\text{Extended Fiber Length}-\text{Relaxed Fiber Length}}{\text{Extended Fiber Length}}\times 100$$

the "crimp product" is the product of

$$\text{Crimp Frequency}\times\text{Crimp Index}$$

The term "twist multiplier" is a factor which relates the twist in turns per inch (t.p.i.) to the cotton count of the yarn being prepared. In cotton spinning systems, the formula used is:

$$\text{t.p.i.}=\text{Twist Multiplier}\times\sqrt{\text{Cotton Count}}$$

Converting this formula into units of denier gives the formula:

$$\text{Twist Multiplier}=\frac{\text{t.p.i.}\times\sqrt{\text{Denier}}}{73}$$

The structure of the yarns of this invention will become more apparent from the following description and the accompanying drawings, in which:

FIGURE 1 is a photomicrograph of a length of yarn of the present invention, and

FIGURE 2 is a photomicrograph of a longitudinal section, 40 microns in thickness, of a length of yarn of the present invention.

Referring to FIG. 1, it can be seen that the yarn has a lofted or bulky appearance with the fibers being interlaced with each other. The surface of the yarn is essentially free of protruding fiber ends.

In FIG. 2, the highly random direction of the fibers and the core-free internal structure is evidenced in the longitudinal section of the yarn. As previously mentioned, the yarn has a very low order of twist but, due to the interlacing of the fibers, it possesses the necessary strength for subsequent processing to form various fabric structures.

The high crimp, low shrinkage fiber used as one member of the blend in this invention may be made by any of several different methods and from any of several different polymers. However, in a preferred embodiment

of the invention, fibers are spun from polymers or co-polymers comprised of at least 85% acrylonitrile, each fiber being composed of two different polymers or co-polymers spun side by side. These and other bi-component fibers are described in U.S. Patents 3,038,236, 3,038,237, 3,038,238, 3,038,239, and 3,039,524. Such bi-component fibers develop the necessary high crimp when wet or steamed and dried. However, single component fibers of high crimp are also satisfactory for this component of the blend. Polyamide, polyester, or polyolefin fibers crimped by means of a stuffer box crimper or by a steam jet as described in Belgian Patent 573,230 are satisfactory when reduced to staple or sliver form.

The second member of the blend, that is the high shrinkage, low crimp but high potential crimp fiber, may be a bi-component fiber in which two different polymers or co-polymers are spun in a side-by-side relationship as described in the just-mentioned U.S patents. Various combinations of polymers and copolymers can be used in this bi-component fiber. In the preferred embodiment of the invention, one side of the fiber would be a polymer or copolymer of acrylonitrile containing at least 85% acrylonitrile, with the other side consisting of a copolymer of acrylonitrile, so chosen that the two sides of the fiber have different shrinkages upon wetting and drying. It is necessary to process this fiber to make it suitable for purposes of this invention, i.e., to provide a high shrinkage fiber. This is best accomplished by hot stretching and stretch breaking the fibers in the form of a tow. This may be accomplished conveniently by processing, using a Turbo Stapler which is well known in the trade and is manufactured by the Turbo Machine Company of Lansdale, Pennsylvania. This yields a sliver of long staple. Conditions are chosen to give the highest shrinkage and maximum crimp development.

Yarns are then prepared by blending and drafting slivers of the two fiber components. The yarn is steamed or boiled-off and dried to develop the bulky yarn of this invention.

In a preferred commercial process, slivers of the two types of fiber are prepared from the same bi-component tow by heat stretching and stretch breaking on the Turbo Stapler. The crimped fiber is relaxed to preshrink and develop crimp, while the other fiber is used without relaxation and therefore has a low crimp but high shrinkage and high crimp potential.

The invention will be further illustrated by the following examples in which parts and percentages are by weight unless otherwise specified.

EXAMPLE I

A 470,000-denier tow of drawn acrylic fiber is prepared as follows:

A copolymer of acrylonitrile and sodium styrene-sulfonate is prepared from the monomers using the technique described in U.S. Patents 2,628,223 and 2,546,238. The monomers are fed to the reactors at the relative rates of 97.0 and 3.0, respectively. This copolymer has an inherent viscosity of 1.5 and contains 204 milliequivalents of acid groups per kilogram of dry polymer.

A polymer is made from acrylonitrile by the same methods described above for the copolymer. This polymer has an intrinsic viscosity of 2.0 and contains 26 milliequivalents of acid groups per kilogram of polymers.

Composite filaments are spun from the polymer and the copolymer in a side-by-side relationship using 22% solutions of each composition. The filaments in the form of a tow are drawn 300% to yield a tow of 470,000 denier with a filament denier of 3.

This tow is next hot stretched 58% between a pair of parallel plates in contact with the tow at a temperature of 280° F. and an input speed of 23 yards per minute. It is next subjected to the stretch-breaking treatment described in Lohrke U.S. Patent 2,419,320. The fibers in the resulting sliver have essentially no crimp. The sliver is further processed by a heat relaxing treatment in which it is subjected alternately to vacuum and to steam at 10 p.s.i.g. In this operation, an initial two-minute period of vacuum is followed by a like period of steaming, followed by a second two minutes of vacuum, then six minutes of steam, and finally four minutes of vacuum. The resulting fiber, hereafter referred to as Fiber IA, has the following properties:

Fiber IA

Crimp frequency (crimps per inch)	21
Crimp index	24
Crimp product	504

An identical tow of 470,000 denier is similarly hot stretched 108% at 320° F. and broken on the Turbo equipment referred to above. In this case, the sliver is not heat relaxed. This will be referred to as Fiber IB. It has the following properties:

Fiber IB

Crimp frequency (after boil-off)	30
Crimp index (after boil-off)	25
Crimp product (after boil-off)	750
Shrinkage (upon boil-off)	30%

Slivers of Fiber IA and IB are combined in the ratio of 70 parts of IA and 30 parts of IB and processed through a Hood Doubler, manufactured by James Smith & Sons, Worcester, Mass., for further breaking to six-inch staple, then blended by three passes through a pin drafter, and finally drawn by one pass through a slubber to yield a roving 3.3/1 cc. with a twist of 2.05 t.p.i. This roving is strong enough for skeining, after which it is shrunk and dried. This is done by boiling off for five minutes at 210° F., and drying at 170° F. to 180° F. The properties of this yarn before and after boil-off are as follows:

	Before Shrinking	After Shrinking
Twist, t.p.i.	2.052	2.362
Twist Multiplier	1.13	2.01
Denier	1,610	2,630
Shrinkage, percent	63	
Bulk, cc./gm.:		
1,122 g./sq. in.[1]		1[illegible].05
396 g./sq. in.[1]		13.5
103 g./sq. in.[1]		21.5

[1] The bulk is measured by cutting the yarn into one-half inch lengths, placing 2 grams in a one-inch diameter cylinder, placing various weights, as shown, on top of the fiber and noting the volume of the compresses, fiber.

	Before Shrinking	After Shrinking
Instron Compression Test:		
Thickness, no load		1.459
Thickness, compressed 25 g./sq. in.		1.126
Compression (percent)		22.8
Yarn Tenacity (g./d.)		0.61
Yarn Elongation (percent)		29.0
Work Recovery (percent) (from 11.7% stretch)		35.8
Modified Tensile Form Recovery (percent) Third Cycle		64.3
Permanent Deformation (percent) (at 11.7% stretch)		1.82

This yarn, after skeining, dyeing and drying, is woven into a blanket as the filling yarn with a warp of 18/1 cc. yarn spun from 3-dpf acrylic fiber made from a terpolymer from 93.65% acrylonitrile, 5.98% methyl acrylate, and 0.37% sodium styrenesulfonate. The warp is reeded 35 ends/inch and the filling yarn is woven at 40 picks per inch. The loom width is 87 inches. From the loom, the blanket is napped. The finished blanket is 72 inches wide, 0.2 inch thick, and weighs 1.8 pounds for a 72 x 90 inch blanket or 0.36 pound/square yard.

Photomicrographs of the yarn, 20X magnification, and a longitudinal section of the yarn, 25X magnification, are shown in FIGURES 1 and 2, respectively.

EXAMPLE II

A polyamide prepared from hexamethylene diamine and adipic acid is melt-spun to yield a 900-denier drawn yarn consisting of 3-denier filaments. This yarn is given a high degree of crimp by passing it through a steam jet with superheated steam in accordance with the teachings of Belgian Patent 573,230. Filaments from this crimped yarn show a shrinkage of less than 2% upon boil-off. The crimp product is 450. This yarn is cut into 3-inch staple and is referred to as Fiber IIA. It is a high crimp, low shrinkage fiber.

Fiber IIB is prepared by melt spinning a bi-component fiber, one side of which is a polyamide from hexamethylene diamine and adipic acid, and the other side is a copolymer made from hexamethylene diamine and a mixture of 90% adipic acid and 10% isophthalic acid. The yarn is drawn to a filament denier of 3. At this stage, the fiber shows a shrinkage of 30% upon boil-off. It is also cut to 3-inch staple.

Thirty (30) parts of Fiber IIB staple are blended with 70 parts of IIA staple and carded and spun on the woolen system to a yarn of 1.8 wool run and a twist multiplier of 1.1. This yarn is wound into skeins and suddenly exposed to superheated steam at 200° C. The yarn develops a high degree of bulk and is essentially core-free.

EXAMPLE III

Fiber IIIA is identical to Fiber IIA of Example II. Fiber IIIB is prepared as follows:

A homogeneous mixed polymeric composition is prepared by adding 10% polyvinylpyrrolidone at an intermediate stage in the condensation polymerization of hexamethylene diamine and adipic acid. The composition is used as one side of a bi-component fiber, the other side being a standard 6–6 polyamide. The fiber is spun and drawn to yield a 3-denier-per-filament two having 30% shrinkage. It develops a high crimp when treated in steam or boiling water. It is cut to 3-inch staple but not heat relaxed.

Fibers IIIA and IIIB are blended in a 70/30 ratio and carded and spun on the woolen system to yield a 1.8 wool run yarn. This yarn is skeined, then steamed. It develops a high bulk. It has a smooth surface and is core-free.

EXAMPLE IV

A copolyester is prepared using 98 parts of terephthalic acid and 2 parts sulfoisophthalic acid with ethylene glycol as the alcohol. A bi-component fiber is melt spun, using this copolymer as one component and terephthalic acid-ethylene glycol polyester as the other component, the polymer and copolymer being in a side-by-side relationship in the fiber. The fiber is then hot drawn to yield a 4-denier-per-filament tow. This tow is heat relaxed at 140° F., then cold stretched and broken on a Turbo Stapler to give a sliver with 30% shrinkage. A part of this sliver is then relaxed by steaming. The result is a sliver with high crimp but low shrinkage. This will be referred to as Fiber IVA. Fiber IVB is the code for the unrelaxed sliver.

Each sliver is processed separately through a Hood Doubler to break the fibers into six-inch staple lengths, then the two fibers are blended through pin drafters in the ratio of 70% Fiber IVA and 30% Fiber IVB. The final sliver is passed through a slubber to yield a final yarn of 1.8 wool run and having a twist multiplier of 1.1. This yarn is skeined, then shrunk in boiling water, centrifuged, and dried relaxed. The final yarn is core-free and bulky.

While the yarns described in the foregoing examples illustrate the use of specific synthetic fibers, other synthetic fibers having the properties heretofore defined may be used to obtain similar results.

The yarns of this invention have a wide range of uses. Due to their high bulk and corresponding light weight, they are particularly desirable for use in blankets. Sweaters knit from these yarns are light and bulky. The smooth surface of the yarns greatly improves the aesthetics of fabrics prepared therefrom.

As many widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that this invention is not to be limited to the specific embodiments thereof except as defined in the appended claims.

I claim:

1. In a process for preparing bulky yarn, the steps comprising

(*a*) blending two species of textile fibers of staple length, one of said species being highly crimped, dimensionally stable fibers having a crimp frequency of at least 15, a crimp index from about 15 to 40, and a crimp product from about 225 to 1600, the other of said species being essentially straight, crimpable fibers having a shrinkage of about 25% to about 45% and developing a crimp frequency of at least 15, a crimp index from about 15 to 40, and a crimp product from about 225 to about 1600 when treated under shrinking conditions,

(*b*) aligning said fibers to form a yarn,

(*c*) twisting said yarn a predetermined amount to provide a twist multiplier not greater than about 2, and

(*d*) shrinking said crimpable fibers whereby they develop crimp and interlace with said crimped fiber to form a bulky, substantially core-free structure.

2. A bulky textile yarn prepared by the process of claim 1.

3. The yarn of claim 2 wherein said highly crimpable dimensionally stable fibers are present in an amount from about 60% to about 70% by weight of said yarn.

4. The yarn of claim 3 wherein the crimp product of both species of fibers is in the range from about 625 to about 1050.

5. The yarn of claim 4 wherein said twist multiplier is between about 0.9 and about 1.1.

6. The yarn of claim 5 wherein said staple fibers are acrylonitrile polymer fibers.

References Cited in the file of this patent

UNITED STATES PATENTS

2,174,878	Hardy	Oct. 3, 1939
2,504,523	Harris et al.	Apr. 18, 1950
2,701,406	Bloch	Feb. 8, 1955
2,810,281	Appleton et al.	Oct. 22, 1957
2,985,940	Weldon	May 30, 1961
3,081,516	Evans	Mar. 19, 1963