A composite yarn includes an aramid fiber and a second fiber incorporating therein at least one of an antimicrobial and a fire retardant. The second fiber is at least one of wrapped around the aramid fiber and entangled with the aramid fiber.
ANTIMICROBIAL FIRE-RETARDANT YARN AND METHOD OF MANUFACTURING SAME

FIELD OF THE INVENTION

[0001] The present invention relates to yarns, and more particularly to yarns for use in body supports.

BACKGROUND OF THE INVENTION

[0002] Safety concerns and regulatory requirements dictate that many textile-laden products, such as body supports or bedding, should exhibit fire-retardant and/or antimicrobial properties. The textile fibers and yarns used in making such products may supply the desired properties. Safe, durable, and cost-effective fire-retardant and/or antimicrobial fibers or yarns would be useful for a wide range of applications.

SUMMARY OF THE INVENTION

[0003] The present invention provides, in one aspect, a composite yarn including an aramid fiber and a second fiber incorporating therein at least one of an antimicrobial and a fire retardant. The second fiber is at least one of wrapped around the aramid fiber and entangled with the aramid fiber.

[0004] The present invention provides, in another aspect, a body support including a foam layer and a sleeve enclosing the foam layer. The sleeve includes an aramid fiber and a second fiber incorporating therein at least one of an antimicrobial and a fire retardant. The second fiber is at least one of wrapped around the aramid fiber and entangled with the aramid fiber.

[0005] The present invention provides, in yet another aspect, a method of making a composite yarn. The method includes providing a first plurality of aramid staple fibers comprising about 20% by weight or less of the composite yarn, providing a second plurality of staple fibers incorporating therein at least one of an antimicrobial and a fire retardant, and mixing the first and second plurality of fibers.

[0006] Other features and aspects of the invention will become apparent by consideration of the following detailed description, and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a cutaway perspective view of a body support in accordance with an embodiment of the invention, including a foam layer and a sleeve enclosing the foam layer.

[0008] FIG. 2 is an enlarged, perspective view of a composite spun yarn in accordance with an embodiment of the invention.

[0009] FIG. 3 is an enlarged, perspective view of a core-spun yarn in accordance with another embodiment of the invention.

[0010] FIG. 4 is an enlarged, perspective view of a composite yarn in accordance with yet another embodiment of the invention.

[0011] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

DETAILED DESCRIPTION

[0012] Various embodiments of the invention include a composite yarn comprising an aramid fiber. A yarn may be an assemblage of fibers spun or twisted together to form a continuous strand, which can be used in weaving, knitting, braiding, plaiting, or otherwise made into a textile or a fabric. As described further below, composite yarns comprise two or more longitudinally coextensive fiber components combined to form a cohesive filament, and the fibers in a composite yarn may include continuous fibers and/or staple fibers. Continuous fibers are long, substantially unbroken filaments of indefinite length that include natural fibers, such as silk, as well as various synthetic materials manufactured to form a continuous filament, for example, through an extrusion process. Staple fibers, in contrast, are relatively short-length fibers that may be of varied or uniform staple length. Staple fibers can include natural fibers, such as plant fibers (e.g., cotton) or animal fibers (e.g., wool), as well as synthetic materials. A continuous fiber can be cut to desired lengths to produce staple fibers.

[0013] Yarns formed entirely of staple fibers are referred to as spun yarns. In a spun yarn, individual staple fibers are spun or otherwise entangled together into an interlocking arrangement to form a continuous filament that exceeds the staple length of any individual staple fiber in the yarn. A composite spun yarn can be produced by directly mixing a first staple fiber with at least a second staple fiber to form a single filament through conventional spinning techniques. As shown in FIG. 2, composite spun yarns can also be produced by spinning a first staple fiber to produce a first spun yarn and spinning a second staple fiber to produce a second spun yarn, and then spinning the first and second spun yarns together to produce a composite spun yarn. As one of skill in the art will recognize, additional staple fibers can be incorporated into composite spun yarns formed by direct entanglement of different staple fibers or by spinning separate spun yarns and/or composite spun yarns together. For example, as shown in FIG. 4, a composite spun yarn can be produced by spinning a first staple fiber to produce a first spun yarn, spinning a second staple fiber to produce a second spun yarn, spinning a third staple fiber to produce a third spun yarn, and that spinning the first, second, and third spun yarns together to produce a composite spun yarn. The yarn disclosed herein can incorporate staple fibers of any suitable staple length and denier. For example, in some embodiments, the staple length of aramid staple fibers may be about 2.0 inches, about 1.5 inches, about 1.0 inch, about 0.9 inch, about 0.8 inch, about 0.7 inch, about 0.6 inch, about 0.5 inch, about 0.4 inch, about 0.3 inch, about 0.2 inch, or about 0.1 inch. Preferably, the staple length of aramid staple fibers may be between about 0.5 inch and about 1.5 inches, and more preferably about 1.0 inch.

[0014] Composite yarns may also include continuous fibers. For example, as shown in FIG. 3, a core-spun composite yarn includes at least a first continuous fiber provided as a continuous core and at least a second fiber wrapped around the core to form a sheath. Such a sheath may substantially surround the core, for example, the sheath may at least about 50% of the core's periphery. The sheath of a core-spun yarn may comprise a continuous fiber and/or a staple fiber.

[0015] Fibers used in the disclosed composite yarns may include aramid fibers as staple fibers in a composite spun yarn, or as a continuous core fiber in a core-spun composite...
yarn. Aramid, also known as aromatic polyamide, is a synthetic polymer that forms strong, fire-retardant fibers. Aramid fibers are inherently fire-retardant and therefore do not require treatment with extrinsic fire-retardant agents that can release hazardous compounds during use, or that can otherwise be removed and rendered ineffective upon liquid contact from spills, urination, sweating, or routine washing. Furthermore, aramid fibers provide excellent strength to the disclosed yarns, which means that the yarns will stay intact and offer resistance and sustained protection to knitted or woven articles after a flame has been extinguished. The disclosed yarns comprising aramid fibers exhibit high strength equal or superior to yarns that contain glass fibers, but without the skin irritation sometimes associated with glass fibers. The aramid fibers used in the disclosed yarns can include metaaramid fibers (in which the amide linkages are in the meta position relative to one another) and para-aramid fibers (in which the amide linkages are in the para position relative to one another).

In some embodiments, an aramid staple fiber is combined with one or more additional staple fibers to produce a composite spun yarn. Any number of additional fibers can be included in the disclosed composite spun yarns—such as a second fiber, second and third fibers; second, third, and fourth fibers; etc.—and an additional fiber may be made from a natural or a synthetic material. An additional fiber may also include a fire retardant and/or an antimicrobial, as described in more detail below. Thus, for example, the composite spun yarn may in some embodiments include an aramid staple fiber entangled with a second staple fiber, wherein the second staple fiber includes at least one of an antimicrobial and a fire retardant. In another exemplary embodiment, the composite spun yarn may include an aramid staple fiber entangled with a second staple fiber and a third staple fiber, in which the second staple fiber includes a fire retardant and the third staple fiber includes an antimicrobial. In some embodiments, the proportion of aramid fiber in the composite spun yarn may comprise about 30% or less, about 20% or less, about 15% or less, about 10% or less, about 5% or less, about 3% or less, about 2% or less, or about 1% or less of the core-spun yarn by weight. Preferably, the proportion of aramid fiber in the core-spun yarn may comprise about 30% or less, about 20% or less, about 15% or less, about 10% or less, about 5% or less, about 3% or less, about 2% or less, or about 1% or less of the core-spun yarn by weight.

As noted, additional fibers (i.e., a second fiber, third fiber, fourth fiber, etc.) incorporated with an aramid fiber into the disclosed yarns may be natural or synthetic fibers. Examples of natural fibers include, but are not limited to, cellulose, cotton, hemp, wool, rayon, silk, linen, flax, mohair, camel, cashmere, bamboo, jute, sisal, feather, and alpaca. Non-limiting examples of synthetic fibers may include acrylic, modified acrylic, carbon fiber, polyester, nylon, polyolefin, spandex, Teflon, polybenzimidazole, and vinyon.

Additional fibers incorporated into the disclosed yarns may include a fire retardant and/or an antimicrobial. In some embodiments, a fire retardant and/or an antimicrobial may be added to a synthetic fiber by addition to a melt composition of the synthetic fiber prior to extrusion of the synthetic fiber. Any extrusion apparatus may be used to prepare the disclosed synthetic fibers. One or more additives (i.e., a fire retardant and/or an antimicrobial) may be added to an extruder containing a melt preparation of a synthetic fiber-forming material to create a blend of the fiber-forming material with the additive. Briefly, an exemplary extrusion process includes melting or dissolving pellets of synthetic fiber-forming material in a melt bath and then continuously extruding a fiber of a desired diameter through one or more spinnerets provided on the extruder. After extrusion, the nascent fiber solidifies via precipitation or cooling. In some embodiments, an additive may be added directly, or an additive may be prepared, for example, as a solution or a particulate dispersion in a suitable liquid carrier before being added to the melt. Once blended with a desired additive, the melt may be extruded using known extrusion methods to produce a synthetic fiber that includes a fire retardant and/or an antimicrobial, consequently exhibiting corresponding fire-retardant and/or antimicrobial properties. The addition of a fire retardant and/or an antimicrobial into the melt before extrusion and resulting incorporation or impregnation into the extruded fibers provides fire-retardant and/or antimicrobial properties as a permanent part of the fiber and resulting yarn itself, eliminating the need for subsequent or secondary topical treatments.

In some embodiments, various substances may be added to a yarn as sizing agents during the sizing process, such as starch, polyvinyl alcohol, carboxymethyl cellulose, acrylates, and waxes. In addition, a fire retardant and/or an antimicrobial may be added as sizing agents during the sizing process, either alone, sequentially with other sizing agents, or mixed and applied with other sizing agents.

In some embodiments, a fire retardant and/or an antimicrobial may be infused into an absorbent fiber, for example, in a jet or dye bath application under heat and pressure. Absorbent fibers typically include, but are not limited to, natural fibers such as cotton, wool, rayon, linen, and cashmere, among others.

Fire retardants for use with the disclosed fibers may include phosphates esters, antimony trioxide, organohalogen compounds such as tetrafluoroethylene polymers, red phosphorous, borates, and any other suitable fire retardant known...
in the art. Antimicrobials may include inorganic metal compounds such as zinc omadine (zinc pyrithione), quaternary silanes, silver ion based antimicrobials, copper ion based antimicrobials, chitosan, isothiazolines, chlorhexidine, triclosan, polymixin, oxalic acid, enoxacin acid, and EDTA, among others known in the art.

[0023] In some embodiments, an antimicrobial may be added to an aramid fiber used in the disclosed yarns. For example, an antimicrobial may be added to the aramid melt in an extruder prior to extruding aramid fibers, as set forth above. In some embodiments, the disclosed fibers could be used in non-woven applications, such as a non-woven batting. For example, an aramid staple fiber could be combined with one or more additional staple fibers to engineer a non-woven batting suitable to provide a safe, strong barrier with fire retardant and/or antimicrobial properties.

[0024] For example, in one embodiment of the invention, a method of manufacturing a composite yarn includes providing a first plurality of aramid staple fibers, providing a second plurality of staple fibers including at least one of an antimicrobial and a fire retardant, and mixing the first and second pluralities of fibers to produce a composite yarn. Preferably, the first plurality of aramid fibers comprises about 20% or less of the composite yarn by weight, more preferably about 10% or less or about 5% or less. Mixing the first and second pluralities of staple fibers can be accomplished by any known method for entangling staple fibers to produce a yarn, such as conventional spinning techniques. In some embodiments, the method further comprises adding a sizing agent comprising at least one of an antimicrobial and a fire retardant.

[0025] The disclosed yarns and materials comprising aramid fiber can be used for a variety of applications. The disclosed yarns and materials may be used for any article with textile and foam support, such as, for example, mattresses, mattress coverings, pillows, pillow coverings, furniture, furniture coverings, seat coverings, cushions, vehicle interiors, other body supports, and more. The disclosed yarns and materials may be useful in bedding, pet bedding, wall coverings, carpeting, and protective clothing. For example, as shown in FIG. 1, a body support 10 includes a foam layer 14 and a sleeve 18 enclosing the foam layer, in which the sleeve is made from any of the disclosed yarns and materials. In one embodiment of the invention, the sleeve 18 may include a yarn comprising an aramid fiber and a second fiber. In such an application, the second fiber may include, for example, at least one of an antimicrobial and a fire retardant, and the second fiber may be entangled with or wrapped around the aramid fiber.

[0026] In some embodiments, char strength may be evaluated by burning a yarn or textile to form a residual char, for example pursuant to the burn test described in 16 C.F.R. §1633. After forming the char, the char can be evaluated to determine whether the char material remains intact against cracking or breaking, and if so, the strength of the char material. Char strength can be evaluated by pressing on the char and evaluating the char's resistance to pressure as weak, medium, or strong. Core-spun yarns containing a glass fiber core exhibit strong char strength. Similarly, the disclosed core-spun yarns with an aramid fiber core exhibit strong char strength. In addition, the inventors have found that the disclosed spun yarns comprising aramid staple fibers also unexpectedly exhibit medium or strong char strength comparable to core-spun yarns comprising continuous glass or aramid fiber cores, even though the disclosed aramid-containing spun yarns contain only staple fibers and lack any continuous fiber.

[0027] Antimicrobials may be used with the disclosed fibers in any suitable concentration, and may vary with the level of desired antimicrobial activity and/or the target organism of concern. An antimicrobial may kill or inhibit the growth of one or more of a bacterial organism, a fungal organism, a mold, a mildew, a virus, etc. For example, a silver-based antimicrobial may target a bacterial organism and may be provided in an active concentration from about 20 to about 4000 ppm in the final yarn product, preferably about 190 ppm. Similarly, silane quaternary ammonium may be provided in an active concentration from about 200 to about 5000 ppm in the final yarn product, preferably about 2500 ppm, and chitosan may be provided in an active concentration from about 20 to about 6000 ppm in the final yarn product, preferably about 5000 ppm. As another example, zinc omadine (zinc pyrithione) may inhibit bacterial and fungal growth and may be provided in an active concentration from about 100 ppm to about 5000 ppm in the final yarn product, such as about 5000 ppm, about 4000 ppm, about 3000 ppm, about 2000 ppm, about 1500 ppm, about 1400 ppm, about 1300 ppm, about 1200 ppm, about 1100 ppm, about 1000 ppm, about 500 ppm, about 300 ppm, and about 100 ppm.

[0028] Exemplary methods for assessing antimicrobial efficacy include AATCC TM 30 Test III (American Association of Textile Chemist and Colorists Antifungal Activity; Assessment on Textile Materials: Mildew and Rot Resistance of Textile Materials, Test Method 30 Test III Agar plate, Aspergillus niger); also AATCC TM 30 Tests I, II, and IV. Those fungal standard test methods involve inoculating a sample (e.g., fiber, yarn, textile) with one or more fungal organisms under conditions specific to each test method. After a defined incubation period, the growth is reported as the percentage of the sample surface area covered by the organism, along with the measurement of any zone of inhibition.

[0029] Exemplary methods for assessing antibacterial efficacy include JIS (Japanese Industrial Standard) L 1902 Testing for antibacterial activity and efficacy on textile products; AATCC TM 100 Antibacterial; Finishes on Textile Materials; ISO (International Standards Organization) Standard 20743—Textiles—Determination of Antibacterial Activity on Textile Products; ASTM E2149 Standard Test Method for Determining the Antimicrobial Activity of Immobilized Antimicrobial Agents Under Dynamic Contact Conditions; and AATCC TM 147 Antibacterial Activity Assessment of Textile Materials: Parallel Streak Method. Those bacterial standard test methods involve inoculating a sample with a specified enumerated bacterial culture and incubating the sample for a defined period under defined conditions, then recovering the sample and enumerating the bacteria after exposure to the sample. Different bacteria can be used in such testing, but a gram-negative and a gram-positive species are often used.

[0030] Antimicrobial efficacy for the disclosed yarns can be evaluated according to methods known in the art, including those examples referenced above. In some embodiments, the disclosed yarns comprising an antimicrobial may reduce microbial counts by at least about 70%, at least about 80%, at least about 90%, at least about 95%, at least about 99%, at least about 99.9%, or at least about 99.99% compared to an analogous yarn lacking an antimicrobial. In some embodiments, the disclosed yarns comprising an antimicrobial may
reduce microbial growth to less than about 10% microbial growth, less than about 1% microbial growth, no observable microbial growth, or no observable microbial growth with a zone of inhibition compared to a control yarn. For example, a yarn prepared according to the disclosure comprising zinc omadine (zinc pyrithione) may achieve about a 2-log (i.e., at least about 99%) reduction in *E. coli* and/or *S. aureus* organisms compared to a matched control yarn.

[0031] Although the invention has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of one or more independent aspects of the invention described.

[0032] Various features of the invention are set forth in the following claims.

What is claimed is:

1. A composite yarn, comprising:
   - an aramid fiber; and
   - a second fiber incorporating therein at least one of an antimicrobial and a fire retardant;
   wherein the second fiber is at least one of wrapped around the aramid fiber and entangled with the aramid fiber.

2. The composite yarn of claim 1, wherein the aramid fiber and the second fiber are staple fibers entangled with one another.

3. The composite yarn of claim 2, further comprising a third staple fiber including the other of the antimicrobial and the fire retardant, wherein the third staple fiber is entangled with the aramid staple fiber and the second staple fiber.

4. The composite yarn of claim 2, wherein the aramid fiber is a meta-aramid fiber.

5. The composite yarn of claim 2, wherein the aramid fiber is a para-aramid fiber.

6. The composite yarn of claim 3, wherein at least one of the second fiber and the third fiber is made from a synthetic material.

7. The composite yarn of claim 6, wherein the second fiber and the third fiber are made from a synthetic material.

8. The composite yarn of claim 7, wherein the second and third fibers are made from synthetic materials using an extrusion process, and wherein the antimicrobial and the fire retardant are added to the synthetic materials comprising the second and third fibers, respectively, before the extrusion process.

9. The composite yarn of claim 2, wherein the second fiber includes the antimicrobial and the fire retardant.

10. The composite yarn of claim 9, wherein the second fiber is made from a synthetic material.

11. The composite yarn of claim 10, wherein the second fiber is made from a synthetic material using an extrusion process, and wherein the antimicrobial and the fire retardant are added to the synthetic material comprising the second fiber before the extrusion process.

12. The composite yarn of claim 2, wherein the antimicrobial is zinc omadine.

13. The composite yarn of claim 12, wherein a concentration of zinc omadine in the composite yarn is between about 100 and about 5000 ppm.

14. The composite yarn of claim 2, wherein the aramid fiber comprises about 20% by weight or less of the composite yarn.

15. The composite yarn of claim 1, wherein the aramid fiber comprises a continuous filament core.

16. The composite yarn of claim 15, wherein the second fiber comprises an outer sheath wrapped around the aramid filament core.

17. A body support comprising:
   - a foam layer; and
   - a sleeve enclosing the foam layer, the sleeve including an aramid fiber, and
   - a second fiber incorporating therein at least one of an antimicrobial and a fire retardant, wherein the second fiber is at least one of wrapped around the aramid fiber and entangled with the aramid fiber.

18. The body support of claim 17, wherein the aramid fiber and the second fiber are staple fibers entangled with one another.

19. A method of making a composite yarn, the method comprising:
   providing a first plurality of aramid staple fibers comprising about 20% by weight or less of the composite yarn; providing a second plurality of staple fibers incorporating therein at least one of an antimicrobial and a fire retardant; and mixing the first and second pluralities of fibers.

20. The method of claim 19, further comprising:
   using an extrusion process to make the second plurality of staple fibers from a synthetic material; and adding at least one of the antimicrobial and the fire retardant to the synthetic material comprising the second plurality of staple fibers before the extrusion process.

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