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(54) PROCESS FOR MAKING AN ARTICLE OF MANUFACTURE

(57) A process, for example a continuous process, for making an article of manufacture containing a fibrous structure and more particularly a process for making an article of manufacture containing a fibrous structure, such as a soluble fibrous structure, containing soluble filaments is provided.

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a process, for example a continuous process, for making an article of manufacture comprising a fibrous structure and more particularly to a process for making an article of manufacture comprising a fibrous structure, such as a soluble fibrous structure, comprising soluble filaments, for example water-soluble filaments.

BACKGROUND OF THE INVENTION

[0002] Processes for making fibrous structures, for example soluble fibrous structures, and/or components thereof, such as soluble filaments, are known in the art. Further, the fibrous structures and/or components thereof have been ultimately incorporated into an article of manufacture, such as a consumer product, for example fabric care products, hair care products, tooth care products, and the like. However, such known processes to date have been discontinuous. In other words, such known processes have at least two or more discrete (discontinuous) steps or unit operations that interrupt the process of making an article of manufacture, for example one or more steps of making a fibrous structure uncoupled and/or discrete from one or more steps of converting the made fibrous structure into the article of manufacture, for example a consumer product. Such a non-continuous/discontinuous process may comprise one or more of the following steps: 1) a filament-forming composition making step, such as a batch process to make a filament-forming composition; 2) a spinning step for spinning the filament-forming composition to make filaments, for example soluble filaments; 3) optionally, a commingling (coforming) step for commingling solid additives, for example particles, with filaments; 4) a collection step for collecting the filaments and/or commingled filaments and solid additives on a collection device to form a fibrous structure, for example a soluble fibrous structure; 5) a converting operation (one or more steps for converting (for example slitting and/or stacking and/or calendering and/or treating with minors, such as perfumes, enzymes, bleaches, flavoring agents, effervescent agents, and the like, die-cutting, and printing) the fibrous structure into one or more articles of manufacture, for example a consumer product); and 6) optionally a packaging step for packaging the articles of manufacture.

[0003] One problem faced by formulators is how to make such articles of manufacture comprising fibrous structures, for example soluble fibrous structures, continuous or more continuous than the known discontinuous process. In other words, one problem faced by formulators is how to combine multiple process steps from above into a continuous process such that they are not discrete, discontinuous process steps.

[0004] Accordingly, there is a need for a process for making articles of manufacture, for example consumer products, comprising a fibrous structure, for example a soluble fibrous structure, in a continuous or at least partially continuous process.

SUMMARY OF THE INVENTION

[0005] The present invention fulfills the need described above by providing a continuous process and/or continuous process steps within the process to make an article of manufacture, for example a consumer product, comprising a fibrous structure, for example a soluble fibrous structure.

[0006] One solution to the problem identified above is to provide a process for making an article of manufacture, for example a consumer product, comprising a fibrous structure, for example a soluble fibrous structure, in a continuous or more continuous process. Such a continuous process comprises at least the following steps: 1) a filament-forming composition making step to make a filament-forming composition; 2) a spinning step for spinning the filament-forming composition to make filaments, for example soluble filaments; 3) optionally, a commingling (coforming) step for commingling solid additives, for example particles, with the filaments; and 4) a collection step for collecting the filaments and/or commingled filaments and solid additives on a collection device to form a fibrous structure, for example a soluble fibrous structure, wherein the steps (1-4) when present are performed in a continuous manner, one step after the other without any breaks or stoppages or interruptions in the process from making a filament-forming composition to spinning the filament-forming composition into filaments (optionally commingling solid additives with the filaments) to collecting the filaments (and/or commingled filaments and solid additives) on a collection to form a fibrous structure, which may then be converted into an article of manufacture and ultimately packaged, for example into a consumer package. The continuous process may further comprise 5) a converting operation (one or more steps for converting (for example slitting and/or stacking and/or calendering and/or treating with minors, such as perfumes, enzymes, bleaches, flavoring agents, effervescent agents, and the like, die-cutting, and printing) the fibrous structure into one or more articles of manufacture, for example a consumer product); and 6) optionally a packaging step for packaging the articles of manufacture.

[0007] The present invention provides a continuous process for making a fibrous structure and ultimately an article of manufacture.

[0008] In one example of the present invention, a process for making a fibrous structure, the process comprising the steps of:

a. providing one or more soluble filament-forming materials;
b. forming an aqueous composition comprising the one or more soluble filament-forming materials;
c. processing the aqueous composition to produce a filament-forming composition;
d. delivering the filament-forming composition to one or more dies;
e. spinning the filament-forming composition to form a plurality of soluble filaments; and
f. collecting the soluble filaments on a collection device to form a fibrous structure is provided. In one example, one or more active agents may be added in the process in at least one of steps b, c, and d.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a schematic representation of an example of a process according to the present invention;
Fig. 2 is a schematic representation of an example of a portion of the process according to the present invention;
Fig. 3 is a schematic representation of an example of an extruder screw suitable for use in the process according to the present invention;
Fig. 4 is a schematic representation of an example of a portion of the process according to the present invention;
Fig. 5 is a top plan view of a die suitable for use in the process according to the present invention;
Fig. 6 is a schematic representation of an example of a portion of the process according to the present invention; and
Fig. 7 is a schematic representation of an example of collection zones on a collection device suitable for use in the process according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Definitions

[0010] "Fibrous structure" as used herein means a structure that comprises one or more filaments and optionally, one or more particles. In one example, a fibrous structure according to the present invention means an association of filaments and optionally, particles that together form a structure, such as a unitary structure, capable of performing a function.

[0011] The fibrous structures of the present invention may be single layered or multi-layered. If multi-layered, the fibrous structures may comprise at least two and/or at least three and/or at least four and/or at least five layers and/or at least six layers, for example one or more filament layers, one or more particle layers and/or one or more composite structure layers having a mixture of filaments and particles. A layer may comprise a particle layer within the fibrous structure or between filament layers within a fibrous structure. A layer comprising filaments may sometimes be referred to as a ply. A ply may be a fibrous structure which may be single layered or multi-layered as described herein. In one example, a layer may be formed by a single spinning die and/or particle delivery source or if it is a composite structure layer, then is may be formed by a single spinning die and a particle delivery source.

[0012] In one example, the fibrous structures of the present invention may comprise single or multiple layers, at least one of which must comprise fibers. Layers may include additives (for example, pastes or sprays) applied to said fibers and/or particles comingled with said fibers in a composite structure.

[0013] In one example, a single-ply fibrous structure according to the present invention or a multiply fibrous structure comprising one or more fibrous structure plies according to the present invention may exhibit a basis weight of less than 5000 g/m^2 as measured according to the Basis Weight Test Method described herein. In one example, the single- or multi-ply fibrous structure according to the present invention may exhibit a basis weight of greater than 10 g/m^2 to about 5000 g/m^2 and/or greater than 10 g/m^2 to about 3000 g/m^2 and/or greater than 10 g/m^2 to about 2000 g/m^2 and/or greater than 10 g/m^2 to about 1000 g/m^2 and/or greater than 20 g/m^2 to about 800 g/m^2 and/or greater than 30 g/m^2 to about 600 g/m^2 and/or greater than 50 g/m^2 to about 500 g/m^2 and/or greater than 300 g/m^2 to about 3000 g/m^2 and/or greater than 500 g/m^2 to about 2000 g/m^2 as measured according to the Basis Weight Test Method.

[0014] In one example, a single ply comprising a multi-layered fibrous structure comprises a first layer, such as a scrim layer comprising a plurality of filaments present at a basis weight of from about 10 to about 200 gsm and/or from about 30 to about 100 gsm and/or from about 50 to about 75 gsm and a second layer, for example a layer comprising a plurality of filaments, alone or as a composite structure layer comprising filaments and solid additives, for example particles, present at a basis weight of from about 400 to about 3000 gsm and/or from about 600 to about 1500 gsm and/or from about 800 to about 1200 gsm.

[0015] In one example, the fibrous structure of the present invention is a "unitary fibrous structure."

[0016] "Unitary fibrous structure" as used herein is an arrangement comprising a plurality of two or more and/or three or more filaments that are inter-entangled or otherwise associated with one another to form a fibrous structure and/or fibrous structure plies. A unitary fibrous structure of the present invention may be one or more plies within a multi-ply fibrous structure. In one example, a unitary fibrous structure of the present invention may comprise three or more different filaments. In another example, a unitary fibrous structure of the present invention may comprise two or more different filaments.

[0017] "Article" as used herein refers to a consumer use unit, a consumer unit dose unit, a consumer use saleable unit, a single dose unit, or other use form comprising a unitary fibrous structure and/or comprising one or more fibrous structures of the present invention.

[0018] "Fibrous element" as used herein means an elongate particulate having a length greatly exceeding its average diameter, i.e. a length to average diameter ratio of at least about 10. A fibrous element may be a filament or a fiber. In one example, the fibrous element is a single filament rather than a yarn comprising a plurality of filaments.

[0019] The fibrous elements of the present invention may be spun from fibrous element-forming compositions also referred to as filament-forming compositions via suitable spinning process operations, such as meltblowing, spunbonding, electro-spinning, and/or rotary spinning.

[0020] The fibrous elements of the present invention may be monocomponent (single, unitary solid piece rather than two different parts, like a core/sheath bicomponent) and/or multicomponent. For example, the fibrous elements may comprise bicomponent fibers and/or filaments. The bicomponent fibers and/or filaments may be in any form, such as side-by-side, core and sheath, islands-in-the-sea and the like.

[0021] "Filament" as used herein means an elongate particulate as described above that exhibits a length of greater than or equal to 5.08 cm (2 in.) and/or greater than or equal to 7.62 cm (3 in.) and/or greater than or equal to 10.16 cm (4 in.) and/or greater than or equal to 15.24 cm (6 in.).

[0022] Filaments are typically considered continuous or substantially continuous in nature. Filaments are relatively longer than fibers. Non-limiting examples of filaments include meltblown and/or spunbond filaments. Non-limiting examples of polymers that can be spun into filaments include natural polymers, such as starch, starch derivatives, cellulose, such as rayon and/or lyocell, and cellulose derivatives, hemicellulose, hemicellulose derivatives, and synthetic polymers including, but not limited to polyvinyl alcohol and also thermoplastic polymer filaments, such as polyesters, nylons, polyolefins such as polypropylene filaments, polyethylene filaments, and biodegradable thermoplastic fibers such as polylactic acid filaments, polyhydroxyalkanoate filaments, polyesteramide filaments and polycaprolactone filaments.

[0023] "Fiber" as used herein means an elongate particulate as described above that exhibits a length of less than 5.08 cm (2 in.) and/or less than 3.81 cm (1.5 in.) and/or less than 2.54 cm (1 in.).

[0024] Fibers are typically considered discontinuous in nature. Non-limiting examples of fibers include staple fibers produced by spinning a filament or filament tow of the present invention and then cutting the filament or filament tow into segments of less than 5.08 cm (2 in.) thus producing fibers.

[0025] In one example, one or more fibers may be formed from a filament of the present invention, such as when the filaments are cut to shorter lengths (such as less than 5.08 cm in length). Thus, in one example, the present invention also includes a fiber made from a filament of the present invention, such as a fiber comprising one or more filament-forming materials and one or more fiber adjuncts, such as active agents. Therefore, references to filament and/or filaments of the present invention herein also include fibers made from such filament and/or filaments unless otherwise noted. Fibers are typically considered discontinuous in nature relative to filaments, which are considered continuous in nature.

[0026] "Fibrous element-forming composition" and/or "filament-forming composition" as used herein means a composition that is suitable for making a filament of the present invention such as by meltblowing and/or spunbonding. The filament-forming composition comprises one or more filament-forming materials that exhibit properties that make them suitable for spinning into a filament. In one example, the filament-forming material comprises a polymer. In addition to one or more filament-forming materials, the filament-forming composition may comprise one or more fiber adjuncts, for example one or more active agents. In addition, the filament-forming composition may comprise one or more polar solvents, such as water, into which one or more, for example all, of the filament-forming materials and/or one or more, for example all, of the active agents are dissolved and/or dispersed prior to spinning a filament, such as a filament from the filament-forming composition.

[0027] In one example, a filament made from a filament-forming composition of the present invention is such that one or more fiber adjuncts, for example one or more active agents, may be present in the filament rather than on the filament, such as a coating composition comprising one or more active agents, which may be the same or different from the active agents in the filaments and/or particles. The total level of filament-forming materials and total level of active agents present in the filament-forming composition may be any suitable amount so long as the filaments of the present invention are produced therefrom.

[0028] In one example, one or more fiber adjuncts, such as active agents, may be present in the filament and one or more additional fiber adjuncts, such as active agents, may be present on a surface of the filament. In another example, a filament of the present invention may comprise one or more fiber adjuncts, such as active agents, that are present in the filament when originally made, but then bloom to a surface of the filament prior to and/or when exposed to conditions of intended use of the filament.

[0029] "Fibrous element-forming material" and/or "filament-forming material" as used herein means a material, such as a polymer or monomers capable of producing a polymer that exhibits properties suitable for making a filament. In one example, the filament-forming material comprises one or more substituted polymers such as an anionic, cationic, zwitterionic, and/or nonionic polymer. In another example, the polymer may comprise a hydroxyl polymer, such as a polyvinyl alcohol ("PVOH"), a partially hydrolyzed polyvinyl acetate and/or a polysaccharide, such as starch and/or a starch derivative, such as an ethoxylated starch and/or acid-thinned starch, carboxymethylcellulose, hydroxypropyl cellulose, hydroxyethyl cellulose, and methyl cellulose. In another example, the polymer may comprise polyethylenes and/or terephthalates. In yet another example, the filament-forming material is a polar solvent-soluble material.

[0030] "Particle" as used herein means a solid additive, such as a powder, granule, agglomerate, encapsulate, microcapsule, and/or prill. The shape of the particle can be in the form of spheres, rods, plates, tubes, squares, rectangles, discs, stars, fibers or have regular or irregular random forms. The particles of the present invention, at least those of at least 44 μm, can be measured by the Particle Size Distribution Test Method described herein. For particles that are less than 44 μm, a different test method may be used, for example light scattering, to determine the particle sizes less than 44 μm, for example perfume microcapsules that typically range from about 15 μm to about 44 μm and/or about 25 μm in size.

[0031] In one aspect, particles may comprise re-cycled fibrous-structure materials, specifically where said fibrous materials are re-cycled by grinding fibers into a finely-divided solid and re-incorporating said finely-divided solids into agglomerates, granules or other particle forms. In another aspect, particles may comprise re-cycled fibrous-structure materials, specifically where said fibrous materials are incorporated into a fluid paste, suspension or solution, and then processed to form agglomerates, granules or other particle forms. In another aspect, said fluid pastes, suspensions or solutions comprising recycled fibrous materials may be directly applied to fibrous layers in the process of making new fibrous articles.

[0032] "Active agent-containing particle" as used herein means a solid additive, for example a particle, comprising one or more active agents. In one example, the active agent-containing particle is an active agent in the form of a particle (in other words, the particle comprises 100% active agent(s)). The active agent-containing particle may exhibit a particle size of 5000 μm or less as measured according to the Particle Size Distribution Test Method described herein.

[0033] In one example of the present invention, the fibrous structure comprises a plurality of particles, for example active agent-containing particles, for example at least one active agent-containing particle, and a plurality of filaments in a weight ratio of particles, for example active agent-containing particles to filaments of 1:100 or greater and/or 1:50 or greater and/or 1:10 or greater and/or 1:3 or greater and/or 1:2 or greater and/or 1:1 or greater and/or 2:1 or greater and/or 3:1 or greater and/or 4:1 or greater and/or 5:1 or greater and/or 7:1 or greater and/or 8:1 or greater and/or 10:1 or greater and/or from about 10:1 to about 1:100 and/or from about 8:1 to about 1:50 and/or from about 7:1 to about 1:10 and/or from about 7:1 to about 1:3 and/or from about 6:1 to 1:2 and/or from about 5:1 to about 1:1 and/or from about 4:1 to about 1:1 and/or from about 3:1 to about 1.5:1.

[0034] In another example of the present invention, the fibrous structure comprises a plurality of particles, for example active agent-containing particles, and a plurality of filaments in a weight ratio of particles, for example active agent-containing particles, to filaments of from about 20:1 to about 1:1 and/or from about 10:1 to about 1:1 and/or from about 10:1 to about 1.5:1 and/or from about 8:1 to about 1.5:1 and/or from about 8:1 to about 2:1 and/or from about 7:1 to about 2:1 and/or from about 7:1 to about 3:1 and/or from about 6:1 to about 2.5:1.

[0035] In yet another example of the present invention, the fibrous structure comprises a plurality of particles, for example active agent-containing particles, and a plurality of filaments in a weight ratio of particles, for example active agent-containing particles, to filaments of from about 1:1 to about 1:100 and/or from about 1:15 to about 1:80, and/or from about 1:2 to about 1:60 and/or from about 1:3 to about 1:50 and/or from about 1:3 to about 1:40.

[0036] In another example, the fibrous structure of the present invention comprises a plurality of particles, for example active agent-containing particles, at a basis weight of greater than 1 g/m^2 and/or greater than 10 g/m^2 and/or greater than 20 g/m^2 and/or greater than 30 g/m^2 and/or greater than 40 g/m^2 and/or from about 1 g/m^2 to about 5000 g/m^2 and/or to about 3500 g/m^2 and/or to about 2000 g/m^2 and/or from about 1 g/m^2 to about 2000 g/m^2 and/or from about 10 g/m^2 to about 1000 g/m^2 and/or from about 10 g/m^2 to about 500 g/m^2 and/or from about 20 g/m^2 to about 400 g/m^2 and/or from about 30 g/m^2 to about 300 g/m^2 and/or from about 40 g/m^2 to about 200 g/m^2 as measured by the Basis Weight Test Method described herein.

[0037] In another example, the fibrous structure of the present invention comprises a plurality of filaments at a basis weight of greater than 1 g/m^2 and/or greater than 10 g/m^2 and/or greater than 20 g/m^2 and/or greater than 30 g/m^2 and/or greater than 40 g/m^2 and/or from about 1 g/m^2 to about 3000 g/m^2 and/or from about 10 g/m^2 to about 5000 g/m^2 and/or to about 3000 g/m^2 and/or to about 2000 g/m^2 and/or from about 20 g/m^2 to about 2000 g/m^2 and/or from about 30 g/m^2 to about 1000 g/m^2 and/or from about 30 g/m^2 to about 500 g/m^2 and/or from about 30 g/m^2 to about 300 g/m^2 and/or from about 40 g/m^2 to about 100 g/m^2 and/or from about 40 g/m^2 to about 80 g/m^2 as measured by the Basis

Weight Test Method described herein. In one example, the fibrous structure comprises two or more layers wherein filaments are present in at least one of the layers at a basis weight of from about 1 g/m^2 to about 500 g/m^2.

[0038] "Commingled" and/or "commingling" as used herein means the state or form where particles are mixed with fibrous elements, for example filaments. The mixture of filaments and particles can be throughout a composite structure or within a plane or a region of the composite structure. In one example, the commingled filaments and particles may form at least a surface of a composite structure. In one example, the particles may be homogeneously dispersed throughout the composite structure and/or plane and/or region of the composite structure. In one example, the particles may be homogeneously distributed throughout the composite structure, which avoids and/or prevents sag and/or free movement and/or migration of the particles within the composite structure to other areas within the composite structure thus resulting in higher concentrated zones of particles and lower concentrated zones or zero concentration zones of particles within the composite structure. In one example, μCT cross-sections of a composite structure can show whether the particles are homogeneously distributed throughout a composite structure.

[0039] "Fiber adjunct" as used herein means any material present in the filament of the present invention that is not a filament-forming material. In one example, a fiber adjunct comprises an active agent. In another example, a fiber adjunct comprises a processing aid. In still another example, a fiber adjunct comprises a filler. In one example, a fiber adjunct comprises any material present in the filament that its absence from the filament would not result in the filament losing its filament structure, in other words, its absence does not result in the filament losing its solid form. In another example, a fiber adjunct, for example an active agent, comprises a non-polymer material.

[0040] In another example, a fiber adjunct may comprise a plasticizer for the filament. Non-limiting examples of suitable plasticizers for the present invention include polyols, copolyols, polycarboxylic acids, polyesters and dimethicone copolyols. Examples of useful polyols include, but are not limited to, glycerin, diglycerin, propylene glycol, ethylene glycol, butylene glycol, pentylene glycol, cyclohexane dimethanol, hexanediol, 2,2,4-trimethylpentane-1,3-diol, polyethylene glycol (200-600), pentaerythritol, sugar alcohols such as sorbitol, manitol, lactitol and other mono- and polyhydric low molecular weight alcohols (e.g., C2-C8 alcohols); mono di- and oligo-saccharides such as fructose, glucose, sucrose, maltose, lactose, high fructose corn syrup solids, and dextrins, and ascorbic acid.

[0041] In one example, the plasticizer includes glycerin and/or propylene glycol and/or glycerol derivatives such as propoxylated glycerol. In still another example, the plasticizer is selected from the group consisting of glycerin, ethylene glycol, polyethylene glycol, propylene glycol, glycidol, urea, sorbitol, xylitol, maltitol, sugars, ethylene bisformamide, amino acids, and mixtures thereof

[0042] In another example, a fiber adjunct may comprise a rheology modifier, such as a shear modifier and/or an extensional modifier. Non-limiting examples of rheology modifiers include but not limited to polyacrylamide, polyurethanes and polyacrylates that may be used in the filaments of the present invention. Non-limiting examples of rheology modifiers are commercially available from The Dow Chemical Company (Midland, MI).

[0043] In yet another example, a fiber adjunct may comprise one or more colors and/or dyes that are incorporated into the filaments of the present invention to provide a visual signal when the filaments are exposed to conditions of intended use and/or when an active agent is released from the filaments and/or when the filament's morphology changes.

[0044] In still yet another example, a fiber adjunct may comprise one or more release agents and/or lubricants. Non-limiting examples of suitable release agents and/or lubricants include fatty acids, fatty acid salts, fatty alcohols, fatty esters, sulfonated fatty acid esters, fatty amine acetates, fatty amide, silicones, aminosilicones, fluoropolymers, and mixtures thereof. In one example, the release agents and/or lubricants may be applied to the filament, in other words, after the filament is formed. In one example, one or more release agents/lubricants may be applied to the filament prior to collecting the filaments on a collection device to form a fibrous structure. In another example, one or more release agents/lubricants may be applied to a fibrous structure formed from the filaments of the present invention prior to contacting one or more fibrous structures, such as in a stack of fibrous structures. In yet another example, one or more release agents/lubricants may be applied to the filament of the present invention and/or fibrous structure comprising the filament prior to the filament and/or fibrous structure contacting a surface, such as a surface of equipment used in a processing system so as to facilitate removal of the filament and/or fibrous structure and/or to avoid layers of filaments and/or plies of fibrous structures of the present invention sticking to one another, even inadvertently. In one example, the release agents/lubricants comprise particulates.

[0045] In even still yet another example, a fiber adjunct may comprise one or more anti-blocking and/or detackifying agents. Non-limiting examples of suitable anti-blocking and/or detackifying agents include starches, starch derivatives, crosslinked polyvinylpyrrolidone, crosslinked cellulose, microcrystalline cellulose, silica, metallic oxides, calcium carbonate, talc, mica, and mixtures thereof.

[0046] "Conditions of intended use" as used herein means the temperature, physical, chemical, and/or mechanical conditions that a filament and/or particle and/or fibrous structure of the present invention is exposed to when the filament and/or particle and/or fibrous structure is used for one or more of its designed purposes. For example, if a filament and/or a particle and/or a fibrous structure comprising a filament is designed to be used in a washing machine for laundry care purposes, the conditions of intended use will include those temperature, chemical, physical and/or mechanical conditions present in a washing machine, including any wash water, during a laundry washing operation. In another example, if a filament and/or a particle and/or a fibrous structure comprising a filament is designed to be used by a human as a shampoo for hair care purposes, the conditions of intended use will include those temperature, chemical, physical and/or mechanical conditions present during the shampooing of the human's hair. Likewise, if a filament and/or a particle and/or a fibrous structure comprising a filament is designed to be used in a dishwashing operation, by hand or by a dishwashing machine, the conditions of intended use will include the temperature, chemical, physical and/or mechanical conditions present in a dishwashing water and/or dishwashing machine, during the dishwashing operation.

[0047] "Active agent" as used herein means a fiber adjunct that produces an intended effect in an environment external to a filament and/or a particle and/or a fibrous structure comprising a filament of the present invention, such as when the filament and/or a particle and/or fibrous structure is exposed to conditions of intended use of the filament and/or a particle and/or a fibrous structure comprising a filament. In one example, an active agent comprises a fiber adjunct that treats a surface, such as a hard surface (i.e., kitchen countertops, bath tubs, toilets, toilet bowls, sinks, floors, walls, teeth, cars, windows, mirrors, dishes) and/or a soft surface (i.e., fabric, hair, skin, carpet, crops, plants,). In another example, an active agent comprises additive fiber adjunct that creates a chemical reaction (i.e., foaming, fizzing, effervescing, coloring, warming, cooling, lathering, disinfecting and/or clarifying and/or chlorinating, such as in clarifying water and/or disinfecting water and/or chlorinating water). In yet another example, an active agent comprises a fiber adjunct that treats an environment (i.e., deodorizes, purifies, perfumes air). In one example, the active agent is formed in situ, such as during the formation of the filament and/or particle containing the active agent, for example the filament and/or particle may comprise a water-soluble polymer (e.g., starch) and a surfactant (e.g., anionic surfactant), which may create a polymer complex or coacervate that functions as the active agent used to treat fabric surfaces.

[0048] "Treats" as used herein with respect to treating a surface means that the active agent provides a benefit to a surface or environment. Treats includes regulating and/or immediately improving a surface's or environment's appearance, cleanliness, smell, purity and/or feel. In one example treating in reference to treating a keratinous tissue (for example skin and/or hair) surface means regulating and/or immediately improving the keratinous tissue's cosmetic appearance and/or feel. For instance, "regulating skin, hair, or nail (keratinous tissue) condition" includes: thickening of skin, hair, or nails (e.g, building the epidermis and/or dermis and/or sub-dermal [e.g., subcutaneous fat or muscle] layers of the skin, and where applicable the keratinous layers of the nail and hair shaft) to reduce skin, hair, or nail atrophy, increasing the convolution of the dermal-epidermal border (also known as the rete ridges), preventing loss of skin or hair elasticity (loss, damage and/or inactivation of functional skin elastin) such as elastosis, sagging, loss of skin or hair recoil from deformation; melanin or non-melanin change in coloration to the skin, hair, or nails such as under eye circles, blotching (e.g., uneven red coloration due to, e.g., rosacea) (hereinafter referred to as "red blotchiness"), sallowness (pale color), discoloration caused by telangiectasia or spider vessels, and graying hair. Treats may include providing a benefit to fabrics like during a cleaning or softening in a laundry machine, providing a benefit to hair like during shampooing, conditioning, or coloring of hair, or providing a benefit to environments like a toilet bowl by cleaning or disinfecting it.

[0049] In another example, treating means removing stains and/or odors from fabric articles, such as clothes, towels, linens, and/or hard surfaces, such as countertops and/or dishware including pots and pans.

[0050] "Fabric care active agent" as used herein means an active agent that when applied to a fabric provides a benefit and/or improvement to the fabric. Non-limiting examples of benefits and/or improvements to a fabric include cleaning (for example by surfactants), stain removal, stain reduction, wrinkle removal, color restoration, static control, wrinkle resistance, permanent press, wear reduction, wear resistance, pill removal, pill resistance, soil removal, soil resistance (including soil release), shape retention, shrinkage reduction, softness, fragrance, anti-bacterial, anti-viral, odor resistance, and odor removal.

[0051] "Dishwashing active agent" as used herein means an active agent that when applied to dishware, glassware, pots, pans, utensils, and/or cooking sheets provides a benefit and/or improvement to the dishware, glassware, plastic items, pots, pans and/or cooking sheets. Non-limiting examples of benefits and/or improvements to the dishware, glassware, plastic items, pots, pans, utensils, and/or cooking sheets include food and/or soil removal, cleaning (for example by surfactants) stain removal, stain reduction, grease removal, water spot removal and/or water spot prevention, glass and metal care, sanitization, shining, and polishing.

[0052] "Hard surface active agent" as used herein means an active agent when applied to floors, countertops, sinks, windows, mirrors, showers, baths, and/or toilets provides a benefit and/or improvement to the floors, countertops, sinks, windows, mirrors, showers, baths, and/or toilets. Non-limiting examples of benefits and/or improvements to the floors, countertops, sinks, windows, mirrors, showers, baths, and/or toilets include food and/or soil removal, cleaning (for example by surfactants), stain removal, stain reduction, grease removal, water spot removal and/or water spot prevention, limescale removal, disinfection, shining, polishing, and freshening.

[0053] "Keratinous tissue active agent" as used herein means an active agent that may be useful for treating keratinous tissue (e.g., hair, skin, or nails) condition. For a hair care active agent, "treating" or "treatment" or "treat" includes regulating and/or immediately improving keratinous tissue cosmetic appearance and/or feel. For instance, "regulating skin, hair, or nail condition" includes: thickening of skin, hair, or nails (e.g., building the epidermis and/or dermis and/or sub-dermal [e.g., subcutaneous fat or muscle] layers of the skin, and where applicable the keratinous layers of the nail and hair shaft) to reduce skin, hair, or nail atrophy, increasing the convolution of the dermal-epidermal border (also known as the rete ridges), preventing loss of skin or hair elasticity (loss, damage and/or inactivation of functional skin elastin) such as elastosis, sagging, loss of skin or hair recoil from deformation; melanin or non-melanin change in coloration to the skin, hair, or nails such as under eye circles, blotching (e.g., uneven red coloration due to, e.g., rosacea) (hereinafter referred to as "red blotchiness"), sallowness (pale color), discoloration caused by telangiectasia or spider vessels, and graying hair. Another example of keratinous tissue active agent may be an active agent used in the shampooing, conditioning, or dyeing of hair.

[0054] "Weight ratio" as used herein means the ratio between two materials on their dry basis. For example, the weight ratio of filament-forming materials to active agents within a filament is the ratio of the weight of filament-forming material on a dry weight basis (g or %) in the filament to the weight of fiber adjunct, such as active agent(s) on a dry weight basis (g or % - same units as the filament-forming material weight) in the filament. In another example, the weight ratio of particles to filaments within a fibrous structure is the ratio of the weight of particles on a dry weight basis (g or %) in the fibrous structure to the weight of filaments on a dry weight basis (g or % - same units as the particle weight) in the fibrous structure.

[0055] "Water-soluble material" as used herein means a material that is miscible in water. In other words, a material that is capable of forming a stable (does not separate for greater than 5 minutes after forming the homogeneous solution) homogeneous solution with water at ambient conditions.

[0056] "Ambient conditions" as used herein means 23°C ± 1.0°C and a relative humidity of 50% ± 2%.

[0057] "Weight average molecular weight" as used herein means the weight average molecular weight as determined using gel permeation chromatography according to the protocol found in Colloids and Surfaces A. Physico Chemical & Engineering Aspects, Vol. 162, 2000, pg. 107-121 as measured according to the Weight Average Molecular Weight Test Method described herein.

[0058] "Length" as used herein, with respect to a filament, means the length along the longest axis of the filament from one terminus to the other terminus. If a filament has a kink, curl or curves in it, then the length is the length along the entire path of the filament from one terminus to the other terminus.

[0059] "Diameter" as used herein, with respect to a filament, is measured according to the Diameter Test Method described herein. In one example, a filament of the present invention exhibits a diameter of less than 100 μm and/or less than 75 μm and/or less than 50 μm and/or less than 25 μm and/or less than 20 μm and/or less than 15 μm and/or less than 10 μm and/or less than 6 μm and/or greater than 1 μm and/or greater than 3 μm.

[0060] "Triggering condition" as used herein in one example means anything, as an act or event, that serves as a stimulus and initiates or precipitates a change in the filament and/or particle and/or fibrous structure of the present invention, such as a loss or altering of the filament's and/or fibrous structure's physical structure and/or a release of a fiber adjunct, such as an active agent therefrom. In another example, the triggering condition may be present in an environment, such as water, when a filament and/or particle and/or fibrous structure of the present invention is added to the water. In other words, nothing changes in the water except for the fact that the filament and/or fibrous structure of the present invention is added to the water.

[0061] "Morphology changes" as used herein with respect to a filament's and/or particle's morphology changing means that the filament experiences a change in its physical structure. Non-limiting examples of morphology changes for a filament and/or particle of the present invention include dissolution, melting, swelling, shrinking, breaking into pieces, exploding, lengthening, shortening, and combinations thereof. The filaments and/or particles of the present invention may completely or substantially lose their filament or particle physical structure or they may have their morphology changed or they may retain or substantially retain their filament or particle physical structure as they are exposed to conditions of intended use.

[0062] "By weight on a dry filament basis" and/or "by weight on a dry particle basis" and/or "by weight on a dry fibrous structure basis" means the weight of the filament and/or particle and/or fibrous structure, respectively, measured immediately after the filament and/or particle and/or fibrous structure, respectively, has been conditioned in a conditioned room at a temperature of 23°C ± 1.0°C and a relative humidity of 50% ± 10% for 2 hours. In one example, by weight on a dry filament basis and/or dry particle basis and/or dry fibrous structure basis means that the filament and/or particle and/or fibrous structure comprises less than 20% and/or less than 15% and/or less than 10% and/or less than 7% and/or less than 5% and/or less than 3% and/or to 0% and/or to greater than 0% based on the dry weight of the filament and/or particle and/or fibrous structure of moisture, such as water, for example free water, as measured according to the Water Content Test Method described herein.

[0063] "Total level" as used herein, for example with respect to the total level of one or more active agents present in the filament and/or particle and/or fibrous structure, means the sum of the weights or weight percent of all of the subject materials, for example active agents. In other words, a filament and/or particle and/or fibrous structure may comprise 25% by weight on a dry filament basis and/or dry particle basis and/or dry fibrous structure basis of an anionic surfactant, 15% by weight on a dry filament basis and/or dry particle basis and/or dry fibrous structure basis of a nonionic surfactant, 10% by weight of a chelant on a dry filament basis and/or dry particle basis and/or dry fibrous structure basis, and 5% by weight of a perfume a dry filament basis and/or dry particle basis and/or dry fibrous structure basis so that the total level of active agents present in the filament and/or particle and/or fibrous structure is greater than 50%; namely 55% by weight on a dry filament basis and/or dry particle basis and/or dry fibrous structure basis.

[0064] "Fibrous structure product" as used herein means a solid form, for example a rectangular solid, sometimes referred to as a sheet, that comprises one or more active agents, for example a fabric care active agent, a dishwashing active agent, a hard surface active agent, and mixtures thereof. In one example, a fibrous structure product of the present invention comprises one or more surfactants, one or more enzymes (such as in the form of an enzyme prill and/or an enzyme liquid), one or more perfumes and/or one or more suds suppressors.

[0065] In one example, one or more active agents, in particle or liquid form, may be deposited onto one or more surfaces of the fibrous structures of the present invention. For example, enzyme suspensions, perfumes, microcapsule slurries, oils, silicones, surfactant pastes, sometimes referred to herein as minors, may be deposited onto one or more surfaces of the fibrous structures during making of the fibrous structures and/or converting of the fibrous structures. Such application may reside on the surface of the fibrous layer or may substantially imbibe into the fibrous structure.

[0066] In another example, a fibrous structure product of the present invention comprises a builder and/or a chelating agent. In another example, a fibrous structure product of the present invention comprises a bleaching agent (such as an encapsulated bleaching agent).

[0067] "Different from" or "different" as used herein means, with respect to a material, such as a filament as a whole and/or a filament-forming material within a filament and/or an active agent within a filament, that one material, such as a filament and/or a filament-forming material and/or an active agent, is chemically, physically and/or structurally different from another material, such as a filament and/or a filament-forming material and/or an active agent. For example, a filament-forming material in the form of a filament is different from the same filament-forming material in the form of a fiber. Likewise, a starch polymer is different from a cellulose polymer. However, different molecular weights of the same material, such as different molecular weights of a starch, are not different materials from one another for purposes of the present invention.

[0068] "Random mixture of polymers" as used herein means that two or more different filament-forming materials are randomly combined to form a filament. Accordingly, two or more different filament-forming materials that are orderly combined to form a filament, such as a core and sheath bicomponent filament, is not a random mixture of different filament-forming materials for purposes of the present invention.

[0069] "Associate," "Associated," "Association," and/or "Associating" as used herein with respect to filaments and/or particle means combining, either in direct contact or in indirect contact, filaments and/or particles such that a fibrous structure is formed. In one example, the associated filaments and/or particles may be bonded together for example by adhesives and/or thermal bonds. In another example, the filaments and/or particles may be associated with one another by being deposited onto the same fibrous structure making belt and/or patterned belt.

[0070] "Machine Direction" or "MD" as used herein means the direction parallel to the flow of the fibrous structure through the fibrous structure making machine and/or fibrous structure product manufacturing equipment.

[0071] "Cross Machine Direction" or "CD" as used herein means the direction perpendicular to the machine direction in the same plane of the fibrous structure and/or fibrous structure product comprising the fibrous structure.

[0072] "Ply" or "Plies" as used herein means an individual fibrous structure optionally to be disposed in a substantially contiguous, face-to-face relationship with other plies, forming a multiple ply fibrous structure. It is also contemplated that a single fibrous structure can effectively form two "plies" or multiple "plies", for example, by being folded on itself. A ply may comprise layers of filaments, filament/particle blends, and/or particles. In another embodiment, there may be a layer of filaments or particles between plies.

[0073] As used herein, the articles "a" and "an" when used herein, for example, "an anionic surfactant" or "a fiber" is understood to mean one or more of the material that is claimed or described.

[0074] All percentages and ratios are calculated by weight unless otherwise indicated. All percentages and ratios are calculated based on the total composition unless otherwise indicated.

[0075] Unless otherwise noted, all component or composition levels are in reference to the active level of that component or composition, and are exclusive of impurities, for example, residual solvents or by-products, which may be present in commercially available sources.

Process for Making an Article of Manufacture

[0076] In one example of the present invention, as shown in Fig. 1, a process 10 for making, for example continuously making, an article of manufacture 12 comprising a fibrous structure 14, for example a soluble fibrous structure, comprises at least the following steps: 1) a filament-forming composition making operation 16 comprising one or more steps to make a filament-forming composition 18, which is then delivered, for example via piping, to the next operation; namely, a spinning operation 20; 2) a spinning operation 20 comprising one or more steps for spinning a filament-forming composition, for example the filament-forming composition 18 made in the filament-forming composition making operation 16, to make filaments 22, for example soluble filaments; 3) optionally, a commingling operation 24 comprising one or more steps of commingling, for example coforming, a plurality of solid additives, for example particles 26, with the filaments 22; and 4) a collecting operation 28 comprising one or more collection steps for collecting the filaments 22 and/or commingled filaments 22 and solid additives, for example particles 26, on a collection device, such as a belt and/or rotary drum, to form a fibrous structure 14 comprising filaments 22 and optionally, solid additives, for example particles 26, for example a soluble fibrous structure, wherein the operations (1-4) when present are performed in a continuous manner, one step after the other without any breaks or stoppages or interruptions in the process from making a filament-forming composition 18 to spinning the filament-forming composition 18 into filaments 22 (optionally commingling solid additives, for example particles 26, with the filaments 22) to collecting the filaments 22 (and/or commingled filaments 22 and solid additives, for example particles 26) on a collection device to form a fibrous structure 14 comprising filaments 22 and optionally, solid additives, for example particles 26.

[0077] Once the fibrous structure 14 is formed, then the fibrous structure 14 may then be converted into an article of manufacture 12, which may be a consumable, saleable unit, via a converting operation 30, which comprises one or more steps for converting the fibrous structure 14 into an article of manufacture 12, wherein one or more of the converting steps may be continuous with the earlier operations (1-4) of the process 10. Once the fibrous structure 14 has been converted into an article of manufacture 12 comprising the fibrous structure 14, for example one or more, two or more, three or more, four or more, five or more plies of the fibrous structure 14, then the article of manufacture 12 can be packaged into a package 32 comprising an external packaging material 34, such as a packaging film, a cardboard box, and the like, via a packaging operation 36.

[0078] In one example, the process for making an article of manufacture and/or process steps such as the spinning operation, the commingling (coforming) operation, the collecting operation, the converting operation, and the packaging operation, according to the present invention may independently be performed at a relative humidity of from about 20% to about 75% and/or from about 30% to about 65% and/or from about 35% to about 60%.

[0079] The converting operation 30 may comprise one or more steps for converting (for example slitting and/or stacking and/or calendering and/or treating with optional ingredients (such as adding optional ingredients to the fibrous structure 14, for example to a surface of the fibrous structure 14), such as perfumes, enzymes, bleaches, flavoring agents, effervescent agents, and the like, die-cutting, and printing) the fibrous structure 14 into one or more articles of manufacture 12, for example a consumer product); and 6) optionally, a packaging operation 36 comprising one or more steps for packaging one or more articles of manufacture 12, for example a consumer product, such as a soluble consumer product, into a package 32.

[0080] In one example, the converting operation may include die cutting into a desired shape, for example to maximize the number of articles of manufacture produced from a fibrous structure or multiple desired shapes, printing, optional ingredient (minors) additions, rolling up a fibrous structure on a roll as converting line step, including where all this is done in a single process or on a single converting line. For example, the process of the present invention may comprise one or more converting operations and/or steps selected from the group consisting of: slitting, stacking, calendering, treating with optional ingredients, die cutting, printing, packaging, mechanical plybonding, chemical plybonding, and/or combinations thereof. In one example, one or more or all of these converting operations and/or steps are performed on a single converting line, which may be directly coupled to the fibrous structure making line (for example spinning/commingling/collecting operations) and the filament-forming composition making operation. In one example, as discussed herein, the total process from filament-forming composition operation through the converting operation, and optionally the packaging operation to make an article of manufacture according to the present invention may occur on a single manufacturing line, for example a single, continuous manufacturing line. The converting operation may ultimately yield a consumer useable saleable unit.

[0081] In one example, process is such that a fibrous structure, for example a composite structure, formed in the collecting operation is further transformed with converting operations and/or steps selected from the group consisting of: slitting, stacking, calendering, treating with optional ingredients, die cutting, printing, packaging, mechanical plybonding, chemical plybonding, and/or combinations thereof on a unitary manufacturing line, for example on a single ply, multi-ply, or any surface of a single or multi-ply article into a consumer useable saleable unit.

a. Filament-Forming Composition Making Operation (16)

[0082] As shown in Fig. 2, in one example, a filament-forming composition 18 is made by providing one or more filament-forming materials 38, for example one or more soluble filament-forming materials, for example one or more hydroxyl polymers, such as polyvinyl alcohol, to which water or another polar solvent are added resulting in an aqueous or polar solvent composition comprising the soluble filament-forming materials and water or polar solvent. The aqueous or polar solvent composition is then processed, for example polymer processed, in an extruder to form a filament-forming composition 18, which is then suitable for delivering to one or more dies for spinning into a plurality of filaments 22 in a spinning operation 20. In one example, the aqueous or polar solvent composition may be processed in a batch tank (not shown).

[0083] In one example, the filament-forming material 38 is sufficiently cooked to form a homogeneous aqueous or polar solvent composition of the filament-forming material 38.

[0084] In one example, at least about 30% and/or at least about 40% and/or to about 70% and/or to about 60% by weight of water is added to the one or more filament-forming materials 38 during the filament-forming composition making operation 16.

[0085] In one example, the filament-forming material 38 may be added at a solids concentration of greater than 40% and/or greater than 50% and/or greater than 60% and/or from about 60% to about 80% and/or from about 60% to about 70%.

[0086] In one example, the filament-forming material 38 may be present in the filament-forming composition at a level of greater than 5% and/or greater than 10% and/or greater than 13% and/or less than 50% and/or less than 40% and/or less than 30% and/or less than 25%

[0087] In one example, the filament-forming material 38 may be present in the extruder at a level of greater than 10% and/or greater than 20% and/or greater than 30% and/or less than 90% and/or less than 80% and/or less than 70% and/or less than 65%.

[0088] In one example, the filament-forming material 38 may be in solid form, for example in a dry solid form 40, such as pellets and/or powder. In one example, the filament-forming material 38 and water and/or another polar solvent utilized to solubilize the filament-forming material 38 are added to an extruder 42 via a hopper 44, for example a twin screw extruder, and heated, processed, and mixed to solubilize the filament-forming material 38. In one example, entrained air within the aqueous solution and/or polar solvent solution comprising the filament-forming material 18 within the extruder 40 is minimized and/or eliminated. The water and/or polar solvent may be added to the extruder 42 via a pump 46.

[0089] When the filament-forming material 38 is in solid form, the solid filament-forming material, for example one or more hydroxyl polymers, such as polyvinyl alcohol, is added from a hopper 44, for example in a continuous process, to an extruder 42, for example a single screw extruder or twin screw extruder, for example a twin screw extruder, such as a Coperion ZSK 26 twin screw extruder (Max. Speed 1200 rpm, Max. Torque per Screw Shaft 106 Nm, Diameter of Screws 25.5 mm, Length of Screws 900 mm, # of Barrel Sections 9, Heating and Cooling for each Zone, Flight Depth 4.55 mm, Est. Throughput 20-60 kg/hr). In this example, as shown in Fig. 3 the addition of the solid filament-forming material to the extruder 42 occurs in Zone 1 of the extruder 42. The purpose of adding the filament-forming material 38 to an extruder 42 is to achieve hydration of the filament-forming material 38 and to solubilize the filament-forming material 38, especially if it is originally in a solid form.

[0090] Non-limiting examples of suitable filament-forming materials 38 include polymers, for example polymers selected from the group consisting of: pullulan, hydroxypropylmethyl cellulose, hydroxyethyl cellulose, hydroxypropyl cellulose, methyl cellulose, polyvinyl pyrrolidone, carboxymethyl cellulose, sodium alginate, xanthan gum, tragacanth gum, guar gum, acacia gum, Arabic gum, polyacrylic acid, methylmethacrylate copolymer, carboxyvinyl polymer, dextrin, pectin, chitin, levan, elsinan, collagen, gelatin, zein, gluten, soy protein, casein, polyvinyl alcohol, carboxylated polyvinyl alcohol, sulfonated polyvinyl alcohol, starch, starch derivatives, hemicellulose, hemicellulose derivatives, proteins, chitosan, chitosan derivatives, polyethylene glycol, tetramethylene ether glycol, hydroxymethyl cellulose, polyethylene oxide, and mixtures thereof.

[0091] In one example, the filament-forming material 38 is a water-soluble material that produces a soluble filament, for example a water-soluble filament.

[0092] In one example, the filament-forming material 38 comprises polyvinyl alcohol.

[0093] Water and/or another polar solvent is added via a pump 46, for example in a continuous process, to the extruder 42 containing the filament-forming material 18, to mix with and solubilize the filament-forming material 18 within the extruder 42. The water and/or other polar solvent are added to the extruder 42 in Zone 3 as shown in Fig. 3.

[0094] The extruder 42 may be run such that it exhibits a wet throughput of at least about 5 and/or at least about 10 and/or at least about 15 and/or at least about 20 and/or at least about 40 at least about 80 and/or from about 5 to about 200 and/or from about 80 to about 135 kg/hr, in one example to produce a full filament-forming material flow rate of from about 100 to about 700 kg/hr and/or from about 345 to about 575 kg/hr, a dry throughput of at least about 2 and/or at least about 4 and/or at least about 6 and/or at least about 10 and/or at least about 15 and/or at least about 20 and/or from about 2 to about 120 and/or from about 10 to about 85 and/or from about 20 to about 85 kg/hr and/or from about 50 to about 85 kg/hr, a maximum screw speed of less than about 1600 rpm and/or less than about 1400 rpm and/or less than about 1200 rpm and/or from about 200 to about 1600 rpm and/or from about 400 to 1400 rpm and/or from about 600 to about 1200 rpm, a % solids (filament-forming material 38) of from about 20 to about 95% and/or from about 30 to about 85% and/or from about 40 to about 70%, an exit pressure of from about 10 to about 80 and/or from about 15 to about 75 and/or from about 20 to about 65 bar setpoint, the filament-forming composition may exit the extruder at a SME (solids throughput basis) of from about 0.10 to about 0.50 and/or from about 0.12 to about 0.45 and/or from about 0.14 to about 0.35 kW-h/kg, and wherein the extruder subjects the filament-forming composition to a temperature of at least 49°C, with example barrel temperatures of the extruder run as shown in Table 1 below:

Table 1

Zone	2	3	4	5	6	7	8	9	8-0	Pump	Die
Temp Setpoint (°C) "A"	25	49	66	121	121	135	135	135	135	135	135
Temp Setpoint (°C) "B"	40	100	150	150	150	150	150	150	150	150	150
Temp Setpoint (°C) "C"	40	100	150	150	160	160	160	160	160	160	160
Temp Setpoint (°C) "D"	40	100	150	150	160	170	170	170	170	170	170
Temp Setpoint (°C) "E"	40	80	80	130	140	140	170	170	170	170	170

[0095] In addition to solubilizing the filament-forming material 38 in an extruder 42 to produce a filament-forming composition 18, one or more active agents 48, for example one or more surfactants, such as a surfactant blend, for example a blend of anionic surfactants, for example two or more different anionic surfactants, may be mixed with the filament-forming composition 18 via one or more static mixers 50, such as SMX mixers.

[0096] In one example, the surfactant and/or surfactant blend comprises one or more anionic surfactants selected from the group consisting of: linear alkylbenzene sulfonates (LAS), alkyl sulfates (AS), and mixtures thereof. The surfactants may be blended and or co-neutralized with sodium hydroxide to form a low water containing paste. In addition, other surfactants, such as alyklethoxylate sulfates (AES), cosurfactants, such as amine oxide, linear alcohol ethoxylates, glucamide-based surfactants, and branched versions of the alkyl chain, such as MLAS and HSAS.

[0097] In one example, in addition to the one or more surfactants, structurant, such as polyethylene oxide, such as a PEO 100K and/or PEO N60K, and/or polyvinylpyrrolidone, may be mixed with the surfactants to provide phase stability. Optionally, other ingredients may also be mixed with the surfactants, such as salts, for example sodium sulfate.

[0098] In one example, the filament-forming composition 18 and thus at least one filament 22 produced from spinning the filament-forming composition 18 comprises one or more active agents 48, in the case of the filament 22 the one or more active agents 48 are present within the filament 22.

[0099] In one example, the active agent 48 comprises a surfactant selected from the group consisting of: anionic surfactants, cationic surfactants, nonionic surfactants, zwitterionic surfactants, amphoteric surfactants, and mixtures thereof.

[0100] In one example, the one or more active agents 48 is selected from the group consisting of: fabric care active agents, dishwashing active agents, carpet care active agents, surface care active agents, air care active agents, oral care active agents (for example teeth cleaning agents, teeth whitening agents, tooth care agents, periodontal gum care agents, mouthwash agents, denture cleaning agents, tongue cleaning agents, breath freshening agents, fluoride agents, mouth rinse agents, anti-cavity agents, flavoring agents), hair care active agents (shampoos and/or conditioners), keratinaceous tissue care agents, toilet bowl cleaning agents, skin care active agents, and mixtures thereof.

[0101] In one example, at least one of the active agents 48 comprises one or more effervescent agents.

[0102] In one example, one or more hueing agents, colorants, and/or dyes are added to the filament-forming composition during the filament-forming composition making operation.

Filament-forming Material

[0103] The filament-forming material is any suitable material, such as a polymer or monomers capable of producing a polymer that exhibits properties suitable for making a fibrous element, such as by a spinning process.

[0104] In one example, the filament-forming material may comprise a polar solvent-soluble material, such as an alcohol-soluble material and/or a water-soluble material.

[0105] In another example, the filament-forming material may comprise a non-polar solvent-soluble material.

[0106] In still another example, the filament forming material may comprise a polar solvent-soluble material and be free (less than 5% and/or less than 3% and/or less than 1% and/or 0% by weight on a dry fibrous element basis and/or dry soluble fibrous structure basis) of non-polar solvent-soluble materials.

[0107] In yet another example, the filament-forming material may be a film-forming material. In still yet another example, the filament-forming material may be synthetic or of natural origin and it may be chemically, enzymatically, and/or physically modified.

[0108] In even another example of the present invention, the filament-forming material may comprise a polymer selected from the group consisting of: polymers derived from acrylic monomers such as the ethylenically unsaturated carboxylic monomers and ethylenically unsaturated monomers, polyvinyl alcohol, polyacrylates, polymethacrylates, copolymers of acrylic acid and methyl acrylate, polyvinylpyrrolidones, polyalkylene oxides, starch and starch derivatives, pullulan, gelatin, hydroxypropylmethylcelluloses, methyl celluloses, and carboxymethycelluloses.

[0109] In still another example, the filament-forming material may comprises a polymer selected from the group consisting of: polyvinyl alcohol, polyvinyl alcohol derivatives, starch, starch derivatives, cellulose derivatives, hemicellulose, hemicellulose derivatives, proteins, sodium alginate, hydroxypropyl methylcellulose, chitosan, chitosan derivatives, polyethylene glycol, tetramethylene ether glycol, polyvinyl pyrrolidone, hydroxymethyl cellulose, hydroxyethyl cellulose, methyl cellulose, and mixtures thereof.

[0110] In another example, the filament-forming material comprises a polymer selected from the group consisting of: pullulan, hydroxypropylmethyl cellulose, hydroxyethyl cellulose, hydroxypropyl cellulose, methyl cellulose, polyvinyl pyrrolidone, carboxymethyl cellulose, sodium alginate, xanthan gum, tragacanth gum, guar gum, acacia gum, Arabic gum, polyacrylic acid, methylmethacrylate copolymer, carboxyvinyl polymer, dextrin, pectin, chitin, levan, elsinan, collagen, gelatin, zein, gluten, soy protein, casein, polyvinyl alcohol, starch, starch derivatives, hemicellulose, hemicellulose derivatives, proteins, chitosan, chitosan derivatives, polyethylene glycol, tetramethylene ether glycol, hydroxymethyl cellulose, and mixtures thereof.

Polar Solvent-soluble Materials

[0111] Non-limiting examples of polar solvent-soluble materials include polar solvent-soluble polymers. The polar solvent-soluble polymers may be synthetic or natural original and may be chemically and/or physically modified. In one example, the polar solvent-soluble polymers exhibit a weight average molecular weight of at least 10,000 g/mol and/or at least 20,000 g/mol and/or at least 40,000 g/mol and/or at least 80,000 g/mol and/or at least 100,000 g/mol and/or at least 1,000,000 g/mol and/or at least 3,000,000 g/mol and/or at least 10,000,000 g/mol and/or at least 20,000,000 g/mol and/or to about 40,000,000 g/mol and/or to about 30,000,000 g/mol as measured according to the Weight Average Molecular Weight Test Method described herein.

[0112] In one example, the polar solvent-soluble polymers are selected from the group consisting of: alcohol-soluble polymers, water-soluble polymers and mixtures thereof. Non-limiting examples of water-soluble polymers include water-soluble hydroxyl polymers, water-soluble thermoplastic polymers, water-soluble biodegradable polymers, water-soluble non-biodegradable polymers and mixtures thereof. In one example, the water-soluble polymer comprises polyvinyl alcohol. In another example, the water-soluble polymer comprises starch. In yet another example, the water-soluble polymer comprises polyvinyl alcohol and starch.

a. Water-soluble Hydroxyl Polymers - Non-limiting examples of water-soluble hydroxyl polymers in accordance with the present invention include polyols, such as polyvinyl alcohol, polyvinyl alcohol derivatives, polyvinyl alcohol copolymers, starch, starch derivatives, starch copolymers, chitosan, chitosan derivatives, chitosan copolymers, cellulose derivatives such as cellulose ether and ester derivatives, cellulose copolymers, hemicellulose, hemicellulose derivatives, hemicellulose copolymers, gums, arabinans, galactans, proteins and various other polysaccharides and mixtures thereof.

[0113] In one example, a water-soluble hydroxyl polymer of the present invention comprises a polysaccharide.

[0114] "Polysaccharides" as used herein means natural polysaccharides and polysaccharide derivatives and/or modified polysaccharides. Suitable water-soluble polysaccharides include, but are not limited to, starches, starch derivatives, chitosan, chitosan derivatives, cellulose derivatives, hemicellulose, hemicellulose derivatives, gums, arabinans, galactans and mixtures thereof. The water-soluble polysaccharide may exhibit a weight average molecular weight of from about 10,000 to about 40,000,000 g/mol and/or greater than 100,000 g/mol and/or greater than 1,000,000 g/mol and/or greater than 3,000,000 g/mol and/or greater than 3,000,000 to about 40,000,000 g/mol as measured according to the Weight Average Molecular Weight Test Method described herein.

[0115] The water-soluble polysaccharides may comprise non-cellulose and/or non-cellulose derivative and/or non-cellulose copolymer water-soluble polysaccharides. Such non-cellulose water-soluble polysaccharides may be selected from the group consisting of: starches, starch derivatives, chitosan, chitosan derivatives, hemicellulose, hemicellulose derivatives, gums, arabinans, galactans and mixtures thereof.

[0116] In another example, a water-soluble hydroxyl polymer of the present invention comprises a non-thermoplastic polymer.

[0117] The water-soluble hydroxyl polymer may have a weight average molecular weight of from about 10,000 g/mol to about 40,000,000 g/mol and/or greater than 100,000 g/mol and/or greater than 1,000,000 g/mol and/or greater than 3,000,000 g/mol and/or greater than 3,000,000 g/mol to about 40,000,000 g/mol as measured according to the Weight Average Molecular Weight Test Method described herein. Higher and lower molecular weight water-soluble hydroxyl polymers may be used in combination with hydroxyl polymers having a certain desired weight average molecular weight.

[0118] Well known modifications of water-soluble hydroxyl polymers, such as natural starches, include chemical modifications and/or enzymatic modifications. For example, natural starch can be acid-thinned, hydroxy-ethylated, hydroxypropylated, and/or oxidized. In addition, the water-soluble hydroxyl polymer may comprise dent corn starch.

[0119] Naturally occurring starch is generally a mixture of linear amylose and branched amylopectin polymer of D-glucose units. The amylose is a substantially linear polymer of D-glucose units joined by (1,4)-α-D links. The amylopectin is a highly branched polymer of D-glucose units joined by (1,4)-α-D links and (1,6)-α-D links at the branch points. Naturally occurring starch typically contains relatively high levels of amylopectin, for example, corn starch (64-80% amylopectin), waxy maize (93-100% amylopectin), rice (83-84% amylopectin), potato (about 78% amylopectin), and wheat (73-83% amylopectin). Though all starches are potentially useful herein, the present invention is most commonly practiced with high amylopectin natural starches derived from agricultural sources, which offer the advantages of being abundant in supply, easily replenishable and inexpensive.

[0120] As used herein, "starch" includes any naturally occurring unmodified starches, modified starches, synthetic starches and mixtures thereof, as well as mixtures of the amylose or amylopectin fractions; the starch may be modified by physical, chemical, or biological processes, or combinations thereof. The choice of unmodified or modified starch for the present invention may depend on the end product desired. In one embodiment of the present invention, the starch or starch mixture useful in the present invention has an amylopectin content from about 20% to about 100%, more typically from about 40% to about 90%, even more typically from about 60% to about 85% by weight of the starch or mixtures thereof.

[0121] Suitable naturally occurring starches can include, but are not limited to, corn starch, potato starch, sweet potato starch, wheat starch, sago palm starch, tapioca starch, rice starch, soybean starch, arrow root starch, amioca starch, bracken starch, lotus starch, waxy maize starch, and high amylose corn starch. Naturally occurring starches particularly, corn starch and wheat starch, are the preferred starch polymers due to their economy and availability.

[0122] Polyvinyl alcohols herein can be grafted with other monomers to modify its properties. A wide range of monomers has been successfully grafted to polyvinyl alcohol. Non-limiting examples of such monomers include vinyl acetate, styrene, acrylamide, acrylic acid, 2-hydroxyethyl methacrylate, acrylonitrile, 1,3-butadiene, methyl methacrylate, methacrylic acid, maleic acid, itaconic acid, sodium vinylsulfonate, sodium allylsulfonate, sodium methylallyl sulfonate, sodium phenylallylether sulfonate, sodium phenylmethallylether sulfonate, 2-acrylamido-methyl propane sulfonic acid (AMPs), vinylidene chloride, vinyl chloride, vinyl amine and a variety of acrylate esters.

[0123] In one example, the water-soluble hydroxyl polymer is selected from the group consisting of: polyvinyl alcohols, hydroxymethylcelluloses, hydroxyethylcelluloses, hydroxypropylmethylcelluloses methyl cellulose, and mixtures thereof. A non-limiting example of a suitable polyvinyl alcohol includes those commercially available from Sekisui Specialty Chemicals America, LLC (Dallas, TX) under the CELVOL® trade name. A non-limiting example of a suitable hydroxypropylmethylcellulose includes those commercially available from the Dow Chemical Company (Midland, MI) under the METHOCEL® trade name including combinations with above mentioned hydroxypropylmethylcelluloses.

[0124] b. Water-soluble Thermoplastic Polymers - Non-limiting examples of suitable water-soluble thermoplastic polymers include thermoplastic starch and/or starch derivatives, polylactic acid, polyhydroxyalkanoate, polycaprolactone, polyesteramides and certain polyesters, and mixtures thereof.

[0125] The water-soluble thermoplastic polymers of the present invention may be hydrophilic or hydrophobic. The water-soluble thermoplastic polymers may be surface treated and/or internally treated to change the inherent hydrophilic or hydrophobic properties of the thermoplastic polymer.

[0126] The water-soluble thermoplastic polymers may comprise biodegradable polymers.

[0127] Any suitable weight average molecular weight for the thermoplastic polymers may be used. For example, the weight average molecular weight for a thermoplastic polymer in accordance with the present invention is greater than about 10,000 g/mol and/or greater than about 40,000 g/mol and/or greater than about 50,000 g/mol and/or less than about 500,000 g/mol and/or less than about 400,000 g/mol and/or less than about 200,000 g/mol as measured according to the Weight Average Molecular Weight Test Method described herein.

Non-polar Solvent-soluble Materials

[0128] Non-limiting examples of non-polar solvent-soluble materials include non-polar solvent-soluble polymers. Non-limiting examples of suitable non-polar solvent-soluble materials include cellulose, chitin, chitin derivatives, polyolefins, polyesters, copolymers thereof, and mixtures thereof. Non-limiting examples of polyolefins include polypropylene, polyethylene and mixtures thereof. A non-limiting example of a polyester includes polyethylene terephthalate.

[0129] The non-polar solvent-soluble materials may comprise a non-biodegradable polymer such as polypropylene, polyethylene and certain polyesters.

[0130] Any suitable weight average molecular weight for the thermoplastic polymers may be used. For example, the weight average molecular weight for a thermoplastic polymer in accordance with the present invention is greater than about 10,000 g/mol and/or greater than about 40,000 g/mol and/or greater than about 50,000 g/mol and/or less than about 500,000 g/mol and/or less than about 400,000 g/mol and/or less than about 200,000 g/mol as measured according to the Weight Average Molecular Weight Test Method described herein.

Active Agents

[0131] Active agents are a class of fiber adjunct that are designed and intended to provide a benefit to something other than the fibrous element and/or particle and/or soluble fibrous structure itself, such as providing a benefit to an environment external to the fibrous element and/or particle and/or soluble fibrous structure. Active agents may be any suitable fiber adjunct that produces an intended effect under intended use conditions of the fibrous element. For example, the active agent may be selected from the group consisting of: personal cleansing and/or conditioning agents such as hair care agents such as shampoo agents and/or hair colorant agents, hair conditioning agents, skin care agents, sunscreen agents, and skin conditioning agents; laundry care and/or conditioning agents such as fabric care agents, fabric conditioning agents, fabric softening agents, fabric anti-wrinkling agents, fabric care anti-static agents, fabric care stain removal agents, soil release agents, dispersing agents, suds suppressing agents, suds boosting agents, anti-foam agents, and fabric refreshing agents; liquid and/or powder dishwashing agents (for hand dishwashing and/or automatic dishwashing machine applications), hard surface care agents, and/or conditioning agents and/or polishing agents; other cleaning and/or conditioning agents such as antimicrobial agents, antibacterial agents, antifungal agents, fabric hueing agents, perfume, bleaching agents (such as oxygen bleaching agents, hydrogen peroxide, percarbonate bleaching agents, perborate bleaching agents, chlorine bleaching agents), bleach activating agents, chelating agents, builders, lotions, brightening agents, air care agents, carpet care agents, dye transfer-inhibiting agents, clay soil removing agents, anti-redeposition agents, polymeric soil release agents, polymeric dispersing agents, alkoxylated polyamine polymers, alkoxylated polycarboxylate polymers, amphilic graft copolymers, dissolution aids, buffering systems, water-softening agents, water-hardening agents, pH adjusting agents, enzymes, flocculating agents, effervescent agents, preservatives, cosmetic agents, make-up removal agents, lathering agents, deposition aid agents, coacervate-forming agents, clays, thickening agents, latexes, silicas, drying agents, odor control agents, antiperspirant agents, cooling agents, warming agents, absorbent gel agents, anti-inflammatory agents, dyes, pigments, acids, and bases; liquid treatment active agents; agricultural active agents; industrial active agents; ingestible active agents such as medicinal agents, teeth whitening agents, tooth care agents, mouthwash agents, periodontal gum care agents, edible agents, dietary agents, vitamins, minerals; water-treatment agents such as water clarifying and/or water disinfecting agents, and mixtures thereof.

[0132] Non-limiting examples of suitable cosmetic agents, skin care agents, skin conditioning agents, hair care agents, and hair conditioning agents are described in CTFA Cosmetic Ingredient Handbook, Second Edition, The Cosmetic, Toiletries, and Fragrance Association, Inc. 1988, 1992.

[0133] One or more classes of chemicals may be useful for one or more of the active agents listed above. For example, surfactants may be used for any number of the active agents described above. Likewise, bleaching agents may be used for fabric care, hard surface cleaning, dishwashing and even teeth whitening. Therefore, one of ordinary skill in the art will appreciate that the active agents will be selected based upon the desired intended use of the fibrous element and/or particle and/or soluble fibrous structure made therefrom.

[0134] For example, if the fibrous element and/or particle and/or soluble fibrous structure made therefrom is to be used for hair care and/or conditioning then one or more suitable surfactants, such as a lathering surfactant could be selected to provide the desired benefit to a consumer when exposed to conditions of intended use of the fibrous element and/or particle and/or soluble fibrous structure incorporating the fibrous element and/or particle.

[0135] In one example, if the fibrous element and/or particle and/or soluble fibrous structure made therefrom is designed or intended to be used for laundering clothes in a laundry operation, then one or more suitable surfactants and/or enzymes and/or builders and/or perfumes and/or suds suppressors and/or bleaching agents could be selected to provide the desired benefit to a consumer when exposed to conditions of intended use of the fibrous element and/or particle and/or soluble fibrous structure incorporating the fibrous element and/or particle. In another example, if the fibrous element and/or particle and/or soluble fibrous structure made therefrom is designed to be used for laundering clothes in a laundry operation and/or cleaning dishes in a dishwashing operation, then the fibrous element and/or particle and/or soluble fibrous structure may comprise a laundry detergent composition or dishwashing detergent composition or active agents used in such compositions. In still another example, if the fibrous element and/or particle and/or soluble fibrous structure made therefrom is designed to be used for cleaning and/or sanitizing a toilet bowl, then the fibrous element and/or particle and/or soluble fibrous structure made therefrom may comprise a toilet bowl cleaning composition and/or effervescent composition and/or active agents used in such compositions.

[0136] In one example, the active agent is selected from the group consisting of: surfactants, bleaching agents, enzymes, suds suppressors, suds boosting agents, fabric softening agents, denture cleaning agents, hair cleaning agents, hair care agents, personal health care agents, hueing agents, and mixtures thereof.

[0137] In one example, at least one of the active agents is selected from the group consisting of: skin benefit agents, medicinal agents, lotions, fabric care agents, dishwashing agents, carpet care agents, surface care agents, hair care agents, air care agents, and mixtures thereof.

[0138] The filament-forming composition 18 may then be mixed via static mixers 50, such as SMX mixers, jacketed or unjacketed, and/or pumped via piping and/or pumps 46, such as a booster pump, to a spinning operation 20. The filament-forming composition 18 produced from the filament-forming composition making operation 16 may be delivered to one or more dies and/or one or more beams of dies via one or more pumps 46. Before being delivered to the spinning operation 20, the rheology of the filament-forming composition 18 may be measured, offline or online, for example with an online rheometer 52, to ensure that the filament-forming composition's 18 rheology is suitable for spinning into filaments 22 via the spinning operation 20.

[0139] In one example, two or more different filament-forming compositions may be produced and spun during the spinning operation, such as from a split die, such as a 50/50 CD width split die wherein each half of the die is spins two or more different filament-forming compositions to form two or more different filaments during the spinning operation and ultimately resulting in a fibrous structure comprising two or more different filaments produced from two or more different filament-forming compositions.

[0140] In another example, two or more different filament-forming compositions may be produced and spun during the spinning operation, such as from two or more parallel dies, for example two or more parallel full CD width dies wherein each die is spins a different filament-forming composition to form two or more different filaments during the spinning operation and ultimately resulting in a fibrous structure comprising two or more different filaments produced from two or more different filament-forming compositions.

[0141] The formation and/or attenuation of a filament requires a delicate balance of forces to be successful. First, the filament-forming composition 18 must form a stable filament 20 as it exits the die. When the viscosity of the filament-forming composition 18 is too high, full attenuation cannot be achieved. When the viscosity of the filament-forming composition 18 is too low, the filament 20 will break under the attenuation forces. Additionally, after the filament 20 has been attenuated down to about 20 um diameter, stabilization ensues. The stabilization process can be achieved in a number of ways, most notably drying and/or crystallization. The rheological properties of the filament 20 as it transitions from a liquid (filament-forming composition 18) to a solid (filament 20) are of paramount importance in successful filament spinning. In one example, the filament-forming composition 18 of the present invention exhibits a Capillary Number of greater than 1 and/or greater than 2 and/or greater than 3 and/or greater than 4 and/or greater than 5. In a fibrous element spinning process, the fibrous elements need to have initial stability as they leave the spinning die. In one example, the filament-forming composition 18 exhibits a Capillary Number of from at least about 1 to about 50 and/or at least about 3 to about 50 and/or at least about 5 to about 30 such that the filament-forming composition 18 can be effectively polymer processed (spun) into a filament 22.

[0142] The Capillary Number is a dimensionless number used to characterize the likelihood of this droplet breakup. A larger Capillary Number indicates greater fluid stability upon exiting the die. The Capillary Number is defined as follows:

$$Ca = \frac{V * \eta}{\sigma}$$

V is the fluid velocity at the die exit (units of Length per Time),
η is the fluid viscosity at the conditions of the die (units of Mass per Length*Time),
σ is the surface tension of the fluid (units of mass per Time^2). When velocity, viscosity, and surface tension are expressed in a set of consistent units, the resulting Capillary Number will have no units of its own; the individual units will cancel out.

[0143] The Capillary Number is defined for the conditions at the exit of the die. The fluid velocity is the average velocity of the fluid passing through the die opening. The average velocity is defined as follows:

$$V = \frac{Vol'}{Area}$$

Vol" = volumetric flowrate (units of Length^3 per Time),
Area = cross-sectional area of the die exit (units of Length^2).

[0144] When the die opening is a circular hole, then the fluid velocity can be defined as

$$V = \frac{Vol'}{\pi * R^2}$$

R is the radius of the circular hole (units of length).

[0145] The shear viscosity of the filament-forming composition 18 may be in the range of from about 0.1 Pa-s to about 50 Pa-s and/or from about 0.3 Pa-s to about 40 Pa-s and/or from about 0.5 Pa-s to about 35 Pa-s at 3000 s^{-1} at the operating temperature range of the spinning operation 20. The extensional viscosity of the filament-forming composition 18 may be in the range of from about 50 Pa-s to about 200 Pa-s and/or grom about 60 Pa-s to about 180 Pa-s and/or from about 70 Pa-s to about 150 Pa-s and/or from about 75 Pa-s to about 125 Pa-s and/or from about 75 Pa-s to about 100 Pa-s at a strain rate of 700 s^{-1} as measured by an e-VROC instrument or equivalent from RheoSense of San Ramon, CA. The Pressure P23/P14 ratio on SSEVR should be greater than 0.8 and/or greater than 0.9 and/or greater than 1.

[0146] In one example, the filament-forming composition may comprise at least 20% and/or at least 30% and/or at least 40% and/or at least 45% and/or at least 50% to about 90% and/or to about 85% and/or to about 80% and/or to about 75% by weight of one or more filament-forming materials, one or more active agents, and mixtures thereof. The filament-forming composition may comprise from about 10% to about 80% by weight of a polar solvent, such as water.

[0147] In one example, non-volatile components of the filament-forming composition may comprise from about 20% and/or 30% and/or 40% and/or 45% and/or 50% to about 75% and/or 80% and/or 85% and/or 90% by weight based on the total weight of the filament-forming composition. The non-volatile components may be composed of filament-forming materials, such as backbone polymers, active agents and combinations thereof. Volatile components of the filament-forming composition will comprise the remaining percentage and range from 10% to 80% by weight based on the total weight of the filament-forming composition.

[0148] For successful fiber spinning of complex mixtures, such as molten fatty alcohols or aqueous surfactant solutions it is generally necessary to add a polymeric ingredient called a structurant. The structurant's purpose is to increase the shear and extensional viscosity of the fluid to enable fiber formation. The structurant is generally a high molecular weight species, usually in the 100,000 - 6,000,000 g/mol range. However, a balance is often struck between concentration and molecular weight, such that when a lower molecular weight species is used, it requires a higher level to function properly. Likewise, when a higher molecular species is used, lower levels can be used to enable fiber spinning. An important aspect of the structurant is its solubility in the spinning fluid to enable viscosity build for fiber formation. The structurants polyvinylpyrrolidone and polyethylene oxide have been found to be two such polymers that meet the criteria of solubility in the spinning fluid and capable of being produced at high molecular weights.

b. Spinning Operation (20)

[0149] The filaments 22 of the present invention comprising one or more filament-forming materials 18 and optionally, one or more active agents 48, present within the filament 22 may be made as shown in Figs. 4 and 5. As shown in Figs. 4 and 5, a spinning operation 20 for making a filaments 22 from a filament-forming composition 18, in a continuous process, according to the present invention comprises the steps of:

a. providing a filament-forming composition 18 delivered to the spinning operation 20 from a filament-forming composition making operation 16, wherein the filament-forming composition 18 comprises one or more filament-forming materials 38 and optionally, one or more active agents 48 and/or one or more polar solvents (such as water), and optionally one or more deterrent agents; and

b. spinning the filament-forming composition 18, such as via one or more dies, for example one or more spinning dies 54, for example a multi-row capillary spinning die, such as a Biax-fiberfilm multi-row capillary die, into one or more filaments 22 comprising the one or more filament-forming materials 38 and optionally, the one or more active agents 48 and the one or more deterrent agents.

[0150] In one example, the step of spinning further comprises the step of providing a filament-forming composition comprising one or more filament-forming materials to the one or more dies, for example one or more spinning dies 54.

[0151] The filament-forming composition 18 may be processed (spun) from the spinning die 54 at a temperature of from about 20°C to about 100°C and/or from about 30°C to about 90°C and/or from about 35°C to about 70°C and/or from about 40°C to about 60°C when making filaments 22 from the filament-forming composition 18.

[0152] The filament-forming composition 18 may be transported via suitable piping 56, with or without a pump 46, from the filament-forming composition making operation 16 to the spinning die 54. A pump 46, such as a Zenith®, H-9000, having a capacity of 30 and/or 45 cubic centimeters per revolution (cc/rev), manufactured by Colfax Corporation, Zenith Pumps Division, of Monroe, N.C., USA may be used to facilitate transport of the filament-forming composition 18 to a spinning die 54. The flow of the filament-forming composition 18 from the filament-forming composition making operation 16 to the spinning die 54 may be controlled by adjusting the number of revolutions per minute (rpm) of the pump 46.

[0153] The filaments 22 spun from the spinning die 54 may be collected, for example continuously onto a collection device 58, such as a belt and/or fabric, for example a patterned belt, and/or a rotary drum, that is continuously operating to move the collected filaments 22, which form a fibrous structure 14, such as a plurality of inter-entangled filaments, on the collection device 58 further down the process to other operations in the making of the article of manufacture 12 of the present invention.

[0154] In one example, the process may further comprise the step of spinning a plurality of filaments from a first die, for example a first spinning die, and then collecting those first filaments on a collection device prior to collecting commingled filaments and solid additives, for example particles, onto the first filaments already present on the collection device.

[0155] The total level of the one or more filament-forming materials present in the fibrous element 10, when active agents are present therein, may be less than 80% and/or less than 70% and/or less than 65% and/or 50% or less by weight on a dry fibrous element basis and/or dry soluble fibrous structure basis and the total level of the one or more active agents, when present in the fibrous element may be greater than 20% and/or greater than 35% and/or 50% or greater 65% or greater and/or 80% or greater by weight on a dry fibrous element basis and/or dry soluble fibrous structure basis.

[0156] As shown in Figs. 4 and 5, the spinning die 54 may comprise a plurality of filament-forming holes that include a melt capillary 34 encircled by a concentric attenuation fluid hole 36 through which a fluid, such as air, passes to facilitate attenuation of the filament-forming composition 22 into a fibrous element 10 as it exits the filament-forming hole 32.

[0157] In one example, the spinning die 54 shown in Fig. 5 has two or more rows of circular extrusion nozzles (filament-forming holes 60) spaced from one another at a pitch P of about 1.524 millimeters (about 0.060 inches). The nozzles have individual inner diameters of about 0.305 millimeters (about 0.012 inches) and individual outside diameters of about 0.813 millimeters (about 0.032 inches). Each individual nozzle comprises a melt capillary 62 encircled by an annular and divergently flared orifice (concentric attenuation fluid hole 64) to supply attenuation air to each individual melt capillary 62. The filament-forming composition 18 extruded through the extrusion nozzles (filament-forming holes 60) is surrounded and attenuated by generally cylindrical, humidified air streams supplied through the orifices to produce filaments 22.

[0158] Attenuation air can be provided by heating compressed air from a source by an electrical-resistance heater, for example, a heater manufactured by Chromalox, Division of Emerson Electric, of Pittsburgh, Pa., USA.

[0159] The embryonic filaments 22 are dried by a drying air stream having a temperature from about 149°C (about 300°F) to about 315°C (about 600°F) by an electrical resistance heater and/or a gas burner (direct or indirect) (not shown) supplied through drying nozzles and discharged at an angle of about 90° relative to the general orientation of the embryonic filaments 22 being spun. The dried filaments 22 may be collected on a collection device 58, such as a belt or fabric, in one example a belt or fabric capable of imparting a pattern, for example a non-random repeating pattern to a fibrous structure 14, such as a soluble fibrous structure, formed as a result of collecting the filaments 22 on the belt or fabric. The addition of a vacuum source 66 directly under a formation zone 68, the area on the collection device 58 where the filaments 22 contact the collection device 58, may be used to aid collection of the filaments 22 on the collection device 58. The spinning and collection of the filaments 22 produce a fibrous structure 14, for example a soluble fibrous structure, comprising inter-entangled filaments.

[0160] In one example, a spinning enclosure 70, which is a housing that at least partially encloses, in one example fully encloses to the extent that the collection device 58 and fibrous structure 14 carried on the collection device 58 are able to move freely under the spinning enclosure 70, the filaments 22 being spun from the spinning die 54 to the collection device 58. The spinning enclosure 70 at least partially controls the environment that the filaments 22 are exposed to down the spinline from the spinning die 54 to the collection device 58.

[0161] In one example, during the spinning step, any volatile solvent, such as water, present in the filament-forming composition 18 is removed, such as by drying, as the filament 22 is formed. In one example, greater than 30% and/or greater than 40% and/or greater than 50% of the weight of the filament-forming composition's 18 volatile solvent, such as water, is removed during the spinning step, such as by drying the filament 22 being produced.

[0162] In one example, the filaments 22 are spun from one die, for example one spinning die 54, for example a multi-row capillary die.

[0163] In one example, two or more different filaments 22 are spun from at least one die, for example one spinning die 54 (the same spinning die 54).

[0164] In one example, the filaments 22 are spun from two or more dies, for example two or more spinning dies 54.

[0165] In one example, the process of the present invention may comprise two or more spinning operations 20. In one example, a first spinning operation 20 comprises spinning filaments 22 from a filament-forming composition 18 comprising one or more filament-forming materials 38 with or without active agents 48 and without the inclusion of solid additives, for example particles 26 via a commingling operation 24, to produce a fibrous structure 14 on a collection device 58, which may be the same collection device 58 upon which the filaments 22 from a second spinning operation 20 are collected. A second spinning operation 20 downstream of the first spinning operation 20 comprises spinning filaments 22 from a filament-forming composition 18 comprising one or more filament-forming materials 38 with or without active agents 48 and with the inclusion of solid additives, for example particles 26 via a commingling operation 24, onto the fibrous structure 14 formed by the first spinning operation 20.

[0166] The filament-forming composition 18 may comprise any suitable total level of filament-forming materials 38 and any suitable level of active agents 48 so long as the filament 22 produced from the filament-forming composition 18 comprises a total level of filament-forming materials 38 in the filament 22 of from about 5% to 100% or less by weight on a dry filament basis and/or dry soluble fibrous structure basis and a total level of active agents 48 in the filament 22 of from 0% to about 95% by weight on a dry filament basis and/or dry soluble fibrous structure basis.

c. Commingling Operation (24)

[0167] In one example, as shown in Fig. 6, particles 26 may be added to the filaments 22 being spun from one die, for example the spinning die 54 within the spinning enclosure 70. The addition of particles 26 may be accomplished during the formation of the filaments 22 and/or after collection of the filaments 22 on the collection device 58. The particles 26 may be added into the fibrous structure 14 and/or filaments 22 from a particle source 72. The particles 26 may be added such that the particles 26 are collected on a surface of the collection device 58 inside the spinning enclosure 70. The collection device 58 may be operable within the formation zone 68, which may be inside the spinning enclosure 70. The spinning enclosure 70 may be positioned above the collection device 58 and encompass the formation zone 68 on the collection device 58.

[0168] The addition of particles 26 may result in said particles 26 being entrapped and/or entrained within the filaments 22 and/or fibrous structure 14 collected on the collection device 58.

[0169] A particle source 72, for example a feeder, suitable to supply a flow of particles is placed directly above the drying region for the fibrous elements as shown in Fig. 6. In this case for example a vibratory feeder made by Retsch® of Haan, Germany, is used. In order to aid in a consistent distribution of particles in the cross direction the particles are fed onto a tray (not shown) that started off the width of the particle source 72 and ended at the same width as the spinning die 54 face to ensure particles 26 are delivered into all areas of filament 22 formation. The tray is completely enclosed with the exception of the exit to minimize disruption of the particle feed.

[0170] In one example, a split particle source or two or more separate particle sources capable of delivering two or more different (for example different in type, composition, size, properties, etc.) particles may be used as the particle source in the commingling operation such that the resulting fibrous structure may comprise different zones and/or regions comprising different particles, which may ultimately result in a layered fibrous structure having different particles in each layer after the initially formed fibrous structure is slit and stacked.

[0171] While filaments 22 are being formed, the particle source 72 is turned on and particles 26 are introduced into the filament 22 stream. The particles 26 are commingled with the filaments 22 within the spinning enclosure 70. The commingled filaments 22 and particles 26 are collected on the collection device 58 as a composite structure (filaments 22 and particles 26 commingled together). In one example, the step of collecting the commingled filaments 22 and particles 26, for example on the collection device 58, occurs within the spinning enclosure 70. The composite structure is referred to as a fibrous structure 14.

[0172] The particles 26 may be introduced into the spinning enclosure 70 between the spinning die 54 and the collection device 58, as shown in Figs. 4 and 6, at any angle so long as at least a portion of the particles 26 contact the filaments 22 at the formation zone 68. As shown in Fig. 6, if the introduction of the particles 26 into the filament 22 stream is not tailored to result in the particles 26 contacting the filaments 22 in the formation zone 68 then the particles may end up downstream (points in the process that are closer to the finished article of manufacture and/or packaged article of manufacture relative to the referenced point, for example if the reference point is the spinning operation or collecting operation, then downstream means converting operation and/or packaging operation) of the formation zone 68 as shown by the particle trajectory line A in Fig. 6 and/or upstream (points in the process that are farther away from the finished article of manufacture 12 and/or packaged article of manufacture 32 relative to the referenced point, for example if the reference point is the spinning operation or collecting operation, then upstream means, for example the filament-forming composition making operation 16) of the formation zone 68 as shown by the particle trajectory line B in Fig. 6.

[0173] In one example, the solid additives, for example particles 26, contact the filaments 22 on the upstream side of the spinning enclosure 70 ("the filaments' upstream side").

[0174] In another example, the solid additives, for example particles 26, contact the filaments 22 on the downstream side of the spinning enclosure 70 ("the filaments' downstream side").

[0175] In another example, the solid additives, for example particles 26, contact the filaments 22 on both the upstream and downstream sides of the spinning enclosure 70 ("the filaments' upstream side and downstream side").

[0176] Fig. 7 illustrates schematically another example of the commingling operation 24 wherein the particles 26 land on the collection device 58 in a particle landing zone 74 and contact the filaments 22 within the formation zone 68.

[0177] The solid additives, for example particles 26, may contact the filaments 22 at a contact angle (the contact angle is relative to the filament stream direction emanating and exiting from the spinning die 54) of greater than or equal to about 0° but less than or equal to about 90° and/or greater than or equal to about 10° but less than or equal to about 90° and/or greater than or equal to about 20° but less than or equal to about 90° and/or greater than or equal to about

30° but less than or equal to about 90° and/or at least about 40° but less than about 90° and/or at a contact angle of at least about 45° but less than about 90°.

[0178] The solid additives, for example particles 26, may be dispersed throughout the fibrous structure 14 at an overall MD basis weight variation % RSD of less than 40.0% and/or less than 30.0% and/or less than 25.0% and/or less than 20.0% and/or less than 15.0% and/or less than 10.0% and/or less than 5.0% and/or about 0% as measured according to the CD and MD Basis Weight Variation Test Method described herein.

[0179] The solid additives, for example particles 26, may be dispersed throughout the fibrous structure 14 at an overall CD basis weight variation % RSD of less than 40.0% and/or less than 30.0% and/or less than 25.0% and/or less than 20.0% and/or less than 15.0% and/or less than 10.0% and/or less than 5.0% and/or about 0% as measured according to the CD and MD Basis Weight Variation Test Method described herein.

[0180] The solid additives, for example particles 26, may contact the filaments at a velocity of greater than 1 m/s and/or at least 2 m/s and/or at least 2.5 m/s and/or less than 10 m/s and/or less than 8 m/s and/or 6 m/s or less and/or from about 1 m/s to about 20 m/s.

[0181] The solid additives, for example particles 26, may be commingled with the filaments 22 such that a solid additive inclusion efficiency (for example particle inclusion efficiency) of greater than 40% and/or at least 42% and/or at least 45% and/or at least 50% and/or at least 54% and/or at least 65% and/or at least 75% and/or at least 85% and/or at least 90% and/or at least 95% and/or at least 98% as measured according to the Inclusion Efficiency Test Method described herein.

[0182] In one example, the step of commingling comprises introducing the solid additives, for example particles 26, into the plurality of filaments 22, for example soluble filaments, between at least one of the dies, for example spinning dies 54 and the collection device 58. In one example, the solid additives, for example particles 26, are introduced more proximal to the at least one die, for example spinning die 54 than to the collection device 58. In another example, the solid additives, for example particles 26, are introduced more proximal to the collection device 58 than to at least one die, for example spinning die 54.

[0183] In one example, the commingling operation (step) comprises introducing the solid additives, for example particles 26, into the filaments 22, for example soluble filaments, spun from two different spinning dies 54.

[0184] The solid additives, for example particles 26, may comprise one or more types or different types of particles 26. In one example, the solid additives, for example particles 26, comprise a mixture of particles 26 of differing compositions. In another example, the solid additives, for example particles 26, comprise a blend of particle of differing composition. In another example, the solid additives, for example particles 26, comprise water-soluble particles and/or water-insoluble particles, which may comprise water-swellable particles. Further, in one example, the particles 26 may be in the form of an agglomerate, for example an agglomerate comprising a water-soluble material and/or a water-insoluble material.

[0185] In one example, the solid additives, for example particles 26, may exhibit a D50 particle size of from about 100 μm to about 5000 μm and/or from about 100 μm to about 2000 μm and/or from about 250 μm to about 1200 μm and/or from about 250 μm to about 850 μm as measured according to the Particle Size Distribution Test Method described herein.

[0186] In one example, the solid additives, for example particles 26, may exhibit a D10 of 250 μm as measured according to the Particle Size Distribution Test Method described herein.

[0187] In another example, the solid additives, for example particles 26, may exhibit a D90 of 1200 μm and/or 850 μm as measured according to the Particle Size Distribution Test Method described herein.

[0188] In one example, the solid additives, for example particles 26, may exhibit a D10 of greater than 44 μm and/or greater than 90 μm and/or greater than 150 μm and/or greater than 212 μm and/or greater than 300 μm as measured according to the Particle Size Distribution Test Method described herein.

[0189] In one example, the solid additives, for example particles 26, may exhibit a D90 of less than 1400 μm and/or less than 1180 μm and/or less than 850 μm and/or less than 600 μm and/or less than 425 μm as measured according to the Particle Size Distribution Test Method described herein.

[0190] In one example, the solid additives, for example particles 26, may exhibit any combination of the above-identified D10, D50, and/or D90 so long as D50, when present, is greater than D10, when present, and D90, when present, is greater than D10 and D50, when present.

[0191] In one example, the solid additives, for example particles 26, may exhibit any combination of the above-identified D10 and D90 so long as D90 is greater than D10.

[0192] In one example, the solid additives, for example particles 26, may exhibit a D10 of greater than 212 μm and a D90 of less than 1180 μm as measured according to the Particle Size Distribution Test Method described herein.

[0193] In one example, the solid additives, for example particles 26, may exhibit a D10 of greater than 90 μm and a D90 of less than 425 μm as measured according to the Particle Size Distribution Test Method described herein.

[0194] In one example, the spinning operation 20 may comprise two or more spinning dies 54 arranged adjacent to each other in the machine direction and/or in the cross-machine direction. In one example, when the spinning operation 20 comprises two or more dies arranged adjacent to each other in the machine direction, a commingling operation 24 may be positioned between two adjacent (in the machine direction) dies, for example two adjacent spinning dies 54.

[0195] The particles 26 used in the present invention for commingling with the filaments 22 may be active agent-containing particles.

d. Collecting Operation (28)

[0196] As shown in Figs. 1, 4, and 6, the filaments 22 from the spinning operation 20, and optionally the solid additives, for example particles 26, from the commingling operation 24, are collected on a collection device 58 during the collecting operation 28 to form a fibrous structure 14, which may be a composite structure (commingled filaments 22 and particles 26).

[0197] In one example, the collection device 58 may be a belt, such as a patterned belt that imparts a texture, such as a three-dimensional texture to at least one surface of the fibrous structure 14 and/or a rotary drum. The collection device 58 may impart a pattern, for example a non-random, repeating pattern which may be continuous, discontinuous, and/or semi-continuous in nature. The collection device 58 may create different regions within the fibrous structure 14, for example different average densities.

Test Methods

[0198] Unless otherwise specified, all tests described herein including those described under the Definitions section and the following test methods are conducted on samples that have been conditioned in a conditioned room at a temperature of 23°C ± 1.0°C and a relative humidity of 50% ± 2% for a minimum of 2 hours prior to the test. The samples tested are "usable units." "Usable units" as used herein means sheets, flats from roll stock, pre-converted flats, and/or single or multiply products. All tests are conducted under the same environmental conditions and in such conditioned room. Do not test samples that have defects such as wrinkles, tears, holes, and like. Samples conditioned as described herein are considered dry samples (such as "dry filaments") for testing purposes. All instruments are calibrated according to manufacturer's specifications.

Basis Weight Test Method

[0199] Basis weight is defined as the weight in g/m^2 of a sample being tested. It is determined by accurately weighing a known area of a conditioned sample using an appropriate balance, recording the weight and area of sample tested, applying the appropriate conversion factors, and finally calculating the basis weight in g/m^2 of the sample.

[0200] Basis weight is measured by cutting a sample from a single web, a stack of webs, or other appropriate plied up, or consumer salable unit and weighing the sample using a top loading analytical balance with a resolution of ± 0.001 g. The sample must be equilibrated at a temperature of 73° ± 2° F (23° ± 1° C) and a relative humidity of 50% (± 2 %) for a minimum of two hours prior to cutting samples. During weighing, the balance is protected from air drafts and other disturbances using a draft shield. A precision cutting die, measuring 1.625 x1.625 in (41.275 x 41.275 mm) is used to prepare all samples. Select usable sample areas which are clean, free of holes, tears, wrinkles and other defects.

[0201] For each sample use the die cutter described above to cut a sample, weigh the mass of the sample, and record the mass result to the nearest 0.001 g.

[0202] The Basis Weight is calculated in g/m2 as follows:

$$\text{Basis Weight} = (\text{Mass of sample}) / (\text{Area of sample}).$$

[0203] Or specifically,

$$\text{Basis Weight (g/m2)} = (\text{Mass of sample (g)}) / (0.001704\ \text{m2}).$$

[0204] Report result to the nearest 0.1 g/m2. Sample dimensions can be changed or varied using a similar precision cutter as mentioned above. If the sample dimension is decreased, then several samples should be measured and the mean value reported as its basis weight.

Particle Size Distribution Test Method

[0205] The particle size distribution test is conducted to determine characteristic sizes of solid additives, for example particles. It is conducted using ASTM D 502 - 89, "Standard Test Method for Particle Size of Soaps and Other Detergents", approved May 26, 1989, with a further specification for sieve sizes and sieve time used in the analysis. Following section 7, "Procedure using machine-sieving method," a nest of clean dry sieves containing U.S. Standard (ASTM E 11) sieves #4 (4.75 mm), #6 (3.35 mm), #8 (2.36 mm), #12 (1.7 mm), #16 (1.18 mm), #20 (850 micrometer), #30 (600 micrometer), #40 (425 micrometer), #50 (300 micrometer), #70 (212 micrometer), #100 (150 micrometer), #170 (90 micrometer), #325 (44 micrometer) and pan is required to cover the range of particle sizes referenced herein. The prescribed Machine-Sieving Method is used with the above sieve nest. A suitable sieve-shaking machine can be obtained from W.S. Tyler Company, Ohio, U.S.A. The sieve-shaking test sample is approximately 100 grams and is shaken for 5 minutes.

[0206] The data are plotted on a semi-log plot with the micrometer size opening of each sieve plotted on the logarithmic abscissa and the cumulative mass percent finer (CMPF) is plotted on the linear ordinate. An example of the above data representation is given in ISO 9276-1:1998, "Representation of results of particle size analysis - Part 1: Graphical Representation", Figure A.4. A characteristic particle size (Dx, x = 10, 50, 90), for the purpose of this invention, is defined as the abscissa value at the point where the cumulative mass percent is equal to x percent, and is calculated by a straight line interpolation between the data points directly above (a) and below (b) the x value using the following equation:

$$Dx = 10\char`^[\mathrm{Log}(Da) - (\mathrm{Log}(Da) - \mathrm{Log}(Db))*(Qa - x\%)/(Qa - Qb)]$$

where Log is the base 10 logarithm, Qa and Qb are the cumulative mass percentile values of the measured data immediately above and below the xth percentile, respectively; and Da and Db are the micrometer sieve size values corresponding to these data.

[0207] Example data and calculations:

sieve size (micrometer)	weight on sieve (g)	cumulative mass% finer (CMPF)
1700	0	100%
1180	0.68	99.3%
850	10.40	89.0%
600	28.73	60.3%
425	27.97	32.4%
300	17.20	15.2%
212	8.42	6.8%
150	4.00	2.8%
Pan	2.84	0.0%

[0208] For D10 (x = 10), the micrometer screen size where CMPF is immediately above 10% (Da) is 300 micrometer, the screen below (Db) is 212 micrometer. The cumulative mass immediately above 10% (Qa) is 15.2%, below (Qb) is 6.8%. D10 = 10^[Log(300) - (Log(300) - Log(212))*(15.2% - 10%)/(15.2% - 6.8%)] = 242 micrometer.

[0209] For D90 (x = 90), the micrometer screen size where CMPF is immediately above 90% (Da) is 1180 micrometer, the screen below (Db) is 850 micrometer. The cumulative mass immediately above 90% (Qa) is 99.3%, below (Qb) is 89.0%. D90 = 10^[Log(1180) - (Log(1180) - Log(850))*(99.3% - 90%)/(99.3% - 89.0%)] = 878 micrometer.

[0210] For D50 (x = 50), the micrometer screen size where CMPF is immediately above 50% (Da) is 600 micrometer, the screen below (Db) is 425 micrometer. The cumulative mass immediately above 50% (Qa) is 60.3%, below (Qb) is 32.4%. D50 = 10^[Log(600) - (Log(600) - Log(425))*(60.3% - 50%)/(60.3% - 32.4%)] = 528 micrometer.

CD and MD Basis Weight Variation Test Method

[0211] The cross direction (CD) basis weight variation is measured with this method by sampling the web in the cross direction at a given fixed machine direction (MD) position, measuring the basis weight for samples taken at this MD position, and then calculating the % Relative Standard Deviation (RSD) for the sample set. This analysis is performed for as many samples as needed to sample the entire cross direction of a given web. As one sampling example, if the web is about 53 cm wide and the sample die cutter for basis eight is 4.1275 cm wide as it is in the Basis Weight Method described herein, then about 12 samples may be taken across the web. Samples at the web edges may not completely fill the sampling die when cutting across a full MD position, for example, the die cutter extends past the edge of the web, should be discarded. Sampling at a given MD position may vary slightly, as long as the entire CD width is reasonably sampled at the respective MD position. The sampling is completed for a total of 10 fixed MD positions spaced about 1 m apart. The CD basis weight variation is recorded for each MD position and the values at each position are used to get a CD basis weight variation % RSD per MD sampled position. The average for the 10 rows or MD positions sampled is reported as the overall CD basis weight variation % RSD.

[0212] The machine direction (MD) basis weight variation is measured with this method by sampling the web in the Machine Direction at a given fixed cross direction (CD) position, measuring the basis weight for samples taken at the given CD position, replicating the measurement at other CD positions, and then calculating the overall MD basis weight variation % RSD for the entire sample set.

[0213] The overall CD basis weight variation % RSD and overall MD basis weight variation % RSD can be averaged to get an overall web basis weight variation % RSD.

Procedure for Measuring Cross Direction Variability at Fixed Machine Direction Position

[0214] Choose a Machine Direction position of the web from which to sample.

[0215] Follow the Basis Weight Test Method described herein to measure the basis weigh of all samples.

[0216] Cut as many samples as necessary to sample the entire web width at a given MD position.

[0217] As one example, if a web is about 53 cm wide and the sample die cutter is 4.1275 cm wide, then about 12 samples may be taken across the web. Sampling at a given MD position may vary slightly, as long as the entire CD width is reasonably sampled at the respective MD position.

[0218] Discard samples at the edges of the full web that do not completely fill the sampling die when cutting.

[0219] Calculate the basis weight for each sample taken along the given MD position.

[0220] Calculate the mean sample basis weight for this fixed MD position.

[0221] Calculate the standard deviation for the samples at the fixed MD position.

[0222] Calculate the % RSD (Relative Standard Deviation) for the samples at this MD position by dividing the standard deviation by the mean sample basis weight and multiply by 100 to yield a % value.

[0223] Repeat the above for a total of 10 rows or 10 MD positions, sampling at about 1 meter intervals of the web from the process.

[0224] Average the % RSD for all ten rows and report it as the overall CD basis weight variation % RSD. This value is reported to the nearest 0.1 %.

Procedure For Measuring Machine Direction Variability at Fixed Cross Direction Position

[0225] Sample from the web at its cross direction centerline position.

[0226] Follow the Basis Weight Test Method described herein to measure the basis weight of all samples.

[0227] Cut ten samples along the web's cross direction centerline position at about 1 m intervals in the MD direction of the web from the process.

[0228] Calculate the basis weight for each sample.

[0229] Calculate the mean sample basis weight for CD centerline position.

[0230] Calculate the standard deviation for the same sample set.

[0231] Calculate the MD basis weight variation % RSD at the CD centerline position by dividing the standard deviation by the mean sample basis weight and multiplying by 100 to get a % value. Report this value to the nearest 0.1%.

[0232] Repeat the above cross direction centerline position measurement by doing the same sampling and measurement along a mid-line on the left half of the CD centerline and then along a mid-line on the right half of the CD centerline.

[0233] From the above analysis, there will be three values generated:

% RSD for the CD centerline position
% RSD for the mid-line on the left half of the CD centerline
% RSD for the mid-line on the right half of the CD centerline

[0234] Average the % RSD for these three CD positions and report it as the overall MD basis weight variation % RSD. This value is reported to the nearest 0.1 %.

Inclusion Efficiency Test Method

[0235] Inclusion efficiency is a measure of the percentage of solid additives, for example particles, captured and retained in the fibrous structure during the commingling (coforming) operation to the number of solid additives, for example particles, introduced (fed) into the commingling (coforming) operation. A higher percentage of inclusion efficiency indicates better solid additive, for example particle, entrainment is being realized by the commingling (coforming) operation and/or coforming apparatus and/or process conditions operable during the commingling (coforming) operation.

[0236] In general, the inclusion efficiency is:

$$\text{Inclusion Efficiency} = \frac{\text{Ratio of mass of particles to mass of filaments in fibrous structure}}{\text{Ratio of mass of particles to mass of dry filament feed rate}} \text{ X } 100$$

which is better calculated as follows:

$$\text{Inclusion Efficiency} = 100 \text{ X } \frac{\dfrac{(\text{(Composite fibrous structure basis weight (g/m}^2\text{)} - \text{Filament fibrous structure (void of solid additives) basis weight (g/m}^2\text{))}}{\text{(Filament fibrous structure (void of solid additives) basis weight (g/m}^2\text{)))}}}{\text{(Total Particle feed rate (g/min))/(Total Filament-forming composition feed rate (g/min) X Filament-forming composition Solids concentration)}}$$

Procedure

[0237] Run the commingling (coforming) operation at steady state conditions to make a base fibrous structure (filament only) with no particles.

[0238] Measure the basis weight of cut sample of base fibrous structure as defined in the Basis Weight method defined herein.

[0239] Sample from the center of the base fibrous structure cross direction or at the base fibrous structure's CD centerline.

[0240] Record this as the base fibrous structure basis weight (g/m^2).

[0241] Make composite fibrous structure (filaments + particles) at a desired dry mass feed rate.

[0242] Measure the basis weight of cut sample of the composite fibrous structure as defined in the Basis Weight method defined herein.

[0243] Sample from the center of the composite fibrous structure cross direction or at the composite fibrous structure's CD centerline.

[0244] Record this as the composite fibrous structure basis weight (g/m^2).

[0245] Total Particle feed rate and Total Filament-forming Composition feed rate are process parameters. Total Particle feed rate is measured by collecting the entire particle feed stream over a one minute interval and reported in g/min to the nearest 1 g/min. Total Filament-forming Composition feed rate is measured using inline process flow meters and is reported in g/min to the nearest 1 g/min. Filament-forming Composition Solids concentration is the ratio of the mass of filament-forming composition material left after drying to the mass of starting filament-forming composition. This can be measured using a Mettler Toledo HC103 or equivalent Moisture Analyzer. Filament-forming Composition Solids concentration is reported as a fractional value to the nearest 0.01 units or as a percentage to the nearest 1%.

[0246] For clarity, an example of an Inclusion Efficiency calculation is shown below.

[0247] A base fibrous structure (filament only - no particles) is made from a filament-forming composition at 55% (0.55) solids concentration. The filament-forming composition feed rate to the die is 1600 g/min. A sample cut the base fibrous structure's centerline exhibits a basis weight of 264 g/m^2. A composition fibrous structure (filaments + solid additives, for example particles) is then made as described above with respect to the base fibrous structure, but the solid additives, for example particles, are added to the filaments at a Total Particle feed rate of 2350 g/min. A sample cut from the composite fibrous structure exhibits a basis weight 870 g/m^2. With these values, the example Inclusion Efficiency calculation is as follows:

$$\text{Inclusion Efficiency} = \frac{(870\text{ g/m}^2 - 264\text{ g/m}^2)/(264\text{ g/m}^2)}{(2350\text{ g/min})/(1600\text{ g/min} * 0.55)} \text{ X } 100 = 86\%$$

[0248] Inclusion Efficiency is reported to the nearest 1%.

Water Content Test Method

[0249] The water (moisture) content present in a fibrous element and/or particle and/or fibrous structure is measured using the following Water Content Test Method. A fibrous element and/or particle and/or fibrous structure or portion thereof ("sample") in the form of a pre-cut sheet is placed in a conditioned room at a temperature of 23°C ± 1.0°C and a relative humidity of 50% ± 2% for at least 24 hours prior to testing. Each fibrous structure sample has an area of at least 4 square inches, but small enough in size to fit appropriately on the balance weighing plate. Under the temperature and humidity conditions mentioned above, using a balance with at least four decimal places, the weight of the sample is recorded every five minutes until a change of less than 0.5% of previous weight is detected during a 10 minute period. The final weight is recorded as the "equilibrium weight". Within 10 minutes, the samples are placed into the forced air oven on top of foil for 24 hours at 70°C ± 2°C at a relative humidity of 4% ± 2% for drying. After the 24 hours of drying, the sample is removed and weighed within 15 seconds. This weight is designated as the "dry weight" of the sample.

[0250] The water (moisture) content of the sample is calculated as follows:

$$\%\text{ Water in sample} = 100\% \text{ x } \frac{(\text{Equilibrium weight of sample} - \text{Dry weight of sample})}{\text{Dry weight of sample}}$$

The % Water (moisture) in sample for 3 replicates is averaged to give the reported % Water (moisture) in sample. Report results to the nearest 0.1%.

Diameter Test Method

[0251] The diameter of a discrete fibrous element or a fibrous element within a fibrous structure is determined by using a Scanning Electron Microscope (SEM) or an Optical Microscope and an image analysis software. A magnification of 200 to 10,000 times is chosen such that the fibrous elements are suitably enlarged for measurement. When using the SEM, the samples are sputtered with gold or a palladium compound to avoid electric charging and vibrations of the fibrous element in the electron beam. A manual procedure for determining the fibrous element diameters is used from the image (on monitor screen) taken with the SEM or the optical microscope. Using a mouse and a cursor tool, the edge of a randomly selected fibrous element is sought and then measured across its width (i.e., perpendicular to fibrous element direction at that point) to the other edge of the fibrous element. A scaled and calibrated image analysis tool provides the scaling to get actual reading in μm. For fibrous elements within a fibrous structure, several fibrous element are randomly selected across the sample of the fibrous structure using the SEM or the optical microscope. At least two portions of the fibrous structure are cut and tested in this manner. Altogether at least 100 such measurements are made and then all data are recorded for statistical analysis. The recorded data are used to calculate average (mean) of the fibrous element diameters, standard deviation of the fibrous element diameters, and median of the fibrous element diameters.

[0252] Another useful statistic is the calculation of the amount of the population of fibrous elements that is below a certain upper limit. To determine this statistic, the software is programmed to count how many results of the fibrous element diameters are below an upper limit and that count (divided by total number of data and multiplied by 100%) is reported in percent as percent below the upper limit, such as percent below 1 micrometer diameter or %-submicron, for example. We denote the measured diameter (in μm) of an individual circular fibrous element as di.

[0253] In the case that the fibrous elements have non-circular cross-sections, the measurement of the fibrous element diameter is determined as and set equal to the hydraulic diameter which is four times the cross-sectional area of the fibrous element divided by the perimeter of the cross-section of the fibrous element (outer perimeter in case of hollow fibrous elements). The number-average diameter, alternatively average diameter is calculated as:

$$d_{num} = \frac{\sum_{i=1}^{n} d_i}{n}$$

Weight Average Molecular Weight Test Method

[0254] The weight average molecular weight (Mw) of a material, such as a polymer, is determined by Gel Permeation

Chromatography (GPC) using a mixed bed column. A high performance liquid chromatograph (HPLC) having the following components: Millenium®, Model 600E pump, system controller and controller software Version 3.2, Model 717 Plus autosampler and CHM-009246 column heater, all manufactured by Waters Corporation of Milford, MA, USA, is utilized. The column is a PL gel 20 μm Mixed A column (gel molecular weight ranges from 1,000 g/mol to 40,000,000 g/mol) having a length of 600 mm and an internal diameter of 7.5 mm and the guard column is a PL gel 20 μm, 50 mm length, 7.5 mm ID. The column temperature is 55°C and the injection volume is 200 μL. The detector is a DAWN® Enhanced Optical System (EOS) including Astra® software, Version 4.73.04 detector software, manufactured by Wyatt Technology of Santa Barbara, CA, USA, laser-light scattering detector with K5 cell and 690 nm laser. Gain on odd numbered detectors set at 101. Gain on even numbered detectors set to 20.9. Wyatt Technology's Optilab® differential refractometer set at 50°C. Gain set at 10. The mobile phase is HPLC grade dimethylsulfoxide with 0.1% w/v LiBr and the mobile phase flow rate is 1 mL/min, isocratic. The run time is 30 minutes.

[0255] A sample is prepared by dissolving the material in the mobile phase at nominally 3 mg of material /1 mL of mobile phase. The sample is capped and then stirred for about 5 minutes using a magnetic stirrer. The sample is then placed in an 85°C convection oven for 60 minutes. The sample is then allowed to cool undisturbed to room temperature. The sample is then filtered through a 5μm Nylon membrane, type Spartan-25, manufactured by Schleicher & Schuell, of Keene, NH, USA, into a 5 milliliter (mL) autosampler vial using a 5 mL syringe.

[0256] For each series of samples measured (3 or more samples of a material), a blank sample of solvent is injected onto the column. Then a check sample is prepared in a manner similar to that related to the samples described above. The check sample comprises 2 mg/mL of pullulan (Polymer Laboratories) having a weight average molecular weight of 47,300 g/mol. The check sample is analyzed prior to analyzing each set of samples. Tests on the blank sample, check sample, and material test samples are run in duplicate. The final run is a run of the blank sample. The light scattering detector and differential refractometer is run in accordance with the "Dawn EOS Light Scattering Instrument Hardware Manual" and "Optilab® DSP Interferometric Refractometer Hardware Manual," both manufactured by Wyatt Technology Corp., of Santa Barbara, CA, USA, and both incorporated herein by reference.

[0257] The weight average molecular weight of the sample is calculated using the detector software. A dn/dc (differential change of refractive index with concentration) value of 0.066 is used. The baselines for laser light detectors and the refractive index detector are corrected to remove the contributions from the detector dark current and solvent scattering. If a laser light detector signal is saturated or shows excessive noise, it is not used in the calculation of the molecular mass. The regions for the molecular weight characterization are selected such that both the signals for the 90° detector for the laser-light scattering and refractive index are greater than 3 times their respective baseline noise levels. Typically, the high molecular weight side of the chromatogram is limited by the refractive index signal and the low molecular weight side is limited by the laser light signal.

[0258] The weight average molecular weight can be calculated using a "first order Zimm plot" as defined in the detector software. If the weight average molecular weight of the sample is greater than 1,000,000 g/mol, both the first and second order Zimm plots are calculated, and the result with the least error from a regression fit is used to calculate the molecular mass. The reported weight average molecular weight is the average of the two runs of the material test sample.

[0259] The dimensions and values disclosed herein are not to be understood as being strictly limited to the exact numerical values recited. Instead, unless otherwise specified, each such dimension is intended to mean both the recited value and a functionally equivalent range surrounding that value. For example, a dimension disclosed as "40 mm" is intended to mean "about 40 mm."

[0260] Every document cited herein, including any cross referenced or related patent or application and any patent application or patent to which this application claims priority or benefit thereof, is hereby incorporated herein by reference in its entirety unless expressly excluded or otherwise limited. The citation of any document is not an admission that it is prior art with respect to any invention disclosed or claimed herein or that it alone, or in any combination with any other reference or references, teaches, suggests or discloses any such invention. Further, to the extent that any meaning or definition of a term in this document conflicts with any meaning or definition of the same term in a document incorporated by reference, the meaning or definition assigned to that term in this document shall govern.

[0261] While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

[0262] Aspects of the present invention are further described with reference to the following numbered paragraphs:

1. A process for making a fibrous structure, the process comprising the steps of:

    a. providing one or more soluble filament-forming materials;
    b. forming an aqueous composition comprising the one or more soluble filament-forming materials;
    c. processing the aqueous composition to produce a filament-forming composition;

d. delivering the filament-forming composition to one or more dies;
e. spinning the filament-forming composition to form a plurality of soluble filaments; and
f. collecting the soluble filaments on a collection device to form a fibrous structure.

2. The process according to paragraph 1 wherein at least one of the one or more soluble filament-forming materials comprises a hydroxyl polymer, preferably wherein the hydroxyl polymer is selected from the group consisting of: pullulan, hydroxypropylmethyl cellulose, hydroxyethyl cellulose, methyl cellulose, hydroxypropyl cellulose, polyvinyl pyrrolidone, carboxymethyl cellulose, sodium alginate, xanthan gum, tragacanth gum, guar gum, acacia gum, Arabic gum, polyacrylic acid, methylmethacrylate copolymer, carboxyvinyl polymer, dextrin, pectin, chitin, levan, elsinan, collagen, gelatin, zein, gluten, soy protein, casein, polyvinyl alcohol, carboxylated polyvinyl alcohol, sulfonated polyvinyl alcohol, starch, starch derivatives, hemicellulose, hemicellulose derivatives, proteins, chitosan, chitosan derivatives, polyethylene glycol, tetramethylene ether glycol, hydroxymethyl cellulose, polyethylene oxide, and mixtures thereof, more preferably wherein the hydroxyl polymer comprises polyvinyl alcohol.

3. The process according to paragraph 1 or paragraph 2 wherein at least one of the one or more filament-forming materials is in the form of pellets.

4. The process according to any of the preceding paragraphs wherein at least 30% by weight of water is added to the one or more filament-forming materials in step b, preferably wherein at least 40% by weight of water is added to the one or more filament-forming materials in step b.

5. The process according to any of the preceding paragraphs wherein the step of processing the aqueous composition occurs within an extruder, preferably wherein the extruder is a twin screw extruder.

6. The process according to paragraph 5 wherein the aqueous composition present in the extruder exhibits a % solids of from 20% to 95%, preferably wherein the aqueous composition present in the extruder exhibits a % solids of from 30% to 85%, more preferably wherein the aqueous composition present in the extruder exhibits a % solids of from 40% to 70%.

7. The process according to paragraph 5 wherein the filament-forming composition exits the extruder at an exit pressure of from 10 to 80 bar, preferably wherein the filament-forming composition exits the extruder at an exit pressure of from 15 to 75 bar, more preferably wherein the filament-forming composition exits the extruder at an exit pressure of from 20 to 65 bar.

8. The process according to paragraph 5 wherein the extruder subjects the filament-forming composition to a temperature of at least 49°C.

9. The process according to paragraph 5 wherein the filament-forming composition exits the extruder on a solids throughput basis of from 0.10 to 0.50 kW-h/kg, preferably wherein the filament-forming composition exits the extruder on a solids throughput basis of from 0.12 to 0.45 kW-h/kg, more preferably wherein the filament-forming composition exits the extruder on a solids throughput basis of from 0.14 to 0.35 kW-h/kg.

10. The process according to any of the preceding paragraphs wherein the process further comprises the step of commingling a plurality of solid additives with the soluble filaments to form a composite structure, preferably wherein the solid additives comprise particles, preferably wherein the particles comprise water-soluble particles and/or water-insoluble particles.

11. The process according to paragraph 10 wherein at least one of the particles is an agglomerate, preferably wherein the agglomerate comprises a water-soluble material and/or a water insoluble material, more preferably wherein the agglomerate comprises a water-soluble particle, a water insoluble particle, or combinations thereof.

12. The process according to paragraph 10 wherein the particles comprise active agent-containing particles.

13. The process according to any of the preceding paragraphs wherein at least one of the soluble filaments comprises one or more active agents present within the filament, preferably wherein at least one of the one or more active agents is selected from the group consisting of: fabric care active agents, dishwashing active agents, carpet care active agents, surface care active agents, air care active agents, oral care active agents, hair care active agents, shampoos, conditioners, keratinaceous tissue care agents, toilet bowl cleaning agents, skin care active agents, and

mixtures thereof.

14. The process according to paragraph 13 wherein at least one of the one or more active agents is added in the process in at least one of steps b, c, and d.

15. The process according to any of the preceding paragraphs wherein the process further comprises the step of converting the fibrous structure into an article of manufacture.

Claims

1. A process for making a fibrous structure, the process comprising the steps of:

a. providing one or more soluble filament-forming materials;
b. forming an aqueous composition comprising the one or more soluble filament-forming materials;
c. processing the aqueous composition to produce a filament-forming composition;
d. delivering the filament-forming composition to one or more dies;
e. spinning the filament-forming composition to form a plurality of soluble filaments; and
f. collecting the soluble filaments on a collection device to form a fibrous structure.

2. The process according to Claim 1 wherein at least one of the one or more soluble filament-forming materials comprises a hydroxyl polymer, preferably wherein the hydroxyl polymer is selected from the group consisting of: pullulan, hydroxypropylmethyl cellulose, hydroxyethyl cellulose, methyl cellulose, hydroxypropyl cellulose, polyvinyl pyrrolidone, carboxymethyl cellulose, sodium alginate, xanthan gum, tragacanth gum, guar gum, acacia gum, Arabic gum, polyacrylic acid, methylmethacrylate copolymer, carboxyvinyl polymer, dextrin, pectin, chitin, levan, elsinan, collagen, gelatin, zein, gluten, soy protein, casein, polyvinyl alcohol, carboxylated polyvinyl alcohol, sulfonated polyvinyl alcohol, starch, starch derivatives, hemicellulose, hemicellulose derivatives, proteins, chitosan, chitosan derivatives, polyethylene glycol, tetramethylene ether glycol, hydroxymethyl cellulose, polyethylene oxide, and mixtures thereof, more preferably wherein the hydroxyl polymer comprises polyvinyl alcohol.

3. The process according to Claim 1 or 2 wherein at least one of the one or more filament-forming materials is in the form of pellets.

4. The process according to any of the preceding Claims wherein at least 30% by weight of water is added to the one or more filament-forming materials in step b, preferably wherein at least 40% by weight of water is added to the one or more filament-forming materials in step b.

5. The process according to any of the preceding Claims wherein the step of processing the aqueous composition occurs within an extruder, preferably wherein the extruder is a twin screw extruder.

6. The process according to Claim 5 wherein the aqueous composition present in the extruder exhibits a % solids of from 20% to 95%, preferably wherein the aqueous composition present in the extruder exhibits a % solids of from 30% to 85%, more preferably wherein the aqueous composition present in the extruder exhibits a % solids of from 40% to 70%.

7. The process according to Claim 5 wherein the filament-forming composition exits the extruder at an exit pressure of from 10 to 80 bar, preferably wherein the filament-forming composition exits the extruder at an exit pressure of from 15 to 75 bar, more preferably wherein the filament-forming composition exits the extruder at an exit pressure of from 20 to 65 bar.

8. The process according to Claim 5 wherein the extruder subjects the filament-forming composition to a temperature of at least 49°C.

9. The process according to Claim 5 wherein the filament-forming composition exits the extruder on a solids throughput basis of from 0.10 to 0.50 kW-h/kg, preferably wherein the filament-forming composition exits the extruder on a solids throughput basis of from 0.12 to 0.45 kW-h/kg, more preferably wherein the filament-forming composition exits the extruder on a solids throughput basis of from 0.14 to 0.35 kW-h/kg.

10. The process according to any of the preceding Claims wherein the process further comprises the step of commingling a plurality of solid additives with the soluble filaments to form a composite structure, preferably wherein the solid additives comprise particles, preferably wherein the particles comprise water-soluble particles and/or water-insoluble particles.

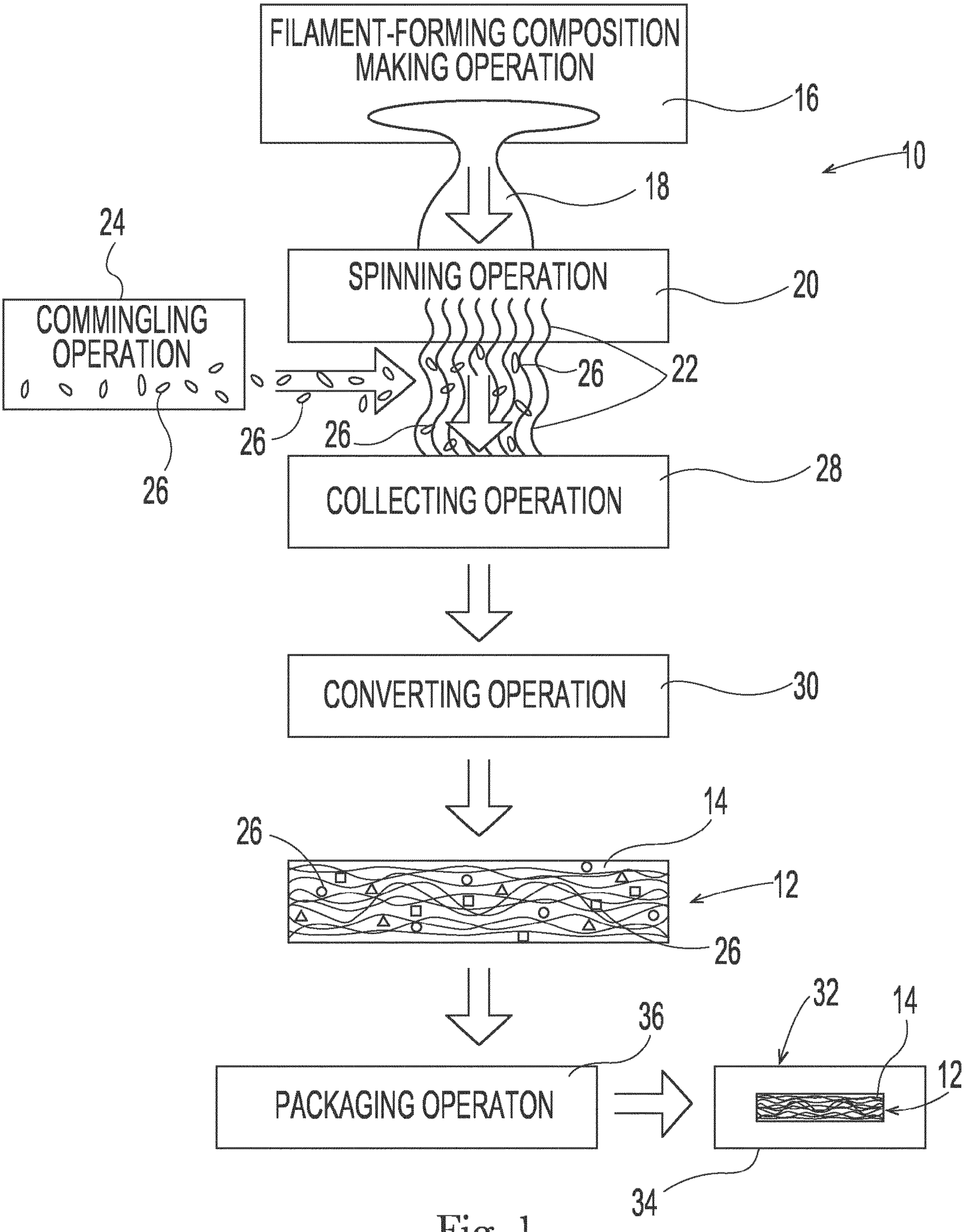
11. The process according to Claim 10 wherein at least one of the particles is an agglomerate, preferably wherein the agglomerate comprises a water-soluble material and/or a water insoluble material, more preferably wherein the agglomerate comprises a water-soluble particle, a water insoluble particle, or combinations thereof.

12. The process according to Claim 10 wherein the particles comprise active agent-containing particles.

13. The process according to any of the preceding Claims wherein at least one of the soluble filaments comprises one or more active agents present within the filament, preferably wherein at least one of the one or more active agents is selected from the group consisting of: fabric care active agents, dishwashing active agents, carpet care active agents, surface care active agents, air care active agents, oral care active agents, hair care active agents, shampoos, conditioners, keratinaceous tissue care agents, toilet bowl cleaning agents, skin care active agents, and mixtures thereof.

14. The process according to Claim 13 wherein at least one of the one or more active agents is added in the process in at least one of steps b, c, and d.

15. The process according to any of the preceding Claims wherein the process further comprises the step of converting the fibrous structure into an article of manufacture.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COMMINGLING OPERATION
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COLLECTING OPERATION
CONVERTING OPERATION
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PACKAGING OPERATON
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Fig. 1

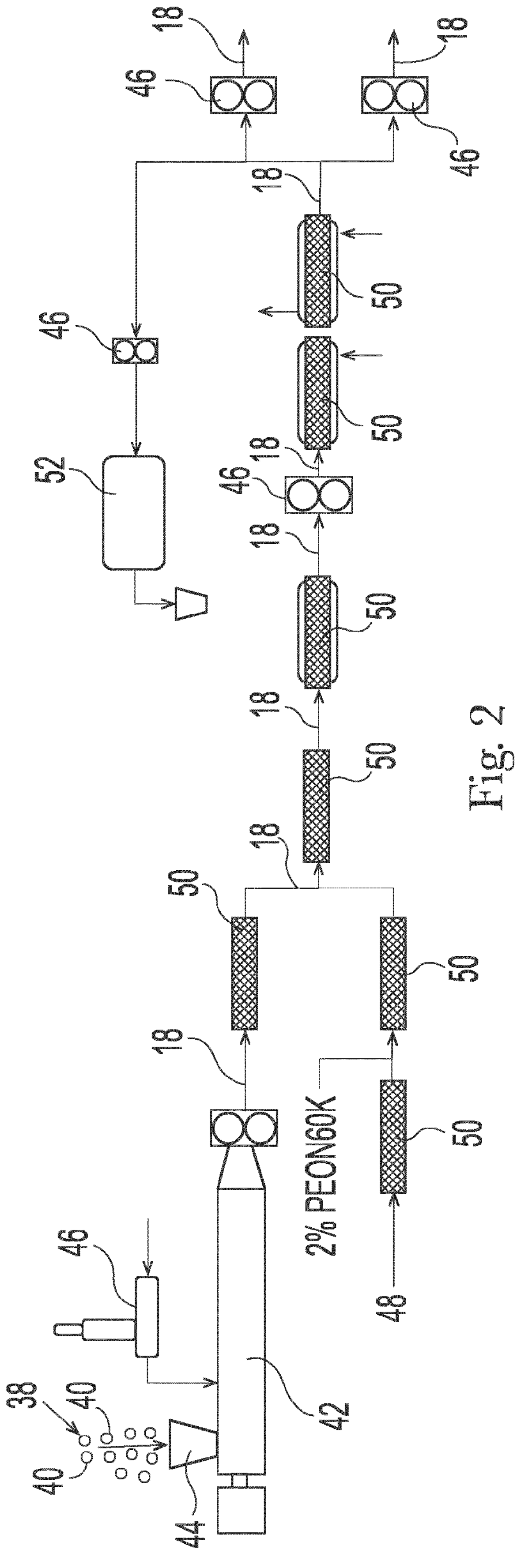
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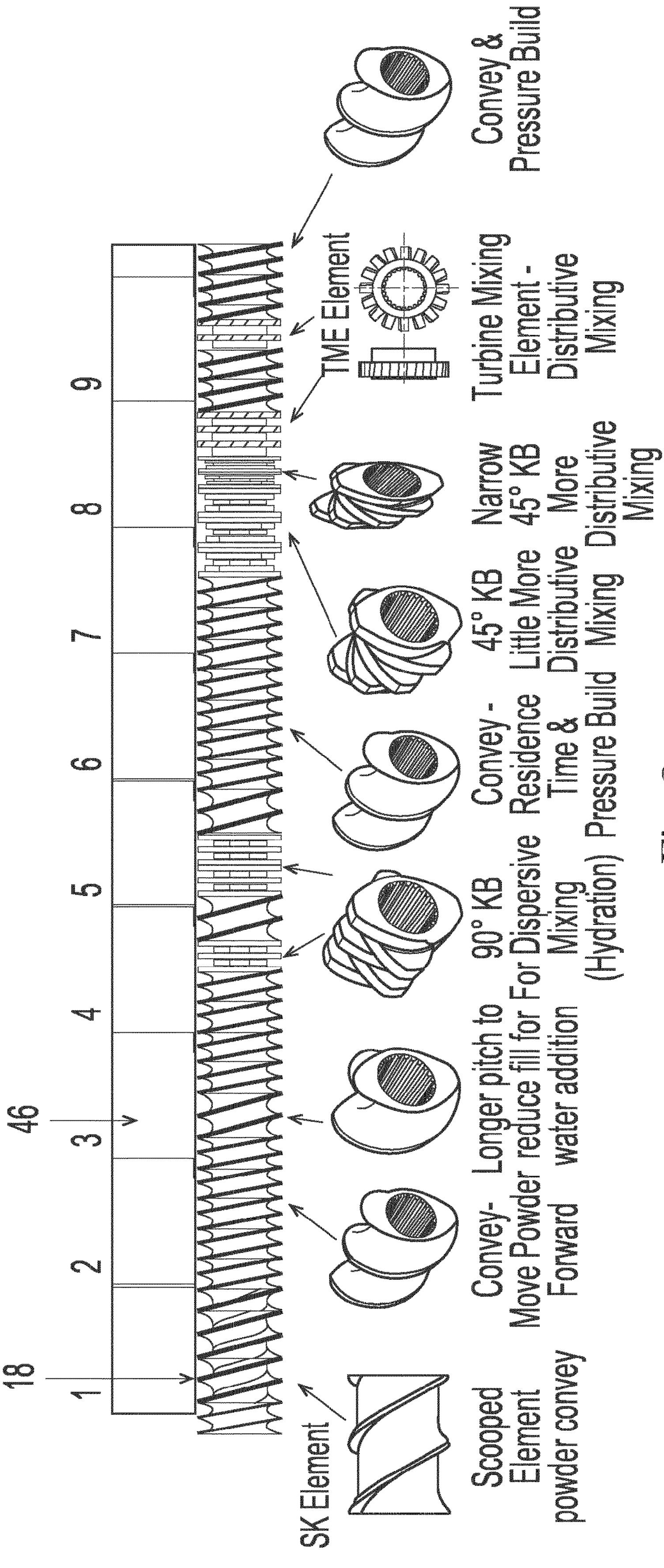
Fig. 2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SK Element
Scooped Element powder convey
Convey- Move Powder Forward
Longer pitch to reduce fill for water addition
90° KB For Dispersive Mixing (Hydration)
Convey - Residence Time & Pressure Build
45° KB Little More Distributive Mixing
Narrow 45° KB More Distributive Mixing
TME Element
Turbine Mixing Element - Distributive Mixing
Convey & Pressure Build

Fig. 3

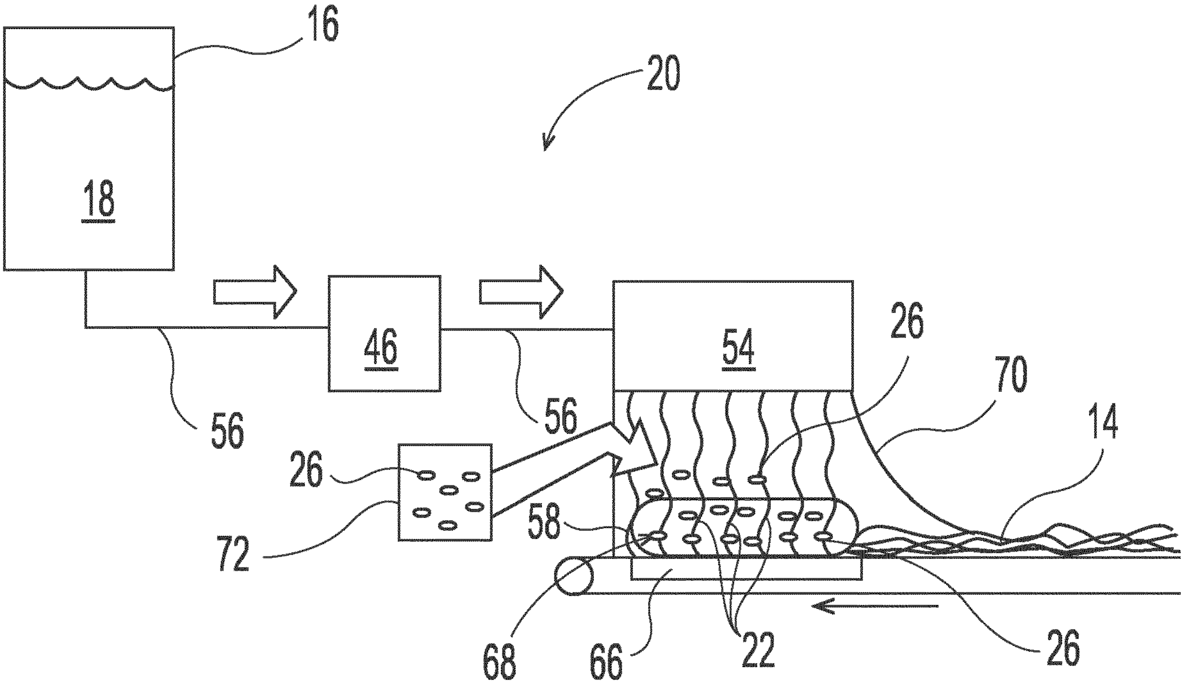
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Fig. 4

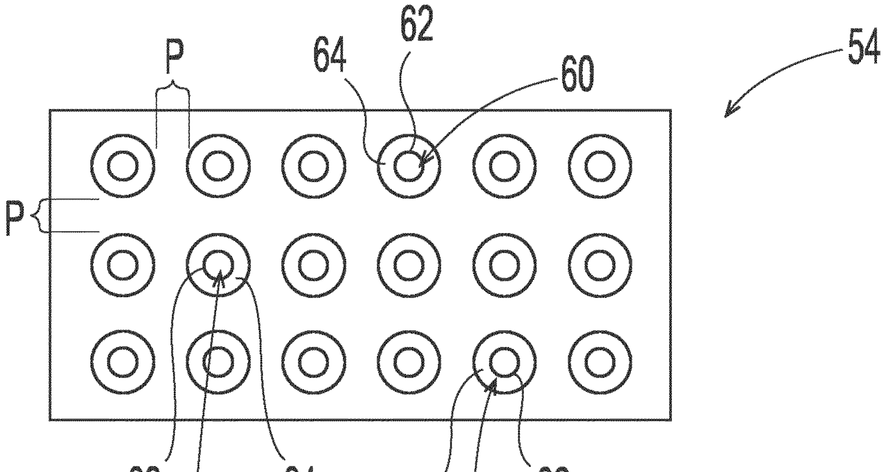
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Fig. 5

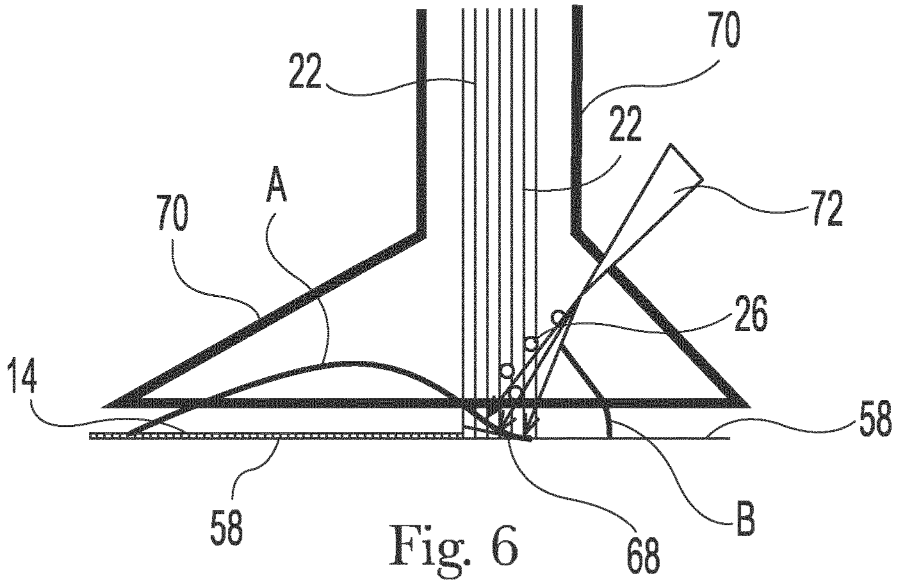

Fig. 6

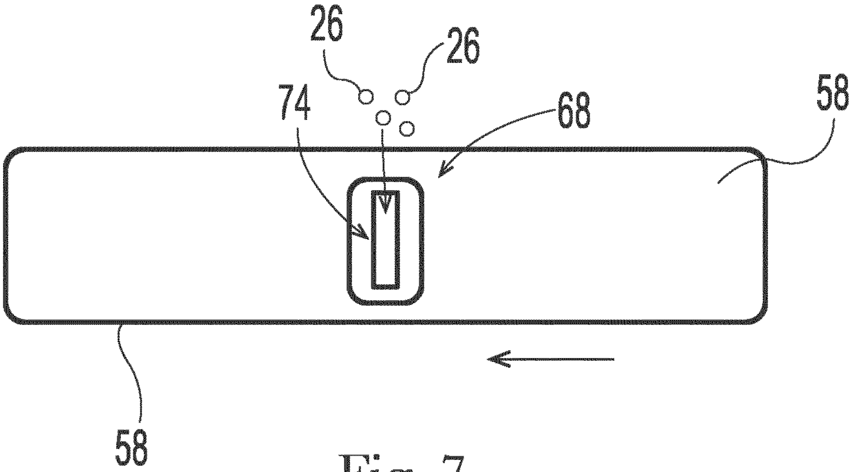

Fig. 7

REFERENCES CITED IN THE DESCRIPTION

Non-patent literature cited in the description

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- CTFA Cosmetic Ingredient Handbook. The Cosmetic, Toiletries, and Fragrance Association, Inc, 1988 **[0132]**