

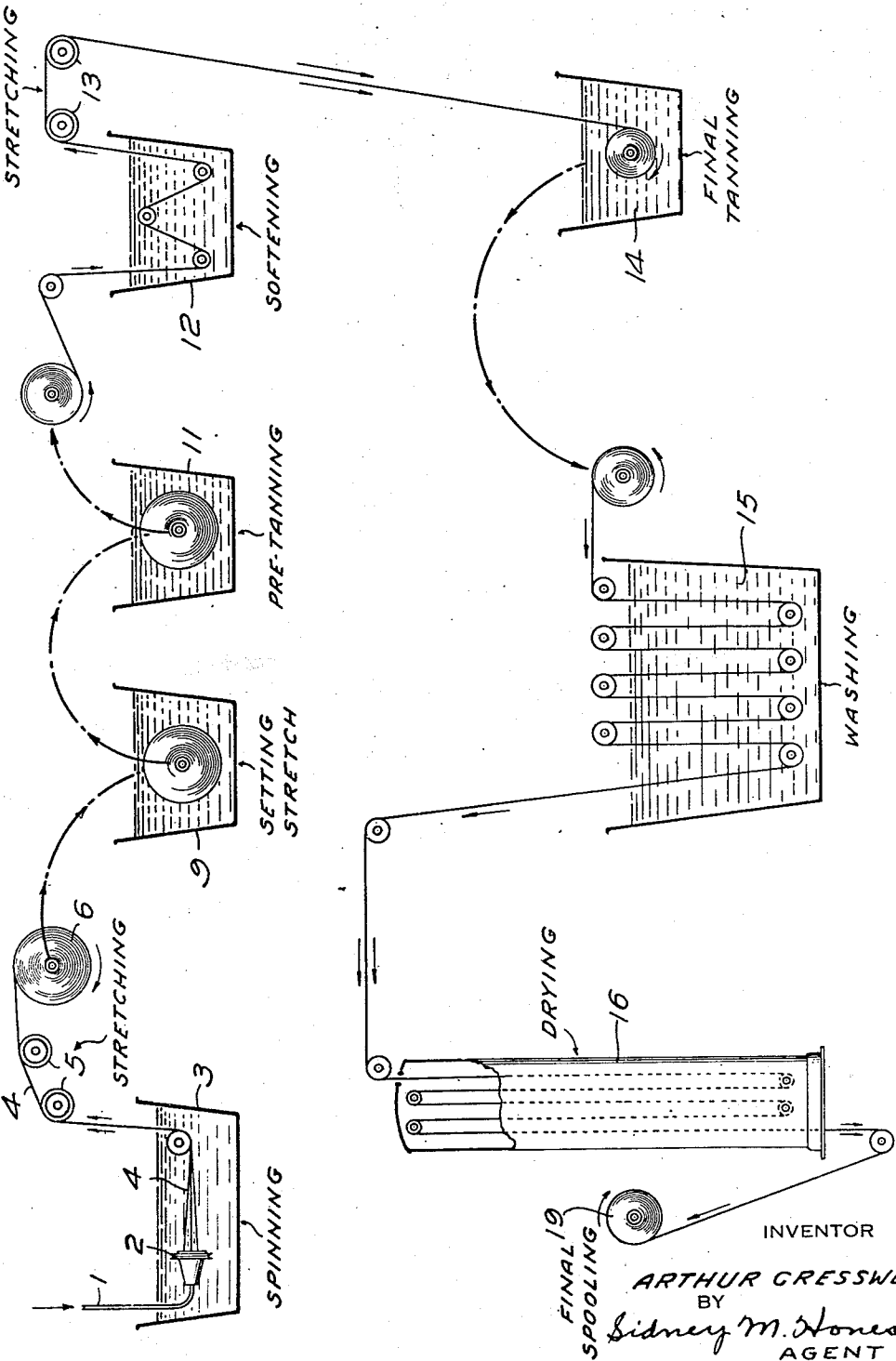
July 12, 1949.

A. CRESSWELL

2,475,697

TREATMENT OF COLLAGEN STRANDS

Filed April 19, 1946



INVENTOR
ARTHUR CRESSWELL
BY
Sidney M. Honea
AGENT

UNITED STATES PATENT OFFICE

2,475,697

TREATMENT OF COLLAGEN STRANDS

Arthur Cresswell, Stamford, Conn., assignor to
American Cyanamid Company, New York,
N. Y., a corporation of Maine

Application April 19, 1946, Serial No. 663,599

7 Claims. (Cl. 18—54)

1

The present invention relates to the manufacture of collagen filaments, threads, strands, tapes and the like and more particularly to an improved process for such manufacture.

Such threads, filaments, strands, tapes and the like are hereinafter referred to as "strands" for convenience of discussion and may be single or multi-filament. Such multi-filament strands may result from the conventional processing step of twisting together a number of smaller filaments. Conversely, a substantially unitary strand may result from twisting together a number of smaller filaments when sufficiently wet and untanned to permit a coalescence or cohesive action to occur.

The manufacture of the collagen strands of the present invention provides a suture material which, being absorbable, is particularly useful for deep sutures, possessing distinct advantage over such materials available in the past. The gut sutures commonly used heretofore have a decided disadvantage in that it is extremely difficult to guarantee freedom from germs or other micro-organisms. Further, gut sutures are of non-uniform thickness and tensile strength and of only limited length, the latter being determined by the length of the intestine material processed. Gelatine sutures have been proposed as being sterile, of uniform quality and unlimited length but such sutures are too low in tensile strength to be suitable. The collagen strands produced by the improved process of the present invention are sterile, of unlimited length, uniform throughout such length as to thickness, tensile strength and capacity for chemical or heat sterilization and of sufficiently high tensile strength to provide substantial elimination of all of the difficulties experienced heretofore.

Collagen strands are prepared by extruding liquified collagen such as a paste, suspension, or solution of collagenous material into a coagulating solution or spinning bath. Such collagen strands are thereafter removed from the spinning bath generally by spooling, employing a godet by which a predetermined, uniform tension is applied to the strands. Such tension serves to orient the material composing the strand in a longitudinal direction and result in increasing the tensile strength of the strand. The stretch imparted at this time is the maximum allowable being just safely below the breaking point of the strands. Thereafter the collagen strands may be treated by prolonged contact with coagulating solution, most conveniently the same as that employed in the spinning bath to set them in their stretched

2

condition and minimize or eliminate retraction upon removal of tension. The strands may also be tanned by treating with solutions of the conventional tanning agents such as the tannins, other vegetable tanning agents, pyrogallol, formaldehyde, and ferric, aluminum and chromic salts. Of these the chromic salts, formaldehyde, and ferric and aluminum salts are by far the preferred agents, being preferred in the order given. In keeping with the practices employed in the spinning of other artificial filaments, strands, threads and the like, it would be desirable that a further stretch be imparted to the collagen strands after the first stretch has been set. Such additional stretching is desirable to further increase the degree of orientation in the strand and result in increased tensile strength in the final product. However, the stretch imparted at the time of spinning has always heretofore appeared to be the only one allowable, attempts to stretch further being found to result in very little stretch and a high occurrence of breakage.

It has now been discovered that an additional stretch may be imparted to the collagen strands if they are first treated with a relatively dilute solution of a tanning agent such as those aforementioned. Treatment with such dilute solution of tanning agent sufficiently increases the wet tensile strength of the already stretched and set strand that an additional stretch may be imparted. Further, such treatment with a dilute solution of a tanning agent, hereinafter sometimes referred to as pretanning, eliminates a tendency on the part of the strands to coalesce when wet so that such tanning treatment also provides for easier handling.

Accordingly, the process of the present invention comprises subjecting the formed collagen strands to the light tanning action of a dilute solution of a tanning agent such as a chromic salt, a ferric salt, formaldehyde and the like and thereafter treating such strands with water or aqueous solution to sufficiently soften the strands so that a stretch may be imparted to the pretanned collagen strand, stretching said strand and setting said stretch by treatment with a more concentrated solution of tanning agent or, as before, by treatment with a solution of coagulating agent, thereafter washing the strand and drying. If desired, a series of such pretanning treatments may be employed before final tanning, imparting a stretch after each of such treatments, the extensibility of the strands decreasing as the concentration of the tanning agent and/or the time of the pretanning treatment is increased.

3

While any of numerous tanning agents may be employed including those aforementioned, it has been found that particularly good results are obtained with chromic salts and still more particularly with chromic sulfate. Chromic sulfate solution is employed at a pH of substantially 2-5. In this pH range chromic sulfate is considered to be a basic chromic sulfate. It is preferred to employ chromic sulfate having about half of the sulfate groups replaced by hydroxyl groups. The concentration of the chromic sulfate or other chromic salt employed in the pretanning step should be within a range equivalent to 0.01-0.50% Cr_2O_3 , the preferred concentration being one equivalent to 0.05% Cr_2O_3 at which concentration a pH of 4.8 prevails. The concentration of chromic salt employed in the final tanning treatment is much higher being within a range equivalent to 1.0-10% Cr_2O_3 , an amount equivalent to 22.5% Cr_2O_3 being preferred at which concentration a pH of 3.8 obtains. The temperature employed in such tanning treatments is of the order of 20-30° C.

Other tanning agents are employed at pH values more suitably adapted to their use and in concentrations dependent upon the particular agent employed, but it will be generally found that the ratio of the concentration in the pretanning bath will be substantially in the same order as that disclosed above for chromic salts. In the case of formaldehyde, about a 5% solution is required to effect suitable final tanning, a proportionately dilute solution being suitable for pretanning. On the other hand, the concentration of the solution employed in pretanning is not particularly critical, especially if approached from the under side.

Preferably, such tanning agent is employed in a solution containing a sufficiently high concentration of a coagulating agent to minimize any tendency of the strand to swell during the tanning treatment and likewise the subsequent treatment with water or aqueous solution to wash the tanning agent from the strand and somewhat soften said strand for stretching is preferably carried out employing a coagulating agent. While organic coagulating agents such as water soluble ketones, alcohols, ethers and the like can be employed with success in preventing swelling it has been found particularly suitable to employ inorganic salt coagulants such as sodium, magnesium and ammonium sulfate and the like for this purpose. In preventing swelling during pretanning the solutions are preferably substantially saturated with respect to such coagulating compounds whereas lower concentrations, of the order of 10%, are employed for the same purpose in the final tanning solution. In preventing swelling while softening prior to stretching, however, such coagulating agent is employed in lower concentration, 15-25% being the range of concentration for the aforementioned sulfates, 20% being the optimum concentration with the small diameter suture strands to which the process of the present invention is particularly directed.

The degree of stretch to which the tanned suture strands may be subjected after such pretanning is such that the strands are increased in length substantially 15-40%. It is preferred to operate with an applied tension such that the increase is within the range of 20-25%. However, any suitable degree of stretch may be applied depending upon the diameter of the strands, the quality of the collagen, the purposes to which the strands are to be put and the like.

4

A detailed example of the preferred embodiment of the present invention follows:

A collagen solution is prepared by treating the cleaned corium of hide or skin material with a solution of organic acid at a pH in the range of 2-4 for about 16-24 hours at 10-30° C. Following the swelling, the material is mechanically subdivided in various types of apparatus ranging from a meat grinder to a colloid mill. Final solution is obtained by adjusting the pH to 2-4 by the addition of organic acid, filtration being employed after these operations to remove any remaining fibers. Such a solution free from fibers or fibrous material may be extruded through small orifices and formed into very fine filaments of exceptional uniformity and purity to render them especially adaptable for use as sutures.

Said collagen solution is of 5-15% collagen content, preferably 9%, and is introduced at 1 to be extruded through a spinnerette 2 having orifices of from 50 microns to 1 mm. Such orifices are preferably from 70 to 250 microns in diameter when suture material is to be prepared from the above 9% solution. The collagen is extruded into a concentrated solution of ammonium sulfate 3 containing at least 35% of the salt maintained at a pH of 7.8, and at a temperature of 20-30° C. In working with acidic collagen solutions the addition of base is required to maintain the desired pH in the spinning bath.

Any suitable coagulant may be employed, although ammonium sulfate is preferred because of its high solubility (about 42%) and low cost. Generally, this coagulant is employed at a concentration of at least 35%. Sodium sulfate and magnesium sulfate can likewise be employed but being considerably less soluble are less effective. Various organic compounds have been suggested, such as ethyl alcohol, acetone, ethylene glycol mono ethyl ether, diacetone alcohol and the like. However, such expensive organic compounds possess no appreciable advantage over the less expensive inorganic salts.

The strands 4 are removed from the coagulating solution or spinning bath 3 by spooling, and preferably a stretch is imparted by passing such strands over a plurality of revolving wheels 5, called godets, which have increasing peripheral speeds so that a tension is applied to the strands before or while they are wound on spool 6. In spinning suture material it has been found advisable to impart a 100% stretch to the strands, although stretching the strands as much as 700% can be employed if desired with larger diameter strands. Satisfactory strands have been spun in this way from a spinnerette with orifices measuring 110 microns in diameter at the rate of 80 meters/min.

The diameter of the strands is dependent upon the concentration of the collagen in the solution being extruded, the rate with which said solution is extruded and the rate of spooling. Preferably, the collagen concentration remains substantially constant at 9-10% and variation in strand diameter is obtained by changing one or all of the other of the aforementioned variables.

Generally, a lubricant is employed in the spinning of the collagen strands to prevent coalescence on gathering them together in the course of spooling. Such lubrication is best provided at the time of spinning and spooling and may be done by emulsifying a lubricant such as a fatty oil in the spinning or coagulating bath. Without such lubrication the wet filaments on being

spooled from the spinning bath tend to coalesce to a substantially unitary strand particularly if forced together under the stress developed during stretching.

After the strands have been spooled, it is preferable to leave them in contact with a coagulating solution 9 for a period of time, such coagulating bath being most conveniently of the same composition as that used in the spinning bath and such period of contact being any convenient period. A contact period in excess of 24 hours serves no useful purpose, however, in that further shrinking does not result. On the other hand this treatment may be dispensed with if desired without imposing undue difficulty on subsequent handling.

Thereafter the spooled strands are pretanned with a dilute solution of chromic sulfate 11 containing the equivalent of 0.05% Cr_2O_3 , at pH 4.8 for a period of about 24 hours. Such pretanning solution contains 35%, or more, of ammonium sulfate which is employed to prevent swelling during the pretanning treatment.

At this concentration the period of treatment is not very critical but should not be less than 12 hours or more than 36 hours if tanning is to result on the one hand and overtanning is to be avoided on the other hand. The optimum period of treatment varies from 2-3 hours at a concentration equivalent to 0.5% Cr_2O_3 , to 48 hours at 0.01% Cr_2O_3 . At the higher chromic sulfate concentrations the period of treatment employed becomes considerably more critical requiring closer attention. This consideration is largely responsible for the preferability of operating at 0.05% Cr_2O_3 . Such pretanning is conveniently effected by pumping the solution through and between the spooled strands, although other methods of manipulation may be employed, care being taken to prevent breakage of the strands and provide uniform contacting of the surface of such strands.

After such pretanning the strands are treated with water or aqueous solution 12 to soften them sufficiently so that a stretch may be imparted. Such softening should be carefully controlled to provide a maximum stretch while still avoiding breakage. While water or any aqueous solution may be employed, provided it is not a solution of tanning agent, it is preferred to use a solution containing a coagulant as aforementioned, 20% being the preferred concentration for such inorganic salt coagulants as ammonium, sodium and magnesium sulfate. The strands are thereafter stretched with the aid of godets 13, the degree of stretch imparted being from 15 to 40%, preferably from 20 to 25% in the case of the strands prepared under the conditions presently outlined, although other degrees of stretch may be used with other collagen strands.

Thereafter such stretched strands are given a final tanning in a solution 14 containing chromic sulfate equivalent to 2.5% Cr_2O_3 at a pH of 3.8, said solution containing about 10% of sodium sulfate. The final tanning treatment likewise requires a period of about 24 hours although here too, as with pretanning, a shorter or longer period can be employed.

Adhering salts or other treating materials may then be washed from the strands by passing the same in contact with water 15 at a temperature of about 20-30° C. Such washed strands may then be dried in drying chamber 16 in air heated from room temperature to 60° C. However, the lower the temperature the less the chance of dam-

age occurring in the treated material. The final product is wound on spool 19.

What is claimed is:

1. The process of claim 7 in which the tanning and softening solutions contain substantial proportions of a coagulating material.

2. In the processing of a collagen strand, the steps comprising pretanning such a strand with an aqueous solution containing chromic sulfate equivalent to 0.01-0.50% Cr_2O_3 and substantially saturated with ammonium sulfate at a pH of 2-5, treating said pretanned strand with water containing substantially 20% ammonium sulfate to soften said strand and permit a stretch to be imparted, stretching said strand, finally tanning said stretched strand with an aqueous solution containing chromic sulfate equivalent to 1.0-10.0% Cr_2O_3 and containing substantially 10% of sodium sulfate at a pH of 2-5, washing said strand to remove said salts and drying said strand.

3. The method of claim 2 in which the strand is pretanned with a solution containing chromic sulfate equivalent to substantially 0.05% Cr_2O_3 at a pH of 4.8 and finally tanned with a solution containing chromic sulfate equivalent to substantially 2.5% Cr_2O_3 at a pH of 3.8, both treatments continuing for substantially 24 hours.

4. An improved method of making a collagenous strand which comprises extruding collagenous material into a coagulating bath, removing the coagulated strand therefrom under sufficient tension to impart a stretch to said strand, pretanning said strand with a solution containing chromic sulfate equivalent to 0.01-0.50% Cr_2O_3 and substantially saturated with ammonium sulfate at a pH of 2-5, treating said lightly tanned strand with water containing substantially 20% ammonium sulfate to soften said strand and permit a stretch to be imparted, stretching said strand, finally tanning said stretched strand with a solution containing chromic sulfate equivalent to 1.0-10.0% Cr_2O_3 and substantially saturated with ammonium sulfate at a pH of 2-5, washing said strand to remove said salts and drying said strand.

5. An improved method of making a collagenous strand which comprises extruding collagenous material into a coagulating bath, removing the coagulated strand therefrom under sufficient tension to impart a stretch to said strand, treating said strand with a solution of coagulant to set said stretch, pretanning said strand with a solution containing chromic sulfate equivalent to 0.01-0.50% Cr_2O_3 and substantially saturated with ammonium sulfate at a pH of 2-5, treating said lightly tanned strand with water containing substantially 20% ammonium sulfate to soften said strand and permit a stretch to be imparted, stretching said strand, finally tanning said stretched strand with a solution containing chromic sulfate equivalent to 1.0-10.0% Cr_2O_3 and substantially saturated with ammonium sulfate at a pH of 2-5, washing said strand to remove said salts and drying said strand.

6. The method of claim 5 in which the strand is pretanned with a solution containing chromic sulfate equivalent to substantially 0.05% Cr_2O_3 at a pH of 4.8 and finally tanned with a solution containing chromic sulfate equivalent to substantially 2.5% Cr_2O_3 at a pH of 3.8, both treatments continuing for substantially 24 hours.

7. In the processing of a collagen strand, the

steps comprising pretanning such a strand with an aqueous solution containing chromic sulfate equivalent to 0.01-0.50% Cr_2O_3 and having a pH of 2-5, softening said pretanned strand with water, stretching said strand, and finally tanning said stretched strand with an aqueous solution containing chromic sulfate equivalent to 1.0-10.0% Cr_2O_3 and having a pH of 2-5.

ARTHUR CRESSWELL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,039,262	Shulte	Apr. 28, 1936
2,046,320	Burbank	July 7, 1936
2,103,163	Lange	Dec. 21, 1937
2,120,851	Becker et al.	June 14, 1938
2,266,672	Wormell	Dec. 16, 1941
2,290,789	Wormell	July 21, 1942
2,338,915	Ferretti	Jan. 11, 1944
2,404,665	Signer	July 23, 1946

OTHER REFERENCES

Ser. No. 313,138, Frendenberg (A. P. C.) pub. Apr. 27, 1943.