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SPINNING PROCESS

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This invention relates to the production of fine denier filaments and multifilament yarns and threads composed of a synthetic linear polymer. More particularly, this invention relates to the production of such filaments, yarns and threads containing incorporated therein a finely divided, inert material in an amount less than that which will produce a substantially visible delustering or dulling effect, whereby the rupturing of the filaments or yarn, during the cold-drawing thereof, will be materially diminished.

The melt-spinning and cold-drawing (that is, drawing under tension in the solid state) of synthetic linear polymers is well known in the art. The U. S. patents to Carothers Nos. 2,071,250, 2,071,251, 2,071,253 and 2,130,948 all disclose the melt-spinning and cold-drawing of synthetic linear polymers including polyamides, polyesters, polyethers and polyanhydrides as well as mixed polymers or interpolymers, for example polyamide-polyesters. Of these polymers, the most interesting and useful are the synthetic linear polyamides, more particularly described in the last two above mentioned patents. It is also well known that other synthetic linear polymers, for example vinylidene dichloride polymers, acrylonitrile polymers and interpolymers of vinyl acetate and vinyl chloride can be melt spun and cold-drawn.

The present invention in its broad aspects is applicable to the melt spinning and cold-drawing of any fiber-forming synthetic linear polymer.

The cold drawing of synthetic linear polymer yarn is usually done by feeding the yarn from one pair of positively driven rollers to a second pair of positively driven rollers rotating at a suitably higher speed than said first pair. Preferably, the draw tension is concentrated at a precise point between the pairs of rollers to prevent wandering of the draw-point.

As might be expected, the cold-drawing of yarns composed of fine denier filaments which involves the stretching of the filaments from 200% up to 500%, or more, presents many problems. One of these is the tendency of the filaments and in some cases the entire yarn to break with the consequent production of inferior yarn. As might be expected, this happens more frequently as the filament denier is decreased and as the degree of drawing is increased. In the production of bright, i. e. substantially undelustered, synthetic linear polyamide hosiery yarn, the breakage of filaments and yarns has been so high as to be a cause of real concern.

It is therefore an object of this invention to produce bright, undrawn, fine denier filaments and multifilament yarns composed of a synthetic linear polymer which can be readily cold-drawn without excessive breakage of yarns and filaments.

It is another object of this invention to improve the melt spinning of bright, fine denier filaments and multifilament yarns from a synthetic linear polymer in such a manner as to reduce the breakage of said yarns and filaments in the subsequent cold-drawing thereof.

Other objects of the invention will appear hereinafter.

The objects of the invention may be accomplished, in general, by producing bright, cold-drawable, fine denier filaments and multifilament yarns composed of a synthetic linear polymer containing, homogeneously dispersed throughout the body thereof, a finely divided, inert material in an amount substantially less than that which will produce a visible delustering effect. The preferred procedure for accomplishing this is to prepare a melt of a synthetic linear polyamide containing from 0.005% to 0.05% by weight of the finely divided, inert material, for example titanium dioxide, and melt spinning the polyamide in a known manner.

The addition of finely divided, inert material, for example pigments and pigment-like material, to synthetic linear polymer filament-forming compositions is, of course, well known. Conventionally, this is done to produce opaque or low luster yarns (delustered yarns). With other yarns, it has however also been done for such purposes as to produce staple yarn having good cohesion, or to produce yarn having low running tension in textile equipment.

There is nothing in the above mentioned, previously known processes which would suggest that the addition of less than 0.05% of a finely divided, inert material to a synthetic linear polymer melt will, upon melt spinning, produce filaments and yarns which can be cold-drawn with decidedly fewer filament and yarn breaks than in the absence of said finely divided, inert material. Such a minute amount of inert material is definitely insufficient to accomplish the objects and purposes of the above mentioned, previously known processes.

It is known that the presence of finely divided, inert material such as titanium dioxide tends to weaken yarn. It is also known that the cold-drawing operation, in view of the high tension employed, is very critical. It would, therefore, be supposed that the cold-drawing of yarn containing such a finely divided, inert material would result in increased breakage of yarns and filaments.

The following specific examples are given to illustrate preferred methods of carrying out the present invention. It is to be understood however that these examples are not to be considered as limitative of the scope of the invention.

Example I

Polyhexamethylene adipamide polymer of relative viscosity 33.5 (determined by the method described below) and containing 0.01% by weight of titanium dioxide intimately dispersed therein was spun from melt to form a 69-filament yarn which was subsequentlly cold-drawn at a draw ratio of 4.40 to produce a 210 denier-69 filament yarn with a tenacity of 6.3 grams per denier and an elongation of 16%. In the drawing operation there were 0.2 complete yarn breaks per pound of yarn and a creel mirror test showed four broken filaments per 1,000 yards of yarn. The yarn was not visibly delustered.

A similar polyhexamethylene adipamide polymer of relative viscosity 33.5 (determined by the method described below), but containing no titanium dioxide was spun from melt to form a 69-filament yarn. The yarn was subsequently cold-drawn at a draw ratio of 4.40 to produce a 210 denier-69 filament yarn with a tenacity of 6.5 grams per denier and an elongation of 14%. In the drawing operation there were 2.0 complete yarn breaks per pound of yarn and a creel mirror test showed forty broken filaments per 1,000 yards of yarn.

Example II

Polyhexamethylene adipamide polymer of relative viscosity 34 (determined by the method described below) and containing 0.05% by weight of titanium dioxide was spun from melt to form a 69-filament yarn which was subsequently cold-drawn at a draw ratio of 4.40 to produce a 210 denier-69 filament yarn with a tenacity of 6.2 grams per denier and an elongation of 15%. In the drawing operation there were 0.2 complete yarn breaks per pound of yarn, and a creel mirror test showed two broken filaments per 1,000 yards of yarn. The yarn was not appreciably delustered.

A similar polyhexamethylene adipamide of relative viscosity 34 (determined by the method described below), but containing no titanium dioxide was melt spun to form a 69-filament yarn which was subsequently cold drawn at a draw ratio of 4.40 to produce a 210 denier-69 filament yarn with a tenacity of 6.5 grams per denier and an elongation of 14%. In the drawing operation there were several complete yarn breaks and a creel mirror test showed seventy broken filaments per 1,000 yards of yarn.

A second sample of the polymer mentioned in the previous paragraph was melt spun to form a 69-filament yarn. The yarn was subsequently cold-drawn at a draw ratio of 4.28 to produce a 210 denier-69 filament yarn with a tenacity of 5.5 grams per denier and an elongation of 19%. In the drawing operation there were several complete yarn breaks and a creel mirror test showed eighty-eight broken filaments per 1,000 yards of yarn.

The above two examples show two very important advantages which follow the teachings of the present invention. In the first place, the presence of a small amount of titanium dioxide in the polymer as spun makes it possible to draw bright yarn without the occurrence, during the drawing, of too many yarn breaks and broken filaments for acceptable plant production. In the second place, the presence of a small amount of titanium dioxide in the polymer results in the production of a yarn having a higher elongation than would be the case in the absence of said titanium dioxide. When similar yarns were cold-drawn at a lower draw ratio (see Example II) the elongation went up and the tenacity down (which is a well recognized observation in the art), but the draw-twister breaks and broken ends were not decreased. Consequently, the titanium dioxide effect is not a draw ratio effect. Conversely, it shows that yarn containing small amounts of titanium dioxide can be drawn at a higher draw ratio to end with the same (desired) elongation and therefore increase the productivity of the spinning machines.

While the examples show a preference for a relative viscosity of 33.5 to 34.0, the relative viscosity may be between 15 and 60.

The term "relative viscosity" as used in this specification is the ratio of absolute viscosity at 25° C. (in centipoises) of the solution of synthetic linear polyamide in 90% formic acid (10% water and 90% formic acid) to the absolute viscosity at 25° C. (in centipoises) of the 90% formic acid. An 8.4% (by weight) solution of the synthetic linear polyamides which are completely soluble in 90% formic acid is used in this determination. Moisture content of polyamides is disregarded in preparation of the polyamide-formic acid test solutions if it is lower than 0.4%. The absolute viscosity of this 8.4% polyamide solution and of the solvent alone (90% HCOOH) is determined at 25° C. in the conventional manner and the relative viscosity calculated as the ratio of the two.

In the examples, the melt spinning and cold-drawing of polyhexamethylene adipamide yarn containing very slight amounts of titanium dioxide has been disclosed. As above stated, the invention is not so limited but is applicable broadly to the melt spinning and cold-drawing of any fiber-forming synthetic linear polymers and is particularly applicable to the melt spinning of synthetic linear polyamides. Also, although the invention shows its greatest utility in the cold-drawing of melt spun filaments and yarn, it includes in its broader aspects the cold-drawing of polyamide filaments and yarns spun by other methods, e. g. from solution. The invention is substantially limited to filamentous structures comprised of fine denier filaments, i. e. less than 20 denier per filament, since such structures are drawn in the atmosphere whereas materially larger filaments are drawn in water and therefore not particularly subject to breakage.

Similarly, the invention is not limited to the use of titanium dioxide, but may be carried out by the use of other finely divided, inert materials, such as, for example, powdered glass, silicon dioxide, calcium sulfate, barium sulfate, kaolin, clay, zinc oxide, lithopone (barium sulfate and zinc sulfide) and other related materials which may be dispersed in their finely divided state in the molten polymer. While it is not desired that the invention be bounded by speculation, it is believed that any inert, discrete, solid, pigment-like particles dispersed in the polymer will result in the same phenomenon. Titanium dioxide is preferred since large quantities of it are conventionally used in practically all operating plants.

Quantities of 0.01% to 0.03% of titanium dioxide, based on the weight of the polyamide, are preferred. The quantities of 0.005% to 0.05% weight are effective to produce the desired results while at the same time permitting the production of bright filaments and yarn and the term "bright" is intended to signify filaments and yarn having a brightness not less than that which is incident to the use of said quantities of titanium dioxide. One skilled in the art can quite readily determine the optimum proportion of any other finely divided, inert material which may be used instead of the titanium dioxide.

By the term "finely divided, inert material" is meant a material which has no chemical action on said polymer and which is in a state of division of the order of yarn delustering or pigmenting material.

The invention described herein has importantly advanced the art of producing cold-drawn, bright filaments and yarns composed of a synthetic linear polymer, thereby permitting maximum production of excellent yarn with existing equipment. It has now been found that, by the practice of this invention, the number of yarn and filament breaks during cold-drawing is decreased and a larger percentage of production can now be classified as completely satisfactory yarn. It has been found too that bright yarn can be produced having the desired high tenacity (highly drawn yarn) and fine denier per filament.

A surprising and unexpected result of the invention is that the yarn produced in accordance with this invention is not nearly so "wild" on a creel mirror as is the normal bright yarn. This characteristic assures much better performance on knitting and weaving machinery and assures a higher quality of fabric.

It is also interesting to note that, unlike the teachings of the prior art, in the present invention we are not concerned with the index of refraction of the pigment, or other finely divided, inert material to be added. It is only important that the quantity of pigment added is insufficient to prevent the formation of bright filaments and yarn.

Since it is obvious that many changes and modifications can be made in the above described details without departing from the nature and spirit of the invention, it is to be understood that the invention is not to be limited to the above said details except as set forth in the appended claims.

I claim:

1. The process of reducing the breakage of cold-drawable filamentous structures composed of a synthetic linear polyamide which comprises preparing a composition containing said polyamide and a finely divided, inert material homogeneously dispersed therein in an amount from 0.005 to 0.05%, spinning a filamentous structure from said composition and cold-drawing said structure.

2. The process of reducing the breakage of cold-drawable filamentous structures composed of a synthetic linear polyamide which comprises preparing a melt of said polyamide containing a finely divided, inert material homogeneously dispersed therein in an amount from 0.005% to 0.05%, spinning a filamentous structure from said melt and cold-drawing said structure.

3. The process of reducing the breakage of cold-drawable filamentous structures composed of polyhexamethylene adipamide which comprises preparing a melt of said polymer containing a finely divided, inert material homogeneously dispersed therein in an amount from 0.005% to 0.05%, spinning a filamentous structure from said melt and cold-drawing said structure.

4. An unoriented, cold-drawable, filamentous structure composed of a synthetic linear polyamide containing, homogeneously dispersed throughout the body thereof, a finely divided, inert material in an amount from 0.005% to 0.05%.

5. An unoriented, cold-drawable, filamentous structure composed of polyhexamethylene adipamide containing, homogeneously dispersed throughout the body thereof, a finely divided, inert material in an amount from 0.005% to 0.05%.

6. The process of reducing the breakage of cold-drawable filamentous structures composed of a synthetic linear polyamide which comprises preparing a melt of said polyamide containing finely divided titanium dioxide homogeneously dispersed therein in an amount from 0.005% to 0.05%, spinning a filamentous structure from said melt and cold drawing said structure.

7. An unoriented, cold-drawable, filamentous structure composed of a synthetic linear polyamide containing homogeneously dispersed throughout the body thereof finely divided titanium dioxide in an amount from 0.005% to 0.05%.

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