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(54) Title: AN ANTIMICROBIAL SILVER HALIDE COMPOSITION

(57) Abstract: This invention relates to a composition comprising at least 50 % water, silver halide particles and a hydrophilic polymer, wherein the composition does not substantially gel or solidify at 25 degrees C; is substantially free of organic solvents; and exhibits antimicrobial activity upon drying. The composition may further comprise a hydrophobic binder or a crosslinker for the hydrophilic polymer.

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AN ANTIMICROBIAL SILVER HALIDE COMPOSITION

FIELD OF THE INVENTION

The present invention relates to an antimicrobial composition of specific silver salts and polymeric binders. The composition may be used to provide antimicrobial activity to a target fiber or textile fabric.

BACKGROUND OF THE INVENTION

The antimicrobial properties of silver have been known for several thousand years. The general pharmacological properties of silver are summarized in "Heavy Metals" - by Stewart C. Harvey and "Antiseptics and Disinfectants: Fungicides; Ectoparasiticides" - by Stewart Harvey in The Pharmacological Basis of Therapeutics, Fifth Edition, by Louis S. Goodman and Alfred Gilman (editors), published by MacMillan Publishing Company, NY, 1975. It is now understood that the affinity of silver ion to biologically important moieties such as sulfhydryl, amino, imidazole, carboxyl and phosphate groups are primarily responsible for its antimicrobial activity.

The attachment of silver ions to one of these reactive groups on a protein results in the precipitation and denaturation of the protein. The extent of the reaction is related to the concentration of silver ions. The diffusion of silver ion into mammalian tissues is self-regulated by its intrinsic preference for binding to proteins through the various biologically important moieties on the proteins, as well as precipitation by the chloride ions in the environment. Thus, the very affinity of silver ion to a large number of biologically important chemical moieties (an affinity which is responsible for its action as a germicidal/biocidal/ viricidal/fungicidal/bacteriocidal agent) is also responsible for limiting its systemic action – silver is not easily absorbed by the body. This is a primary reason for the tremendous interest in the use of silver containing species as an antimicrobial i.e. an agent capable of destroying or inhibiting the growth of microorganisms, including bacteria, yeast, fungi and algae, as well as viruses.

In addition to the affinity of silver ions to biologically relevant species, which leads to the denaturation and precipitation of proteins, some silver

compounds, those having low ionization or dissolution ability, also function effectively as antiseptics. Distilled water in contact with metallic silver becomes antibacterial even though the dissolved concentration of silver ions is less than 100 ppb. There are numerous mechanistic pathways by which this oligodynamic effect is manifested i.e. by which silver ion interferes with the basic metabolic activities of bacteria at the cellular level, thus leading to a bacteriocidal and/or bacteriostatic effect.

A detailed review of the oligodynamic effect of silver can be found in "Oligodynamic Metals" by I.B. Romans in Disinfection, Sterlization and Preservation, C.A. Lawrence and S.S. Bloek (editors), published by Lea and Fibiger (1968) and "The Oligodynamic Effect of Silver" by A. Goetz, R.L. Tracy and F.S. Harris, Jr. in Silver in Industry, Lawrence Addicks (editor), published by Reinhold Publishing Corporation, 1940. These reviews describe results that demonstrate that silver is effective as an antimicrobial agent towards a wide range of bacteria. However, it is also known that the efficacy of silver as an antimicrobial agent depends critically on the chemical and physical identity of the silver source. The silver source may be silver in the form of metal particles of varying sizes, silver as a sparingly soluble material such as silver chloride, silver as a highly soluble salt such as silver nitrate, etc. The efficiency of the silver also depends on i) the molecular identity of the active species – whether it is Ag^+ ion or a complex species such as $(AgCl_2)^-$, etc., and ii) the mechanism by which the active silver species interacts with the organism, which depends on the type of organism. Mechanisms may include, for example, adsorption to the cell wall which causes tearing; plasmolysis where the silver species penetrates the plasma membrane and binds to it; adsorption followed by the coagulation of the protoplasma; or precipitation of the protoplasmic albumin of the bacterial cell. The antibacterial efficacy of silver is determined, among other factors, by the nature and concentration of the active species; the type of bacteria; the surface area of the bacteria that is available to interaction with the active species; the bacterial concentration; the concentration and/or the surface area of species that could consume the active species and lower its activity; and the mechanisms of deactivation.

It is clear from the literature on the use of silver based materials as antibacterial agents that there is no general procedure for precipitating silver based materials and/or creating formulations of silver based materials that would be suitable for all applications. Since the efficacy of the formulations depends on so many factors, there is a need for i) a systematic process for generating the source of the desired silver species, ii) a systematic process for creating formulations of silver based materials with a defined concentration of the active species; and iii) a systematic process for delivering these formulations for achieving predetermined efficacy. It is particularly a need for processes which are simple and cost effective.

One very important use of silver based antimicrobials is for textiles. Various methods are known in the art to render antimicrobial properties to a target fiber. The approach of embedding inorganic antimicrobial agents, such as zeolites, into low melting components of a conjugated fiber is described in U.S. 4,525,410 and U.S. 5,064,599. In another approach, the antimicrobial agent may be delivered during the process of making a synthetic fiber such as those described in U.S. 5,180,402, U.S. 5,880,044, and U.S. 5,888,526, or via a melt extrusion process as described in U.S. 6,479,144 and U.S. 6,585,843. In still yet another process an antimicrobial metal ion may be ion exchanged with an ion exchange fiber as described in U.S. 5,496,860.

Methods of transferring an antimicrobial agent, in the form of an inorganic metal salt or zeolite, from one substrate to a fabric are disclosed in U.S. 6,461,386. High-pressure laminates containing antimocrobial inorganic metal compounds are disclosed in U.S. 6,248,342. Deposition of antimicrobial metals or metal-containing compounds onto a resin film or target fiber has also been described in U.S. 6, 274,519 and U.S. 6,436,420.

It is also known in the art that fibers may be rendered with antimicrobial properties by applying a coating of silver particles. Silver ion-exchange compounds, silver zeolites and silver glasses are all known to be applied to fibers through topical applications for the purpose of providing antimicrobial properties to the fiber as described in U.S. 6,499,320, U.S. 6,584,668, U.S. 6,640,371 and U.S. 6,641,829. Other inorganic antimicrobial agents may be

contained in a coating that is applied to a fiber as described in U.S. 5,709870, U.S. 6,296,863, U.S. 6,585,767 and U.S 6,602,811.

It is known in the art to use binders to apply coating compositions to impart antimicrobial properties to various substrates. U.S. 6,716,895 describes the use of hydrophilic and hydrophobic polymers and a mixture of oligodynamic metal salts as an antimicrobial composition, wherein the water content in the coating composition is preferably less than 50%. The mixture of oligodynamic metal salts are intended to span a wide range of solubilities and would not be useful in a durable coating application. U.S. 5,709,870 describes the use of carboxymethyl cellulose-silver complexes to provide an antimicrobial coating to a fiber. The use of silver halides in an antimicrobial coating, particularly for medical devices, is described in U.S. 5,848,995.

In particular, the prior art has disclosed formulations that are useful for highly soluble silver salts having solubility products, herein referred to as pKsp, of less than 1. Generally, these silver salts require the use of hydrophobic addenda to provide the desired combinations of antimicrobial behavior and durability. Conversely, it is also know that very insoluble metallic silver particles, having a pKsp greater than 15 would require hydrophilic addenda to provide the desired combinations of antimicrobial behavior and durability. There exists a need to provide formulations of sparingly soluble silver salts, in the range of pKsp from about 8-12, that can be highly efficient in antimicrobial behavior and durability when applied to a fiber or textile fabric.

It is well known in the photographic art that gelatin is a useful hydrophilic polymer in the production of photographic silver halide emulsions. Gelatin is present during the precipitation of, for example, silver chloride from its precursor salts. For most practical photographic coating formulations the amount of gelatin is above 3% during the precipitation stages and preferably above 10% during the coating applications for film or paper products. It is a desirable feature that the gelatin is present in an amount sufficient to solidify or gel the composition. This is desired to minimize settling of the dense silver halide particles. The high gelatin levels are themselves a source of bio-activity and it is

common practice to add biostats or biocides to minimize or prevent spoilage of the photographic emulsion prior to the coating application.

Although the approaches in the prior art for rendering antimicrobial properties to a fiber through the use of an inorganic metal compounds may be viable, there remains the need to deliver a cost effective source of inorganic metal compounds that is easy to apply to the target fiber and which is durable and efficient in it's antimicrobial behavior.

SUMMARY OF THE INVENTION

This invention provides a composition comprising at least 50 % water, silver halide particles and a hydrophilic polymer, wherein the composition does not substantially gel or solidify at 25 degrees C; is substantially free of organic solvents; and exhibits antimicrobial activity upon drying. It further provides a composition comprising at least two separately packaged parts, the first part being a composition comprising at least 50 % water, silver halide particles and a hydrophilic polymer, wherein the composition does not substantially gel or solidify at 25 degrees C and substantially does not contain an organic solvent; and the second part being a composition comprising an aqueous suspension of a hydrophobic binder, or a composition comprising a crosslinker for the hydrophilic polymer. The preferred hydrophilic polymer is gelatin.

This invention also provides a method of coating a fabric or fiber comprising providing a composition comprising at least two separately packaged parts, the first part being a composition comprising at least 50 % water, silver halide particles and a hydrophilic polymer, wherein the composition does not substantially gel or solidify at 25 degrees C and substantially does not contain an organic solvent; and the second part being a composition comprising an aqueous suspension of a hydrophobic binder, or a composition comprising a crosslinker for the hydrophilic polymer; mixing the two separately packaged parts; and coating the mixture on fabric or fiber. It further provides a method of coating a fiber or fabric comprising providing a composition comprising at least 50 % water, silver halide particles, a hydrophilic polymer, and a hydrophobic binder or a crosslinker

for the hydrophilic polymer, wherein the composition does not substantially gel or solidify at 25 degrees C and substantially does not contain an organic solvent; providing a yarn or fabric; and coating said fiber or fabric with said composition. This invention also provides a fabric or fiber having coated thereon an antimicrobial composition comprising silver chloride particles and gelatin.

The compositions of the invention impart durable antimicrobial properties to yarn, fabrics or textiles. The silver halide particles are applied to the target fiber or textile fabric with the aid of a hydrophilic binder that imparts colloidal stability to the particles prior to and during the application process to the fiber or textile fabric. The composition may also be aided with the use of a hydrophobic binder to impart improved durability to extended washing cycles that would otherwise remove the particles and the associated antimicrobial properties of the fiber or textile fabric.

DESCRIPTION OF THE INVENTION

The composition of the invention is a composition comprising at least 50 % water, silver halide particles, and a hydrophilic polymer. The hydrophilic polymer is of a type and used in an amount wherein the composition does not substantially gel or solidify at 25 degrees C. In practical terms the composition, when sold as a concentrate, must be able to flow at 25 degrees C and be easily mixed with an aqueous diluent or other addenda prior to use as an antimicrobial coating for yarn or textile. The composition also encompasses a more diluted form that is suitable for dip, pad, or other types of coating. The composition is substantially free of organic solvents. Preferably, no organic solvent is intentionally added to the composition. The composition must exhibit antimicrobial activity upon drying.

In its concentrated form the composition must comprise at least 50 % water by weight. In one embodiment it comprises at least 70 % water by weight. In its diluted form the composition may be greater than 95 % water.

The silver halide particles may be of any shape and halide composition. The type of halide may include chloride, bromide, iodide and

mixtures of them. The silver halide particles may be, for example, silver bromide, silver iodobromide, bromoiodide, silver iodide or silver chloride. In one embodiment the silver halide particles are predominantly silver chloride. The predominantly silver chloride particles may be, for example, silver chloride, silver bromochloride, silver iodochloride, silver bromoiodochloride and silver iodobromochloride particles. By predominantly silver chloride, it is meant that the particles are greater than about 50 mole percent silver chloride. Preferably, they are greater than about 90 mole percent silver chloride; and optimally greater than about 95 mole percent silver chloride. The silver halide particles may either be homogeneous in composition or the core region may have a different composition than the shell region of the particles. The shape of the silver halide particles may be cubic, octahedral, tabular or irregular. More silver halide properties may be found in "The Theory of the Photographic Process", T. H. James, ed., 4th Edition, Macmillan (1977). In one embodiment the silver halide particles have a mean equivalent circular diameter of less than 1 micron, and preferably less 0.5 microns.

The solubility of silver halide, hence the free silver ion concentration, is determined by Ksp, particle size, structure and shape of the particle. While not being held to the theory, it is believed that the free silver ion concentration plays a role in antimicrobial efficacy. By controlling the above variables one can control silver ion release rate and antimicrobial activity.

The silver halide particles and associated coating composition of the present invention are applied to the fiber or fabric in an amount sufficient to provide antimicrobial properties to the treated fiber for a minimum of at least 10 washes, more preferably 20 washes and most preferably after 30 washes in accordance with ISO 6330:2003. The amount of silver halide particles applied to the target fiber or textile fabric is determined by the desired durability or length of time of antimicrobial properties. The amount of silver halide particles present in the composition will depend on whether the composition is one being sold in a concentrated form suitable for dilution prior to coating or whether the composition has already been diluted for coating. Typical levels of silver salt particles (by weight percent) in the formulation are preferably from about 0.000001% to about

10%, more preferably from about 0.0001% to about 1% and most preferably from about 0.001% to 0.5%. In a concentrated format the composition preferably comprises silver halide particles in an amount of 0.001 to 10%, more preferably 0.001 to 1 %, and most preferably 0.001 to 0.5 %. In a diluted format the composition preferably comprises silver halide particles in an amount from about 0.000001% to about 0.01%, more preferably from about 0.00001% to about 0.01% and most preferably from about 0.0001% to 0.01%. It is a desirable feature of the invention to provide efficient antimicrobial properties to the target fiber or textile fabric at a minimum silver halide level to minimize the cost associated with the antimicrobial treatment.

The preferred hydrophilic polymers of the present invention are soluble in water at concentrations greater than about at least 2%, preferably greater than 5 %, and more preferably greater than 10 %. Therefore, suitable hydrophilic polymers do not require an organic solvent to remain fluid at 25 degrees C. Suitable hydrophilic polymers useful in the invention include, for example, gelatin, polyacrylic acid, polyacrylamide, polyvinyl alcohol, polyvinylpyrrolidones, cellulose etc. into the reaction vessel. The polymers peptize or stabilize silver halide particles to help maintain colloidal stability of the solution. A preferred hydrophilic polymer is gelatin.

Gelatin is an amphoteric polyelectrolyte that has excellent affinity to a number of substrates. The gelatin of the present invention may be processed by any of the well-known techniques in the art including; alkali- treatment, acid-treatment, acetylated gelatin, phthalated gelatin or enzyme digestion. The gelatin may have a wide range of molecular weights and may include low molecular weight gelatins if it is desirable to raise the concentration of the gelatin in the inventive composition without solidifying the composition. The gelatin in the present invention is added in an amount sufficient to peptize the surface of the silver halide and some excess of gelatin will always be present in the water phase. The gelatin level may be chosen such that the composition does not substantially solidify or gel. In one embodiment the weight percentage of gelatin is less than 3 %, preferably less than 2 %, and more preferably less than 1%. The gelatin of the

present invention may also be cross-linked in order to improve the durability of the coating composition containing the antimicrobial silver halide particles.

In a preferred embodiment the silver halide particles may be formed by reacting silver nitrate with halide in aqueous solution. In the process of silver halide precipitation one can add the hydrophilic polymers to peptize the surface of the silver halide particles thereby imparting colloidal stability to the particles, see for example, Research Disclosure September 1997, Number 401 published by Kenneth Mason Publications, Ltd., Dudley Annex, 12a North Street, Emsworth, Hampshire PO10 7DQ, ENGLAND, the contents of which are incorporated herein by reference.

In addition to the hydrophilic binder, a hydrophobic binder resin is preferably used to improve the adhesion and durability of the silver salt particles once applied to the fabric surface. Such hydrophobic binders are well known in the art and are typically provided as aqueous suspensions of polymer microparticles. Materials suitable for use as hydrophobic binders include acrylic, styrene-butadiene, polyurethane, polyester, polyvinyl acetate, polyvinyl acetal, vinyl chloride and vinylidine chloride polymers, including copolymers thereof. Acrylic polymers and polyurethane are preferred.

The hydrophobic binders should have film-forming properties that include a range of glass transition temperatures from about –30 C to about 90 C. The hydrophobic binder particles may have a wide range of particle sizes from about 10 nm to about 10,000 nm and can be polydisperse in distribution. The hydrophobic binders may also be thermally or chemically crosslinkable in order to modify the desired durability properties of the antimicrobial fiber or fabric textile. The hydrophobic binders may be nonionic or anionic in nature. Useful ranges of the hydrophobic binders are generally less than about 10% of the composition. It is understood that the choice of the hydrophobic binder may be related to specific end use requirements of the fiber or fabric textile including, wash resistance, abrasion (crock), tear resistance, light resistance, coloration, hand and the like. As described in more detail below the hydrophobic binder is generally kept separate from the hydrophilic polymer/silver halide particle composition until a short time prior to coating.

As noted above, the composition may also comprise a crosslinker for the gelatin. The crosslinker is also generally kept separate from the hydrophilic polymer/silver halide particle composition until a short time prior to coating. Examples of compounds useful in crosslinking the gelatin include, but are not limited to, Alum, formaldehyde and free dialdehydes such as glutaraldehyde, bis(imniomethyl)ether salts, s-trazines and diazines, such as dihydroxychlorotriazine, epoxides, aziridines, and the like.

The inventive composition comprising silver salt particles, hydrophilic binder and optionally, hydrophobic binder or gelatin cross-linker, can be applied to the target fiber or textile fabric in any of the well know methods in art including, pad coating, knife coating, screen coating, spraying , foaming and kiss-coating. The components of the inventive composition are preferably delivered as a separately packaged two-part system involving colloidal silver halide particles and hydrophilic binder as one part and a second part comprising an aqueous suspension of a hydrophobic binder, or gelatin cross-linker and, optionally, a second hydrophilic binder that may be the same or different as the hydrophilic binder from part A. The first part, comprising colloidal silver halide particles and hydrophilic binder, is excellent in shelf-life without compromising colloidal stability. The two parts may be combined prior to a padding or coating operation and exhibit colloidal stability for the useful shelf-life of the composition, typically on the order of several days.

There may also be present optional components, for example, thickeners or wetting agents to aid in the application of the inventive composition to the target fiber or textile fabric. Examples of wetting materials include surface active agents commonly used in the art such as ethyleneoxide-propyleneoxide block copolymers, polyoxyethylene alkyl phenols, polyoxyethylene alkyl ethers, and the like. Compounds useful as thickeners include, for example, particulates such as silica gels and smectite clays, polysaccharides such as xanthan gum, polymeric materials such as acrylic-acrylicacid copolymers, hydrophobically modified ethoxylated urethanes, hydrophobically modified nonionic polyols, hydroxypropyl methylcellulose and the like.

Also of use in the compositions is an agent to prevent latent image formation. Some silver salts are light sensitive and discolor upon irradiation of light. However, the degree of light sensitivity may be minimized by several techniques known to those who are skilled in the art. For example, storage of the silver halide particles in a low pH environment will minimize discoloration. In general, pH below 7.0 is desired and more specifically, pH below 4.5 is preferred. Another technique to inhibit discoloration involves adding compounds of elements, such as, iron, iridium, rhuthinium, palladium, osmium, gallium, cobalt, rhodium, and the like, to the silver halide particles. These compounds are known in the photographic art to change the propensity of latent image formation; and thus the discoloration of the silver salt. Additional emulsion dopants are described in *Research Disclosure*, February 1995, Volume 370, Item 37038, Section XV.B., published by Kenneth Mason Publications, Ltd., Dudley Annex, 12a North Street, Elmsworth, Hampshire PO10 7DQ, England.

The present invention is not limited to any particular fiber or textile fabric or yarn including, exhaustively any natural or manufactured fibers. Examples of natural fibers include, cotton (cellulosic), wool, or other natural hair fibers, for example, mohair and angora. Examples of manufactured fibers include synthetics, such as, polyester, polypropylene, nylon, acrylic, polyamide, or, regenerated materials such as cellulosics. The target fiber or yarn may include any number of chemistries or applications prior to, during and/or after the application of the antimicrobial composition including, for example, antistatic control agents, flame retardants, soil resistant agents, wrinkle resistant agents, shrink resistant agents, dyes and colorants, brightening agents, UV stabilizers, lubricants, antimigrants, and the like.

The following examples are intended to demonstrate, but not to limit, the invention.

EXAMPLES

Testing Methodologies

The antimicrobial properties of the fiber or textile fabric treated with the inventive compositions may be evaluated according to the procedures

documented in AATCC-100 for the quantitative evaluation of textiles treated with antimicrobial finishes, or the so called New York State Proposal. Durable antimicrobial performance is judged to be acceptable when survival rates according to the procedures outlined in the New York State Proposal are less than 10%, more preferably less than 1% and most preferably less than 0.1%. This activity must be observed before and after washing cycles in standard domestic operating conditions such as described in the document ISO 6330:2000 for domestic washing and drying procedures for textile testing, or AATCC Test Method 138-2000 for Cleaning and Washing of Textile Floor Coverings.

Testing of antimicrobial activity is based on the contact between the antimicrobial substance and the targeted microorganisms followed by the measurement of the impact on the microorganism's viability or growth rate. In the case of surfaces, surface treatment or coatings integrating antimicrobials, the activity is relying on the diffusion of the antimicrobial from the surface to the environment in which microorganisms are present. Alternatively the activity can also be based on the contact of the microorganism with the surface, with no or very low release of the antimicrobial substance.

The quantitative method used to measure antimicrobial diffusing from a surface was the dipping test. Operating conditions can be very different according to the targeted application. Some are normalized in standard methods, for instance: AATCC-100 for the quantitative evaluation of textiles treated with antimicrobial finishes, or the so called New-York State Proposal.

The principle of these methods is to put a piece of material (yarn, textile etc.) with a known surface area in contact with a solution inoculated with microorganisms. The leaching of antimicrobials from the surface into the solution impacts the microorganism growth when the activity is significant. Following the microorganism's number in solution (planktonic) over time allows one to evaluate quantitatively the antimicrobial activity.

The operating conditions were selected in order to fit most of potential applications of the new antimicrobial surface. Samples of fabrics (2 x 2 cm) were aseptically cut and placed in the center of a small petri dish. The dish was then placed into a larger petri dish containing 10 mL sterile HP H20. A 0.1

mL inoculum of *Staphylococcus aureus* (ATCC 6538) was placed on the surface of the fabric. The plates were incubated at 35 ± 2 °C for 24 hours. The plates were then removed and the fabric was aseptically transferred to sterile containers containing 5 mL of 0.2 μm water. The containers were shaken for 1 minute to remove any bacteria and filtered onto Trypticase Soy Agar plates. The plates were incubated at 35 ± 2 °C degrees C for 24 hours and then observed for growth. The lower the number of bacteria, the higher the antimicrobial activity.

Example 1:

Silver chloride grains were prepared by the following process: to a reactor charged with 184 g of gelatin, 15 g of sodium chloride and 6,490 g of water, 2.8 molar silver nitrate solution and 3 molar sodium chloride solution were added at 186 cc/min and 182 cc/min, respectively, over 16.2 minutes with vigorous stirring. The temperature of the reactor was maintained at 46.1 °C throughout the precipitation process. The solution was then washed with an ultra-filtration column to remove soluble salts. The resulting silver chloride grains had a mean equivalent circular diameter of 0.2 micron.

Five sample compositions used for antimicrobial treatment of fabrics were prepared by mixing various amounts of the following components: (1) Silver Chloride/Gelatin emulsion in water (Silver Index ≈ 1.693 kg/mol Ag, Gelatin Level ≈ 20 g/mol Ag), (2) Acrylic binder dispersion (Rhoplex® TS-934HS), (3) Thickener solution (2% by weight Benecel® M042 in water), (4) Water. The table below shows the approximate percentage by weight of each active component in each of the five compositions.

Table 1: Percentage of Components

Sample	Wt % AgCl	Wt% Gelatin	Wt % acrylic Binder	Wt % Thickener	Wt % Water
19--1	0.0075	0.001	0.7	0.35	98.94
19-2	0.0075	0.001	0.5	0.25	99.24
19-3	0.0075	0.001	0.3	0.15	99.54
19-4	0.0075	0.001	0.1	0.05	99.84
19-5	0.0075	0.001	0.9	0.45	98.64

About 0.1% by weight of a non-ionic surfactant (Triton® X-100) was added to each of the samples described above. A strip of 100% polyester fabric (100% Dacron Type 54) was immersed for about 5 seconds in each of the samples. The immersed fabric strips were then removed and passed through a nip/roll. The average wet pickup by these fabrics was about 215%. The resulting fabric strips were then heated to 150°C for 10 minutes.

Description of Laundering Conditions:

The treated fabrics listed above were washed according to the procedure adapted from ISO 6330:2000, in which treated fabrics were laundered multiple times in a standard domestic washing machine. Washings were performed in a warm/cold cycle. Each wash cycle was about 20 minutes. Ultra Tide 2 was used at a concentration of about 5 grams per 20 liters of wash water. After every 8 wash cycles with detergent the fabrics were washed twice without detergent. This was done to minimize the potential buildup of biocidal components found within the detergent.

Fabrics were tested for antimicrobial activity according to the method described above adapted from AATCC 100 and NYS proposal. A control without antimicrobial material was run in the same conditions. The results are listed in Table 2. The control showed a 100% survival score before washing, and along all wash cycles. There is no antimicrobial activity displayed by the control.

Fabrics 19-1 to 19-5 have the same amount of antimicrobial with various binder concentrations. Survival scores before washing are very low : < 0.1 % up to 0.2 %. This shows very good antimicrobial activity. After 10 and 20 washes the survival scores are still very low showing a sustained antimicrobial activity despite washing. After 30 washes the survival scores were still very low for fabrics 19-3 to 19-5. A slight increase of survival is observed for fabrics 19-1 and 19-2, but it is still lower than 1%.

Table 2: Survival Scores after Washing

Sample	0 Wash	10 Wash	20 wash	30 wash
19-Control Detergent	100 %	0.2 %	100 %	100 %
19-1	<0.1 %	0.1 %	<0.1 %	0.6 %
19-2	0.2 %	0.1 %	<0.1 %	0.3 %
19-3	0.2 %	0.2 %	<0.1 %	0.1 %
19-4	<0.1 %	<0.1 %	<0.1 %	0.1 %
19-5	0.1 %	<0.1 %	<0.1 %	0.1 %

To summarize, the fabrics treated with the antimicrobial material described herein all have very good antimicrobial activity that is sustained after 30 washes with detergent in standard domestic laundry conditions. This is recognized as good and sustainable antimicrobial activity in the textile industry. See for instance the publication of Payne, J.D.& Kudner, D.W, "A new durable antimicrobial finish for cotton textiles." In American Dyestuff Reporter (1996), 85(6), 26-30.

Example 2:

Two samples used for antimicrobial treatment of fabrics were prepared by mixing various levels of the following components: (1) Silver Chloride/Gelatin emulsion from Example 1 in water (Silver Index ≈ 1.693 kg/mol Ag, Gelatin Level ≈ 20 g/mol Ag), (2) Polyurethane binder dispersion (Witcobondâ W-240), (3) De-ionized water. Table 3 below shows the

approximate percentage by weight of each component in each sample mixed to prepare antimicrobial fabric treatments.

Table 3: Percentage of Components

Sample	**Wt % AgCl**	**Wt% Gelatin**	**Wt % Polyurethane binder**	**Wt % Water**
17-2	0.0075	0.001	1.0	98.99
17-3	0.0075	0.001	3.0	96.99

About 0.1% by weight of a non-ionic surfactant (Tritonâ X-100) was added to the samples. A strip of 100% polyester fabric (100% Dacron Type 54) was immersed in each sample for about 5 seconds. The immersed fabric strips were then removed and passed through a nip/roll. The resulting fabric strips were then heated to 150 °C for 10 minutes.

The treated fabrics listed above were washed according to the procedure described above that was adapted from ISO 6330:2000 and test for antimicrobial activity according to the method described above adapted from AATCC 100 and NYS proposal. The survival scores for these samples are as follows in Table 4.:

Table 4: % Survival scores after washing

	0 Wash	30 Wash
17-2W	<0.1 %	<0.1 %
17-3W	<0.1 %	<0.1 %

Both treated fabrics showed excellent antimicrobial activity after 30 washes.

Example 3:

Three sample compositions used for antimicrobial treatment of fabrics were prepared by mixing various levels of the following components: (1) Silver Chloride/Gelatin emulsion from Example 1 in water (Silver Index ≈ 1.693 kg/mol Ag, Gelatin Level ≈ 20 g/mol Ag), (2) Additional gelatin not used in the AgCl precipitation, (3) De-ionized water. Additionally, a solution of aluminum potassium sulfate dodecahydrate (Alum) was added to crosslink the hydrophilic gelatin. Table 5 below shows the approximate percentage by weight of each component in each sample.

Table 5: Percentage of Components .

Sample	Weight % AgCl	Weight % gelatin	Weight % Alum	Wt % Water
Fabric only	0	0	0	100
26-1	0.0075	0.6	0.01	99.3
26-2	0.0075	0.6	0.03	99.3
26-3	0.0075	0.6	0.05	99.3

Just prior to the fabric treatment with the antimicrobial composition the Alum crosslinker was added to each sample. A strip of 100% polyester fabric (100% Dacron Type 54) was immersed in each sample for about 5 seconds. The immersed fabric strips were then removed and passed through a nip/roll. The resulting fabric strips were then heated to 150 °C for 10 minutes.

The treated fabrics listed above were washed according to the procedure described above that was adapted from ISO 6330:2000 and the test for antimicrobial activity according to the method described above adapted from AATCC 100 and NYS proposal. The survival scores for these samples are as follows in Table 6:

Table 6: Survival scores after Washing

	0 Wash	**10 Wash**	**20 wash**	**30 wash**
Fabric only	100 %	100 %	100 %	100 %
26-1A	<0.1 %	<0.1 %	<0.1 %	0.6 %
26-2A	<0.1 %	<0.1 %	<0.1 %	0.1%
26-3A	<0.1 %	<0.1 %	0.2 %	0.1 %

All treated fabrics showed excellent antimicrobial activity after 30 washes.

CLAIMS:

1. A composition comprising at least 50 % water, silver halide particles and a hydrophilic polymer, wherein the composition does not substantially gel or solidify at 25 degrees C; is substantially free of organic solvents; and exhibits antimicrobial activity upon drying.

2. The composition of claim 1 wherein the hydrophilic polymer is gelatin.

3. The composition of claim 2 wherein the weight percentage of gelatin is less than 3 percent.

4. The composition of claim 2 wherein the weight percentage of gelatin is less than 2 percent.

5. The composition of claim 2 wherein the weight percentage of gelatin is less than 1 percent.

6. The composition of claim 1 wherein the silver halide particles are predominantly silver chloride

7. The composition of claim 1 wherein the amount of silver halide is 0.0000001 to 10.0 % by weight.

8. The composition of claim 1 wherein the amount of silver halide is 0.0001 to 1.0 %

9. The composition of claim 1 wherein the amount of silver halide is 0.001 to 0.5 %

10. The composition of claim 2 wherein the silver halide particles are predominantly silver chloride

11. The composition of claim 2 wherein the amount of silver halide is 0.0000001 to 10.0 % by weight.

12. The composition of claim 2 wherein the amount of silver halide is 0.0001 to 1.0 %

13. The composition of claim 2 wherein the amount of silver halide is 0.001 to 0.5 %

14. The composition of claim 1 wherein the silver particles are less than 1 micron in diameter.

15. The composition of claim 2 wherein the silver particles have a mean equivalent circular diameter of less than 1 micron.

16. The composition of claim 1 further comprising a wetting agent

17. The composition of claim 2 further comprising a wetting agent

18. The composition of claim 1 further comprising an agent to prevent latent image formation.

19. The composition of claim 2 further comprising an agent to prevent latent image formation.

20. The composition of claim 1 further comprising a hydrophobic binder.

21. The composition of claim 2 further comprising a hydrophobic binder..

22. The composition of claim 20 wherein the hydrophobic binder is contained an in amount of less than 10 % by weight of the composition.

23. The composition of claim 21 wherein the hydrophobic binder is contained an in amount of less than 10 % by weight of the composition.

24. The composition of claim 20 wherein the hydrophobic binder is an acrylic, styrene-butadiene, polyurethane, polyester, polyvinyl acetate, polyvinyl acetal, vinyl chloride or vinylidine chloride polymer, including copolymers thereof.

25. The composition of claim 21 wherein the hydrophobic binder is an acrylic, styrene-butadiene, polyurethane, polyester, polyvinyl acetate, polyvinyl acetal, vinyl chloride or vinylidine chloride polymer, including copolymers thereof.

26. The composition of claim 2 further comprising a crosslinker for the gelatin.

27. The composition of claim 1 comprising at least 70 % water.

28. A composition comprising at least two separately packaged parts, the first part being a composition comprising at least 50 % water, silver halide particles and a hydrophilic polymer, wherein the composition does not substantially gel or solidify at 25 degrees C and substantially does not contain an organic solvent; and the second part being a composition comprising an aqueous suspension of a hydrophobic binder, or a composition comprising a crosslinker for the hydrophilic polymer.

29. The composition of claim 28 wherein the hydrophilic polymer is gelatin.

30. The composition of claim 29 wherein the weight percentage of gelatin is less than 3 percent.

31. The composition of claim 29 wherein the weight percentage of gelatin is less than 2 percent.

32. The composition of claim 29 wherein the weight percentage of gelatin is less than 1 percent.

33. The composition of claim 28 wherein the silver halide particles are predominantly silver chloride

34. The composition of claim 28 wherein the amount of silver halide is 0.0000001 to 10.0 % by weight.

35. The composition of claim 28 wherein the amount of silver halide is 0.0001 to 1.0 % by weight.

36. The composition of claim 28 wherein the amount of silver halide is 0.001 to 0.5 % by weight.

37. The composition of claim 29 wherein the silver halide particles are predominantly silver chloride

38. The composition of claim 28 wherein the silver particles are less than 1 micron in diameter.

39. The composition of claim 28 wherein the hydrophobic binder is an acrylic, styrene-butadiene, polyurethane, polyester, polyvinyl acetate,

polyvinyl acetal, vinyl chloride or vinylidine chloride polymer, including copolymers thereof.

40. The composition of claim 28 wherein the first part and the second part comprise at least 70 % water.

41. A method of coating a fabric or fiber comprising providing a composition comprising at least two separately packaged parts, the first part being a composition comprising at least 50 % water, silver halide particles and a hydrophilic polymer, wherein the composition does not substantially gel or solidify at 25 degrees C and substantially does not contain an organic solvent; and the second part comprising an aqueous suspension of a hydrophobic binder, or a composition comprising a crosslinker for the hydrophilic polymer; mixing the two separately packaged parts; and coating the mixture on the fabric or fiber.

42. The method of claim 41 wherein the hydrophilic polymer is gelatin.

43. A method of coating a fiber or fabric comprising providing a composition comprising at least 50 % water, silver halide particles, a hydrophilic polymer, and a hydrophobic binder, or a crosslinker for the hydrophilic polymer, wherein the composition does not substantially gel or solidify at 25 degrees C and substantially does not contain an organic solvent; providing a fiber or fabric; and coating said fiber or fabric with said composition.

44. The method of claim 43 wherein the hydrophilic polymer is gelatin.

45. A fabric or fiber having coated thereon an antimicrobial composition comprising silver chloride particles and gelatin.

46. The fabric or fiber of claim 45 wherein the composition further comprises a hydrophobic binder or a crosslinker for the gelatin.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2005/034473

A. CLASSIFICATION OF SUBJECT MATTER
A61K47/42 A61K47/32 A01N59/16

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

B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61K A01N

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, EMBASE, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X	EP 0 911 297 A (KING, JOSEPH A) 28 April 1999 (1999-04-28) paragraph '0007! example 1 claims 1,3	1-46
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X	US 3 265 638 A (GOODMAN ROBERT M ET AL) 9 August 1966 (1966-08-09) column 2, line 62 - line 65 example 1	1-40

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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