

DURABLE ANTIMICROBIAL COMPOSITION

FIELD OF THE INVENTION

The present invention relates to compositions having durable antibacterial activity. The compositions include a carbonate/bicarbonate salt of a quaternary ammonium cation, an organic acid, hydrogen peroxide and a cationic polymer. The cationic polymer includes a (3-acrylamidopropyl)trimethylammonium chloride monomer or a [2-(acryloyloxy)ethyl]trimethylammonium chloride monomer combined with another monomer selected from a polar, water-soluble monomer, a hydrophobic, silicone-containing monomer and mixtures of such monomers.

10 BACKGROUND OF THE INVENTION

In order to protect health and maintain hygiene, a variety of environments require controlled and limited microbial growth. Such environments include temporary and permanent healthcare facilities, caregiver facilities (e.g. daycares, nursing homes, etc.) and households. When growth of potentially harmful microbes is not controlled/limited in these environments, the risk of infection and spread of disease increases. Infection and disease may compromise the health and safety of humans and/or animals occupying these environments. While potentially not as sensitive as the above-identified environments, workplace and public environments may also be negatively impacted by uncontrolled/unlimited growth of disease-causing microbes.

Some types of microorganisms (bacteria, viruses, fungi, etc.) are capable of negatively impacting the health and/or safety of living organisms. Such microorganisms can be transmitted by contact with surfaces on which the microorganisms are present and/or multiplying and by contact between humans/animals already infected with particular microorganisms. When such microorganisms spread and infect new "hosts", the "host" can either go from an otherwise healthy state to a state of illness or from a "compromised" state (i.e. a state of pre-existing illness or a weak immune system) to a more serious/severe state. The public health impact of the undesired spread of microorganisms is

significant as reflected by time out of school, time away from work (either for self or to care for others not able to care for themselves), additional time for which professional health care is needed, etc. Therefore, it is desirable to be able to prevent or inhibit microbial presence/growth on targeted surfaces. The presence
5 of microorganisms can be eliminated/controlled using surface treatments that may be applied directly (as from a spray bottle) and by using wipes or other carriers that include the surface treatment. Further, it is desirable that such surface treatments have durability and persistence so that they do not need to be re-applied on a frequent basis.

10 There are many detergent, disinfectant, cleaning and antimicrobial compositions known in the art for killing and preventing growth of microorganisms. Those compositions include components/ingredients that are well-known for antimicrobial functionality. For example, quaternary ammonium compounds are considered "broad spectrum" antimicrobial cationic compounds that are effective
15 against both Gram positive (e.g. *Staphylococcus* species) and Gram negative (e.g. *Escherichia coli*) microorganisms. Other components/ingredients that may be incorporated into products for removing/reducing microorganisms on surfaces include alcohols, acids and bleaching agents, such as hydrogen peroxide. Not all of the antimicrobial components can be used at the same time because some of
20 them form unstable combinations.

Disinfecting and cleaning compositions that provide antimicrobial activity over a period of time are also known in the art. For example, U.S. Patent No. 6,270,754 issued to Zhou et al. and entitled "Antimicrobial Cleaning Composition" (hereinafter "the '754 patent") is directed to an antibacterial cleaning composition that exhibits
25 germicidal activity for sustained periods of time. The '754 patent discloses an aqueous cleaning composition that includes a quaternary ammonium compound, an anionic polymer (where the anionic polymer has an acid number greater than 10 and the anionic polymer is partially or completely neutralized by the quaternary ammonium compound to form a polymer complex), a dispersing agent and/or a
30 water-miscible solvent. The aqueous cleaning composition of the '754 patent has antibacterial activity against both Gram positive and Gram negative bacteria.

However, the components of the '754 patent may not be effective against a broader range of microorganisms, such as non-enveloped viruses.

In addition to the composition of the '754 patent, there are compositions known in the art that are effective against a broad spectrum of microorganisms and continue to have activity for a period of time. For example, U.S. Patent No. 7,598,214 issued to Cusack et al. and entitled "Disinfecting Compositions Containing A Polymer Complex Of an Organic Acid" (hereinafter "the '214 patent") is directed to compositions that include at least one organic acid and at least one polymer capable of forming a complex with the at least one organic acid. The compositions of the '214 patent may also optionally include an anionic surfactant and an organic solvent. The organic acid may be citric acid and examples of suitable polymers include vinylpyrrolidinone/dimethylaminoethylmethacrylate copolymer, vinylpyrrolidinone/vinylacetate copolymers, vinylpyrrolidinone/vinylcaprolactum/ammonium derivative terpolymers and polyvinylpyrrolidinone. The compositions of the '214 patent need an organic solvent and they are pH sensitive. Because of the acid-based reaction between the polymer having a tertiary amine functionality and the organic acid, the compositions are not effective in higher pH environments. In a higher pH environment, the reaction would reverse and the polymer would be rendered ineffective because it would be neutral. Though the compositions of the '214 patent are effective against a broader spectrum of microorganisms, the compositions may not be effective against the spore-form of all microorganisms because the compositions cannot penetrate through the outer wall of the spores.

While many antimicrobial compositions are known and while some of those compositions maintain their antimicrobial activity over a period of time, there remains a need in the art for a durable antimicrobial composition that is effective against a broad range of microorganisms, including the spore-form of potentially harmful microorganisms. Additionally, there remains a need for a durable antimicrobial composition that is stable (i.e. is not reactive) so that it is not unnecessarily harsh (causing wear or corrosion) on the surfaces on which it is used. Further, there remains a need for a durable antimicrobial composition that does not require a volatile solvent that may have an unpleasant smell.

SUMMARY OF THE INVENTION

The present invention relates to durable antimicrobial compositions that are effective against a broad range of potentially harmful microorganisms and that do not have to be reapplied on a frequent basis to the surfaces on which controlled microbial growth is desired. The compositions of the invention are effective against a broad range of microorganisms, including the spore-form of microorganisms, because of the composition components, which are unexpectedly stable in combination with each other. Additionally, the compositions of the invention do not need to contain a volatile solvent that could make the compositions unpleasant to use.

In one aspect, the compositions of the invention have durable antimicrobial activity and include a carbonate/bicarbonate salt of a quaternary ammonium cation, an organic acid, hydrogen peroxide and a cationic polymer. The cationic polymer includes a (3-acrylamidopropyl)trimethylammonium chloride monomer combined with another monomer selected from a polar, water-soluble monomer, a hydrophobic, silicone-containing monomer and mixtures of such monomers. The polar, water-soluble monomer may be selected from vinyl pyrrolidinone, hydroxyl ethyl acrylate, hydroxyl ethyl methacrylate, N,N'-dimethyl acrylamide, acrylamide and N-isopropyl acrylamide. The hydrophobic, silicone-containing monomer may be selected from unsubstituted or substituted vinyl or ethynyl group terminated siloxyl compounds, comprising monomethacryloxypropyl terminated polydimethylsiloxane, methacryloxypropyl tris(trimethylsiloxysilane) and methacryloxypropyl terminated T-structure siloxane. As described herein, the compositions have a durable or persistent activity to kill and prevent the growth of potentially-harmful microorganisms. The durability of the compositions is indicated by the compositions retaining antimicrobial activity after twenty-five insults of *E. coli* organisms as measured by a log 2 reduction in organisms upon the twenty-fifth insult of 10^6 total organisms. The compositions of the invention are stable; the stability of the compositions is reflected by the compositions maintaining their efficacy during shelf-life studies. For example, the compositions remain effective (meaning, they have the same level of durability to effect a log 2 reduction in organisms after twenty-five insults of 10^6 organisms) after storage for three months

at 40°C; further, the compositions remain effective after storage for one month at 50°C, nine months at 25°C and after three freeze-thaw cycles. The compositions are liquid at room temperature and can be applied directly to a surface for which it is desired to prevent or inhibit microbial growth. The compositions may be applied using a spray bottle or other known structure for dispensing liquids. Alternatively, the compositions may be applied to a surface by transfer from a basesheet, such as a wiper, into which a representative composition has been incorporated. The basesheet may be made of a nonwoven material or of a cellulosic material. More particularly, the composition may include from 0.2% by weight to 15.0% by weight of the carbonate/bicarbonate salt of a quaternary ammonium cation. The composition may include from 0.1% by weight to 3.0% by weight of the organic acid, which may be selected from citric, malic, maleic, oxalic, glutaric, succinic, lactic, glycolic, fumaric, acetic, benzoic, propionic, sorbic, tartaric, formic and mixtures of such organic acids. The composition may include from 0.5% by weight to 5.0% by weight of hydrogen peroxide and the composition may include from 0.5% by weight to 10% by weight of cationic polymer. Even more particularly, the cationic polymer may include from 0.70 to 0.90 mole fraction of (3-acrylamidopropyl)trimethylammonium chloride monomer.

In another aspect, the compositions of the invention have durable antimicrobial activity and include a carbonate/bicarbonate salt of a quaternary ammonium cation, an organic acid, hydrogen peroxide and a cationic polymer. The cationic polymer includes a [2-acryloyloxy)ethyl]trimethylammonium chloride monomer combined with another monomer selected from a polar, water-soluble monomer, a hydrophobic, silicone-containing monomer and mixtures of such monomers. The polar, water-soluble monomer may be selected from vinyl pyrrolidinone, hydroxyl ethyl acrylate, hydroxyl ethyl methacrylate, N,N'-dimethyl acrylamide, acrylamide and N-isopropyl acrylamide. The hydrophobic, silicone-containing monomer may be selected from unsubstituted or substituted vinyl or ethynyl group terminated siloxyl compounds, comprising monomethacryloxypropyl terminated polydimethylsiloxane, methacryloxypropyl tris(trimethylsiloxysilane) and methacryloxypropyl terminated T-structure siloxane. As described herein, the compositions have a durable or persistent activity to kill and prevent the growth of potentially-harmful microorganisms. The durability of the compositions is indicated

by the compositions retaining antimicrobial activity after twenty-five insults of *E. coli* organisms as measured by a log 2 reduction in organisms upon the twenty-fifth insult of 10^6 total organisms. The compositions of the invention are stable; the stability of the compositions is reflected by the compositions maintaining their efficacy during shelf-life studies. For example, the compositions remain effective (meaning, they have the same level of durability to effect a log 2 reduction in organisms after twenty-five insults of 10^6 organisms) after storage for three months at 40°C; further, the compositions remain effective after storage for one month at 50°C, nine months at 25°C and after three freeze-thaw cycles. The compositions are liquid at room temperature and can be applied directly to a surface for which it is desired to prevent or inhibit microbial growth. The compositions may be applied using a spray bottle or other known structure for dispensing liquids. Alternatively, the compositions may be applied to a surface by transfer from a basesheet, such as a wiper, into which a representative composition has been incorporated. The basesheet may be made of a nonwoven material or of a cellulosic material. More particularly, the composition may include from 0.2% by weight to 15.0% by weight of the carbonate/bicarbonate salt of a quaternary ammonium cation. The composition may include from 0.1% by weight to 3.0% by weight of the organic acid, which may be selected from citric, malic, maleic, oxalic, glutaric, succinic, lactic, glycolic, fumaric, acetic, benzoic, propionic, sorbic, tartaric, formic and mixtures of such organic acids. The composition may include from 0.5% by weight to 5.0% by weight of hydrogen peroxide and the composition may include from 0.5% by weight to 10% by weight of cationic polymer. Even more particularly, the cationic polymer may include from 0.70 to 0.90 mole fraction of [2-(acryloyloxy)ethyl]trimethylammonium chloride monomer.

In another aspect, the present invention relates to a method of inhibiting the growth of microorganisms on a surface. The method may be practiced to inhibit the growth of targeted microorganisms or to indiscriminately inhibit the growth of microorganisms. The surface may be any material capable of supporting the growth of microorganisms. The surface may be part of a relatively durable object or part of a disposable object. The surface may be hard, such as a countertop, tabletop, doorknob, telephone, keyboard or light switch; alternatively, the surface may be soft, such as a fabric surface (e.g. curtains, pillows, upholstery,

bedspreads, etc.). The method includes a step of providing a composition; the composition includes a carbonate/bicarbonate salt of a quaternary ammonium cation, an organic acid, hydrogen peroxide and a cationic polymer. The cationic polymer includes either a (3-acrylamidopropyl)trimethylammonium chloride monomer or a [2-(acryloyloxy)ethyl]trimethylammonium chloride monomer. The cationic polymer also includes another monomer selected from a polar, water-soluble monomer, a hydrophobic, silicone-containing monomer or mixtures of both types of monomers in combination with one of the trimethylammonium chloride monomers. The method also includes a step of applying the composition to the surface in an amount to substantially cover the surface. Further, the method includes a step of re-applying the composition to the surface after 48 hours. The composition is re-applied after 48 hours to maintain the desired antimicrobial activity. Alternatively, the composition may be re-applied to the surface after 24 hours. The antimicrobial activity is indicated by antimicrobial activity persisting after twenty-five insults of *E. coli* as measured by a log 2 reduction in organisms upon the twenty-fifth insult of 10^6 total organisms.

These aspects and additional aspects of the invention will be described in greater detail herein. Further, it is to be understood that both the foregoing general description and the following detailed description are exemplary and are intended to provide further explanation of the invention claimed.

DETAILED DESCRIPTION OF THE INVENTION

The present disclosure of the invention will be expressed in terms of its various components, elements, constructions, configurations, arrangements and other features that may also be individually or collectively be referenced by the term, "aspect(s)" of the invention, or other similar terms. It is contemplated that the various forms of the disclosed invention may incorporate one or more of its various features and aspects, and that such features and aspects may be employed in any desired, operative combination thereof.

It should also be noted that, when employed in the present disclosure, the terms "comprises", "comprising" and other derivatives from the root term "comprise" are intended to be open-ended terms that specify the presence of any

stated features, elements, integers, steps, or components, and are not intended to preclude the presence or addition of one or more other features, elements, integers, steps, components, or groups thereof.

The present invention relates to compositions having durable antimicrobial activity. The compositions may be used to kill or to inhibit the growth of microorganisms that are potentially harmful or capable of causing disease. The compositions of the invention do not need to contain a volatile solvent and therefore, do not generate an unpleasant smell when used. The compositions are effective at killing and/or inhibiting growth of a broad range of microorganisms. For example, the compositions are effective against both Gram positive and Gram negative bacteria. Additionally, the compositions are effective against viruses, fungi, mildew and mold. Further, the compositions are effective against bacteria that form spores, bacteria with waxy outer layers, fungi that form spores (fungal spores) and enveloped and non-enveloped viruses. Without wishing to be bound by theory, it is believed that the composition is capable of breaking down the waxy outer layer of a bacteria or outer layer of a spore so that the composition can penetrate into the microorganism beyond the outer layer.

The compositions of the invention may be used to control microbial growth on a variety of surfaces, including relatively durable objects having both hard and soft surfaces; for example, appropriate surfaces may include door knobs, light switches, countertops, sinks, wash basins, telephones, keyboards, remote controls, medical instruments, upholstery, curtains, bedspreads, towels and shoes. The compositions may be applied to the targeted surface either directly, in liquid form, such as by a spray bottle or similar packaging capable of delivering a liquid composition in a relatively uniform amount over the full surface to be covered. Alternatively, the compositions may be applied to the targeted surface by a carrier, such as a basesheet (i.e. a "wet" wipe or wiper). Because the compositions are liquid at room temperature, the composition may be applied to a surface by wiping the surface with a basesheet that has been saturated with the composition; the composition will transfer from the basesheet to the surface. The basesheet may be formed from one or more woven materials, nonwoven materials, cellulosic materials and combinations of such materials. More specifically, the basesheet

may be formed of nonwoven fibrous sheet materials that include meltblown, spunlace, coform, air-laid, bonded-carded web materials, hydroentangled materials and combinations of such materials. Such materials can be made of synthetic or natural fibers or a combination of such fibers. Typically, the basesheet will have a basis weight of from 25 grams per square meter to 120 grams per square meter and desirably from 40 grams per square meter to 90 grams per square meter.

The basesheet may be constructed of a coform material of polymer fibers and absorbent fibers having a basis weight of from 45 to 80 grams per square meter and desirably 60 grams per square meter. Typically, such coform basesheets are constructed of a gas-formed matrix of thermoplastic polymeric meltblown fibers and cellulosic fibers. Various suitable materials may be used to provide the polymeric meltblown fibers, such as, for example, polypropylene microfibers. Alternatively, the polymeric meltblown fibers may be elastomeric polymer fibers, such as those provided by a polymer resin. For instance, VISTAMAXX elastic olefin copolymer resin designated PLTD-1810, available from ExxonMobil Corporation of Houston, TX, or KRATON G-2755, available from Kraton Polymers of Houston, TX, may be used to provide stretchable polymeric meltblown fibers for the coform basesheets. Other suitable polymeric materials or combinations thereof may alternatively be utilized as known in the art.

The coform basesheet additionally may be constructed of various absorbent cellulosic fibers, such as, for example, wood pulp fibers. Suitable commercially available cellulosic fibers for use in the coform basesheets can include, for example, NF 405, which is a chemically treated bleached southern softwood Kraft pulp, available from Weyerhaeuser Co. of Washington, DC; NB 416, which is a bleached southern softwood Kraft pulp, available from Weyerhaeuser Co.; CR-0056, which is a fully debonded softwood pulp, available from Bowater, Inc. of Greenville, SC; Golden Isles 4822 debonded softwood pulp, available from Koch Cellulose of Brunswick, GA; and SULPHATATE HJ, which is a chemically modified hardwood pulp, available from Rayonier, Inc. of Jessup, GA. The relative percentages of the polymeric meltblown fibers and cellulosic fibers in the coform basesheet may vary over a wide range depending upon the desired characteristics of the wipes. For example, the coform basesheet may have from 10 weight percent to 90 weight percent, desirably from 20 weight percent to 60 weight

percent, and more desirably from 25 weight percent to 35 weight percent of polymeric meltblown fibers based on the dry weight of the coform basesheet.

The compositions of the invention may be incorporated into the basesheet in an add-on amount of from 50% (by weight of the basesheet) to 800% (by weight of the basesheet). More specifically, the compositions may be incorporated into the basesheet in an add-on amount of from 200% (by weight of the basesheet) to 600% (by weight of the basesheet) or from 400% (by weight of the basesheet) to 600% (by weight of the basesheet). The composition add-on amounts may vary depending on the composition of the basesheet.

The present invention relates to compositions having durable antimicrobial activity. The "durability" or "persistence" of antimicrobial activity is descriptive of a benefit provided by the compositions of the invention. From a cost and efficiency standpoint, it is desirable to maintain antimicrobial activity on a surface over a period of time with one application of a composition rather than having to frequently apply a composition because its antimicrobial activity rapidly dissipates. From a public health standpoint, a durable antimicrobial composition is desirable because such a composition is more likely to prevent microbial growth than a composition that is weaker to begin with and a durable antimicrobial composition introduces less liquid/material into the environment, thereby decreasing the opportunity for microbes to develop resistance. The durability of the compositions of the invention is measured by activity after twenty-five (25) insults with a representative Gram negative bacterium, *Escherichia coli* (*E. coli*). The compositions of the invention retain activity sufficient to cause a log 2 reduction upon the twenty-fifth insult of 10^6 total *E. coli* organisms. Additionally, the durability of the compositions of the invention is measured by ability to effect > log 2 reduction against Gram positive bacteria, Gram negative bacteria, enveloped viruses, non-enveloped viruses, fungi, mildew and mold twenty-four (24) hours after application of the composition to a surface. Further, the durability of the compositions of the invention is measured by ability to effect > log 2 reduction in microorganisms in the presence of soil after either of the first two assays described above (i.e. (1) 25th insult of 10^6 total organisms; or (2) twenty-four hours after application). From a practical standpoint, a standard surface, such as a countertop, table, telephone, etc., in a susceptible environment, such as a hospital

or daycare facility, is continuously exposed to potentially harmful microorganisms. Given the rate at which exposure to new microorganisms typically occurs, a durable antimicrobial composition may be applied to the surface in a timeframe of every 24 hours to 48 hours in order to kill and/or to prevent the growth of microorganisms. Comparatively, an antimicrobial composition that is not durable would need to be applied continuously to a surface to maintain a comparable level of antimicrobial activity. In a less susceptible environment and with a less susceptible surface, such as draperies in a home, the durable antimicrobial composition may last up to seven days at full activity.

10 The compositions of the invention include a carbonate/bicarbonate salt of a quaternary ammonium cation. Quaternary ammonium compounds are generally considered "broad spectrum" antimicrobial cationic compounds that have efficacy against both Gram positive and Gram negative microorganisms. The carbonate/bicarbonate salts of quaternary ammonium cations may be selected from dioctyldimethylammonium carbonate, decyloctyldimethylammonium carbonate, didecyldimethylammonium carbonate, benzalkonium carbonate, benzethonium carbonate, stearylalkonium carbonate, cetrimonium carbonate, behentrimonium carbonate, dioctyldimethylammonium bicarbonate, decyloctyldimethylammonium bicarbonate, didecyldimethylammonium bicarbonate, benzalkonium bicarbonate, benzethonium bicarbonate, stearylalkonium bicarbonate, cetrimonium bicarbonate, behentrimonium bicarbonate and mixtures of one or more such carbonate salts. The compositions of the invention may include from 0.2% by weight to 15.0% by weight of one or more carbonate/bicarbonate salts of quaternary ammonium cations. Alternatively, the compositions of the invention may include a chloride salt such as benzalkonium chloride, benzethonium chloride, cetrimonium chloride, stearylalkonium chloride and behentrimonium chloride.

 The compositions of the invention also include an organic acid. Organic acids are also known to have efficacy against the growth of microorganisms. The organic acid may be selected from citric, malic, maleic, oxalic, glutaric, succinic, lactic, glycolic, fumaric, acetic, benzoic, propionic, sorbic, tartaric, formic and mixtures of one or more such organic acids. The compositions of the invention may include from 0.1% by weight to 3.0% by weight of one or more organic acids.

Additionally, the compositions of the invention include hydrogen peroxide. The hydrogen peroxide is stable in the compositions of the invention, despite the presence of the carbonate/bicarbonate salt. Existing antimicrobial compositions do not contain stabilized hydrogen peroxide in combination with a

5 carbonate/bicarbonate salt. The stability of the hydrogen peroxide is measured by the compositions of the invention maintaining their initial concentration and efficacy during shelf-life studies. For example, the compositions remain effective (meaning, they have the same level of durability to effect a log 2 reduction in organisms after twenty-five insults of 10^6 organisms) after storage for three months

10 at 40°C; further, the compositions remain effective after storage for one month at 50°C, nine months at 25°C and after three freeze-thaw cycles. While not wishing to be bound by theory, it is believed that the ability to provide compositions with stabilized hydrogen peroxide significantly expands the range of microorganisms that the compositions of the invention are effective against. Some microorganisms

15 exist or are spread in spore form, where the spores have an outer layer; the outer layer presents a barrier to penetration by some conventional antimicrobial compositions. It is believed that the stabilized hydrogen peroxide in the compositions of the invention is capable of penetrating the outer layer of spores, thereby facilitating exposure of the spore interior to the carbonate/bicarbonate salt

20 of a quaternary ammonium cation. The carbonate/bicarbonate salt of a quaternary ammonium cation prevents future germination or development of the spore. The compositions of the invention may include from 0.5% by weight to 5.0% by weight of hydrogen peroxide.

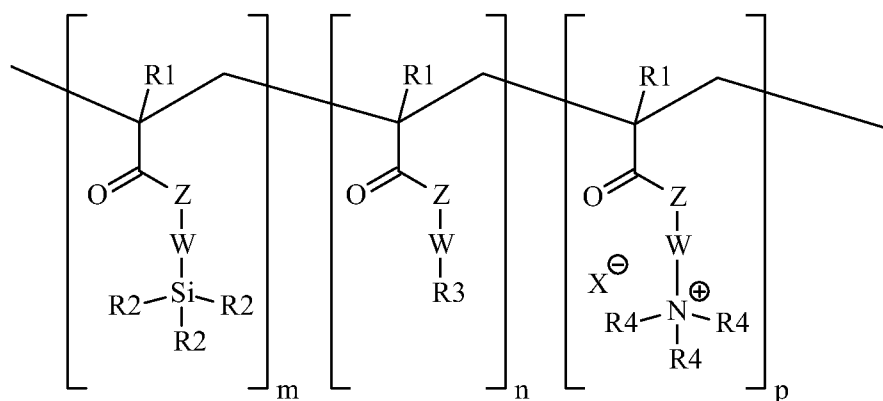
The stability of the compositions of the invention is also measurable by the

25 ongoing/sustained detectable concentration of the carbonate/bicarbonate salt of a quaternary ammonium cation, organic acid and hydrogen peroxide components of the compositions. The carbonate/bicarbonate salt of a quaternary ammonium cation component may be detected using high pressure liquid chromatography (HPLC) with an evaporative light-scattering (ELS) detector. The mobile phase for

30 the HPLC is an acidic mixture of acetonitrile and water. The organic acid component may be detected using HPLC with an ultra-violet (UV) absorption detector monitoring the 220 nanometer wavelength. The mobile phase for the HPLC for the detection of the organic acid is also an acidic mixture of acetonitrile

and water. The hydrogen peroxide component may be detected by titrating the sample with a solution of ceric sulfate and ferroin indicator as described in the journal article, Frank P. Greenspan and Donald G. MacKellar entitled "Analysis of Aliphatic Per Acids" published in *Analytical Chemistry*, 1948, 20, 1061. The compositions of the invention have a sustained and detectable presence of these components after experiencing the accelerated shelf-life conditions described herein.

The durability of the hydrogen peroxide in the presence of the carbonate/bicarbonate salt is provided by novel cationic polymers that are components of the compositions of the invention. The cationic polymers have the following structure:



With respect to this structure, R1 may be independently selected from H (hydrogen) or methyl (CH₃); R2 may be independently selected from H (hydrogen), halide (fluoride, chloride, bromide, iodide), C1 through C6 alkyl or alkoxy, aryl, linear or branched oligomeric or polymeric dimethyl siloxane; R3 may be independently selected from hydroxyl, alkyl amine, dialkyl amine or polyether; R4 may be independently selected from H (hydrogen), C1 through C6 alkyl, or benzyl; Z may be independently selected from O (oxygen) or NH; W may be independently selected from C1 through C6 alkyl; and X may be independently selected from fluoride, chloride, bromide, iodide, methosulfate or ethosulfate. Alternatively, the monomer represented by subscript "n" may be a vinyl pyrrolidinone. The values of m, n and p may be the same or they may be different. The values of m, n and p are integers and are selected to make the number average molecular weight in the range of 1000 to 100,000 g/mol.

In one aspect, the compositions of the invention include a cationic polymer that includes a (3-acrylamidopropyl)trimethylammonium chloride monomer combined with another monomer selected from a polar, water-soluble monomer, a hydrophobic, silicone-containing monomer and mixtures of one or more polar, water-soluble monomers and hydrophobic, silicone-containing monomers. The polar, water-soluble monomer may be selected from vinyl pyrrolidinone, hydroxyl ethyl acrylate, hydroxyl ethyl methacrylate, N,N'-dimethyl acrylamide, acrylamide, N-isopropyl acrylamide and mixtures of one or more such polar water-soluble monomers. The hydrophobic, silicone-containing monomer may be selected from unsubstituted or substituted vinyl or ethynyl group terminated siloxyl compounds, comprising monomethacryloxypropyl terminated polydimethylsiloxane (commercially available from Gelest, Inc. as product "MCR-M11"), methacryloxypropyl tris(trimethylsiloxysilane), methacryloxypropyl terminated T-structure siloxane (commercially available from Gelest, Inc. as product "RTT-1011") and mixtures of one or more such hydrophobic, silicone-containing monomers. The compositions of the invention may include from 0.5% by weight to 10% by weight of cationic polymer. Additionally, the cationic polymer may include from 0.70 to 0.90 mole fraction of (3-acrylamidopropyl)trimethylammonium chloride monomer.

In another aspect, the compositions of the invention include a cationic polymer that includes a [2-(acryloyloxy)ethyl]trimethylammonium chloride monomer combined with another monomer selected from a polar, water-soluble monomer, a hydrophobic, silicone-containing monomer and mixtures of one or more polar, water-soluble monomers and hydrophobic, silicone-containing monomers. The polar, water-soluble monomer may be selected from vinyl pyrrolidinone, hydroxyl ethyl acrylate, hydroxyl ethyl methacrylate, N,N'-dimethyl acrylamide, acrylamide, N-isopropyl acrylamide and mixtures of one or more such polar, water-soluble monomers. The hydrophobic, silicone-containing monomer may be selected from unsubstituted or substituted vinyl or ethynyl group terminated siloxyl compounds, comprising monomethacryloxypropyl terminated polydimethylsiloxane (commercially available from Gelest, Inc. as "MCR-M11"), methacryloxypropyl tris(trimethylsiloxysilane), methacryloxypropyl terminated T-structure siloxane (commercially available from Gelest, Inc. as product "RTT-

1011”) and mixtures of one or more such hydrophobic, silicone-containing monomers. The compositions of the invention may include from 0.5% by weight to 10% by weight of cationic polymer. Additionally, the cationic polymer may include from 0.70 to 0.90 mole fraction of [2-(acryloyloxy)ethyl]trimethylammonium chloride monomer.

The cationic polymers may be synthesized using a typical acrylate copolymer synthesis. For example, in a typical procedure, methacryloyloxypropyl tris(trimethylsiloxy)silane (0.2g, 0.574mmol), (3-acrylamidopropyl)trimethylammonium chloride solution (75wt% in water, 1.86g, 6.77mmol), hydroxyethyl acrylate (0.4g, 3.44mmol), isopropanol (10ml), and azobisisobutyronitrile (AIBN) solution (5wt% in THF, 0.015mol/L, 0.98ml) are added to a 20ml vial inside a glove box under nitrogen atmosphere. The reagents are degassed by bubbling nitrogen through the solutions for 20 to 30 minutes at room temperature prior to entering the glove box. The reaction mixture may then be heated to 60°C for 18 hours under magnetic agitation. After the reaction is complete, the polymer solution is approximately 20 wt%. The polymer may then be used without further purification. This exemplary procedure for synthesizing the cationic polymer is adapted from the synthetic procedures described in the journal article by Charles L. McCormick and Andrew B. Lowe entitled “Aqueous RAFT polymerization: recent developments in synthesis of functional water-soluble (co)polymers with controlled structure” *Accounts of Chemical Research*, **2004**, 37, 312-325 and the journal article by Yulia A. Vasilieva, David B. Thomas, Charles W. Scales, and Charles L. McCormick entitled “Direct controlled polymerization of a cationic methacrylamido monomer in aqueous media via the RAFT process” *Macromolecules*, **2004**, 37, 2728-2737.

In addition to the components described herein, the compositions of the invention may also include a polar carrier solvent, pH adjuster, fragrance, preservative, dye, corrosion inhibitor, builder, compatible surfactant, cleansing solvent and other components known to be useful in antimicrobial compositions. The compositions of the invention may include from 67% by weight to 98% by weight of one or more of these other components.

While other blending methods may be used, an example of one method of blending the compositions of the invention is as follows: (1) Add water to vessel for mixing of the components of the compositions; (2) Slowly add the carbonate/bicarbonate salt of the quaternary ammonium cation component to the vessel; (3) Slowly add the organic acid component to the vessel and begin mixing at low revolutions per minute (RPM) (i.e. 150-250 RPM); (4) Continue mixing until any foam that is present dissipates (e.g. up to 10 minutes for a 1 liter batch); (5) If desired for additional stability when the final composition is applied to a surface, add a stabilizer such as urea and continue mixing at low RPM (e.g. add 0.4% by weight of urea if adding 3.0% by weight hydrogen peroxide); (6) Slowly add hydrogen peroxide to the vessel and continue mixing at low RPM; (7) Slowly add the cationic polymer component to the vessel and continue mixing at low RPM; (8) If desired for solution clarity, an appropriate organic solvent (e.g. ethanol, isopropanol, ethylene glycol, propylene glycol, butylene glycol, ethylene glycol monobutyl ether, etc.) may slowly be added to the vessel; and (9) If necessary, adjust the pH of the final composition in the vessel to pH 3.0 (+/- 0.25) with a dilute (10-25% by weight) solution of potassium hydroxide. Those of skill in the art will appreciate that there are other methods by which the components of the compositions of the invention may be blended. However, it is an aspect of the present invention that the carbonate/bicarbonate salt of the quaternary ammonium cation is neutralized by the addition of the organic acid in step 3 prior to the addition of the hydrogen peroxide.

Representative examples of the cationic polymers of the compositions of the invention are provided in Table 1 below. Each exemplary cationic polymer described in Table 1 was used in a composition of the invention that included the following components: (1) 2% by weight of CARBOQUAT H solution as available from Lonza Group Limited Switzerland; (2) 0.85% by weight of citric acid; (3) 3% by weight hydrogen peroxide; and (4) 5% by weight of the cationic polymers described in Table 1 below. The compositions also included 0.4% by weight urea and 20% ethanol; the remainder was water. Note, while ethanol was used for purposes of these examples, the ethanol is not needed for the compositions of the invention to have the described efficacy and durability. In fact, before the treated surfaces were insulted as described below, the treated surfaces were allowed to

dry and the ethanol and water would have evaporated. Similarly, while not required, the urea is added to provide enhanced stability of the compositions after application to a surface. Each of these compositions produced at least a log 3 reduction of microorganisms within five minutes after twenty-five, individual insults of 10^6 *E. coli* organisms. The values in Table 1 represent the mole fractions of the individual monomers forming the cationic polymer.

Table 1.

Exempl e	APTEC	AETA C	VP	HEA	DMA	AM	MAPDM S	TRIS	TPDM S
1		0.70- 0.80	0.30- 0.20						
2		0.70- 0.80	0.15- 0.25						0.05- 0.10
3		0.70- 0.80	0.10- 0.20					0.05- 0.10	
4		0.70- 0.80	0.10- 0.20				0.10		
5		0.90	0.05				0.05		
6		0.80- 0.90		0.10- 0.20					
7		0.80- 0.90		0.05- 0.15					0.05- 0.10
8		0.70- 0.90		0.05- 0.20				0.05- 0.10	
9		0.70- 0.90		0.05- 0.25			0.05-0.10		
10		0.90							0.10
11		0.90						0.10	
12	0.70- 0.90			0.10- 0.30					
13	0.70- 0.90			0.05- 0.20			0.05-0.10		
14	0.90				0.05		0.05		
15	0.80- 0.90				0.05- 0.10			0.05- 0.10	
16	0.70- 0.80				0.15- 0.25				0.05- 0.10
17	0.70- 0.90		0.10- 0.30						
18	0.70- 0.90		0.05- 0.25				0.05-0.10		
19	0.80- 0.90		0.05- 0.15					0.05- 0.10	
20	0.70- 0.90					0.10- 0.30			

21	0.80-0.90					0.05-0.15	0.05-0.10		
22	0.70-0.90					0.05-0.25		0.05-0.10	
23	0.70-0.80					0.15-0.25			0.05-0.10
24	0.90						0.10		
25	0.90							0.10	
26	0.90								0.10

Legend: APTAC = (3-acrylamidopropyl)trimethylammonium chloride

AETAC = ([2-(Acryloyloxy)ethyl]trimethylammonium chloride

VP = vinyl pyrrolidinone

5 HEA = hydroxyl ethyl acrylate

DMA = dimethyl acrylamide

AM = acrylamide

MAPDMS = monomethacryloxypropyl terminated polydimethylsiloxane
(product MCR-M11 from Gelest, Inc.)

10 TRIS = methacryloxypropyl tris(trimethylsiloxysilane)

TPDMS = methacryloxypropyl T-Structure siloxane
(product RTT-1011 from Gelest, Inc.)

Unless indicated otherwise, the monomers were commercially-available and obtained from Sigma-Aldrich Co.

15 In addition to the combinations of monomers provided in Table 1 above, there are additional examples of monomer combinations forming the cationic polymers of the invention provided in Table 2 below. In addition to the mole fractions of the specific monomers forming the cationic polymer component, Table 2 also includes the log reduction in microorganisms after the 25th and (where appropriate) the 50th

20 insults of 10⁶ *E. coli* organisms. The compositions of the invention represented in Table 2 have the same components described for the exemplary compositions in Table 1 and the same legend for the names of the monomers.

Table 2.

Ex. #	APTAC	AETAC	VP	HEA	DMA	AM	MAPDMS	TRIS	TPDMS	Log Reduction after 25 insults	Log Reduction after 50 insults
1		0.90		0.05			0.05			4.6	1.5
2	0.90			0.05			0.05			4.2	1.0
3		0.90	0.05				0.05			5.6	1.9
4	0.90		0.05				0.05			4.4	0.4
5		0.80		0.15			0.05			4.7	1.5
6	0.80			0.15			0.05			3.3	not tested
7	0.80		0.15				0.05			2.5	not tested
8		0.70		0.25			0.05			4.9	0.5
9	0.70			0.25			0.05			4.2	1.7
10	0.70		0.25				0.05			3.0	not tested
11		0.90		0.05				0.05		5.6	4.1
12	0.90		0.05					0.05		3.2	not tested
13		0.80		0.15				0.05		4.1	4.8
14		0.80	0.15					0.05		3.8	not tested
15	0.80		0.15					0.05		2.7	not tested
16	0.70					0.25		0.05		2.1	not tested
17	0.70				0.25			0.05		2.1	not tested
18	0.90				0.05			0.05		6.8	2.8
19	0.90					0.05		0.05		3.3	not tested
20		0.90		0.10						5.3	2.5
21		0.90		0.10						3.3	not tested
22		0.90		0.10						3.1	not tested
23	0.90			0.10						4.2	0.4
24		0.90						0.10		4.0	5.3
25	0.90							0.10		4.7	1.8
26	0.90							0.10		3.3	not tested
27	0.90							0.10		2.0	not tested
28		0.80		0.10					0.10	3.4	not tested
29		0.70	0.20						0.10	2.6	not tested
30	0.70				0.20				0.10	2.5	not tested
31		0.90							0.10	3.1	not tested
32	0.90								0.10	3.9	1.5

Some of the examples in Table 2 were not tested at the 50th insult level. The reason is because the composition provided a log reduction in organisms of

between 2 and 3 after twenty-five insults and therefore, was unlikely to achieve the same level of log reduction after an additional twenty-five insults.

While the compositions of the invention have been described in detail with respect to specific aspects thereof, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing, may readily conceive of alterations to, variations of and equivalents to these compositions. Accordingly, the scope of the present invention should be assessed as that of the claims and any equivalents thereto.

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WE CLAIM:

1. A composition having durable antimicrobial activity comprising:
 - a carbonate/bicarbonate salt of a quaternary ammonium cation;
 - an organic acid;
 - hydrogen peroxide; and
 - a cationic polymer that includes a (3-acrylamidopropyl)trimethylammonium chloride monomer combined with another monomer selected from a polar, water-soluble monomer, a hydrophobic, silicone-containing monomer and mixtures thereof;
2. The composition of claim 1 wherein the composition includes from 0.5% by weight to 10% by weight of cationic polymer.
3. The composition of claim 2 wherein the cationic polymer includes from 0.70 to 0.90 mole fraction of (3-acrylamidopropyl)trimethylammonium chloride monomer.
4. A composition having durable antibacterial activity comprising:
 - a carbonate/bicarbonate salt of a quaternary ammonium cation;
 - an organic acid;
 - hydrogen peroxide; and
 - a cationic polymer that includes [2-(acryloyloxy)ethyl]trimethylammonium chloride monomer combined with another monomer selected from a polar, water-soluble monomer, a hydrophobic, silicone-containing monomer and mixtures thereof.
5. The composition of claim 1 and 4 wherein the polar, water-soluble monomer is selected from vinyl pyrrolidinone, hydroxyl ethyl acrylate, hydroxyl ethyl methacrylate, N,N'-dimethyl acrylamide, acrylamide and N-isopropyl acrylamide.

6. The composition of claim 1 and 4 wherein the hydrophobic, silicone-containing monomer is selected from unsubstituted or substituted vinyl or ethynyl group terminated siloxyl compounds, comprising monomethacryloxypropyl terminated polydimethylsiloxane, methacryloxypropyl tris(trimethylsiloxysilane) and methacryloxypropyl terminated T-structure siloxane.
7. The composition of claim 1 and 4 wherein the carbonate/bicarbonate salt of a quaternary ammonium cation is selected from dioctyldimethylammonium carbonate, decyloctyldimethylammonium carbonate, didecyldimethylammonium carbonate, benzalkonium carbonate, benzethonium carbonate, stearylalkonium carbonate, cetrimonium carbonate, behentrimonium carbonate, dioctyldimethylammonium bicarbonate, decyloctyldimethylammonium bicarbonate, didecyldimethylammonium bicarbonate, benzalkonium bicarbonate, benzethonium bicarbonate, stearylalkonium bicarbonate, cetrimonium bicarbonate, behentrimonium bicarbonate and mixtures thereof.
8. The composition of claim 1 and 4 wherein the organic acid is selected from citric, malic, maleic, oxalic, glutaric, succinic, lactic, glycolic, fumaric, acetic, benzoic, propionic, sorbic, tartaric, formic and mixtures thereof.
9. The composition of claim 1 and 4 wherein the composition further comprises urea.
10. The composition of claim 1 and 4 wherein the composition retains antimicrobial activity after twenty-five insults of *E. coli* as measured by a log 2 reduction in organisms upon the twenty-fifth insult of 10^6 total organisms.
11. The composition of claim 1 and 4 wherein the composition is effective against Gram positive bacteria, Gram negative bacteria, enveloped viruses, non-enveloped viruses, fungi, fungal spores, mildew and mold.

12. The composition of claim 1 and 4 wherein the composition includes from 0.2% by weight to 15.0% by weight of the carbonate/bicarbonate salt of a quaternary ammonium cation.
13. The composition of claim 1 and 4 wherein the composition includes from 0.1% by weight to 3.0% by weight of the organic acid.
14. The composition of claim 1 and 4 wherein the composition includes from 0.5% by weight to 5.0% by weight of hydrogen peroxide.
15. The composition of claim 4 wherein the composition includes from 0.5% by weight to 10% by weight of cationic polymer.
16. The composition of claim 15 wherein the cationic polymer includes from 0.70 to 0.90 mole fraction of [2-(acryloyloxy)ethyl]trimethylammonium chloride monomer.
17. The composition of claim 1 and 4 wherein the composition is incorporated into a nonwoven basesheet.

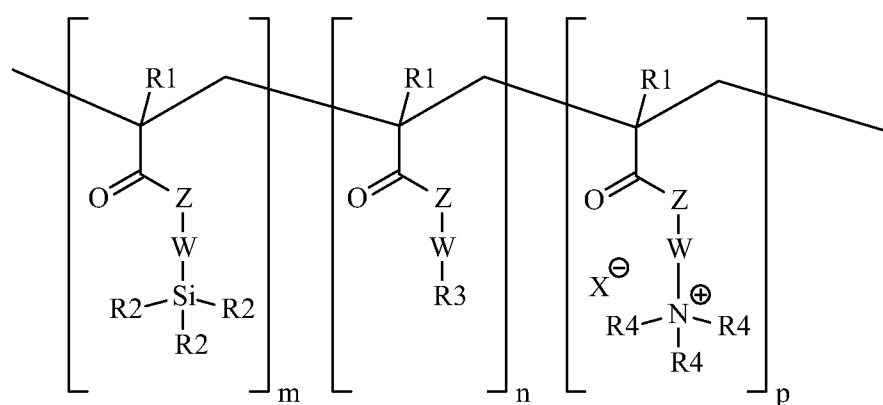
18. A composition having durable antimicrobial activity comprising:

a carbonate/bicarbonate salt of a quaternary ammonium cation;

an organic acid;

hydrogen peroxide; and

a cationic polymer that has the following structure:



wherein R₁ is selected from hydrogen and methyl; R₂ is selected from hydrogen, a halide and a C₁ through C₆ alkyl or alkoxy, aryl, linear or branched oligomeric or polymeric dimethyl siloxane; R₃ is selected from hydroxyl, alkyl amine, dialkyl amine and polyether; R₄ is selected from hydrogen, C₁ through C₆ alkyl and benzyl; Z is selected from oxygen and NH; W is selected from C₁ through C₆ alkyl; X is selected from fluoride, chloride, bromide, iodide, methosulfate and ethosulfate; and the values of m, n and p are integers and are selected to make the number average molecular weight in the range of 1000 to 100,000 g/mol.