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MULTIFILAMENT POLYOLEFIN CARPETS OF NON-REGULAR CROSS-SECTION AND METHOD OF MANUFACTURE

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This application is a continuation-in-part of our earlier application Serial No. 212,436, filed July 25, 1962, now U.S. Patent 3,194,002. Disclosed therein are a number of methods of manufacturing fine denier multifilaments, novel yarns therefrom and articles such as rugs made from such yarn. In the present invention we have found how our methods have natural application to and may be further extended for the manufacture of a wider range of novel multifilament special cross-section yarns and articles therefrom.

This invention relates to the manufacture of multifilament polyolefin carpets made up of filaments having a predetermined cross-section wherein the yarn in the carpet has sufficient flexibility for good processing and yet also has increased cover, stiffness and other improved properties.

In the prior art a number of processes and apparatuses have been provided for the production of man-made filaments of certain cross-sections. Generally, these prior art cross-sections fall within the classification of round or cloverleaf cross-sections (see Patents Nos. 2,000,047 and 2,000,048) or for flat or rectangular cross-section (see Patent No. 1,964,159).

It has also been proposed in the prior art to make relatively large inflexible monofilaments of X or Y cross-section (U.S. Patent No. 2,637,893), such monofilaments being utilized for brushes. Such large monofilaments as required for brushes may be likened to steel rods which have rigidity and stiffness. In contrast thereto, in the present invention we are dealing with finer denier multifilaments which may perhaps be likened to wire rope which has greater flexibility, utility and strength. In addition when our multifilaments are made into an article as carpets and rugs they have additional different characteristics not found in the wire rope-rod analogy aforementioned.

Accordingly, it is believed apparent that the development of novel polyolefin multifilament carpets of small denier filaments, and which permits the production of better carpets and the like articles, represents a highly desirable result. After extended investigation and further application of our original invention we have discovered such type polyolefin multifilament carpets and certain processes for the production thereof.

An object of the present invention is to provide polyolefin and particularly polypropylene multifilament carpets with an increased cover, bulk and stiffness as compared to prior art products. Another object of this invention is to provide polyolefin multifilament carpets wherein the polyolefin filaments making up the carpets have increased surface area as compared to the above discussed filaments known heretofore in this art. Still another object is to provide polyolefin multifilament carpets made up of Y-shaped, or modified Y-shaped cross-section polyolefin filaments of small flexible denier of the nature hereinafter described.

Another and particular object is to provide new and novel polypropylene yarn products in the form of carpets and rugs having a crisp feel, less apparent soiling, improved covering power and luster containing a substantial content of such Y-shaped or modified Y-shaped cross-section polyolefin multifilament yarns.

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Other objects will appear hereinafter.

In the broader aspects of our invention of making a new polyolefin multifilament yarn made up of a large number of small denier, flexible filaments having a Y-type cross-section processes and apparatus such as shown in our application Serial No. 212,436, now U.S. Patent No. 3,194,002, may be used and detailed reference may be made to such patent. For the purposes of the present invention, the following process description will suffice.

The polyolefin multifilament yarn of the present invention may be formed by forcing a suitable polyolefin spinning composition through a spinnerette having a plurality of non-circular forming orifices therein as will be described and curing the resulting filaments in a spinning cabinet under controlled conditions of temperature while subjecting the filaments to drafting.

In general, spinnerettes having a plurality of small non-circular orifices may be employed with any suitable spinning cabinet to produce multifilament flexible yarn to be used in making the products described herein. The Y-shaped type cross-section filaments can be prepared in accordance with our invention within a wide range of spinning, drafting and other conditions as is described hereinafter. However, in accordance with a feature of the present invention we have discovered the following: Polymeric spinning compositions, such as a molten composition containing a substantial amount of polyolefin or the like polymeric component may be extruded through a Y-shaped orifice. The Y-shape may be symmetrical or unsymmetrical or other tripodal shape as referred to in our parent patent. However, when using such tripodal shape, we have found that the orifice should be somewhat oversized as compared with the size (denier) of the polyolefin multifilament yarn to be produced. In brief, an oversized Y type polyolefin filament is first extruded and then the oversized polyolefin Y filament is drafted to the desired size.

As indicated above, we have found that the Y-type cross-section polyolefin multifilament yarns of our invention of small denier filaments have the proper and sufficient flexibility for textile purposes yet provides more cover, bulk and stiffness than obtained from the yarns from filaments of the various round and round-like cross-sections heretofore known in this art. By small denier we mean a D/F of not greater than 30. There are also a number of other benefits from our polyolefin multifilament yarn as will be set forth hereinafter.

It is noted that a circle taking in the three tips of the legs of the Y will be greater in diameter than one taking in the lobes of the well-known cloverleaf type of cross-section. This larger "circle" is, therefore, the effective area of the Y-shaped cross-section and explains to some extent the increased cover, bulkiness and the like of our novel Y-type polyolefin multifilament yarn. By the small denier filaments of the present invention we obtain the flexibility and other advantages without rigidity and stiffness of monofilaments.

For assistance in a consideration of the examples, reference may be made to the apparatus shown in our Patents Nos. 2,829,027 and 3,194,002 referred to above. In carrying out the processes of the following examples, certain of the apparatus as shown in our patents just mentioned may be used with the substitution of spinnerettes having a plurality of oversized Y-type orifices as described above.

*Example 1*

This example is for illustrating the general operation of the process as referred to above of spinning a polymeric composition through an oversize Y orifice to obtain an oversized Y-type filament. We prefer that the ratio of the length of the arms of the Y to the width of the arms be within the following range 2:1 to 20:1. This oversized filament is then drafted and otherwise processed as will be apparent from the further description.

In this example the spinning solution converted into the multifilament yarn was a modified polymeric composition. It contained approximately 29 percent of a polymer which was approximately 40 percent of a polyacrylonitrile together with certain other constituents. The exact polymeric composition is not a limitation on the process as other polymeric compositions such as the polyolefins to be referred to may be employed.

This spinning composition had a relatively high viscosity and was extruded at 100 m./m. through a Y-shaped orifice, the legs of which were equally spaced and had the dimensions of .025 by .10 m./m. Filaments with cross-sections approximating a Y shape but somewhat oversized were obtained. The filaments after spinning were then drafted 6/1 in a heated zone beyond the extrusion zone subsequently subjected to a relaxing treatment. This relaxing treatment was also performed in a heated zone. This modified the Y filaments to a more rounded shape after the drafting and relaxing.

The drafting in the extrusion step may be as low as .25 and as high as 1.5. We have found that the higher draft gives somewhat better Y-type cross-sections.

The advantages and utility of our multifilament flexible yarn comprised of filaments of non-circular drafted Y cross-section are manifold. The processes of manufacturing such filaments may be more rapid than a comparable process for producing the round or cloverleaf cross-section. This is the situation whether such filaments are solvent spun or melt spun as would usually be the spinning of polyolefin filaments of the present invention. In either instance there is a faster curing or cooling rate with the non-circular filaments of the present invention. The filaments as produced have a higher luster.

The Y filaments have a slower apparent soil rate. This is advantageous when such multifilament yarns are made into products exemplified by carpets and rugs and other articles of manufacture which frequently come in contact with soil. The filaments after production may be readily processed by known procedures exemplified by bulking, lofting, texturizing or interlocking. Such are procedures wherein multifilament yarns are fed through an air jet and subjected to treatment with air, steam or other similar gaseous fluid or subject to false twist and heat setting or the like. We have found that the Y cross-section polymeric multifilament yarns described herein process faster and better by such jet treatments than the regular round or cloverleaf filaments. This improvement is to the extent of the order of 19 percent faster and the resultant product had 14 percent more strength as well as 10 percent more stretch.

While the above example has been described using the spinning composition containing polyacrylonitrile as a polymeric constituent, the present invention has applicability to a variety of other polymeric yarn spinning compositions. Melt spun multifilament yarn of the character described herein when applied to polypropylene, nylon and the like tends to eliminate to a substantial extent the greasy or slick synthetic hand of such synthetic fibers.

The luster of the Y-shaped cross-section yarn is appreciably better than that of the regular or cloverleaf cross-section of equivalent denier and composition. Luster is measured by means of a photo-electric cell. The filaments are wound in a parallel manner around a flat piece of cardboard or other similar flat surface. Light reflected off these panels to the photoelectric cell imparts a potential which is translated into a numerical luster level. On comparative tests the cloverleaf panel of filaments record 0.77 volt whereas the Y-shaped cross-section filaments of the same denier record 0.83 volt.



*Example 2*

In accordance with a principal feature of the invention, rugs and carpets were prepared from multifilament Y-shaped cross-section polymeric polyolefin yarn alone and with other fibers, rayon, nylon, wool, etc. The bulk and stiffness properties of the Y-shaped fibers permit the construction of rugs of improved construction.

In further detail loop pile carpets were tufted from round cross section, 3:1 Y cross section, and 5:1 Y cross section polypropylene yarns. The carpeting was identified as CT 1306. Staple yarns were processed from 4" staple into 2.5/3 cotton counts with 2.1 TPIZ in the singles, and 2.7 TPIZ in the ply. Results of D/F checks and specific volume tests on the yarns were as follows:

| CT 1306 | 1 | 2 | 3 |
|---|---|---|---|
| Cross Section | Round | 3:1Y | 5:1Y |
| D/F | 19 | 16 | 19 |
| Specific Volume (in.$^3$/lb.) | 83 | 92 | 99 |

The 3:1, 5:1 refers to orifice design wherein the length of the arm or leg of the Y to the width is in the ratio indicated.

The 3 staple yarns were tufted together in bands on a 5/32" gauge Cobble Brothers tufting machine, into 25 oz./yd.$^2$ level, and high-low loop pile constructions. After tufting it was observed that the Y cross section section samples had higher luster, an unusual sparkle, better hand, and cover than the regular cross section sample. Floor test performance was comparable for the 3 samples except that the Y section samples showed a definite improvement in soil resistance over the regular cross section sample.

It is estimated that fibers made with a Y cross-section are about 20 percent stiffer than fibers made with a round cross-section. This increased stiffness is believed to contribute to the greater bulk, better hand and increased cover noted in carpets tufted from Y cross-section yarns.

The operation of our process is now described in connection with the production of less uniform Y-shaped cross-section filaments through spinnerettes having orifices other than equilateral.

The cross-section of some of the filaments were of a modified Y-shape having substantially no center leg. Contrasted to this some cross-sections were obtained which have a long center leg which is a little more than twice the length of the other two legs which are of similar size. Cross-sections were obtained which are somewhat intermediate between those just referred to and may be described as of a Y shape having a center leg somewhat longer than the other two legs which are symmetrical. The angle between the other two legs is greater than in the case of the cross-section just mentioned. A cross-section was obtained which is somewhat like that just mentioned except that the center leg is now half as long as the other two symmetrical legs. A cross-section was obtained which approaches that of a true Y cross-section in that the center leg is about the length and size of the other two legs but the angles between the legs are not quite equal.

As the Y becomes more rounded the shear strength appears to improve slightly according to the twistability and Walker abrasion tests. It appears that these changes in Y-shaped cross-section from the more perfect Y-shaped cross-section give not only a slight improvement in strength and stretch but a reduction in waste and fly in staple processing. The gain in this respect is obtained at some expense of lessening the bulk.

We have noted that multifilament polyolefin yarns composed of Y-shaped cross-section and modified Y-shaped cross-section filaments are much stiffer and more resilient than similar multifilament yarns having normal or cloverleaf cross-sections. The effect on stiffness of cross-sectional shape can be estimated by comparing moments of inertia of fibers having different shapes but the same cross-sectional area. By this method we have determined the Y-shaped cross-section multifilament yarns are approximately 60 percent stiffer than regular filaments of equal size. Furthermore, we have found that when a plurality of Y-shaped cross-section filaments are collected in a bundle as in a rug or carpet, a greatly increased resilience or stiffness is noted which is more than would be expected from the increase in stiffness of individual fibers. We attribute this effect to the interlocking or tongue and groove mingling of the legs of the Y-shaped cross-section filaments making up the mass of fibers. This interlocking of fibers causes much greater resistance to interfiber slippage than can be obtained in a bundle of normal filaments. This is particularly important with respect to polyolefin filaments which may be more slippery than other type filaments. Thus the aggregate stiffness of a bundle of Y-shaped cross-section polyolefin filaments is much greater than the sum of the stiffnesses of the individual fibers.

*Example 3*

In this example automotive carpets of 100 percent polypropylene fibers in accordance with this invention, F 402M, 50/50 blend of F 402M polypropylene and viscose and 100 percent commercial viscose carpet, were tested to compare the polypropylene yarn of this invention and viscose fibers and the effect of blending the two fibers.

A sample of dyeable 100 percent polypropylene F 402M, 11 D/F x 4", and a 50/50 blend of dyeable polypropylene F 402M, 11 D/F x 4"/viscose 15 D/F x 4", spun as D 4939, were processed into 1.5/1 counts, 3 Z spun twist and tufted into ¼" and ⅛" pile height automotive carpets. The 100 percent polypropylene ¼" pile height carpet is identified as CT 833–1; the ⅛" pile height carpet as CT 833–1A; the 50/50 blend ¼" pile height carpet as CT 833–2; the ⅛" pile height carpet as CT 833–2A; and the 100 percent viscose commercial carpet ¼" pile height at CT 833–3. Carpets of 100 percent polypropylene and 50/50 polypropylene/viscose were piece dyed black to match the color of the 100 percent viscose carpet.

Carpets from CT 833–1A, 2A, and 3 were exposed under glass to sunlight for 94 days and put into tests along with unexposed carpets.

The table leg tests show the polypropylene of the present invention as having better recovery than viscose. In the accelerated abrasion test, the wear resistance of the 50/50 blend of polypropylene/viscose was about double the 100 percent viscose. The 100 percent polypropylene sample was about 3¼ times better for abrasion than 100 percent viscose. The low, dense construction (1A and 2A) were better than the higher, less dense construction. In the floor test, on 10,000 and 20,000 steps, the percent thickness retained was about the same for both polypropylene and viscose. On wet crushing, the polypropylene recovered thickness better than the viscose. The stair test results correlate with the accelerated abrasion test although the advantage of polypropylene was greater in actual use. Blending polypropylene with viscose increases the abrasion resistance of viscose. The 94 day roof exposure caused a color and hand change in polypropylene and viscose with viscose having a little better hand retention than polypropylene. The stair test showed the exposed samples to have about 20 percent less abrasion resistance than the unexposed.

The crushing and recovery curve of polypropylene shows it to be somewhat firmer than viscose. Crushing and recovery tests were run on CT 833–1A heat set for one hour at 285° F. and CT 833–1A with no heat setting. The firmness of the heat set samples was less than for the sample with no heat setting. There was about 11 percent shrinkage loss in initial thickness due to the sample being heat set. There was less thickness loss in crushing and recovery of the heat set sample because of the lower initial



thickness or pile height and the stiffer hand resulting from the yarn being heat set.

Samples of CT 833–1, 2, and 3 soiled in Building 70 were given on-location shampoo and graded for matting, pilling, and texture before and after shampooing. CT 833–1, 100 percent polypropylene, had a better texture appearance and less matting than CT 833–3, 100 percent viscose, before they were shampooed. CT 833–2, 50/50 viscose/polypropylene blend was rated in between.

It can be seen from the foregoing example that blending polypropylene yarn of this invention with viscose greatly increases the abrasion resistance of viscose. In table leg and wet crushing tests, the recovery of polypropylene is some better than viscose. In the sunlight exposure tests, the hand retention of viscose is some better than polypropylene. There is less thickness loss on polypropylene than viscose on crushing and recovery tests.

*Example 4*

Prior experience with (woolen) spun modacrylic carpet yarns has shown that yarns made on the (woolen) system have better bulk and cover than worsted spun yarns. This example concerns a comparison of 100 percent (woolen) spun polypropylene yarn and 50/50 woolen spun polypropylene/wool to 100 percent polypropylene spun on the worsted system.

CT 935–1 and 2 were carpets tufted on the 5/32" gauge tufting machine from the woolen system 100 percent bright polypropylene 402, and the 50/50 polypropylene 402/wool blend. CT 888–4 was tufted from a yarn spun on the worsted system. Lot 6600 polypropylene 402 was used in both the woolen system and the worsted system yarns. The carpet samples were subjected to table leg tests, accelerated pilling, accelerated abrasion, and a 20,000 step floor test. At the end of the floor test, half of each carpet sample was given a rotary cleaning using commercial shampoo.

The table leg recovery and floor test thickness retention show little difference between the two spinning systems. The table leg test shows advantage for the wool blend in the five minute recovery period. The 50/50 wool blend had slightly less pilling than did the 100 percent woolen spun sample and slightly more than the 100 percent worsted spun sample.

The 50/50 wool blend was better than the 100 percent sample. The two 100 percent samples were about equal for soiling and cleaning, and the blend was slightly better. Increased abrasion resistance was the major contribution of the polypropylene in the blend with wool. It can be seen from the foregoing that in a blend with wool, polypropylene yarn of this invention gives increased abrasion resistance. Adding 50 percent wool to the blend gave improved soil resistance, improved pilling resistance, and a slight improvement in crushing resistance.

*Example 5*

The purpose of this example was to evalute carpets made of polyester yarns blended with polypropylene yarns of the present invention. Two hundred pounds of polyester yarn marketed as Kodel yarn, 15 D/F x 4" semi dull was stock dyed rose beige for spinning on the woolen system. An additional 100 pounds was stock dyed gold to match the shade of solution dyed polypropylene yarn, 12 D/F x 4". The two fibers were blended in the following proportions and spun on a modified worsted system:

(1) 100 percent polypropylene yarn
(2) 75 percent polypropylene/25 percent Kodel polyester yarn
(3) 50 percent polypropylene/50 percent Kodel polyester yarn
(4) 25 percent polypropylene/75 percent Kodel polyester yarn
(5) 100 percent Kodel polyester yarn

Forty pounds of each sample were processed into yarn on the worsted system and tufted into construction for testing. That is, the five samples were spun into a 3.25/1 cc. yarn with 3.8 Z T.P.I. and three-plied with 2.6 S T.P.I. Carding was done on the roller top card, delivering a 100 grain sliver. Drawing was accomplished on the pin drafter, breaker drawing delivering a 65 grain sliver and finisher drawing delivering a 50 grain sliver. The yarn was spun and then plied on an Atwood twister.

Very slight static was noticed on the 25 percent polyester/75 percent polypropylene sample. The long staple counts on the two 100 percent samples indicated that both were well cut. No difficulty was encountered on the pin drafter during breaker and finisher drawing.

The yarn was spun on a roving frame. The 75 percent polyester/25 percent polypropylene had .04 end down per hank and the 50/50 blend had .07 end down per hank. Durometer checks indicated that the higher the percent polypropylene, the harder the package except in the case of the 75 percent polypropylene sample having the highest reading.

The yarns were tufted on the 5/32″ gauge tufting machine into 1/4″ pile height, 24.6 oz./yd.$^2$ loop pile carpets. The carpet samples were weighed and thickness measurements carefully taken to insure equal constructions on all the yarns tufted. After tufting, the carpets were steamed, latexed, and air cured. A piece of each carpet was scoured before latexing to remove the lubricant.

After tufting, the samples were subjected to the following tests:

Accelerated pilling
Accelerated abrasion
Flammability
Water spotting
Table leg tests
Floor tests
Heat sensitivity tests
Crushing and recovery tests

In addition to the above carpet tests, specific volume and hot water shrinkage tests were run. The 100 percent polyester did not pill but tended to be slightly fuzzy.

The polypropylene sample had about 50 percent higher abrasion resistance than the polyester sample. Blending polypropylene with polyester upgrades the abrasion resistance of the polyester in proportion to the amount of polypropylene in the blend.

The carpets were subjected to 100 p.s.i. table leg tests for 24 hours and 7 days' loading periods. Carpet thickness was measured initially, 5 minutes after the load was removed, and 24 hours after the load was removed. From these measurements, the percent thickness retained was calculated. The polyester showed about 20 percent better short term recovery (after 5 minutes), and about 10 percent better recovery after 24 hours than the polypropylene. As the amount of polyester in the blend increased, the percent thickness retained increased. The 7 day test averaged about 18 percent lower thickness retention after 5 minutes recovery and about 13 percent lower thickness retention after 24 hours' recovery than the 24 hour test.

Scoured and unscoured carpet samples were floor tested in a commercial floor test area for 20,000 steps. At the end of the test, half of each carpet was given a rotary cleaning using shampoo. The carpets were then graded for soiling, cleaning, matting, pilling and fuzzing, and texture before and after cleaning. It was noted that the pill and fuzz rating was the same for polypropylene as polyester. The polypropylene pilled only slightly in the floor test. The polyester did not pill but did become fuzzy. On balance, it was felt that the slight pilling of the polypropylene was about the same as the fuzzing of the polyester.

Because of the low melting point of polypropylene yarns of the present invention, tests concerning the extent of



damage which may occur to the carpet when such accidents happen as dropping a lighted match, burning cigarette, etc. In order to evaluate this factor, special heat sensitivity tests have been run as follows:

(A) A burning cigarette was placed on the carpet for (1) 5 seconds, (2) 15 seconds, (3) 1 minute, and (4) 5 minutes.

(B) A 100 watt electric light bulb was placed on the carpet for 2 minutes.

(C) A wooden match was placed on the carpet, ignited, and allowed to burn out.

As the percent polyester in the blend was increased, the carpet became more resistant to damage from the lighted cigarette. In the 100 percent polyester sample, no noticeable damage occurred until the 1 minute exposure. In the light bulb test, damage was sustained by the 100 percent polypropylene. The damage became less as the percent polyester was increased until in the 100 percent polyester no visible damage occurred. All the carpet samples suffered damage in the match test.

As to crushing and recovery, the higher the percent polyester, the more crush resistant the carpet sample. The polyester had the firmest hand and the polypropylene the softest. From the foregoing it can be summarized: In blends with polypropylene yarns of the present invention, polyester yarn contributes to improvement in these areas in proportion to the amount of polyester in the blend. The 100 percent polypropylene is superior to 100 percent polyester in the following areas:

(1) Abrasion resistance
(2) Soiling

In blends with polyester, improvement in abrasion resistance and soiling is in proportion to the amount of polypropylene in the blend. Blends of polyester/polypropylene in accordance with the present invention perform very well compared to other carpets tested. Considering the cost/performance relationship, such blends are attractive commercially.

Other blends may be prepared. For example, nylon could be substituted for viscose above or it might be substituted in any one of the other examples. A rug containing a blend of 50/50 nylon/polypropylene would have excellent abrasion resistance and strength. The nylon would improve resilience, matting, and dye properties. A particular advantage of the polypropylene yarn of the present invention is that it would permit the fabrication of a more economical rug.

Although this invention has been described in considerable detail with particular reference to certain preferred embodiments thereof, variations and modifications can be effected within the spirit and scope of the invention as described hereinabove, and as defined in the appended claims.

We claim:

1. As a new article of manufacture a blend of fibers in strand form useful for the manufacture of fabric floor covering and other fabric type products where it is desirable to improve the resistance to indentation of the fabric product from the weight of an object resting on the fabric, said blend of fibers containing substantial amounts of at least two different man-made fibers from the group consisting of polyolefins, polyesters, polyamides, polyacrylonitriles, modacrylics, cellulose esters and viscose, the blend being particularly characterized in that one of the man-made fibers therein is present from a substantial and easily observable amount up to 50% of the blend by weight and that said one fiber in said strand is comprised of at least 7 relatively small non-circular cross-section filaments of a denier per filament less than 30 and a total denier of less than 6250, said filaments having an essentially uniform cross-section along the fiber length and said cross-section consisting of three integrally joined, substantially symmetrical lobes, said cross-section having a tip radius ratio and an arm angle such that said tips of

the individual filaments contact other filaments in the blend to reinforce each other and thereby impart improved resistance as aforesaid, said filaments having in general a Y-shaped cross-section in which the ratio of the length of the legs of said Y to the width of said legs is within the range of 3:1 to 5:1.

2. The blend article of manufacture of claim **1** wherein all of the 7 relatively small cross-section filaments consist of polypropylene.

3. The blend of claim **1** wherein the major portion of all of the fibers are comprised of staple fiber.

4. The blend of claim **1** wherein at least a major portion of the fibers consist of polyesters and modacrylics.

5. As a new article of manufacture a blend of fibers in strand form useful for the manufacture of floor covering and other fabric type products where it may be desirable to improve the resistance to indentation of the fabric product as from the weight of an object resting on the product, said blend of fibers consisting essentially of at least two different fibers for making up a strand, the blend being particularly characterized in that said strand contains at least a substantial and easily observable amount of polyester fibers which are further characterized in that they are comprised of at least seven relatively small non-circular cross-section filaments of a denier per filament less than 30 and a total denier of less than 6,250, said polyester fibers making up the strands consisting of filaments having an essentially uniform cross-section along the fiber length and said cross-section consisting of three-integrally joined, substantially symmetrical lobes, said cross-section having a tip radius ratio and arm angle such that said tips of the individual filaments contact other filaments in the blend making up the strand to reinforce each other and thereby impart improved resistance as aforesaid, said filaments having in general a Y-shaped cross-section in which the ratio of the length of the legs of said Y to the width of said legs is within the range of 3:1 to 5:1, and the remainder of the blend making up the strand is essentially comprised of at least one natural fiber from the group consisting of cotton and wool.




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