NYLON COMPOSITE FIBER AND FABRIC THEREOF

Applicant: Taiwan Textile Research Institute, New Taipei City (TW)

Inventors: Wei-Hung Chen, New Taipei City (TW); Wei-Peng Lin, New Taipei City (TW); Ta-Yo Chen, New Taipei City (TW); Hsiao-Wen Cheng, New Taipei City (TW); Ta Ko, New Taipei City (TW); Ta-Chung An, New Taipei City (TW)

Assignee: Taiwan Textile Research Institute, New Taipei City (TW)

Appl. No.: 13/958,676

Filed: Aug. 5, 2013

Foreign Application Priority Data
Dec. 20, 2012 (TW) .......................... 101148667
Jul. 9, 2013 (TW) .......................... 102124542

Publication Classification
Int. Cl.
D01F 8/12 (2006.01)
D03D 15/00 (2006.01)

CPC ............... D01F 8/12 (2013.01); D03D 15/0027 (2013.01)
USPC ......... 442/197; 525/432; 442/200; 442/199; 428/395; 428/370

ABSTRACT
A nylon composite fiber and a nylon fabric thereof are provided. This nylon composite fiber is a dual-component fiber, and contains a long chain polyamide and a polyether modified polyamide polyamide. One monomer of the long chain polyamide contains a long aliphatic chain. One monomer of the polyether modified polyamide contains a polyether chain.
NYLON COMPOSITE FIBER AND FABRIC THEREOF

RELATED APPLICATIONS

[0001] This application claims priority to Taiwanese Application Serial Numbers 101148667, filed Dec. 20, 2012 and 102124452, filed Jul. 9, 2013. The entire disclosures of all the above applications are hereby incorporated by reference herein.

BACKGROUND

[0002] 1. Technical Field
[0003] The disclosure relates to a composite fiber and a fabric thereof.
[0004] 2. Description of Related Art
[0005] It is difficult that the structure of the existing dual-component fibers has a new breakthrough to present improved or new functions. The improved or new functions, such as higher elasticity, better moisture absorption and description, or better fiber strength, usually come from a special material used in new dual-component fibers.

SUMMARY

[0006] In one aspect, the present invention is directed to a nylon composite fiber for having better protofilament crimp contraction. The nylon composite fiber comprises a first nylon fiber and a second nylon fiber arranged in a way of side-by-side or eccentric core-sheath.
[0007] The first nylon fiber contains a long chain polyamide including one repeating unit having at least 10 carbons. The long chain polyamide above is polymerized by a straight-chain aliphatic diamine having m carbons, and a first straight-chain aliphatic diacid having a carbons. For getting better crystallinity of the first polyamide, the number (n-2) is better to be an integral multiple of the number (m-2). For example, the long chain polyamide can be nylon 6.10, nylon 6.14, or nylon 10.10. The second nylon fiber contains a polyether modified polyamide. The polymerized modified polyamide is co-polymerized by a lactam (i.e. a cyclic amide), a polyether diamine and a second straight-chain aliphatic diacid. The lactam can have 4-12 carbons, for example. The polyether diamine has 2-6 carbons between adjacent two oxygen atoms, such as polyethyleneoxy diamine, polybutyleneoxy diamine, or polyoxylalkyleneoxy diamine. The average molecular weight of the polyether diamine is about 400-5000, or 1000-2000. The second straight-chain aliphatic diacid can have 6-12 carbons, for example. In the added monomers for synthesizing the second polyamide, the added amount of the polyether diamine is 3-20 wt %, such as 5-12 wt %. In another aspect, the present invention also directs to a fabric made from the nylon composite fibers above to have better elongation-recovery rate. The fabric above can have excellent elasticity without using a false-twist texturing process and adding with spandex.
[0008] The foregoing presents a simplified summary of the disclosure in order to provide a basic understanding to the reader. This summary is not an extensive overview of the disclosure and it does not identify key/critical elements of the present invention or delineate the scope of the present invention. Its sole purpose is to present some concepts disclosed herein in a simplified form as a prelude to the more detailed description that is presented later. Many of the attendant features will be more readily appreciated as the same becomes better understood by reference to the following detailed description considered in connection with the accompanying drawings.

DETAILED DESCRIPTION

[0009] In the following detailed description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

Nylon Composite Fiber

[0010] In this disclosure, a nylon composite fiber is provided. The nylon composite fiber comprises a first nylon fiber and a second nylon fiber arranged in a way of side-by-side or eccentric core-sheath.
[0011] The first nylon fiber contains a long chain polyamide having long aliphatic straight chains. Since the long aliphatic straight chains can be aligned and then highly crystallized by sufficiently extending the first nylon fiber, the dimensional stability of the first nylon fiber is better. That is, the first nylon fiber has lower residual internal stress and lower boiling water shrinkage.
[0012] The second nylon fiber contains a polyether modified polyamide having a polyether chain. Since the polyether chain is softer and cannot be easily crystallized by extending the second nylon fiber, the flexibility of the second nylon fiber is better, and the dimensional stability of the second nylon fiber is poorer. That is, the second nylon fiber has higher residual internal stress and higher boiling water shrinkage.
[0013] Therefore, the nylon composite fiber can be a helical fiber after processed by tension, heat treatment (such as treated by boiling water) or both due to the different dimensional stabilities of the first and the second nylon fibers. The helical shape of the nylon composite fiber can provide a certain extending length. The second nylon fiber containing the polyether segments can help to restore the original length of the nylon composite fiber after extending the nylon composite fiber. The first nylon fiber containing the long aliphatic chain can help to stabilize the curl of the nylon composite fiber. Accordingly, a fabric made from the nylon composite fibers above can have durable stretchability.
[0014] The long chain polyamide above is polymerized by a straight-chain aliphatic diamine having m carbons, and a first straight-chain aliphatic diacid having a carbons. For getting better crystallinity of the first polyamide, the number (n-2) is better to be an integral multiple of the number (m-2). For example, the long chain polyamide can be nylon 6.10, nylon 6.14, or nylon 10.10.
[0015] The polyether modified polyamide above is co-polymerized by a lactam (i.e. a cyclic amide), a polyether diamine and a second straight-chain aliphatic diacid. The lactam can have 4-12 carbons, for example. The polyether diamine has 2-6 carbons between adjacent two oxygen atoms, such as polyethyleneoxy diamine, polybutyleneoxy diamine, or polyoxylalkyleneoxy diamine. The average molecular weight of the polyether diamine is about 400-5000, such as 1000-2000. The second straight-chain aliphatic diacid can have 6-12 carbons, for example. In the added monomers for synthesizing the second polyamide, the added amount of the polyether diamine is 3-20 wt %, such as 5-12 wt %.
The nylon composite fiber above can be formed by the method described below. First, the long chain polyamide and the polyether modified polyamide are melt-spun together to form the nylon composite fiber. Then, the nylon fiber can be stretched by a tension to obtain a helical fiber. Next, the helical nylon composite fiber can be further treated by boiling water to increase the helical density of the nylon composite fiber.

**Embodiment 1: Preparation of Nylon Side-by-Side Composite Fibers**

In this embodiment, various nylon side-by-side composite fibers were obtained by melt spinning.

In examples 1-3, the long chain polyamide was nylon 6.10, and the polyether modified polyamide was copolymerized with caprolactam, polyethyleneoxy dianine, and adipic acid. The added amount and the average molecular weight of the polyethyleneoxy dianine were 8 wt.%, and 2000, respectively. The weight ratios of the long chain polyamide to the polyether modified polyamide for examples 1-3 were 60:40, 50:50, and 40:60, respectively.

In examples 4-6, the long chain polyamide was nylon 6.10, and the polyether modified polyamide was copolymerized with caprolactam, polyethyleneoxy dianine, and adipic acid. The added amount and the average molecular weight of the polyethyleneoxy dianine were 0.82 wt.%, and 1000, respectively. The weight ratios of the long chain polyamide to the polyether modified polyamide for examples 4-6 were 60:40, 50:50, and 40:60, respectively.

In comparative example 1, the polyether modified polyamide of example 5 was replaced by nylon 6. In comparative example 2, the long chain polyamide of example 5 was replaced by nylon 6. In comparative example 3, the long chain polyamide of example 2 was replaced by nylon 11. The weight ratios of the long chain polyamide to the polyether modified polyamide for comparative examples 1-3 were all 50:50.

The related preparation variables are listed in Table 1 below.

**TABLE 1**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Long chain Polyamide</th>
<th>Polyether modified Polyamide</th>
<th>Long chain polyamide:Polyether modified polyamide (Weight Ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1</td>
<td>Nylon 6.10</td>
<td>polyethyleneoxy dianine</td>
<td>60:40</td>
</tr>
<tr>
<td>Example 2</td>
<td>Nylon 6.10</td>
<td>polyethyleneoxy dianine</td>
<td>50:50</td>
</tr>
<tr>
<td>Example 3</td>
<td>Nylon 6.10</td>
<td>polyethyleneoxy dianine</td>
<td>40:60</td>
</tr>
<tr>
<td>Example 4</td>
<td>Nylon 6.10</td>
<td>polyethyleneoxy dianine</td>
<td>60:40</td>
</tr>
<tr>
<td>Example 5</td>
<td>Nylon 6.10</td>
<td>polyethyleneoxy dianine</td>
<td>50:50</td>
</tr>
<tr>
<td>Example 6</td>
<td>Nylon 6.10</td>
<td>polyethyleneoxy dianine</td>
<td>40:60</td>
</tr>
<tr>
<td>Comparative Example 1</td>
<td>nylon 6.10</td>
<td>nylon 6</td>
<td>50:50</td>
</tr>
<tr>
<td>Comparative Example 2</td>
<td>Nylon 6</td>
<td>polyethyleneoxy dianine</td>
<td>50:50</td>
</tr>
<tr>
<td>Comparative Example 3</td>
<td>Nylon 11</td>
<td>polyethyleneoxy dianine</td>
<td>50:50</td>
</tr>
</tbody>
</table>

**Embodiment 2: Properties of the Nylon Composite Fibers**

The weight ratios of the long chain polyamide to the polyether modified polyamide (examples 1-3 and 4-6) were respectively varied to test various properties of the obtained nylon side-by-side composite fibers.

First, crimp contraction of a protofilament was measured for the obtained nylon side-by-side composite fibers, and the measured results of the obtained nylon side-by-side composite fibers are listed in Table 2. The crimp contraction test was performed by the method described below. The length of a tested fiber loaded with a weight of 0.22 g/denier (i.e., 2 g/ tex) for 10 seconds was measured to be L1. Then, the tested fiber was unloaded and kept at 160°C for 30 minutes. Next, the length of the tested fiber loaded with a weight of 0.011 g/denier (i.e., 0.1 g/tex) for 10 minutes was measured to be L2. Accordingly, the crimp contraction (CC) is calculated by the formula (1) below.

\[
CC(\%) = \frac{(L1-L2)}{L1} \times 100\% 
\]

Moreover, the fiber strength of the obtained nylon composite fibers was also measured to estimate the spinning stability. If the fiber strength is greater than 3.5 g/d, the spinning stability of the nylon fiber is acceptable.

**TABLE 2**

<table>
<thead>
<tr>
<th>Sample</th>
<th>CC (%) Of Protofilament*</th>
<th>Fiber Strength (g/d)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1</td>
<td>18.4</td>
<td>3.7</td>
</tr>
<tr>
<td>Example 2</td>
<td>24.0</td>
<td>3.9</td>
</tr>
<tr>
<td>Example 3</td>
<td>24.9</td>
<td>4.0</td>
</tr>
<tr>
<td>Example 4</td>
<td>24.2</td>
<td>4.0</td>
</tr>
<tr>
<td>Example 5</td>
<td>26.9</td>
<td>4.1</td>
</tr>
<tr>
<td>Example 6</td>
<td>29.4</td>
<td>4.3</td>
</tr>
<tr>
<td>Comparative Example 1</td>
<td>10.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Comparative Example 2</td>
<td>8.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Comparative Example 3</td>
<td>10.9</td>
<td>3.2</td>
</tr>
</tbody>
</table>

*Calculated by the formula (1) above  
**measured by following the method of ASTM D4258

In examples 1-3, the monomers of the polyether modified polyamide contained polyethyleneoxy dianine. The crimp contraction of examples 1-3 were all above 18%, and the measured crimp contraction was maximum when the weight ratio of the long chain polyamide to the polyether modified polyamide was 40:60 (example 3).

However, comparing the example 2 and the comparative example 3, the crimp contraction was greatly reduced from 24.0 to 10.9 when the nylon 6.10 in the example 2 was replaced by nylon 11 in the comparative example 3. This result showed that although nylon 11 is a polyamide having long aliphatic chains, the long aliphatic chain is not the only factor that can increase the value of the crimp contraction. The long aliphatic chain of the long chain polyamide still needs to have a proper length to facilitate alignment and crystallization and thus good dimensional stability by sufficiently extending the first nylon fiber.

In examples 4-6, the monomers of the polyether modified polyamide contained polybutyleneoxy dianine. The crimp contraction of examples 4-6 were all above 24%, and the measured crimp contraction was maximum when the weight ratio of the long chain polyamide to the polyether modified polyamide was 40:60 (example 6). However, com-
paring the example 5 and the comparative examples 1-2, either the long chain polyamide or the polyether modified polyamide was replaced by nylon 6, the crimp contraction was greatly reduced from 26.9% to 10.5% or 8.0%. These results show that even though the nylon side-by-side composite fibers of the examples 1-3 were not treated by false-twist texturing, the crimp contraction of the obtained nylon side-by-side composite fibers was still very good. The fiber strength of examples 1-6 were all above 3.5 g/f. This result shows that the fiber strength is good enough for maintaining good spinning stability of the nylon side-by-side composite fibers. The good fiber strength is due to good compatibility between the long chain polyamide and the second polyamide, since both the two components of the side-by-side composite fibers are polyamide, i.e. nylon.

Embodiment 3: Properties of Nylon Fabrics Containing the Nylon Composite Fibers

[0028] In examples 4-6 and comparative examples 1-3, the above obtained nylon side-by-side composite fibers were woven to form a nylon fabric. The warps were 70d/24f DJTY, and the wefts were side-by-side 70d/24f SDY. In examples 4-6 and comparative examples 1-3, garters woven from the nylon side-by-side composite fibers above were used. In the garters, the warp density is 92 warp/inch, and the weft density is 80 well/inch.

[0029] Elongation-recovery rates and wear resistance were measured, and the results are listed in Table 3 below.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Elongation-Recovery Rate (%)</th>
<th>Wear Resistance (Circles)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 4</td>
<td>92</td>
<td>137</td>
</tr>
<tr>
<td>Example 5</td>
<td>95</td>
<td>130</td>
</tr>
<tr>
<td>Example 6</td>
<td>94</td>
<td>122</td>
</tr>
<tr>
<td>Comparative Example 1</td>
<td>82</td>
<td>128</td>
</tr>
<tr>
<td>Comparative Example 2</td>
<td>73</td>
<td>98</td>
</tr>
<tr>
<td>Comparative Example 3</td>
<td>78</td>
<td>118</td>
</tr>
</tbody>
</table>

*Measured by following the method of CNS 8039 L3139-1981 5.2 A.  
**Measured by following the method of AASTM D688 H-22 with a 1000 g abrasive wheel.

[0030] In examples 4-6, the elongation-recovery rates were all above 90%, which were greater than the comparative examples 1-3 (73-82%). Therefore, the nylon fabrics of the Examples 4-6 can provide much better wearing comfort.

[0031] Comparing example 2 and comparative example 3, the only difference is the nylon 6.10 was replaced by nylon 11 in the long chain polyamide of the first nylon fiber. As discussed above for the crimp contraction difference, this result shows that the crystallinity of the nylon 11 is poorer than the crystallinity of the nylon 6.10, and thus maintain higher residual stress. Therefore, the elongation-recovery rate of the comparative example 3 was poorer than the elongation-recovery rate of the example 2.

[0032] The wear resistance of the nylon fabrics in the examples 4-6 was comparative with the comparative example 1 and greater than the comparative examples 2-3. Therefore, the nylon fabrics of the examples 4-6 can provide longer service lifetime for the fabrics.

[0033] In light of the foregoing, the embodiments of this invention provides a nylon composite fibers containing a long chain polyamide containing long aliphatic chains and a polyether modified polyamide containing polyether diamine segments. The nylon composite fibers can spontaneously crimp contract to form helical fibers, and the measured protofilament crimp contraction can more than 20% and can up to 29.4%, which can provide durable stretchability to a fabric made from the nylon composite fibers.

[0034] All the features disclosed in this specification (including any accompanying claims, abstract, and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, each feature disclosed is one example only of a generic series of equivalent or similar features.

What is claimed is:

1. A nylon composite fiber, comprising: a first nylon fiber containing a long chain polyamide polymerized by a straight-chain aliphatic diamine having m carbons and a first straight-chain aliphatic diacid having n carbons, wherein (m-n) is an integral multiple of (m-2), and one of m and n is at least 10; and a second nylon fiber containing a polyether modified polyamide co-polymerized by a lactam, a polyether diamine and a second straight-chain aliphatic diacid, wherein the lactam has 4-12 carbons, the polyether diamine has 2-6 carbons between adjacent two oxygen atoms, and the second straight-chain aliphatic diacid has 4-12 carbons, wherein the nylon composite fiber is a side-by-side composite fiber or an eccentric core-sheath fiber.

2. The nylon composite fiber of claim 1, wherein the long chain polyamide is nylon 6.10, nylon 6.14, or nylon 10.10.

3. The nylon composite fiber of claim 1, wherein an added amount of the polyether diamine in added monomers of the polyether modified polyamide is 3-20 wt %.

4. The nylon composite fiber of claim 1, wherein the average molecular weight of the polyether diamine is about 400-5000.

5. The nylon composite fiber of claim 1, wherein the polyether diamine is polyethyleneoxy diamine, polybutyleneoxy diamine, or polyhexyleneoxy diamine.

6. The nylon composite fiber of claim 1, wherein the nylon composite fiber is a helical fiber.

7. A fabric comprising the nylon composite fiber of claim 1.

8. The fabric of claim 7, wherein the long chain polyamide is nylon 6.10, nylon 6.14, or nylon 10.10.

9. The fabric of claim 7, wherein an added content of the polyether diamine in added monomers of the polyether modified polyamide is 3-20 wt %.

10. The fabric of claim 7, wherein the average molecular weight of the polyether diamine is about 400-5000.

11. The fabric of claim 7, wherein the polyether diamine is polyethyleneoxy diamine, polybutyleneoxy diamine, or polyhexyleneoxy diamine.

12. The fabric of claim 7, wherein the nylon composite fiber is a helical fiber when the nylon composite fiber is a side-by-side composite fiber.

13. A fabric comprising a nylon composite fiber, wherein the nylon composite fiber comprises: a first nylon fiber made from nylon 6.10; a second nylon fiber made from a polyether modified polyamide co-polymerized by caprolactam, a polyether diamine, and adipic acid, wherein the polyether diamine is polyethyleneoxy diamine, or polybutyleneoxy diamine.
14. The fabric of claim 13, wherein the nylon composite fiber is a side-by-side composite fiber or an eccentric core-sheath fiber.