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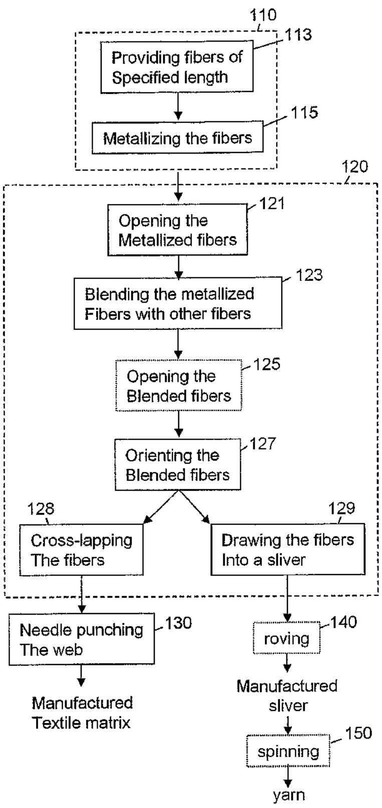
(54) Title: PROCESS FOR CREATING SPUN YARN



(57) Abstract: Input fibers to be used for the manufacture of textile components are cut to a proper length [113]. The fibers are metallized [115] with silver and copper. The metallized fibers are opened [121] and blended [123] with other fibers. The blended fibers are preferably opened again [125]. Then the blended fibers are oriented [127] and drawn [129] into a sliver. Roving [140] may be applied to the sliver to condense the fibers. The length of the fibers, the denier of the fibers, the amount of metal coating and composition of the metal coating are selected to provide an optimum amount of metal ion discharge to have the proper antimicrobial properties, while optimizing wound healing properties, and minimizing manufacturing costs.

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PROCESS FOR CREATING SPUN YARN

Cross Reference to Related Applications

This application is related to, and claims priority from U.S. Patent Application 10/938,868 "Process for Creating Spun Yarn" filed May 10, 2005, and hereby incorporates by reference this application as set forth in its entirety herein.

1. Field of the Invention

The present invention relates to an antimicrobial, absorbent yarn textile matrix fostering a moist wound-healing environment which minimizes or eliminates the possibility of infection, and is especially useful as a component of a wound dressing.

Background of the Invention

Silver has been used as an antimicrobial since ancient times. It has been used to stop bacterial infections. Recent years have seen a renewed interest in silver. This renewed interest is driven in part by the development of antibiotic-resistant bacteria, such as methicillin-resistant *Staphylococcus aureus* (MRSA). Conventional antibiotics have little or no effect on these resistant bacteria. Resistant bacteria are especially problematic in wounds, causing infections, destroying tissue, delaying the healing process and causing unpleasant odors. Silver is a broad-spectrum antibiotic that is effective against such resistant bacteria. Even though these bacteria develop resistance to antibiotics, they do not develop resistance to silver. There is a current need for an antibiotic wound care product that uses silver to treat and/or prevent MRSA and other infections caused by resistant bacteria.

Silver is also known to exhibit wound-healing properties. Expeditious wound healing benefits the patient by providing increased comfort and decreased susceptibility to further infection and secondary injury. There is a current need for wound care products that utilize silver to increase the rate of wound healing.

Many presently existing antimicrobial wound care products have been used to treat infections, however, these lose their effectiveness in a short period of time. This is especially true for wound care products that contain silver in an ionic form. Ionic silver is readily dissolved in an aqueous environment and dissipated. Such dressings must be replaced frequently often resulting in extreme pain or discomfort and inconvenience for the patient as the dressing is removed and a new dressing is applied.

Similarly, silver creams (including silver sulfadiazine) must be consistently reapplied to the injured area, and the dressing must be removed for reapplication of the cream. There is currently a need for a wound care product that releases silver ions over an extended period of time and which alleviates the need for frequent removal or replacement of the dressing or application of silver creams.

Silver may be commonly applied in ionic form as a silver salt. Such salts can be irritating to the skin. Moreover, prolonged contact with silver salts can cause argyria, which is characterized by a pronounced, permanent ashen-gray skin discoloration, which can be localized or universal. There currently is a need for a non-irritating silver wound care product that does not rely on silver salts for the delivery of silver ions. There is also a current need for an ionic silver wound care product that does not cause argyria.

Metallic silver is a costly substance. Silver wound care products that use too much silver would be unduly expensive and wasteful. On the other hand, silver wound care products that use too little silver would be ineffective. There currently is a need for a silver wound care product that enables the delivery of an optimal dosage of silver to the wound area.

Silver is known to affect the operation of matrix metalloproteinases (MMPs). Excessive MMPs are known to interfere with and slow the wound healing process. Existing silver-based wound care products inhibit MMPs too much, and also interfere with the wound healing process. There is currently a need for a silver wound care product that delivers a proper amount of silver, which limits the activity of MMPs without unduly restricting MMP activity.

Other existing silver-based wound care products are made from silver-plated films with limited flexibility. These dramatically reduce the flexibility and comfort of the bandages. Textile bandages are much more flexible and hence, much more comfortable for patients. There is currently a need for a silver-based wound care product that is more flexible and comfortable.

Summary of the Invention

The present invention may be embodied as a method of manufacturing a textile matrix having improved anti-microbial properties comprising the steps of:

a) preparing input fibers [110], the preparation includes the following substeps:

i. providing input fibers [113] with a predetermined length range, and
ii. metalizing the input fibers [115];

b) carding the metallized fibers [120] by the following sub-steps:

i. opening the metallized fibers [121] to separate the individual fibers from each other,
ii. blending the metallized fibers [123] with other fibers,
iii. orienting the blended fibers [127] in generally the same direction to create a web, and
iv. cross-lapping the fibers [128] of the web.

The present invention may also be embodied as a method of manufacturing textile components from an input fiber having improved anti-microbial properties comprising the steps of:

a) preparing input fibers [110], the preparation includes the following substeps:

i. providing input fibers [113] with a predetermined length range, and

ii. metallizing the input fibers [115];

b) carding the metallized fibers [120] by the following sub-steps:

i. opening the metallized fibers [121] to separate the individual fibers from each other,

ii. blending the metallized fibers [123] with other fibers,

iii. orienting the blended fibers [127] in generally the same direction to create a web, and

iv. drawing the web [129] to create a sliver having fibers with antimicrobial properties.

Objects of the Invention

It is another object of the present invention to provide a wound care product which employs silver metallized yarn capable of releasing ionic silver to inhibit infections and facilitate wound healing.

It is another object of the present invention to provide a wound care product which is capable of releasing ionic silver, copper and zinc ions over an extended period of time without the use of irritating metal salts.

It is another object of the present invention to provide a wound care product which is capable of releasing ionic silver which does not cause argyria.

It is another object of the present invention to provide a wound care product which maintains a moist wound-healing environment while preventing the growth of bacteria and fungi.

It is another object of the present invention to provide a wound care product which retains a moist wound environment, but eliminates unpleasant odors.

It is another object of the present invention to provide an anti-bacterial, and anti-fungal metallized yarn which employs a large surface area for discharge of metal ions.

It is another object of the present invention to provide an anti-bacterial, and anti-fungal metallized yarn in which the metal ions do not become detached from the yarn substrate.

It is another object of the present invention to provide a wound care product which enables the delivery of an optimal dosage of silver ion.

It is another object of the present invention to provide a wound care product which delivers a predetermined rate of silver release, which limits MMP activity to a level roughly associated with optimum wound healing.

It is another object of the present invention to provide an anti-bacterial, and anti-fungal metallized yarn which can be used in applications including hosiery and other knit-wear.

It is another object of the present invention to provide an anti-bacterial, and anti-fungal metallized yarn which is easy and inexpensive to manufacture.

It is another object of the present invention to provide a combination of silver metallized and copper metallized yarn to create wound care products which treat and/or prevent resistant bacterial infections such as MRSA and fungal infections.

Brief Description of the Drawings:

A complete understanding of the present invention may be obtained by reference to the accompanying drawing, when considered in conjunction with the subsequent detailed description, in which:

FIG. 1 is a flowchart showing one embodiment of a process for creating textile components according to the present invention.

Detailed Description of the Preferred Embodiment:

One embodiment of the present invention is a novel antibiotic textile matrix made of a metallized yarn having absorptive properties that are especially useful in wound care products, such as wound dressings.

Metallized Fibers

The textile matrix of the invention includes silver coated fibers. The silver coated fibers may be manufactured as described in U.S. Patent U.S. Patent 4,042,737, entitled "Process For Producing Crimped Metal-Coated Filamentary Materials, And Yarns And Fabrics Obtained Therefrom," issued to Rohm and Haas Company (Philadelphia, PA), on August 16, 1977, hereby incorporated by reference as if set forth in its entirety herein. Similar fibers are commercially available from Noble Fiber Technologies sold under the tradename X-static®.

Copper has been known and proven to be a very effective anti-fungal agent and also has other anti-microbial properties. It is also very ductile and can be used to metallize a surface of a textile substrate. The combination of silver with copper is very effective in providing not only anti-bacterial, but also anti-fungal properties.

Silver-coated fibers, such as the X-Static® product, can be copper coated using conventional electrodeless copper chemistry. Zinc-coated fibers can also be incorporated into the textile matrix.

In addition to providing an antimicrobial effect, the addition of the metallized fibers also reduce physical adherence of the dressing to the wound site.

This reduced physical adherence reduces the amount that a wound dressing sticks to, and pulls on the wound and making the dressing more comfortable to wear. The reduced adherence also decreases pain and discomfort when the dressing is removed or replaced.

The preferred substrate of the silver-coated fiber is nylon. The following table describes the preferred characteristics of the metallized fibers:

	Length (cm)	**Denier (dpf)**	**Silver/Copper (% w/w)**
Outside range	½ - 8	0.5 - 50	3% - 75%
Intermediate range	¼ - 6	0.7 - 30	9% - 60%
Optimal range	1 - 3	1 - 10	12% - 30%
Ideal	~2	~3	~21

Using fibers having the length, denier per fiber and silver to copper ratio, the optimum ion release is obtained to prevent infections and optimizes healing.

Composition of the Textile Matrix

The textile matrix of the present invention is spun yarn using fibers of the length, denier per fiber and silver to copper ratio as specified in the table above.

The desirable antimicrobial properties and efficacy of the textile matrix are determined using the Dow Corning Shake Flask Test over 24 hours of the **New NY State** 63 Test for Bacteriostatic Activity. Other tests included, but are not limited to ASTM E-2149 for a time period ranging from 10 minutes to 7 days. Preferably the kill rate is not less than about 70%. More preferably the kill rate is not less than about 85%, and ideally the kill rate is not less than about 95%.

The present invention can also be used for other applications such as being woven into material for odor prevention, socks for athlete's foot prevention and into bedding liners to kill dust mites, etc.

Method of Making

Manufacturing the textile matrix involves preparing the input fiber, carding the fiber (includes sub-steps: opening the silver-coated fiber, blending and orienting the fiber, cross-lapping the fiber) and optionally, needle punching the web.

Manufacturing a sliver involves preparing the input fiber, carding the fiber (includes sub-steps: opening the silver-coated fiber, blending and orienting the fiber, drawing the fiber) and optionally roving to further condense the fiber.

Each of these steps is described in the ensuing text.

<u>MANUFACTURING</u>

Referring now to FIG. 1, the steps of the manufacturing process according to one embodiment of the present invention are shown.

1. Preparing the input fiber

In step 110, the metal coated fiber is prepared. One such method is that described in U.S. Patent 4,042,737, referenced above.

In step 113, the metallized fiber is preferably manufactured in the form of a continuous filament and then cut into short segments having lengths as described above. The inventors have surprisingly discovered that by using cut yarn, rather than staple fiber, the properties of the final product are dramatically improved. In step 115 the fibers are significantly easier to metallize in the manufacturing process because there is less clumping (adhesion to itself) of fibers. The inventors believe that this improvement is facilitated by the general axial alignment of the fibers after they are cut, relative to the random orientation of the fibers that result from coating staple product. Another factor that helps prevent clumping is the manufacture of the short fibers from long fibers after aqueous processing, as opposed to processing short (staple) fibers and allowing them to dry together.

Copper-coated yarn is prepared by using commercially available copper chemistry applied to silver-coated fibers.

2. Carding

In step 120, carding is accomplished using a traditional carding process. A preferred carding machine is the Bematic card, manufactured by Bettarinj & Serafirij Sarl. (Prato, Italy).

Carding blends the fibers together and orients them in generally the same direction, i.e., generally parallel. Carding includes the following sub-steps:

2a. Opening the silver-coated fiber with or without Copper-coated fibers

In step 121, the metallized fibers are opened. When the silver-coated fiber is processed wet and subsequently dried, it clumps together (though not to the same extent as staple fiber that is processed and then dried). The fiber is opened, to separate the individual staple fibers from each other to enable it to be blended with the alginate.

2b. Blending and orienting the fibers

The silver-coated fiber and the absorbent fiber are then blended in step 123 and oriented in step 127 to create a web.

Optionally, the blended fibers may be opened in step 125.

2c. Drawing the fiber

In step 129, the output of above steps is drawn to create a sliver having absorbent and antimicrobial properties.

3. Roving to further condense the fiber (optional)

To further condense the fiber, the sliver may optionally be put through a roving process in step 140.

4. Spinning

In step 150 the manufactured sliver is spun onto a bobbin to be knit, woven, etc. in a traditional textile operation.

Optionally, the step of cross-lapping the fiber, step 128 and needle punching the web, step 130 may be employed as is known in the prior art to result in a textile matrix.

Method of Using

The end result will result in textile components used in making clothing and wound care products with optimum metal ion release and superior anti-odor, anti-static, anti-microbial, hydrodynamic, thermodynamic properties.

The percentage of metallized fiber, such as the X-Static® product used in the textiles typically range from 2% to 25% by weight, but overall from 1% to 75% of the spun yarn by weight.

Example

Three textile matrix samples were manufactured according to the foregoing procedure with varying amounts of silver thread and cotton blend (10/90, and 50/50).

The matrix was tested for antimicrobial activity and absorbance using the NY State 63 Test for Bacteriostatic Activity. Five (5) 1" inch squares of the textile matrix were used as samples.

Ten bottom sections of 35 X 10 mm disposable tissue culture dishes were placed in standard petri dishes containing 10 ml of sterile distilled water. 0.2 ml of a 24 hour broth culture containing 10^5 organisms was placed in the center of each disposable tissue culture dish. The test and control squares were then placed in the disposable tissue culture dishes, with one side in contact with the inoculum. The covers were than replaced on the standard petri dishes. The petri dishes were then placed on a level shelf of an incubator at 37^0 C and incubated for 24 hours. After 24 hours, the samples were removed from the petri dishes by means of a flamed forceps and placed into 100 ml of Letheen broth in an 8 oz. wide mouth jar. The jar was shaken vigorously for about 1 minute. Serial dilutions were made and placed on AATCC bacteriostasis agar. Plates containing the agar were then incubated for 24-48 hours at 37^0 C. The percentage reduction of inoculum by samples and controls was calculated.

% Silver	**% Cotton**	**Antimicrobial Activity Kill Rate**
10	90	>99.9%
50	50	>99.9%

Other Fibers

As described in more detail below, the textile matrix may include additional fibers other than the silver-coated fibers and absorptive fibers. Examples include cotton, cellulose, polyester, acrylic and nylon.

Other Therapeutic Agents

The textile matrix of the invention may also include other antibiotics, such as doxycycline or other topical antibiotics. The textile matrix may also include hormone treatments, such as estrogen, to facilitate wound healing. For example, antibiotics and hormones may be used in conjunction with the textile matrix as described in U.S. Patent 5,914,124.

The textile matrix may also include fibers, particles or similar substrates coated with antibiotic (e.g., anti-microbial, anti-bacterial, and/or anti-fungal) metals, such as copper and/or zinc. A preferred combination textile matrix product includes silver-coated fibers and copper-coated fibers.

Another preferred combination textile matrix product includes silver-coated fibers and zinc-coated fibers.

While several presently preferred embodiments of the novel invention have been described in detail herein, many modifications and variations will now become apparent to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and variations as fall within the true spirit of the invention.

Claims

What is claimed is:

1. A method of manufacturing a textile matrix having improved anti-microbial properties comprising the steps of:

   a) preparing input fibers [110], the preparation includes the following substeps:

      i. providing input fibers [113] with a predetermined length range, and
      ii. metalizing the input fibers [115];

   b) carding the metallized fibers [120] by the following sub-steps:

      i. opening the metallized fibers [121] to separate the individual fibers from each other,
      ii. blending the metallized fibers [123] with other fibers,
      iii. orienting the blended fibers [127] in generally the same direction to create a web, and
      iv. cross-lapping the fibers [128] of the web.

2. The method of claim 1 wherein the step of providing input fibers [113] with a predetermined length range comprises the step of:

   providing input fibers [113] generally within the range of ½ - 8cm.

3. The method of claim 1 wherein the step of providing input fibers [113] with a predetermined length range comprises the step of:

   providing input fibers [113] with an average fiber length of ¾ - 6 cm.

4. The method of claim 1 wherein the step of providing input fibers [113] with a predetermined length range comprises the step of:

   providing input fibers [113] with an average fiber length of 1 - 3cm.

5. The method of claim 1 wherein the step of providing input fibers [113] with a predetermined length range comprises the step of:

providing input fibers [113] with an average fiber length of approximately 2 cm.

6. The method of claim 1 wherein the step of metalizing the input fibers [115] comprising the step of:

coating at least a portion of the input fibers with silver and copper at a ratio within the range of 3 - 75% silver to copper by weight.

7. The method of claim 1 wherein the step of metallizing [115] the input fibers comprising the step of:

coating at least a portion of the input fibers with silver and copper at a ratio within the range of 9 - 60% silver to copper by weight.

8. The method of claim 1 wherein the step of metallizing [115] the input fibers comprising the step of:

coating at least a portion of the input fibers with silver and copper at a ratio within the range of 12 - 30% silver to copper by weight.

9. The method of claim 1 wherein the step of metallizing [115] the input fibers comprising the step of:

coating at least a portion of the input fibers with silver and copper at a ratio of approximately 21% silver to copper by weight.

10. The method of claim 1 wherein the step of metallizing [115] the input fibers comprising the step of:

coating at least a portion of the input fibers with zinc.

11. The method of claim 1 wherein the step of blending the metallized fibers [123] with other fibers includes the step of blending the metallized fibers [123] with one or more types of fibers of the group consisting of:

cotton fibers, cellulose fibers, polyester fibers, acrylic fibers and nylon fibers.

12. The method of claim 1 wherein the step of blending the metallized fibers [123] with other fibers includes the step of:

blending the metallized fibers [123] with bio-absorbable materials intended to be dissolved within a living body.

13. The method of claim 1 wherein the step of blending the metallized fibers [123] with other fibers includes the step of:

blending the metallized fibers [123] with other metallized fibers having a different metal composition.

14. The method of claim 11 wherein the bio-absorbable material is an alginate.

15. The method of claim 1 further comprising, after the substep of blending [123], the step of:

opening the blended fibers [125].

16. The method of claim 1, further comprising, after the step of carding [120], the step of:

needle punching the web [130].

17. A method of manufacturing textile components from an input fiber having improved anti-microbial properties comprising the steps of:

a) preparing input fibers [110], the preparation includes the following substeps:

i. providing input fibers [113] with a predetermined length range, and

ii. metallizing the input fibers [115];

b) carding the metallized fibers [120] by the following sub-steps:

i. opening the metallized fibers [121] to separate the individual fibers from each other,

ii. blending the metallized fibers [123] with other fibers,

iii. orienting the blended fibers [127] in generally the same direction to create a web, and

iv. drawing the web [129] to create a sliver having fibers with antimicrobial properties.

18. The method of claim 17 wherein the step of providing input fibers [113] with a predetermined length range comprises the step of:

providing input fibers [113] generally within the range of ½ - 8cm.

19. The method of claim 17 wherein the step of providing input fibers [113] with a predetermined length range comprises the step of:

providing input fibers [113] with an average fiber length of ¾ - 6 cm.

20. The method of claim 17 wherein the step of providing input fibers [113] with a predetermined length range comprises the step of:

providing input fibers [113] with an average fiber length of 1 - 3cm.

21. The method of claim 17 wherein the step of providing input fibers [113] with a predetermined length range comprises the step of:

providing input fibers [113] with an average fiber length of approximately 2 cm.

22. The method of claim 17 wherein the step of metallizing the input fibers [115] comprising the step of:

coating at least a portion of the input fibers with silver and copper at a ratio within the range of 3 - 75% silver to copper by weight.

23. The method of claim 17 wherein the step of metalizing [115] the input fibers comprising the step of:

coating at least a portion of the input fibers with silver and copper at a ratio within the range of 9 - 60% silver to copper by weight.

24. The method of claim 17 wherein the step of metallizing [115] the input fibers comprising the step of:

coating at least a portion of the input fibers with silver and copper at a ratio within the range of 12 - 30% silver to copper by weight.

25. The method of claim 17 wherein the step of metallizing [115] the input fibers comprising the step of:

coating at least a portion of the input fibers with silver and copper at a ratio of approximately 21% silver to copper by weight.

26. The method of claim 17 wherein the step of preparing the fibers [110] comprises the step of:

preparing the fibers [110] to have a denier per fiber in the range of 0.5 – 50 dpf.

27. The method of claim 17 wherein the step of preparing the fibers [110] comprises the step of:

preparing the fibers [110] to have a denier per fiber in the range of 0.7 - 30 dpf.

28. The method of claim 17 wherein the step of preparing the fibers [110] comprises the step of:

preparing the fibers [110] to have a denier per fiber in the range of 1-10 dpf.

29. The method of claim 17 wherein the step of preparing the fibers [110] comprises the step of:

preparing the fibers [110] to have a denier per fiber is approximately 3 dpf.

30. The method of claim 17 wherein the step of blending [123] the metallized fibers with other fibers includes the step of blending [123] the metallized fibers with one or more types of fibers of the group consisting of:

cotton fibers, cellulose fibers, polyester fibers, acrylic fibers and nylon fibers.

31. The method of claim 17, further comprising, after the step of carding [120], the step of:

roving [140] to further condense the fibers.

32. The method of claim 17, further comprising, after the step of drawing [129] the web, the step of:

spinning [150] the sliver into a yarn having antimicrobial properties.

33. The method of claim 17 wherein the textile matrix includes one of the group consisting of:

antibiotics, antifungals, zinc coated fibers, and hormones.

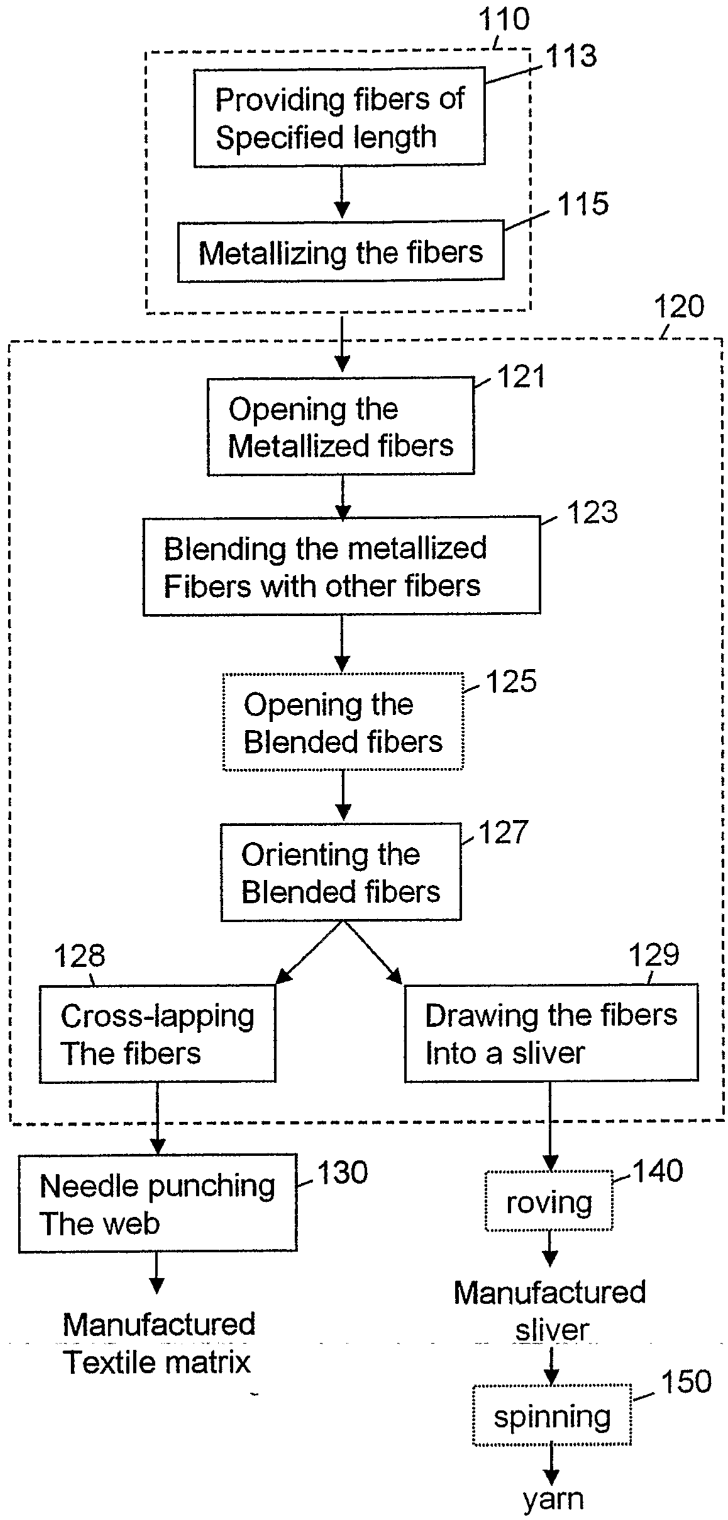
110
113
Providing fibers of Specified length
115
Metallizing the fibers
120
121
Opening the Metallized fibers
123
Blending the metallized Fibers with other fibers
125
Opening the Blended fibers
127
Orienting the Blended fibers
128
Cross-lapping The fibers
129
Drawing the fibers Into a sliver
Needle punching The web
130
Manufactured Textile matrix
roving
140
Manufactured sliver
spinning
150
yarn

FIG. 1