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METHOD OF SEPARATING ADHERING COLLAGEN MONOFILAMENTS

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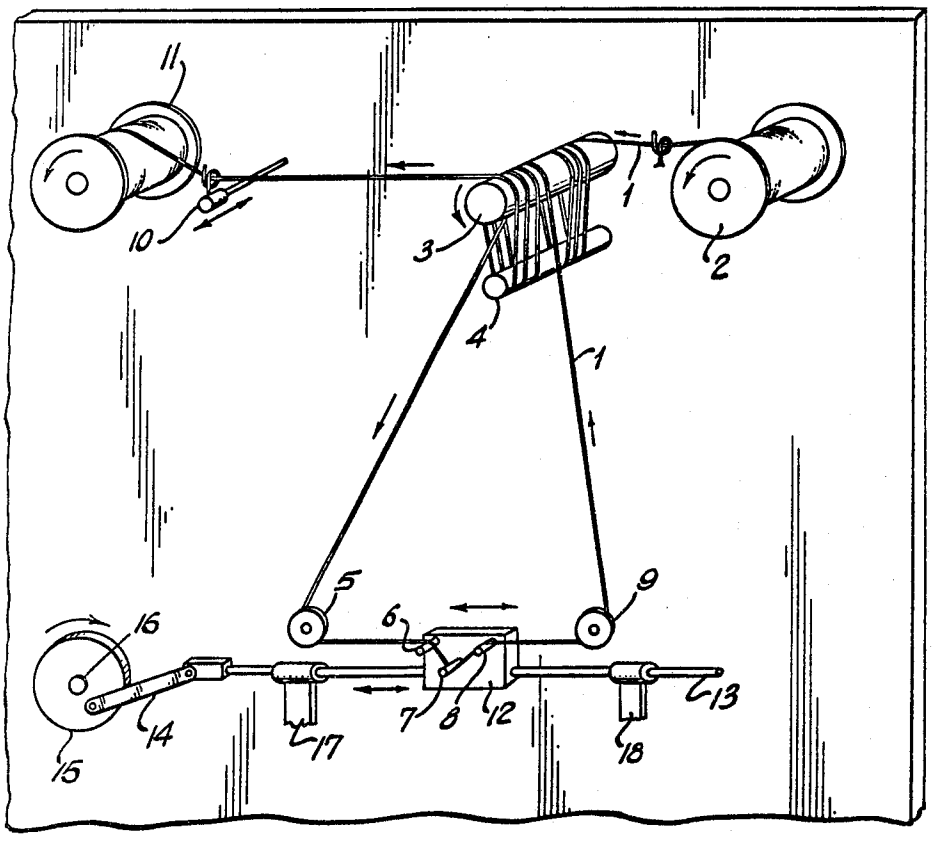

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METHOD OF SEPARATING ADHERING COLLAGEN MONOFILAMENTS

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Original application Aug. 10, 1962, Ser. No. 216,247, now abandoned. Divided and this application June 29, 1967, Ser. No. 650,004

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U.S. Cl. 156—344 5 Claims

ABSTRACT OF THE DISCLOSURE

A group of parallel adherent collagen monofilaments are separated by isolating a section of the bonded multifilament between two fixed points and applying a variable tension thereto.

The present application is a division of my copending application, Ser. No. 216,247, filed Aug. 10, 1962, now abandoned and relates to an open collagen multifilament and to apparatus and methods for the manufacture of such a multifilament.

For the sake of clarity, the terms used herein are defined as follows:

The term "monofilament," as used herein, means a single thread of oriented collagen fibrils as extruded through a single orifice in a spinnerette.

The term "multifilament," as used herein, means a group of individual separate collagen filaments extruded through a spinnerette.

The term "semi-bonded multifilament," as used herein, means a group of individual monofilaments that adhere to one another and are united at various points along their length.

The term "strand," as used herein, means a group of individual monofilaments that have been united to form a unitary structure of circular cross-section.

Collagen is a naturally occurring protein and is the primary constituent of absorbable sutures and ligatures. Such surgical materials may be manufactured by extruding swollen collagen fibrils as described in U.S. Patent No. 2,920,000.

The collagen strands described in the above patent may be woven to form a collagen fabric or cloth that is useful in surgical operations, such as, for example, hernia repair. Such collagen fabrics have been found to be nonantigenic and absorbable in the body at a rate dependent upon the degree of tanning. Tubes woven of collagen have been used to replace blood vessels with some degree of success. Such collagen products have important advantages over inert non-absorbable fabric prosthesis that never become a part of the body tissues.

Porosity is an important characteristic of a collagen fabric designed for use in surgery since the physician desires to promote the growth through the fabric of repair tissue. An open, fluffy, yarn-like collagen multifilament would obviously be the best material from which to weave surgical collagen fabrics, however, prior to the present invention, apparatus and methods for the manufacture of such multifilament were unknown.

The extrusion of an aqueous dispersion of pure acid swollen collagen fibrils through a spinnerette into an acetone dehydration bath has been described in U.S. Patent No. 2,920,000. The collagen monofilaments as they leave the spinnerette orifice and travel through the dehydrating bath are very weak and, until the water is removed, must be handled gently to avoid breakage. In passing over the godets that follow the dehydrating bath the partially dehydrated collagen monofilaments are forced together and adhere to one another forming semi-bonded multi-

filament in which the individual monofilaments are generally parallel but intertwined and united at various points along their length. This is not a disadvantage if the extruded collagen is to be further processed and twisted to form a strand. However, these adhesions that occur as a result of the pressure exerted by the godet on the partially wet monofilaments prevent the manufacture of an open multifilament in which the individual collagen monofilaments are uniformly separated and have both lateral and longitudinal freedom of motion.

It is an object of the present invention therefore to produce an open collagen multifilament comprising a group or bundle of individual spaced collagen monofilaments that do not adhere to one another.

Another object of the present invention is to produce an open collagen multifilament comprising a plurality of collagen monofilaments each of which possess freedom of movement with respect to all other monofilaments that make up the multifilament.

A further object of the present invention is to manufacture a collagen multifilament suitable for weaving, knitting or braiding into porous collagen fabrics and tubes for surgical repairs.

It has now been discovered that the adhesive bonds found between the individual collagen monofilaments can be disrupted and the multifilaments recovered in essentially the same form in which it leaves the spinnerette surface by isolating a section of the dryed bundle of adhered monofilaments between two points and imparting thereto a variable tension in a direction parallel to the longitudinal axis of the bundle. Since it is important to avoid breaking any of the collagen monofilaments, the applied tension must at no time exceed the elastic limit of the monofilaments.

The invention will appear more clearly from the full detailed description when taken in connection with the accompanying drawing, showing by way of example a preferred embodiment of the inventive idea.

Referring now to the drawing the dry collagen semi-bonded multifilament is supplied from the creel spool **2** to a driven godet **3** and is wrapped around an idler godet **4** three or more times to prevent slippage. The semi-bonded multifilament from the godet **3** passes over the fixed guide pulley **5** and is converted to an open multifilament between this pulley and the fixed guide pulley **9**. Between the pulleys **5** and **9** the collagen is laced over the bar **6**, under the bar **7** and over the bar **8**. From the guide pulley **9** the open collagen multifilament returns to the godets **3** and **4**. Three wraps around these godets are sufficient to prevent slipping. The open collagen multifilament from the godet **3** contacts the traverse rod **10** and is guided onto the take-up spool **11**.

The three bars **6**, **7** and **8** that frictionally engage the collagen tape may be made of porcelain and are mounted on a movable carrier **12** supported by the reciprocating rod **13**. Rod **13** is supported by the bearings **17** and **18** and is moved in the direction indicated by the arrow by the connecting rod **14** and wheel **15** keyed to axle **16**. The axle **16** and wheel **15** may be rotated by a motor, not shown.

It will be understood that the foregoing general description is exemplary and explanatory but does not restrict the invention. The process for manufacturing an open collagen multifilament may be more fully understood from the following description and example.

Fifteen hundred parts of tendon slices are cleaned and sliced to a thickness of 23 mils and treated with 15,000 parts of an aqueous solution containing 15 parts (0.1%) of ficin, 3.63 parts of disodium ethylenediamine tetraacetic acid and 1.95 parts of ethylenediamine tetrasodium tetraacetic acid. The tendon slices, prior to enzyme treat-

ment, analyze 36.9% solids. After standing for 17 hours at room temperature, the enzyme solution is decanted and a swelling solution containing 50 parts of 30% hydrogen peroxide solution in 15,000 parts of water is added to the slices. The solution is decanted from the tendon slices after 30 minutes and the slices are rinsed with water. The weight of the water of hydration amounts to 5890.5 parts.

A swelling solution is prepared by adding 235.2 parts (2.76 mols) of cyanoacetic acid to a mixture of 30,473 parts of methanol and 24,576 parts of water and stirring. The enzyme treated slices are added to the acid solution in the dispersion kettle and agitated for 1 hour at 60 r.p.m. This dispersion is calculated to contain 0.9% collagen, 0.38% cyanoacetic acid, and equal amounts of water and methanol.

The dispersion is homogenized by repeated passes through a ½-inch pipe. It is then pumped through a ⅛-inch jet and the dispersion is next circulated through a 60-mil jet for about 15 minutes, finally passing through a leaf filter containing 15-, 9- and 5.5-mil screens.

The deaerated dispersion contains 0.86% collagen solids. This dispersion of swollen solvated collage fibrils is extruded through a spinnerette having 18 orifices into a dehydrating bath. The semi-bonded collagen multifilament so obtained is tanned with chromium, stretched, and dried. The dried semi-bonded multifilament, 180 denier, is placed in the creeling position. The semi-bonded multifilament is laced to the driven godet **3**, around the freely rotating pulley **5**, through the reciprocating guide bars **6**, **7**, and **8**, under another freely rotating pulley **9**, around the godet **3** a second time and to the collection spool **11**.

The feed rate of the semi-bonded multifilament is three feet per minute and the reciprocating block **12** moves at the rate of 168 cycles per minute. The collagen multifilament collected at the take-up spool was uniformly opened throughout the entire length of the doff.

If an untanned collagen multifilament is desired, the tanning step described in the example may be omitted.

What is claimed is:

1. A method of separating adhering collagen monofilaments to form an open multifilament which comprises moving a group of parallel and adherent monofilaments over a plurality of offset guides at a predetermined speed between two fixed points while reciprocating said guides in a direction parallel to the motion of the monofilaments; whereby a variable tension is imparted to the adhering collagen monofilaments between fixed points in a direction parallel to said monofilaments.

2. A method of manufacturing an open collagen multifilament which comprises subjecting semibonded collagen multifilaments to frictional surface contact with a reciprocating surface while simultaneously advancing said multifilament in a direction parallel to the reciprocating motion and periodically relaxing and applying tension to said multifilament whereby the monofilaments are spread apart transversely to the direction of advance thereof.

3. Apparatus for breaking lateral adhesions that exist in a bundle of adjacent collagen monofilaments comprising two fixed spaced guides and a plurality of movable guides aligned to contact and exert pressure on the bundle of monofilaments as it travels between the fixed guides, means to move the bundle of monofilaments between the fixed guides at a constant rate of speed and means to reciprocate the movable guides in a direction parallel to the direction of travel of the bundle of multifilaments.

4. Apparatus for breaking lateral adhesions that exist in a bundle of adjacent collagen monofilaments comprising two fixed spaced and rotating roller elements, a plurality of offset guides aligned to contact and exert pressure on the bundle of monofilaments as it travels between the roller elements, means to move the bundle of monofilaments between the roller elements at a constant rate of speed, and means to reciprocate the offset guides in a direction parallel to the direction of travel of the bundle of multifilaments.

5. Apparatus for opening continuous semi-bonded collagen multifilament comprising a first fixed guide, a reciprocating member and a second fixed guide, means for advancing multifilament in a path which is contiguous to a surface of each of said guides and said reciprocating member, and means for moving said reciprocating member parallel to said multifilament path in a reciprocating straight line path.

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