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(54) Title: VIRICIDAL COMPOSITIONS AND USES THEREOF

(57) Abstract: The present disclosure encompasses compositions comprising a surfactant, and an acid such as, but not limited to, levulinic acid, that together have a synergistic effect in reducing the viability of a virus population compared to the efficacy of the individual compounds. This synergy allows the formulation of compositions where the active agents (including an acid and a surfactant) are present at concentrations effective to inactivate viruses on surfaces, including human skin. The viricidal compositions disclosed herein are efficacious without damaging the surface to which they may be applied, or even altering the organoleptic properties of a treated food substance. The viricidal compositions and wipes containing such compositions are suitable for sanitizing any surface suspected of having a viral load thereon, or where it is desirable to ensure that a viral load is as low as possible.

# VIRICIDAL COMPOSITIONS AND USES THEREOF

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application Serial No.: 61/226,093, entitled "VIRICIDAL COMPOSITION AND USE" filed on July 16, 2009, and to U.S. Provisional Patent Application Serial No.: 61/313,894, entitled "SANITIZING WIPE" filed on March 15, 2010, the entireties of which are hereby incorporated by reference.

## TECHNICAL FIELD

The present disclosure is generally related to microbicidal compositions and particularly compositions having viricidal activity and to methods of use thereof.

## BACKGROUND

Many human diseases are caused by viruses that may be divided into two groups: enveloped and non-enveloped. "Enveloped" or "lipophilic" viruses have an outer lipid-based membrane enveloping the capsid (comprised solely of capsomere proteins) that in turn protects the innermost viral genetic material. The enveloping membrane contains both viral and host cell proteins, and is acquired during budding from the host cell at the end of the viral replication process. Enveloped viruses include respiratory syncitial virus (RSV), and coronavirus, as well as influenza, measles, Hepatitis B and C and Herpes simplex viruses.

Non-enveloped viruses do not have an enveloping membrane; their outer surface is the protein capsid. Such viruses include caliciviruses (norovirus and sapovirus), astrovirus, rhinovirus, rotavirus, adenovirus, Hepatitis E virus and Hepatitis A virus. Non-enveloped viruses may be less susceptible to conventional viricides than enveloped viruses. Typical antimicrobial agents such as alcohol that affect cell membranes may also affect the outer membrane of an enveloped virus, but as a sole active agent may have little or no effect on the capsids of either virus type, either enveloped or non-enveloped.

Non-enveloped viruses are particularly difficult to adequately disinfect from environmental surfaces. Strong oxidizers like peracetic acids and bleaches inactivate most viruses with sufficient time, concentration, and no organic load, but they cannot be used on many surfaces without damaging them. Traditional disinfectants based on quaternary ammonium compounds (QACs) as the sole active agent may also have little or no effect on such viruses.

Norovirus, a member of the family *Caliciviridae*, is one of the most difficult viruses to disinfect. Human noroviruses (NoV) have emerged globally as the leading cause of non-bacterial gastroenteritis and the second most frequent agent of severe childhood gastroenteritis. While the majority of outbreaks in hospitals, nursing homes, daycares, cruise ships and schools are the result of person-to-person transmission, NoV is also the leading cause of outbreaks of food borne gastroenteritis, causing an estimated 30-50% of all

food borne outbreaks in the United States. Of produce-related outbreaks involving greens-based salads, lettuce, and fruits, 67%, 47% and 67% were attributed to NoV, respectively, in the US in 1990-2005, exceeding the contribution of bacterial food-borne pathogens. Foodhandler contamination of ready-to-eat foods is of particular concern where human NoVs are concerned, because they can be shed in feces for days to weeks after symptoms have subsided, and even in the complete absence of symptomatic infection. An infectious norovirus dose can be as small as 1-10 viral units so that even low contamination levels can jeopardize food safety. In addition, noroviruses are environmentally robust, surviving on surfaces for several days to more than a week, and recent data indicate washing with chlorinated water, at concentrations typically used on food and food preparation surfaces, may be inadequate to remove and inactivate high levels of contamination of NoV on fruit such as raspberries.

To date, there is no reliable cultivation assay for human norovirus. Thus all studies addressing norovirus survival and inactivation have relied on physically similar and genetically related surrogate viruses, such as Murine Norovirus (MNV) or Feline Calicivirus (FCV). Since its discovery and cultivation in 2003, MNV has often proven to be a more robust and reliable surrogate for human NoV than FCV.

A levulinic acid plus sodium dodecyl sulfate solution has been shown to be effective in inactivating *Salmonella* and *E. coli* O157:H7 on fresh lettuce by greater than 6 log CFU/g in less than 20 sec. In addition, this composition is highly effective in the presence of organic debris, making it an attractive alternative to chlorine-based wash treatments that become less effective with an increase in organic load.

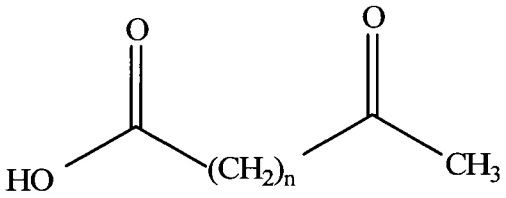
## SUMMARY

The present disclosure encompasses compositions comprising surfactants and an acid, particularly, but not limited to, levulinic acid that has a synergistic effect in reducing the viability of a virus population compared to the efficacy of the individual compounds. This synergy allows the formulation of compositions where the active agents (including an acid and a surfactant) are present at concentrations effective to inactivate viruses on surfaces, including human skin. The viricidal compositions disclosed herein are efficacious without damaging the surface to which they may be applied, or even altering the organoleptic properties of a treated food substance. The viricidal compositions and the wipes containing such compositions are suitable for sanitizing any surface suspected of having a viral load thereon or where it is desirable to ensure that a viral load is as low as possible.

One aspect of the disclosure, therefore, encompasses embodiments of a liquid antimicrobial composition comprising: (i) a surfactant, where the total concentration of the surfactant in said composition is about 0.05% to about 5% by weight per volume of solvent, and (ii) a monoprotic organic acid comprising a carbon backbone of 3 to 13 carbons, wherein

the total concentration of the acid in said antimicrobial composition is about 0.2% to about 20% by weight per volume of solvent, and (iii) a solvent, and where the antimicrobial composition is effective in reducing the viability of a virusl population.

In some embodiments of this aspect of the disclosure, the monoprotic organic acid can have the general structure of:

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wherein n is an integer selected from 1 to 10.

In embodiments of this aspect of the disclosure, the surfactant can be an anionic surfactant selected from the group consisting of: sodium dodecyl sulfate, sodium laureth sulfate, cetylpyridinium chloride, cetylpyridinium bromide, and benzalkonium chloride.

In embodiments of this aspect of the disclosure, the solvent can be water or an alcohol:water mix, where the alcohol is selected from the group consisting of ethanol, propanol, butanol, propylene glycol, diethylene glycol, dipropylene glycol, or a mixture thereof.

In embodiments of this aspect of the disclosure, the composition can further comprise a cationic agent selected from the group consisting of: benzalkonium chloride, benzethonium chloride, triclocarban, tricolsan, chlorhexidine, and any combination thereof.

In embodiments of the antimicrobial compositions of the disclosure, the compositions may be formed as a foam having a cylinder foam test half life of at least ten minutes.

In some embodiments of the antimicrobial composition of the disclosure, the surfactant is sodium dodecyl sulfate.

In some embodiments of the antimicrobial composition of the disclosure, the monoprotic organic acid is levulinic acid.

In the embodiments of this aspect of the disclosure, antimicrobial compositions can comprise about 0.5% to about 5% sodium dodecyl sulfate by weight per volume in water and about 2% to about 20% levulinic acid by weight per volume in water.

In one embodiment of the antimicrobial composition of this aspect of the disclosure, the composition consists essentially of about 3% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

In one embodiment of the antimicrobial composition of this aspect of the disclosure, the composition consists essentially of about 2% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

Another aspect of disclosure encompasses a composition substantially free of a solvent and comprising: (i) a surfactant, and (ii) a monoprotic organic acid comprising a carbon backbone of 3 to 13 carbons, wherein the surfactant and the monoprotic organic acid are in a weight ratio of between about 1:400 to about 25:1, and wherein when the composition is mixed with a solvent provides an antimicrobial composition effective in reducing the viability of a virus population.

In embodiments of this aspect of the disclosure, the composition can comprise a surfactant and a monoprotic organic acid, and where the surfactant can be sodium dodecyl sulfate, and the monoprotic organic acid can be levulinic acid.

In embodiments of this aspect of the disclosure, the weight ratio of sodium dodecyl sulfate to levulinic acid can be about about 1:2 to about 1:3.

Still another aspect of the present disclosure provides embodiments of a method of reducing the viability of a population of viruses, the method comprising obtaining an antimicrobial composition comprising about 0.05% to about 5% sodium dodecyl sulfate by weight per volume in water and about 0.2% to about 20% levulinic acid by weight per volume in water and contacting a population of viruses with said antimicrobial composition, whereby the viability of the virus population is reduced.

In embodiments of this aspect of the disclosure, the virus population is disposed on a non-liquid surface.

In some embodiments of this aspect of the disclosure, the composition can comprise about 3% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

In some embodiments of this aspect of the disclosure, the composition can comprise about 2% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

In some embodiments of this aspect of the disclosure, the composition can be disposed on a flexible base material and the composition is applied to a surface desired to have a reduced viable viral load thereon.

In some embodiments of this aspect of the disclosure, the flexible base material includes a positive ionic charge thereon.

In embodiments of this aspect of the disclosure, the antimicrobial composition is applied to a virus population as a liquid wash, a spray, a foam, a paste, a cream, a gel, or a wipe.

Yet another aspect of the present disclosure encompasses embodiments of sanitizing wipes comprising an flexible base support material and an antimicrobial composition absorbed thereon, wherein the antimicrobial composition comprises (i) a surfactant, wherein the total concentration of surfactant in said composition is about 0.05%

to about 5% by weight per volume of solvent, and (ii) a monoprotic organic acid comprising a carbon backbone of 3 to 13 carbons, wherein the total concentration of the acid in said antimicrobial composition is about 0.2% to about 20% by weight per volume of solvent, and wherein the antimicrobial composition is effective in reducing the viability of a virus population.

In some embodiments of this aspect of the disclosure, the flexible base support material can have a surface positive charge thereon.

In some embodiments of this aspect of the disclosure, the antimicrobial composition can comprise about 0.5% to about 5% by weight per volume in water sodium dodecyl sulfate and about 0.2% to about 20% by weight per volume in water levulinic acid.

In an embodiment of this aspect of the disclosure, the composition can comprise about 5% by weight per volume in water sodium dodecyl sulfate and about 5% by weight per volume in water levulinic acid.

In an embodiment of this aspect of the disclosure, the composition can comprise about 2% by weight per volume in water sodium dodecyl sulfate and about 5% by weight per volume in water levulinic acid.

## BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of the present disclosure will be more readily appreciated upon review of the detailed description of its various embodiments, described below, when taken in conjunction with the accompanying drawings. The drawings are described in greater detail in the description and examples below.

Fig. 1 is a graph showing the log reduction of MNV dried on stainless steel coupons after treatment with dry wipes of various surface charges using 1 or 5 wiping motions. Error bars indicate standard deviation.

Fig. 2 is a graph showing the log reduction of murine norovirus (MNV) dried on stainless steel coupons after treatment with wet wipes of various surface charges in combination with levulinic acid plus sodium dodecyl sulfate and compared to water using 1 or 5 wiping motions. Error bars indicate standard deviation.

Fig. 3 is a graph showing the log reduction of Hepatitis A virus (HAV) dried on stainless steel coupons after treatment with dry wipes of various surface charges using 1 or 5 wiping motions. Error bars indicate standard deviation.

Fig. 4 is a graph showing the log reduction of HAV dried on stainless steel coupons after treatment with wet wipes of various surface charges in combination with levulinic acid plus sodium dodecyl sulfate and compared to water using 5 wiping motions. Error bars indicate standard deviation.

Fig. 5 is a graph showing the log reduction of *Salmonella enterica* dried on stainless steel coupons after treatment with dry wipes of various surface charges using 1 or 5 wiping motions. Error bars indicate standard deviation.

Fig. 6 is a graph showing the log reduction of *Salmonella enterica* dried on stainless steel coupons after treatment with wet wipes of various surface charges in combination with levulinic acid plus sodium dodecyl sulfate and compared to water using 1 or 5 wiping motions. Error bars indicate standard deviation.

Fig. 7 is a graph showing the log reduction of MNV dried on latex gloves after treatment with wet wipes of positive and neutral charge in combination with levulinic acid plus sodium dodecyl sulfate and compared to water using 1 or 5 wiping motions. Error bars indicate standard deviation.

Fig. 8 is a graph showing the log reduction of MNV on stainless steel with 5% levulinic acid plus 2% sodium dodecyl sulfate as a liquid or as a foaming treatment with varying concentrations of FBS in the inoculum (n = 5).

Fig. 9 is a graph showing the log reduction of MNV on the surface of grapes after treatment with 5% levulinic acid plus 2% sodium dodecyl sulfate or water for 1 min or 5 mins.

Before the present disclosure is described in greater detail, it is to be understood that this disclosure is not limited to particular embodiments described, and as such may, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting, since the scope of the present disclosure will be limited only by the appended claims.

## DESCRIPTION OF THE DISCLOSURE

Where a range of values is provided, it is understood that each intervening value, to the tenth of the unit of the lower limit unless the context clearly dictates otherwise, between the upper and lower limit of that range and any other stated or intervening value in that stated range, is encompassed within the disclosure. The upper and lower limits of these smaller ranges may independently be included in the smaller ranges and are also encompassed within the disclosure, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either or both of those included limits are also included in the disclosure.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. Although any methods and materials similar or equivalent to those described herein can also be used in the practice or testing of the present disclosure, the preferred methods and materials are now described.

All publications and patents cited in this specification are herein incorporated by reference as if each individual publication or patent were specifically and individually

indicated to be incorporated by reference and are incorporated herein by reference to disclose and describe the methods and/or materials in connection with which the publications are cited. The citation of any publication is for its disclosure prior to the filing date and should not be construed as an admission that the present disclosure is not entitled to antedate such publication by virtue of prior disclosure. Further, the dates of publication provided could be different from the actual publication dates that may need to be independently confirmed.

As will be apparent to those of skill in the art upon reading this disclosure, each of the individual embodiments described and illustrated herein has discrete components and features which may be readily separated from or combined with the features of any of the other several embodiments without departing from the scope or spirit of the present disclosure. Any recited method can be carried out in the order of events recited or in any other order that is logically possible.

Embodiments of the present disclosure will employ, unless otherwise indicated, techniques of medicine, organic chemistry, biochemistry, molecular biology, pharmacology, and the like, which are within the skill of the art. Such techniques are explained fully in the literature.

It must be noted that, as used in the specification and the appended claims, the singular forms “a,” “an,” and “the” include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to “a support” includes a plurality of supports. In this specification and in the claims that follow, reference will be made to a number of terms that shall be defined to have the following meanings unless a contrary intention is apparent.

As used herein, the following terms have the meanings ascribed to them unless specified otherwise. In this disclosure, "comprises," "comprising," "containing" and "having" and the like can have the meaning ascribed to them in U.S. Patent law and can mean " includes," "including," and the like; "comprising" or "consists essentially" or the like, when applied to methods and compositions encompassed by the present disclosure refers to compositions like those disclosed herein, but which may contain additional structural groups, composition components or method steps (or analogs or derivatives thereof as discussed above). Such additional structural groups, composition components or method steps, etc., however, do not materially affect the basic and novel characteristic(s) of the compositions or methods, compared to those of the corresponding compositions or methods disclosed herein. "Comprising" or "consists essentially" or the like, when applied to methods and compositions encompassed by the present disclosure have the meaning ascribed in U.S. Patent law and the term is open-ended, allowing for the presence of more than that which is recited so long as basic or novel characteristics of that which is recited is not changed by the presence of more than that which is recited, but excludes prior art embodiments.

Prior to describing the various embodiments, the following definitions are provided and should be used unless otherwise indicated.

*Definitions*

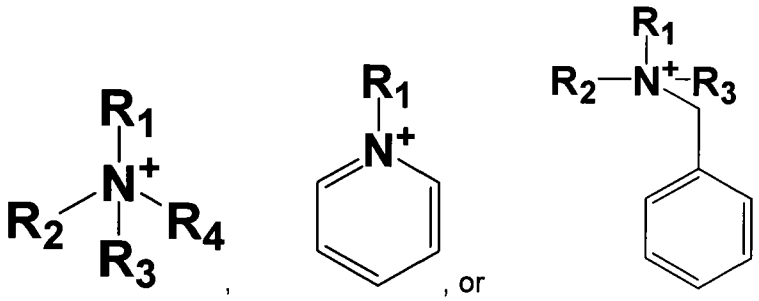
In describing and claiming the invention, the following terminology will be used in accordance with the definitions set forth below.

The terms “antimicrobial”, “antiviral” and the term "viricide" as used herein are intended to include any compound or composition that inactivates or decreases the ability of a virus to infect a cell and/or replicate. Typically an effective antiviral or viricide will reduce the viral infectivity by at least a 2-5 log factor for a single application of the compound, although a 7 log factor can also be contemplated. Higher levels of reduction in viral infectivity may be achieved by repeat application of the compound or if used in conjunction with other cleansing or sanitizing agents. It is contemplated that an “antimicrobial” as herein referred may include, in addition to an antiviral activity other antimicrobial activity including, but not limited to, an antibacterial activity.

The term “acid” or “organic acid” as used herein refers to a compound having a hydrocarbon chain and an acid group covalently bound to the hydrocarbon chain. The hydrocarbon chain can be of any length and can be a straight chain or branched chain. The most common organic acids are the carboxylic acids whose acidity is associated with their carboxyl group -COOH. However, additional compounds that lack a carboxylic function group can still function as an acid in accordance with the present invention if the compound ionizes in aqueous solution to yield hydrogen ions. Accordingly, eugenol is considered an acid within the context of the present invention due to the electron withdrawing properties of the phenol ring on the hydroxyl group subsitutent. Sulfonic acids, containing the group -$OSO_3H$, are another typical, but relatively stronger group of organic acids. In accordance with one embodiment the organic acid is a carboxylic acid comprising a maximum of 3 to 8 carbon atoms. The organic acids used in the embodiments of the present disclosure may also include additional functional groups extending from the hydrocarbon backbone. The carbon chain of the orgainic acid is functionalized by a hydroxyl, a carbonyl, an amino, an alkylamino, a sulfonyl, or a thiol group.

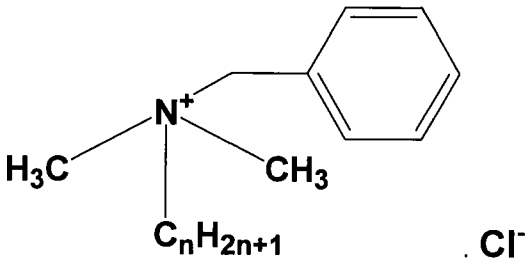
A monoprotic acid is an acid that is able to donate one proton per molecule during ionization.

A quaternary ammonium cation is a compound of the general structure:



where $R_1$, $R_2$, $R_3$, and $R_4$ are independently selected from the group consisting of $C_1$-$C_{20}$ alkyl and salts thereof.

As used herein the term "benzalkonium chloride" refers to a single alkylbenzyldimethylammonium chloride of the general structure



wherein n is an integer selected from the group consisting of 6, 8, 10, 12, 14, 16, 18 and 20, or mixtures of two or more such compounds.

The terms "effective" and "effective amount" as used herein refers to a concentration of active agent of an anti-microbial composition that provides the desired effect, i.e., log orders of reduction in surface microbial counts on a surface, including the surface of foodstuffs without reducing organoleptic properties of the food substance.

The term "surface" as used herein refers to a surface that is desired to be sanitized such as, but not limited to, a glove (latex or non-latex) including surgical gloves, a tool, a surgical tool or apparatus, a machine, equipment, a structure, a building, play materials, bathroom interiors, or other household surfaces, or the like, or the skin surface of an animal or human. Examples of food processing surfaces include surfaces of food processing or preparation equipment (e.g., slicing, canning, or transport equipment, including flumes), of food processing wares (e.g., utensils, dishware, wash ware, and bar glasses), and of floors, walls, or fixtures of structures in which food processing occurs. Food processing surfaces are found and employed in food anti-spoilage air circulation systems, aseptic packaging sanitizing, food refrigeration and cooler cleaners and sanitizers, ware washing, blancher cleaning, food packaging materials, cutting boards, beverage chillers and warmers, meat chilling or scalding equipment, cooling towers, food processing garment areas (including drains).Play material surfaces include, but are not limied to, surfaces of toy articles, playground equipment, cards and poker chips. Bathroom surfaces include such as sinks, toilets, walls, door handles, and fixtures.

The compositions and methods according to the disclosure are especially useful, therefore, for sanitizing, thereby reducing the level of a viable population on the surfaces of buildings where large numbers of individuals may congregate or be confined such as in a hotel or cruise ship, hospital or medical offices, day cares, schools, or military barracks, or where the individuals have access to surfaces where repeated handling or animal or human contact can transmit or have the potential to transmit and cross-contaminate with bacterial and viral organisms.

Advantageously, the present compositions have been found to remain effective even in an organic-rich environment (high organic load). Thus the compositions can be used as a single wash treatment of surfaces such as food preparation surfaces that may contain such materials in addition to pathogenic microbes, but the compositions can also be used as a repeat treatment or a treatment used in conjunction with other cleansers or sanitizers which can further assist in the removal of organic debris.

The term "cylinder foam test" as used herein refers to a test for measuring both the foamability of compositions and the persistence of the foamed state. In general, the test comprises the steps of placing a test composition into a stoppered, graduated cylinder so that the composition occupies a predetermined height of the cyclinder (e.g., about 1/3 to about 1/2 of the height of the stoppered, graduated cylinder). The stoppered, graduated cylinder is then inverted approximately 10 times to generate a foam. The height of foam is measured immediately after the inverting step as a measure of the foamability of the composition. The foamed composition is then left undisturbed to determine the foam half life (time required for the foam to lose half its height in the graduated cylinder). The cylinder foam test is conducted at room temperature under 1 standard atmosphere pressure (i.e., 100 kPa (about 750.01 mm Hg) or 29.53 in Hg).

*Description*

Acid stable, non-enveloped enteric viruses, such as human norovirus and Hepatitis A virus (HAV), are not readily inactivated by treatment with organic acids, surfactants, or detergents. Individually, levulinic acid and SDS provide only minimal ($\leq$ 2 log CFU/ml) inactivation of bacterial pathogens, but the combination acts synergistically for much greater levels of inactivation.

The need still exists for a composition that comprises generally recognized as safe (GRAS) chemicals, that has efficacy in rapidly killing both enveloped and non-enveloped viruses on all substrates, absent negative impacts to the environment or to the surface to which the composition is applied. It would also be beneficial for such a composition to have long-lasting residual effects, so that the surfaces would remain free of active viruses long after the application of the composition to the surface.

As reported herein, combining a surfactant with an acid synergistically enhances the antimicrobial activity of the respective surfactant and acid. The present disclosure encompasses compositions comprising surfactants, and particularly, but not intended to be limiting in any way, levulinic acid that have a synergistic effect in reducing the viability of a virus population compared to the efficacy of the individual compounds. This synergy allows the formulation of compositions where the active agents (including an acid and a surfactant) are present at concentrations effective to inactivate viruses on surfaces, including human skin, between $10^2$- and $10^7$-fold.

The viricidal compositions disclosed herein are efficacious with little or no damage to the surface to which they may be applied, or even altering the organoleptic properties of a treated food substance. The viricidal compositions and the wipes containing such compositions are suitable for sanitizing any surface suspected of having a viral load thereon or where it is desirable to reduce a viral load. The surfaces to be treated by the compositions of the disclosure include human skin (particularly hands) or surfaces likely to come in contact with human skin, as well as the surfaces of food substances such as poultry, meat or fresh produce, and surfaces that come in contact with food substances such as poultry, meat or fresh produce.

The compositions as described in the present disclosure, while comprising a surfactant and a monoprotic acid as the synergistically cooperating active viricidal agents, may further include such as, but not limited to, L-lysine, peroxacetic acid, N-halamine, D-limonene, hydrogen peroxide, Polysorbate 20, Polysorbate 80, allylisothiocyanate, eugenol, cetylpyridinium chloride, cetylpyridinium bromide, ethanolamine, EDTA or other compounds that may serve to increase the antiviral activity of the composition.

It is further contemplated to be within the scope of the disclosure for the antiviral compositions herein described to be deposited on or within a flexible base and pliable laminar material that may then be used as a wipe to spread the antiviral composition over a surface desired to be sanitized. The present disclosure, therefore, further encompasses embodiments of a wipe, including a hand wipe or other flexible base material including but not limited to, a fabric, a woven mesh, a pad, a paper towelette, a paper towel, and the like, that may absorb and/or retain thereon a quantity of the liquid antimicrobial composition. The wipe may then be used to apply the antimicrobial solution to a surface that it is desired to sanitize by reducing or eleiminating the viability of any microorganisms. Hand wipes can be devised that have both cleansing and sanitizing properties, making them an appealing method of delivery of antimicrobial compositions according to the present disclosure for reducing microbial populations on hand surfaces or other surfaces desired to be substantially freed of potential microbial pathogens. Their efficacy against norovirus,

Hepatitis A virus, and *Salmonella* are of particular interest, given recent foodborne outbreaks associated with contaminated food (Greig *et al.*, (2007). *J. Food Prot.* 70: 1752-1761).

Suitable flexible base and pliable materials for use in the methods and compositions of the present disclosure include, but are not limited to, a fabric composed partially or entirely of natural fibers including cotton, flax, linen, hemp, and the like, or partially or entirely of artificial materials such as nylon, DACRON.RTM, rayon, polyester, polythene, and the like. The most suitable flexible base materials may be woven or molded as meshes that provide spaces for impregnation of viricidal compositions according to the present disclosure. In one contemplated embodiment, the fibers of the flexible base material may be hollow to adsorb an increased amount of the antiviral composition.

It has been found that a particularly useful material for impregnating with the antiviral compositions according to the present disclosure are those materials have a net positive ionic charge thereon. Such materials have an increased capacity to attract negatively charged microorganisms thereby furthering the removal of viral and bacterial particles from a surface and contacting the particles with the antimicrobial composition impregnated in the wipe material.

Although a wipe impregnated with the antimicrobial composition of the present disclosure provides a convenient means of delivery of the composition to a surface to be sanitized, it is further contemplated that the composition may be contacted with the surface to be treated by a variety of dispensing methods, including by such as, but not limited to, spraying, wiping, dousing, and the like. Particularly useful is applying the composition as a foam that prolongs the application of the antimicrobial to the applied surface and will assist in the physical removal of dislodged viral, bacterial, and organic debris from the treated surface. Accordingly, it is contemplated that the compositions of the disclosure may be formulated to provide a foam having mechanical properties adequate to provide the desired prolonged treatment or debris removal activity. The surfactant component of the compositions herein described can provide the foaming action or additional foaming agents known in the art may be included.

In the antimicrobial compositions of the present disclosure that have antiviral activity, the concentration of total acid present in the composition can be about 0.2 to about 20% by weight per volume in water (2-200 grams/L) and the concentration of total surfactant is about 0.05% to about 5% by weight per volume in water (0.5-50 grams/L). In embodiments thereof, the acid is an acid that has been classified by the US Department of Agriculture as being Generally Regarded As Safe (GRAS) and includes, but is not limited to, levulinic acid, caprylic acid, caproic acid, citric acid, eugenol, adipic acid, tartaric acid, fumaric acid, lactic acid, phosphoric acid, hydrochloric acid, succinic acid, malic acid and sorbic acid.

The surfactant can be selected from any ionic (cationic or anionic) or non-ionic surfactants. Surfactants for application to the human skin or which might be in contact with foodstuffs consumed by animals or humans preferably should be compatible for human use and not lead to adverse reactions by the recipients. The surfactant component may comprises one or more functionalized organic acids having a hydrocarbon chain length of 2 to 25 carbons, wherein the functionalizing group is selected from hydroxyl, amino carbonyl, sulphonyl, phosphate and thiol groups. Such surfactants are known in the art in the field of food industry and include, for example, sodium dodecyl sulfate (SDS), sodium laureth sulfate (SLS; or sodium lauryl ether sulfate, SLES), cetylpyridinium chloride (CPC), cocamide MEA (MEA), cocamide DEA (DEA), benzalkonium chloride and ethylenediaamine tetraacetic acid ($H_4EDTA$) and salts thereof such as $Na_4EDTA$ and $Na_2H_2EDTA$. The surfactants used may also include side group substituents attached to the hydrocarbon backbone. Such substituents can be selected from $-PO_3$, $C_1$-$C_8$ hydroxylalkyl and $C_5$-$C_6$ aryl hydroxyl groups. The surfactant may also be selected from the group consisting of mono-, di-, tri- and tetra-alkylammonium halides, sulfates and phosphates wherein at least one of the alkyl substituents of the alkylammonium halide comprises at least carbon atoms and more typically 10-25 carbon atoms. In some embodiments, the surfactant can be selected from the group consisting of sodium dodecyl sulfate, sodium laureth sulfate, cetylpyridinium chloride, cetylpyridinium bromide and benzalkonium chloride and the organic acid is levulinic acid.

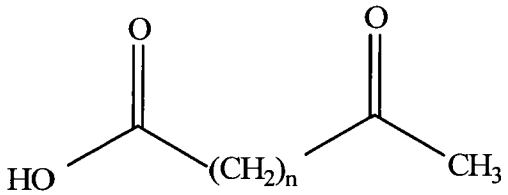
The compositions disclosed herein may further comprise two or more different acids or two or more different surfactants provided that the total concentration of acid present in the composition is about 0.2% to about 20% by weight per volume in water (2-200 grams/L) and the total concentration of surfactant is about 0.05% to about 5% by weight per volume in water (0.5-50 grams/L). In accordance with one embodiment of the compositions of the disclosure, a viricidal composition can be provided that comprises levulinic acid and a surfactant, where the total concentration of acid in said composition is about 0.5% to about 5.0% (w/v) and the total concentration of surfactant in said composition is about 0.5% to 5% (w/v).

The compositions disclosed herein are capable of reducing resident virus populations in liquids, on solid surfaces, the surfaces of food substance (or surfaces coming in contact with food substances), or on human skin (or on surfaces coming in contact with human skin) by a factor equal to, or greater than, $10^2$, including by a factor of at least $10^3$, and between a factor of $10^3$ and a factor of $10^7$, using a combination of an acid and surfactant at concentrations that are ineffective when used separately. Repeat application of the sanitizer compositions of the disclosure can provide an accumulative effect whereby each application can reduce the viral load by 1-3 log so that after three applications the viral load can be

reduced by a factor of 7 log or more. The active ingredients of the present compositions (i.e., the acid and surfactant) are individually ineffective in reducing viral cell count by a factor greater than $10^2$, even when the active agents are used separately at 2x or 5x the effective concentration used in the combination.

Accordingly, the antimicrobial (viricidal) compositions of the present disclosure comprise a linear monoprotic organic acid and an ionic long chain ($C_8$-$C_{30}$) surfactant. The organic acid is preferably, but not limited to, a linear monoprotic organic acid comprising a carbon backbone of 3 to about 13 carbons. A viricidal composition is provided comprising an acid and a surfactant, wherein the general structure of the acid is $CH_3(CH_2)_mCOOH$, with m being an integer selected from 2-12, and the surfactant can be, but is not limited to, sodium dodecyl sulfate (SDS), sodium laureth sulfate (SLS), or sodium lauryl ether sulfate (SLES), cetylpyridinium chloride (CPC) and benzalkonium chloride. In some compositions of the disclosure, the acid has the general structure $CH_3(CH_2)_mCOOH$, with m being an integer selected from 2-12 and the surfactant can be sodium dodecyl sulfate (SDS), sodium laureth sulfate (SLS), or sodium lauryl ether sulfate (SLES).

The composition can comprise an acid of the general structure $CH_3(CH_2)_mCOOH$, or



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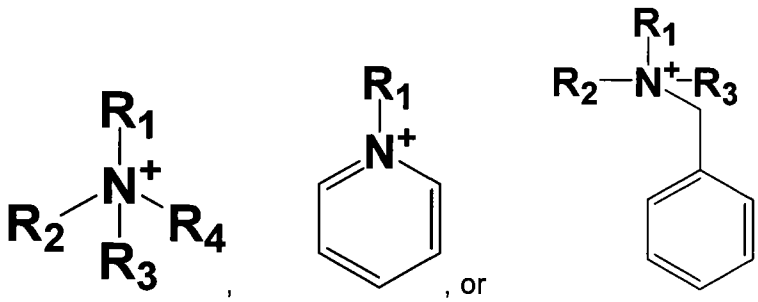
wherein n is an integer selected from 1-10, and the surfactant is a cation of the general structure:



, , or

wherein $R_1$, $R_2$, $R_3$, and $R_4$ are independently selected from the group consisting of $C_1$-$C_{20}$ alkyl, and salts thereof. In one embodiment $R_1$ is $C_6$-$C_{20}$ alkyl and $R_2$, $R_3$, and $R_4$ are independently selected from the group consisting of $C_1$-$C_2$ alkyl.

Previous studies revealed that combinations of different organic acids can be used as anti-bacterial agents based on their killing effects on *E. coli* O157:H7 and *Campylobacter* (Zhao, et al. 2006). Levulinic acid is an organic acid that can be produced cost effectively and in high yield from renewable feedstocks (Bozell, et al., (2000); Fang & Hanna (2002)). Its safety for humans has been widely tested and FDA has given it GRAS status for direct

addition to food as a flavoring agent or adjunct (21 CFR, 172.515). Its application to fresh produce may extend shelf life because levulinic acid can arrest light-induced chloroplast development during greening and can be removed by washing the leaves to restore the developmental process (Jilani et al., (1996) *Physiol. Plantarum* 96: 139-145).

Sodium dodecyl sulfate (SDS) also has GRAS status (21 CFR, 172.210) at 0.5% wt of gelatin, as a whipping agent in gelatin used in marshmallows and at 0.0125% in liquid and frozen egg whites. It has been widely studied and is used as a surfactant in household products such as toothpastes, shampoos, shaving foams, and bubble baths. The SDS molecule has a tail of 12 carbon atoms attached to a sulfate group, giving the molecule the amphiphilic properties required of a surfactant.

The compositions of the disclosure may optionally further include one or more additional compounds to increase the antimicrobial activity spectrum, to provide a general cleansing activity, and/or to provide a commercially desirable product having a particular odor, color, consistency and the like such as including one or more compounds selected from the group consisting of peroxacetic acid, N-halamine, D-limonene (1-methyl-4-(prop-1-en-2-yl)-cyclohexene), hydrogen peroxide, acidic copper sulfate, an aliphatic alcohol, an aromatic alcohol, a polyquaternium, allylisothiocyanate, eugenol (4-Allyl-2-methoxyphenol), L-lysine, Polysorbate 20 (TWEEN 20.RTM; polyoxyethylene (20) sorbitan monolaurate), Polysorbate 80 (TWEEN 80.RTM; polyoxyethylene (20) sorbitan monooleate), ammonium lauryl sulfate, sodium laureth sulfate, benzalkonium chloride, cetylpyridinium chloride, EDTA, alcohols and polyquaterniums (including for example, polyquaternium-1 [Ethanol, 2,2',2'' -nitrilotris-, polymer with 1,4-dichloro-2-butene and N,N,N',N'-tetramethyl-2-butene- 1,4-diamine]; polyquaternium-2 [Poly[bis(2-chloroethyl) ether-alt-l,3-bis[3-(dimethylamino)propyl]urea]]; polyquaternium-4; polyquaternium-5 [copolymer of acrylamide and quaternized dimethylammoniumethyl methacrylate]; polyquaternium-6 [poly(diallyldimethylammonium chloride)]; polyquaternium-7 [copolymer of acrylamide and diallyldimethylammonium chloride]; polyquaternium-8; polyquaternium-9; polyquaternium-[quaternized hydroxyethylcellulose] ; polyquaternium-11 [copolymer of vinylpyrrolidone and quaternized dimethylaminoethyl methacrylate]; polyquaternium-12; polyquaternium-13; polyquaternium-14; polyquaternium-[acrylamide-dimethylaminoethyl methacrylate methyl chloride copolymer]; polyquaternium-16 [copolymer of vinylpyrrolidone and quaternized vinylimidazole]; polyquaterniurn-17; polyquaternium-18; polyquaternium-19.

When the present composition is provided as a foam, the composition has a cellular structure that can be characterized as having several layers of air cells that provide the composition with a foamy appearance. It should be understood that the characterization of a foam refers to the existence of more than simply a few air bubbles and the foam can retain over 20, 30, 40, 50, 60 or 70% of its maximum height in a cylinder foam test 10 minutes after

agitation ceases. The foamed antimicrobial composition of the present disclosure can retain at least 20% of its height in a cylinder foam test 5 minutes after agitation is ceased.

Typically, the antimicrobial compositions disclosed herein can be formed as a foam using simple mechanical foaming heads known to those skilled in the art that function by mixing air and the composition to create a foamed composition. However, the use of known chemical foaming mechanisms is also suitable for forming foams in accordance with the present invention. For chemical foaming, the antimicrobial composition can include ingredients that create foam as a result of a chemical interaction, either with other ingredients in the composition, or with substances present in the applicable environment. These components can be provided as a 2-part composition that can be combined when foaming is desired.

Foaming can be accomplished, for example, using a foam application device such as a foaming soap dspenser, tank foamer or an aspirated wall mounted foamer, e.g., employing a foamer nozzle of a trigger sprayer. For example, foaming can be accomplished by placing the composition in a fifteen gallon foam application pressure vessel, such as a fifteen gallon capacity stainless steel pressure vessel with mix propeller. The foaming composition can then be dispensed through a foaming trigger sprayer. A wall mounted foamer can use air to expel foam from a tank or line.

The antimicrobial compositions disclosed herein can be optionally administered to a surface as a foam. The foam can be prepared by mixing air with the antimicrobial composition through use of a foam application device. Mechanical foaming heads that can be used according to the invention to provide foam generation include those heads that cause air and the foaming composition to mix and create a foamed composition. That is, the mechanical foaming head causes air and the foaming composition to mix in a mixing chamber and then pass through an opening to create a foam.

Suitable mechanical foaming heads that can be used according to the invention include those available from Airspray International, Inc. (Pompano Beach, Fla.), and from Zeller Plastik, a division of Crown Cork and Seal Co. Suitable mechanical foaming heads that can be used according to the invention are described in, for example, U.S. Pat. No. D-452,822; U.S. Pat. No. D-452,653; U.S. Pat. No. D-456,260; and U.S. Pat. No. 6,053,364. Mechanical foaming heads that can be used according to the invention includes those heads that are actuated or intended to be actuated by application of finger pressure to a trigger that causes the foaming composition and air to mix and create a foam. That is, a person's finger pressure can cause the trigger to depress thereby drawing the foaming composition and air into the head and causing the foaming composition and air to mix and create a foam.

Foam boosting agents can be added to the antimicrobial compositions to enhance either foamability and/or longevity of the formed foam, such as, but not limited to, glycols,

glycol ethers, derivatives of glycol ethers, and mixtures thereof. Suitable glycols include those having at least four carbon atoms such as hexylene glycol.

The viricidal compositions of the disclosure can further comprise an anti-foam or suds suppression agent. Incorporation of said agents is particularly desired for applications in which the viricidal compositions will be subjected to agitation in conjunction with the treatment of food substances (e.g., viricidal wash solutions). The viricidal compositions may comprise an anti-foam or suds suppression agent, present at a level of from about 0.0001% to about 15%, or about 0.001 % to about 20%, or about 0.005% to about 5.0% by weight of the viricidal composition. Suitable suds suppressing systems for use herein may comprise essentially any known anti-foam compound that exhibits stability at a pH of about 2.0 to about 4.5, including, but not limited to, those selected from the group consisting of silicone antifoam compounds, silicone emulsions, 2-alkyl and alkanol anti-foam compounds, Antifoam A, mineral oil emulsions, hydrocarbon oil emulsions, polyalkylene emulsions and combinations thereof.

Silicone suds suppressors can be the compounded types known for use in antimicrobial compositions, including, for example, polydimethylsiloxanes having trimethylsilyl or alternate endblocking units. Such compounds may be compounded with silica and/or with surface-active nonsilicon components, as illustrated by a suds suppressor comprising 12% silicone/silica, 18% stearyl alcohol and 70% starch.

The viricidal composition according to the disclosure can comprise about 0.05 to about 5% sodium dodecyl sulfate by weight per volume in water, about 0.2 to about 20% levulinic acid by weight per volume in water and, optionally: 1) about 0.05% to about 70%, or about 0.05% to about 62%, or about 0.05% to about 20% or about 0.05% to about 1%, of an alcohol solvent. In one embodiment the alcohol solvent is about 50% to about 80% or about 75% to about 85%. Suitable alcohol solvents include, but are not limited to, ethanol, propanol, butanol, propylene glycol, diethylene glycol, dipropylene glycol and mixtures thereof; 2) about 0.05% to about 20% or about 0.05% to about 5%, or about 0.05% to about 1 % of a cationic agent selected from the group consisting of benzalkonium chloride, benzethonium chloride, triclocarban, tricolsan, chlorhexidine and mixtures thereof; 3) about 0.05% to about 5%, or about 0.05% to about 2%, or about 0.05% to about 1 % of a heavy metal salt selected from the group consisting of silver, zinc, copper and mixtures thereof.

The present disclosure further provides composition substantially free of a solvent and comprising: a surfactant; and a monoprotic organic acid comprising a carbon backbone of 3 to 13 carbons, where the pharmaceutically acceptable surfactant and the monoprotic organic acid are in a weight ratio of between about 1:400 to about 25:1 that when added to an appropriate solvent will provide an antimicrobial (antiviral) composition according to the present disclosure.

The viricidal compositions disclosed herein can be used to reduce the population of an undesirable virus on a surface. Successful reduction of a population of a virus can be achieved when the infectivity of a virus population is reduced by at least 2 log. The viricidal compositions can be used to inactivate a wide range of viruses including, but not limited to, gastroenteritis viruses and their surrogates, caliciviruses such as Murine norovirus, Feline Calicivirus, Human Norovirus and Sapovirus, Human Rotavirus, Sapovirus, Astrovirus, Bocavirus; Hepatitis viruses, such as Hepatitis A and Hepatitis E virus; and respiratory viruses, such as Rhinovirus, Corona virus, Influenza virus, and Adenovirus serotypes.

The viricidal compositions can be formulated in various carriers for administration to inactivate viruses on a surface. For example the compositions can be formulated as a hand sanitizer (either as a water based or water free formulation) using standard techniques known to those skilled in the art. Similarly the composition can be added to fibrous materials to formulate hand sanitizing wipes or towelettes for sanitizing hard surfaces. Such sanitizing wipes may further include such components as alumina nanofibers, charged glass and the like, and which may aid in attracting charged microorganisms from the contaminated surface. These additional compounds can be interwoven in such as NANOCERAM.RTM filters.

In addition, the viricidal compositions can be formulated as a packaging insert for fresh produce or meat products consisting of a cellulose-based material soaked in viricidal composition, wherein any virus present will be inactivated upon food contact with the insert. The viricidal compositions can be encapsulated (using standard techniques) to provide delayed or prolonged release of the active components.

In one embodiment a packaging insert for fresh produce or meat products is provided which consists of a cellulose based material soaked in a slow-release viricide composition for virus inactivation within the package (not necessarily coming into contact with the insert). Alternatively, the viricidal composition can be provided as a foodstuff wash solution, optionally containing an antifoaming agent. In an additional embodiment the composition is provided as a foaming decontamination spray for use on hard surfaces (especially in cruise-ships, daycares, hospitals, and the like).

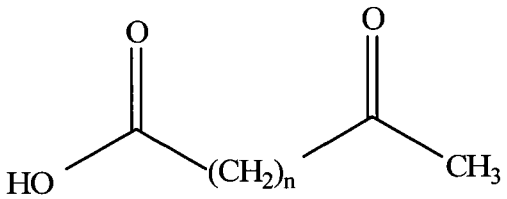
Accordingly, it was determined that low concentrations of levulinic acid plus sodium dodecyl sulfate solution were rapidly effective against the Human Norovirus surrogates, MNV and FCV and the agent of the common cold, Human Rhinovirus. As little as 0.5% levulinic acid plus 0.5% sodium dodecyl sulfate provided a >3 log reduction of virus infectivity in less than 1 min. MNV was rapidly inactivated on stainless steel surfaces using a 5% levulinic acid plus 2% sodium dodecyl sulfate solution and a 5% levulinic acid plus 2% sodium dodecyl sulfate foam, resulting in > 3 log reductions of MNV within 5 min of treatment, regardless of the presence of up to 10% organic material. The levulinic acid plus

sodium dodecyl sulfate solution disclosed herein, therefore, demonstrates rapid efficacy against the Human Norovirus surrogates, MNV and FCV in solution and when used on the surfaces of stainless steel and in the context of organic debris. The liquid sanitizer was also effective against Human Rhinovirus and, therefore, provides an alternative to alcohol-based sanitizers which have limited efficacy against non-enveloped viruses. Combinations of 5% levulinic acid plus 2% sodium dodecyl sulfate were more effective than lower concentrations of levulinic acid plus sodium dodecyl sulfate (2% levulinic acid plus 1% sodium dodecyl sulfate and 5% levulinic acid plus 2% sodium dodecyl sulfate) and water.

Dry wipes, regardless of charge or number of wipes were ineffective, resulting in <1 log for removal of norovirus, Hepatitis A virus, and *Salmonella enterica.* In contrast, wet wipes, particularly those carrying a cationic charge on the base material and those impregnated with levulinic acid plus sodium dodecyl sulfate sanitizer effectively reduced populations of MNV on stainless steel surfaces by > 1 log. Multiple (5) wiping passages (motions) in most of the tested scenarios was more effective than a single wipe and the 5% levulinic acid plus 2% sodium dodecyl sulfate solution effectively reduced MNV on stainless steel surfaces by > 2 log after 5 wipes.

One aspect of the disclosure, therefore, encompasses embodiments of a liquid antimicrobial composition comprising: (i) a surfactant, where the total concentration of the surfactant in said composition is about 0.05% to about 5% by weight per volume of solvent, and (ii) a monoprotic organic acid comprising a carbon backbone of 3 to 13 carbons, wherein the total concentration of the acid in said antimicrobial composition is about 0.2% to about 20% by weight per volume of solvent, and where the antimicrobial composition is effective in reducing the viability of a virus population.

In some embodiments of this aspect of the disclosure, the monoprotic organic acid can have the general structure of:

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wherein n is an integer selected from 1 to 10.

In embodiments of this aspect of the disclosure, the surfactant can be an anionic surfactant selected from the group consisting of: sodium dodecyl sulfate, sodium laureth sulfate, cetylpyridinium chloride, cetylpyridinium bromide, and benzalkonium chloride.

In embodiments of this aspect of the disclosure, the solvent can be water or an alcohol:water mix, where the alcohol is selected from the group consisting of ethanol,

propanol, butanol, propylene glycol, diethylene glycol, dipropylene glycol or a mixture thereof.

In embodiments of this aspect of the disclosure, the composition can further comprise a cationic agent selected from the group consisting of: benzalkonium chloride, benzethonium chloride, triclocarban, tricolsan, chlorhexidine, and any combination thereof.

In embodiments of the antimicrobial compositions of the disclosure, the compositions may be formed as a foam having a cylinder foam test half life of at least ten minutes.

In some embodiments of the antimicrobial composition of the disclosure, the surfactant is sodium dodecyl sulfate.

In some embodiments of the antimicrobial composition of the disclosure, the monoprotic organic acid is levulinic acid.

In the embodiments of this aspect of the disclosure, antimicrobial compositions can comprise about 0.05% to about 5% sodium dodecyl sulfate by weight per volume in water and about 2% to about 20% levulinic acid by weight per volume in water.

In one embodiment of the antimicrobial composition of this aspect of the disclosure, the composition consists essentially of about 5% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

In one embodiment of the antimicrobial composition of this aspect of the disclosure, the composition consists essentially of about 2% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

Another aspect of disclosure encompasses a composition substantially free of a solvent comprising: (i) a surfactant, and (ii) a monoprotic organic acid comprising a carbon backbone of 3 to 13 carbons, wherein the surfactant and the monoprotic organic acid are in a weight ratio of between about 1:400 to about 25:1, and wherein when the composition is mixed with a solvent provides an antimicrobial composition effective in reducing the viability of a virus population.

In embodiments of this aspect of the disclosure, the composition can comprise a surfactant and a monoprotic organic acid, and where the surfactant can be sodium dodecyl sulfate, and the monoprotic organic acid can be levulinic acid.

In embodiments of this aspect of the disclosure, the weight ratio of sodium dodecyl sulfate to levulinic acid can be about about 1:2 to about 1:5.

Still another aspect of the present disclosure provides embodiments of a method of reducing the viability of a population of viruses, the method comprising obtaining an antimicrobial composition comprising about 0.05% to about 5% sodium dodecyl sulfate by weight per volume in water and about 0.2% to about 20% levulinic acid by weight per volume in water and contacting a population of viruses with said antimicrobial composition, whereby the viability of the virus population is reduced.

In embodiments of this aspect of the disclosure, the virus population can be disposed on a non-liquid surface.

In some embodiments of this aspect of the disclosure, the composition can comprise about 5% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

In some embodiments of this aspect of the disclosure, the composition can comprise about 2% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

In some embodiments of this aspect of the disclosure, the composition can be disposed on a flexible base material and the composition is applied to a surface desired to have a reduced viable viral load thereon.

In some embodiments of this aspect of the disclosure, the flexible base material includes a positive ionic charge thereon.

In embodiments of this aspect of the disclosure, the antimicrobial composition is applied to a virus population as a liquid wash, a spray, a foam, a paste, a cream, a gel, or a wipe.

Yet another aspect of the present disclosure encompasses embodiments of sanitizing wipes comprising an flexible base support material and an antimicrobial composition absorbed thereon, wherein the antimicrobial composition comprises (i) a surfactant, wherein the total concentration of surfactant in said composition is about 0.05% to about 5% by weight per volume of solvent, and (ii) a monoprotic organic acid comprising a carbon backbone of 3 to 13 carbons, wherein the total concentration of the acid in said antimicrobial composition is about 0.2% to about 20% by weight per volume of solvent, and wherein the antimicrobial composition is effective in reducing the viability of a virus population.

In some embodiments of this aspect of the disclosure, the flexible base support material can have a surface positive charge thereon.

In some embodiments of this aspect of the disclosure, the antimicrobial composition can comprise about 0.05% to about 5% sodium dodecyl sulfate by weight per volume in water and about 0.2% to about 20% levulinic acid by weight per volume in water.

In an embodiment of this aspect of the disclosure, the composition can comprise about 5% by weight per volume in water sodium dodecyl sulfate and about 5% by weight per volume in water levulinic acid.

In an embodiment of this aspect of the disclosure, the composition can comprise about 2% by weight per volume in water sodium dodecyl sulfate and about 5% by weight per volume in water levulinic acid.

The specific examples below are to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way whatsoever. Without further elaboration, it is believed that one skilled in the art can, based on the description herein, utilize the present disclosure to its fullest extent. All publications recited herein are hereby incorporated by reference in their entirety.

It should be emphasized that the embodiments of the present disclosure, particularly, any "preferred" embodiments, are merely possible examples of the implementations, merely set forth for a clear understanding of the principles of the disclosure. Many variations and modifications may be made to the above-described embodiment(s) of the disclosure without departing substantially from the spirit and principles of the disclosure. All such modifications and variations are intended to be included herein within the scope of this disclosure, and the present disclosure and protected by the following claims.

The following examples are put forth so as to provide those of ordinary skill in the art with a complete disclosure and description of how to perform the methods and use the compositions and compounds disclosed and claimed herein. Efforts have been made to ensure accuracy with respect to numbers (*e.g.*, amounts, temperature, *etc.*), but some errors and deviations should be accounted for. Unless indicated otherwise, parts are parts by weight, temperature is in °C, and pressure is at or near atmospheric. Standard temperature and pressure are defined as 21 °C and 1 atmosphere.

It should be noted that ratios, concentrations, amounts, and other numerical data may be expressed herein in a range format. It is to be understood that such a range format is used for convenience and brevity, and thus, should be interpreted in a flexible base manner to include not only the numerical values explicitly recited as the limits of the range, but also to include all the individual numerical values or sub-ranges encompassed within that range as if each numerical value and sub-range is explicitly recited. To illustrate, a concentration range of "about 0.1% to about 5%" should be interpreted to include not only the explicitly recited concentration of about 0.1 wt% to about 5 wt%, but also include individual concentrations (*e.g.*, 1%, 2%, 5%, and 4%) and the sub-ranges (*e.g.*, 0.5%, 1.1%, 2.2%, 3.5%, and 4.4%) within the indicated range. The term "about" can include ±1%, ±2%, ±5%, ±4%, ±5%, ±6%, ±7%, ±8%, ±9%, or ±20%, or more of the numerical value(s) being modified.

## EXAMPLES

### Example 1

*Virus cultivation and plaque assay:* RAW 264.7 cells (ATCC# TIB-71), Crandell Reese Feline Kidney (CRFK) cells (ATCC# CCL-94) were maintained in either (a) complete Dulbecco's Modified Eagles Medium (DMEM) (Fisher Scientific #SH30081LS) containing 20% low endotoxin fetal bovine serum (FBS) (HyClone, Logan, UT) for RAW 264.7 cells, or (b) 20%

FBS (Atlanta Biological, GA) for CRFK cells. HeLa-Ohio cells were maintained in complete Modified Eagles Medium (MEM) (Fisher scientific #SH30024LS) containing 20% fetal bovine serum (FBS). RAW 264-7 DMEM was supplemented with penicillin (100 U/ml), streptomycin (100 μg/ml) with 100 mM HEPES, and 1 mM sodium pyruvate, CRFK DMEM was supplemented with penicillin (100 U/ml), streptomycin (100 μg/ml), 1% L-glutamine and 1% non-essential amino acids. Complete MEM for HeLa-Ohio cells was supplemented with penicillin (100 U/ml), streptomycin (100 μg/ml), 1 mM sodium pyruvate and 1% non-essential amino acids. Murine norovirus (MNV), Feline Calicivirus (FCV) (ATCC # VR-2057), and Human Rhinovirus-16 were cultured by infecting 80-90% confluent monolayers of RAW 264.7, CRFK, HeLa-Ohio cells, respectively in complete maintenance medium.

Virus was harvested after complete CPE (cytopathic effect) was apparent (typically after 48 h) by three cycles of freeze-thawing. Cellular debris was removed by centrifugation for 10 min at 1,731 x g and the supernatant was filtered through a 0.2 μm membrane filter (Millipore, Billerica, MA) before storing as 1-4 ml aliquots at -70 °C until use. For experiments requiring a high titer of virus stock, additional concentration by ultracentrifugation (80,000 x g for 1 hr at 4 °C) was performed. Pelleted virus was suspended in PBS (pH 7.2) containing 0%, 5%, or 20% FBS (Atlanta Biological) overnight prior to use or storage at -70 °C.

**Example 2**

*Quantification of virus infectivity:* To determine the infectious titer of MNV and FCV, standard plaque assay techniques were employed (Cannon *et al.*, (2006) *J. Food Prot.* 69: 2761-2765, incorporated herein by reference in its entirety). Briefly, cells were dispensed in 60 mm diameter cell culture plates at a density of $2 \times 10^6$ cells per plate and grown to 80-90% confluence in complete DMEM. Immediately preceding infection, the cell culture media was replaced with 0.5 ml of complete MEM without phenol red (Cellgro, Mediatech, Inc, Manassas, VA), supplemented with either (a) 5% low endotoxin FBS, penicillin (100 U/ml), and streptomycin (100 μg/ml) with 100 mM HEPES, and 10 mM sodium pyruvate for MNV or (b) 4% FBS, 1% L-glutamine and 1% non-essential amino acids for FCV.

Ten-fold serial dilutions of virus were prepared in phosphate buffered saline (PBS) pH 7.5 and cell monolayers were infected in duplicate with 0.1 ml of each virus dilution, and 0.5ml of complete MEM (see below) for 1 h at 37 °C and 5% $CO_2$ with gentle rocking every 15 min. Subsequently, the cells were overlaid with complete MEM (without phenol red) (Cellgro) supplemented as described above but also containing 0.5% agarose (SeaKem GTG, Lonza, Rockland, ME). Viruses were incubated for 48 h at 37 °C and 5% $CO_2$. Plaques were subsequently counted 5-8 h after a second agarose overlay (0.5% agarose diluted in deionized water and including 1% neutral red solution (Sigma-Aldrich, St. Louis,

MO)) was added. Plates with 5 to 50 plaques were used to determine the virus titer in plaque forming units (PFU).

To determine the infectious titer of HRV-16, a Most Probable Number (MPN) technique was employed. HeLa-Ohio cells were grown to 80-90% confluence in 96-well tissue culture dishes in complete MEM. Virus was serially diluted (10x) in PBS and inoculated onto eight replicate wells (50 µl each) per sample. Cells were incubated for 1 h at 33°C with 5% $CO_2$ with gentle rocking every 15 min. After removal of inoculums, cells were supplemented with complete MEM and incubated for an additional 48 hrs. Replicate wells were visually scored (positive for cytopathic effect (CPE) or negative) for virus infection and MPNs were determined using the Build 23 MPN Calculator. Virus log reductions for each treatment were determined by comparison to a positive control (serial dilution of virus stock).

**Example 3**

*Determination of MNV, FCV, and HRV-16 inactivation by levulinic acid plus sodium dodecyl sulfate solution:* Working concentrations of levulinic acid plus sodium dodecyl sulfate (SDS) (both from Sigma-Aldrich, St. Louis, MO) were prepared from 20% or 98% stock solutions by dilution in sterile, ultra-purified, de-ionized water on the day of each experimental trial. Partially purified virus cell culture lysate or concentrated virus cell culture lysate (0.1 ml) was added to each concentration of levulinic acid plus sodium dodecyl sulfate solution (0.9 ml) and mixed on a shaking platform (200 rpm) at 21 °C. At each time interval (0 secs, 20 secs, 40 secs, 1 min or 5 min), 0.1 ml of the solution was removed and immediately diluted 1:10 (for all concentrations less than or equal to 2% levulinic acid plus 1% sodium dodecyl sulfate) or 1:1000 (for concentrations greater than 2% levulinic acid plus 1% sodium dodecyl sulfate) in complete DMEM containing 20% FBS for neutralization. Samples were then 10-fold serially diluted in PBS and inoculated onto cell culture monolayers. Virus inoculated in water and processed identically to the experimental trials served as a control for determining the virus reduction by the levulinic plus sodium dodecyl sulfate solution. Positive and negative control experiments were performed in duplicate and parallel with each experimental trial. Neutralization controls for which virus was added to sanitizer subsequent to sanitizer neutralization were also included for each experiment with each virus.

**Example 4**

*Determination of cytotoxic effects of levulinic acid plus sodium dodecyl sulfate on RAW 264.7 cells:* Working concentrations of levulinic acid plus sodium dodecyl sulfate (as listed in Table 1) were prepared as described above, mixed on a shaking platform (200 rpm) for 2 min at 21 °C, and diluted 1:10 in 0.1 M PBS to for neutralization. Duplicate cell culture monolayers were inoculated with 100 µl of ten-fold serial dilutions (in 0.01 M PBS) of each levulinic acid plus sodium dodecyl sulfate solution and 100 µl of MNV cell culture lysate

(diluted to approximately 70 pfu/ml). To quantify cell cytotoxicity caused by the levulinic acid plus sodium dodecyl sulfate solution, plaques numbers on duplicate cell culture plates were averaged for each treatment group and compared to control plates containing the same quantity of virus, but without containing the levulinic acid plus sodium dodecyl sulfate solution.

**Example 5**

*Determination of MNV inactivation by levulinic acid plus sodium dodecyl sulfate on stainless steel and produce surfaces with liquid or foaming treatments:* Sterile stainless steel coupons (4 cm x 2.5 cm) or red grapes were inoculated with 100 µl or 10 µl of MNV partially purified cell culture lysate (approximately 7 x $10^6$ PFU/ml stock) or concentrated cell culture lysate (approximately 6 x $10^7$ PFU/ml stock) and allowed to dry in a BSC-2 for 30-40 min at 21 °C, or until visibly dry. Levulinic acid plus sodium dodecyl sulfate solutions prepared at 2% levulinic acid plus 1% sodium dodecyl sulfate, 5% levulinic acid plus 2% sodium dodecyl sulfate, 5% levulinic acid plus 1% sodium dodecyl sulfate or 5% levulinic acid plus 2% sodium dodecyl sulfate concentrations were used as a liquid solution (50 ml) or aerated by a hand pumping device (foaming soap container) to create a foaming solution (approximately 25 ml) that was applied to completely cover the virus inoculated stainless steel coupons. At each time interval (1 or 5 min), the coupon or grape was transferred to a 50 ml conical tube containing 10 ml of complete DMEM containing 20% FBS and gently rocked for 5 seconds to neutralize the sanitizer. The stainless steel coupon or grape was then transferred to a 50 ml conical tube containing 10 ml of 0.1 M PBS with 1M NaCl and vigorously vortexed to elute viruses from the stainless steel coupon. A non-inoculated stainless steel coupon and uninoculated grape was also processed and served as a negative control. Neutralization controls, where virus was added to 50 ml conical tubes containing the elution buffer after sanitizer neutralization, were also included. Recovery of virus dried on the surface of untreated controls processed identically to the experimental trials were included as positive controls and served as a comparison for determining virus log reduction after each treatment. Sanitizer efficacy was compared to virus removal by treatment with sterile deionized water in a procedure identical to that of the sanitizer treatment experiments.

**Example 6**

*Statistical analysis:* Each experimental treatment was performed in triplicate and a positive control experiment (MNV in water) was included with each trial. Log concentrations of MNV were calculated based on average plaque counts of duplicate cell culture plates and the dilution factor. Average MNV log reductions were calculated based on subtraction of experimental trial counts from control trial counts. Because all levulinic acid plus sodium dodecyl sulfate combinations greater than 0.5% w/v produced cytotoxicity in neutralized,

undiluted samples, the assay limit of detection was reduced by 1.0 log units for the experimental results in Table 1. For statistical analysis, log reductions of 3.0 PFU/ml or greater were assigned a value of 3.0 PFU/ml. A two-tailed student's T-test (Microsoft Excel) was used to determine significant differences ($P \leq 0.05$) between the experimental treatment and control groups.

**Example 7**

All concentrations of levulinic acid plus sodium dodecyl sulfate solution began to inactivate MNV almost immediately, resulting in at least 1.3 log reduction of viable MNV upon contact with the solution (time = 0), as shown in Table 1.

*Table 1: Log reduction of Murine norovirus after treatment with varying concentrations of levulinic acid plus sodium dodecyl sulfate solution at 21 °C (n = 3).*

| **MNV log reduction after treatment with levulinic acid plus sodium dodecyl sulfate wash solution** | | | |
|---|---|---|---|
| **Log reduction** | **Time 0 sec** | **Time 20 sec** | **Time 40 sec** |
| **Water** | 0 (± 0) | 0 (± 0.2) | 0 (± 0.2) |
| **1% levulinic acid.plus 1% sodium dodecyl sulfate** | 2.2 (± 0.7)* | >3.0 (± 0)* | >3.0 (± 0)* |
| **1% levulinic acid.plus 0.5% sodium dodecyl sulfate** | 1.5(± 1.1)* | 2.6 (± 0.7) | >3.0 (± 0)* |
| **0.5% levulinic acid.plus 0.5% sodium dodecyl sulfate** | 1.3 (± 0.3)* | 2.6 (± 0.4) * | >3.0 (± 0)* |
| **1% levulinic acid.plus 2% sodium dodecyl sulfate** | 2.1(± 0.5)* | >3.0 (± 0)* | >3.0 (± 0)* |
| **0.5% levulinic acid.plus 1% sodium dodecyl sulfate** | 1.5 (± 0.2)* | 2.8 (± 0.3)* | >3.0 (± 0)* |
| **2% levulinic acid.plus 1% sodium dodecyl sulfate** | 2.0 (± 1.2)* | >3.0 (± 0)* | >3.0 (± 0)* |

* Indicates significant difference from water control ($P < 0.05$)

Within 20 sec, a >3.0 log reduction in MNV viability was observed after treatment with combinations of levulinic acid plus sodium dodecyl sulfate that were at least 1% for each component. Extending the treatment time to 40 sec resulted in a >3.0 log reduction in MNV viability for all concentrations of the levulinic acid plus sodium dodecyl sulfate solution. With the assay limit of detection at 3.0 log, no viable virus could be detected by plaque assay after each 40 sec treatment, whereas controls (MNV inoculated in water) remained infectious throughout the duration of the experiment with no reduction in virus infectivity (n = 5; mean log reduction = 0, standard deviation = 0.2).

All concentrations of the levulinic acid plus sodium dodecyl sulfate solution (greater than 0.5% w/v) produced cytotoxicity after neutralization unless diluted 10 fold. Elimination of cytotoxicity by the solution was demonstrated by inoculating duplicate cell culture monolayers with 10 fold serial dilutions of the neutralized levulinic acid plus sodium dodecyl sulfate solution and a known concentration of MNV (approximately 70 PFU/ml). Control experiments performed in parallel included only the known concentration of MNV. When

compared to controls, no reduction in plaque numbers was observed for any of the treatments that were diluted at least fold (n = 3, P values ≥0.1).

**Example 8**

All concentrations of levulinic acid plus sodium dodecyl sulfate solution greater than or equal to 0.5% levulinic acid plus 0.5% sodium dodecyl sulfate inactivated MNV, FCV and HRV-16 by 3 log or greater within 1 min With lower concentrations of SDS (0.5% levulinic acid plus 0.05% sodium dodecyl sulfate), FCV was inactivated by > 3.6 log, MNV was reduced by only 1.04 log, as shown in Table 2.

*Table 2: Log reduction of MNV, FCV and HRV-16 after treatment with varying concentrations of levulinic acid plus sodium dodecyl sulfate solution at 21 °C for 1 min (n = 3).*

| | MNV | FCV | HRV-16 |
|---|---|---|---|
| **0.5% levulinic acid plus 0.05% sodium dodecyl sulfate** | 1.04 (± 0.17) | >3.6 (± 0.17) | ND |
| **0.5% levulinic acid plus 0.5% sodium dodecyl sulfate** | > 4.00 (± 0.34) | >3.6 (± 0.17) | >4.38 (± 0.0) |
| **2% levulinic acid plus 1% sodium dodecyl sulfate** | >3.08 (± 0.13) | ND | >4.94 (± 0.0) |

On stainless steel coupons, the 2% levulinic acid plus 1% sodium dodecyl sulfate and 5% levulinic acid plus 2% sodium dodecyl sulfate liquid and foam treatments resulted in less than 3 log reductions in viable MNV after 5 min of treatment (data not shown). After 1 min of treatment, the liquid and foam sanitizer produced variable results for efficacy against MNV, as shown in Fig. 8. However, the 5% levulinic acid plus 1% sodium dodecyl sulfate and the 5% levulinic acid plus 2% sodium dodecyl sulfate effectively inactivated MNV on the surface of stainless steel coupons, resulting in 3.38-4.25 log reduction in viable MNV after 5 min for both liquid and foam treatments. The addition of increasing amounts of proteinaceous material (FBS) up to 20% did not impact the efficacy of the liquid or foam sanitizer. MNV removal from stainless steel coupons by water remained low (<2.7 log removal).

For grapes, MNV was not inactivated at 1 min, but was reduced by 3.41 log after the 5 min treatment with 5% levulinic acid plus 2% sodium dodecyl sulfate. MNV removal from the grape surface by water was only 2.11 log after 5 min, as shown in Fig. 9.

**Example 9**

*Bacteria cultivation and plaque assay*: Five serovars of *Salmonella enterica*, (Typhimurium, Enteritidis, Gaminara, Agona, and Montevideo) were inoculated separately in 10 mL of tryptic soy broth (Difco, Franklin Lakes, NJ). Cultures were incubated at 37 °C and transferred twice to fresh vials of TSB, 24 hours apart. For each strain, 5 ml of inoculated broth was transferred to a conical 50 ml tube and centrifuged at 8,000 x g at 4 °C for 10

minutes. The supernatant was removed and replaced with 25 ml of 0.1M phosphate buffered saline before the tube was vortexed for 1 minute to resuspend the pellet.

To determine the infectious titer of Salmonella, 1:10 dilutions of the stock were made in 0.1% wt/vol peptone water to a final concentration of $1x10^6$ of the original stock. A wasp spiral plater (Don Whitley Scientific, West Yorkshire, UK) was used to inoculate 0.1 ml of diluted stock on 100 mm diameter media plates of both tryptic soy agar (Difco) plates as a general media and XLT4 agar (Difco) as a selective media. Plates were incubated at 37 °C for 24 hours. Counting of colonies was performed on a colony plate counter (Acolyte, Don Whitley Scientific, West Yorkshire, UK). Plates with 25-250 colonies were used to determine the bacteria titer in colony forming units (CFU).

**Example 10**

*Protocol for removal for pathogen inactivation on stainless steel and gloves:* Sterile stainless steel coupons (4 cm x 2.5 cm) were inoculated with 50 µl of MNV or HAV partially purified cell culture lysate (approximately 7 x $10^6$ PFU/ml stock) spread over the coupon with the pipette tip and 100 µl of Salmonella stock (approximately 6 x $10^8$ PFU/ml stock) as ten 10 µl inoculations before allowing to dry in a BSC-2 for 40 min at 21 °C or until visibly dry.

Coupons were placed on an electronic scale, sterilized by exposure to UV light for 15 minutes. For each repetition, 1 or 5 wiping motions was made over the inoculated area using a gloved hand at 50 ± 5 g pressure. All wipes were cut into 1.5x1.5 cm squares and autoclaved at 121 °C and 16 psi for 30 minutes before use.

Wipes tested included water filters containing nano-alumina fibers (NANOCERAM.RTM, Sanford, FL), charge modified glass fibers (VIROSORB.RTM 1MDS, Cuno, Meriden, CT) and cellulose filters (Millipore, Billerica, MA) and (Whatman, Kent, UK).

For wet wipes, each wipe was immersed into a 50 ml conical tube containing the desired sanitizer (2% levulinic acid plus 1% sodium dodecyl sulfate, 5% levulinic acid plus 2% sodium dodecyl sulfate, 5% levulinic acid plus 1% sodium dodecyl sulfate or 5% levulinic acid plus 2% sodium dodecyl sulfate) or water, removed with a pipet tip and gently squeezed by pressing the wipe against the side of the tube with the tip to remove excess moisture.

To mimic hand sanitation procedures, the index fingers of latex gloves decontaminated by UV light for 15 minutes were placed over a sterile 15 ml conical tube. The finger tip was inoculated with 10 µl of MNV stock (approximately $1x10^6$) and dried in a BSC-2 for 30 mins or until visibly dry. The tube was placed on an electronic scale and secured with tape. Wiping was performed as previously described.

**Example 11**

*Recovery of pathogen*: Post-wipe, coupons inoculated with MNV or HAV were immediately placed in a 50 ml tube containing 10 ml 0.1M PBS with 1M NaCl and vortexed for 30 secs to

neutralize the sanitizer. The eluate was plated in 1:10 dilutions on the cell culture using previously described methods. For *Salmonella*, coupons were placed in a stomacher bag (Seward, West Sussex, UK) containing 50 ml 0.1M PBS with 0.02% vol/vol TWEEN.RTM 80. Using a Seward stomacher 400 model (Seward, West Sussex, UK), the bags were stomached at 230 rpm for 1 minute. Homogenate was plated in 1:10 dilutions on TSA and XLT4 media as previously described. Duplicate cell culture plates for all pathogens were averaged and used to calculate titer after treatment. For a positive control, an inoculated coupon or latex glove finger was dried and pathogen was recovered without any wipe treatment. Negative controls, stainless steel without inoculation, were performed in duplicate and included with each experimental trial. Log reduction of pathogen was calculated as follows: log value of pfu recovered from wiped coupon or glove subtracted from the log value recovered from positive control.

**Example 12**

For MNV, dry wipes yielded <0.5 log reduction for all wipes regardless of surface charge (Fig. 1). While positively-charged NANOCERAM.RTM.RTM wipes had the highest log reduction value (0.49) after 5 wiping motions, no differences were found between the different types of wipes or the number of wiping motions ($p > 0.05$). For wipes soaked in water using 5 wiping motions, both types of positively charged wipes were capable of more MNV removal than dry wipes (1.30-1.33 avg. log reduction; $p \leq 0.03$), but no difference was observed for neutrally charged wipes (1.13 avg. log reduction; $p = 0.06$).

Wiping with positively charged wipes (5 wiping motions) soaked in different combinations of levulinic acid plus sodium dodecyl sulfate resulted in greater log reductions of MNV than did wiping with wipes soaked in water ($p > 0.05$) for all treatments except 5% levulinic acid plus 2% sodium dodecyl sulfate. Using 5 swiping motions, average log reductions were 2.29, 2.78, and 2.08 for NANOCERAM.RTM, 1MDS and Whatman at the 2% levulinic acid plus 1% sodium dodecyl sulfate level, and 2.71, 2.42, and 2.08 for the same wipes at the 5% Levulinic acid plus 2% sodium dodecyl sulfate level.

The greatest log reduction for MNV using wet wipes yielded as high as a 2.99 log reduction using the 1MDS wipe in combination with a 5% Levulinic acid/2% sodium dodecyl sulfate solution (as shown in Fig. 2) which was significantly greater than using the 1MDS wipe with water (1.30 average log reduction). No differences in MNV log reduction were observed between treatment with 5% levulinic acid plus 1% sodium dodecyl sulfate or 5% levulinic acid plus 2% sodium dodecyl sulfate. One wiping motion was less effective than 5 for nearly all experiments involving wet wipes.

Dry wipes tested with HAV yielded a maximum of 0.5 logs reduced using the positively charged 1MDS wipe with 5 wiping motions (as shown in Fig. 3). While a positive charge did not improve HAV removal from stainless steel surfaces, both positive and neutral

charge wipes were more effective than negatively charged (Millipore) wipes ($p = 0.002$) using 5 swiping motions.

For wipes soaked in water or 5% levulinic acid plus sodium dodecyl sulfate, all tests resulted in <1.5 average log reduction regardless of the ionic charge of the wipes, as shown in Fig. 4. Wipes soaked in levulinic acid plus sodium dodecyl sulfate did not provide significantly greater log reduction of HAV than was achieved using water ($p \geq 0.05$).

Neutral charge, dry, Whatman wipes yielded a maximum reduction of 0.59 logs using 5 wiping motions for *Salmonella enterica,* (Fig. 5). However, this value was not significantly greater than the log reduction achieved by the positive or negative charge wipes ($p \geq 0.21$). For wet wipes, the positively charged NANOCERAM.RTM and 1MDS wipes did not show a significant increase over the neutral Whatman wipe (Fig. 6). All tests yielded <2 log reduction regardless of the charge or number of wipes made. Comparison among NANOCERAM.RTM and 1MDS vs. Whatman wipes soaked in water of Lev plus sodium dodecyl sulfate showed no significant difference in log reduction ($p \geq 0.05$). Comparison of 1 or 5 wiping motions yielded a significant difference using Whatman wipes with water for both 1 and 5 swiping motions ($p \leq 0.02$).

Positive charge NANOCERAM.RTM and 1MDS and neutral charge Whatman wipes all yielded <1 log reduction of MNV on latex gloved hands, as shown in Fig. 7. No significant differences were observed regardless of the charge of the wipe, treatment of the wipe or number of swiping motions ($p \geq 0.05$).

## CLAIMS

What is claimed:

1. A liquid antimicrobial composition comprising:

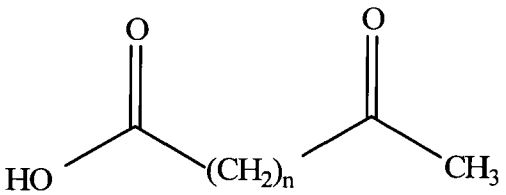
a surfactant, wherein the total concentration of surfactant in said composition is about 0.05% to about 5% by weight per volume of solvent; and

a monoprotic organic acid comprising a carbon backbone of 3 to 13 carbons, wherein the total concentration of the acid in said antimicrobial composition is about 0.2% to about 20% by weight per volume of solvent;

and a solvent,

wherein the antimicrobial composition is effective in reducing the viability of a virus population.

2. The antimicrobial composition of claim 1 wherein said monoprotic organic acid has the general structure of:

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wherein n is an integer selected from 1 to 10.

3. The antimicrobial composition of claim 1, wherein said surfactant is an anionic surfactant selected from the group consisting of: sodium dodecyl sulfate, sodium laureth sulfate, cetylpyridinium chloride, cetylpyridinium bromide, and benzalkonium chloride.

4. The antimicrobial composition of claim 1, wherein the antimicrobial composition is formed as a foam having a cylinder foam test half life of at least ten minutes.

5. The antimicrobial composition of claim 1, wherein the surfactant is sodium dodecyl sulfate.

6. The antimicrobial composition of claim 1, wherein the monoprotic organic acid is levulinic acid.

7. The antimicrobial composition of claim 1, wherein the solvent is water or an alcohol:water mix, wherein the alcohol is selected from the group consisting of ethanol, propanol, butanol, propylene glycol, diethylene glycol, dipropylene glycol, or any mixture thereof.

8. The antimicrobial composition of claim 1, wherein the composition further comprises a cationic agent selected from the group consisting of: benzalkonium chloride, benzethonium chloride, triclocarban, tricolsan, chlorhexidine, and any combination thereof.f

9. The antimicrobial composition of claim 1, wherein the composition consists essentially of about 0.5% to about 5% sodium dodecyl sulfate by weight per volume solvent, about 2% to about 20% levulinic acid by weight per volume solvent, and the solvent.

10. The antimicrobial composition of claim 1, wherein the composition consists essentially of about 5% sodium dodecyl sulfate by weight per volume solvent and about 5% levulinic acid by weight per volume solvent.

11. The antimicrobial composition of claim 1, wherein the composition consists essentially of about 2% sodium dodecyl sulfate by weight per volume solvent and about 5% levulinic acid by weight per volume solvent.

12. A composition substantially free of a solvent and comprising:

a surfactant; and

a monoprotic organic acid comprising a carbon backbone of 3 to 13 carbons,

wherein the pharmaceutically acceptable surfactant and the monoprotic organic acid are in a weight ratio of between about 1:200 to about 16.6:1, and wherein when the composition is mixed with a solvent provides an antimicrobial composition effective in reducing the viability of a virus population.

13. The composition of claim 12, wherein the composition consists essentially of a surfactant and a monoprotic organic acid, and wherein the surfactant is sodium dodecyl sulfate, and the monoprotic organic acid is levulinic acid.

14. The composition of claim 13, wherein the weight ratio of the sodium dodecyl sulfate to the levulinic acid is about 1:2 to about 1:5.

15. A method of reducing the viability of a population of viruses, said method comprising obtaining an antimicrobial composition comprising about 0.5% to about 5% sodium dodecyl sulfate by weight per volume in water and about 2% to about 5% levulinic acid by weight per volume in water and contacting a population of viruses with said antimicrobial composition, whereby the viability of the

16. The method of claim 15, wherein the virus population is disposed on a non-liquid surface.

17. The method of claim 15, wherein the composition consists essentially of about 5% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

18. The method of claim 15, wherein the composition consists essentially of about 2% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

19. The method of claim 15, wherein the composition is disposed on a flexible base material and the composition is applied to a surface desired to have a reduced viable viral load thereon.

20. The method of claim 19, wherein the flexible base material includes a positive ionic charge thereon.

21. The method of claim 15, wherein the antimicrobial composition is applied to a virus population as a liquid wash, a spray, a foam, a paste, a cream, a gel, or a wipe.

22. A sanitizing wipe comprising an flexible base support material and an antimicrobial composition absorbed thereon, wherein the antimicrobial composition comprises (i) a surfactant, wherein the total concentration of surfactant in said composition is about 0.05% to about 5% by weight per volume of solvent, and (ii) a monoprotic organic acid comprising a carbon backbone of 3 to 13 carbons, wherein the total concentration of the acid in said antimicrobial composition is about 0.2% to about 20% by weight per volume of solvent, and wherein the antimicrobial composition is effective in reducing the viability of a virus population.

23. The sanitizing wipe of claim 22, wherein the flexible base support material has a surface positive charge thereon.

24. The sanitizing wipe of claim 22, wherein the antimicrobial composition consists essentially of about 0.5% to about 5% sodium dodecyl sulfate by weight per volume in water and about 2% to about 20% levulinic acid by weight per volume in water.

25. The sanitizing wipe of claim 22, wherein the composition consists essentially of about 5% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

26. The sanitizing wipe of claim 22, wherein the composition consists essentially of about 5% sodium dodecyl sulfate by weight per volume in water and about 5% levulinic acid by weight per volume in water.

Sheet 1 of 9

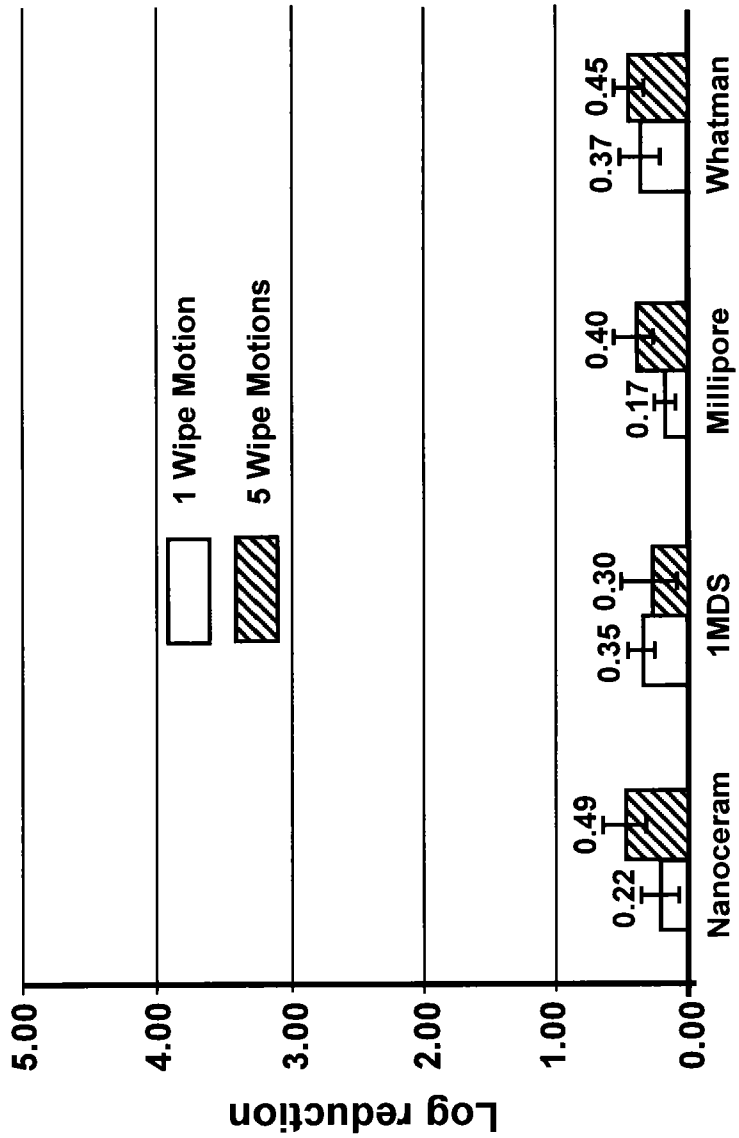
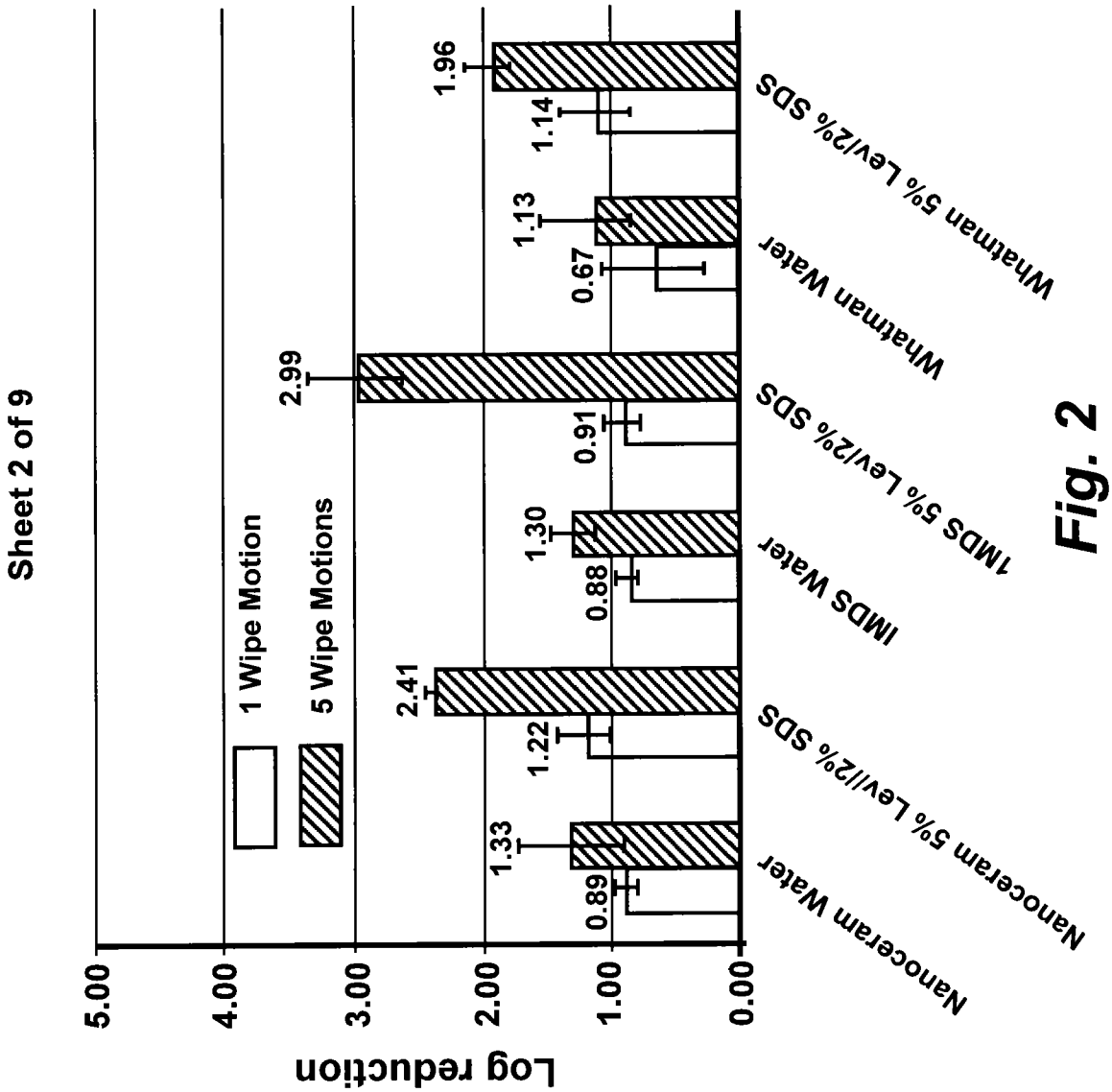



*Fig. 1*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0.91
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2.41
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1.33
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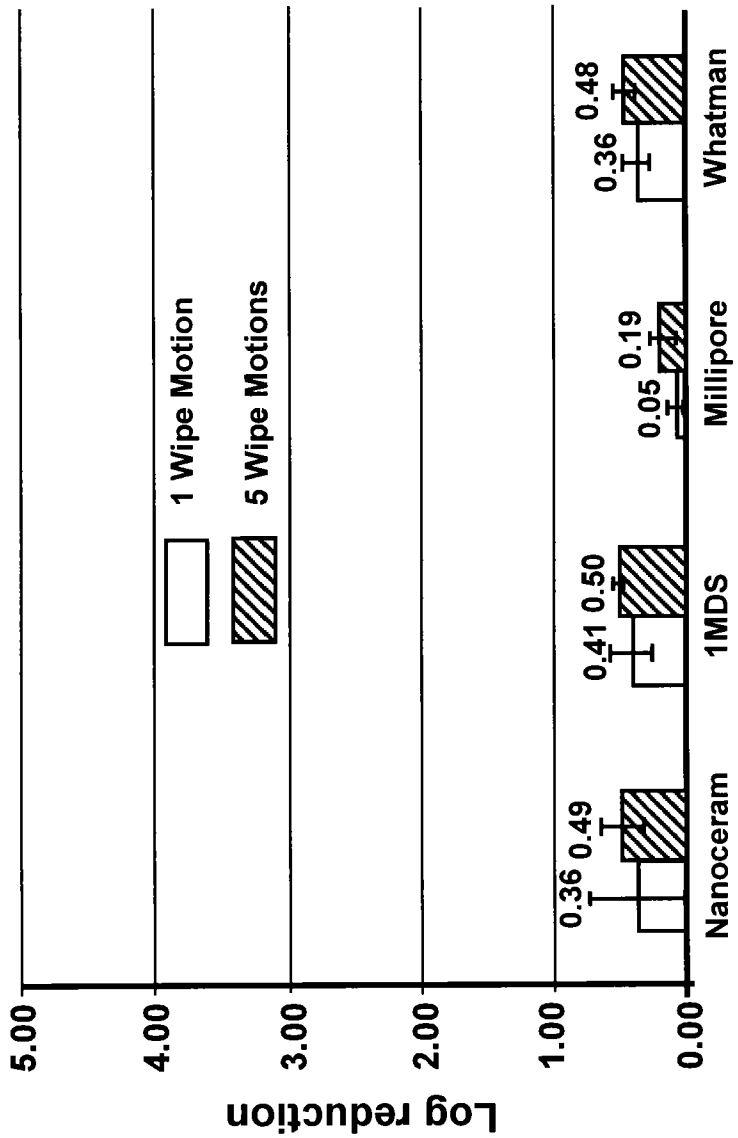
Whatman Water
Whatman 5% Lev/2% SDS

Fig. 2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1MDS
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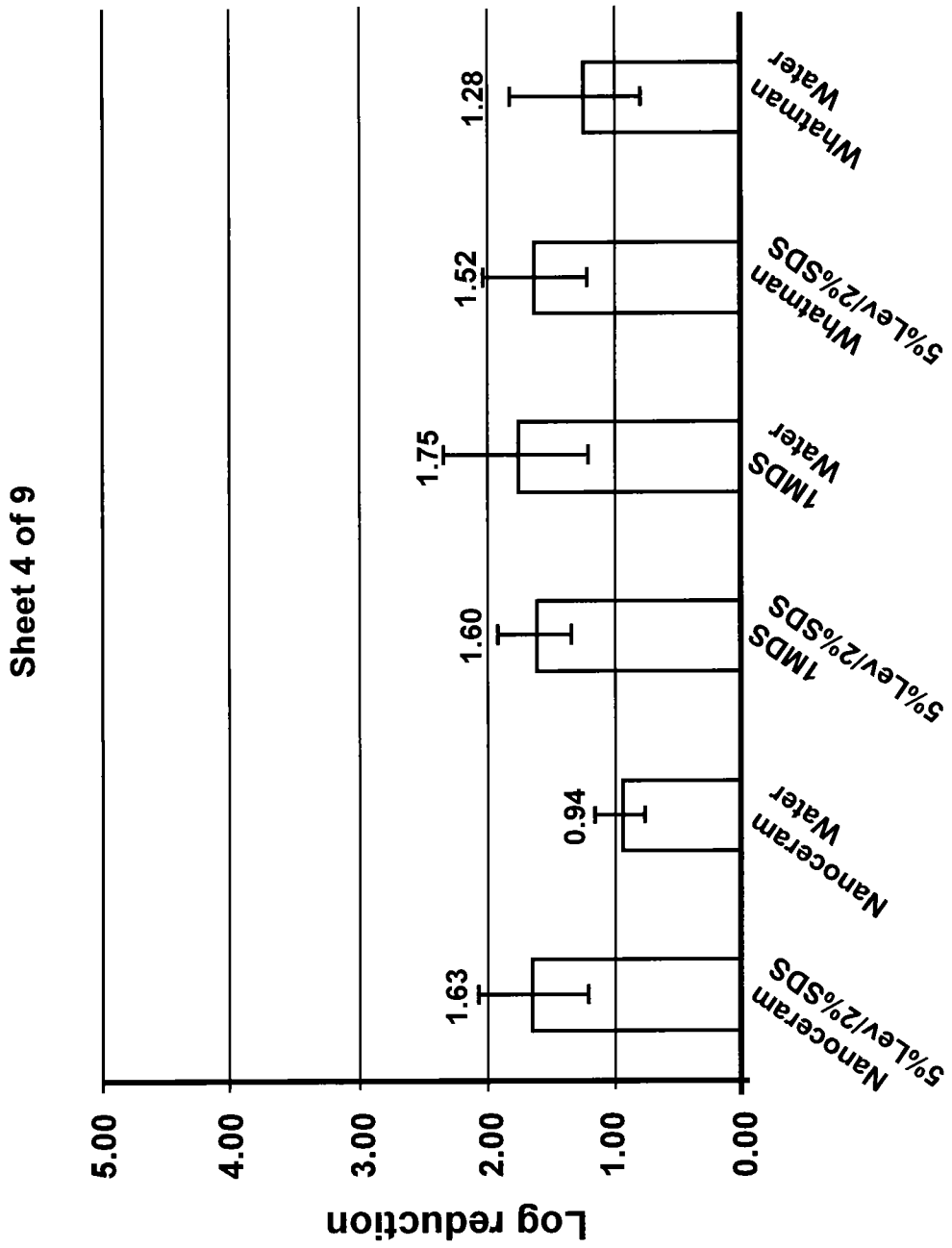
Whatman

*Fig. 3*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1.52
1.28
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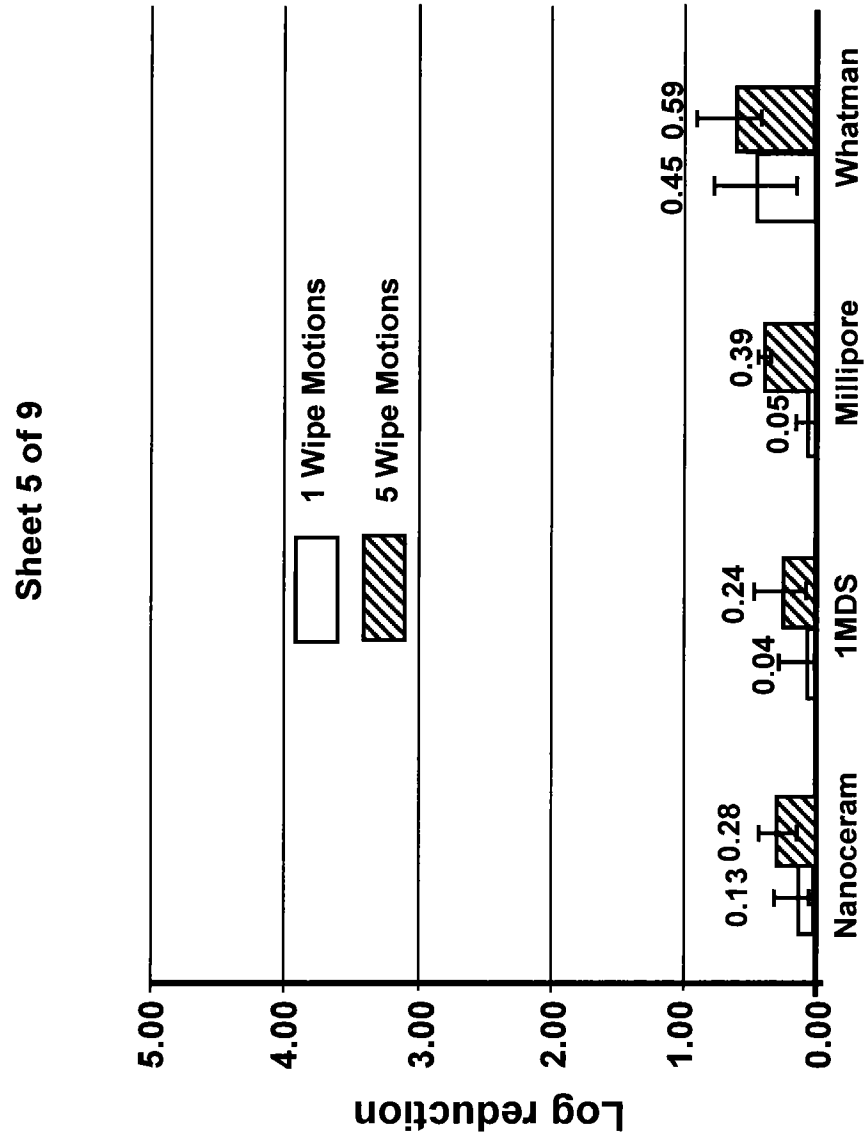
Whatman 5%Lev/2%SDS
Whatman Water

Fig. 4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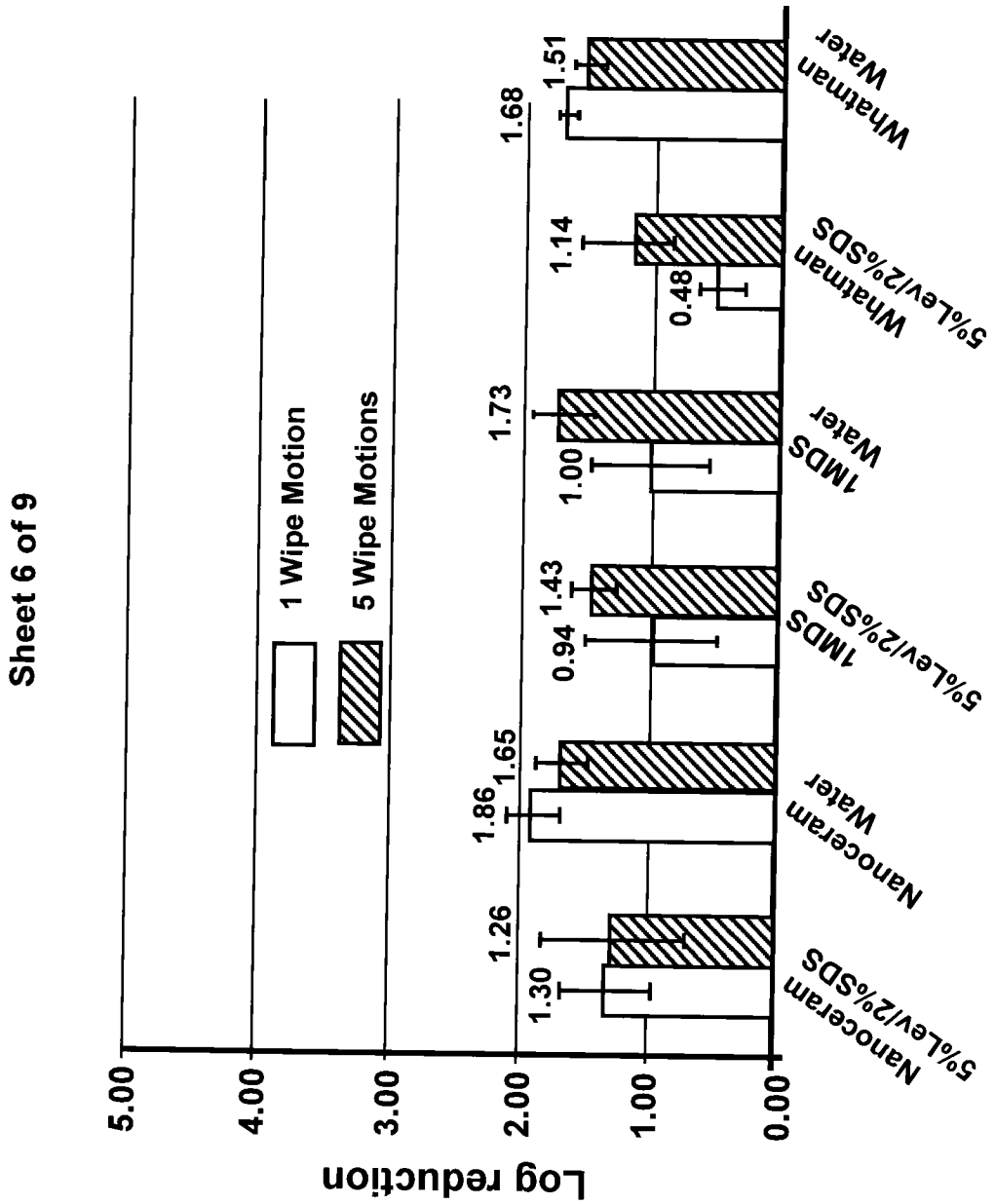
Nanoceram
1MDS
Millipore
Whatman

*Fig. 5*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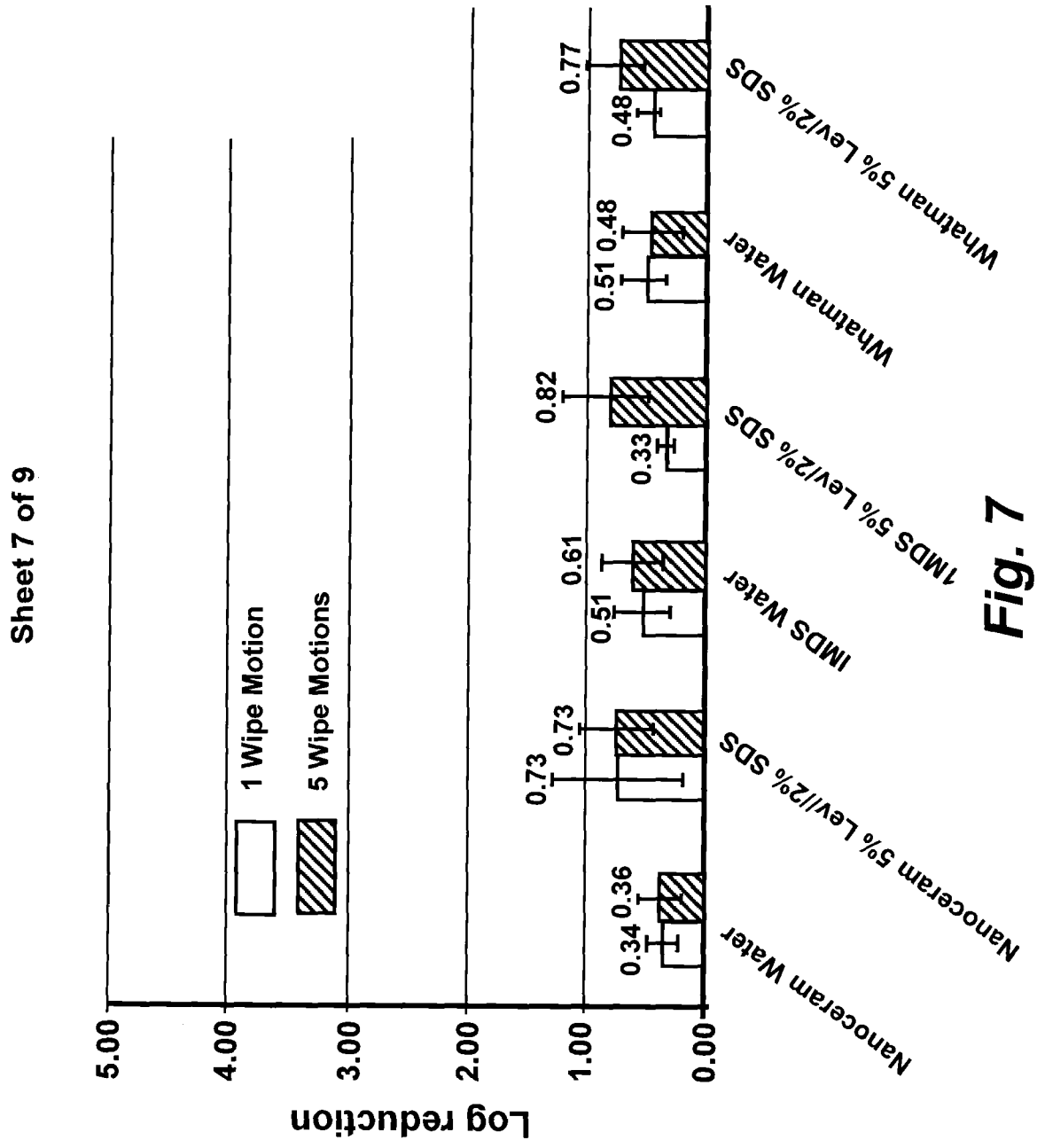
1.73
0.48
1.14
1.68
1.51
Nanoceram 5%Lev/2%SDS
Nanoceram Water
1MDS 5%Lev/2%SDS
1MDS Water
Whatman 5%Lev/2%SDS
Whatman Water

Fig. 6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3.00
2.00
1.00
0.00
0.34
0.36
0.73
0.73
0.51
0.61
0.33
0.82
0.51
0.48
0.48
0.77
Nanoceram Water
Nanoceram 5% Lev//2% SDS
IMDS Water
IMDS 5% Lev/2% SDS
Whatman Water
Whatman 5% Lev/2% SDS

Fig. 7

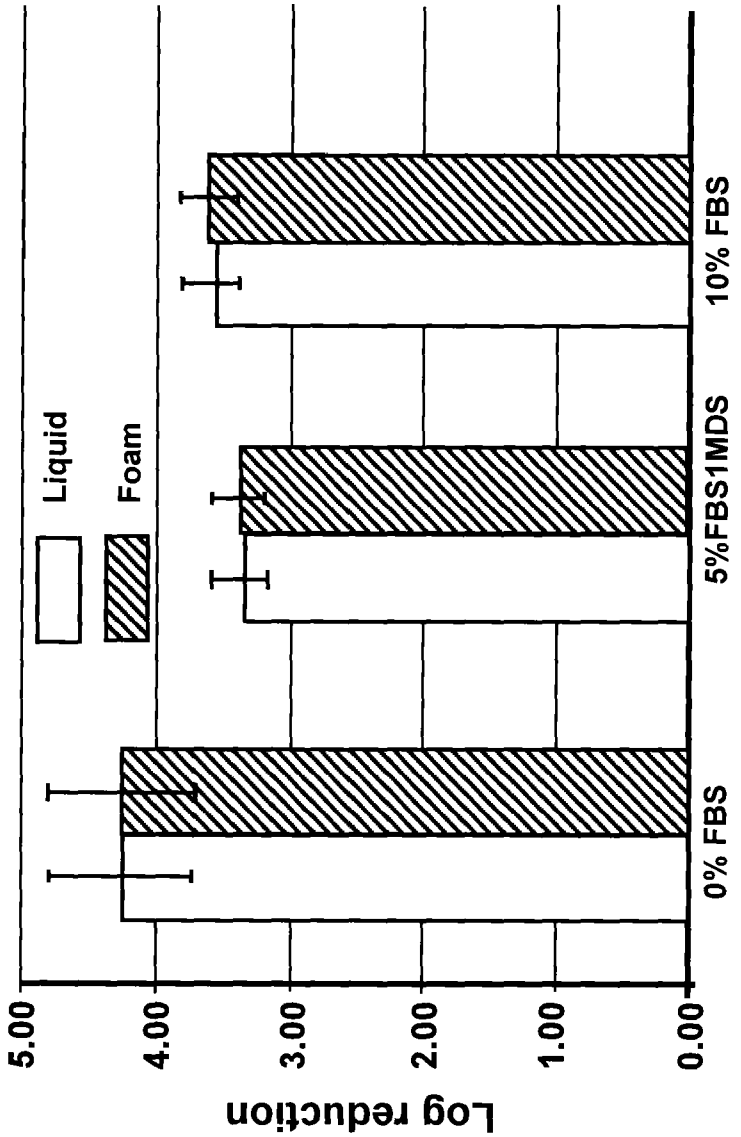
Log reduction
5.00
4.00
3.00
2.00
1.00
0.00
Liquid
Foam
0% FBS
5%FBS1MDS
10% FBS

*Fig. 8*

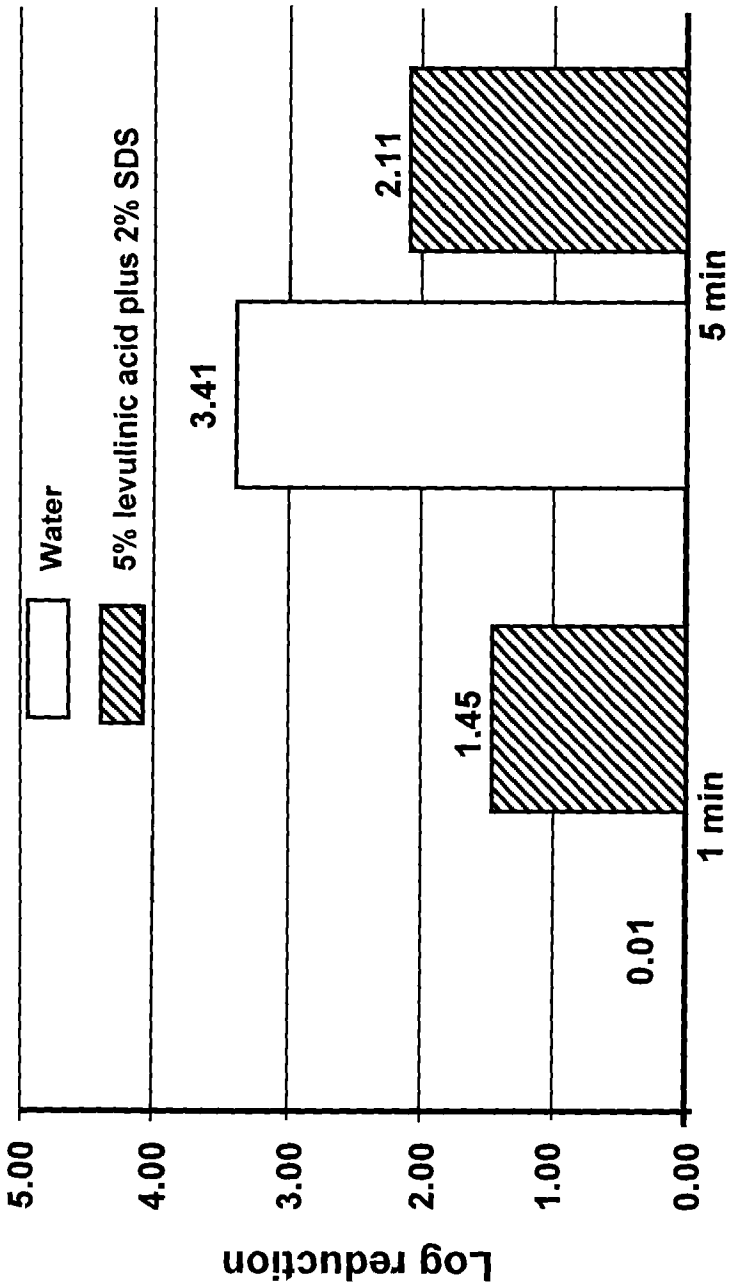
Water
5% levulinic acid plus 2% SDS
Log reduction
5.00
4.00
3.00
2.00
1.00
0.00
3.41
2.11
1.45
0.01
5 min
1 min

*Fig. 9*