Dec. 19, 1967 J. MYLO 3,359,356

PROCESS FOR CRIMPING FILAMENTS AT THE SPINNERET FACE

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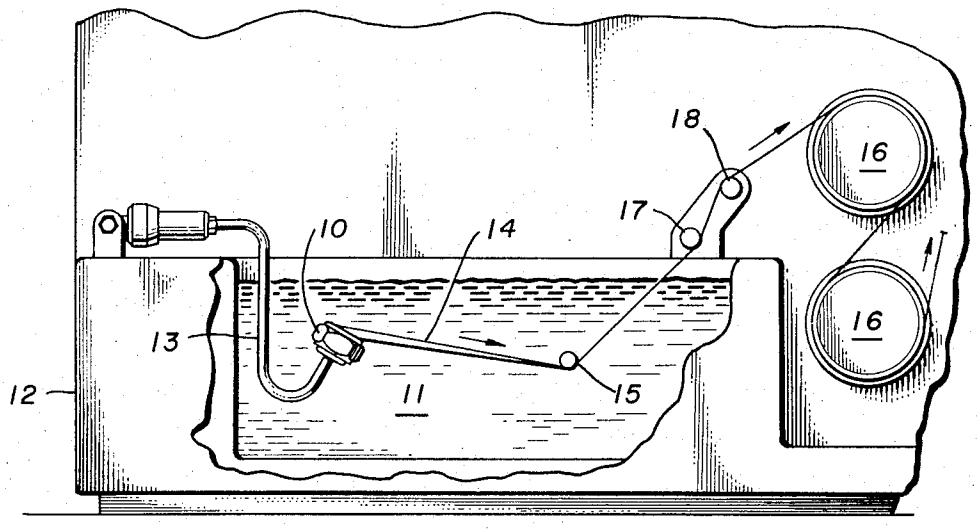

FIG. 1.

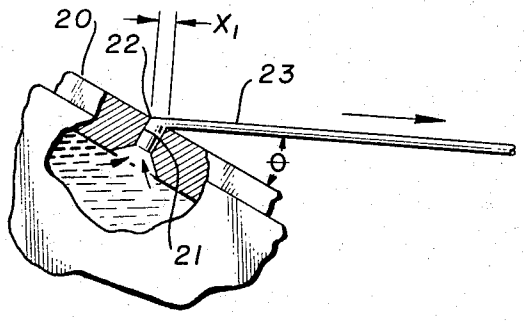

FIG. 2.

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PROCESS FOR CRIMPING FILAMENTS AT THE SPINNERET FACE

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ABSTRACT OF THE DISCLOSURE

Filaments are crimped during the spinning process by drawing the filaments from the spinneret at an acute angle therewith to impart a preferential arrangement of the molecular structure to one side of said filaments prior to their becoming completely coagulated or solidified and thereafter subjecting them to heat to develop a crimped condition.

This invention relates to the production of textile filaments from a thermoplastic polymer and, more particularly, this invention relates to a process for establishing a preferential molecular orientation along one side of the filament axis whereby a permanent crimp retentivity is imparted to said filaments.

In the manufacture of continuous filaments from a fiber-forming thermoplastic material such as acrylonitrile polymers and copolymers, the filaments must be subjected to some type of special treatment in an attempt to overcome the lack of interfilamentary cohesion exhibited by the newly formed filaments to thereby render such filaments suitable for subsequent processing thereof. Several methods which are too numerous to discuss herein have been utilized for improving interfilament cohesion by imparting a crimped or curled condition to continuous synthetic filaments. The basic principle employed by all of the most commonly used methods, which are referred to generally as mechanical processes, is essentially the same except for composite filaments formed from fiber-forming thermoplastic materials having different shrinkage characteristics. The mechanical processes comprise deformation of the spun filaments by some type mechanical aparatus to reorient the molecular structure of said filaments for the purpose of imparting thereto a memory of the deformation experienced previously by the filaments. For example, the deformation or crinkle is imposed mechanically by means of intermeshing gear-like elements; by drawing the filaments over a dull knifed edge; by means of a stuffer box; or by twisting the yarns, setting the twist, and then removing the twist.

A plastic memory or crimped condition in the filaments is achieved through the well known process of heating the filaments a selected amount prior to mechanically crimping said filaments. The deformation of the filaments while heated causes a rearrangement of the molecules therein. If the filaments are cooled slightly to reduce the plasticity thereof in the absence of tension, the crimp will be "set" and thereby retained. However, if a tension is imposed on the filaments during the cooling cycle the crimp will be removed but may be redeveloped by annealing the filaments in the absence of tension.

Some apparent limitations are imposed by the above discussed methods. In some cases it is not practical because of the investment in special equipment required. In other instances the use of heat and softening agents is undesirable because of their effect on the physical properties of the filaments. Another serious limitation is that the molecular rearrangement caused by the mechanical deformations imparted to the filaments results in a lot of broken ends occurring in the filament bundle. These broken ends, if too frequent, render the tow unsuitable for

processing on textile machinery such as the Pacific Converter. Perhaps the most serious problem encountered with filaments crimped by the known methods occurs during subsequent processing steps such as dyeing in which the crimped filaments elongate to the extent that substantially all of the crimp is removed from said filaments. Obviously, this characteristic imposes a serious limitation upon the dyeing of textured acrylic fibers.

Although the known methods are used extensively, it would be highly desirable to provide a method for producing textile filaments having a permanent plastic memory and being free from damage attributable to mechanical crimping processes.

It is therefore an object of the present invention to provide an improved method of imparting a potential crinkled or curled condition to filaments formed from fiber-forming thermoplastic materials and particularly acrylonitrile polymers and copolymers.

Another object of the present invention is to provide a method for producing, during normal spinning operations, textile filaments having a permanent plastic memory which is not destroyed by subsequent heating and processing thereof.

A further object of the present invention is to impart a potential curliness, which may be developed later into a permanent crimp, to synthetic filaments spun from a conventional spinneret by a novel process.

Still another object of this invention is to provide a novel method of producing potentially crimped filaments having a permanent plastic memory during the usual course of production with a minimum investment in additional equipment.

Yet another object of the invention is to provide a novel method of orienting the molecular structure of spun synthetic filaments during the spinning process in a preferential manner whereupon the filaments will exhibit uniform, regularly spaced helixes around the longitudinal axis thereof when heated.

Other objects and advantages of the invention will be apparent from the description that follows.

The novel filamentary products of this invention are produced by the wet spinning process in which a solution comprising essentially a thermoplastic filament-forming material dissolved in an organic solvent or solvent mixture is extruded in the form of fine streams through a spinneret into a coagulating bath to form shaped filaments which are drawn from the spinneret at an angle across the face thereof.

The filaments produced in accordance with the present invention are characterized by a combination of properties unique in the manufacture of artificial thermoplastic organic solvent-soluble filaments. They are comprised of a molecular structure having preferential orientation of the molecules along the direction of the filaments. Continuous filaments produced by the method described for carrying out this invention will attain a spiral or helical shaped form upon subsequent relaxation. A preferential orientation of the molecules is accomplished by diverting the direction of extrusion of the filament-forming material whereby a variable strain is imposed across the cross-section of the filaments while they are still in a semi-plastic state to rearrange the spatial structure thereof. This irregular cross-sectional distribution of the molecules comprising the filaments is responsible for permanence of the crimped condition possessed by filaments produced in accordance with this invention. What is meant by "permanent crimp" as referred to herein is a developed crimp which is not destroyed when subjected to a subsequent heat relaxation. Once the crimp has been developed, as for example, during a normal annealing process, it is not destroyed if exposed to further heating during later processing such as dyeing. A filament which possesses crimp

imposed by mechanical means elongates when it is heat relaxed whereby the amplitude of the crimps is reduced until the filament regains its original straightness.

The present invention may be employed in the spinning of any organic solvent-soluble, thermoplastic, fiber-forming substance by the wet spinning process wherein the direction of the newly formed filaments is diverted at the face of the spinneret before they become self-sustaining. Diversion of the semi-fluid filaments is affected by means of a guide bar spaced near the spinneret. The guide bar may be shifted to change the angle of the filaments with respect to the spinneret. This angle may vary from 1° to 45° depending upon the amount of crimp required. As the angle across the face of the spinneret decreases the amount of crimp or curls per inch is increased. While the filaments may be drawn under tension at angles ranging from 1° to 45°, the preferred range is from 10° to 30°.

The filaments of this invention may be produced on any conventional spinning machine of the wet spinning type by making the simple and inexpensive addition of a guide means for changing the path of the filaments being drawn from the spinneret. A single spinneret may be used or a number of spinnerets grouped together may be used to produce the filaments contemplated by the invention. For the purpose of illustrating the method employed to accomplish the expected results of this invention a single spinneret is shown in the accompanying drawing wherein:

FIGURE 1 is a diagrammatic, elevational view of a conventional spinning apparatus modified to illustrate the invention; and

FIGURE 2 is a cross-sectional view of the spinneret illustrating the stretch differential imposed on opposite sides of a single semi-fluid filament.

Referring to FIGURE 1, a spinneret **10** is immersed in a coagulating bath **11** contained in a tub **12**. A spinning solution is pumped to the spinneret through a pipe **13** from a source not shown. The solution is extruded through the spinneret to form filaments **14**. An adjustably mounted guide bar **15** is positioned near the lower level of the bath **11** on the face side of the spinneret. The filaments **14** are drawn from the spinneret **10** at an acute angle off the face thereof by a series of take-up rolls **16**. Stripper bars **17** and **18** are provided to aid in the recovery of the solvent. As the spinning solution emerges from the spinneret in a semi-fluid state, the abrupt drawing of the newly formed filaments at a close angle across the face of the spinneret imposes a variation in strain on the opposite sides of the filaments which remains unchanged when they become self-sustaining. The guide bar **15** may be raised or lowered to vary the drawing angle of the filaments. If an increase in the number of crimps per inch is desired, the bar **15** can be lowered until the filaments are drawn substantially parallel with the face of the spinneret. Obviously, if the bar is raised the amount of crimp retentivity of the filaments is correspondingly diminished.

In FIGURE 2 a fragmentary view of a spinneret face **20**, depicting a single hole **21**, is illustrated for the purpose of facilitating a better understanding of the phenonomena which occurs in accordance with the principles of this invention. As discussed herein previously, the newly formed filaments are in a semi-liquid state at the area **22** near the face **20** of the spinneret. If θ is referred to as being the size of the acute angle formed between the spinneret face **20** and filament **23**, it is readily apparent that one side of the filament is stretched substantially more than the opposite side, as indicated by X_1, when θ approaches zero. Since the stretching takes place while the filament is in a semi-fluid state the molecular structure is preferentially oriented along the longitudinal side of the filament opposite the direction of bend whereby a permanent crimp retentivity is imparted thereto without exceeding its critical yield point.

The following specific example further illustrates the invention. Parts are by by weight unless otherwise indicated.

Example

A spinning solution comprised of 93% acrylonitrile and 7% vinyl acetate dissolved in a suitable solvent and heated to 80° C. was spun using the apparatus shown in the accompanying drawing. A single spinneret having 3,000 holes of 3.5 mils in diameter was used for spinning a bundle of 3 denier filaments at the rate of 2.3 pounds per hour. The filaments were drawn across the face of the spinneret at a 10° angle and collected in an orderly manner. These filaments were subjected to a normal annealing process wherein fine, regularly spaced crimps in the form of a helix were developed in the filaments. A microscopic observation of the individual filaments revealed that they possessed up to 18 crimps per inch. Thereafter the filaments were placed in a container of water. The water temperature was elevated to its boiling point and the filaments were removed from the boiling water. After drying, the filaments exhibited substantially the same amount of crimp as previously.

The present process provides an inexpensive method for imparting a permanent crimp retentivity to synthetic filaments which will reduce the steps presently used to process such filaments for utilization in subsequent processing operations in the textile industry. For example, in the manufacture of carpets from acrylic fibers, which tend to elongate when heat relaxed, serious limitations have been imposed because of the fact that during the dyeing process normal crimp is destroyed. Heretofore, the fibers have been spun from pigmented dope solutions to overcome this problem. Acrylic fibers produced in accordance with this invention can be dyed on skeins, or products formed therefrom may be dyed, without removing the crimp or bulk possessed by such products.

Although the invention has been described primarily with reference to spinning acrylic fibers by the wet spinning process, it is also applicable to such thermoplastics as nylon which is melt spun. However, an attempt to spin a thermoplastic fiber-forming material by the dry spinning process proved to be unsuccessful.

It will be apparent from the above description of the process and products of this invention that they are susceptible to extensive modification without departing from the spirit of the invention. Therefore, it is to be understood that the invention is not to be limited except as set forth in the following claims.

I claim:

1. The process of producing crimped, continuous filaments which comprises extruding a synthetic thermoplastic filament-forming material through a spinneret having a plurality of orifices to form continuous filaments, imposing a tension on said filaments in a direction ranging from 10 to 30 degrees with respect to the face of said spinneret, said change in direction occurring at the spinneret face whereby a preferential orientation of the molecular structure of the filaments is imparted thereto, and subsequently relaxing said filaments.

2. A process for producing crimped synthetic filaments from a thermoplastic composition which comprises extruding said composition through a spinneret to form continuous filaments, withdrawing the filaments from the face of the spinneret at an angle to cause preferential arrangement of the molecular structure of said filaments, and heat relaxing the withdrawn filaments to develop a crimped condition in said filaments.

3. The process of claim **2** in which the filaments are withdrawn under uniform tension at an angle of less than 45 degrees with respect to the face of the spinneret.

4. The process of claim **3** in which the filaments are wet-spun.

5. The process of claim **4** in which the composition is comprised of at least 80 percent acrylonitrile.

6. A process for producing continuous filaments from a thermoplastic composition which comprises extruding said composition through a spinneret into a liquid coagulating bath to form continuous filaments, imposing a tension on said filaments at the face of the spinneret at an angle thereto so that substantially more stretch is imparted to one side of the filaments, said stretch being variable across the cross-sectional area thereof, and heat relaxing the stretched filaments to impart crimp thereto.

7. The process of claim 6 in which the composition is comprised of at least 85 percent acrylonitrile.

8. The process of claim 7 in which the filaments are tensioned uniformly at an acute angle with the spinneret.

9. The process of claim 8 in which the angle is less than 30 degrees.

10. The process of claim 9 in which the direction of the filaments is changed abruptly at the point of extrusion to impart preferential orientation to the filaments.

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