

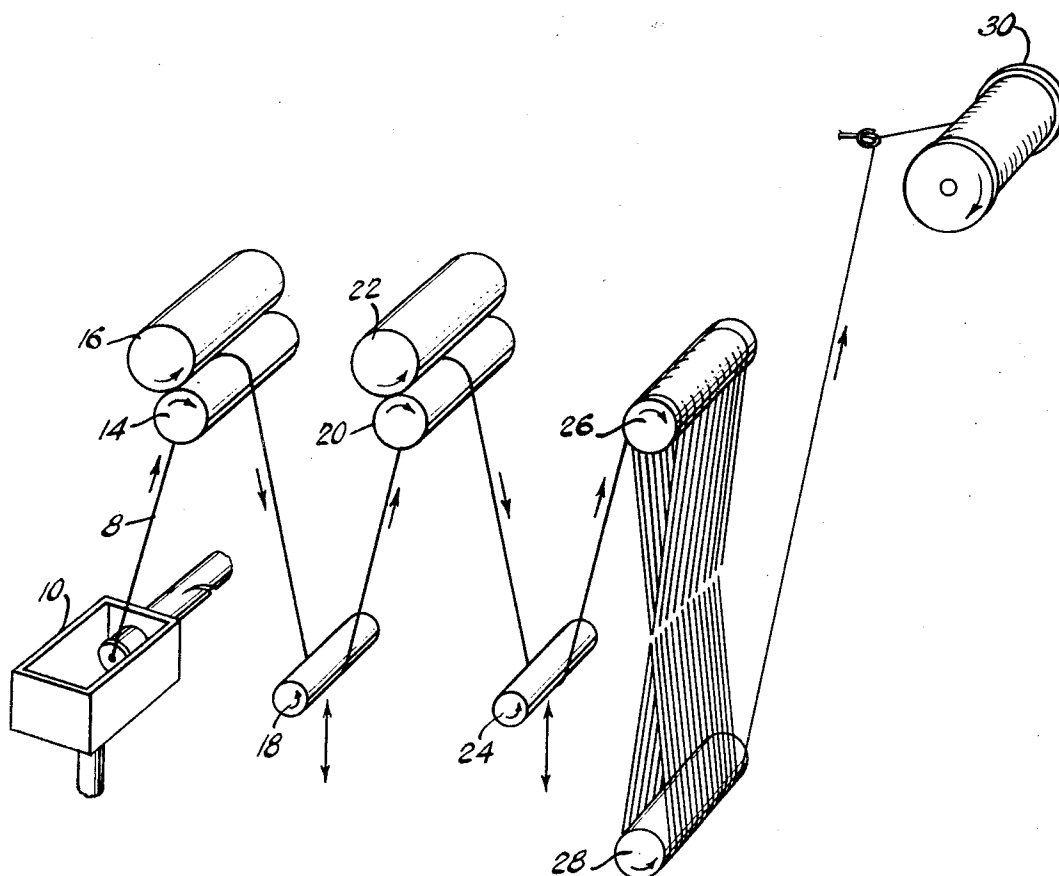
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METHOD FOR THE MANUFACTURE OF COLLAGEN TAPE

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METHOD FOR THE MANUFACTURE OF COLLAGEN TAPE

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ABSTRACT OF THE DISCLOSURE

In the manufacture of a collagen tape which may be twisted to form a round strand that is useful as an absorbable surgical suture, an acid dispersion of collagen fibrils is extruded into a dehydrating bath to form a multifilament. The multifilament, while still wet from the dehydrating bath, is compressed and stretched to form a ribbon-like tape in two or more steps by passage between two or more sets of squeeze rolls, the space between succeeding sets of rolls decreasing so that the compression of the multifilament is accomplished in two or more increments. A certain amount of stretch is imparted to the tape as it passes between the sets of squeeze rolls to assist in the orientation of the collagen fibrils. By varying the total compression and stretching of the wet multifilament, the width and thickness of the tape can be controlled.

BACKGROUND OF THE INVENTION

This invention relates to strand-like materials, such as absorbable sutures and ligatures, made from collagen fibrils. More specifically, the present invention is an improvement in the method of producing a collagen strand as described in United States Pat. No. 3,114,593.

The aforesaid patent describes the continuous extrusion of a homogeneous dispersion of pure swollen collagen fibrils into a dehydrating bath to form a bonded multifilament tape that is further processed, for example, by tanning, twisting, and stretching in proper sequence to obtain a round strand of uniform diameter and physical properties having utility as an absorbable suture. The method for manufacturing a continuous length of a ribbon-like collagen tape wherein the individual filaments that make up the tape cohere together to form a unitary structure is described in Example X and is illustrated in FIG. 28 of Pat. No. 3,114,593.

It is a disadvantage of the manufacturing process described that precise control of the width and thickness of the tape is difficult to achieve, and variations in excess of ten percent in these dimensions may be experienced. Such variations have a profound effect on tannage penetration which is dependent on the relationship of the surface area to volume. Variations in the width and thickness of the tape also effects the roundness and coherence of the finished strand, which is dependent on the number of turns that are required to roll the flat tape into the finished round string.

Another problem that may occur in the manufacturing process illustrated in FIG. 28 of Pat. No. 3,114,593 relates to the control of the flow of air through the drying chamber. If the tape within the drying chamber 66 is too wet, an attempt to correct this situation by increasing the air flow can cause folding of the tape and inordinately high tape tension that may cause the tape to break.

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It is an advantage of the improved process to be described that precise control of tape tension during spinning can be maintained.

It is another advantage of the improved process to be described that precise control of tape dimensions can be maintained.

It is an additional advantage of the improved process to be described that the tape production speed can be increased.

It is an additional advantage of the improved process to be described that it permits the manufacture of a thinner, wider tape than could be obtained by the process described in U. S. Pat. No. 3,114,593.

It is an additional advantage of the improved process to be described that it practically eliminates breakage of the tape during the stretching procedure.

SUMMARY OF THE INVENTION

In accordance with the present invention, the extruded collagen multifilament is passed between a first driven godet and a first squeeze roll and compressed to form a ribbon-like tape, the amount of compression being controlled by the space between the driven godet and squeeze roll. The resultant wet tape is then passed to a second driven godet and a second squeeze roll with some stretching to assist in orienting the collagen fibrils, where it is again compressed by virtue of the space between the second driven godet and second squeeze roll being less than the space between the first godet and first squeeze roll. The distance that the tape travels between the first and second squeeze rolls effects the tape tension between these two points.

This process of compressing and stretching the tape may be repeated as often as desired. The end product is a well-bonded, wet tape consisting of highly-oriented, partially swollen collagen fibrils and containing essentially no free fluid. Final drying of the tape to equilibrium with ambient relative humidity is accomplished by passing the tape many times between a driven godet and an idler roll. The dried tape is then collected continuously on a take-up drum (spool). In this manner, a tape of the desired width and thickness, consisting of highly-oriented collagen fibrils, is produced with essentially no machine down time due to breakage.

For a more complete understanding of the invention, reference should be made to the accompanying drawing which illustrates a method of continuously squeezing and stretching an extruded collagen tape as it is transported from the dehydrating bath to a take-up drum.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a schematic view of a machine that may be used to manufacture a collagen tape and illustrates the physical handling steps and the apparatus employed.

With specific reference to the drawing, a wet, extruded collagen multifilament 8 passes from the dehydrating bath 10 and over the driven godet 14. A squeeze roller 16 in rolling contact with the godet 14 flattens the wet multifilament by a controlled amount and removes excess liquid therefrom. The wet multifilament in passing over the godet 14 under the pressure of the roller 16 is bonded together to form a ribbon-like tape. The tape from the godet 14 passes around the idler roller 18 and over the driven godet 20 which rotates more rapidly than the godet 14 stretching the tape. The tape is again compressed by a

controlled amount as it passes over the godet 20 by a second squeeze roller 22 which removes additional liquid from the tape. The process of alternately compressing and stretching the tape may be repeated as often as desired. If only the first and second squeeze rollers are used, the tape from the godet 20 passes around the idler roller 24 and is further air dried between the driven godet 26 and godet 28, being continuously collected on the take-up drum 30.

The stretch that is applied between the godets 14 and 20 will depend upon their relative peripheral speeds. Thus, if the peripheral speed of the godet 20 is 7.5 percent greater than the peripheral speed of the godet 14, a 7½ percent stretch will be applied between these two godets. In a similar manner, further stretching of the moving collagen tape can be obtained between godet 20 and 26 by increasing the peripheral speed of the godet 26. It will be obvious that a differential stretch is applied to the tape by increasing the peripheral speed of successive godets and that this may be accomplished by either increasing the diameter of successive godets, increasing the angular velocity of rotation of successive godets, or increasing both the diameter and angular velocity.

It has been discovered that movement of the idler 18 upwardly to decrease the distance traveled by the tape between godets 14 and 20 increases the tape tension at the idlers 18 and 24, and that the movement of the idler 18 downwardly to increase the distance traveled by the tape between godets 14 and 20 decreases the tape tension in both zones. Likewise, movement of the idler 24 vertically upward to shorten the tape travel will increase the tape tension; and when moved down to increase the tape travel will decrease the tape tension. Movement of the idler 24, however, affects only the tension on the tape between the godet 20 and 26 and does not change the tape tension between godet 20 and 14.

By vertical movement of the idlers 18 and 24, therefore (either up or down), one may control the tape tension to avoid breaking the tape even under conditions imparting a high degree of stretch thereto.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Example I

A dispersion of acid-swollen collagen fibrils in an aqueous methanol cyanoacetic acid solution is prepared as described in Example X of Pat. No. 3,114,593. This collagen dispersion is extruded through a stainless steel spinnerette, drilled with 192 openings arranged in concentric circles into an acetone dehydrating bath 10 containing 130 mg. of ammonia and 50 g. of water per liter. The extruded multifilament is squeezed a controlled amount by adjusting the clearance between the driven godet 14 and the squeeze roller 16 to remove excess acetone and ammonia and compress and bond the individual filaments into a unitary ribbon-like tape. The collagen tape from the godet 14 passes around the idler roller 18 and is squeezed by a controlled amount between the driven godet 20 and a second squeeze roller 22, which presses additional liquid from the tape and reduces the thickness of the collagen tape. The godet 20 is of the same diameter as godet 14 but rotates at an angular velocity that is 7½ percent greater than that of godet 14 thereby producing the stretch of 7½ percent in the collagen tape as it moves between the godet 14 and the godet 20. The position of the idler 18 is such that the tension on the tape in the zone between godets 14 and 20 is 135 g. Additional stretch is applied to the collagen tape as it moves between the godets 20 and 26, the idler 24 being positioned so that the tape tension in this zone is 200 g. The amount of stretch as the tape passes between godets 20 and 26 is 15.5 percent. Thus a

total stretch of about 23 percent is applied to that length of tape that is moving between the godets 14 and 26.

The stretched collagen tape is air dried as it moves over the rollers 18, 24, and passes between the driven godet 26 and the idler roller 28. The product is collected in its dry state at equilibrium with ambient relative humidity on the take-up drum 30. The collagen tape collected on the take-up drum 30 is about 100 mils in width and about 3 mils in thickness. It may be processed as described in Example XI of Pat. No. 3,114,593 to obtain a collagen strand that has a diameter of 15.0 mils (1270 denier), a dry tensile strength of 4.2 grams per denier, a dry knot strength of 2.3 grams per denier, and a wet knot strength of 1.35 grams per denier.

A thin cross-section of this strand upon microscopic examination resembles the strand prepared in accordance with Example XI of U.S. Pat. No. 3,114,593 in that it resembles a jelly roll, the collagen ribbon or tape being rolled upon itself. Because the tape is thinner and wider than the tape prepared in accordance with Example X of the above-mentioned patent, however, there are more convolutions of the tape that form the strand.

Example II

The method of Example I is repeated, but the tape is stretched 19.5 percent between godets 14 and 20 and 10.5 percent between godets 20 and 26. The tension in the first stretching zone is adjusted to 30 grams by movement of the idler 18 and the tension in the second stretching zone is adjusted to 140 grams by movement of the idler 24.

Example III

The method of Example I is repeated, but the tape is stretched 23 percent between godets 14 and 20 and 12 percent between godets 20 and 26. The tension in the first stretching zone is adjusted to 50 grams by movement of the idler 18 and the tension in the second stretching zone is adjusted to 200 grams by movement of the idler 24.

It should be understood that the above description has been made with reference to the preferred embodiment illustrated in the drawing and that modification and alterations can be made therein without departing from the invention, except as expressly limited hereafter in the claims.

What is claimed is:

1. In the manufacture of a collagen tape by the continuous extrusion of an acid dispersion of collagen fibrils to form a multifilament wherein the multifilament is passed between a driven godet and a first squeeze roller to form a ribbon-like tape in which the individual filaments cohere and the tape is stretched while wet and dried, the improvement which comprises:

stretching the tape as it passes between said first squeeze roller and a second squeeze roller and controlling the tape tension by adjusting the distance that the tape travels between said first and second squeeze roller.

2. The method of claim 1, wherein said tape is stretched a second time after it leaves the second squeeze roller.

3. In the manufacture of a collagen tape by the continuous extrusion of an acid dispersion of collagen fibrils into a dehydrating bath to form a multifilament wherein the multifilament as it leaves the dehydrating bath is passed between a driven godet and a first squeeze roller to form a ribbon-like tape in which the individual filaments cohere and the tape is stretched while wet and dried, the improvement which comprises:

stretching the tape as it passes between said first squeeze roller and a second squeeze roller and imparting additional stretch to the tape as it moves away from the second squeeze roller by contacting the tape with a godet, which revolves in the direction that the tape

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is moving at a peripheral speed greater than that of the second squeeze roller.

4. The method of claim 3, wherein the tape tension is controlled in each stretching zone by varying the distance that the tape travels in moving through that zone.

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