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**Dugan**(10) **Pub. No.: US 2007/0077427 A1**(43) **Pub. Date: Apr. 5, 2007**(54) **SOLUBLE MICROFILAMENT-GENERATING  
MULTICOMPONENT FIBERS****Publication Classification**(51) **Int. Cl.****D01D 5/32** (2006.01)(52) **U.S. Cl.** ..... **428/375; 264/172.14; 264/172.12**(75) Inventor: **Jeffrey S. Dugan**, Erwin, TN (US)

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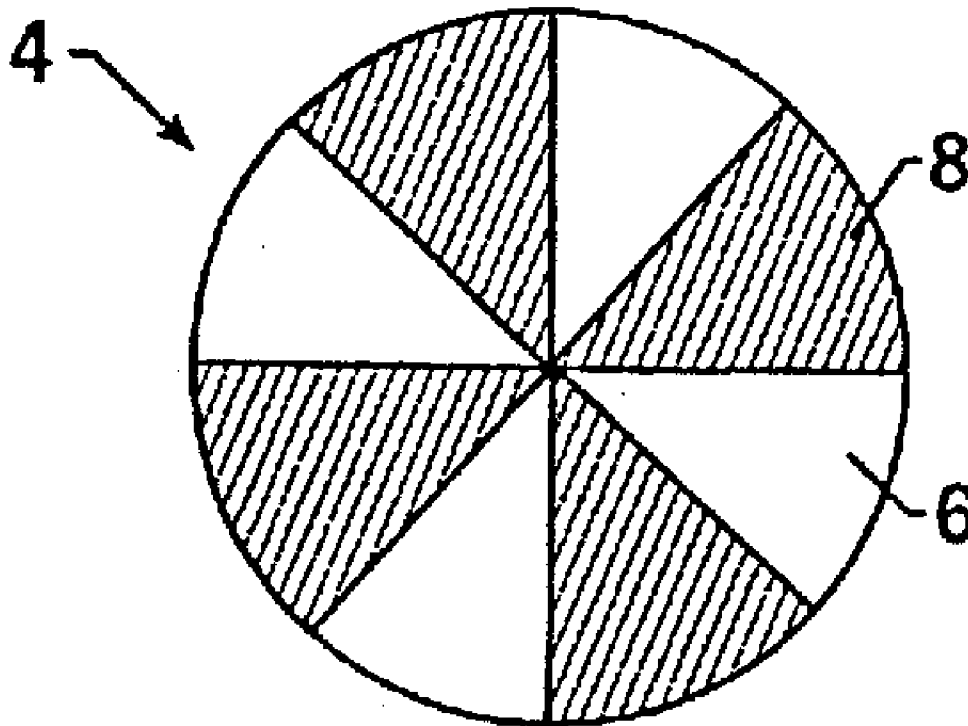
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**ABSTRACT**

Microfilament-generating multicomponent fibers are provided that include a first polymer component and a second polymer component extruded together in separate contiguous polymer segments extending along the length of the fiber. The first polymer component comprises a synthetic melt-processable polymer that is substantially soluble in a first relatively benign solvent selected from water, aqueous caustic solution, and non-halogenated organic solvents. The second polymer component is formed from a second synthetic melt-processable polymer dimensioned to produce one or more microfilaments upon dissolution of the first polymer, and that is substantially soluble in an aqueous solvent selected from water and aqueous caustic solution. The two polymer components are dissolvable in different solvents.

(73) Assignee: **Fiber Innovation Technology, Inc.**(21) Appl. No.: **11/539,742**(22) Filed: **Oct. 9, 2006****Related U.S. Application Data**

(63) Continuation of application No. 10/967,837, filed on Oct. 18, 2004, now abandoned.



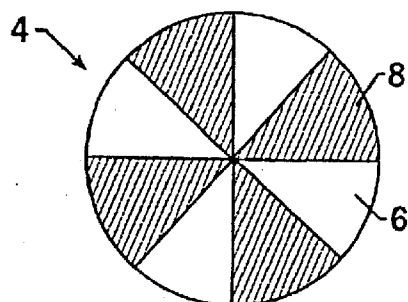


FIG. 1A.

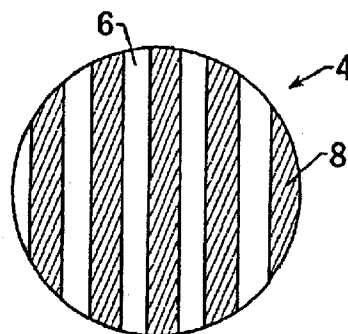


FIG. 1B.

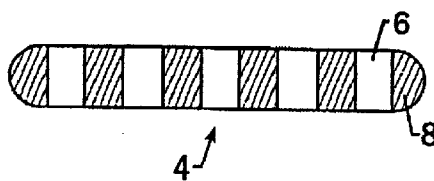


FIG. 1C.

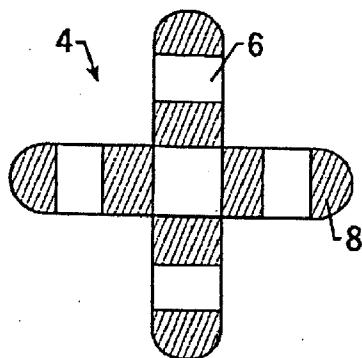


FIG. 1D.

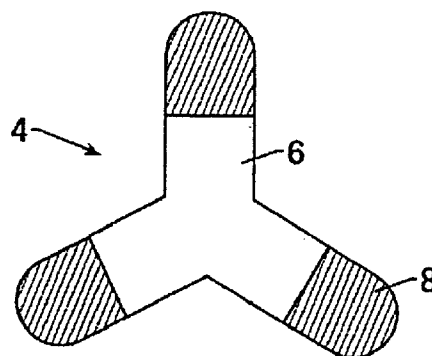


FIG. 1E.

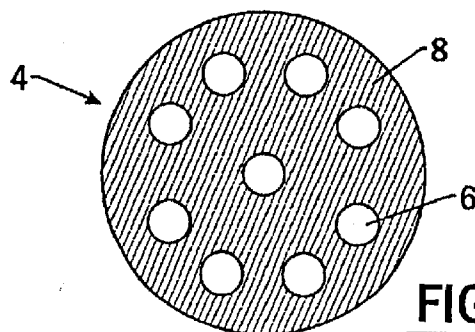
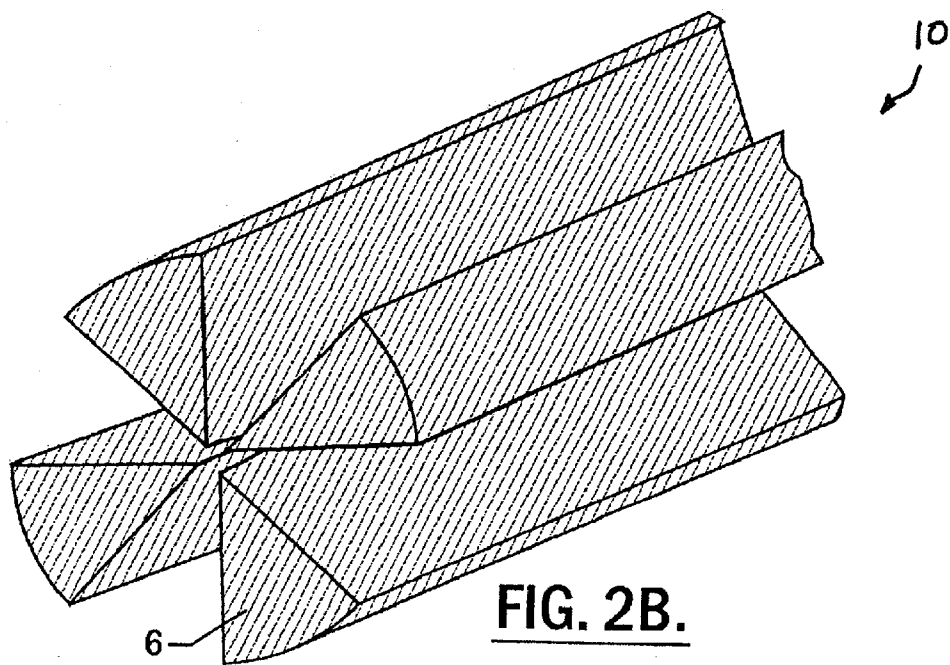
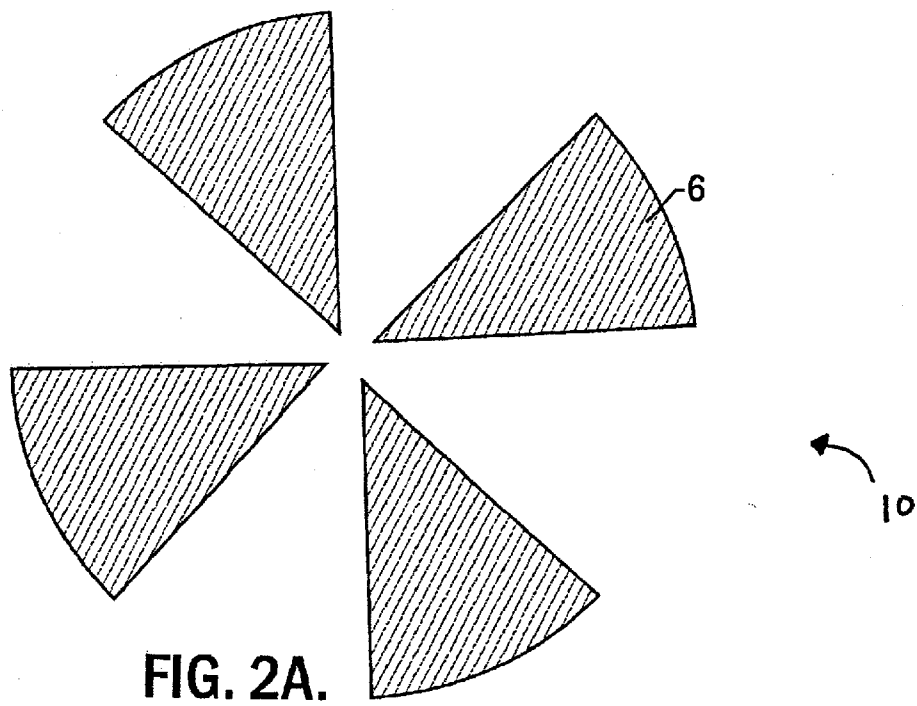


FIG. 1F.



## SOLUBLE MICROFILAMENT-GENERATING MULTICOMPONENT FIBERS

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 10/967,837, filed Oct. 18, 2004, which is hereby incorporated herein in its entirety by reference.

### FIELD OF THE INVENTION

[0002] The invention is directed to microfilament-generating multicomponent fibers comprising two or more soluble polymer components and methods of making such fibers.

### BACKGROUND OF THE INVENTION

[0003] The use of nonwoven fabrics has become increasingly prevalent in a number of industries, and in particular, has found increasing usefulness as a component of a variety of consumer products. Exemplary uses for nonwoven fabrics include, without limitation, absorbent personal care products such as diapers, incontinence pads, feminine hygiene products and the like; medical products such as surgical drapes and sterile wipes; filtration devices; interlinings; disposable wipes; furniture and bedding construction; insulating products; apparel and the like. A variety of thermoplastic and thermobondable synthetic fibers have been found to be particularly useful for nonwoven fabric manufacture due to their advantageous strength and weight characteristics, as well as their ease of processing.

[0004] Conventional thermoplastic synthetic fibers, however, do not naturally degrade, thus creating problems associated with the disposal of products containing such fibers. The recycling of articles containing nonwoven fabrics is generally not cost-effective, leading to the creation of non-degradable waste material. The disposal of diapers provides a good example of the problems associated with non-degradable waste. Disposable diapers rely heavily on the use of nonwoven fabrics in their construction. Millions of diapers are discarded every year, thereby contributing to landfill capacity problems.

[0005] The use of multicomponent fibers that generate microfilaments upon dissolution of a soluble polymer component is known in the art. Fiber bundles comprising the resulting microfilaments or microfibers exhibit many desirable characteristics. For example, microfiber fabrics are generally lightweight, resilient or wrinkle-resistant, have a luxurious drape and body, retain shape, and resist pilling. Also, such fabrics are relatively strong and durable in relation to other fabrics of similar weight. Microfilament fibers are used commercially in a variety of products such as filtration media, apparel, towels, and wipes. However, the synthetic polymers conventionally used to form the microfilaments are neither biodegradable nor soluble in relatively benign solvents. Thus, the use of such microfilaments contributes to the waste problems discussed above.

[0006] Thus, there remains a need in the art for a microfilament-generating multicomponent fiber that does not exacerbate existing waste problems associated with the use of conventional synthetic fibers.

### SUMMARY OF THE INVENTION

[0007] The present invention provides a microfilament-generating multicomponent fiber comprising at least two

polymer components that are soluble in different, but relatively benign, solvents. That is to say, both the polymer component that is dissolved during fiber or fabric manufacture to form the microfilaments, and the resulting microfilaments themselves, are soluble in relatively benign solvents. In a preferred embodiment, the polymer component that is removed to form the microfilaments is a synthetic melt-processable polymer that is substantially soluble in water at a temperature of 70° C. or above, water at a temperature of less than 70° C., aqueous caustic solution, or a non-halogenated organic solvent. The microfilament-generating multicomponent fiber further comprises a second synthetic melt-processable polymer, at least a portion of which is dimensioned to produce one or more microfilaments upon dissolution of the first polymer. The second synthetic melt-processable polymer is substantially soluble in an aqueous solvent, such as water (e.g., water at a temperature of 70° C. or above or water at a temperature of less than 70° C.), or an aqueous caustic solution. The solvent for the first polymer component and the solvent for the second polymer component are different such that the first polymer component can be removed to form the microfilaments without substantially degrading the microfilament-forming second polymer component. In this manner, microfilaments can be generated that are soluble in a relatively benign aqueous solvent. The present invention provides an economical means for producing a fiber bundle of microfilaments or microfibers that can be easily dissolved in a relatively benign solvent at the end of its useful life, or the useful life of the article of manufacture incorporating the fiber bundle. In some cases, the dissolved solution of the microfilament-generating polymer can be recycled and reused in a fiber-forming process.

[0008] In one embodiment, the solvent for the first polymer component that is removed to form the microfilaments is water at a temperature of less than 70° C. and the aqueous solvent in which the microfilament-forming polymer is soluble is water at a temperature of 70° C. or above. Thus, in this embodiment, the entire multicomponent fiber is water-soluble at some temperature.

[0009] In another embodiment, the solvent for the first polymer component that is removed to form the microfilaments is water (e.g., water at a temperature of less than 70° C. or water at a temperature of 70° C. or above) and the second aqueous solvent in which the microfilament-forming polymer is soluble is an aqueous caustic solution.

[0010] In yet another embodiment, the first solvent is a non-halogenated organic solvent and the second aqueous solvent is either water at various temperatures or an aqueous caustic solution.

[0011] In a further embodiment, the solvent used to dissolve the first polymer in order to form the microfilaments is an aqueous caustic solution and the microfilament-forming polymer is soluble in water at a temperature of 70° C. or above.

[0012] Exemplary polymers that can be used as the first polymer component include sulfonated polyesters, sulfonated polystyrene, ethylene vinyl alcohol, polyvinyl alcohol, polyethylene oxide, polyglycolic acid, polylactic acid, polycaprolactone, and polystyrene. Exemplary polymers for use as the second polymer component that forms the microfilaments includes sulfonated polyesters, sulfonated

polystyrene, ethylene vinyl alcohol, polyvinyl alcohol, polyethylene oxide, polyglycolic acid, polylactic acid, and polycaprolactone.

[0013] The microfilaments generated by the multicomponent fibers of the present invention have a fineness of less than about 1.5 denier, more preferably a fineness of less than about 1.0 denier, and most preferably a fineness of less than about 0.5 denier. In some embodiments, the fineness is less than about 0.2 denier, such as a fineness in the range of about 0.01 to about 0.2 denier.

[0014] The configuration and type of fiber may vary. The multicomponent fiber of the invention can be in the form of a continuous filament, tow, staple fiber, spunbond fiber, or meltblown fiber, and can have one of various cross-sectional configurations, such as pie/wedge, segmented round, segmented oval, segmented ribbon, segmented multi-lobal, segmented cross, islands-in-the-sea, and the like. The cross-sectional shape of the microfilaments themselves may also vary. Exemplary cross-sectional shapes for the microfilaments include wedge, multi-lobal, hexagonal, rectangular, oval and circular.

[0015] In another aspect of the invention, a fiber bundle comprising a plurality of microfilaments is provided, the microfilaments formed of a synthetic melt-processable polymer that is substantially soluble in an aqueous solvent such as water at a temperature of 70° C. or above, water at a temperature of less than 70° C., and aqueous caustic solution.

[0016] In yet another aspect, the invention provides a fabric comprising the fiber bundle of the invention. The fabric may be in the form of woven fabric, nonwoven fabric, or knit fabric.

[0017] Further, in another aspect, the invention provides a method of forming a microfilament-generating multicomponent fiber by providing a first molten viscous polymer composition comprising a first synthetic melt-processable polymer substantially soluble in a first solvent selected from water at a temperature of 70° C. or above, water at a temperature of less than 70° C., aqueous caustic solution, and a non-halogenated organic solvent. A second molten viscous polymer composition is also provided, the second polymer composition comprising a second synthetic melt-processable polymer substantially soluble in a second aqueous solvent selected from water at a temperature of 70° C. or above or less than 70° C., or an aqueous caustic solution. The first solvent and the second solvent are different such that the second synthetic polymer is not dissolvable in the first solvent. The two molten viscous polymer compositions are extruded together through a spinneret to form a multicomponent fiber comprising one or more separate contiguous segments of each of the first and second polymer compositions extending the length of the fiber. At least a portion of the polymer segments comprising the second polymer composition are dimensioned to form microfilaments upon dissolution of the first polymer composition. Thereafter, the resulting multicomponent fibers are collected and, optionally, formed into a fabric. The first polymer composition can be dissolved using the first solvent at any point following manufacture of the multicomponent fiber, including after manufacture of the resulting fabric, thereby forming one or more microfilaments.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

[0019] FIGS. 1A-1F are cross-sectional views of exemplary embodiments of multicomponent fibers in accordance with the present invention; and

[0020] FIGS. 2A and 2B are cross-sectional and longitudinal views, respectively, of an exemplary dissociated fiber in accordance with one embodiment of the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

[0021] The present invention now will be described more fully hereinafter. However, this invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout.

[0022] As used in this specification and the claims, the singular forms “a,” “an,” and “the” include plural referents unless the context clearly dictates otherwise.

[0023] The term “fiber” as used herein means both fibers of finite length, such as conventional staple fiber, as well as substantially continuous structures, such as continuous filaments, unless otherwise indicated. The fibers of the invention can be hollow or non-hollow fibers, and further can have a substantially round or circular cross section or non-circular cross sections (for example, oval, rectangular, multi-lobed, and the like).

[0024] As used herein, a “multicomponent fiber” is a fiber formed of two or more polymeric materials that have been extruded together to provide continuous contiguous polymer segments which extend the length of the fiber. For purposes of illustration only, the present invention will generally be described in terms of a bicomponent fiber. However, it should be understood that the scope of the present invention is meant to include fibers with two or more components.

[0025] The term “denier” is an expression of fiber diameter and defined conventionally as grams per 9,000 meters of fiber. A lower denier indicates a finer fiber and a higher denier indicates a thicker or heavier fiber, as is known in the art.

[0026] The term “synthetic melt-processable polymer” describes thermoplastic polymer materials comprising a polymer backbone that is synthetically derived and having the necessary physical properties, such as a suitable melting point, for processing by melt spinning. Typically, the synthetic melt-processable polymers of the invention will have a melting point in the range of about 50° C. to about 260° C., more typically in the range of about 65° C. to about 180° C.

[0027] The term “copolymer” as used herein is intended to encompass polymers formed from any combination of two or more polymers, including random copolymers, block copolymers, alternating copolymers, and the like.

[0028] The term “relatively benign solvent” is intended to encompass aqueous solvents and non-halogenated organic solvents that typically create fewer handling and environmental problems as compared to generally disfavored halogenated solvents, such as methylene chloride, perchloroethylene, and trichloroethylene, which are listed as hazardous air pollutants in the Clean Air Act (CAA), toxic chemicals in the Superfund Amendments and Reauthorization Act (SARA), and hazardous substances in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Examples include water at various temperatures, aqueous caustic solutions, xylene, hexane, acetone, pyrrolidones (e.g., N-methyl-2-pyrrolidone), turpentine, kerosene, isopropanol, methanol, tetrahydrofuran, toluene, cresols, and the like.

[0029] The term “aqueous caustic solution” refers to an aqueous salt solution that provides an alkaline pH, such as a solution of an alkali metal or alkaline earth metal hydroxide (e.g., sodium hydroxide or potassium hydroxide). Typically, the aqueous caustic solution comprises about 2 to about 10 percent by weight of the salt (e.g., about 3 weight percent), such as sodium hydroxide. Typically, treatment of the fiber with the aqueous caustic solution occurs at a solution temperature of about 80-100° C. (e.g., 90° C.) and over a treatment period of about 3-20 minutes, although other treatment temperatures or times could be used. For example, a caustic solution temperature below about 70° C. could be used to avoid degradation of hot water soluble fiber components.

[0030] As used herein, the terms “substantially soluble” or “dissolvable” are intended to refer to polymers that dissolve, decompose (e.g., by hydrolysis), or otherwise disperse in solution to the point where no visually discernible solid portions of the polymer remain after 60 minutes of exposure to the solvent. Typically, the polymer breaks apart into discrete particles having an average particle size of no more than about 1 micron following dissolution, and preferably the polymer breaks down on a molecular level.

[0031] The present invention provides a microfilament-generating multicomponent fiber that includes at least two polymer components that are soluble in relatively benign solvents. Thus, the multicomponent fiber of the invention includes a first polymer component and a second polymer component that are extruded together in separate contiguous polymer segments extending along the length of the fiber. The first polymer component is adapted for removal by dissolution in order to form microfilaments. This polymer component is sometimes referred to in the art as the “fugitive” polymer component. In the present invention, the fugitive polymer component is a synthetic melt-processable polymer that is substantially soluble in a first benign solvent, such as water (e.g., water at a temperature of 70° C. or above or water at a temperature of less than 70° C.), an aqueous caustic solution, or a non-halogenated organic solvent.

[0032] The second polymer component, at least a portion of which is dimensioned to produce one or more microfilaments upon dissolution of the first polymer, also comprises a synthetic melt-processable polymer. In one embodiment, the entire second polymer component is dimensioned to produce microfilaments, meaning each discrete portion of the second polymer component is dimensioned to produce a microfilament upon dissolution of the fugitive polymer.

Alternatively, as shown in the example, a portion of the second polymer can be dimensioned to produce a fiber cross sectional segment of larger size. For example, the second polymer component may comprise a plurality of microfilament-sized sections surrounding a larger core section. The synthetic melt-processable polymer used for the second polymer component is also substantially soluble in a relatively benign solvent. In the case of the second polymer component, the relatively benign solvent is an aqueous solvent, such as water (e.g., water at a temperature of 70° C. or above or water at a temperature of less than 70° C.) or an aqueous caustic solution. In order to successfully form microfilaments by dissolution of the first polymer, the solvent for the fugitive polymer component and the solvent for the second polymer component must be different such that the solvent for the fugitive polymer does not substantially degrade or dissolve the second polymer component.

[0033] Unlike prior art microfilament-generating multi-component fibers, the present invention provides a multi-component fiber wherein both the fugitive polymer component and the microfilament-generating polymer component are soluble in relatively benign solvents, such as water, aqueous caustic solutions, or non-halogenated organic solvents. In a preferred embodiment, both polymer components are soluble in an aqueous solvent. In this manner, an economical method for forming microfibers is provided that does not require the use of highly toxic and environmentally-unfriendly solvents. Further, unlike prior art microfilaments, the microfilaments of the invention are soluble in an aqueous solvent, such as water or an aqueous caustic solution. Thus, the microfilaments of the invention can be readily dissolved as a means of disposal at the end of the useful life of the microfilaments or the fabric or other article of manufacture made using the microfilaments. Depending on the polymer, the dissolved microfilaments may be recycled for reuse in fiber formation. By providing microfilaments that can be dissolved in benign solvents at the end of their useful life, both environmental concerns and waste disposal concerns associated with fiber production and use can be favorably addressed.

[0034] Examples of polymers that are substantially soluble in water at a temperature of 70° C. or above include, without limitation, sulfonated polyesters (e.g., sulfonated polyethylene terephthalate), sulfonated polystyrene, and copolymers or polymer blends containing such polymers. A commercially available example of a sulfonated polyester is the Eastman AQ line of copolyesters, such as Eastman AQ 55S.

[0035] Examples of polymers that are substantially soluble in water at a temperature of less than 70° C. include, without limitation, ethylene vinyl alcohol (EVOH), polyvinyl alcohol (PVOH), polyethylene oxide, and copolymers or polymer blends containing such polymers.

[0036] Examples of polymers that are substantially soluble in aqueous caustic solution include, without limitation, polyglycolic acid (PGA), polylactic acid (PLA), polycaprolactone (PCL), and copolymers or blends thereof. The term “polylactic acid” is intended to encompass polymers that are prepared by the polymerization of either lactic acid or lactide. Reference is made to U.S. Pat. Nos. 5,698,322; 5,142,023; 5,760,144; 5,593,778; 5,807,973; and 5,010,145, the entire disclosure of each of which is hereby incorporated by reference.

[0037] An example of a polymer that is substantially soluble in one or more non-halogenated organic solvents, such as hexane or xylene, is polystyrene.

[0038] Referring now to FIG. 1, cross-sectional views of exemplary multicomponent fibers of the present invention are provided. The multicomponent fibers of the invention, designated generally as 4, include at least two structured polymeric components, a first polymer component 6, comprising a synthetic melt-processable polymer dimensioned to form microfilaments or microfibers, and a second fugitive polymer component 8, comprising a synthetic melt-processable polymer that can be dissolved to provide one or more microfilaments of the first component 6. As noted above, the first and second components, 6 and 8, are both soluble in relatively benign solvents, with the microfilament-generating polymer component 6 being dissolvable in an aqueous solvent and the fugitive polymer component 8 being dissolvable in either an aqueous solvent different from the solvent for the microfilament-generating polymer component or a non-halogenated organic solvent.

[0039] Exemplary embodiments include the following combinations of microfilament-generating polymer components 6/fugitive polymer component 8: sulfonated polyester or sulfonated polystyrene/PVOH; PVOH/polystyrene; sulfonated polyester or sulfonated polystyrene/polystyrene; PLA/polystyrene; PLA/sulfonated polyester or sulfonated polystyrene; PLA/polystyrene; and PLA/PVOH.

[0040] As illustrated in FIGS. 1A-1E, a wide variety of fiber configurations that allow the polymer components to be free to dissociate are acceptable. Typically, the fiber components are arranged so as to form distinct unocclusive cross-sectional segments along the length of the fiber so that none of the components is physically impeded from being separated. One advantageous embodiment of such a configuration is the pie/wedge arrangement, shown in FIG. 1A. The pie/wedge fibers can be hollow or non-hollow fibers. In particular, FIG. 1A provides a bicomponent filament having eight alternating segments of triangular shaped wedges of microfilament-generating components 6 and fugitive components 8. It should be recognized that more than eight or less than eight segments can be produced in fibers made in accordance with the invention. Other fiber configurations known in the art may be used, such as but not limited to, the segmented round configuration shown in FIG. 1B. Reference is made to U.S. Pat. No. 5,108,820 to Kaneko et al., U.S. Pat. No. 5,336,552 to Strack et al., and U.S. Pat. No. 5,382,400 to Pike et al. for a further discussion of multicomponent fiber constructions.

[0041] The multicomponent fibers need not be conventional round fibers. For example, the fibers can be in the form of a segmented oval. Other useful shapes include the segmented rectangular or ribbon configuration shown in FIG. 1C, the segmented cross configuration in FIG. 1D, and the multi-lobal configuration of FIG. 1E. Such unconventional shapes are further described in U.S. Pat. No. 5,277,976 to Hogle et al., and U.S. Pat. Nos. 5,057,368 and 5,069,970 to Largman et al. As shown in FIG. 1F, the multicomponent fiber of the invention can also be configured as an islands-in-the-sea fiber, with the microfilament-generating segments or islands 6 of the fiber imbedded in a sea of the fugitive polymer component 8.

[0042] Both the shape of the fiber and the configuration of the components therein will depend upon the equipment

used to prepare the fiber, the process conditions, and the melt viscosities of the two components. As described above, a wide variety of fiber configurations are possible.

[0043] To provide dissociable properties to the multicomponent fiber, the polymer components are chosen so as to be mutually incompatible. In particular, the polymer components do not substantially mix together or enter into chemical reactions with each other. Specifically, when spun together to form a multicomponent fiber, the polymer components exhibit a distinct phase boundary between them so that substantially no blend polymers are formed therebetween, preventing dissociation. In addition, a balance of adhesion/incompatibility between the components of the multicomponent fiber is considered highly beneficial. The components advantageously adhere sufficiently to each other to allow the unsplit multicomponent fiber to be subjected to conventional textile processing such as winding, twisting, weaving, or knitting without any appreciable separation of the components until desired. Conversely, the polymers should be sufficiently incompatible so that adhesion between the components is sufficiently weak, so as to provide ready dissolution upon extraction of the fugitive polymer component.

[0044] The weight ratio of the microfilament-generating polymer component and the fugitive polymer component can vary. Preferably the weight ratio is in the range of about 10:90 to 90:10, more preferably from about 20:80 to about 80:20, and most preferably from about 50:50 to about 80:20.

[0045] The fugitive polymer component and the microfilament-generating polymer component of the multicomponent fibers of the invention may optionally include other additives or components that do not adversely affect the desired properties of the polymer composition. Exemplary conventional additives include, without limitation, pigments, anti-oxidants, stabilizers, surfactants, waxes, flow promoters, solid solvents, particulates, and other materials added to enhance processability. These additives can be used in conventional amounts, which typically do not exceed about 10% by weight based on the total weight of the polymer composition.

[0046] Dissociation of the multicomponent fibers provides a plurality of fine denier filaments or microfilaments, each formed of the microfilament-generating polymer component of the multicomponent fiber. As used herein, the terms "microfilament" or "microfiber" refer to filaments and fibers having a fineness of less than about 1.5 denier, more preferably a fineness of less than about 1.0 denier, and most preferably a fineness of less than about 0.5 denier. In some embodiments, the fineness is less than about 0.2 denier, such as a fineness in the range of about 0.01 to about 0.2 denier. The cross-sectional shape of the microfilaments may vary. Exemplary cross-sectional shapes for the microfilaments include wedge, multi-lobal, hexagonal, rectangular, oval and circular.

[0047] FIG. 2 illustrates an exemplary multicomponent fiber of the present invention which has been separated into a coherent fiber bundle 10 of microfilaments 6 as described above. In the illustrated example, the fiber bundle 10 comprises 4 microfilaments 6. Typically, the fiber bundle 10 produced upon dissolution of the fugitive polymer component will comprise 1 to about 64 microfilaments, preferably about 4 to about 37 microfilaments.

[0048] The extrusion process for making multicomponent continuous filament fibers is well known and need not be described here in detail. Generally, to form a multicomponent fiber, at least two polymers are extruded separately and fed into a polymer distribution system wherein the polymers are introduced into a spinneret plate. The polymers follow separate paths to the fiber spinneret and are combined in a spinneret hole. The spinneret is configured so that the extrudant has the desired overall fiber cross section (e.g., round, trilobal, etc.). Such a process is described, for example, in U.S. Pat. No. 5,162,074 to Hills, the contents of which are incorporated herein by reference in their entirety.

[0049] In the present invention, a microfilament-generating polymer stream and a fugitive polymer stream are fed into the polymer distribution system. The polymers typically are selected to have melting temperatures such that the polymers can be spun through a common capillary at substantially the same temperature without degrading one of the components. The two polymer components are extruded together into a continuous filament comprising separate contiguous segments of each polymer component extending along the length of the filament.

[0050] Following extrusion through the die, the resulting thin fluid strands or filaments remain in the molten state for some distance before they are solidified by cooling in a surrounding fluid medium, which may be chilled air blown through the strands. Once solidified, the filaments are taken up on a godet or other take-up surface. In a continuous filament process, the strands are taken up on a godet which draws down the thin fluid streams in proportion to the speed of the take-up godet.

[0051] Continuous filament fiber may further be processed into staple fiber. In processing staple fibers, large numbers, e.g., 10,000 to 1,000,000 strands, of continuous filament are gathered together following extrusion to form a tow, which is then cut into predetermined lengths to form the staple fiber. The length of the staple fibers generally ranges from about 25 to about 50 millimeters, although the fibers can be longer or shorter as desired. See, for example, U.S. Pat. No. 4,789,592 to Taniguchi et al. and U.S. Pat. No. 5,336,552 to Strack et al. Optionally, the tow may be subjected to a crimping process prior to the formation of staple fibers, as is known in the art. Crimped multicomponent fibers are useful for producing lofty woven and nonwoven fabrics since the microfilaments formed from the multicomponent fibers largely retain the crimps of the composite fibers and the crimps increase the bulk or loft of the fabric. Such lofty fine fiber fabric of the present invention exhibits cloth-like textural properties, e.g., softness, drapability and hand, as well as the desirable strength properties of a fabric containing highly oriented fibers.

[0052] Rather than being taken up on a godet, continuous multicomponent fiber may also be melt spun as a direct laid nonwoven web. In a spunbond process, for example, the strands are collected in a jet, such as an air jet or air attenuator, following extrusion through the die and then blown onto a take-up surface such as a roller or a moving belt to form a spunbond web. As an alternative, direct laid multicomponent fiber webs may be prepared by a meltblown process, in which air is ejected at the surface of a spinneret to simultaneously draw down and cool the thin fluid polymer streams which are subsequently deposited on a take-up

surface in the path of cooling air to form a fiber web. The techniques of spunbonding and meltblowing are known in the art and are discussed in various patents, e.g., U.S. Pat. No. 3,987,185 to Buntin et al.; U.S. Pat. No. 3,972,759 to Buntin; and U.S. Pat. No. 4,622,259 to McAmish et al.

[0053] Regardless of the type of melt spinning process that is used, typically the thin fluid streams are melt drawn in a molten state, i.e., before solidification occurs, to orient the polymer molecules for good tenacity. Typical melt draw down ratios known in the art may be utilized. The skilled artisan will appreciate that specific melt draw down is not required for meltblowing processes.

[0054] In another aspect, the present invention provides a fabric formed from the multicomponent fibers of the invention. In a preferred embodiment, the fabric is a nonwoven product, wherein the multicomponent fibers can be either melt-spun into fibers, which are then formed into a fibrous web using methods known in the art (e.g., carding, airlaying, or wetlaying), or as noted above, melt-spun directly into the form of a fibrous web by a spunbonding or meltblowing process. The fibrous web can then be bonded to form a nonwoven fabric. Webs of the fibers of the invention can be made according to any of the known commercial processes for making nonwoven fabrics, including processes that use mechanical, electrical, pneumatic, or hydrodynamic means for assembling fibers into a web, for example carding, wetlaying, carding/hydroentangling, wetlaying/hydroentangling, and spunbonding.

[0055] The webs can be bonded using techniques as known in the art, such as but not limited to mechanical bonding, such as hydroentanglement and needle punching, adhesive bonding, thermal bonding, and the like, to form a coherent fabric structure. An example of thermal bonding is air bonding, although other thermal bonding techniques, such as calendering, microwave or other RF treatments, can be used.

[0056] The fibers of the invention can also be used to make other textile structures such as, but not limited to, woven and knit fabrics. Yarns prepared for use in forming such woven and knit fabrics are similarly included within the scope of the present invention. Such yarns may be prepared from the continuous filament or staple fibers of the present invention by methods known in the art, such as twisting or air entanglement.

[0057] The present invention will be further illustrated by the following non-limiting example.

#### EXAMPLE

[0058] In a bicomponent fiber melt-spinning process, one extruder was fed with dried pellets of NATUREWORKS™ 6201D polylactic acid (PLA) from Cargill Dow LLC, and the second extruder was fed with dried pellets of EXCEVAL™ polyvinyl alcohol (PVOH) from Kuraray. The PLA was melted and extruded at 245° C. and pumped by a gear pump into a spinneret assembly. The PVOH was melted and extruded at 255° C. and pumped into the same spinneret assembly. Polymer distribution plates in the spinneret assembly delivered the polymers independently through multiple flow paths to positions in each spinneret backhole such that in each, the PLA formed islands in the contiguous “sea” of PVOH, forming a polymer-to-polymer cross sec-



tional arrangement that was maintained in the fiber through extrusion through the round capillaries of the spinneret and subsequent solidification in a cross-current air stream, and takeup across rolls and onto a winder at a speed of 815 meters/minute. In each fiber cross section, the PLA was delivered to form a single, relatively large core "island" surrounded in the PVOH "sea" by twelve smaller satellite "islands."

[0059] This process formed bicomponent 8 denier bicomponent filaments with about 80% of the cross sectional area comprising the PLA islands and about 20% of the cross sectional area comprising the PVOH sea.

[0060] The PVOH sea was removed from the fibers by dissolution in water at 35° C., accompanied by agitation. The resulting fibers were a blend of the relatively large core islands of PLA, each with a denier of approximately 4 and the smaller satellite islands of PLA, each with a denier of approximately 0.2. The PLA fibers, including the 0.2 denier microfibers, maintained their integrity and strength during and after the dissolution of the PVOH component.

[0061] At a later time, the PLA fibers, including the 0.2 denier microfibers, were immersed in a caustic aqueous solution of 3% NaOH at 90° C. for ten minutes, with agitation. The PLA fibers lost their integrity and disappeared into the solution.

[0062] Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing description. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

That which is claimed:

1. A method of forming a microfilament-generating multicomponent fiber, comprising:

- i) providing a first molten viscous polymer composition comprising a first synthetic polymer soluble in a first solvent such that the polymer breaks apart into particles having an average particle size of no more than 1 micron after 60 minutes of exposure to the first solvent, the first solvent being selected from the group consisting of water at a temperature of 70° C. or above, water at a temperature of less than 70° C., aqueous caustic solution, and a non-halogenated organic solvent;
- ii) providing a second molten viscous polymer composition comprising a second synthetic polymer soluble in a second aqueous solvent such that the polymer breaks apart into particles having an average particle size of no more than 1 micron after 60 minutes of exposure to the second aqueous solvent, the second aqueous solvent being selected from the group consisting of water at a temperature of 70° C. or above, water at a temperature of less than 70° C., and aqueous caustic solution, wherein the first solvent and the second aqueous solvent are different such that the second synthetic polymer is not dissolvable in the first solvent;

- iii) extruding the first molten viscous polymer composition and the second molten viscous polymer composition together through a spinneret to form a multicomponent fiber comprising one or more separate contiguous segments of each of the first polymer composition and the second polymer composition extending the length of the fiber, wherein at least a portion of the polymer segments comprising the second polymer composition are dimensioned to form microfilaments having a denier of less than 1.5; and

- iv) collecting the multicomponent fiber.

2. The method of claim 1, further comprising dissolving the first polymer composition, thereby forming one or more microfilaments comprising the second polymer composition.

3. The method of claim 1, further comprising forming a fabric comprising a plurality of the collected multicomponent fibers.

4. The method of claim 3, further comprising dissolving the first polymer composition, thereby forming a fabric comprising a plurality of microfilaments comprising the second polymer composition.

5. The method of claim 1, wherein the first solvent is water at a temperature of less than 70° C. and the second aqueous solvent is water at a temperature of 70° C. or above.

6. The method of claim 1, wherein the first solvent is water at a temperature of less than 70° C. and the second aqueous solvent is aqueous caustic solution.

7. The method of claim 1, wherein the first solvent is water at a temperature of 70° C. or above and the second aqueous solvent is aqueous caustic solution.

8. The method of claim 1, wherein the first solvent is a non-halogenated organic solvent and the second aqueous solvent is water at a temperature of less than 70° C.

9. The method of claim 1, wherein the first solvent is a non-halogenated organic solvent and the second aqueous solvent is water at a temperature of 70° C. or above.

10. The method of claim 1, wherein the first solvent is a non-halogenated organic solvent and the second aqueous solvent is aqueous caustic solution.

11. The method of claim 1, wherein the first solvent is aqueous caustic solution and the second aqueous solvent is water at a temperature of 70° C. or above.

12. The method of claim 1, wherein said first polymer is selected from the group consisting of sulfonated polyesters, sulfonated polystyrene, ethylene vinyl alcohol, polyvinyl alcohol, polyethylene oxide, polyglycolic acid, polylactic acid, polycaprolactone, and polystyrene.

13. The method of claim 1, wherein said second polymer is selected from the group consisting of sulfonated polyesters, sulfonated polystyrene, ethylene vinyl alcohol, polyvinyl alcohol, polyethylene oxide, polyglycolic acid, polylactic acid, and polycaprolactone.

14. The method of claim 1, wherein said first polymer is polyvinyl alcohol or a sulfonated polyester and said second polymer is polylactic acid.

15. The method of claim 1, wherein said first polymer is polystyrene and said second polymer is selected from the group consisting of sulfonated polyesters, sulfonated polystyrene, ethylene vinyl alcohol, polyvinyl alcohol, polyethylene oxide, polyglycolic acid, polylactic acid, and polycaprolactone.

16. The method of claim 1, wherein said one or more microfilaments have a fineness of less than about 1.0 denier.

17. The method of claim 16, wherein said one or more microfilaments have a fineness of less than about 0.5 denier.

18. The method of claim 1, wherein the fiber has a cross-sectional configuration selected from the group consisting of pie/wedge, segmented round, segmented oval, segmented ribbon, segmented multi-lobal, segmented cross, and islands-in-the-sea.

19. The method of claim 1, wherein the fiber has a pie/wedge cross-sectional configuration.

20. The method of claim 1, wherein the fiber has an islands-in-the-sea cross-sectional configuration.

21. A fiber bundle comprising a plurality of microfilaments generated from one or more multicomponent fibers made according to the process of claim 2.

22. The fiber bundle of claim 21, wherein the microfilaments have a cross-sectional shape selected from the group consisting of pie wedge, multi-lobal, hexagonal, rectangular, oval, and circular.

23. A fabric comprising the fiber bundle of claim 21.

24. The fabric of claim 23, wherein the fabric is selected from the group consisting of woven fabrics, nonwoven fabrics, and knit fabrics.

25. A fabric comprising a plurality of multicomponent fibers made according to the process of claim 1.

26. The fabric of claim 25, wherein the fabric is selected from the group consisting of woven fabrics, nonwoven fabrics, and knit fabrics.

27. A method of forming a microfilament-generating multicomponent fiber, comprising:

- i) providing a first molten viscous polymer composition comprising a first synthetic polymer soluble in water such that the polymer breaks apart into particles having an average particle size of no more than 1 micron after 60 minutes of exposure to water;

- ii) providing a second molten viscous polymer composition comprising a second synthetic polymer soluble in an aqueous caustic solution such that the polymer breaks apart into particles having an average particle size of no more than 1 micron after 60 minutes of exposure to the aqueous caustic solution, wherein the second synthetic polymer is not dissolvable in water;

- iii) extruding the first molten viscous polymer composition and the second molten viscous polymer composition together through a spinneret to form a multicomponent fiber comprising one or more separate contiguous segments of each of the first polymer composition and the second polymer composition extending the length of the fiber, wherein at least a portion of the polymer segments comprising the second polymer composition are dimensioned to form microfilaments having a denier of less than 1.5; and

- iv) collecting the multicomponent fiber.

28. The method of claim 27, further comprising dissolving the first polymer composition, thereby forming one or more microfilaments comprising the second polymer composition.

29. The method of claim 27, further comprising forming a fabric comprising a plurality of the collected multicomponent fibers.

30. The method of claim 29, further comprising dissolving the first polymer composition, thereby forming a fabric comprising a plurality of microfilaments comprising the second polymer composition.

31. The method of claim 27, wherein said first polymer is polyvinyl alcohol or a sulfonated polyester and said second polymer is polylactic acid.

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