EUROPEAN PATENT SPECIFICATION

HOLLOW TRILOBAL CROSS SECTION FIBER
TRILOBALE HOHLFASE
FIBRE CREUSE A SECTION TRILOBEE

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Description

This invention relates generally to synthetic polymeric fibrous materials. More specifically, this invention relates to hollow trilobal cross-section fibers.

The term "fiber" as used herein includes fibers of extreme or indefinite length (i.e., filaments) and fibers of short length (i.e., staple). The term "yarn" as used herein means a continuous strand of fibers.

For many uses of fibrous synthetic polymers, it is desirable to minimize the weight of fiber needed to spread over an area. This qualitative property of a fiber is known as "cover". Another quality of fibers for certain end uses (like for carpet yarn) is the fiber's ability to hide soil. Additionally, it is important that contract carpets stand up to the severe wear these carpets get due to high traffic. Particularly important to contract carpeting are pile height recovery and appearance retention after wear traffic.

Trilobal fibers are known to provide cover superior to round cross-sections and it is known to make trilobal and pseudo-trilobal fibers (e.g., deltas, T-shapes). Exemplary are U.S. Patent No. 3,981,948 to Phillips, U.S. Patent No. 3,194,002 to Reynolds et al., U.S. Patent No. 2,593,201 to Holland, U.S. Patent No. 4,492,731 to Bankar et al. and Japanese Kokai 42-22574.

It is also known to provide voids in fibers and that many times these voids result in improved soiling hiding performance. However, lower void volumes (less than about 10%) can result in carpeting with a high streak appearance. Moreover, it is known also to provide trilobal or pseudo-trilobal fibers which have one or more voids. Exemplary are U.S. Patent No. 3,095,258 to Scott, U.S. Patent No. 3,357,048 to Cobb, Jr., U.S. Patent No. 3,493,459 to McIntosh et al., U.S. Patent No. 3,558,420 Oppelt, U.S. Patent No. 4,279,053 to Payne et al., U.S. Patent No. 4,364,996 to Sugiyama, U.S. Patent No. 4,956,237 to Samuelson, British Patent No. 843,179 to Siemer et al. and particularly EP-A-516,119.

U.S. Patent No. 4,648,830 to Peterson et al. discloses a spinneret for manufacturing hollow trilobal cross-section fibers. The fibers disclosed therein have one axially extending hole in each lobe.

To address the foregoing deficiencies, the present invention concerns a trilobal synthetic polymeric thermoplastic fiber having a single void extending approximately axially central, a total cross-section void area between greater than about 10 and 20 percent void, a modification ratio between about 2 and 6, and an arm angle between about 5° and about 50°.

It is an object of the present invention to provide an improved hollow trilobal fiber.

Related objects and advantages will be apparent to the ordinarily skilled artisan after reading the following detailed description of the invention.

Fig. 1 is a cross-sectional plan view of a fiber according to the present invention.

Fig. 2 is a plan view of a spinneret useful to prepare the fiber of Fig. 1.

The term "modification ratio" (MR) means the ratio of the radius R2 of the circumscribed circle to the radius R1 of the inscribed circle as shown in Fig. 1. The term "arm angle" (AA) is the angle formed by extension of sides of an arm as shown in Fig. 1.

Depicted in Fig. 1 is an enlarged view of fiber 10 which is representative of the present invention. Fiber 10 is trilobal having three (3) lobes, 11, 12 and 13 and axially extending, more or less central, void 15.

According to the present invention, fiber 10 preferably has a modification ratio of between about 2 to about 6, more preferably about 2.0 to about 3.5 and an arm angle between about 5° and about 50°, preferably from 7° to 40°. The single approximately central void represents greater than about 10 to about 20 percent, preferably 11 to 20 percent, in particular 12-20 and particularly preferably 12 to 15 percent, of the total fiber volume measured including the volume of the void.

Fig. 2 illustrates a spinneret useful for preparing the fiber of the present invention.

Fibers of the present invention may be prepared from synthetic thermoplastic polymers which are melt spinnable. Exemplary polymers are polyamides such as poly(hexamethylene adipamide), polycaprolactam and polyamides of bis(4-aminocyclohexyl)methane and linear aliphatic dicarboxylic acids containing 9, 10 and 12 carbon atoms; copolyamides; polyester such as poly(ethylene terephthalate) and copolymers thereof; and polyolefins such as polyethylene and polypropylene.

Both heterogeneous and homogeneous mixtures of such polymers may also be used.

As is apparent to one ordinarily skilled in the art, the fibers may be prepared by known methods of spinning fibers. Molten polymer is spun through spinneret orifices shaped to provide the desired void volume and fiber cross-sections under spinning conditions which give the desired denier. Specific spinning conditions and spinneret orifices, shapes and dimensions will vary depending upon the particular polymer and fiber product being spun.

To achieve the desired percent void, the spinning and quenching conditions are modified appropriately. For example, the percent void can generally be increased by more rapid quenching of the molten fibers or by increasing the polymer melt viscosity.

As demonstrated by the Examples and Table below, the present invention provides a carpet fiber having low streak potential without sacrificing wear qualities.

Test Methods

Percent Void:

The void-to-fiber ratio for hollow fibers is obtained
by measuring the size of the hole within the fiber and comparing it to the size of the fiber as if no hole existed. This comparison is performed via computer analysis of the image of a fiber as projected on a television-type monitor. Before an image analysis is performed, the yarn must be dyed. If the yarn provided is bright or semi-dull, it is dyed with a disperse green stock solution, but the color is not particularly important. When the yarn must be dyed, it is placed in 400 ml of water with 50 ml of disperse green stock solution and 50 ml of disperse green additives and heated to approximately 95°C. A section of the sample approximately 7 inches long is placed into the solution for five minutes, then removed, washed with cold water, and dried.

In the following examples, a Leitz TAS Plus Image Analyzer and associated equipment is used and operated according to the instructions. The analyzer integrates void area and total cross-sectional area. The ratio of these two integrals times 100 equals percent void.

**Arm Angle**

Fiber cross sections are magnified (200X) to determine the arm angle. Two tangent straight lines are drawn for each arm and the angle formed from the two straight lines is measured. The reported arm angle represents the average of ten measurements.

**Streak Potential**

Streak potential is evaluated by visual comparison. Results are reported as vivid streaking, moderate streaking or essentially streak free.

**Pile Height Recovery**

**Static Compression**

Static compression testing is performed using a standard static compression apparatus with air pressure adjusted to 50 psi (351,000 Pa). Four and 1/2 inch (11.4 cm) diameter samples are placed under the legs of the compression apparatus and 50 psi (351,000 Pa) of air pressure is applied by lowering the legs. The legs remain on the samples for 24 hours. Results are reported as the percent of original pile height retained after the load is removed.

**Vetterman Drum**

Vetterman drum testing is done with a metal drum having an internal diameter of 730 mm, an internal depth of 270 mm, an effective depth of 240 mm, and a thickness of the curved surfaces of 8 mm. This drum is used at a speed of 16 revolutions per minute, and the direction of rotation is reversed every five minutes with approximately a one second stationary time between changes of direction. The revolutions of the drum are counted, and specimens are held in place by adjustable retaining segments. Loose pile fibers are continuously extracted by a vacuum cleaner. Inside the drum, a round steel ball is situated. The steel ball is 120 mm in diameter and weighs 6800 grams. The ball is fitted with 14 rubber studs located to be equally spaced on the ball's surface (118 mm apart).

Four specimens, 570 mm long in the direction of manufacture and 265 mm wide, are cut, and a similarly sized and positioned specimen is cut for comparison purposes. The samples are placed into the drum and held securely with the retaining segments. The revolution counter is set for 22,000 cycles. After all cycles are complete, the specimens are cleaned with the vacuum cleaner, making four forward and backward passes along the length, ensuring that all of the area is covered, and that the final pass is in the direction of the pile lay. The specimens are allowed to lie flat pile side up for at least 24 hours before comparison with the control. Results are reported as percent of original pile height retained after 22,000 revolutions.

**Tetrapod**

Tetrapod wear testing is performed according to ASTM standard method D5251-92 using 500,000 revolutions. Results are reported as the percent of original pile height retained after 500,000 revolutions.

All relative viscosities given in the examples are determined as 1 g/100 ml solution in 96 wt.% H₂SO₄ and measured at 25°C.

**Example 1**

A spinneret having 440 filament capillaries arranged rectangularly in 7 rows and 62 to 64 capillaries per row is used to make hollow trilobal fibers. The capillaries are formed generally according to Fig. 2 with appropriate design for the desired arm angle, percent void and modification ratio and are offset with respect to the capillaries of each next adjacent row.

Nylon 6 polymer (Relative Viscosity measured in H₂SO₄ = 2.7) is extruded with conventional spinning conditions into a quench stack and taken up onto packages and then further processed by drawing, crimping and cutting into typical 20 denier per filament staple carpet fiber. The staple fiber is spun via conventional known methods into spun, plied heatset carpet yarn. The melt temperature is 265°C. Throughout is 1000 gm/min. Quench flow is 200 ft./min (60.8 m/min). The draw ratio is 3.0.

The carpet yarn is then tufted into a primary backing using conventional tufting methods to make 1/8 gauge (3.17 mm), 11.3 stitches per inch (4.45 stitches/cm) carpet having a pile height of 0.375 inch (0.95 cm) and a pile weight of 40 ounces per square yard (1.35 kg/m²). Samples of this carpet are evaluated for percent void, arm angle, streak potential, and pile height recovery.
The results are reported in the Table.

Example 2 (Comparative)

A spinneret has 440 filament capillaries arranged rectangularly in 7 rows and 62 to 64 capillaries per row. The capillaries are formed to make a hollow trilobal fiber within the scope of U.S. Pat. 5,208,107 (= EP 516,119) with appropriate design for the desired arm angle, percent void and modification ratio. The capillaries are offset with respect to the capillaries of each next adjacent row.

Nylon 6 polymer (Relative Viscosity measured in H₂SO₄ = 2.7) is extruded with conventional spinning conditions into a quench stack and taken up onto packages and then further processed by drawing, crimping and cutting into typical 20 denier per filament staple carpet fiber. The staple fiber is spun via conventional known methods into spun, plied heatset carpet yarn. The melt temperature is 265°C. Throughput is 1000 gm/min. Quench flow is 200 ft./min (60.8 m/min). The draw ratio is 3.0.

The carpet yarn is then tufted into a primary backing using conventional tufting methods to make 1/8 gauge (3.17 mm), 11.3 stitches per inch (4.45 stitches/cm) carpet having a pile height of 0.375" (0.95 cm) and a pile weight of 40 ounces per square yard (1.35 kg/m²). Samples of this carpet are evaluated for percent void, streak potential, and pile height recovery. The results are presented in the Table.

Example 3 (Comparative)

A spinneret has 440 filament capillaries arranged rectangularly in 7 rows and 62 to 64 capillaries per row. The capillaries are formed to make solid trilobal fibers with the modification ratio set forth in the Table. The capillaries are offset with respect to the capillaries of each next adjacent row.

Nylon 6 polymer (Relative Viscosity measured in H₂SO₄ = 7) is extruded with conventional spinning conditions into a quench stack and taken up onto packages and then further processed by drawing, crimping and cutting into typical 20 denier per filament staple carpet fiber. The staple fiber is spun via conventional known methods into spun, plied heatset carpet yarn. The melt temperature is 265°C. Throughput is 1000 gm/min. Quench flow is 200 ft./min (60.8 m/min). The draw ratio is 3.0.

The carpet yarn is then tufted into a primary backing using conventional tufting methods to make 1/8 gauge (3.17 mm), 11.3 stitches per inch (4.45 stitches/cm) carpet having a pile height of 0.375" (0.95 cm) and a pile weight of 40 ounces per square yard (1.35 kg/m²). Samples of this carpet are evaluated for percent void, streak potential and pile height recovery. The results are reported in the Table.

Example 4 (Comparative)
Claims

1. A trilobal synthetic polymeric thermoplastic fiber having a single void extending approximately axially central, characterised by a total cross-sectional void area between greater than about 10 and 20 percent void, a modification ratio between about 2 and about 6, and an arm angle between about 5° and about 50°.

2. The fiber of claim 1 wherein the total cross-sectional void area is from 12 to 20 percent void.

3. The fiber of any of claims 1 to 2 wherein the modification ratio is between about 2 and about 3.5.

4. The fiber of any of claims 1 to 3 wherein the arm angle is between about 10° and 35°.

5. The fiber of any of claims 1 to 4 wherein the modification ratio is between about 11 and 15.

6. A carpet made from fibers according to any of claims 1 to 5.

Patentansprüche

1. Dreilappige Synthesefaser aus thermoplastischem Kunststoff mit einem einzigen, sich ungefähr mittig axial erstreckenden Hohlraum, gekennzeichnet durch eine Querschnittsgesamthohlfläche zwischen größer als etwa 10 und 20% hohl, einen Modifizierungsquotienten zwischen etwa 2 und etwa 6 und einen Armwinkel zwischen etwa 5° und etwa 50°.

2. Faser nach Anspruch 1, bei der die Querschnittsgesamthohlfläche etwa 12 bis 20% hohl beträgt.

3. Faser nach einem der Ansprüche 1 bis 2, bei der der Modifizierungsquotient zwischen etwa 2 und etwa 3,5 liegt.

4. Faser nach einem der Ansprüche 1 bis 3, bei der der Armwinkel zwischen etwa 10° und 35° liegt.

5. Faser nach einem der Ansprüche 1 bis 4, bei der der Modifizierungsquotient zwischen etwa 11 und 15 liegt.

6. Teppich aus Fasern nach einem der Ansprüche 1 bis 5.

Revendications

1. Fibre thermoplastique polymérique synthétique tri-
lobale possédant un vide unique qui s'étend approximativement axialement au centre, caractérisée par une aire de vide en section transversale totale comprise entre plus d'environ 10 et 20% de vide, un rapport de modification compris entre environ 2 et environ 6, et un angle de bras compris entre environ 5° et environ 50°.

2. Fibre suivant la revendication 1, caractérisée en ce que l'aire de vide en section transversale totale varie de 12 à 20% de vide.

3. Fibre suivant l'une quelconque des revendications 1 et 2, caractérisée en ce que le rapport de modification varie d'environ 2 à environ 3,5.

4. Fibre suivant l'une quelconque des revendications 1 à 3, caractérisée en ce que l'angle de bras varie d'environ 10° à 35°.

5. Fibre suivant l'une quelconque des revendications 1 à 4, caractérisée en ce que le rapport de modification varie d'environ 11 à 15.

6. Moquette fabriquée à partir des fibres suivant l'une quelconque des revendications 1 à 5.
FIG. 1

[Diagram showing geometric relationships with labeled parts R1, R2, 10, 11, 13, and 15, and an indication of ARM ANGLE.]
FIG. 2

Radius 0.023 places
Diameter 0.90
Radius 0.356 places
Diameter 2.10

0.07 Slit Width
0.04 Slit Width @ Tip
0.07 Slit Width @ Base

0.11 Gap Width

Leg Length 0.58

120° ± 3°

2.30 Diam

TYP CAPILLARY
ALL DIMENSIONS ARE IN MILLIMETERS
NOT TO SCALE nor PROPORTION