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- (71) Applicant (for all designated States except US): **DOW GLOBAL TECHNOLOGIES INC.** [US/US]; WASHINGTON STREET, 1790 BUILDING, Midland, MI 48674 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **PENG, Hong** [US/US]; 420 GARLAND DRIVE APT. 1403, Lake Jackson, TX 77566 (US). **PEPPER, Randy, E.** [US/US]; 101 ZINNIA STREET, Lake Jackson, TX 77566 (US). **KNICKERBOCKER, Edward, N.** [US/US]; 217 DOGWOOD, Lake Jackson, TX 77566 (US). **VAN DUN, Jozef, J.I.** [BE/BE]; PETER DAMIAANLAAN 76, 2240 Zandhoven (BE).
- (74) Agents: **BERGMAN, Jeffrey, S.** et al.; OSHA LIANG LLP, 1221 MCKINNEY ST., SUITE 2800, Houston, TX 77010 (US).

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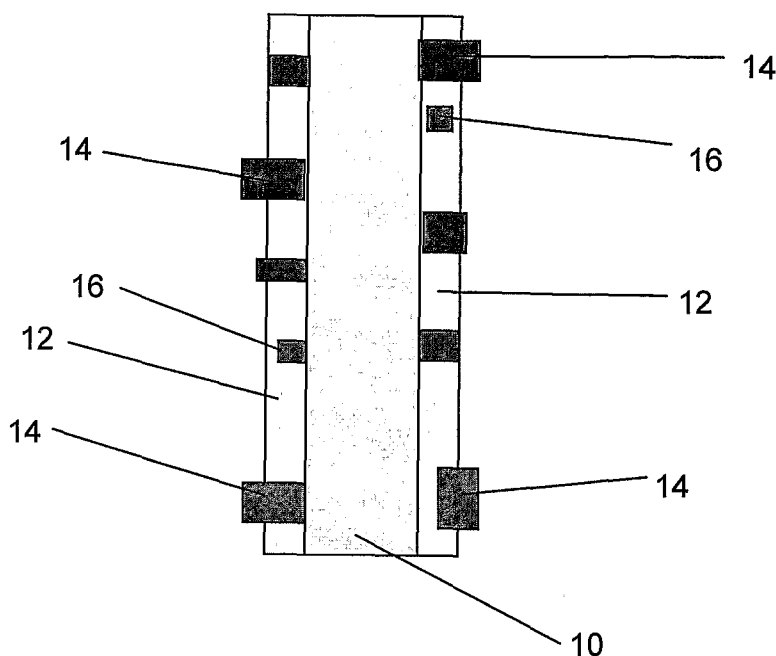
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(54) Title: SURFACE MODIFIED BI-COMPONENT POLYMERIC FIBER



(57) Abstract: The present invention provides a bicomponent fiber having increased surface roughness. The fiber includes a first polymer and a composite, wherein the composite forms a layer which forms at least a portion of the fiber's surface. The composite is formed by a second polymer and a filler, where an average particle size of the filler is greater than a thickness of the layer formed by the composite. The fibers can have a round, oval, trilobal, triangular, dog-boned, flat or hollow shape and a symmetrical or asymmetrical sheath/core or side-by-side configuration. When the fiber has a sheath/core configuration, the composite can form the sheath, and the average particle size of the filler is greater than the thickness of the sheath.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SURFACE MODIFIED BI-COMPONENT POLYMERIC FIBER

BACKGROUND OF INVENTION

Field of the Invention

- [0001]** The invention relates generally to fibers and processes to produce the same. More specifically, the invention relates to synthetic fibers having increased surface roughness and an improved hand feel.

Background Art

- [0002]** Many forms of fibers and fabrics have been made from thermoplastics. The properties of the fibers and fabrics are a function, at least in part, of the polymer(s) from and the processes by which they are made. Representative of these various polymers, fiber and fabric types, and processes for making the fibers and fabrics are those described in U.S. Pat. Nos. 4,076,698, 4,644,045, 4,830,907, 4,909,975, 4,578,414, 4,842,922, 4,990,204, 5,112,686, 5,322,728, 4,425,393, 5,068,141 and 6,190,768, the entirety of each is incorporated herein by reference.
- [0003]** Mineral additives can advantageously be used to affect the properties of the fibers produced from thermoplastics. For example, in U.S. Patent No. 4,254,182 fibers are produced by incorporating silica ranging in size from 10 to 200 millimicrons. The silica is then extracted from the fiber to produce surface irregularities or recesses in the fiber. As a result, the effective fiber surface area and coefficient of friction can be increased, which can reduce the slick, waxy feel, the glossy appearance, and the perception of color depth of the fiber.
- [0004]** Minerals have also been encapsulated in a polymer to form a composite and to achieve a desired physical property benefit. U.S. Patent No. 6,797,377 describes fibers made from a thermoplastic polymer (particularly polypropylene) containing titanium dioxide, wax and at least one mineral filler, such as kaolin or calcium carbonate. The fillers are added in an amount such that the fillers become encapsulated within the polymeric material. It is also noted from the patent that when a mixture of oil and minerals is added together to the polypropylene, the softness of web is improved while the tensile strength of the web is generally reduced.
- [0005]** U.S. Patent No. 5,413,655 and 5,344,862 describe the use of silica as an encapsulated additive in mono-component fibers for nonwoven applications. The additive system includes two components: polysiloxane polyether and hydrophobic

fumed silica. The silica is added in an amount from 3 to 1500 ppm of the thermoplastic polyolefin, and the polyether is added in an amount from 0.1 to 3 weight percent of the thermoplastic polyolefin. The claimed benefit is a significant increase of tensile strength of spunbond nonwoven fabrics.

[0006] Accordingly, there exists a need to improve the cloth-like perception (natural fiber feel) of synthetic fibers.

SUMMARY OF INVENTION

[0007] In one aspect, the present invention relates to a bicomponent fiber having increased surface roughness. The bicomponent fiber can comprise a first polymer and a composite. The composite can form a layer which forms at least a portion of the fiber's surface. The composite can comprise a second polymer and a filler. An average particle size of the filler can be greater than a thickness of the layer formed by the composite.

[0008] The present invention also provides a method of forming a bicomponent fiber including the steps of blending a first polymer and a filler to form a composite, and coextruding under thermal bonding conditions a second polymer and the composite to form the bicomponent fiber. The second polymer may form the polymeric core, and the composite may form a layer that forms at least a portion of a surface of the fiber. An average particle size of the filler may be greater than a thickness of the composite layer.

[0009] The present invention also provides an improvement of a method for manufacturing a bicomponent fiber including coextruding under thermal bonding conditions (a) a first polymer, and (b) a second polymer which forms a layer which forms at least a portion of the fiber's surface. The improvement includes blending a filler with the second polymer to form a composite, wherein the average particle size of the filler is greater than a thickness of the layer formed by the composite.

[0010] Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0011] Figure 1 is a schematic representation of an embodiment of the core/sheath bicomponent fibers of the present invention.

[0012] Figure 2 is a schematic representation of an embodiment of the side-by-side bicomponent fibers of the present invention.

[0013] Figure 3 illustrates simplified particle distribution formats used in developing a model useful in manufacturing embodiments of the bicomponent fibers of the present invention.

[0014] Figures 4 through 6 are SEM pictures of embodiments of the bicomponent fibers of the present invention.

DETAILED DESCRIPTION

[0015] Typical synthetic fibers, which are extruded and drawn, have a very smooth surface with very few imperfections, thus creating a slick, oily feel. In one aspect, embodiments of the invention relate to modifying fiber surface roughness to improve the hand feeling perception of synthetic fibers. The present invention provides a method to impart surface roughness to synthetic fibers, where the surface roughness extending out of the sheath of a bicomponent fiber results in an improved hand feel perception, decreasing the slick, oily feel of the fiber. In one embodiment, adding mineral fillers such as calcium carbonate (CaCO_3) to the polymeric sheath, where the mineral fillers have an average particle size being greater than sheath thickness, can provide a "stick-out" effect, providing a rougher surface, and improving the hand feel perception.

[0016] General Definitions

[0017] As used herein, a "fiber" means a material in which the length to diameter ratio is greater than about 10. Fibers are typically classified according to their diameter. A filament fiber is generally defined as having an individual fiber diameter greater than about 15 denier, usually greater than about 30 denier. A fine denier fiber generally refers to a fiber having a diameter less than about 15 denier. Microdenier fiber is generally defined as fiber having a diameter less than about 100 microns.

[0018] "Filament fiber" or "monofilament fiber" means a continuous strand of material of indefinite (i.e., not predetermined) length, as opposed to a "staple fiber" which is a discontinuous strand of material of definite length (i.e., a strand which has been cut or otherwise divided into segments of a predetermined length).

[0019] "Polyolefin polymer" means a thermoplastic polymer derived from one or more olefins. The polyolefin polymer can bear one or more substituents, e.g., a functional group such as a carbonyl, sulfide, etc. For purposes of this invention, "olefins" include aliphatic, alicyclic and aromatic compounds having one or more double bonds. Representative olefins include ethylene, propylene, 1-butene, 1-hexene,

1-octene, 4-methyl-1-pentene, butadiene, cyclohexene, dicyclopentadiene, styrene, toluene, alpha-methylstyrene and the like.

[0020] "Temperature-stable" and similar terms mean that the fiber or other structure or article comprising the polyolefin polymer of this invention will substantially maintain its elasticity during repeated extensions and retractions after exposure to about 90°C (about 200°F), e.g., temperatures such as those experienced during the manufacture, processing (e.g., dyeing) and/or cleaning of a fabric made from the structure or article.

[0021] "Elastic" means that a fiber will recover at least about 50 percent of its stretched length after the first pull and after the fourth to 100 percent strain (doubled the length). Elasticity can also be described by the "permanent set" of the fiber. Permanent set is the converse of elasticity. A fiber is stretched to a certain point and subsequently released to the original position before stretch, and then stretched again. The point at which the fiber begins to pull a load is designated as the percent permanent set. "Elastic materials" are also referred to in the art as "elastomers" and "elastomeric". Elastic material (sometimes referred to as an elastic article) includes a polyolefin polymer itself as well as, but not limited to, the polyolefin polymer in the form of a fiber, film, strip, tape, ribbon, sheet, coating, molding and the like. The preferred elastic material is fiber. The elastic material can be cured or uncured, radiated or unirradiated, and/or crosslinked or uncrosslinked.

[0022] "Nonelastic material" means a material, such as a fiber, that is not elastic as defined above.

[0023] "Substantially crosslinked" and similar terms mean that the polyolefin polymer, shaped or in the form of an article, has xylene extractables of less than or equal to 70 weight percent (i.e., greater than or equal to 30 weight percent gel content), preferably less than or equal to 40 weight percent (i.e., greater than or equal to 60 weight percent gel content). Xylene extractables (and gel content) are determined in accordance with ASTM D-2765.

[0024] "Cured" and "substantially cured" mean that the polyolefin polymer, shaped or in the form of an article, was subjected or exposed to a treatment which induced substantial crosslinking. The fibers of the present invention can be cured or crosslinked by various methods known to those skilled in the art.

[0025] "Curable" and "crosslinkable" mean that the polyolefin polymer, shaped or in the form of an article, is not cured or crosslinked and has not been subjected or exposed to treatment that has induced substantial crosslinking (although the polyolefin polymer, shaped or in the form of an article, comprises additive(s) or functionality which will effectuate substantial crosslinking upon subjection or exposure to such treatment). In the practice of this invention, curing, irradiation or crosslinking can be accomplished by UV-radiation.

[0026] "Homofil fiber" means a fiber that has a single polymer region or domain, and that does not have any other distinct polymer regions (as do bicomponent fibers).

[0027] "Bicomponent fiber" means a fiber that has two or more distinct polymer regions or domains. Bicomponent fibers are also known as conjugated or multicomponent fibers. The polymers are usually different from each other although two or more components may comprise the same polymer. The polymers are arranged in substantially distinct zones across the cross-section of the bicomponent fiber, and usually extend continuously along the length of the bicomponent fiber. The configuration of a bicomponent fiber can be, for example, a sheath/core arrangement (in which one polymer is surrounded by another), a side by side arrangement, a pie arrangement or an "islands-in-the sea" arrangement. Bicomponent fibers are further described in U.S. Pat. Nos. 6,225,243, 6,140,442, 5,382,400, 5,336,552 and 5,108,820. These patents are incorporated by reference in their entirety.

[0028] "Meltblown fibers" are fibers formed by extruding a molten thermoplastic polymer composition through a plurality of fine, usually circular, die capillaries as molten threads or filaments into converging high velocity gas streams (e.g. air) which function to attenuate the threads or filaments to reduced diameters. The filaments or threads are carried by the high velocity gas streams and deposited on a collecting surface to form a web of randomly dispersed fibers with average diameters generally smaller than 10 microns.

[0029] "Meltspun fibers" are fibers formed by melting at least one polymer and then drawing the fiber in the melt to a diameter (or other cross-section shape) less than the diameter (or other cross-section shape) of the die.

[0030] "Spunbond fibers" are fibers formed by extruding a molten thermoplastic polymer composition as filaments through a plurality of fine, usually circular, die capillaries of a spinneret. The diameter of the extruded filaments is rapidly reduced,

and then the filaments are deposited onto a collecting surface to form a web of randomly dispersed fibers with average diameters generally between about 7 and about 30 microns.

[0031] "Nonwoven" means a web or fabric having a structure of individual fibers or threads which are randomly interlaid, but not in an identifiable manner as is the case of a knitted fabric. The elastic fiber of the present invention can be employed to prepare nonwoven structures as well as composite structures of elastic nonwoven fabric in combination with nonelastic materials.

[0032] "Yarn" means a continuous length of twisted or otherwise entangled filaments which can be used in the manufacture of woven or knitted fabrics and other articles. Yarn can be covered or uncovered. Covered yarn is yarn at least partially wrapped within an outer covering of another fiber or material, typically a natural fiber such as cotton or wool. As here used, "fiber" or "fibrous" means a particulate material in which the length to diameter ratio of such material is greater than about 10. Conversely, "nonfiber" or "nonfibrous" means a particulate material in which the length to diameter ratio is about 10 or less.

[0033] Fiber and other Article Manufacture

[0034] The present inventors have advantageously discovered that bicomponent fibers having improved hand feel can be manufactured by modifying the fiber surface roughness. A bicomponent fiber may include at least two components, i.e., those having at least two distinct polymeric regimes. The first component, i.e., "Component A", serves the purpose of generally retaining the fiber form during thermal bonding at elevated temperatures. The second component, i.e., "Component B", serves the function of an adhesive. Component A can have a higher melting point than Component B. For example, in one embodiment, Component A can have a melt temperature at least about 20°C, preferably at least 40°C, higher than the temperature at which component B will melt. In other embodiments, Component A and Component B can have similar melting points. In yet other embodiments, component B can have a higher melting point than Component A.

[0035] For simplicity, the structure of the bicomponent fibers will be referred to herein as a core/sheath structure. However, the structure of the fiber can have any one of a number of multi-component configurations, as described above, such as

core/sheath, side by side, pie or "islands-in-the sea" arrangements, where Component B forms a layer which forms at least a portion of the surface of the fiber.

[0036] In some embodiments, the core (Component A) may include a thermoplastic polymer, such as a polyolefin. In other embodiments, the core may include an elastomeric polymer illustrative of which are homogenously branched polyolefins, di-block, tri-block or multi-block elastomeric copolymers such as olefinic copolymers such as styrene-isoprene-styrene, styrene-butadiene-styrene, styrene-ethylene/butylene-styrene or styrene-ethylene/propylene-styrene; polyurethanes; polyamides; and polyesters. In certain embodiments, the core may include the olefin block copolymers disclosed in WO2005/090427, herein incorporated by reference.

[0037] The sheath (the adhesive or Component B) may also be elastomeric, such as a homogeneously branched polyolefin, preferably a homogeneously branched ethylene or propylene. These materials are well known. For example, U.S. Pat. No. 6,140,442 provides an excellent description of homogeneously branched, substantially linear polyolefins, especially ethylene polymers; the contents of which are herein incorporated by reference.

[0038] Mineral fillers may be added to the sheath to form a composite and to enhance desired properties. In preferred embodiments, the average particle size of the mineral filler is greater than the sheath thickness, providing a "stick-out" effect. The "stick-out" effect can be illustrated for a core/sheath bicomponent fiber as shown in Figure 1, where a polymeric core 10 is surrounded by a composite sheath that includes a polymeric matrix 12 and mineral filler 14. Figure 2 illustrates the "stick-out" effect for a side-by-side bicomponent fiber. Other forms of bicomponent fibers will have similar characteristics, where the composite Component B will form at least a portion of the surface of the fiber so as to provide a "stick-out" effect, generating surface roughness on the fiber.

[0039] In certain embodiments, the mineral filler may make up from about 1 to about 25 percent by weight of the sheath. In other embodiments, the mineral filler may make up from about 2 to about 20 percent; from about 3 to about 15 percent; or, from about 5 to about 10 percent by weight of the sheath. The sheath may also include other additives, ranging from about 0 to about 5 weight percent of the sheath, including plasticizers, compatibilizers, and other additives common in the art.

[0040] Fillers useful in the present invention to enhance coefficient of friction characteristics of the fiber or to produce a “stick-out” effect include, but are not limited to, untreated and treated silica, alumina, silicon dioxide, talc, calcium carbonate, and clay. In certain embodiments, the preferred mineral filler is a calcium carbonate (CaCO_3). In other embodiments, the mineral filler may be a compatibilized mineral, where the mineral is coated with a compound to enhance the dispersibility and compatibility of the mineral in the polymer matrix. For example, the mineral may be calcium carbonate, where the calcium carbonate is coated with stearic acid to enhance the dispersibility and compatibility of the calcium carbonate in the polymer matrix.

[0041] The average particle size of the mineral filler used in the sheath composite may be selected based upon the desired sheath thickness, and may typically range from about 0.1 to about 20 microns. For example, for a fiber having a sheath thickness of 1 micron, mineral filler having an average particle size greater than about 1 micron can produce the desired “stick-out” effect. In some embodiment, a ratio of the average particle size of the mineral filler to the sheath thickness may be equal to or greater than about 1.0. In other embodiments, the ratio may be greater than about 1 but less than about 2; in other embodiments, the ratio may be greater than about 1.2 but less than about 1.8.

[0042] The mineral filler may have a particle size distribution, where some particles are smaller than the average particle size and other particles are larger than the average particle size. The particle size distribution may affect the “stick-out” effect realized; for example, many particles smaller than the sheath thickness may be encapsulated within the sheath, such as particles 16 in Figures 1 and 2. Particles having a size well in excess of the sheath thickness may result in adhesion problems, where the particles do not remain in the composite matrix. A larger particle size distribution may also lead to a greater spacing between particles sticking out from the sheath (as described further below). In some embodiments of the present invention, a preferred particle size distribution may be less than about 5. In other embodiments, a preferred particle size distribution may be less than about 3; less than about 2.5, less than about 2.0, or less than about 1.5 in other embodiments.

[0043] Fiber diameter can be measured and reported in a variety of fashions. Generally, fiber diameter is measured in denier per filament. Denier is a textile term

[0043] Fiber diameter can be measured and reported in a variety of fashions. Generally, fiber diameter is measured in denier per filament. Denier is a textile term which is defined as the grams of the fiber per 9000 meters of that fiber's length. Monofilament generally refers to an extruded strand having a denier per filament greater than 15, usually greater than 30. Fine denier fiber generally refers to fiber having a denier of about 15 or less. Microdenier (or microfiber) generally refers to fiber having a diameter not greater than about 100 micrometers. For the fibers of this invention, the diameter may be widely varied, with little impact upon the elasticity of the fiber. The fiber denier, however, may be adjusted to suit the capabilities of the finished article and as such, would preferably be from about 0.5 to about 30 denier/filament for melt blown fiber; from about 1 to about 30 denier/filament for spunbond fiber; and, from about 1 to about 20,000 denier/filament for continuous wound filament. The sheath thickness and mineral filler average particle size may be selected based upon the desired filament diameter or denier.

[0044] The bicomponent fibers of the present invention can have a core that comprises from 80 to 99 percent by weight of the fiber. In other embodiments, the core can be from 85 to 95 percent by weight of the fiber. The bicomponent fibers of the present invention can have a sheath that comprises from about 1 to about 20 percent by weight of the fiber. In other embodiments, the sheath comprises from about 5 to about 15 percent by weight of the fiber.

[0045] The shape of the fiber is not limited. For example, typical fibers have a circular cross-sectional shape, but sometimes fibers have different shapes, such as a trilobal shape, or a flat (i.e., "ribbon" like) shape. The bicomponent fibers disclosed herein are not limited by the shape of the fiber.

[0046] The bicomponent fiber of the present invention may be used with other fibers such as PET, nylon, cotton, KEVLAR® (available from E.I. Du Pont de Nemours Co.), etc. to make elastic fabrics. As an added advantage, the heat (and moisture) resistance of certain bicomponent fibers can enable polyester-PET fibers to be dyed at ordinary PET dyeing conditions. Other commonly used elastic fibers, especially spandex (e.g., LYCRA®, a spandex available from E.I. Du Pont de Nemours Co.), are typically used at less severe PET dyeing conditions to prevent degradation of properties.

3,485,706 and 4,939,016, carding and thermally bonding staple fibers; spunbonding continuous fibers in one continuous operation; or by melt blowing fibers into fabric and subsequently calendering or thermally bonding the resultant web. These various nonwoven fabric manufacturing techniques are well known to those skilled in the art and the scope of the present invention is not limited to any particular method. Other structures made from such fibers are also included within the scope of the invention, including, for example, blends of the fibers of the present invention with other fibers (e.g., PET, cotton, etc.).

[0048] Fabricated articles which may be made using the bicomponent fibers and fabrics of this invention include elastic composite articles (e.g., diapers) that have elastic portions. For example, elastic portions are typically constructed into diaper waist band portions to prevent the diaper from falling and leg band portions to prevent leakage (as shown in U.S. Patent No. 4,381,781, which is herein incorporated by reference in its entirety). Often, the elastic portions promote better form fitting and/or fastening systems for a good combination of comfort and reliability. The fibers and fabrics of the present invention may also produce structures that combine elasticity with breathability. For example, the inventive elastic fibers, fabrics and/or films may be incorporated into the structures disclosed in U.S. Patent No. 6,176,952, which is herein incorporated by reference in its entirety.

[0049] The inventive elastic fibers and fabrics can also be used in various structures as described in U.S. Patent No. 2,957,512 (the '512 Patent), which is herein incorporated by reference in its entirety. For example, layer 50 of the structure described in the '512 Patent (i.e., the elastic component) may be replaced with the inventive elastic fibers and fabrics, especially where flat, pleated, creped, crimped, etc., nonelastic materials are made into elastic structures. Attachment of the inventive elastic fibers and/or fabric to nonelastic fibers, fabrics or other structures may be performed by melt bonding or with adhesives. Gathered or shirted elastic structures may be produced from the inventive elastic fibers and/or fabrics and nonelastic components by pleating the non-elastic component (as described in the '512 Patent) prior to attachment, pre-stretching the elastic component prior to attachment, or heat shrinking the elastic component after attachment.

[0050] The inventive fibers may also be used in a spunlaced (or hydrodynamically entangled) process to make novel structures. For example, U.S. Patent No. 4,801,482,

which is herein incorporated by reference in its entirety, discloses an elastic sheet (12) which can now be made with the novel elastic fibers and/or fabric described herein. Continuous elastic filaments as described herein may also be used in woven applications where high resilience is desired.

[0051] U.S. Patent No. 5,037,416 (the '416 Patent), which is herein incorporated by reference in its entirety, describes the advantages of a form fitting top sheet by using elastic ribbons (see member 19 of the '416 Patent). The inventive elastic fibers may serve the function of member 19 of the '416 Patent, or could be used in fabric form to provide the desired elasticity.

[0052] Elastic panels may also be made from the inventive elastic fibers and fabrics disclosed herein, and may be used, for example, as members 18, 20, 14, and/or 26 of U.S. Patent No. 4,940,464 (the '464 Patent), which is herein incorporated by reference in its entirety. The inventive elastic fibers and fabrics described herein may also be used as elastic components of composite side panels (e.g., layer 86 of the '464 Patent).

[0053] The elastic materials of the present invention may also be rendered pervious or "breathable" by any method well known in the art including by aperturing, slitting, microperforating, mixing with fibers or foams, or the like and combinations thereof. Examples of such methods include, U.S. Patent No. 3,156,242 by Crowe, Jr., U.S. Patent No. 3,881,489 by Hartwell, U.S. Patent No. 3,989,867 by Sisson, and U.S. Patent No. 5,085,654 by Buell, each of which is herein incorporated by reference in their entirety.

[0054] Surface Roughness Model of Calcium Carbonate Filled Sheath

[0055] As described above, the bicomponent fibers of the present invention may include a sheath that includes a polymeric material and a filler producing a "stick-out" effect. A simple model describing the fiber surface roughness in terms of the ratio of particle size to sheath thickness and the particle spacing distance in sheath is presented below to allow a better understanding of the present invention.

[0056] The hand-feel perception of a PP nonwoven fabric can be related to the surface roughness of the fabrics at the microscopic level, as in the Kawabata measurement system. The surface roughness may be defined as the departure of the surface shape from some ideal or prescribed form. Thus, for a nominally flat surface, the roughness could be defined in terms of the ratio of the true overall area of the

projected nominal area, or as the slope of a profile taken along some prescribed line, or as the distance between high points and low points on the surface. Two terms are used herein to describe the roughness of a fiber surface: the ratio of average particle size to sheath thickness and the particle spacing in the sheath. As will be shown below, the roughness is directly correlated to the physical properties of the fiber and filler. To establish a simple mathematical model for the thickness of micro composite sheath, the sheath is assumed to be a two-phase filled composite system, while the core is assumed to be a homogeneous polymeric resin, such as homogeneous polypropylene (hPP).

[0057] Correlation between Weight and Volume Content of a Component in Two-Phased Composite.

[0058] For a two-phased composite system, it can be shown that to convert weight percentage to volume percentage, the following formulation can be used:

$$\alpha_{av} = 1 / (1 + (1/\alpha_{aw} - 1) \rho_a/\rho_b) \quad (1)$$

or, equation (2) can be used to convert from volume percentage to weight percentage:

$$\alpha_{aw} = 1 / (1 + (1/\alpha_{av} - 1) \rho_b/\rho_a) \quad (2)$$

where: α_{av} is the volume percentage of component 'a', α_{aw} is the weight percentage of component 'a', ρ_a is the density of the component 'a', and ρ_b is the density of component 'b'.

[0059] For example, for a calcium carbonate filled hPP composite, the density of PP is assumed as 0.90, the density of calcium carbonate is 2.7, and the volume percentage of CaCO_3 to be used is 2 percent. From equation (2), the filling level of this calcium carbonate filled hPP composite is equivalent to 5.77 percent by weight.

[0060] Prediction of Thickness of Two-Phased Composite Sheath for a Bi-component Fiber

[0061] Assumptions used for the prediction of thickness include: (1) the cross section of a bicomponent fiber consists of two perfect concentric circles; and, (2) the composite sheath and homogeneous core sections of the bi-component fiber form as two distinctive phases without intrusion from one to another.

[0062] When the sheath content in the bicomponent fiber is given by a weight percentage, the requisite formulas for estimating the thickness of the composite sheath are:

$$\rho_s = A_f \rho_{\text{filler}} + (1 - A_f) \rho_m$$

$$k = 0.5 \{ (\rho_c w_s / \rho_s w_c + 1)^{0.5} - 1 \}$$

$$h = 11.894 k [\text{dpf} / (\rho_c + 4 \rho_s k (1 + k))]^{0.5}$$

$$D_c = h / k$$

$$D_f = D_c + 2h$$

where ρ_{filler} is the density of the filler in g/cm^3 ; ρ_m is the density of the polymer matrix in g/cm^3 ; A_f is the volume percent of the filler in the microcomposite; w_f is the weight percent of the filler in the microcomposite; ρ_c is the density of the polymer in the core section of a bicomponent fiber in g/cm^3 ; ρ_s is the density of the polymer in the sheath section of a bicomponent fiber in g/cm^3 ; w_c is the weight percent of the core section; w_s is the weight percent of the sheath section (note that: $w_c + w_s = 1$); V_c is the volume percent of the core section; V_s is the volume percent of the sheath section (note that: $V_c + V_s = 1$); dpf is denier per filament, or grams of a filament in 9000 meters; k is a parameter relating the sheath to the core; h is the thickness of the sheath in microns; D_c is the diameter of the core section in microns; and, D_f is the diameter of the bicomponent fiber in microns.

[0063] Examples of estimated values of sheath thickness of a calcium carbonate filled bicomponent hPP fiber based on known filler content by weight percent (w_f) are shown in Table 1. The core is hPP polymer (density = $\rho_c = 0.90 \text{ g/cm}^3$), while the sheath is a calcium carbonate (density = 2.70 g/cm^3) filled hPP microcomposite, resulting in a sheath density, ρ_s , greater than the core density, ρ_c .

Table 1. Estimated sheath thickness for a calcium carbonate filled PP sheath based on w_f .

$w_f = 10$						
	$w_s = 10$		$w_s = 15$		$w_s = 20$	
dpf	4	2	4	2	4	2
ρ_s	0.931	0.931	0.931	0.931	0.931	0.931
k	0.026	0.026	0.041	0.041	0.057	0.057
$h (\mu\text{m})$	0.623	0.440	0.947	0.670	1.282	0.906
$D_c (\mu\text{m})$	23.79	16.82	23.12	16.35	22.43	15.86
$D_f (\mu\text{m})$	25.03	17.70	25.01	17.69	24.99	17.67
$w_f = 20$						
	$w_s = 10$		$w_s = 15$		$w_s = 20$	
dpf	4	2	4	2	4	2
ρ_s	0.964	0.964	0.964	0.964	0.964	0.964
K	0.025	0.025	0.040	0.040	0.055	0.055
$h (\mu\text{m})$	0.602	0.425	0.916	0.647	1.240	0.877
$D_c (\mu\text{m})$	23.79	16.82	23.12	16.35	22.43	15.86
$D_f (\mu\text{m})$	24.99	17.67	24.95	17.64	24.91	17.61

[0064] When the sheath content in a bicomponent fiber is known as a volume percentage, the formulation for calculating the thickness of composite sheath is modified based upon the relationship between volume percentage and weight percentage as given above.

[0065] The filler content in the sheath can be expressed either as a weight percent or as a volume percent, thus the formulas for estimating sheath thickness can be developed accordingly. It should be noted that the formulas only approximate sheath thickness as the volume of the "stick-out" portion of particles was included as if submerged in the polymer matrix. As a result, the actual sheath thicknesses should be less than the predicted thickness. However, because the volume percent of the filler in the sheath is typically low (15% or less), the error involved is small and can be neglected in most instances.

[0066] From Table 1 it can be shown that for a constant sheath content by weight percent in a bicomponent fiber, the larger the diameter of the bicomponent fiber (or the larger the dpf), the larger the thickness of the micro-composite sheath will be. Further, for a constant diameter (or dpf) of a bicomponent fiber, the higher the weight percentage of the sheath content, the thicker the sheath will be. Finally, the effect of filler content in the sheath on the sheath thickness is relatively small. As the filling level increases, the thickness of the sheath increases in a small amount. Similar observations can be made relating to the thickness of sheath when viewed by volume percent.

[0067] The fiber surface roughness represented by the filler particle "stick-out" effect may be partially described in terms of the ratio of the filler particle size to the sheath thickness. If this ratio is less than 1, the particle would be submerged in the polymeric sheath matrix and less effective in creating surface unevenness. On other hand, if the ratio exceeds 2, more than one-half of the volume of a mineral particle could stick out of the sheath and be exposed to air, possibly causing the sheath to lose its holding power to the imbedded particle. It should be noted, however, that this approximation does not consider mechanical and adhesion effects that, when present, may allow the ratio to be significantly higher. In one embodiment, the ratio of the filler particle size to sheath thickness may range from about 1 to about 2. In another embodiment, the ratio may range from about 1.2 to about 1.8. In yet other embodiments, the ratio may be greater than about 2.

[0068] Estimation of Particle Spacing in Two-Phased Composite Sheath of a Bi-component Fiber

[0069] From the above discussions, the importance of selecting a proper particle size to ensure the “stick-out” effect is clearly demonstrated. Another factor influencing the perceived hand feel perception in micro scale is the particle spacing in the sheath, which can be correlated to the particle size, the volume percentage of the fillers, and the spatial arrangement of the particles. Wang et al. proposed the following models representing the mean distance between spherical filling particles (Meng-Jiao Wang, Siegfried Wolff, and Ewe-Hong Tan, “Filler-Elastomer Interactions. Part VIII. The Role of the Distance Between Filler Aggregates in the Dynamic Properties of Filled Vulcanizates”, Rubber Chemistry and Technology, Vol 66, 178-195 (1993)). In the case of the loosest, i.e., cubic, form of arrangement of the particle, the particle center to center distance is given by:

$$L = 0.805 \phi^{-1/3} d$$

where ϕ is the volume percentage of the filler, and d is a characteristic length of a particle.

[0070] For the closest arrangement of the particles, i.e., face-centered cubic arrangement, the particle center to center distance is given by:

$$L = 0.906 \phi^{-1/3} d$$

[0071] For a random packing arrangement, the averaged value of $0.86 \phi^{-1/3} d$ can be used.

[0072] The particle size variation in the thickness direction (or the z-direction) can be effectively eliminated by assuming that the particle size is in the same order of magnitude of the thickness of the sheath, resulting in the model simplifying to a planar or 2 dimensional particle size distribution. Four possible cases are considered: particle in cubic and spherical shapes, and particle distribution in square and equilateral triangle arrangements.

[0073] Four assumptions were made to estimate the particle spacing. First, the thickness of sheath is in same order of average particle size of CaCO_3 fillers, i.e., if the average particle size is 1 μm , the thickness of the sheath is also 1 μm . Thus, the distribution of fillers in the sheath can be considered two-dimensional. Second, filler particles are uniformly distributed in the polymer matrix of the sheath. Third, all particles are evenly distributed in the sheath, either formed as squares or equilateral

triangles. And, fourth, the particle sizes are very narrow distributed, thus only the average particle size is used for modeling the spacing distance.

[0074] Particle spacing can then be estimated based upon the formatting of the particles in space. Particles can be in a square format or an equilateral triangle format, as illustrated in the left and right sides of Figure 3, respectively. The results also depend upon whether the particles are assumed to be spheres or cubes (affecting the characteristic length of the particle). The resulting formulas to calculate particle spacing are given in Table 2, where L is the particle spacing, d is the particle size (characteristic length: the side length for a cubic particle or the diameter for a spherical particle), and α_{av} is the ratio of particle volume percentage to the polymer matrix volume percentage.

Table 2. Filler particle spacing estimates.

	Particles as Cubes	Particles as Spheres
Square Formatting	$L = (1/\alpha_{av})^{1/2} d$	$L = (0.524/\alpha_{av})^{1/2} d$
Equilateral Triangle Formatting	$L = (1.155/\alpha_{av})^{1/2} d$	$L = (0.605/\alpha_{av})^{1/2} d$

[0075] For each of the above formulas, particle spacing is directly proportional to the particle size. Thus, at a constant volumetric filling level, the particle spacing distance is determined by the characteristic dimension of the particles for each of the above formulas. The ratio of particle spacing to the particle characteristic dimension (L/d) is listed in Table 3 for systems having 3 to 15 weight percent filler. It should be pointed out that the maximum filling level of particles in the polymer matrix will also depend on the mixing capacity of the extruder.

Table 3. L/d Ratio for 3 to 15 weight percent filler

Wt. %	vol. %	Particles in Cubes		Particles in Spheres		Average
		Square	Equilateral triangle	Square	Equilateral triangle	
3	1.0	9.90	10.64	7.16	7.70	8.85
5	1.7	7.62	8.19	5.51	5.92	6.81
8	2.8	5.96	6.40	4.31	4.63	5.33
10	3.6	5.29	5.69	3.83	4.12	4.73
15	5.6	4.24	4.56	3.07	3.30	3.79

[0076] Several observations can be made from the data shown in Table 3. First, as the filling content increases, the particle concentration level increases, thus the distance between particles becomes shorter. Second, when keeping the loading level, particle arrangement, and particle characteristic dimensions constant, the distance

between spherical particles is less than that between cubic particles (by definition, the volume of a cubic particle is larger than that of a spherical particle having the same characteristic length d). Conversely, there are a greater number spherical particles than cubic particles under the same loading level, thus the particle spacing distance becomes shorter.

[0077] For this simplified model, the particles of the filler are modeled as small cubes or spheres. The distribution of particles in the sheath is treated as in arrangement of square or equilateral triangle. In real life, the particles are most likely random packed, and the shapes of the particles are more or less irregular. One way to treat this variation is to use an averaged value for the packing arrangement. The particle diameter is also replaced by an aggregate diameter (as described in Wang et al.). For simplicity, a mean particle spacing distance was adopted for the model by averaging the four values of particle spacing distances shown in Table 3 (alternatively, $L/d \approx (0.8/\alpha_{av})^{1/2}$).

[0078] It was discovered that the fiber surface roughness in a scale of 1 to 10 micron would generate an improved hand feel perception. To generate the desired fiber roughness, the required ratio of particle spacing to particle size, L/d , may vary based upon particle size. In particular embodiments the L/d ratio may range from 1 to 10. For example, if the particle size is less than 1 micron, the ratio may be chosen to be from 3 to 6 to generate the desired roughness. If the particle size is equal to or greater than 1 micron, the ratio may be chosen to be from 2 to 4. It is thus seen from Table 3 that when a filler loading level is less than 5 percent by weight, the particle spacing may be too large to be effective for improving the fiber's tactile properties.

[0079] The actual particle size is typically not the same for all filling particles, as fillers are generally available having an average particle size and a particle size distribution, from narrow to broad. The above calculations relating particle size to the sheath thickness can be determined by using averaged (or mean) particle size, noting that particle size distribution will affect the actual spacing and fiber surface roughness. For mineral fillers with narrow particle size distribution (less than about 2.0), the effect of the distribution on particle spacing can be neglected. For fillers with a broader particle size distribution (greater than about 3.0), the broader particle size distribution would lead to a greater distance between the particles. For example, the surface roughness of a fiber with a narrow particle size distribution will be

different than that with a broader particle size distribution because the fiber incorporating the broad size distribution has more particles that are smaller than the average particle size. Thus these smaller particles could possibly be submerged in the sheath, potentially resulting in a decreased “stick-out” effect. A broad size distribution also has a greater number of particles larger than the average particle size than does a narrow distribution. However, the effect of having a greater number of particles larger than the average particle size might be negated by the increased particle spacing for particles that do in fact create a “stick-out” effect and the increased likelihood of potential adhesion problems.

[0080] Although the above model can be used for estimating the ratio of average particle size to the sheath thickness and the particle spacing distance in the sheath, the model should be used qualitatively rather than quantitatively as many approximations were used to derive the formulas. The general principles for using mineral filler for changing fiber surface morphology are, however, clearly represented by the model, and the model can provide initial design guidance.

[0081] Examples

[0082] A spinning trial was conducted by producing bicomponent fibers, with the sheath being a calcium carbonate filled polymer micro-composite. The core was Polypropylene 5D49, a commercially available homopolymer available from the Dow Chemical Company (38 MFR; 0.90 g/cm³ density). The sheath was 5D49 compounded with various grades of calcium carbonate, as shown in Table 4. These fibers were compared to a 5D49 homofil fiber (2 or 4 dpf, as appropriate) as a control (comparative) sample.

[0083] *Selection of Calcium Carbonate.* Three commercially available grades of calcium carbonate having average particle sizes ranging from 0.4 to 1.2 micron were selected for studying the “stick-out” effect: TUFFGARD® (a precipitated calcium carbonate having a 0.4 micron average particle size and a top cut at about 2 microns, commercially available from Specialty Minerals Inc., Adams, MA); SUPER-PFLEX® 200 (a precipitated calcium carbonate having a 0.7 micron average particle size and a top cut at about 4 microns, surface coated with 2% stearic acid to promote dispersion in the polymer, also commercially available from Specialty Minerals Inc., Adams, MA); and, FILMLINK® 400 (a ground calcium carbonate having a 1.2

micron average particle size and a top cut at about 8 microns, surface coated with 0.8 to 1.2% stearic acid, commercially available from Imerys, Roswell, GA).

[0084] *Compounding.* Compounding was performed in two steps to ensure dispersion of calcium carbonate in the hPP. First, calcium carbonate was compounded with hPP (5D49) at a 40/60 weight ratio to form concentrates by using a Banbury® mixer. Second, the calcium carbonate – hPP concentrates were diluted to the desired compositions according to the formulations in Table 4 by using a HAAKE® 1" twin screw extruder at mild torque and mild melt temperature settings (about 210°C).

[0085] *Fiber Spinning.* The fiber samples were prepared with a fiber spinning line consisting of two 1" single screw extruders, two Zenith gear pumps, a 144-hole spinneret, a fiber quenching cabinet, and a wind-up station. The capillary hole of the spinneret was 0.65 mm in diameter with a length to diameter ratio of 4:1. The melt temperature was setup at 240°C. The throughput was 0.4 grams per hole per minute. The spinning speed was set at 1000 m/min for producing 4 dpf (denier per filament) fiber and 2000 m/min for 2dpf fiber, respectively. Fibers were collected in spools for subsequent property testing. The fiber spinning ran very smoothly, and no fiber breaks were detected in producing any of the samples.

Table 4. CaCO₃ Surface Modified Bicomponent Fiber Samples

Sample	CaCO ₃	Filler, wt.% in sheath	Sheath vol.% of total fiber	Fiber Denier dpf	Particle Diameter d (μm)	Sheath Thickness h (μm)	d/h Ratio	Fiber Diameter D (μm)	Estimated Particle Spacing L (μm)
1	TUFFGARD®	5	10	4	0.4	0.64	0.63	25	3.0
2	TUFFGARD®	5	10	2	0.4	0.45	0.89	17.7	3.0
3	TUFFGARD®	10	10	4	0.4	0.58	0.69	24.9	2.1
4	TUFFGARD®	10	10	2	0.4	0.45	0.89	17.7	2.1
5	SUPER-PFLEX®	5	10	4	0.7	0.64	1.09	25	5.3
6	SUPER-PFLEX®	5	10	2	0.7	0.45	1.56	17.7	5.3
7	SUPER-PFLEX®	10	10	4	0.7	0.58	1.21	24.9	3.7
8	SUPER-PFLEX®	10	10	2	0.7	0.45	1.56	17.7	3.7
9	FILMLINK®	10	15	4	1.2	0.97	1.24	24.9	6.3
10	FILMLINK®	10	15	2	1.2	0.69	1.74	17.6	6.3

[0086] *SEM Analysis on Fiber Surface Morphology.* Small areas of the fibers were cut and placed on aluminum scanning electron microscopy (SEM) sample mounts in order to acquire surface and cross sectional images. Samples were coated with gold

palladium twice for 20 seconds. Secondary electron images of the fiber surface were collected on a Hitachi S4100 scanning electron microscope using a 5kV accelerating voltage.

[0087] SEM images of the surface of three representative surface modified bicomponent fibers, Samples 4, 8, and 10, are displayed in Figures 4 – 6, respectively. All three fibers are 2dpf (17.7 micron in diameter) and contain 10% sheath by volume.

[0088] Referring to Figure 4, the SEM image of fiber Sample 4 indicates that the calcium carbonate particles in this sample were smaller and more concentrated when compared to the SEM images of the other two fiber samples (Figures 5 and 6). This observation is in accord with the predictions from the model – because the grade of calcium carbonate, TUFFGARD®, has a smaller particle size (0.4 micron), and the ratio of particle size to the sheath thickness is less than 1, the model predicts a less significant “stick-out” effect, and a closer particle spacing distance. Further, the differences in topography were not discernable between the 5% (Sample 2, SEM image not presented) and 10% samples, with the images of the fiber surfaces appearing very similar.

[0089] Referring to Figure 5, the image of Sample 8 indicates that this fiber has the most overall surface roughness. The fiber not only has calcium carbonate “bumps”, but also has craters or depressions formed around the calcium carbonate particles, which were not evident in Figure 4. The calcium carbonate contained in Sample 8, SUPER-PFLEX® 100, has a particle size of 0.7 micron. Thus the ratio of size to sheath thickness is greater than 1, and the improvement in “stick-out” effect over Sample 4 is anticipated from model.

[0090] Referring to Figure 6, the particle size of Sample 10 appears the largest and the least concentrated on the fiber. There was some evidence of depressions or craters, but less severe than Sample 8. The calcium carbonate, FILMLINK® 400, in this fiber has the largest particle size (1.2 micron), and the ratio of particle size to sheath thickness is greater than 1. The SEM images appear to validate the model, as the “stick-out” effect appears to be the strongest of the three fiber samples, and the spacing distance also appears to be the largest.

[0091] The formation of craters or depressions on the fiber surface is not fully understood. One hypothesis is that craters or depressions may be generated when

some large calcium carbonate particles are sloughed due to centrifugal force or other causes encountered during the spinning process. A loss of some calcium carbonate particles during fiber spinning does not hinder the creation of surface roughness, as craters left by the discarded particles do provide surface roughness. However, the discarding of particles during the spinning process may cause a concern of dusting. For a spunbond line, dusting should not be an issue, as there are suction fans underneath the forming web where the fibers are hitting the web and forming the pre-form nonwovens. In other applications, improved ventilation conditions around the fabrication line may be needed; however, as the filling content of calcium carbonate in the fiber is low, about 1% of fiber by weight, any dusting that might occur should not be severe and could be easily overcome.

[0092] *Knitted Socks*

[0093] The 2 dpf fiber samples, including the hPP control, were knitted on a Lawson-Hemphill sock knitter. The wales and courses per inch (wpi and cpi) are a measure of the knit density. The wales go in the machine direction of the fabric, the courses in the cross direction. The fabric density is defined as the product of wales and courses. The wpi and cpi of the six samples were measured as 26 and 32, respectively. The density of each sample was 832.

[0094] *The Hand Feel Result.* The hand feel perception of the knitted socks made from the 2 dpf fibers are given in Table 5. Samples 2 and 4, with a particle to sheath thickness ratio less than 1, did not generate a significant improvement in hand feel. There is no significant “stick-out” effect, as predicted by the model and observed in the SEM image of Sample 4 in Figure 4. Samples 8 and 10 did have an improved hand feel perception as compared to the control sample, which is made of hPP (5D49) mono fibers without the surface modifications.

Table 5. Hand Feel Ranking for Select Fiber Samples

Sample	Particle Diameter, d (μm)	Sheath Thickness, h (μm)	d/h Ratio	Particle Spacing, L (μm)	Hand Feel of knitted socks
Control	--	--	--	--	Slick, wet
2	0.4	0.45	0.89	3.0	No difference from Control
4	0.4	0.45	0.89	2.1	A little slick
6	0.7	0.45	1.56	5.3	A little slick
8	0.7	0.45	1.56	3.7	Soft and Dry (best of those tested)
10	1.2	0.69	1.74	6.3	Less slick, dry, better than the control sample

[0095] As shown by the description and examples above, bicomponent fibers having a micro-composite surface component can improve the hand feel perception of synthetic fibers. By incorporating mineral fillers having a particle size larger than the thickness of the micro-composite polymer matrix, a "stick-out" effect can be obtained, resulting in surface roughness and an improved feel. In certain embodiments, the bicomponent fibers having an improved feel are useful in end products such as carpets, synthetic hair, feminine hygiene products, diapers, athletic sportswear, apparel, upholstery, bandages and sterilizable medical apparel and instrument wraps

[0096] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

[0097] All priority documents are herein fully incorporated by reference for all jurisdictions in which such incorporation is permitted. Further, all documents cited herein, including testing procedures, are herein fully incorporated by reference for all jurisdictions in which such incorporation is permitted.

CLAIMS

We claim:

1. A bicomponent fiber having increased surface roughness comprising:
a first polymer; and
a composite comprising a second polymer and a filler, wherein the composite forms a layer that forms at least a portion of the fiber's surface, and wherein an average particle size of the filler is greater than a thickness of the layer formed by the composite.
2. The bicomponent fiber of claim 1, wherein the bicomponent fiber has a sheath/core configuration, the sheath comprising the composite, the core comprising the first polymer, and wherein a thickness of the sheath is less than an average particle size of the filler.
3. The bicomponent fiber of claim 1, wherein the first polymer is selected from the group consisting of a polyolefin, a di-block, tri-block or multi-block elastomeric copolymer, a polyurethane, a polyamide, a polyester, or combinations thereof.
4. The bicomponent fiber of claim 3, wherein the di-block, tri-block, or multi-block elastomeric copolymer is selected from the group consisting of styrene-isoprene-styrene, styrene-butadiene-styrene, styrene-ethylene/butylene-styrene, styrene-ethylene/propylene-styrene, or combinations thereof.
5. The bicomponent fiber of claim 1, wherein the first polymer comprises a polyolefin.
6. The bicomponent fiber of claim 5, wherein the polyolefin is a homogenously branched polyolefin.
7. The bicomponent fiber of claim 5, wherein the polyolefin is derived from at least one monomer selected from the group consisting of ethylene, propylene, 1-butene, 1-hexene, 1-octene, 4-methyl-1-pentene, butadiene, cyclohexene, dicyclopentadiene, styrene, toluene, alpha-methylstyrene, or combinations thereof.
8. The bicomponent fiber of claim 1, wherein the composite comprises an elastomeric polymer.
9. The bicomponent fiber of claim 8, wherein the elastomeric polymer is selected from the group consisting of a homogenously branched polyolefin, a di-block, tri-block or multi-block elastomeric copolymer, a polyurethane, a polyamide, a polyester, or combinations thereof.
10. The bicomponent fiber of claim 9, wherein the polyolefin is derived from at least one monomer selected from the group consisting of ethylene, propylene, 1-butene, 1-

- hexene, 1-octene, 4-methyl-1-pentene, butadiene, cyclohexene, dicyclopentadiene, styrene, toluene, alpha-methylstyrene, or combinations thereof.
11. The bicomponent fiber of claim 1, wherein the filler is selected from the group consisting of silica, alumina, calcium carbonate, silicon dioxide, a clay, or combinations thereof.
 12. The bicomponent fiber of claim 1, wherein the filler comprises calcium carbonate.
 13. The bicomponent fiber of claim 11, wherein the filler is coated with a compatibilizer.
 14. The bicomponent fiber of claim 13, wherein the compatibilizer is stearic acid.
 15. The bicomponent fiber of claim 1, wherein the composite comprises from about 1 to about 20 weight percent of the fiber.
 16. The bicomponent fiber of claim 15, wherein the composite comprises from about 5 to about 15 weight percent of the fiber.
 17. The bicomponent fiber of claim 1, wherein the filler comprises from about 1 to about 25 weight percent of the composite.
 18. The bicomponent fiber of claim 1, wherein the filler comprises from about 3 to about 15 weight percent of the composite.
 19. The bicomponent fiber of claim 1, wherein the average particle size of the filler ranges from about 0.1 to about 20 microns.
 20. The bicomponent fiber of claim 1, wherein a ratio of the average particle size of the filler to the composite layer thickness is greater than 1 and less than 2.
 21. The bicomponent fiber of claim 20, wherein a ratio of the average particle size of the filler to the composite layer thickness is from 1.2 to 1.8.
 22. The bicomponent fiber of claim 1, wherein a particle size distribution of the filler is less than 3.0.
 23. The bicomponent fiber of claim 22, wherein a particle size distribution of the filler is less than 2.0.
 24. The bicomponent fiber of claim 1:
 - wherein a ratio of a filler particle center to center distance (L) to the average particle size (d) of the filler
 - a) is between about 3 and about 6 when the average particle size is less than 1 micron, or
 - b) is between about 2 and about 4 when the average particle size of the filler is 1 micron or greater;

wherein the center to center distance (L) is calculated as equal to $(0.8/\alpha_{av})^{1/2}d$,
where α_{av} is the ratio of particle volume percentage to the polymer matrix
volume percentage.

25. The bicomponent fiber of claim 1, wherein the fiber is elastic.
26. The bicomponent fiber of claim 1, wherein the fiber is crosslinked.
27. An article comprising the fiber of claim 1.
28. A method of forming a bicomponent fiber comprising:
 - blending a first polymer and a filler to form a composite;
 - coextruding under thermal bonding conditions a second polymer and the composite to form the bicomponent fiber;
 - wherein the second polymer forms the polymeric core and the composite forms a layer that forms at least a portion of a surface of the fiber; and
 - wherein an average particle size of the filler is greater than a thickness of the composite layer.
29. The method of claim 28 wherein the coextruding comprises forming a fiber having a round, oval, trilobal, triangular, dog-boned, flat or hollow shape and a symmetrical or asymmetrical sheath/core or side-by-side configuration.
30. The method of claim 29 wherein the bicomponent fiber has a round shape and a sheath/core configuration.
31. In a method for manufacturing a bicomponent fiber by coextruding under thermal bonding conditions (a) a first polymer, and (b) a second polymer which forms a layer which forms at least a portion of the fiber's surface, the improvement comprising:
 - blending a filler with the second polymer to form a composite;
 - wherein the average particle size of the filler is greater than a thickness of the layer formed by the composite.
32. A bicomponent fiber comprising a composite comprising a polymer and a filler wherein a composite forms a layer that forms at least a portion of the fiber's surface, and wherein an average particle size of the filler is greater than a thickness of the layer formed by the composite.

Figure 1

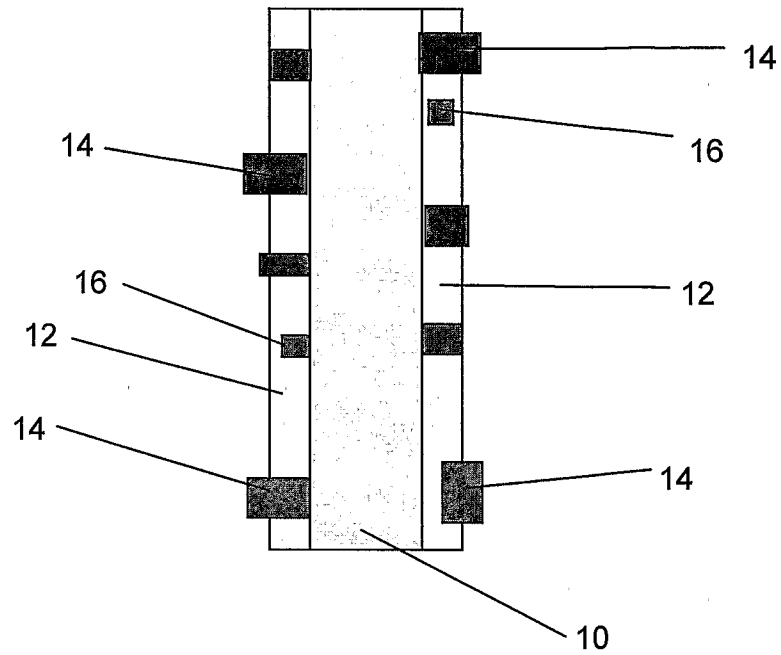


Figure 2

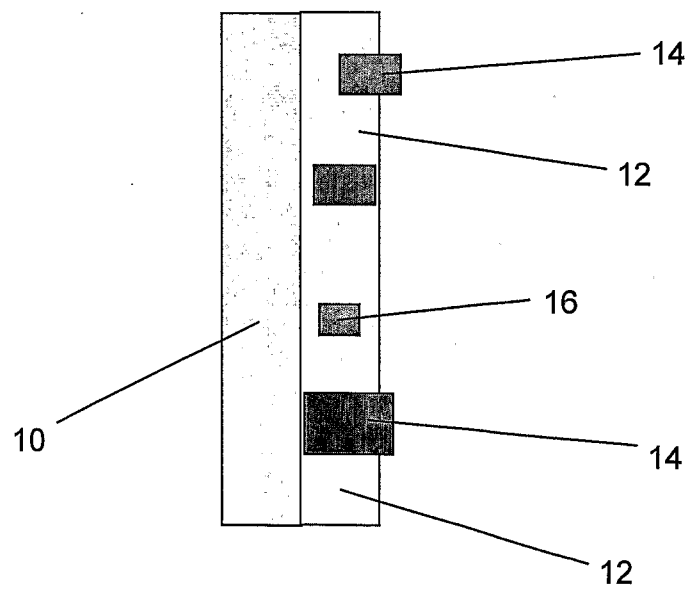


Figure 3

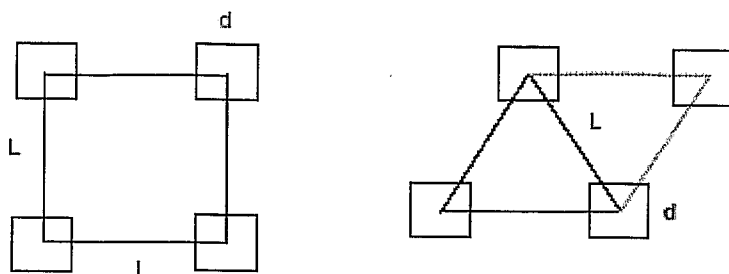


Figure 4

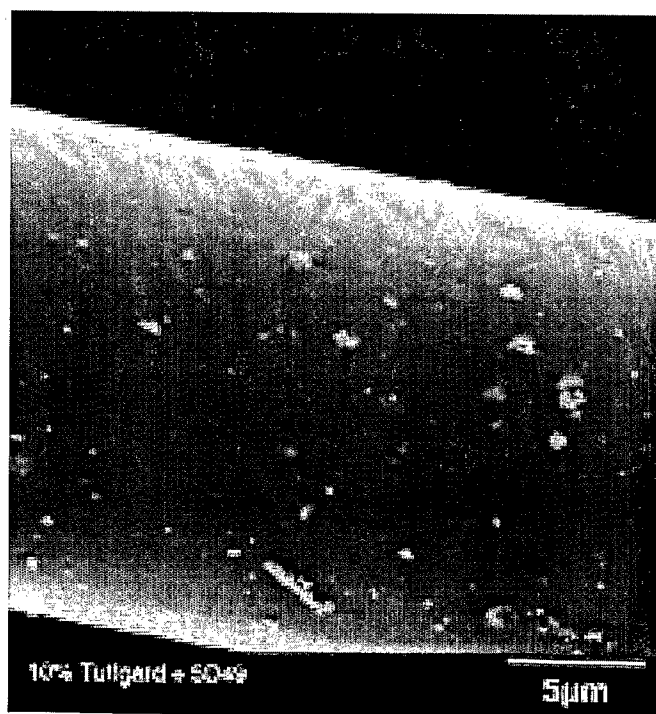


Figure 5

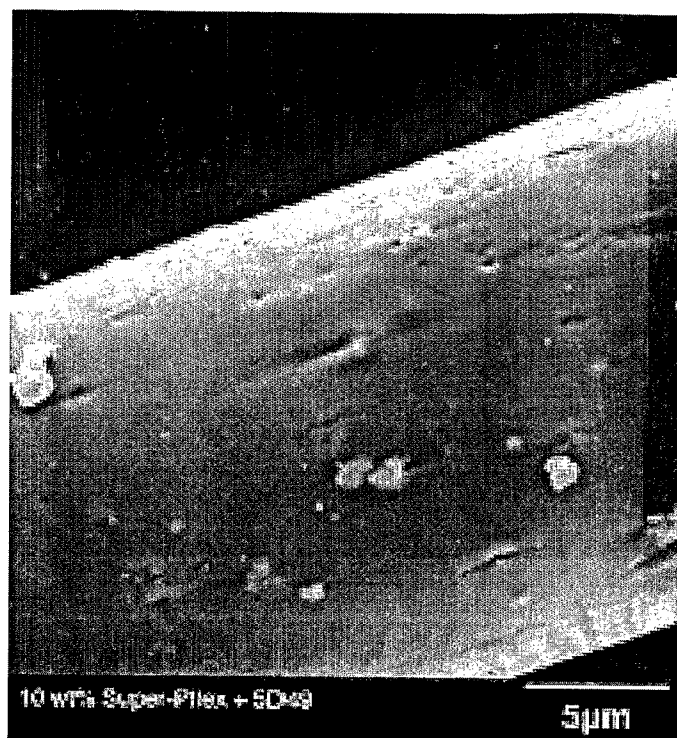
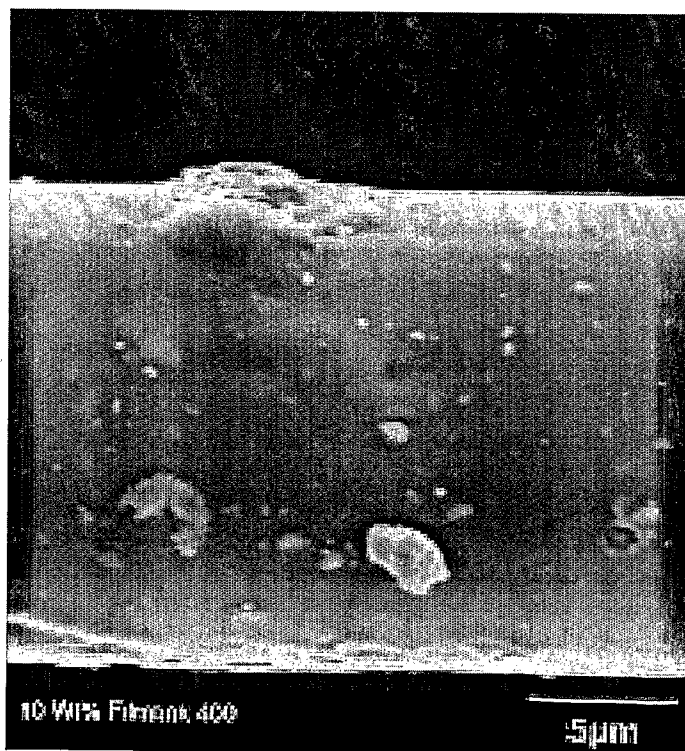


Figure 6



INTERNATIONAL SEARCH REPORT

International application No

PCT/US2006/045725

A. CLASSIFICATION OF SUBJECT MATTER
 INV. D01F1/10 D01F8/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 D01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DATABASE CA [Online] CHEMICAL ABSTRACTS SERVICE, COLUMBUS, OHIO, US; 30 April 1994 (1994-04-30), IIZUKA, SHIHO ET AL: "Abrasion-resistant far-IR-radiating insulative synthetic conjugate fibers" XP002422911 retrieved from STN Database accession no. 120:220287 abstract -& JP 05 321028 A (TEIJIN LTD, JAPAN) 7 December 1993 (1993-12-07)	1-3,9, 17, 19-21, 27-32
A	WO 2005/017240 A (FOSS MFG CO INC [US]; FOSS STEPHEN W [US]; PFORTNER PETER [US]; SAWVEL) 24 February 2005 (2005-02-24) the whole document ----- -/--	1-32

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

2 March 2007

Date of mailing of the international search report

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Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
 Fax: (+31-70) 340-3016

Authorized officer

Barker, Stephan

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2006/045725

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2002/148060 A1 (NEEDHAM MICHAEL CHRISTOPHER [US] ET AL) 17 October 2002 (2002-10-17) paragraphs [0010] - [0012]; claims 1-30 -----	1-32
A	EP 0 162 564 A2 (TEIJIN LTD [JP]) 27 November 1985 (1985-11-27) claims 1-6 -----	1-32
A	GB 2 016 364 A (KURURAY CO LTD) 26 September 1979 (1979-09-26) claims 1-12 -----	1-32

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2006/045725

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
JP 5321028	A	07-12-1993	NONE	
WO 2005017240	A	24-02-2005	NONE	
US 2002148060	A1	17-10-2002	NONE	
EP 0162564	A2	27-11-1985	NONE	
GB 2016364	A	26-09-1979	DE 2909188 A1	06-12-1979
			JP 1449452 C	11-07-1988
			JP 54120728 A	19-09-1979
			JP 62028229 B	18-06-1987
			US 4254182 A	03-03-1981