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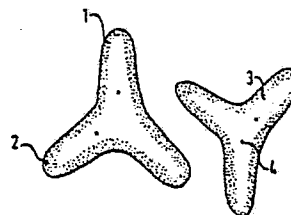
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(54) Textured nylon-6 filament.

(57) A textured nylon-6 continuous filament is characterized by the absence of a spherulitic ring structure along the periphery of the cross section thereof when the cross section is viewed under polarized light.

FIG. 1



BACKGROUND OF THE INVENTIONField of the Invention

TITLE

see front page

5 The present invention relates generally to textiles, spinning, twisting, and twining. More particularly, the invention relates to a crimped, continuous nylon-6 filament.

10 Prior Art Background

In the majority of textile products, two important functional properties are required--viz., protection and thermal insulation-- both of which can be statis-
15 fied by adequate bulkiness of the product. In general, a bulky product will have to be made of a bulky fiber or filament, as the basic constructional element of any textile product is the fiber or filament.

20 As a consequende, a considerable effort has been made over the years to impart higher bulk to fibers and filaments by texturing or crimping thereof, especially those which are man-made for example, from polyamides such as nylon-6. The present invention is an improved
25 crimped, continuous nylon-6 filament.

Statement of Closest Known Prior Art

30 The closest prior art of which the inventors are aware is set forth below.

- 35 1. U.S. 3,186,155, Breen, et al., discloses a mono-component synthetic organic filament, such as a nylon-6 filament, which has: (a) alternate S and Z twist sections throughout its length; (b) a random number of turns between twist reversals; (c) a random, continuously varying angle of twist along

its length; a random number of twist reversals per inch; at least one S turn and at least one Z turn per inch which have a twist angle averaging at least 5 degrees.

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2. U.S. 4,096,226, Martin, et al., discloses the production of a crimped nylon-6 filament similar to that disclosed in Breen, et al., U.S. 3,186,155, supra. However, the Martin process is an integrated process, in contradistinction to that of Breen, wherein the following steps are effected in immediate succession: (a) melt spinning; (b) drawing the spun filaments at a draw ratio such that the drawn filaments on leaving the drawing stage have an extensibility of between 20 and 35 percent; and (c) texturing the drawn filaments at a velocity of between 800 and 3,000 meters per minute by an air jet process, the temperature of the filaments being between 50 and 180 °C prior to texturing.

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3. U.S. 3,975,484, Okada, et al., discloses the production of a crimped nylon-6 filament similar to that disclosed in Breen, et al., U.S. 3,186,155, supra, by a process somewhat similar to that disclosed in Martin, et al., U.S. 4,096,226, supra. Non-circular cross section polyamide filaments are melt spun, allowed to cool, and treated with an oil. Thereupon the filaments are passed around a feed roll having a peripheral speed of more than about 200 meters per minute, passed in contact with a heated body through a contact angle between about 80 ° and 160 ° with the surface temperature of the heated body maintained in the range of about 170°-250°C. The filaments are thereby subjected to one-sided heating

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and drawing, whereupon they are passed through a steam jet crimper which is supplied with steam at a temperature in the range of about 200-350°C.

5 4. Theijin Limited, British 1,565,007, discloses a
nylon-6 multifilament yarn wherein the individual
filaments have an internal microstructure
characterized by α -type crystallinity in combination
with γ -type crystallinity in a given proportion.
10 In particular, each of the individual filaments of
the yarn has a birefringence of at minimum 0,045,
a maximum denier of 0.8, an an x-ray diffraction
intensity ratio statisfying a specific equation.

15 None of the filamentary products described above is
dexdribe as having no characteristic spherulitic ring
structure along the periphery of the cross section
thereof when the cross section is viewed under
polarized light. Spherulitic rings normally have a
20 diffused transition to a non-spherulitic core. The
depth of the spherulitic ring varies usually from
about 10 to about 20 μ .

25 Completely unsuggested by the prior art teachings,
the crimped nylon-6 continuous filament of the
present invention shows a complete absence of a
spherulitic ring structure when the cross section
thereof is viewed under polarized light. The result
of the absence of such a spherulitic ring structure
30 is that the filament is more luxtrous than available
prior art filaments under otherwise identical
conditions. As a consequende, the fiber producer may
increase bulk and cover in a fibrous structure such
as a carpet without any loss in luster.

SUMMARY OF THE INVENTION

5 In order to furnish a textile fiber which affords increased bulk and cover in a fibrous structure fabricated therefrom without any sacrifice in luster, there is provided a crimped nylon-6 continuous filament characterized by the absence of a spherulitic ring structure along the periphery of the cross section thereof when the cross section is viewed under polarized light.

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BRIEF DESCRIPTION OF THE DRAWING

15 For a more complete understanding of the present invention, including the primary object and benefits thereof which are set forth immediately above, reference should be made to the Detailed Description of the Preferred Embodiments, which is set forth below. This detailed description should be read together with the accompanying drawing, wherein:

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FIG. 1 depicts two cross sections of crimped nylon-6 continuous filaments of the prior art, which show a characteristic spherulitic ring structure along the periphery of the cross sections; and

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FIG. 2 depicts two cross sections of crimped nylon-6 continuous filaments according to the present invention, which show a complete absence of the spherulitic ring structure which is characteristic of the prior art filaments shown in FIG. 1.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawing, FIG. 1 depicts an available crimped nylon-6 continuous filament (1) of the prior art, which is shown in two cross sections thereof as viewed under a microscope under polarized light. A characteristic spherulitic ring (2) is observed along the periphery of the cross sections. Also seen in the cross sections are small particles (4) of a delustrant such as titanium dioxide. The spherulitic ring (2) is comprised of a multiplicity of individual partial spherulites (3), which, although not visible under ordinary conditions, are visible under polarized light. The filaments depicted here have a modification ratio of between about 2 and 3, i.e., the configuration thereof is commonly referred to as "trilobal".

To determine the modification ratio as well as the presence or absence of a spherulitic ring structure, the following procedure is employed. A filament or yarn sample is placed in a suitable embedding agent. A thin section thereof is then cut with a microtome. A photomicrograph of this section is then obtained, and the modification ratio (MR) is calculated, with the use of a template, employing the following equation:

$$MR = \frac{D_0}{D_1}$$

wherein D_0 = Diameter of circumscribed circle to cross section, and
 D_1 = Diameter of inscribed circle into cross section.

The presence or absence of any peripheral ring is determined by visual observation of the section, under polarized lighting (phase-contrast or dark field may also be employed); a photomicrograph can also be obtained under these conditions.

Depicted in FIG. 2 is one embodiment (5) of the crimped nylon-6 continuous filament according to the present invention, which is shown in two cross sections thereof as viewed under a microscope under polarized light. No spherulitic ring is observed along the periphery of the cross sections, as at (6). Seen in the cross sections are small particles (4) of a delustrant such as titanium dioxide. The filaments depicted here also have a modification ratio as discussed above of between about 2 and 3, i.e., the configuration thereof is commonly referred to as "trilobal".

To be sure, it is not necessary that delustrants such as titanium dioxide be present in the filaments according to the present invention. Indeed, the same advantages and benefits over the prior art are obtained when a filament according to the present invention is substantially free of any delustrant. Moreover, although a modification ratio of between about 2 and 3 is advantageously employed, filaments according to the present invention may have other cross sectional configurations as well, under which conditions the same advantages and benefits over the prior art are observed. That is to say, filaments of the present invention have a higher luster-- as determined visually or by any of many standard optical methods known to the skilled artisan--when compared with otherwise equivalent filaments of the prior art which have the same level of crimp, or the

same level of delustrant in an amount which is substantially below the saturation level thereof, or the same cross sectional configuration.

5 As is understood by those of skill in the art, filaments according to the present invention which are substantially free of any delustrant are considered to be very highly lustrous. If not as much
10 luster is desired, one of the delustrants known to those of skill in the art may be employed. These include not only the usual non-chromatic delustrant and fillers such as titanium dioxide, zinc sulfide, calcium carbonate, glass particles, etc., but also
15 delustering agents which impart color as well. Such include organic and inorganic pigments and dyes that are added to the molten nylon-6 polymer prior to or during extrusion and spinning, or to the nylon-6 polymer in chip form in a dyeing operation prior to extrusion and spinning. When titanium dioxide is
20 employed, it is advantageously present in an amount of not greater than about 0.1 percent by weight.

The crimped nylon-6 continuous filament of the present invention advantageously has a tank bulk of
25 at least .8 percent and a denier of at least 5. Under these conditions it is especially suitable for use in the fabrication of a large number of textile structures desirable in today's market. Tank bulk is determined by first measuring the length change in a
30 skein of fiber exposed to boiling water under two loads of approximately 0.0003 g/dtex (L_2) and 0.09 g/dtex (L_1), respectively. Tank bulk is then calculated employing the following equation:

$$\begin{aligned} \% \text{ Bulk} &= \frac{L_1 - L_2}{L_1} \times 100 \end{aligned}$$

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Moreover, especially beneficial results are obtained when the crimped nylon-6 continuous filament according to the present invention has a modification ratio of between about 2 and 3 and a denier of between about 5
5 and 25. Under these conditions, use of the filament according to the present invention results in carpets having outstanding characteristics.

In addition to showing no spherulitic ring structure
10 along the periphery of the cross section thereof when the cross section is viewed under polarized light, a crimped nylon-6 continuous filament according to the present invention which has a denier of at least 5 is found to have another significant morphological
15 characteristic, viz: the ratio of γ -form nylon-6 to α -form nylon-6 is at least 1 to 1, and often about 3/1 to 3.5/1, as measured on non-heat treated, undyed, crimped filamentary material. This compares with γ -form to α -form ratios of about 1/3 to 1/3.5 for
20 available prior art products under the same conditions of treatment. However, after heat setting of the crimped filamentary material of the present invention, the α -form is predominant. Such a phenomenon clearly demonstrates that a higher
25 proportion of the entire filamentary structure of the present invention is rearranged during heat setting, thereby increasing heat setting efficiency over that obtained with prior art products. To determine the crystallinity ratios referred to above, the
30 equatorial x-ray diffraction pattern of the sample is measured and recorded continuously between 2θ values of 12° and 30° . The alpha crystalline form has a peak at $2\theta = 20.0^\circ$ to 20.5° , and another at $2\theta = 23.2^\circ$ to 24.0° . The pseudo-gamma form has a single peak at
35 about $2\theta = 21.2^\circ$. By visual examination of the curve, one can determine the relative preponderance

of a particular crystalline form. Such products according to the present invention which have a ratio of γ -form nylon-6 to α -form nylon-6 are especially desirable when substantially free of any delustrant, or when a delustrant such as titanium dioxide is present therein in an amount not greater than about 0.1 percent by weight. Moreover, modification ratios of between about 2 and 3 are highly advantageous, as is a tank bulk as specified supra of at least about 8 percent.

Any of the filaments according to the present invention may be employed in a multifilament yarn--e.g., grouped together with other filaments according to the present invention--which may be interlaced and/or twisted, utilizing standard techniques well-known to those of skill in the art, to produce carpets, upholstery, and other such textile structures having outstanding characteristics.

The present invention, including its object and benefits, may be better understood by reference to the following illustrative examples:

Example 1

Nylon-6 chips having a relative viscosity of 2.69 as measured in 96-98% sulfuric acid and containing less than 0.01% titanium dioxide were melted in an extruder and spun at a temperature of 265° through two spinnerettes with 99 irregular shaped holes each at a thruput of 335 grams per minute per spinnerette forming two 99 filament threadlines. The spun filaments were quenched with a crossflow of air at approximately 12°C, and were lubricated with an oil spin finish comprising a polyalkoxylated alcohol

containing essentially no water. The fiber was stretch pre-tensioned 1 1/1%, pre-heated to 45°C, and stretched 3.25X to a speed of 2119 meters per minute and heated to 165°C. The stretched threadlines were

5 crimped in a hot air texturizer such as that in US Patent 3,908,248, and deposited onto a rotating cooling sieve through which air was moved by means of a vacuum. The sieve moved at a velocity of 45 meters per minute. The threadlines were unraveled from their

10 plug form on the cooling sieve to a speed of 1732 meters per minute established by a cold pair of godets. The yarns were subsequently interlaced in a conventional air jet and wound up under 200 pond tension on a double cup winder. There was no spherulitic

15 ring structure along the periphery of the cross section of the fiber when viewed under a microscope under polarized light. Some of the fiber produced was processed in a commercial space dyeing operation and exhibited excellent uniformity and bulk/cover. Other

20 fiber was commercially cabled, continuously heatset, tufted, and dyed into an excellent residential type carpet.

The fiber exhibited physical properties common to

25 Bulked Continuous Filament (BCF) products including:

	Luster	:	Excellent
	Dtex	:	1990
	Tenacity	:	2.3 g/dtex
30	Elongation at Break	:	40 %
	Tank Bulk	:	10.2 %
	Dyeability	:	Piece dyeable in Acid Red; absence of noticeable streaks in Ortalon Blue G
35	Filament Modifica-		
	tion Ratio	:	2.5

Example 2

A procedure essentially equivalent to that of Example 1 was followed, resulting in a product having the following characteristics:

	Luster	:	Excellent
	Dtex	:	1430
	Filament Modifica-		
10	tion Ratio	:	2.5
	Tank Bulk	:	11 %
	Ratio of γ -form		
	nylon-6 to α -form		
	nylon-6	:	3.5/1
15	Dyeability	:	Piece dyeable in Acid Red; absence of noticeable streaks in Ortolon Blue G

After heat setting of this fiber, the α -form nylon-6 was determined to be predominant..

In order to produce crimped nylon-6 continuous filaments according to the present invention, it is necessary to orient the fiber before allowing any moisture migration into the fiber. This is advantageously accomplished by employing an essentially non-aqueous spin finish, as utilized in the examples above.

Although the present invention has been described in detail with respect to certain preferred embodiments thereof, it is understood by those of skill in the art that variations and modifications in this detail may be effected without any departure from the spirit and scope of the present invention, as defined in the hereto-appended claims.

WE CLAIM:

1. A crimped nylon-6 continuous filament characterized by the absence of a spherulitic ring structure along the periphery of the cross section thereof when the cross section is viewed under polarized light.
2. The filament of claim 1, which is substantially free of any delustrant.
3. The filament of claim 1 having TiO_2 as a delustrant therein, the TiO_2 being present in an amount not greater than 0.1 percent by weight.
4. The filament of claim 1, which has a modification ratio of between about 2 and 3.
5. The filament of claim 1, which has a tank bulk of at least 8 percent.
6. The filament of claim 1, which has a denier of at least 5.
7. The filament of claim 4, which has a denier of between about 5 and 25.
8. The filament of claim 6, wherein the ratio of γ -form nylon-6 to α -form nylon-6 is at least 1 to 1, as measured on non-heat treated, undyed, crimped filamentary material.
9. The filament of claim 8, which is substantially free of any delustrant.

10. The filament of claim 8, having TiO_2 as a delustrant therein, the TiO_2 being present in an amount not greater than 0.1 percent by weight.
- 5 11. The filament of claim 8, which has a modification ratio of between about 2 and 3.
12. The filament of claim 8, which has a tank bulk of at least 8 percent.
- 10 13. The filament of claim 8, wherein the α -form nylon-6 is predominant after heat setting of the crimped filamentary material.
- 15 14. The filament of claim 1, which is grouped together with other filaments according to claim 1 to present a multifilament yarn.

FIG. 1

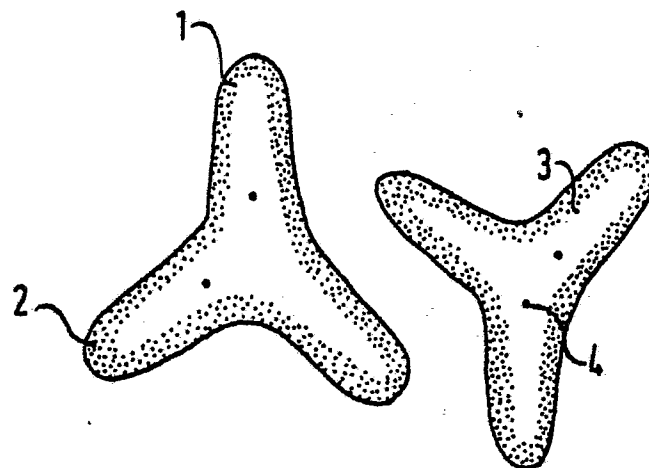


FIG. 2

