United States Patent Office 2,758,908 Patented Aug. 14, 1956

2,758,908

PROCESS OF CRIMPING POLYETHYLENE TEREPHTHALATE FILAMENTS BY HEAT STRETCHING AND HEAT RELAXING

Harry John Kolb, Wilmington, Del., assignor to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

No Drawing. Application June 25, 1952, Serial No. 295,565

3 Claims. (Cl. 8—130.1)

This invention relates to a process of making crimped filaments of linear polymers and yarns, tows, staples, or the like resulting therefrom. The synthetic filamentary material, to which this invention is especially directed, comprises the high molecular weight linear polymers that are fiber-forming, such as, the highly polymeric linear esters as polyethylene terephthalate.

While there are ways for producing crimped filaments, yarns, staples and the like, further improved processes that are far superior to the older processes are desired. Procedures that produce more sharply crimped products, eliminate one or more of the processing steps, are capable of operation at much higher speeds, or vastly improve the quality or properties of the crimped filaments or surprisingly reduce the manufacturing cost are sought.

It is an object of this invention to provide an improved process for sharply crimping filaments of fiber-forming linear polymers. A further object of this invention is to provide an improved process for obtaining filaments or fibers having a large number of sharp crimps generally lying in a single plane. A still further object of the invention is to provide an improved process for rapidly crimping polymeric filaments obtained from polyethylene terephthalate. Other objects will be apparent from the description that follows.

The objects of this invention are accomplished by subjecting undrawn linear polymeric filaments of polyethylene terephthalate to drawing within the range of from 2.3× to 3.6× at a temperature of from 65° to 100° C., tensioning the filaments as will be described hereinafter, and then relaxing the tensioned filaments in boiling water, in a swelling agent, or in hot air at 95° to 180° C., whereupon about 50% shrinkage and good crimp in the filaments spontaneously takes place. The crimped yarn may be wound up immediately at a speed of about ½ the speed at which it is being fed to the relaxing, crimping treatment and thereafter dried and heat set at 125° C.

Drawing the yarn under the conditions above given is essential for the production of well crimped filaments of polyethylene terephthalate. When such filaments were drawn at ratios above or below the limits given, but otherwise subjected to the treatment described above, substantial filament shrinkage took place but the filaments did not crimp. Likewise, if the draw temperature is outside the range given, even though the required draw ratio is maintained, the filaments shrink but do not crimp on immersion in the boiling water. It is important, too, after the yarns are drawn that they be subjected to a brief period of tensioning and preferably held under some tension for a time before continuing to the relaxing step. The application, on the run, of tensions in the range of from 0.1 to 0.93 gram per denier for a short period of time immediately following the drawing contributes to the production of a desirable crimp. For best results this pre-relaxation tension should be of the order of 0.7 to 0.9 gram per denier even though this tension is maintained for but a very short time.

The following examples, in which parts and percentages

are by weight unless otherwise specified, are given as illustrative and not limitative of the invention.

Example I

An ethylene glycol terephthalate polymer of about 30,000 molecular weight was melt spun and collected as 180 denier-30 filament yarn. Four ends of this yarn were plied together to make 720 denier-120 filament bundle, and drawn by passing the bundle around suitable rolls, heated to 80° C. to impart a draw of about 3.1×, i. e., the feed roll of the drawing set had a peripheral speed of 16 yards per minute and the draw roll was driven at a peripheral speed of 50 yards per minute. From the draw roller the drawn yarn was passed to a twister-pirn feed roller operating at a speed slightly higher than the draw roller to give a tension of about 0.7 gram per denier to the yarn (approximately 160 grams total tension on the 225 denier yarn resulting from drawing), and thence, the yarn was passed to a ring twister which wound up the yarn on a wooden pirn with 3 turns per inch of twist. After completion of the yarn package, the pirn was mounted vertically upside down over a large funnel and the yarn was drawn off over the end of the pirn at a speed of approximately 30 yards per minute and allowed to drop into the funnel and thence, into a tank of boiling water below the funnel. A shrinkage of about 50% occurred with simultaneous formation of crimp. As a result the twist increased from 3 turns per inch to 6 turns per inch. The yarn was then wound wet on a perforated aluminum bobbin at 15 yards per minute. The bobbin of yarn was heat treated for 2 hours at 125° C. to dry the yarn and set the crimp. The yarn had about 20 sharp saw-tooth crimps per inch generally lying in a common plane.

Example II

A melt spun yarn, like that described in Example I, plied to four times its spun denier was taken from a bobbin and passed over and around several rolls, the feed roll being driven at a speed of about 16 yards per minute and the draw roll at 50 yards per minute while the hot roll was heated to 80° C., to give a draw ratio of about 3.1×. After that the yarn passed around the roller guide, below the stretching roller, and onto the tension roller to tension the yarn during this passage to about 0.7 gram per denier. The speed of the tension roller, very slightly more than the stretch roller, was approximately twice the speed of the bobbin windup, so that about 50% shrinkage with crimping took place in the bath of boiling water containing a small amount of wetting agent such as a higher fatty alcohol sulfate. On completion of a bobbin, it was doffed and subjected to a 45 minute heat treatment at 150° C., after which the yarn was twisted. The yarn obtained had substantially the same crimp as described in Example I.

Example III

The same general process is followed here with the same starting material except the yarn is allowed to wind up on a bobbin located in the position of the tension roller. When a suitable size bobbin cake was formed the bobbin was doffed and the drawn yarn was slit from the bobbin into 10 inch lengths. The chips were dropped into boiling water and allowed to remain there for 45 minutes. The resulting staple was about 4½ inches long with about 20 sharp saw-tooth crimps per inch.

Example IV

An ethylene glycol terephthalate polymer of about 30,000 molecular weight was melt spun and collected at 245 denier-35 filament yarn. This untwisted yarn was drawn by passing it around suitable rollers heated to 70° C. to impart a draw of 2.2× e. g., the feed wheel of the drawing set had a peripheral speed of 25 Y. P. M. and

the draw roller was driven at a peripheral speed of 55 Y. P. M. From the draw roller the yarn was passed over another advancing roller running at a higher speed so as to tension the drawn yarn to 0.73 g. p. d. (approximately 81 grams total tension on the 111 denier yarn resulting from drawing) and then the yarn was allowed to drop into a tank of boiling water where it remained for 5 minutes under substantially no tension. It was conducted from the boiling water bath at a much reduced speed so as to impart substantially no tension nor stretch to the yarn which had shrunk about 50% in the hot water bath. Sections of this yarn were fairly well crimped with about 10 crimps per inch, while other sections displayed no crimp at all. It appears, therefore, that while an average draw of 2.2× was applied to the yarn some sections were drawn more than this, perhaps as much as 2.5×, while other sections may have been drawn no more than 2.0×. As seen in the previous examples, at the proper draw ratio this difficulty is overcome and all yarn sections are well crimped.

Example V

In a similar test with the same starting yarn as in the preceding example, the draw roller speeds were set to impart a draw of 3.7× e. g., the feed wheel had a peripheral speed of 25 Y. P. M. and the draw rollers were driven at a peripheral speed of 82.5 Y. P. M. A drawing temperature of 70° C. was used and tension imposed on the yarn prior to dropping it into the boiling water was 0.73 g. p. d. In this case only about 20% shrinkage took place in the water bath and the yarn displayed no evidence of crimp.

The crimp will vary depending on the denier of the filament, upon the draw ratio, temperature of the relaxing bath and the freedom the filaments have to relax in the relaxing bath. A high amount of crimp, 10 to 50 crimps per inch, may be secured by the practice of this invention. As previously pointed out however, if the draw ratio or other conditions are not within the limits specified, the filaments may shrink substantially 50% of their length when dropped into the boiling water bath without any substantial crimp resulting. However, by following the process of this invention, in addition to producing a highly crimped yarn, the filaments or staples have wool-like properties as evidenced by high modulus and compliance ratio. Crimped fibers having moduli of 18 to 40 g. p. d. have been obtained. Furthermore, the process is simple and rapid and may be carried out substantially continuously thereby adding very little to the cost of yarn, filament or fiber production.

As can be seen from the above description, the drawing step is within the range of 2.3× to 3.6×. Drawing below or above this range does not lead to the desired crimped filaments. The temperature at which the drawing is effected is not critical but drawing is most readily effected if the yarn is heated to a temperature of about 65° C. to about 100° C. The length of time in the tensioning step is very short, a matter of seconds or a minute, but is not critical. The application of tension is required and the preferred tensions are about 0.7 to about 0.9 g. p. d. The relaxation step is done in such a way that the relaxation is instantaneous. For this reason, the bath or medium used, such as water or air, is heated to a temperature of about 95° C. to about 180° C. If hot air is used, pressure of 8 to 30 p. s. i. are usually applied. If the temperatures are too low or if the relaxation is done too slowly, the yarn or the tow does not develop the optimum crimp. Swelling agents, such as nitric acid, may be employed in the relaxing step.

The polymers used in this invention may be any filament forming polyethylene terephthalate. Such polymers are usually prepared from terephthalic acid and ethylene glycol, but other dibasic acids or other glycols may be used in small amounts to produce copolymer esters. The polymers usually melt above 200° C. and have molecular weights usually above 10,000. The polymers are generally described in U. S. 2, 465,319.

The crimp produced by the process of this invention is regular and sharp. The regular, saw-toothed arrangement of the crimp differs from the conventional helical crimp. Further, the extent of crimping is great. As many as 50 crimps per inch have been produced in staple by this invention. The continuous, rapid nature of the process of this invention coupled with the production of highly crimped articles having wool-like properties makes the process of this invention highly attractive.

The high crimp obtained by this invention is achieved through a combination of high strain and high shrinkage. At the low draw ratios, high shrinkage is obtainable but the fibers are not strained to the degree necessary for good crimp. For example, relaxation as much as 50% does not give the desired crimp in the absence of the proper strains. At draw ratios above the range, the shrinkage obtained in the relaxation step is too low. The combination of the critical strain, or draw ratio, with the high shrinkage leads to the novel spontaneous crimp of this invention, this crimp being saw-toothed in character rather than helical.

Any departure from the above description which conforms to the present invention is intended to be included within the scope of the claims.

I claim:

1. A process for crimping filaments consisting essentially of an ethylene glycol terephthalate polymer which comprises stretching the said filaments from 2.3 to 3.6 times their original length at a temperature of about 65° C. to 100° C.; thereafter applying a tension of 0.1 to 0.93 gram per denier to the resultant stretched filaments; and then placing the resultant strained filaments in a hot relaxing medium at a temperature of 95° C. to 180° C. until a crimp is formed, the said relaxing medium being a fluid chemically inert to the said filaments.

2. The process of claim 1 wherein said tension is in the order of 0.7 to 0.9 gram per denier.

3. The process of claim 1 in which the relaxing medium is water.

References Cited in the file of this patent

UNITED STATES PATENTS

2,249,756	Finzel	July 22, 1941
2,287,099	Hardy et al.	June 23, 1942
2,296,329	Bell et al.	Sept. 22, 1942
2,515,834	Nicoll	July 18, 1950
2,570,173	Von Kohorn	Oct. 2, 1951
2,604,689	Hebeler	July 29, 1952

FOREIGN PATENTS

463,567	Canada	Mar. 7, 1950
610,171	Great Britain	Oct. 12, 1948