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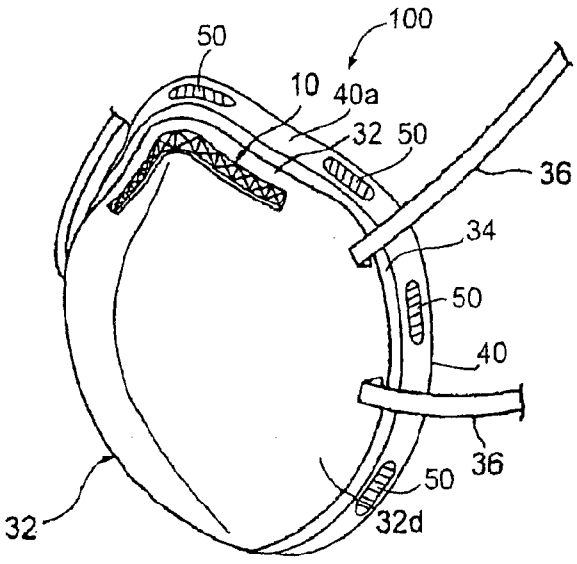
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[Continued on next page]

(54) Title: ANTIMICROBIAL APPAREL AND FABRIC AND COVERINGS

(57) Abstract: An apparel or material which may be placed anywhere or worn about the neck or other parts of the body of a human. The apparel/ material has a structure that, when repositioned from about the wearer, will retain a position about a mouth and nose of the human, as by elasticity or taughtness of a wrapping about the face. The apparel is sufficiently porous as to allow a human to breath comfortably through the fabric when placed over the mouth and nose of the human. The fabric has as a coating is created with on at least the outer surface and through at least 25% of the thickness of the fabric a moisture-sensitive antimicrobial composition, wherein the antimicrobial moisture-sensitive composition comprises an antimicrobially active compound and a carrier, the carrier by hydrophilic and able to absorb sufficient moisture from exhaled breath from the human as to maintain a wet surface on the carrier to which viral particles will adhere more strongly than to a dry surface of the same carrier.

Figure 2



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ANTIMICROBIAL APPAREL AND FABRIC AND COVERINGS

BACKGROUND OF THE INVENTION

FIELD OF INVENTION

The present invention relates to drapable, wrappable or donnable In particular, the invention relates to articles for controlling the spread of pathogens and infectious diseases.

BACKGROUND OF THE ART

In recent years, the prevalence of nosocomial infections has had serious implications for both patients and healthcare workers and the severity of airborne diseases brought into medical care facilities (including clinics, hospitals and long-term care homes) has reached a level of concern for health care workers. Such significant airborne diseases include at least SARS, H1N1 virus, and mutations in seasonal viruses. Nosocomial infections are those that originate, persist or occur in a hospital, long-term care facility, or other health care setting, and are sometimes referred to as "hospital associated infections" or HAI. In general nosocomial infections are more serious and dangerous than external, community-acquired infections because the pathogens in hospitals are more virulent and tend to be more resistant to typical antibiotics. These HAIs are usually related to a procedure or treatment used to diagnose or treat the patient's illness or injury and may be spread by indirect, inadvertent contact. Published U.S. Patent Application Document 2007/0044801 and Published U.S. Patent Application Document 2007/0141126 and U.S. Patent No. 4,856,509 disclose face masks containing antimicrobial ingredients that are used as a first barrier against inhalation of such diseases, usually viruses. Bacterial infections are also becoming significant issues, with Methicyllin Resistant Strep A (MRSA) becoming a major health issue, although this is usually spread by contact rather than inhalation.

An additional area of commercial concern is also deterioration of wrappings, covers and overlays (generically referred to herein as covers) for wounds. Even without medicinal treatment to a wound or covered area, most existing covers allow or even assist in drying of the covered area by venting the area without retaining and/or resupplying moisture to the covered area.

Infection control has been a formal discipline in the United States since the 1950s, due to the spread of staphylococcal infections in hospitals. Because there is both the risk of health care providers acquiring infections themselves, and of them passing infections on to patients, the Centers for Disease Control and Prevention have established guidelines for infection control procedures. In addition to hospitals, infection control is important in nursing homes, clinics, physician offices, child care centers, and restaurants, as well as in the home. The purpose of infection control in hospital and

clinical environments is to reduce the occurrence of infectious diseases. These diseases are usually caused by bacteria or viruses and can be spread by human to human contact, animal to human contact, human contact with an infected surface, airborne transmission, and, finally, by such common vehicles as food or water. The use of medical devices such as gloves, gowns, and masks as barriers to pathogens is already well appreciated by infection control practitioners. It is apparent by the increase in antibiotic resistance and the persistence of HAIs, however, that these practices alone are not enough.

Hospitals and other healthcare facilities have developed extensive infection control programs to prevent nosocomial infections. Even though hospital infection control programs and a more conscientious effort on the part of healthcare workers to take proper precautions when caring for patients can prevent some of these infections, a significant number of infections still occur. Therefore, the current procedures are not sufficient. Despite enforcement of precautionary measures (e.g. washing hands, wearing gloves, face mask and cover gowns), contact transfer is still a fundamental cause of HAIs. That is, individuals who contact pathogen-contaminated surface such as table tops, bed rails, hands, clothing and/or medical instruments, can still transfer the pathogens from one surface to another immediately or within a short time after initial contact. To improve this situation, a standard device or article can be enhanced for infection control by addition of actives that can kill pathogens when they come in contact with the article or can bind the pathogen such that dispersal is not possible. One problem with masks is that they tend to concentrate microbes on the surface of the mask, and even where antimicrobial activity is provided with the mask, that activity tends to ne internal and slow acting, and diminishes over time, allowing microbial buildup on the mask surface. Therefore when the mask is contacted, even for removal, the user can pick up concentrated microbes on their hands and spread them to others, other surfaces and to themselves.

Superabsorbent polymers (SAP) (also called slush powder) are polymers that can absorb and retain extremely large amounts of a liquid relative to their own mass. SAP's are defined herein as a water-absorbing polymer that may be, but not necessarily are classified as hydro gels when cross-linked, absorb aqueous solutions through hydrogen bonding with water molecules. A SAP's ability to absorb water is a factor of the ionic concentration of the aqueous solution. In deionized and distilled water, a SAP is defined as a polymer that absorbs at least 50 times its weight in deionized pure water. SAP's may absorb 500 times its weight or more (from 30–60 times its own volume), but when put into a 0.9% saline solution. The presence of valence cations in the solution will impede the polymers ability to bond with the water molecule.

Water absorbing polymers, classified as hydrogels, absorb aqueous solutions through hydrogen bonding with the water molecule. So an SAP's ability to absorb water is a factor of the ionic concentration of an aqueous solution. In deionized and distilled water, SAP may absorb 500 times its weight (from 30–60 times its own volume), but when put into a 0.9% saline solution, the absorbency drops to maybe 50 times its weight. The presence of valent cations in the solution will impede the polymers ability to bond with the water molecule.

The total absorbency and swelling capacity are controlled by the type and degree of cross-linking to the polymer. Low density cross-linked SAP generally has a higher absorbent capacity and swell to a larger degree. These types of SAPs also have a softer and more cohesive gel formation. High cross-link density polymers exhibit lower absorbent capacity and swell. The gel strength is firmer and can maintain particle shape even under modest pressure.

A wide range of grating combinations were attempted including work with acrylic acid, acrylamide and polyvinyl alcohol (PVA). Polyacrylate/polyacrylamide copolymers were originally designed for use in conditions with high electrolyte/mineral content and a need for long term stability including numerous wet/dry cycles. Uses include agricultural and horticultural. With the added strength of the acrylamide monomer, used as medical spill control, wire and cable waterblocking properties can be provided.

Copolymer chemistry Superabsorbent polymers are now commonly made from the polymerization of acrylic acid blended with sodium hydroxide in the presence of an intiator to form a poly-acrylic acid sodium salt (sometimes referred to as sodium polyacrylate). This polymer is the most common type of SAP made in the world today. Other materials are also used to make a superabsorbent polymer, such as polyacrylamide copolymer, ethylene maleic anhydride copolymer, cross-linked carboxy-methyl-cellulose, polyvinyl alcohol copolymers, cross-linked polyethylene oxide, and starch grafted copolymer of polyacrylonitrile to name a few. The latter is one of the oldest SAP forms created. Today superabsorbent polymers are made using one of two primary methods; suspension polymerization or solution polymerization. Both processes have their advantages over the other and both yield a consistent quality of product.

Solution polymerization Solution polymers offer the absorbency of a granular polymer supplied in solution form solutions and can be diluted with water prior to application. Can coat most substrates or used to saturated. After drying at a specific temperature for a specific time, the result is a coated substrate with superabsorbent functionality. For example, this chemistry can be applied directly onto wires & cables, though it is especially optimized for use on components such as rolled goods or sheeted substrates. Solution based polymerization is the most common process used today for SAP

manufacture. This process is efficient and generally has a lower capital cost base. The solution process uses a water based monomer solution to produce a mass of reactant polymerized gel. The polymerization's own reaction energy (exothermic) is used to drive much of the process, helping reduce manufacturing cost. The reactant polymer gel is then chopped, dried and ground to its final granule size. Any treatments to enhance performance characteristics of the SAP is usually accomplished after the final granule size is created.

Suspension polymerization The suspension process is practiced by only a few companies because it offers a higher degree of production control and product engineering during polymerization step. This process suspends the water based reactant in a hydrocarbon based solvent. The net result is that the suspension polymerization creates the primary polymer particle in the reactor rather than mechanically in post-reactions stages. Performance enhancements can also be during or just after the reaction stage.

U.S. Patent No. 7,528,291 (Herfert et al.) describes a color-stable superabsorbent polymer having long-term color stability, and methods of manufacturing the polymer, are disclosed. The color-stable superabsorbent polymer is prepared in the essential absence of a persulfate, and is subjected to a low dose of ultraviolet radiation. The resulting superabsorbent polymer resists color degradation during periods of extended storage, even at an elevated temperature and humidity.

U.S. Patent No. 5,837,789 (Stockhousen) describes superabsorbing polymers for watery liquids, processes used in their production and their application. The polymers, based on monomers containing carboxylate groups and obtained by a special combination of cross-linking agents and other comonomers, show a combination of properties never attained before with regard to absorption rate, high retention at high absorption under pressure, low soluble content and good permeability of the gel layer for watery liquids under pressure load and stable surface cross-linkage.

U.S. Patent No. 5,669,894 (Goldman et al.) describes absorbent polymers and materials useful in the containment of fluids, that have at least one region containing hydrogel-forming absorbent polymer in a concentration of from about 60 to 100% by weight and providing a gel-continuous fluid transportation zone when in a swollen state.

Published U.S. Patent Publication 20040077744 (Naylor) describes a process of preparing water soluble or water swellable polymer comprising the steps: a) forming an aqueous mixture comprising, i) a water soluble ethylenically unsaturated monomer or blend of monomers and, ii) at least one first ultra-violet initiator, iii) at least one second ultra-violet initiator; b) effecting polymerisation by subjecting the aqueous mixture formed in step (a) to irradiation by ultraviolet light at an intensity of

up to 1,000 micrometers Wcm^{-2}; subjecting the product of step (b) to irradiation by ultraviolet light of greater than 1,000 micrometers Wcm^{-2}, characterised in that a significant amount of the first initiator(s) is/are activated in step (b) and a significant amount of the second initiator(s) is/are activated in step (c).

U.S. Patent No. 7,462,753 (Ma) discloses a nano-silver wound dressing consisting of a skin contact layer made from hydrophilic cloth and directly contacting a wound on the surface of the skin, a disinfecting (or bactericidal) antitoxic layer made from activated charcoal cloth impregnated with nanocrystalline silver, a blood absorbing and styptic layer made from a superabsorbent polymer non-woven cloth, an isolation layer made from a composite fabric with a pore size of less than 5 micrometers and an elastic bandage for fixing a main body on the site of wound. Edges of the isolation layer and the skin contact layer are integrated to form a main body while the disinfecting (or bactericidal) antitoxic layer as well as the blood absorbing and styptic layer are separated from each other and both enclosed inside the main body.

U.S. Patent No. 6,967,261 (Soereus) describes a bandage or wrap with antibiotics therein. It is further described that an included nonwoven material may be treated to be hydrophilic or may include superabsorbent materials.

U.S. Patent No. 7,541,395 (Reimann) describes a process for producing an absorbent polymer including a first mixing event, in which a plurality of absorbent polymer particles (1) are mixed with a liquid (2) and a second mixing event, in which the liquid (2) is homogenized within the interior of the polymer particles. The polymer particles (1) in the first mixing event are mixed with a speed such that the kinetic energy of the individual polymer particles (1) is on average larger than the adhesion energy of the individual polymer particles (1), and the polymer particles (1) in the second mixing event are stirred at a lower speed than in the first mixing event. The different speeds effect a fluidization of the polymer particles (1), which prevents a clumping of the polymer particles (1) during the mixing event. The absorbent polymers thus produced are distinguished by a particularly rapid swelling behavior.

U.S. Patent No. 7,879,746 (Klun et al.) describes polypropylene fibers and devices that include a fatty acid monoglyceride added to the polypropylene as a melt additive. A hydrophilic enhancer material can be advantageously added to the polypropylene as a melt additive to enhance the hydrophilicity of the fibers and devices. An antimicrobial enhancer material can be added to the fibers to enhance the antimicrobial activity. The hydrophilic material is structurally incorpprated into the solid fiber structure and is not a coating on the fiber material itself.

All references cited herein are incorporated by reference herein in their entirety for information on polymers, especially those with regard to SAP materials and antibiotics and fabric processing.

SUMMARY OF THE INVENTION

In discussing technology enabled herein, C& K stands for "catch and kill" of microbes, especially viruses, it is intended to be of such a design so as to intercept the air born virus and expose it to a killing agent before it enters a person's breathing passages. The system includes a fabric as a platform for carrying out the task of catching and killing microbes, and especially an apparel worn (at least in-part) about the neck that is used to cover the entry air passages (mouth and nasal ports) and provide an active and regularly reactivated or maintained microbial activity because of the injection of moisture into the fabric by exhalation from the wearer. The material can also provide a platform wherein a flowable internal component (gel, liquid, liquid layer, liquid coating, constant or activatable) provides a platform for maintaining activity in the fabric during use over an extended period of time.

The C&K system has alternative wound protection benefits (with or without antimicrobial activity) by providing a covering that retains moisture over a wound to retain a moist environment by holding moisture in the environment over a wound to keep the wound environment moist. If there is also antimicrobial activity in the cover, that activity prevents the covering from becoming a growth site for microbes.

To accomplish this more durable and constantly active or reactivatable antimicrobial agent to the apparel delivery system, the antimicrobial agent has to be carried in a medium that remains in the apparel with a hygroscopic, or humectants or fluid film-forming material that is referred to herein as a layer activating agent. This is done so that exhalation, and the passage of humid gas expelled from the lungs of the user, provides moisture that is retained or used by the composition in the fabric to maintain, initiate or reactivate the antimicrobial material. In this manner, an apparel may be used in its normal fashion (e.g., as a scarf, as the neck in a turtleneck shirt, sweater, sweatshirt or the like, or as a false neck worn with other apparel. The antimicrobial system described herein may be used in a typical face mask, as a less preferred embodiment.

The antimicrobial material, which may be a quaternary compound (e.g., has an N^+ group that is antimicrobially active) or any other antimicrobial agent that is active in a moist environment should be carried in an immobilizing layer, such as a hydrophilic binder, which may be the layer activating agent or carry a further material as the layer activating agent. In descriptions of the antimicrobial, because certain quaternary compounds have been initially preferred, the antimicrobial agent is often referred to herein as a Quat, even though that shorthand term "Quat" even though it is not intended to limit the description of the invention herein to that single subspecies of antimicrobial. Thus to present

the Quat in the material (e.g., fabric material) of the apparel, we intend to place a Quat or other antimicrobial agent in or on an immobilizing material such that the Quat is exposed to the virus but the Quat is not allowed to enter the air entering the lungs or exposing mucus membranes to the Quat. Because the Quat is immobilized, yet constantly active within the material/fabric because of its ability to flow, change its state of activity when contacted by moisture/humidity from exhalation or the ambient environment, and it can be used in higher concentrations than those found in spray on type sterilizers. The Quat Immobilizing Material (QIM) can be any material that prevents the Quat from entering the air stream, and maintains a humid environment, with a relatively low surface tension (e.g., with an aqueous surfactant [T less than 24 dynes] to readily wet out the virus or provide a layer that allows the virus to physically penetrate the surface of the liquid to come into contact with the active antimicrobial, thus insuring intimate contact between the Quat antimicrobial and the virus. Two such commonly available QIM's are glycerin and SuperAbsorbent Polymers(SAP), both will immobilize the Quat and maintain a humid environment in the air filtration device. The QIM is intended to allow the Quat to be mobile within the QIM due to submicroscopic molecular movement (e.g., due to concentration gradients of mass flow of solutions over surfaces, including serum and blood) or even microscopic Brownian Movement, such that an effective amount of Quat is always available at the doped QIM/Virus interface as a hydrophilic surface. Surfaces with a contact angle <90° are referred to as hydrophilic and those with an angle >90° as hydrophobic, so the surface of the immobilized antimicrobial should have a water contact angle of less than 90° when moisture has activated the agent. Additionally, it may be desirable to create a tortuous pathway that insures that the virus comes in contact with the Quat.

The present technology also relates to the preparation of a distinct superabsorbent polymer (SAP) fiber that is combined with conventional textile fibers (including natural and synthetic fibers, and even non-textile fibers such as wood fibers, insoluble cellulosic fibers, glass fibers, ceramic fibers) and an antimicrobial agent. The blending of the SAP fiber into the other fiber materials (within a thread, within a yarn, as a fiber mixed within a non-woven blend), with an antimicrobial agent specifically associated with the SAP fiber, provides an ease of manufacture and an ease of control of the overall properties of a final fabric, including feel, drape, flexibility and antimicrobial activity. It is preferred that the antimicrobial agent be associated specifically with the SAP fiber before association with the other fibers, but because of the increased absorbency of the SAP fibers compared to the other fibers in the final material, after manufacture application is possible. The antimicrobial agent can be imbibed o blended into the SAP and then the SAP provided into the fabric.

The SAP fiber concentration in the final product should be from 1 to50% by total weight of the fabric and the antimicrobial should be present as from 0.25% to 15% by weight of the SAP fiber. The SAP

fiber may be uniformly distributed throughout the additional fibers, or may be strategically positioned in discontinuous concentrations or patterns within the final fabric.

The viruses' nominal size is on the order of 300nm. The industry standard of an N95 mask will not filter out 1005 of the virus directly. The treatments to the filter media according to the present invention will afford the masks the ability to remove the viruses by creating a more tortuous path of "sticky stuff" (a surface that will hold the virus because of its lower surface tension) while it is actively doped with the antimicrobial.

When the term masks is used, we refer to any filtration material be it in mask form or as part of a more elaborate device whose purpose is the removal of particulate matter from the air. As used herein, "hydrophilic", "hydrophilicity" or similar terminology is used to describe substrates (e.g., fibers, woven or nonwoven fabrics, webs, knits or fiber batts etc.) that can be wet by water, by aqueous solutions of acids and bases (e.g., aqueous potassium hydroxide) and by polar liquids (e.g. sulfuric acid and ethylene glycol).

As used herein, "antimicrobial" or "antimicrobial activity" means that a material has sufficient antimicrobial activity as measured by American Association of Textile and Color Chemists (AATCC) Test Method 100-1993 (AATCC Technical Manual, 1997, pp. 143 to 144), to reduce an initial bacterial load by at least 90% over a 24-hour exposure period at 23-24.degree. C.

The terms "fiber" and "fibrous" as used herein refer to particulate matter, generally comprising thermoplastic resin, wherein the length to diameter ratio of the particulate matter is greater than or equal to about 10. Fiber diameters may range from about 0.5 micron up to at least 1,000 microns and each fiber may have a variety of cross-sectional geometries, may be solid or hollow, and may be colored by, e.g., incorporating dye or pigment into the polymer melt prior to extrusion.

The term "nonwoven web" or "nonwoven fabric" means a web or fabric having a structure of individual fibers which are interlaid, but not in a regular manner, such as knitting and weaving. Nonwoven fabrics or webs have been formed from many processes such as, for example, melt blowing processes, spunbonding processes, and bonded carded web processes.

The term "spunbonded fibers" refers to small diameter fibers which are formed or "spun" by extruding molten thermoplastic material in the form of filaments from a plurality of fine, usually circular, capillaries of a spinneret, and then rapidly reducing the diameter of the extruded filaments, for example, by the methods described in U.S. Patent No. 4,340,563 (Appel et al.) and U.S. Patent No. 3,692,618 (Dorschner et al.). The "spun" fabric is then passed between the rolls of a heated calender to bond the fibers together. Various patterns can be imparted to the fabric by the calender rolls, but the

principle purpose of bonding is to increase the integrity of the fabric. The bond area in thermal bonding is usually about 15%, but may vary widely depending on the desired web properties. Bonding may also be accomplished by needling, hydroentanglement, or other methods known in the art.

The term "melt blown fibers" refers to fibers which are typically formed by extruding the molten thermoplastic material through a plurality of fine, usually circular, die capillaries as molten threads or filaments into a high velocity, usually heated gas (e.g., air) stream which attenuates the filaments of molten thermoplastic material to reduce their diameter. Thereafter, the melt-blown fibers are carried by the high velocity gas stream and are deposited on a collecting surface to form a web of randomly disbursed melt-blown fibers. Any of the nonwoven webs may be made from a single type of fiber or two or more fibers which differ in composition and/or thickness. Alternatively, sheath-core fibers can be extruded containing different polymer compositions in each layer, or containing the same polymer composition in each layer but employing the more hydrophilicity-imparting component in the outer sheath layer.

A few of the possible configurations for this technology are (specifics not given here)

1. a spray dopant to be sprayed on the outer surfaces of fabric masks, such as N95 Masks
2. a modified replaceable cartridge for a mobile CPAP style device
3. a device that could be employed for buildings, cars, airplanes and alike.
4. replaceable and/or repositionable liners for face masks.

The present invention is directed to a germicidal surface-covering assembly that includes at least one custom (fit for a person) apparel, which may comprise one or more different wrappable, donnable, pullover or drapable garments. Each garment defines at least one treated surface that is susceptible to pathogen contamination in a physical contamination event when used as intended in an environment subject to contamination (e.g., a clinical environment, a laboratory or a workplace) and is treated with an active or activatable hydrophilic environment that may provide even a liquid surface to attract and attach virus particles. The treated surface is typically oriented at least outwardly away from a user's body and toward the environment or the source of contamination.

BRIEF DESCRIPTION OF FIGURES

Figure 1A shows a woven fabric with SAP fibers blended into both threads and yarns in the fabric.

Figure 1B shows an alternative woven fabric with SAP fibers blended into both threads and yarns in the fabric.

Figure 1C shows a second alternative woven fabric with SAP fibers blended into both threads and yarns in the fabric.

Figure 2 shows an exploded, perspective view of a multi-layer face mask having a layer of a fabric according to the present technology.

DETAILED DESCRIPTION OF THE INVENTION

As used herein, the terms “antimicrobial agent(s)” or "germicidal agent(s)" refer to materials (e.g., elemental silver) or chemicals or other substances that either kill or slow the growth of microbes. Among the antimicrobial agents or germicidal agents in use today are antibacterial agents (which kill bacteria), antiviral agents (which kill viruses), and antifungal agents (which kill fungi). A main category of antimicrobial agents are surface disinfectants, otherwise known as "biocides."

The term "biocides" is a general term describing a chemical agent, such as a pesticide, usually broad spectrum, which inactivates living microorganisms. Because biocides range in germicidal activity, other terms may be more specific, including "-static," referring to agents that inhibit growth (e.g., bacteriostatic, fungistatic, or sporistatic) and "-cidal," referring to agents that kill the target organism (e.g., bactericidal, fungicidal, sporicidal, or virucidal). Biocides have multiple targets and modes of action, which for instance, may include physical disruption and permanent damage to the outer cell membrane of a bacterial microbe. Some example of useful biocide chemistries include biguanides (e.g., : chlorohexidine, alexidine, polyhexamethylene biguanide, and relevant salts thereof), halogen-releasing agents (e.g.,: iodine, iodophors, sodium hypochlorite, N-halamine, etc.), stabilized oxidants such as chlorine dioxide, stabilized peroxide (e.g., urea peroxide, mannitol peroxide) metal-containing species and oxides thereof (e.g., : silver, copper, selenium, etc. either in particle form or incorporated into a support matrix such as a zeolite or polymer), sulfides (e.g., sodium metabisulfite), bis-phenols (e.g., triclosan, hexachlorophene, etc), quaternary ammonium compounds (e.g., benzalkonium chloride, cetrimide, cetylpyridium chloride, quaternized cellulose and other quaternized polymers, etc.), various "naturally occurring" agents (e.g., polyphenols from green or black tea extract, citric acid, chitosan, anatase TiO_2, tourmaline, bamboo extract, neem oil, etc.), hydrotropes (e.g., strong emulsifiers) and chaotropic agents (e.g., alkyl polyglycosides) and synergistic combinations thereof. Depending on substrate chemistry (polyolefin vs. cellulosic-based materials) and the method of incorporation into the product (topical vs. grafting), many of the above chemistries could be used alone or in concert to achieve the final claimed product properties of interest.

As used herein, the phrase "broad spectrum of microorganisms," is defined to include at a minimum Gram positive and Gram negative bacteria, including resistant strains thereof, for example methicillan-resistant Staphylococcus aureus (MRSA), vancomycin-resistant Enterococci (VRE) and penicillin-resistant Streptococcus pneumoniae (PRSP) strains. Preferably, it is defined to include all bacteria (Gram+, Gram- and acid fast strains) and yeasts such as Candida albicans. Most preferably, it is defined to include all bacteria (Gram+, Gram-, and acid fast), yeasts, and both envelope and naked viruses such as human influenza, rhinovirus, poliovirus, adenovirus, hepatitis, HIV, herpes simplex, SARS, and avian flu.

As used herein, the phrase "results in fewer viable pathogens on a treated surface compared to an untreated control surface" and the phrase "prevents or minimizes the contact transfer" are both defined to mean that the item in question will lead to at least a 0.5 $\log_{10}$ reduction in the transfer of a broad spectrum of viable microorganisms when contacting another surface as compared to an untreated control item as measured by the contact transfer protocol generally outlined in U.S. Patent Application Publication No. 2004/0151919, incorporated herein by reference with respect to the protocol, and described further in the Examples. Desirably, it leads to a reduction in viable microorganisms transfer by a factor of 1 $\log_{10}$. More desirably, it leads to a reduction in viable microorganisms transferred by a factor of 2 $\log_{10}$ or greater.

A "non-leaching" germicidal surface is one that passes ASTM E2149-01 testing protocol entitled "Standard Test Method for Determining the Antimicrobial Activity of Immobilized Antimicrobial Agents Under Dynamic Contact Conditions." The lack of a zone of inhibition with the treatment agents chosen demonstrates the active species do not leach from the treated substrate, especially into skin in contact with a surface distal from the coated or embedded antimicrobial materials. Transcutaneous transfer may occur and is allowed to occur when the skin is in actual contact with the active antimicrobial agent. In a third set of experiments different coatings were tested for their efficiency against *E. coli* , American Type Culture Collection (ATCC) No. 8739 with both testing methods ASTM E2149-01 (dynamic contact test) and E2180-01 (static test for hydrophilic materials, Table 3). For ASTM E2149-01 two contact time points of 2 h and 24 h were chosen as to access short and long term effects. The film containing only film composition, without the fabric or additive to the fabric showed no change in bacteria concentration for both time points. Without being bound to theory, it is believed that the mechanism is not instantaneous but rather proceeds via a slow and steady bacteria destruction keeping in mind that for the reference film a 3-log CFU/ml increase was observed in the 24 hours experiment. Hence, the antimicrobial film has not only to struggle with the initial bacteria but also has to prevail over the bacteria's growth. For the static contact test ASTM E2180-01 the bacteria concentration for film sample containing the fabric antimicrobial additives

increased by a factor of ten compared to the film composition reference, which could also be a superabsorbent polymer (SAP) film or powder.

A fabric that provides particulate filtering capability and moisture retention may have at least 1% to 50% by weight of all fibers in the fabric of superabsorbent polymer and fibers on the fabric having a hydrophilic carrier associated with the fibers, the carrier able to absorb moisture from a gas stream having at least 50% relative humidity at 30C so as to maintain a wet surface on the fibers to which viral particles will adhere more strongly than to a dry surface of the same fiber. The hydrophilic carrier may have an antimicrobial composition that is active in a moist environment. The composition may be active in a dry environment, but must be active in an aqueous environment. The carrier may be a liquid at room temperature. The antimicrobial agent may be from 5 to 90% by weight or 10 to 80% by weight of the hydrophilic carrier. The SAP may be capable of absorbing from 50 to 500 times the weight of the SAP of deionized water and the SAP comprises 1% to 25% of the total weight of fibers in the fabric, and the fabric may be a non-woven fabric. At least 10%, at least 20%, at least 25% or at least 50% by weight of the non-woven fabric may be a thermoplastic fiber other than the SAP fiber.

An apparel for wearing about the neck and/or head of a human may have structure that, when repositioned from about the neck or on top of the head will retain a position about a mouth and nose of the human, the apparel comprising a fabric that is sufficiently porous as to allow a human to breath comfortable through the fabric when placed over the mouth and nose of the human, wherein the fabric comprises the fabric described herein. Face masks are apparel specifically designed to be positioned and held around the mouth and nose.

A facial mask may be constructed as a first support fabric having a first main fabric material having a width and a height, the mask having a support element that is connected to ends of the width of the first main fabric and a layer of the fabric of the technology described herein is contiguous with the height and width of the first main fabric.

A method for the manufacture of a fabric having antimicrobial activity may have steps of:

a. providing a superabsorbent polymer composition;
b. associating an antimicrobial composition into the fabric of the technology described herein or superabsorbent polymer composition to form a final composition;
c. extruding the final composition to form active fibers or active filaments;
d. blending the active fibers or active filaments with textile fibers or textile filaments to form a textile blend; and

e. fabricating the textile blend to form a final fabric material having antimicrobial activity.

According to the invention, each treated surface is adapted to provide a rapid-acting, even if time-dependent reduction in the number of pathogens available at that treated surface after a physical contamination event (including especially inhalation through the apparel), such that at least a predetermined time after a physical contamination event at a first location on a first treated surface of a first garment (and optionally a first physical contact between the first location on the first treated surface and a second location on a second treated surface of a second garment) results in fewer viable pathogens on the surfaces as compared to an untreated control.

According to an aspect of the invention, the germicidal surface-covering assembly includes garments may be selected from facemasks, head covers, sweaters (especially turtle necks), scarves or the like that can be readily positioned over the mouth and nasal passages of a wearer.

According to the invention, the surface of the germicidal surface-covering assembly may be treated with an antimicrobial agent that is lethal to microbes (especially a viricide) selected from, but not limited to, one or more of: polyhexamethylene biguanide (PHMB), other biguanide compounds, chlorohexidine, alexidine, and relevant salts thereof, a quaternary ammonium compound, a quaternary siloxane, a polyquaternary amine; metal-containing species and oxides thereof, either in particle form or incorporated into a support matrix or polymer; halogens, a halogen-releasing agent or halogen-containing polymer, a bromo-compound, a chlorine dioxide, a thiazole, a thiocynate, an isothiazolin, a cyanobutane, a dithiocarbamate, a thione, a triclosan, an alkylsulfosuccinate, an alkyl-amino-alkyl glycine, a dialkyl-dimethyl-phosphonium salt, a cetrimide, hydrogen peroxide, 1-alkyl-1,5-diazapentane, cetyl pyridinium chloride, stabilized peroxide, sulfides, bis-phenols, polyphenols, chitosan, anatase TiO_2, tourmaline, hydrotropes, chaotropic agents, and synergistic combinations thereof. The germicide may be present on the germicidal garment substrate at a final concentration or add-on in a range of about 0.05-8 weight percent of the apparel or garment material. In addition, there must be a hydrophilic agent for the antimicrobial agent in a weight percent of 0.05 to 8% by weight of the apparel and in proportions with the antimicrobial agent of between 5 and 90% or between10-90% by total weight of the hydrophilic carrier and the antimicrobial material.

In an aspect of the invention, the germicidal surface-covering assembly will reduce the contact transfer or indirect transmission from the surface and/or through the apparel to the ingestion passages of the wearer. This reduction is at least a 0.5 $\log_{10}$ CFU reduction of a broad spectrum of microorganisms within about 40 to about 60 seconds of initial contact, under ambient conditions as compared to an untreated control. Of course, greater reductions may occur over longer periods of time

and with greater concentrations or more intensely active, or synergistically active antimicrobial compositions. Desirably, the germicidal surface-covering assembly will reduce the contact transfer or indirect transmission from the first surface by at least a 1 or 2 or even 3 $\log_{10}$ CFU reduction within a period of about 40 to about 60 seconds after contact, as compared to an untreated control. The microorganisms generally may include at least one of the following: Staphylococcus aureus, Enterococcus faecalis, Pseudomonas aeruginosa, Moraxella catarrhalis, Klebsiella pneumoniae, or Candida albicans. Generally speaking, the reduction in viable pathogens should take place at least 40 seconds after the physical contamination event. Desirably, the reduction in viable pathogens should take place at least 40 to about 60 seconds after the physical contamination event. Greater reductions in viable pathogens may take place over longer periods of after the physical contamination event. For example, it is contemplated that greater reductions in viable pathogens will take place over minutes, tens of minutes or even hours.

One of the difficulties in providing fabric materials that are resistant to the growth of microbes or which can act to reduce the spread of microbes by filtering out and killing microbes that are attempting to pass through the fabric (in a gas or liquid medium) the fabric (in a gas or liquid medium) is the ability to control the antimicrobial activity over time and area in the fabric. Additionally, the provision of colors and visual patterns in the fabric can be diminished by after application of liquids to the fabric because of dye bleaching or pigment dissolution and bleeding from the applied antibiotics, which are usually carried in a liquid solvent. The present technology assists in overcoming or reducing many of these deficiencies.

The technology includes creation of a fiber or filament or yarn which can be woven into products alongside standard yarns that offer a high rate of efficacy in the killing of bacteria, virus/influenzas, fungi and other microbes before they can enter the respiratory track via nasal or oral routes. The fiber will have a constant state of mobility within its makeup.

This fiber can then be interwoven with other materials into products that are used daily by the general public, but have heretofore not been viewed as a health care benefit. These will include items such as, scarves, turtleneck sweaters and shirts, burkas, medical coverings, baby blankets, etc which will now capable of offering the additional protection of being antimicrobial in addition to their normal use. The classic medical masks offer no protection to the large majority of the population that will not use them for a variety of reasons, from stigma, appearance, lack of efficacy, to fashion and comfort

The use of these new fibers in the creation of apparel or wearables that offer the public an increased level of protection will also allow for the economic and social interaction of society to continue by increasing the comfort level of the public when wishing to enter a heavily occupied area, such a grocery stores, shopping malls, events, or small gatherings in homes and offices.

A superabsorbent polymeric material is provided in fiber or filament form. The fibers (usually blended with other fibers to form threads or yarns or filaments, also blended to form fibers or yarns or knit directly into fine fabric may be, for example, from 0.01 to 100 decitex before addition to the other materials. SAP fibers tend not to have the tensile strength desirable for most usual fabric apparel (although some reduced tensile strength is acceptable in masks, covers and the like), and so the addition of the SAP fibers with stronger fibers is desirable. The other fibers should have a water absorbance that is less than 5% of the SAP fiber.

The SAP polymer can be easily imbibed with a controlled amount of aqueous borne antimicrobial material, either as a solute, suspension, dispersion or emulsions. The SAP generally has sufficiently open pores as to allow the somewhat larger molecular antimicrobials (e.g., silver particles, iodine crystals, etc.) to be carried into the SAP polymer network. The SAP fibers are then extruded or have the antimicrobial added after extrusion. Colorant may also be added at that time of extrusion or post-extrusion processing. After formation of the SAP fibers or filaments, those fibers or filaments may be processed into fabric along with other fabric fiber and materials as non-woven, woven, knitted or other manufactured fabric. The use of non-woven fabrics is preferred for a number of reasons in the practice of the present technology. The fabric pieces can be easily shaped by pressing, they can be molded with shape retention by subsequent thermal treatment bonding the molded shape permanently, the SAP can be blended in with relative ease and equal distribution and the fbric sides can be trimmed with fewer loose fibers resulting.

In forming threads and yarns, the individual threads may comprises from 1% to 75% of total threads in the fabric. The SAP fiber concentration in the final product should be from 1 to 50% by total weight of the fabric, 1 to 35% by total weight of the fabric or from 1 to 20% by total weight of the fabric. The antimicrobial agent in the SAP fiber or filament may be about 0.25% to 15% by weight of the SAP (solids or active liquids) and preferably is from 0.50% to 10% by weight of the SAP (solids or active liquids) in the individual SAP fibers or in the total fabric.

There are definite functional advantages for having the antimicrobials in the SAP and added before final fabrication of the fabric. There is the ability to better control the overall and/or local distribution of SAP and antimicrobials in the final fabric, as the SAP-bearing threads or yarns can be distributed as desired by known manufacturing techniques, such as timed feeding or positioned feeding of the SAP-bearing threads, yarns or filaments into the manufacturing process, whether forming non-woven fabrics or knitted or woven fabrics.

Figure 1A shows a woven fabric **2** with SAP fibers **4** blended into both threads and yarns in the fabric. Figure 1B shows an alternative woven fabric **2B** with SAP fibers **4** blended into both threads and

yarns in the fabric. Figure 1C shows a second alternative woven fabric **2C** with SAP fibers **4** blended into both threads and yarns in the fabric. The distribution of the SAP fibers containing the antimicrobial agents can be readily seen from these figures to be highly controllable in a final location in the fabric.

Germicidal Compositions

The germicidal compositions utilized may be one or more germicidal reagents. These reagents may be effective by themselves or may be combined to produce a synergistic effect that is non-additive of the individual components. These germicidal reagents may be further combined with processing aids and/or other ingredients that provide functional properties to the compositions. Exemplary germicidal compositions may be based on cationic polymers, such as quaternary ammonium compounds and polymeric biguanides, alcohols, and surfactants. Combinations of cationic polymers such as quaternary ammonium compounds (e.g., quaternary ammonium cellulose and quaternary ammonium siloxane), polymeric biguanides, surfactants, alcohols, and organic acids, such as acetic, citric, benzoic acids, may produce non-additive, synergistic systems with broad pathogen efficacy. The combinations with other germicidal compounds, surfactants, appear to improve germicidal efficacy of polymeric biguanides over treatments with that employ polymer biguanides alone. Poly-hexamethylene biguanide (PHMB) hydrochloride is an exemplary cationic biguanide that is useful for providing germicidal surface-covering assemblies. Commercially available versions of PHMB, such as under the trade names Cosmocil CQ (20 wt. % PHMB in water) or Vantocil, a heterodisperse mixture of PHMB with a molecular weight of approximately 3,000 grams/mole, are active against gram-positive and gram-negative bacteria, but may not be sporicidal. Additional active germicidal agents may include, but are not limited to, a quaternary ammonium compound, a quaternary ammonium siloxane, a polyquaternary amine; metal-containing species and oxides thereof, either in particle form or incorporated into a support matrix or polymer; halogens, a halogen-releasing agent or halogen-containing polymer, a bromo-compound, a chlorine dioxide, a thiazole, a thiocynate, an isothiazolin, a cyanobutane, a dithiocarbamate, a thione, a triclosan, an alkylsulfosuccinate, an alkyl-amino-alkyl glycine, a dialkyl-dimethyl-phosphonium salt, a cetrimide, hydrogen peroxide, 1-alkyl-1,5-diazapentane, or cetyl pyridinium chloride.

Various biocides and processing aids may be used in germicidal compositions to make the germicidal surface-covering assembly. Common chemical names or commercial names are shown below. Quaternary ammonium compounds, such as commercially available under the names of Aegis™ AEM 5700 (Dow Coming, Midland, Mich.) and Crodacel QM (Croda, Inc., Parsippany, N.J.), with certain surfactants such as alkyl-polyglycosides, available commercially under the name Glucopon 220 UP (Cognis Corp, Ambler, Pa.), and chitosan glycolate, available under the name Hydagen CMF

and Hydagen HCMF (Cognis Corp., Cincinnati, Ohio), can significantly enhance the killing efficacy of PHMB in a synergistic fashion as will be demonstrated in the tables herein. One should note that many of the biocides described herein may be used singly or in combination in a variety of products which vary considerably in activity against microorganisms. Common Name Vendor Names and weight percentages include Polyhexamethylene biguanide (PHMB), 0.01-20 Cosmocil CQ Arch Chemicals, Inc. Norwalk, CT Chitosan glycolate 0.01-10 Hydagen CMF and HCMF Cognis Corp., Ambler, PA Octadecylaminodimethyl Trimethoxysilylpropyl 0.01-10 AEGIS AEM 5700 Dow-Corning, Ammonium Chloride Midland, MI N-Alkyl Polyglycoside 0.01-10 Glucopon 220 UP Cognis Corp., Ambler, PA PG-Hydroxyethylcellulose Cocodimonium 0.01-10 Crodacel QM Croda Inc., Chloride (Quaternary Ammonium Persipanny, NJ CellulosicSalt) Xylitol 0.01-10 Xylitol Sigma-Aldrich, Milwaukee, WI 2-hydroxy-1,2,3-propanetricarboxylic acid 0.01-10 Citric Acid Hach Company Ames, IA Benzenecarboxylic acid 0.1-2.0 Benzoic acid Mallinckrodt Baker, Inc Phillipsburg, NJ 2-hydroxybenzoic acid 0.01-10 Salicylic acid Mallinckrodt Baker, Inc Phillipsburg, NJ Methane-carboxylic acid 0.01-2.0 Acetic acid Sigma-Aldrich St. Louis, MO 1,3-Propanedicarboxylic Acid 0.01-10 Glutaric acid Sigma-Aldrich St. Louis, MO Iodine 0.05-10 Iodine Sigma-Aldrich St. Louis, MO Ethyl Hydroxyethyl cellulose 0.01-5.0 Bermocoll EBS 481 FQ Akzo Nobel, Inc., ("E 481") Stamford, CT Polyvinyl pyrrolidone 0.01-10 Plasdone K90 ISP Technologies, Inc., Wayne, NJ Poly(vinyl pyrrolidone-co-vinyl acetate) 0.01-10 PVP/VA S-630 ISP Technologies, Inc., Wayne, NJ Polyvinyl pyrrolidone-Iodine complex 0.01-10 PVP-Iodine ISP Technologies, Inc., Wayne, NJ Guanidine Hydrochloride and Sorbitol 0.01-5.0 Nicepole FL NICCA USA, Inc. Fountain Inn, SC Acrylic Co-Polymer Compound and Isopropyl 0.01-5.0 Nicepole FE 18U NICCA U.S.A., Inc. Alcohol Fountain Inn, SC 25% Copper oxide (CuO, Cu_2O) 0.01-20.0 Cupron, Cupron, Inc. (CAS #1317-39-1), 75% polypropylene Greensboro, NC (PP) resin Silver Sodium Hydrogen Zirconium 0.01-20.0 AlphaSan® RC 2000* Milliken, Phosphate Spartanburg, SC Silver Zinc glass (70-100%,) barium sulfate 0.01-20.0 Irgaguard B 7520 Ciba Specialty Chemicals Corp. (1-30%), PP resin (10-30%) Tarrytown, NY. These additives have been typically compounded in thermoplastic # resins (e.g., polypropylene (PP)) to produce a concentrate which is then dry blended with the # virgin resin and co-extruded to produce fibers and webs containing such additives.

In certain embodiments the germicidal composition includes combinations of biocide active agents that work against both bacteria and viruses. For instance, a composition may include: PHMB, quaternary ammonium cellulose, xylitol, citric acid, benzoic acid, surfactant, complexing agent (e.g., PVP), and/or antistatic agent (e.g., Nicepole FL). A desirable antistatic agent is one that does not reduce surface tension of water by more than 20 dynes/cm. The present composition desirably is moderately hydrophilic; hence, a droplet of a formulation applied to a surface can produce a contact angle of less than about 90.degree. with respect to, for example, a polypropylene substrate surface.

The compositions have a pH in a range of about 2 to about 5 or 6. Preferred pH ranges are about 2.5-4, or 2.5-3.5, depending on the desired, particular environmental conditions for use. The compositions may also contain an acrylic co-polymer compound and isopropyl alcohol, which serves as an antistatic agent useful for treating nonwoven fabrics such as those commonly found in medical fabrics.

A germicidal solution may contain a primary microbial active agent, for example, 0.1-99.9 wt % polyhexamethylene biguanide (PHMB) by weight of active agents, and a secondary active agent selected from at least one of the following: alkyl polyglycosides, quaternized cellulose derivatives, quaternized siloxanes, surfactants, and organic acids. The final concentration for each of the active reagent and processing aids on a treated substrate can range from about 0.01-20 wt %. The exact concentrations may depend on the specific kind of microorganism that one is targeting against and/or the nature of the coated substrate material.

Substrates

The apparel substrates used in the practice of the present technology must be porous enough to allow wearers to breathe through the fabric without excessive air flow being drawn parallel to the surface of the fabric in the apparel. Otherwise the air would be drawn around, rather than through, the apparel. This is another advantage of using a repositionable fabric apparel element such as a turtle neck. The neck may be pulled over the lower portions of the face and adjusted easily into a comfortable position that best control flow through, and not around the fabric. Generally speaking, the treated surface of the germicidal surface-covering assembly would be outward or exterior facing and away from the skin-contacting surface such as a lining of a garment or article, although internal compositions work well also. The purpose of this orientation is to address the indirect transmission or the contact transfer of pathogens.

The material may have a natural and significant elasticity, or may be a material with low elastic stretchability or memory, such as a tightly woven fabric with less than 5% elastic elongation or a loosely woven fabric with 15-20% elongation in at least one direction. The elongation may also be created by the elastic nature of the fabric composition itself or by added elements such as elastic edges or inserts. Taughtness in an applied position may be also provided in whole or in part by fabric closure systems such as ties, belts, velour and crochet (e.g., Velcro™ attachments) and adhesive.

Generally speaking, nonwoven materials treated with the germicidal compositions may even largely maintain their liquid barrier properties when segregated to the surface of the materials, as the moisture flow through the fabric may wet or moisten the carrier (which is preferably in addition to the fabric structural material) and acts as a moisture holder or even liquid/pasty film forming layer actively supporting and presenting the antimicrobial agent. It is believed that by means of controlling the topical placement of the antimicrobial composition, in which the agents are confined to the outermost

or top spunbond layer of a substrate, for instance, one can enhance the creation of a liquid conduit or liquid support in the layers of the substrate material, thereby achieving the beneficial combination of retention of particles (e.g., viruses) and germicidal properties. In addition, placing the germicidal chemistry on the surface of the substrate will make the biocides more readily available to interact with pathogens, thus improving overall efficacy.

Process Methods

The germicidal compositions can be applied topically to the external surfaces of the fabric, which may be knitted, woven or nonwoven web filaments, yarns or final fabrics after they are formed. Desirably, an even, but not necessarily exactly uniform coating is applied over the substrate surfaces. The coating has a relatively even distribution over or within the treated substrate surface. Any processing aid may evaporate or flash off once the germicidal composition dries on the substrate surface, but the coated composition must or should retain its hydrophilic and even hygroscopic ability so that a liquid or floating layer that attracts and holds particles is formed on fabric internal and/or external surfaces. Suitable processing aids may include alcohols, such as isopropanol, butanol, hexanol or octanol.

The active compositions should comprise as a single layer or blended layer or combinations of layers at least the antimicrobial agent, a water-absorbing or water-holding component (WHA), a surfactant, and other possible ingredients. It is preferred that the WHA be hygroscopic, a term understood in the art as requiring that the material actively withdraw moisture from air in contact with the material. Materials such as commercially available super-absorbent polymers, humectants, hygroscopic salts (particularly in water soluble polymers), glycerine, viscous sugar solutions (mannitol, rabbitol included as higher molecular weight, less volatile sugar solutions), and the like.

The materials described herein may be part of or the entirety of materials used as clothing, coverings (e.g., wraps and blankets, sheets, pillow cases, surgical drapes, equipment such as backpacks, hoods, jackets, shirts, dental tray covers, sheets on trays for carrying or supporting devices that should be kept free of active microbes, and the like) and articles.

According to an embodiment, the antimicrobial composition(s) and associated materials in the same or adjacent layer can be applied to the material substrate via conventional saturation processes such as a so-called "dip and squeeze" or "padding" technique. The "dip and squeeze" or "padding" process can coat both sides of and/or through the bulk of the substrate with the germicidal composition. When dipped in a bath, the germicidal solution be a unitary medium containing all components, or in subsequent multiple step processing, other desired components may be later added to the base germicidal layer. For instance, a formulation of a unitary germicidal solution may include leveling and/or antistatic agents. On substrates containing polypropylene, an antistatic agent can help dissipate

static charge build-up from mechanical friction. An antistatic agent can be added to the germicidal solution, and the mixture can be introduced simultaneously to the material substrate in one application step. Alternatively, the antistatic solution can be applied using a spray after the germicidal solution in a second step. The antimicrobial material may also be dusted over a wet carrier layer on the substrate and that will fix the antimicrobial on the surface.

In certain product forms, where one wishes to treat only a single side and not only the inner layers that make up a fabric substrate or opposing side of the sheet substrate, in which the substrate material any layered to another sheet ply (e.g., filter or barrier media) that is without the antimicrobial treatment, other processes are preferred such as at rotary screen, reverse roll, Meyer-rod (or wire wound rod), Gravure, slot die, gap-coating, or other similar techniques, familiar to persons in the printing and textile industry. Also one may consider printing techniques such as flexographic, ink jet, bubble jet or digital techniques. Alternatively one may use a combination of more than one coating to achieve a controlled placement of the treatment composition. Such combination may include, but not limited to, a reverse Gravure process followed by a Meyer rod process. Alternatively, the germicidal composition may be applied through an aerosol spray on the substrate surface. The spray apparatus can be employed to apply the germicidal solution and/or antistatic agent only on one side of the substrate sheet or on both sides separately if desired. An antistatic agent can be applied to the substrate in a secondary step, for example, using a spray system or any other conventional application process.

Various other methods may be employed for contacting and /or creating or attached to a substrate(s) with the treatment composition or compositions in accordance with the invention. For example, a substrate may be printed on by means of print rolls or other coating steps, or spray techniques may be employed. Preferably, the treatment composition or compositions are applied as an overlayer onto the substrate by a Meyer rod, reverse Gravure or flexographic techniques, for example, in such a way that the treatment composition forms a uniform and homogeneous layer on top of the substrate with minimum penetration of the treating composition into the bulk of the substrate. The overlayer coating, in general, results in more uniform distribution of the anti-microbial treatment on the substrate and permits the anti-microbial agent(s) to be more readily available on the surface of the substrate, although it is preferred to have the antimicrobial material distributed with its carrier throughout the apparel fabric to provide greater surface area for catching and holding the virus particles.

Germicidal Test Method

A. Sample Preparation

Test organisms are grown in 25 mL appropriate broth medium for about 24±2 hours at 37 ±2° C in a orbital shaker. The bacterial culture is then transferred by placing about 100 .mu.L aliquot in 25mL of broth and grown again for about 24±2 hours at 37±2°C. The organisms are then centrifuged and

washed three times with phosphate buffered saline (PBS). The organisms are then suspended in PBS to obtain an inoculum of approximately $1x10^8$ CFU/mL.

The test articles and control swatches are exposed to an ultraviolet light source for about 5-10 minutes per side before testing to assure that the swatches are sanitized prior to inoculation with the bacteria. The test materials are brought into contact with a known population of test bacteria from the inoculum for a specified period of time. A sample is then plated at the end of the exposure time to enumerate the surviving bacteria. The log.sub.10 reduction from the control material and the original population is calculated using the following formula: Log_{10} Control* -Log_{10} CFU/swatch Test Article = Log_{10} Reduction *CFU/swatch from control swatches or theoretical CFU/swatch.

After exposing the bacteria to the surface of a treated product for a designated amount of time (.about.40 seconds), the substrate is placed in a flask and a buffer solution is added to elute the microorganisms off the substrate prior to plating them to see how many are left alive. This buffer solution contains a chemical to de-activate or "neutralize" the germicidal agent to (a) stop the active agent from killing the organisms after the designated time period and (b) to prevent artifacts that may arise from exposing the microorganisms to the germicidal in solution rather than solely on the substrate. The neutralizer is pre-screened to make sure that they do not affect the microorganisms. The neutralizer employed may be selected from a list that is commonly used in the field. These include non-ionic detergents, Bisulphate, lecithin, Leethen broth, thiosulfate, thioglycollate, and pH buffers. Method similar to those described in American Society for Testing and Materials, Standard Practices for Evaluating Inactivators of Germicidal Agents Used in Disinfectant, Sanitizer, Antiseptic, or Preserved Products, Amer. Soc. Testing Mat. E 1054-91 (1991) can be used.

B. Contact Transfer Protocol

The following generalized discussion relates to a method for determining viable microbe transmission levels or contact transfer of microbes from one contaminated article to at least one other article. Generally speaking, the method includes applying an inoculum including a microbe to a first surface, contacting a transfer substrate to the first surface, extracting the transferred inoculum from the transfer substrate, permitting the extracted inoculum to incubate, and quantifying the microbe level to determine a percent recovery. As used herein, "inoculum" refers to any material containing at least one microbe that may act as a source of infection in a host.

The method may be used to measure viable contact transfer of various microbes, including, for example, Aspergillus niger (American Type Culture Collection (ATCC.RTM.) No. 16404), Candida albicans (ATCC® No. 10231), Hepatits A HM175/18f (ATCC® No. VR-1402), Herpes simplex virus 1 GHSV-UL46D (ATCC® No. VR-1545), Acinetobacter baumannii (ATCC® No.15149),

Clostridium difficle (ATCC® No.43594), Enterobacter cloacae (ATCC® No.29249), Enterococcus faecalis (ATCC® No.51299), Enterococcus faecium (ATCC® NO. 700221), Enterococcus hirae (ATCC® No. 10541), Escherichia coli (ATCC® No. 13706), Escherichia coli (ATCC® No. 31705), Mycobacterium smegmatis (ATCC® No. 10143), Mycobacterium tuberculosis (ATCC® 27294), Pseudomonas aeruginosa (ATCC® No. 9027), Pseudomonas aeruginosa (ATCC® No. 27853), Staphylococcus aureus (ATCC® No. 6538), Staphylococcus aureus (ATCC® No. 33592), Staphylococcus epidermidis (ATCC® No. 12228), and Staphylococcus epidermidis (ATCC® No. 51625).

After the desired microbe is selected, an inoculum is prepared by diluting a stock culture of the microbe. The culture may be diluted to any desired level using a sterile buffered liquid, and in some instances, may be diluted to an inoculum level of from about $1x10^6$ colony forming units (CFU)/ml to about $3x10^6$ CFU/ml. However, for the present testing, the inoculum level was $5x10^8$ CFU/ml. Prior to performing the evaluation, a sterile buffer solution may be prepared for later use. The buffer solution may be replaced about every two months. In some instances, the buffer solution may be sterile phosphate buffered water. The desired inoculum is then placed aseptically onto a first surface. Any quantity of the desired inoculum may be used. However, for the contact transfer testing of the germicidal surface-covering assembly, a quantity of about 0.5 ml is applied to the first surface. Furthermore, the inoculum may be applied to the first surface over any desired area. In some instances, the inoculum may be applied over an area of about 7 inches (178 mm) by 7 inches (178 mm). However, in the present testing, the inoculum is applied to substantially all of a 4 inch (101 mm) by 4 inch (101 mm) square piece of material that constitutes the first surface.

The innoculum is then permitted to remain on the first surface for a relatively short amount of time. For example, about 20 seconds before the article to be evaluated, i.e., the transfer substrate is brought into contact with the first surface.

The transfer substrate may be any apparel as defined herein that is worn about the head (bandana, headband, etc,) or neck (scarf, "Dickie" or turtleneck apparel. Masks may also be used, but the apparel is an approved embodiment as it may be repositioned from its normal use.

The solution on the sample plates may then be incubated for a desired amount of time to permit the microbes to propagate. In some instances, the solution may incubate for at least about 48 hours. The incubation may take place at any optimal temperature to permit microbe growth, and in some instances may take place at from about 33.degree. C. to about 37.degree. C. In some instances, the incubation may take place at about 35°C. After incubation is complete, the microbes present are counted and the results are reported as CFU/ml. The percent recovery may then be calculated by

dividing the extracted microbes in CFU/ml by the number present in the innoculum in (CFU/ml), and multiplying the value by 100.

The technology included herein has been shown to have significant measurable antimicrobial effects as measured above. The technology also include a method for the manufacture of a fabric having antimicrobial activity with steps that might include:

b) providing a superabsorbent polymer composition;
c) associating an antimicrobial composition into the superabsorbent polymer composition to form a final composition;
d) extruding the final composition to form active fibers or active filaments;
e) blending the active fibers or active filaments with textile fibers or textile filaments to form a textile blend; and
f) fabricating the textile blend to form a final fabric material having antimicrobial activity.

The antimicrobial composition preferably comprises a quaternary ammonium salt and may further comprises a humectant. Fabricating the textile blend may comprise forming a non-woven fabric comprising the textile blend. The textile blend may be distributed with at least 20% by weight higher concentrations of the textile blend in some areas of the final fabric material than other areas of the final fabric material so that there is greater antimicrobial activity in some areas of the final fabric material than in other areas. The fabricating of the textile blend may includes weaving or knitting a final fabric comprising the textile blend.

Face Masks Face masks are used to prevent inhalation of materials (including microbes) from the environment and/or exhalation of materials into the environment. Most modern face masks are constructed of fabric that contain porosity that allows a user to breathe through the fabric as it filters the flow of gases through the fabric during inhalation and exhalation. The fabric usually has a securing element (e.g., a strap, elastic band, clips, tie or the like) to retain a position on a wearer's face. The fabric of the mask may be stiff or limp, but it should have a shape (e.g., squre, rectangular, oblong with curved edges, oval, etc.) and size (e.g., at least 5 x7 cm, preferably at least 7 x 10 cm, and even long enough to wrap around the face of a user, although dimensions in excess of 20 cm tend to waste fabric, and dimensions less than 5 cm will not easily cover the nose of a user) that be comfortably worn by a human. The mask is often sufficiently stiff that it can retain a shape and from when lain on a hard surface.

The mask may be shaped and/or molded to retain a form that more easily adjusts to facial features, with a convex area for the nose and concave areas for the cheeks, although variably convex shapes are

commonly used. Bendable, shape retaining elements (such as metal strips, metallized strips, formable polymer strips, wires and the like) may be attached to or in the fabric and shape of the mask to assist in shaping the mask to a face.

The fabric of the mask can be formed of the fabric materials described herein, or preferably may have one or more permanent or detachable or replaceable layers of the fabrics of the present technology. With the use of high quality or even reusable commercial grade masks, it is desirable to have replaceable or fabric that can be fit to and applied to the interior or exterior of the masks, and then replaced as needed (e.g., when worn out or the microbial activity exhausted). The novel fabric material of the present technology may be attached to the mask (again, to either the interior or exterior or midway between multiple sheets on the mask) by mechanical or chemical attachments such as, clips, ties, pin, snaps, toggles, string laces, adhesives, fusion of thermal materials, form fitting, edge overlap support, shape tension between elements, and the like. Adhesive strips, adhesive patches, thermal adhesive strips, two-sided pressure-sensitive adhesive tapes are readily convenient materials and systems used to apply removable fabric to the masks. The pressure-sensitive adhesive may be traditional pressure-sensitive adhesives (e.g., acrylics, polyurethanes, polysiloxanes) or be repositionable (e.g., Post-It® adhesives, which include microspherical adhesives). The adhesives may be used in continuous or discontinuous strips or lines at convenient and effective locations around the mask and fabric. For example, the adhesives may be placed along the exterior edges of the interior face or exterior face of the mask. The adhesive may extend all the way to the edges of the mask faces (interior or exterior) or may be recessed away from the edge to prevent excess adhesive from extending over the edges of the mask (or fabric) and this makes the mask and replaceable liner more easily handlable.

Reference to Figure 2 will further assist in understanding of the use of the fabric with face masks. The commercially available mask **100** is shown with multiple fabric layers **32, 34 (optional)** and **40**. Only one of these layers **32, 34, 40** need be a fabric according to the present technology. In this Figure 2, for purposes of convenience in use and in the structure, the innermost layer **40** is the novel fabric materials according to the present technology. Directions on the mask will be described as the outer mask layer **32** being a forward direction and the rear mask layer **40** being the back direction. On the forward face **40a** of the rear mask layer **40** are shown discontinuous lines of pressure-sensitive adhesive **50**. AS an option, if the fabric of the present technology were to be on the front 32d of the mask 32m attachment element **10** could be used. The shape of the rear mask **40** and the central fabric mask layer **34** (optional) are shaped to fit or nest comfortably against the rear surface (or in an alternative embodiment, against the forward surface) of the forward mask layer **32**. Head securing straps **36** are also shown.

The present invention has been described in general and in detail by way of examples. The words used are words of description rather than of limitation. Persons of ordinary skill in the art understand that the invention is not limited necessarily to the embodiments specifically disclosed, but that modifications and variations may be made without departing from the scope of the invention as defined by the following claims or their equivalents, including other equivalent components presently known, or to be developed, which may be used within the scope of the present invention. Therefore, unless changes otherwise depart from the scope of the invention, the changes should be construed as being included herein and the appended claims should not be limited to the description of the preferred versions herein.

WHAT IS CLAIMED:

1. A fabric that provides particulate filtering capability and moisture retention comprising at least 1% to 50% by weight of all fibers in the fabric of superabsorbent polymer and fibers on the fabric having a hydrophilic carrier associated with the fibers, the carrier able to absorb moisture from a gas stream having at least 50% relative humidity at 30C so as to maintain a wet surface on the fibers to which viral particles will adhere more strongly than to a dry surface of the same fiber.

2. The fabric material of claim 1 wherein the hydrophilic carrier comprises an antimicrobial composition that is active in a moist environment.

3. The fabric material of claim 1 wherein the carrier comprises a liquid at room temperature.

4. The fabric material of claim 2 wherein the carrier comprises a liquid at room temperature.

5. The fabric material of claim 4 wherein the antimicrobial agent comprises from 5 to 90% by weight of the hydrophilic carrier.

6. The fabric material of claim 4 wherein the antimicrobial agent comprises from 10 to 80% by weight of the hydrophilic carrier.

7. The fabric material of claim 6 wherein the SAP is capable of absorbing from 50 to 500 times the weight of the SAP of deionized water and the SAP comprises 1% to 25% of the total weight of fibers in the fabric, and the fabric is a non-woven fabric.

8. The fabric material of claim 7 wherein at least 25% by weight of the non-woven fabric comprises a thermoplastic fiber other than th SAP fiber.

9. An apparel for wearing about the neck and/or head of a human having structure that, when repositioned from about the neck or on top of the head will retain a position about a mouth and nose of the human, the apparel comprising a fabric that is sufficiently porous as to allow a human to breath comfortable through the fabric when placed over the mouth and nose of the human, wherein the fabric comprises the fabric of claim 4.

10. An apparel for wearing about the neck and/or head of a human having structure that, when repositioned from about the neck or on top of the head will retain a position about a mouth and nose of the human, the apparel comprising a fabric that is sufficiently porous as to allow a human to breath comfortable through the fabric when placed over the mouth and nose of the human, wherein the fabric comprises the fabric of claim 7.

11. The fabric of claim 7 wherein the antimicrobial agent comprises an antimicrobial salt.
12. The fabric of claim 11 wherein the antimicrobial agent comprises a quaternary ammonium compound.
13. The fabric of claim 1 wherein the carrier comprises a hygroscopic material.
14. The fabric of claim 4 wherein the carrier comprises a hygroscopic material.
15. The fabric of claim 7 wherein the carrier comprises a hygroscopic material.
16. A facial mask comprising a first support fabric having a first main fabric material having a width and a height, the mask having a support element that is connected to ends of the width of the first main fabric and a layer of the fabric of claim 4 contiguous with the height and width of the first main fabric.
17. A facial mask comprising a first support fabric having a first main fabric material having a width and a height, the mask having a support element that is connected to ends of the width of the first main fabric and a layer of the fabric of claim 7 contiguous with the height and width of the first main fabric.
18. A facial mask comprising a first support fabric having a first main fabric material having a width and a height, the mask having a support element that is connected to ends of the width of the first main fabric and a layer of the fabric of claim 11 contiguous with the height and width of the first main fabric.
19. A facial mask comprising a first support fabric having a first main fabric material having a width and a height, the mask having a support element that is connected to ends of the width of the first main fabric and a layer of the fabric of claim 15 contiguous with the height and width of the first main fabric.

20. A method for the manufacture of a fabric having antimicrobial activity comprising:
    a. providing a superabsorbent polymer composition;
    b. associating an antimicrobial composition into the superabsorbent polymer composition to form a final composition;
    c. extruding the final composition to form active fibers or active filaments;
    d. blending the active fibers or active filaments with textile fibers or textile filaments to form a textile blend; and
    e. fabricating the textile blend to form a final fabric material having antimicrobial activity.

FIG. 1A

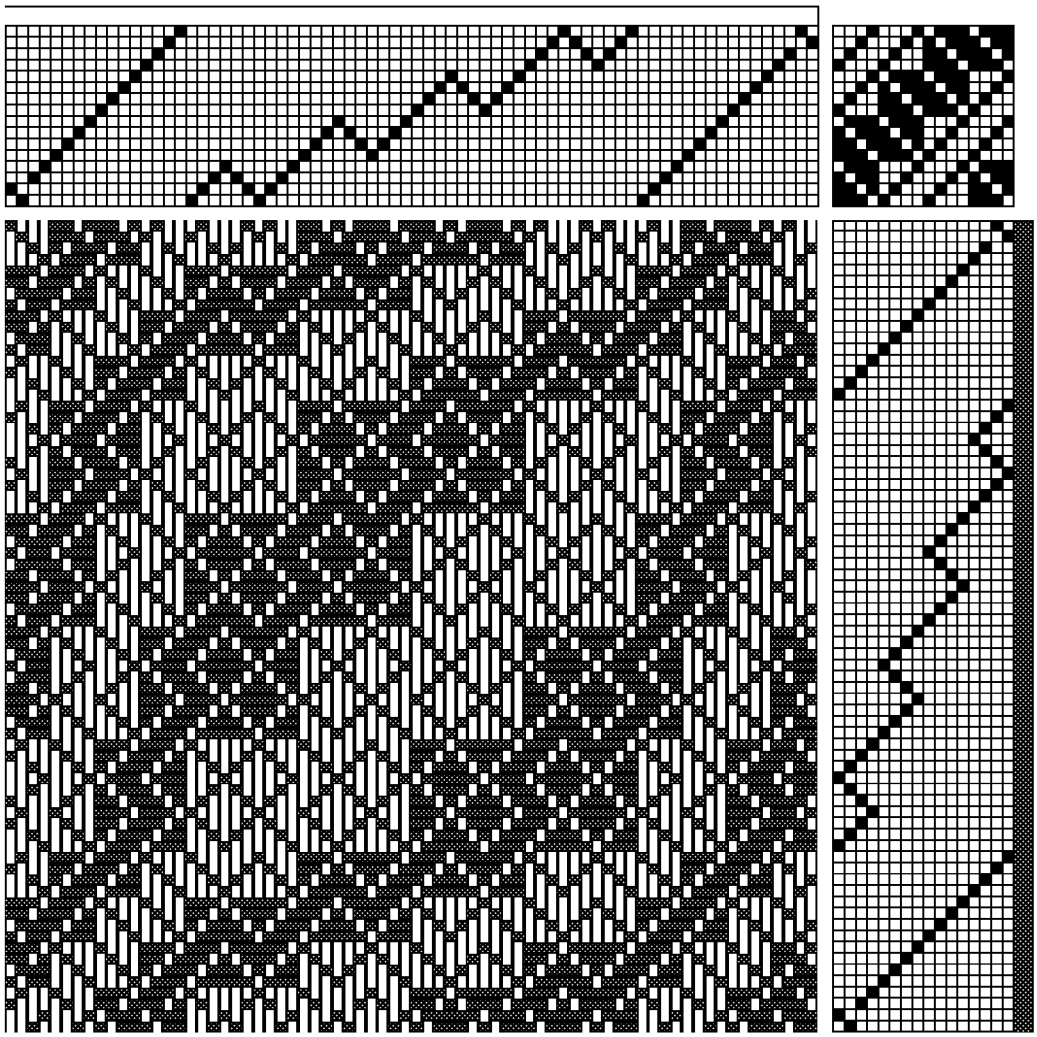


FIG. 1B

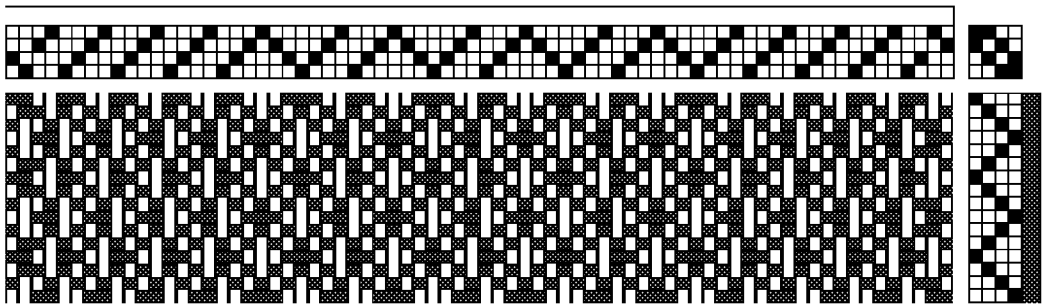


FIG. 1C

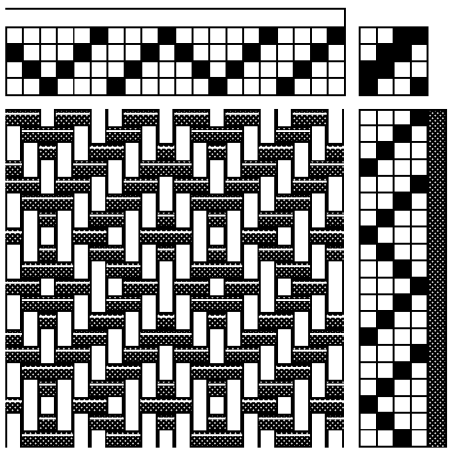


Figure 2

