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(54) **ANTIMICROBIAL NONWOVEN FILTERS COMPOSED OF DIFFERENT DIAMETER FIBERS AND METHOD OF MANUFACTURING THE SAME**

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(57) **ABSTRACT**

The present invention is directed to manufacturing an antimicrobial nonwoven material composed of two or more distinct fibers that are entangled to form a three-dimensional nonwoven web. The individual fiber components of the web are chosen to have properties that impart both excellent filtering capacity and antimicrobial activity to the web. At least one fiber of the composite web is selected to have excellent filtering characteristics. Moreover, at least one fiber of the composite web is selected to be able to incorporate an active agent, such as an iodinated resin, with a sufficient loading capacity and diffusivity such that the active agent can migrate to the surface of the fiber and exert its antimicrobial effect.

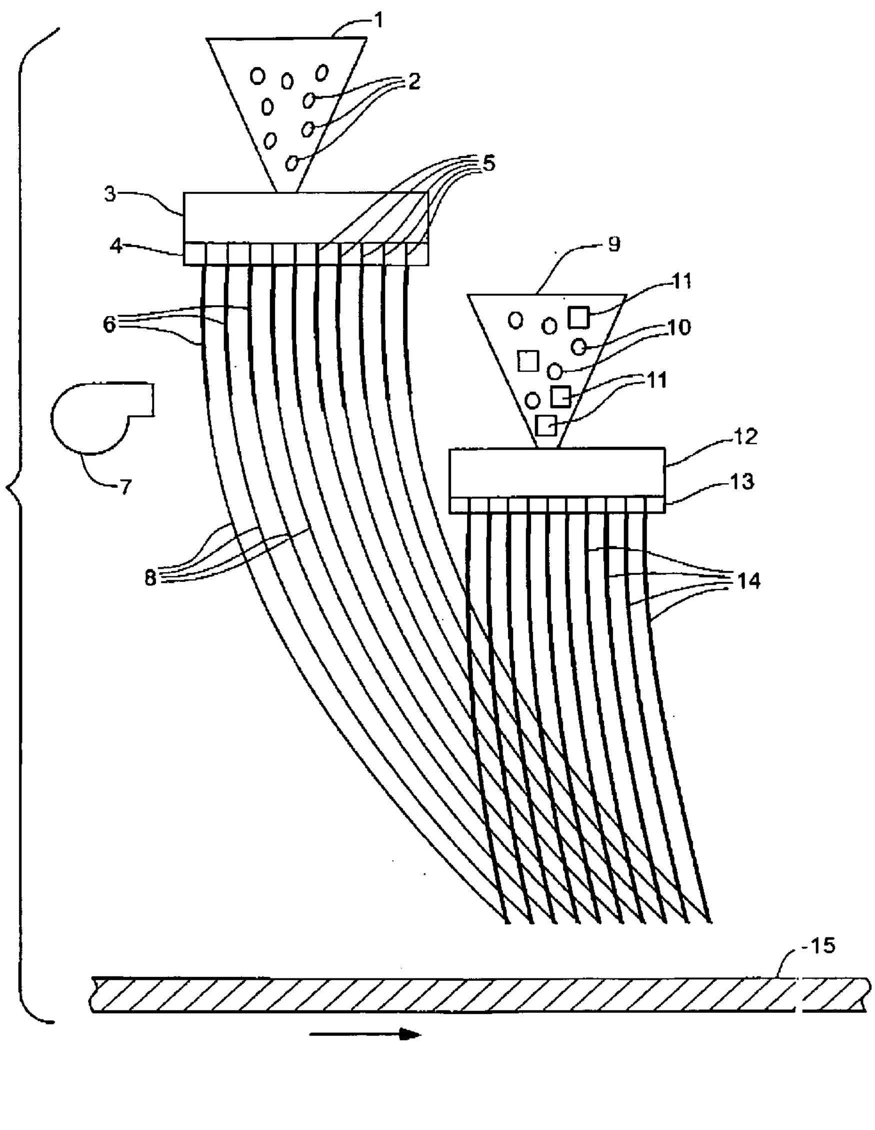


Fig. 1

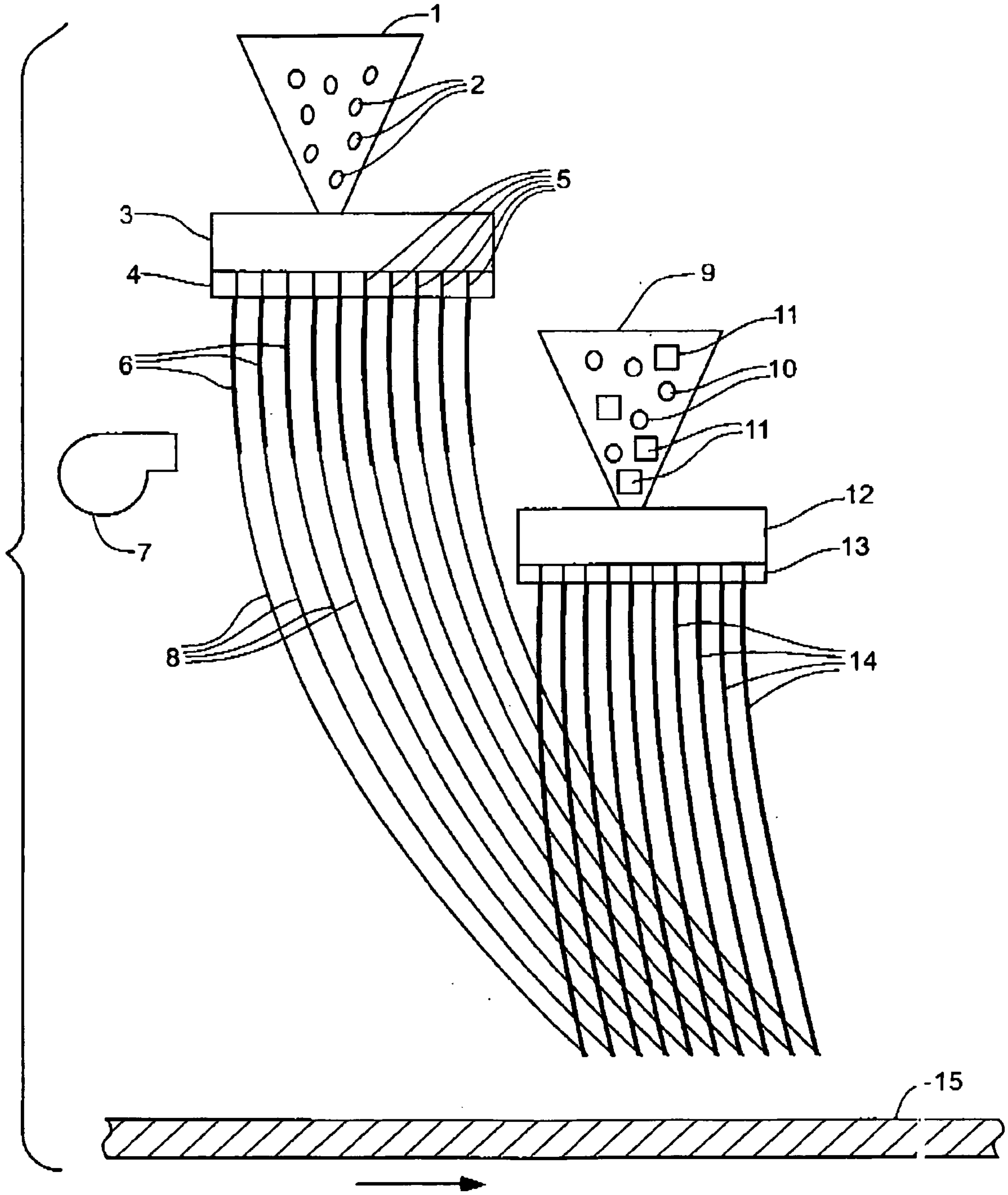
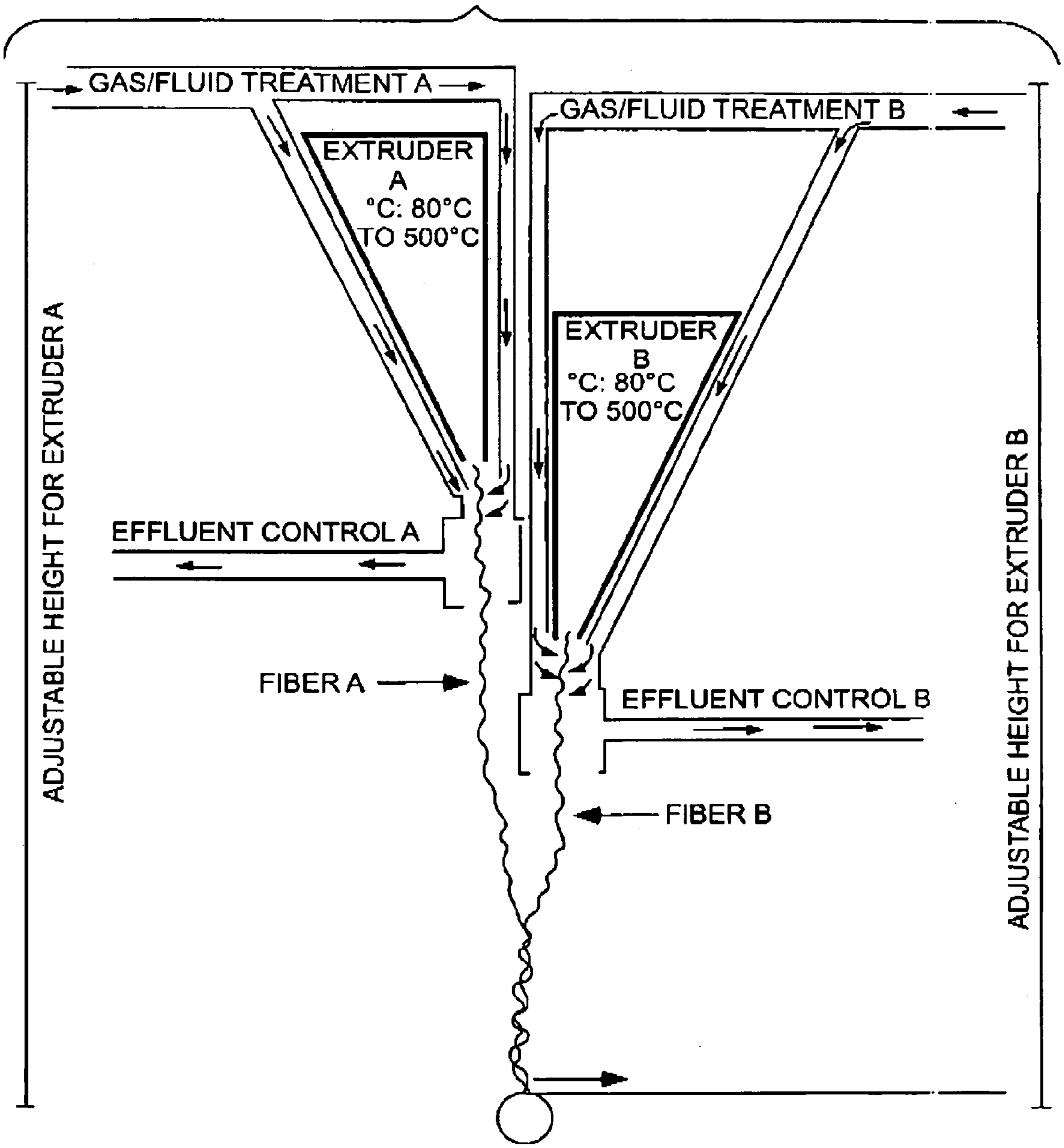


Fig. 2


GAS/FLUID TREATMENT A
GAS/FLUID TREATMENT B
EXTRUDER A °C: 80°C TO 500°C
EXTRUDER B °C: 80°C TO 500°C
ADJUSTABLE HEIGHT FOR EXTRUDER A
ADJUSTABLE HEIGHT FOR EXTRUDER B
EFFLUENT CONTROL A
EFFLUENT CONTROL B
FIBER A
FIBER B

ANTIMICROBIAL NONWOVEN FILTERS COMPOSED OF DIFFERENT DIAMETER FIBERS AND METHOD OF MANUFACTURING THE SAME

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of provisional application 61/069,000 filed on Mar. 11, 2008.

BACKGROUND OF THE INVENTION

[0002] Prior art filter methods include, for example, mechanical filtration—a physical retention of particles larger than the pores of the filter media; electrostatic filtration—adhering particles to fibers in the filter without killing/deactivating the particles. When it is desired to kill micoorganisms or deactivate other particles an agent has been incorporated in a filter. One such filter system is taught in U.S. Pat. No. 5,980,827 which issued to the inventor hereof on Nov. 9, 1999 and is entitled "Disinfection Of Air Using An Iodine/Resin Disinfectant." Another is taught in U.S. Publication No. 2006/0251879 (the '879 publication). The entire contents of U.S. Pat. No. 5,980,227 and the '879 publication are incorporated herein by reference. It has been determined that improved iodinated resin filtration occurs in a thin media when the product is incorporated to a media with a convoluted pathway. By forcing the microorganism/toxin to pass through a circuitous route, the microorganism/toxin is eventually killed/deactivated. One method for providing a circuitous route is to employ an electrostatically charged nonwoven media.

[0003] Various techniques of incorporating an antimicrobial agent in a fiber are known in the art. One such method involves physically entrapping the active agent within the three-dimensional structure of the nonwoven material. The active agent must have the appropriate size to be entrapped within the matrix structure of the nonwoven web. For instance, U.S. Publication No. 2006/0144403 (the '403 publication), to Messier, describes several methods of physically entrapping an active agent such as iodine demand disinfectant resin in a three-dimensional nonwoven matrix. The '403 publication is hereby incorporated by reference. One such method involves making use of a meltblown system where the desired active agent is provided in a cloud at the location closest to the extrusion point of polypropylene fibers. The cloud of active agent envelops the extruded fibers exiting a spinerett. Upon cooling, the active agent becomes physically entrapped within the fibers on the collecting web.

[0004] In addition to physically entrapping the active agent, the active agent may be incorporated directly into the fiber. Methods of incorporating an antimicrobial agent into a nonwoven material are also known in the art. Generally, the active agent is blended with the polymer prior to extrusion so that it is present throughout the polymer. Upon solidification of the polymer, the active agent is dispersed throughout the resultant fiber. The active agent may diffuse to the surface of the nonwoven, where it exerts is toxic effect on the microorganism/toxin. For example, the '403 publication describes a method in which polymer granules are placed in a hopper along with active agent in dust form, preferably an iodine/resin disinfectant, prior to extrusion. The two components are then heated, extruded and attenuated to form fibers having the active agent incorporated thereto. The resulting fibers having the active agent embedded can be air laid, vacuum laid or water laid. Nonwoven materials generated from this process may be utilized as antibacterial filters in various applications.

[0005] Despite the advantages of incorporating an active agent in a nonwoven material, there are several problems associated with the manufacture of such materials with limit their utility. For example, using a conventional meltblown or spunbond process to manufacture fibers or microfibers for nonwoven filters requires high temperatures. In a meltblown process typically used to generate filter-grade fibers, molten polymer extruded from the die holes is hit with high velocity hot air streams to reduce the diameter of the fiber. If certain antimicrobial agents, such as an iodinated rein, is incorporated into the molten polymer, iodine may vaporize from the molten polymer. Besides the associated environmental hazards, the effectiveness of the resultant nonwoven material will be mitigated. Moreover, the chemical integrity and stability of the antimicrobial agent may be compromised by subjecting the active agent to such high temperatures.

[0006] To serve as an antimicrobial filter, a nonwoven web must have the ability to trap and retain particulate matter. Generally, these filters can be made using a meltblown process where the extruded polymers can be drawn into very thin microfibers. The nonwoven webs formed from these microfibers have a large surface area, a small pore size and are lightweight, characteristics which are important for a high degree of filtering efficiency. Moreover, the density of the web formed from these microfibers imparts excellent filtering characteristics to the web.

[0007] The manufacture of an antimicrobial nonwoven material is thus limited to the use of filtration grade materials produced from polymers that can be formed into very fine fibers, in particular polypropylene. As discussed above, owing to the high temperature needed to generate these fine fibers, extruding an active agent with polypropylene followed by attenuation of the fibers is highly problematic, leading to vaporization of the active agent and/or thermal decomposition. Moreover, the size of active agent limits the amount of active ingredient that can be incorporated into the fiber. We have found that this is particularly problematic when using active agents such as iodinated resins as antimicrobial agents. At the present time, iodinated resins with particulate sizes of approximately 5 microns is as small as can be uniformly manufactured. The loading capacity of these iodinated resin particles on polypropylene microfibers is limited. Furthermore, producing very thin fibers ideal for filtering applications is a significant problem when using iodinated resin particles as an active agent. Because the diameter of the resin may be larger than the diameter of the fiber, the resin incorporated fibers may be unstable. For instance, we have found that such fibers are prone to breaking during the manufacturing process. As a result, the efficacy of the filter formed from these may be compromised to a significant degree.

[0008] Given the shortcomings of the prior art, it is advantageous to develop an antimicrobial filter that is easy to manufacture while at the same time being highly efficacious. The present invention comprises a nonwoven antimicrobial fiber that is manufactured from a composite of different fibers each optimized for a different property, one for excellent filtering capability and the other antimicrobial activity.

SUMMARY OF INVENTION

[0009] The present invention provides a method of manufacturing a nonwoven material, and the fibers that make the same, with both a high degree of filtering capacity and antimicrobial activity. The process involves using two different extruders to generate fibers of different diameters. Fibers generated in the first extruder are ideally drawn into very thin microfibers or nanofibers that when bonded, display excellent filtering capacity. Fibers generated in the second extruder will be drawn into fibers that have a larger diameter than fibers formed from the first extruder. The second fibers are formed by extruding a polymer together with an antimicrobial agent such that the antimicrobial agent becomes embedded within the fiber. The two different size fibers exiting the respective extruders are elongated and solidified as they move in the direction of a collecting belt. In the process, the two different size fibers become physically entangled. Subsequently, the entangled, composite fibers are bonded to form a three-dimensional nonwoven web.

[0010] The nonwoven composite structures of the present invention have excellent strength, flexibility and filtering capacity. Moreover, because the antimicrobial agent need not be incorporated into very thin microfibers, a large variety of different types of fibers can be used to incorporate the antimicrobial agent. An advantage of this methodology is that polymers with significantly different melting points can be used to form the composite fiber. Accordingly, the size and chemical nature of the fiber incorporating the active agent can be varied depending on the desired filtering application.

[0011] In certain embodiments, the thicker fiber is a melt-extrudable polymer with embedded iodinated resin particles. The iodinated resin particles are mixed with polymer granules to form an emulsion. Following extrusion and quenching of the fibers, the iodinated resin is embedded in the fiber. It is believed that iodine (I_2) released from the resin migrates to the surface of the fiber where it can exert its antibacterial effect. The rate of migration of iodine to the surface of the fiber can be controlled by the appropriate selection of fiber and/or the addition of other additives. Hence, the nonwoven articles of the present invention have significant advantages over antimicrobial nonwoven materials in the prior art.

BRIEF DESCRIPTION OF DRAWINGS

[0012] FIG. **1** is a schematic view of the apparatus used to produce a composite antimicrobial nonwoven web, in accordance with one embodiment of the present invention.

[0013] FIG. **2** is a view of apparatus used to produce a composite antimicrobial nonwoven web using gas/fluid treatment as a means of temperature control, in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The following sections describe exemplary embodiments of the present invention. It should be apparent to those skilled in the art that the described embodiments of the present invention provided herein are illustrative only and not limiting, having been presented by way of example only. All features disclosed in this description may be replaced by alternative features serving the same or similar purpose, unless expressly stated otherwise. Therefore, numerous other embodiments of the modifications thereof are contemplated as falling within the scope of the present invention as defined herein and equivalents thereto.

[0015] Generally speaking, the present invention is directed to manufacturing an antimicrobial nonwoven material composed of two or more distinct fibers that are entangled to form a three-dimensional nonwoven web. The individual fiber components of the web are chosen to have properties that impart both excellent filtering capacity and antimicrobial activity to the web. At least one fiber of the composite web is selected to have excellent filtering characteristics. Moreover, at least one fiber of the composite web is selected to be able to incorporate an active agent with a sufficient loading capacity and diffusivity such that the active agent can migrate to the surface of the fiber and exert its antimicrobial effect.

[0016] In one preferred embodiment of the present invention, the composite fiber comprises two distinct fibers which are entangled to form a three-dimensional nonwoven web. The first fiber is selected to have excellent filtering capacity. Generally, a polymer which can be drawn into very thin fibers (e.g. microfibers or nanofibers) is ideal for filtering applications. The second fiber will have a larger diameter than the first fiber. The second fiber will have an antimicrobial agent embedded within it. The two different diameter fibers are physically entangled and formed into a nonwoven web.

[0017] The present invention also provides for a method of manufacturing an antimicrobial filter comprising two different size fibers that are physically entangled to form a nonwoven web. The process relies on using two different extruders to form two distinct fibers having different diameters. The polymers used to form the different size fibers may be the same or different. Fibers generated in the first extruder are ideally drawn into very thin microfibers or nanofibers that when bonded, display excellent filtering capacity. Fibers generated in the second extruder are able to incorporate an antimicrobial agent that has the ability to diffuse or migrate to the surface of the fiber. To form the second fiber, polymer or resins are intimately mixed with active agent and then extruded together. If desired, the extruded fibers incorporating active agent can be attenuated after exiting the extruder. Alternatively, the fibers incorporating the active agent are quenched and solidified immediately after exiting the extruder. After cooling and solidifying the different diameter fibers, they are physically entangled. The composite fiber then is deposited on a collecting belt where the three-dimensional nonwoven web is generated.

[0018] The first thinner fiber may be formed by various methods known in the art, including meltblowing processes, spunbonding processes, air laying processes and bonded carded web processes. Meltblown and spunbonding processes are preferred owing to the capability of forming very thin fibers ideal for filtering. Spunbonded fibers refer to small diameter fibers which are formed by extruding molten thermoplastic material as filaments from a plurality of fine capillaries of a spinneret having a circular diameter which are then attenuated. In spunbond processes, the attenuation force is applied at some distance from the extruder/spinneret, after the fiber has solidified. Meltblown fibers are formed by extruding a molten thermoplastic material through a plurality of fine die capillaries as molten filaments into converging high velocity heated gas streams which attenuate the fibers. The attenuation force is applied immediately after the fibers leave the spinneret. The diameter of the fibers formed in a meltblown process can be significantly thinner than that of a fiber formed in a spunbond process. For this reason, meltblown fibers are often ideal for filtering applications.

[0019] The first fiber may be generated from any polymer that can be drawn into a thin fiber suitable for filtering. Preferred polymers are those polymers that can be meltblown. These polymers include but are not limited to polypropylene, polyethylene, PBT, nylon, polycarbonate, poly(4-methyl pentene-1) and polystyrene. Polypropylene is particularly preferred. Generally, the diameter of the first fiber following attenuation may be in the range of from about 1 micron to about 10 microns, preferably in the range of about 1 micron to about 5 microns and most preferably in the range of about 1 micron to about 2 microns.

[0020] The first thinner fiber may be formed by formed by co-extruding a polymer with an antimicrobial agent. However, it is preferred that the first fiber extruded with no or a minimal amount of antimicrobial agent. This will avoid vaporization of the active agent when the fibers leaving the extruder are elongated and formed into microfibers.

[0021] The second fiber, which incorporates antimicrobial agent, may also be formed using conventional techniques including meltblowing processes, spunbonding processes, air laying processes and bonded carded web processes. The polymer granules or resins used to generate the second fiber will be placed in a different hopper then the polymer granules used to form the first, thinner fiber. Preferably, this second hopper will contain both a polymer and an active antimicrobial agent. The antimicrobial agent forms an emulsion with the polymer. The resultant mixture is then extruded and exists a spinneret with the antimicrobial agent incorporated into the polymer in a molten state. The molten polymer can then be attenuated or directly quenched and solidified after leaving the spinneret. Following solidification of the second fiber with embedded active agent, the second fiber is entangled with the first thinner fiber and the resultant composite is formed into a nonwoven web.

[0022] The polymer used to make the second, thicker fiber will depend on the desired application of nonwoven material. Generally, any polymer that can incorporate an antimicrobial agent may be used. Examples of polymers include, but are not limited to polyamides, polyesters, polyolefins, copolymers of ethylene and propylene, copolymers of ethylene or propylene, terpolymers of ethylene with propylene, polylactic acid, ethylene vinyl acetate copolymers, propylene vinyl acetate copolymers, styrene-poly(ethylene-alpha-olefin) elastomers, polyurethanes, polyethers, polyether esters, polyacrylates, ethylene alkyl acrylates, polyisobutylene, polybutadiene, isobutylene-isoprene copolymers, and combinations of any of the foregoing.

[0023] Alternative substrates may further include glass fibers and fibers, such as cellulose, that are ultimately formed into a paper-based filter media. Any substrate capable of acting as carrier for the active agent and having dielectric properties or capable of having dielectric properties imparted to it, would be a suitable substrate for the present invention. When substrates that do not have strong dielectric properties are used, such as glass fibers, additives may be provided to improve the dielectric properties of the substrate. The present invention is not limited to a nonwoven material. Other suitable substrates may include spongy materials or foam.

[0024] The diameter of the second fiber will vary depending on the antimicrobial agent incorporated and the desired filtering application. Generally, the second fiber will be thick enough to allow for a significant loading of the active antimicrobial agent. In a preferred embodiment, the diameter of the second antimicrobial containing fiber is in the range of about 10 to about 40 microns. More preferably, the diameter of the second fiber is between about 15 to about 25 microns. In a particularly preferred embodiment, the diameter of the second fiber is about 20 microns.

[0025] Prior to extrusion, the polymer used to make the second fiber may be blended with additives such as binders, stabilizers, slip agents, antioxidants. Additionally, the polymer/active agent may be blended with a retardant coadditive, such as those described in U.S. Pat. No. 5,300,167, which is hereby incorporated by reference. The purpose of such a coadditive is to slow down diffusion of the active substance to the surface of the fiber, thus delaying the time the antimicrobial agent becomes active.

[0026] The polymer used to form the second fiber may have a different melting point from the polymer used to form the second, thinner fiber. Thus, the temperature of the second extruder where the polymer is mixed with antimicrobial agent may be operated at a lower temperature than the first hopper, where the first thinner fiber is generated. As such, the chemical integrity and stability of the antimicrobial agent will not be compromised.

[0027] Turning to FIG. **1**, an exemplary embodiment of manufacturing the antimicrobial composite fibers of the present invention is disclosed. In first hopper **1**, granules of polymer **2** is added and then fed into extruder **3**, where polymer **2** is melted. The melted polymer is fed to die assembly **4**, where it is spun. The polymer leaves the die assembly **4**, through spinnerets **5**, as filament strands **6**. Upon exiting the die assembly, the filament strands **6** are hit with high velocity hot air **7**, which attenuate the filaments to form streams of microfibers **8**. The attenuated fibers are then cooled and solidified. This apparatus prepares webs of meltblown fibers but other types of fibers, including spunbond fibers, may be used.

[0028] A second hopper **9** is placed downstream (below) of hopper **1**. This second hopper is positioned to be directly adjacent to attenuating filament strands **6** exiting from die assembly **4**. In second hopper **9** is placed granules of polymer **10**, which may be the same or different then polymer **2**. Also added to hopper **9** is antimicrobial agent **11**, which may in the form of fine particles, pellets, resin or dust. The mixture of polymer **10** and antimicrobial agent **11** are fed through extruder **12** and die assembly/spineret **13** where it exists as filaments strands of fiber **14**. The fibers **14** are cooled and elongated after exiting die assembly **13**. It is noted that the second hopper **9** is positioned such that solidified filaments leaving die assembly/spinneret **13** are directly adjacent to solidified microfibers **8** leaving the first hopper assembly. Ideally, second hopper **9** is displaced from first hopper **1** by the distance needed to attenuate filament strands **6** leaving hopper **1**. This set up enables efficient intermingling of the two fibers emanating from hopper **1** and hopper **9**.

[0029] The stream of microfibers **8** and the thicker stream of fiber strands **14** with embedded antimicrobial agent **11** are then mixed. The mixed stream of entangled fibers heads towards collecting belt **15** to form a web of intermingled fibers.

[0030] It will be appreciated that other methods of entangling fibrous components into a composite may be used in accordance with the present invention. These methods include hydraulic entanglement, air entanglement and mechanical entanglement. The proportion of thinner and thicker fibers in the composite may vary depending on the desired application.

[0031] When using the two extruder system described above, efficient temperature control is important. This is particularly true of the second extruder system containing the antimicrobial agent. It is important to minimize the amount of vaporization of the antimicrobial agent from fibers **14**. This can be achieved by adding a quench blower positioned adjacent to the fibers **14** exiting die assembly **13**. As such, the filaments will be solidified immediately after exiting the die assembly. However, it may be necessary to elongate the fibers **14** before they are entangled with the smaller diameter fibers **8**. If so, it is imperative to control the temperature decrease during elongation in order to eliminate the vaporization of the antimicrobial agent. This may be achieved by gas/fluid treatment which allows for temperature control to be inserted at the die tip where the fibers exit the spinneret.

[0032] An embodiment which uses gas/fluid treatment is shown in FIG. **2**. In FIG. **2**, the second extruder (Extruder B), which contains a polymer and antimicrobial agent is subjected to Gas/Fluid Treatment B, which uses cooled gases and fluids. Hence, Fiber B leaving Extruder B will be cooled as it is being elongated. The gas/fluid control minimizes the amount of antimicrobial agent that vaporizes from Fiber B leaving the die assembly. Effluent Control B will eliminate any vapors from the antimicrobial agent or any other chemicals used in the process. Following elongation, Fiber B is solidified and it moves towards a collecting belt where it mixes with Fiber A which emanates from Extruder A. It is noted that in FIG. **2**, Extruder A is also subjected to gas/fluid treatment using Gas/Fluid Treatment A and Effluent Control A. The temperature of Gas/Fluid Treatment A should be significantly higher than the temperature of Gas/Fluid Treatment B, being that Fiber A will ideally be drawn into very thin microfibers.

[0033] In FIG. **2**, it is noted that the temperature of the two extruders can range from about 80° C. to about 500° C. The temperature of the extruder will be dependent on the melting points of the polymers used to form the respective fibers.

[0034] As discussed above, the positions of the respective extruders used to generate the two different diameter fibers may be varied depending on the elongation requirements of the different diameter fibers that comprise the composite nonwoven. Elongation is defined by the distance (time) between exiting the die tip in a molten state and being elongated by air jet and/or gravity. In the present invention, it is desirable that the fiber leaving the first extruder (the smaller diameter fiber) be elongated for a longer distance that the fiber leaving the second extruder (the larger diameter fiber). The extent to which the second fiber is elongated relative to the first fiber may have a significant effect on the properties of the resultant composite fiber, including its antimicrobial capacity. As such, the present invention enables the height of the two extruders to be adjusted in order to generate different combinations of polymers, these polymers having very different melting points and elongation requirements. The resulting composites are used to generate nonwovens with improved and novel properties.

[0035] Various active agents may be used in accordance with the present invention. The active agent of the present invention may be, for example, an antimicrobial, an antitoxin, or the like. The antimicrobial may be biostatic and/or biocidal. Biostatic is a material that inhibits the growth of all or some of bacteria spores, viruses, fungi, etc. (having bioactive particles), and a biocidal is a material that kills all or some of bacteria spores, viruses, fungi, etc. Preferably, the biocidal comprises the iodinated resin particles, such as those described in U.S. Pat. No. 5,980,827 above in as described above. Other suitable active agents include silver, copper, zeolyte with an antimicrobial attached thereto, halogenated resins, and agents capable of devitalizing/deactivating micro-organisins/toxins that are known in the art, including for example activated carbon, other metals and other chemical compounds.

[0036] The choice of polymers used to make the fibers will depend on the filtering application and the active agent being employed. In one exemplary embodiment, the thinner fiber generated by the first extruder is made from polypropylene while the second thicker fiber generated by the second extruder is a mixture of polyethylene and iodinated resin particles.

[0037] Although the active agent is not initially present in the melt used to produce the first, thinner fiber, it is conceivable that the active agent may be able to migrate from the thicker fiber to the thinner fiber during or after the entangling of the two different sizes. Alternatively, an antimicrobial agent can be added to the thinner fiber prior to the thinner fiber being entangled with the thicker fiber. Examples of physically entrapping or incorporating an antimicrobial material in a nonwoven are described in '403 Publication.

[0038] In one embodiment of the present invention, the composite filter may be electrostatically charged. Accordingly, there is a potential across the surface(s) of the media creating a field wherein the field can attract and/or repel charged particles introduced to the media so that in some instances it alters the path of travel of the charged particles. Methods of incorporating an electrostatic charge onto a nonwoven surface are described in the '403 publication. One reason for adding an electrostatic charge is to increase the travel time of microbes through the filter, thereby increasing the amount of time the microbe is exposed to the active agent.

[0039] The composite nonwoven antimicrobial nonwoven webs of the present invention may be used in a variety of different applications. Uses in various goods include both durable and disposable goods. For example, nonwovens can be used products such as diapers, feminine hygiene, adult incontinence, wipes, bed linings, automotive products, face masks, air filtration, water filtration, biological fluids filtration, home furnishings and geotextiles. The media described herein can also be used in, for example: clothing, wound dressing, air filter, shelters, and liners. Additional uses include those known in the art for electrostatic filters and antimicrobial or antitoxin filters.

[0040] In a particular embodiment, the filter media according to the present invention can be used as a closure or to make a-filter closure for air filters for products such as facemasks and HVAC. According to the present invention there is provided a closure material made of substrate having electrostatic properties and an electrostatic material with an active agent incorporated therein, where the material is a high loft (in one embodiment, approximately, 1" thick) breathable material of a tri-dimensional structure and is placed around the mask or air filter in order to not create a so-called airtight junction but instead creates a breathable closure that actually covers all the contours of the different geometrical surface to provided a permeable closure, having filtering properties. This approach makes the closure into a filter whereby air that bypasses the mask through gaps caused by a non-perfect fit, still passes through the closure and is filtered. In addition, contrary to a "resilient" closure the pressure differential that is detrimental in an airtight approach is reversed in our approach since the air following the path of least resistance will pass through the filter material of the mask instead In another embodiment, the nonwovens of the present invention may be used for wound management. The current use of anionic iodinated polymer particulates in wound management is limited by the capacity to insure that no particulates are left in the wound. In addition, the requirements of using an absorbing materials for the body exudates generates the necessity to use numerous layering and adhesive, both insufficient to guarantee that no particulates are left in the wound and also physical distance (micron) between the iodinated anionic resin and the microorganisms. This invention would allow for the generation of a nonwoven for wound management that would be composed of a polymer super absorbent (polypropylene/polyester) blend fiber and a polyethylene/iodinated resin fiber. This material would have the advantage of ensuring that no particulates would be left behind in the wound since the particulates would be within the fiber. Moreover, the particulates would be in direct contact with the microorganisms both in the wound and in the body exudates (maintaining a microorganisms free wound dressing) of eliminating industrial manufacturing steps such as adhesive and multiple layering, to name a few of the advantages.

[0041] Although not wishing to be bound by theory, it is believed that antimicrobial filters of the present invention, particularly those incorporating iodinated resins, exert their effect when the active agent migrates to the surface of the fiber. After web formation, the active agent may be homogeneously or randomly dispersed in the fiber. The active agent can then migrate to the surface of the fiber. The rate of migration may be dependent on the properties of the fiber in which the active agent is embedded. These properties include porosity, density, permeability and affinity for particular active agents. The rate of migration also may be related to the diffusivity of the particular active agent being utilized.

[0042] It is further believed that iodinated resins, as described above, exert their antimicrobial effect through the release of molecular iodine (I_2). It has been found that when such an iodinated resin is used as an antimicrobial agent in the composite nonwoven filters of the present invention, the efficacy, the "kill rate" and the duration of action can be effectively controlled by the nature of the polymer of polymers used to manufacture the composite fiber. In particular, the second fiber, which contains the active agent, has a pronounced effect on these properties.

What claimed is:

1.) A filter media comprising a first fiber and a second fiber which are physically entangled to form a composite fiber, said first fiber having a larger diameter than said second fiber, wherein an iodinated resin is embedded in said first fiber.

2.) The filter media as defined in claim **1** in which said media is a nonwoven material.

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