



US 20150328116A1

(19) **United States**

(12) **Patent Application Publication**

**Patel et al.**

(10) **Pub. No.: US 2015/0328116 A1**

(43) **Pub. Date: Nov. 19, 2015**

(54) **ORAL CARE COMPOSITION CONTAINING IONIC LIQUIDS**

**Publication Classification**

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(51) **Int. Cl.**  
*A61K 8/49* (2006.01)  
*A61K 8/36* (2006.01)  
*A61K 8/46* (2006.01)  
*A61Q 11/00* (2006.01)  
*A61K 8/55* (2006.01)

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(52) **U.S. Cl.**  
CPC ..... *A61K 8/4946* (2013.01); *A61Q 11/00* (2013.01); *A61K 8/55* (2013.01); *A61K 8/463* (2013.01); *A61K 8/36* (2013.01); *A61K 8/466* (2013.01); *A61K 2800/70* (2013.01)

(21) Appl. No.: **14/654,316**

(22) PCT Filed: **Dec. 20, 2012**

(86) PCT No.: **PCT/US2012/070949**

§ 371 (c)(1),  
(2) Date: **Jun. 19, 2015**

(57) **ABSTRACT**

The present invention relates to oral care compositions comprising an ionic liquid where the ionic liquid contains an imidazolium cation and to a method of removing or reducing plaque using said oral care composition.

## ORAL CARE COMPOSITION CONTAINING IONIC LIQUIDS

### BACKGROUND OF THE INVENTION

**[0001]** An ionic liquid is a class of salt comprising a cation and an anion that is in liquid at a temperature of 100° C. or less and commonly have melting points below room temperature. While not wishing to be bound by theory, ionic liquids generally have much lower symmetry than conventional salts and the charge of cation and anion is distributed over a larger volume of the molecule by resonance in ionic liquids which is thought to contribute to their liquid state at much lower temperatures than conventional salts (e.g. NaCl, mp 801° C.). Ionic liquids are often composed of a cation comprising a heterocyclic ring and a counter anion, often inorganic in nature. The nature of the cation and anion will determine the hydrophobicity, viscosity, density and other physical parameters and properties of the ionic liquid.

**[0002]** Ionic liquids have been evaluated as environmentally-friendly or 'green' alternatives to conventional organic solvents for a wide range of organic synthetic applications. Ionic liquids have unique characteristics that distinguish them from conventional organic solvents. For example, ionic liquids are non-volatile (i.e. they do not evaporate readily into the atmosphere), they have a high polarity and charge density, they may be hydrophobic or hydrophilic, and they have unique solvating properties. As such, ionic liquids are known to be used in cleaning compositions (for example, as disclosed in US 2006/0090777 A1 and U.S. Pat. No. 7 939 485 B2). A range of ionic liquids are commercially available, or they may be readily synthesized by simple ion-exchange reactions.

**[0003]** A biofilm is a structured group of microorganisms encapsulated within a self-developed polymeric extracellular matrix. Biofilms are typically adhered to a living or inert surface. In the human or animal body biofilms can form on any internal or external surface. Biofilms have been found to be involved in a wide variety of microbial infections in the body and cause a number of conditions including urinary tract infections, middle-ear infections, and in particular, diseases of the oral cavity.

**[0004]** Dental plaque is formed from a biofilm precursor, and is present to some degree on virtually all dental surfaces whether in the oral cavity or on dental instruments used by dentists and hygienists. It comprises a dense microbial layer consisting of a mass of microorganisms embedded in a polysaccharide matrix. Plaque may form on any part of the tooth surface, and is found particularly at the gingival margin, and in cracks in the enamel. The danger associated with the formation of plaque on the teeth lies in the tendency of plaque to build up and eventually produce gingivitis, periodontitis and other types of periodontal disease, as well as dental caries and dental calculus.

**[0005]** Plaque itself adheres very firmly to dental surfaces and rapidly reforms on the tooth surface after it is removed. Current plaque removal methods rely primarily on the mechanical removal of plaque. These methods, which include brushing, brushing with an abrasive toothpaste, flossing, using interdental cleaners, scraping, using sonic energy (e.g. Sonicare toothbrushes) and ultrasound (e.g. Ulteo toothbrushes), in part, rely on a good brushing or flossing technique which many consumers simply do not possess. Moreover, these methods are particularly inefficient in removing

stubborn plaque, or plaque hidden deep within cavities and fissures of teeth, between teeth, or within gum pockets.

**[0006]** It is also known in the art to incorporate antimicrobial agents in oral compositions which destroy or retard the growth of bacteria. However, bacteria present in a biofilm or plaque deposit exhibit increased resistance to antimicrobial agents because the dense extracellular matrix and the outer layer of cells protect the bacteria found in the interior of the deposit from the effects of the antimicrobial agents.

**[0007]** There is therefore the need to provide improved methods and compositions for removing plaque which mitigate some of the inefficiencies resulting from a poor brushing/flossing technique and which effectively remove plaque hidden between teeth, within cavities and fissures of teeth, and in gum pockets.

### BRIEF SUMMARY OF THE INVENTION

**[0008]** The present invention aims at least partially to meet these needs in the art.

**[0009]** In a first aspect, the present invention provides an oral care composition comprising an ionic liquid, wherein the ionic liquid comprises:

**[0010]** a) an imidazolium cation and

**[0011]** b) an anion selected from the group consisting of salicylate, acetate, halide, phosphate, alkyl phosphate, phosphonate, pyrophosphate, hexametaphosphate, poly-metaphosphate, orthophosphate, tripolyphosphate, sulfate, alkyl sulfate (e.g. methylsulfate, ethylsulfate), lauryl sulfate, phenolsulfate, benzoate, acetylacetonate, carboxylate, citrate, ascorbate, dicyamide, L- or D-amino acids (e.g. arginate, glycinate, proline, etc.), glycolate, gluconate, maleate, sweetener anions (e.g. saccharinate, aspartamate, cyclamate), hydroxide, succinate, tartrate, docosate, linoleate, oleate and tosylate.

**[0012]** Typically, the cation is an imidazolium ion having the formula 1-R<sup>1</sup>-2-R<sup>2</sup>-3-R<sup>3</sup>-imidazolium, wherein R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected from H, alkyl and alkenyl.

**[0013]** Optionally, R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected from H, C<sub>1-22</sub> alkyl and C<sub>2-22</sub> alkenyl. In another embodiment, R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected from H, C<sub>12-22</sub> alkyl and C<sub>12-22</sub> alkenyl. In still another embodiment, R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected from H, C<sub>1-8</sub> alkyl and C<sub>2-8</sub> alkenyl. In yet another embodiment, R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected from H, C<sub>14</sub> alkyl and C<sub>24</sub> alkenyl. Further optionally, R<sup>1</sup> and R<sup>3</sup> are independently selected from C<sub>1-10</sub> alkyl and C<sub>2-10</sub> alkenyl, and R<sup>2</sup> is independently selected from, H, C<sub>1-10</sub> alkyl and C<sub>2-10</sub> alkenyl.

**[0014]** Still further optionally, the C<sub>1-10</sub> alkyl and C<sub>2-10</sub> alkenyl are linear.

**[0015]** Optionally, R<sup>1</sup> is C<sub>6-10</sub> alkyl or C<sub>6-10</sub> alkenyl. Further optionally, R<sup>3</sup> is methyl.

**[0016]** Typically, R<sup>2</sup> is H.

**[0017]** Optionally, R<sup>1</sup> is selected from ethyl, butyl, hexyl, decyl, and allyl.

**[0018]** Further optionally, the halide ion is a fluoride, chloride, bromide or iodide ion.

**[0019]** Still further optionally, the alkyl sulfate and alkyl phosphate comprise from 1 to 22 carbon atoms. Still further optionally, the alkyl sulfate and alkyl phosphate comprise 1 to 4 carbon atoms, or 6 to 10 carbon atoms or 12 to 22 carbon atoms. Typically, the anion is selected from the group consisting of acetate, bromide, chloride, methyl sulfate, ethyl sulfate, octyl sulfate, diethyl phosphate, and tosylate.

[0020] Optionally, the anion is selected from acetate, octyl sulfate or tosylate.

[0021] Optionally, the ionic liquid is selected from the group consisting of 1-ethyl-3-methylimidazolium (EMIM) chloride, EMIM bromide, EMIM ethyl sulfate, EMIM diethyl phosphate, EMIM acetate, EMIM tosylate, 1-butyl-3-methylimidazolium (BMIM) chloride, BMIM bromide, BMIM methyl sulfate, BMIM octyl sulfate, BMIM acetate, 1-allyl-3-methylimidazolium (AMIM) chloride, 1-decyl-3-methylimidazolium (DMIM) chloride, and 1,2,3-trimethylimidazolium (TMIM) methyl sulfate. Typically, the oral care composition comprises an abrasive in an amount of less than 0.1 wt % by total weight of the composition. Optionally, the oral care composition comprises an abrasive in an amount of less than 0.01 wt % by total weight of the composition. Further optionally, the oral care composition is substantially free of any abrasives.

[0022] Typically, the ionic liquid is present in the oral care composition in an amount of about 0.1 wt % to about 30 wt % based on the total weight of the composition. Optionally, the ionic liquid is present in the oral care composition in an amount of about 0.5 wt % to about 20 wt % based on the total weight of the composition. Further optionally, the ionic liquid is present in the oral care composition in an amount of about 5 wt % to about 15 wt % based on the total weight of the composition. Still further optionally, the ionic liquid is present in the oral care composition in an amount of about 8 wt % to about 10 wt % based on the total weight of the composition.

[0023] Typically the ionic liquid is present in the oral care composition at a concentration of about 1 mM to about 500 mM. Optionally, the ionic liquid is present in the oral care composition at a concentration of about 5 mM to about 300 mM. Further optionally, the ionic liquid is present in the oral care composition at a concentration of about 15 mM to about 250 mM or about 1 mM to about 50 mM.

[0024] Typically, the oral care composition comprises an orally acceptable carrier for a mouth rinse, toothpaste, oral beads or strips, irrigation fluid, plaque removal liquid, tongue spray, dental floss, candy, lozenge, chewing gum, patches (e.g. intra oral patch similar to smokeless tobacco pouches) and lollipop.

[0025] Typically, the oral care composition further comprises one or more agents selected from diluents, bicarbonate salts, pH modifying agents, surfactants, foam modulators, thickening agents, viscosity modifiers, humectants, sweeteners, flavorants, pigments, anticaries agents, anticalculus or tartar control agents, abrasives and mixtures thereof

[0026] Optionally, the oral care composition is for removing or reducing plaque, for teeth whitening, and/or for inhibiting the growth of bacteria.

[0027] Optionally, the oral care composition is for preventing or treating tooth decay, periodontal disease, gingivitis, or xerostomia (dry mouth).

[0028] In a second aspect, the present invention provides a method of removing or reducing plaque from the oral cavity of a subject comprising administering a therapeutically effective amount of a composition comprising at least one ionic liquid to the subject.

[0029] Optionally, the composition disrupts, detaches and/or dissolves plaque from the oral cavity.

[0030] Further optionally, the method comprises preventing or treating tooth decay, periodontal disease or gingivitis.

[0031] In a third aspect, the present invention provides a method of whitening teeth in a subject comprising administering a therapeutically effective amount of a composition comprising at least one ionic liquid to the subject.

[0032] Typically, in the methods of the present invention defined above, the ionic liquid comprises:

[0033] a) an imidazolium cation, and

[0034] b) an anion selected from the group consisting of salicylate, acetate, halide, phosphate, alkyl phosphate, phosphonate, pyrophosphate, hexametaphosphate, poly-metaphosphate, orthophosphate, tripolyphosphate, sulfate, alkyl sulfate (e.g. methylsulfate, ethylsulfate), lauryl sulfate, phenolsulfate, benzoate, acetylacetonate, carboxylate, citrate, ascorbate, dicyamide, L- or D-amino acids (e.g. arginate, glycinate, proline, etc.), glycolate, gluconate, maleate, sweetener anions (e.g. saccharinate, aspartamate, cyclamate), hydroxide, succinate, tartrate, docusate, linoleate, oleate and tosylate.

[0035] Typically, in the methods of the present invention defined above, the cation is an imidazolium ion having the formula 1-R<sup>1</sup>-2-R<sup>2</sup>-3-R<sup>3</sup>-imidazolium, wherein R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected from H, alkyl and alkenyl. Optionally, R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected H, C<sub>1-22</sub> alkyl and C<sub>2-22</sub> alkenyl. In another embodiment, R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected from H, C<sub>12-22</sub> alkyl and C<sub>12-22</sub> alkenyl. In still another embodiment, R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected from H, C<sub>1-8</sub> alkyl and C<sub>2-8</sub> alkenyl. In yet another embodiment, R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected from H, C<sub>1-4</sub> alkyl and C<sub>2-4</sub> alkenyl. Further optionally, R<sup>1</sup> and R<sup>3</sup> are independently selected from C<sub>1-10</sub> alkyl and C<sub>2-10</sub> alkenyl, and R<sup>2</sup> is independently selected from H, C<sub>1-10</sub> alkyl and C<sub>2-10</sub> alkenyl.

[0036] Still further optionally, the C<sub>1-10</sub> alkyl and C<sub>2-10</sub> alkenyl are linear.

[0037] Optionally, R<sup>1</sup> is C<sub>6-10</sub> alkyl or C<sub>6-10</sub> alkenyl. Further optionally, R<sup>3</sup> is methyl.

[0038] Typically, R<sup>2</sup> is H.

[0039] Optionally, R<sup>1</sup> is ethyl, R<sup>2</sup> is H and R<sup>3</sup> is methyl.

[0040] Optionally, in the methods of the present invention, R<sup>1</sup> is selected from ethyl, butyl, hexyl, decyl, and allyl.

[0041] Further optionally, in the methods of the present invention, the halide ion is a chloride ion or a bromide ion.

[0042] Still further optionally, the alkyl sulfate and alkyl phosphate comprise from 1 to 22 carbon atoms. Still further optionally, the alkyl sulfate and alkyl phosphate comprise 1 to 4 carbon atoms, or 6 to 10 carbon atoms or 12 to 22 carbon atoms. Typically, in the methods of the present invention, the anion is selected from the group consisting of acetate, bromide, chloride, methyl sulfate, ethyl sulfate, octyl sulfate, diethyl phosphate, and tosylate. Optionally, the anion is selected from acetate, octyl sulfate or tosylate.

[0043] Optionally, in the methods of the present invention, the ionic liquid is selected from the group consisting of 1-ethyl-3-methylimidazolium (EMIM) chloride, EMIM bromide, EMIM ethyl sulfate, EMIM diethyl phosphate, EMIM acetate, EMIM tosylate, 1-butyl-3-methylimidazolium (BMIM) chloride, BMIM bromide, BMIM methyl sulfate, BMIM octyl sulfate, BMIM acetate, 1-allyl-3-methylimidazolium (AMIM) chloride, 1-decyl-3-methylimidazolium (DMIM) chloride, and 1,2,3-trimethylimidazolium (TMIM) methyl sulfate.

[0044] Typically, in the methods of the present invention, the composition comprises an abrasive in an amount of less than 0.1 wt % by total weight of the composition. Optionally,

the composition comprises an abrasive in an amount of less than 0.01 wt % by total weight of the composition. Further optionally, composition is substantially free of any abrasives.

**[0045]** Typically, in the methods of the present invention, the ionic liquid is present in the composition in an amount of about 0.1 wt % to about 30 wt % based on the total weight of the composition. Optionally, the ionic liquid is present in the composition in an amount of about 0.5 wt % to about 20 wt % based on the total weight of the composition. Further optionally, the ionic liquid is present in the composition in an amount of about 5 wt % to about 15 wt % based on the total weight of the composition. Still further optionally, the ionic liquid is present in the composition in an amount of about 8 wt % to about 10 wt % based on the total weight of the composition.

**[0046]** Typically, in the methods of the present invention, the ionic liquid is present in the composition at a concentration of about 1 mM to about 500 mM. Optionally, the ionic liquid is present in the composition at a concentration of about 5 mM to about 300 mM. Further optionally, the ionic liquid is present in the composition at a concentration of about 15 mM to about 250 mM or about 1 mM to about 50 mM.

**[0047]** Typically, in the methods of the present invention, the composition comprises an orally acceptable carrier for a mouth rinse, toothpaste, oral beads or strips, irrigation fluid, plaque removal liquid, tongue spray, dental floss, candy, lozenge, chewing gum, patches (e.g. intra oral patch similar to smokeless tobacco pouches) and lollipop.

**[0048]** Typically, in the methods of the present invention, the composition further comprises one or more agents selected from diluents, bicarbonate salts, pH modifying agents, surfactants, foam modulators, thickening agents, viscosity modifiers, humectants, sweeteners, flavorants, pigments, anticaries agents, anticalculus or tartar control agents, abrasives and mixtures thereof. In a fourth aspect, the present invention provides a method of reducing the amount of bacteria in the oral cavity of a subject comprising administering a therapeutically effective amount of a composition comprising at least one ionic liquid to the subject, wherein the ionic liquid comprises:

**[0049]** a) an imidazolium cation

**[0050]** and

**[0051]** b) an anion selected from the group consisting of salicylate, acetate, halide, phosphate, alkyl phosphate, phosphonate, pyrophosphate, hexametaphosphate, poly-metaphosphate, orthophosphate, tripolyphosphate, sulfate, alkyl sulfate (e.g. methylsulfate, ethylsulfate), lauryl sulfate, phenolsulfate, benzoate, acetylacetonate, carboxylate, citrate, ascorbate, dicyamide, L- or D-amino acids (e.g. arginate, glycinate, prolinatate, etc.), glycolate, gluconate, maleate, sweetener anions (e.g. saccharinate, aspartamate, cyclamate), hydroxide, succinate, tartrate, docosate, linoleate, oleate and tosylate.

**[0052]** Typically, in the method of the present invention, the cation is an imidazolium ion having the formula  $1-R^1-2-R^2-3-R^3$ -imidazolium, wherein  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H, alkyl and alkenyl.

**[0053]** Optionally,  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H,  $C_{1-22}$  alkyl and  $C_{2-22}$  alkenyl. In another embodiment,  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H,  $C_{12-22}$  alkyl and  $C_{12-22}$  alkenyl. In still another embodiment,  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H,  $C_{1-8}$

alkyl and  $C_{2-8}$  alkenyl. In yet another embodiment,  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H,  $C_{1-4}$  alkyl and  $C_{2-4}$  alkenyl.

**[0054]** Further optionally,  $R^1$  and  $R^3$  are independently selected from  $C_{1-10}$  alkyl and  $C_{2-10}$  alkenyl, and  $R^2$  is independently selected from, H,  $C_{1-10}$  alkyl and  $C_{2-10}$  alkenyl.

**[0055]** Still further optionally, the  $C_{1-10}$  alkyl and  $C_{2-10}$  alkenyl are linear.

**[0056]** Optionally,  $R^1$  is  $C_{6-10}$  alkyl or  $C_{6-10}$  alkenyl. Further optionally,  $R^3$  is methyl.

**[0057]** Typically,  $R^2$  is H.

**[0058]** Optionally,  $R^1$  is decyl,  $R^2$  is H, and  $R^3$  is methyl

**[0059]** Optionally, in the method of the present invention,  $R^1$  is selected from ethyl, butyl, hexyl, decyl, and allyl.

**[0060]** Further optionally, in the method of the present invention, the halide ion is a chloride ion or a bromide ion.

**[0061]** Still further optionally, the alkyl sulfate and alkyl phosphate comprise from 1 to 22 carbon atoms. Still further optionally, the alkyl sulfate and alkyl phosphate comprise 1 to 4 carbon atoms, or 6 to 10 carbon atoms or 12 to 22 carbon atoms. Typically, in the method of the present invention, the anion is selected from the group consisting of acetate, bromide, chloride, methyl sulfate, ethyl sulfate, octyl sulfate, diethyl phosphate, and tosylate. Optionally, the anion is selected from acetate, octyl sulfate or tosylate.

**[0062]** Optionally, in the method of the present invention, the ionic liquid is selected from the group consisting of 1-ethyl-3-methylimidazolium (EMIM) chloride, EMIM bromide, EMIM ethyl sulfate, EMIM diethyl phosphate, EMIM acetate, EMIM tosylate, 1-butyl-3-methylimidazolium (BMIM) chloride, BMIM bromide, BMIM methyl sulfate, BMIM octyl sulfate, BMIM acetate, 1-allyl-3-methylimidazolium (AMIM) chloride, 1-decyl-3-methylimidazolium (DMIM) chloride, and 1,2,3-trimethylimidazolium (TMIM) methyl sulfate.

**[0063]** Typically, in the method of the present invention, the composition comprises an abrasive in an amount of less than 0.1 wt % by total weight of the composition. Optionally, the composition comprises an abrasive in an amount of less than 0.01 wt % by total weight of the composition. Further optionally, composition is substantially free of any abrasives.

**[0064]** Typically, in the method of the present invention, the ionic liquid is present in the composition in an amount of about 0.1 wt % to about 30 wt % based on the total weight of the composition. Optionally, the ionic liquid is present in the composition in an amount of about 0.5 wt % to about 20 wt % based on the total weight of the composition. Further optionally, the ionic liquid is present in the composition in an amount of about 5 wt % to about 15 wt % based on the total weight of the composition. Still further optionally, the ionic liquid is present in the composition in an amount of about 8 wt % to about 10 wt % based on the total weight of the composition.

**[0065]** Typically, in the method of the present invention, the ionic liquid is present in the composition at a concentration of about 1 mM to about 500 mM. Optionally, the ionic liquid is present in the composition at a concentration of about 5 mM to about 300 mM. Further optionally, the ionic liquid is present in the composition at a concentration of about 150 mM to about 250 mM or about 1 mM to about 50 mM.

**[0066]** Typically, in the method of the present invention, the composition comprises an orally acceptable carrier for a mouth rinse, toothpaste, oral beads or strips, irrigation fluid, plaque removal liquid, tongue spray, dental floss, candy, loz-

enge, chewing gum, patches (e.g. intra oral patch similar to smokeless tobacco pouches) and lollipop. If used in animals or pets, veterinary pastes, chewables or treats may also be used as the orally acceptable carrier.

**[0067]** Typically, in the method of the present invention, the composition further comprises one or more agents selected from diluents, bicarbonate salts, pH modifying agents, surfactants, foam modulators, thickening agents, viscosity modifiers, humectants, sweeteners, flavorants, pigments, anticaries agents, anticalculus or tartar control agents, abrasives and mixtures thereof. Optionally, the method further comprises preventing or treating tooth decay, periodontal disease, gingivitis or xerostomia (dry mouth).

**[0068]** In a fifth aspect, the present invention provides a use of an ionic liquid, in an oral care composition, for removing or reducing plaque in the oral cavity of a subject.

**[0069]** In a sixth aspect, the present invention provides a use of an ionic liquid, in an oral care composition, for whitening teeth in the oral cavity of a subject.

**[0070]** In a seventh aspect, the present invention provides a use of an ionic liquid, in an oral care composition, for reducing the amount of bacteria the oral cavity of a subject, wherein the ionic liquid comprises:

**[0071]** a) an imidazolium cation

**[0072]** and

**[0073]** b) an anion selected from the group consisting of salicylate, acetate, halide, phosphate, alkyl phosphate, phosphonate, pyrophosphate, hexametaphosphate, poly-metaphosphate, orthophosphate, triphosphosphate, sulfate, alkyl sulfate (e.g. methylsulfate, ethylsulfate), lauryl sulfate, phenolsulfate, benzoate, acetylacetonate, carboxylate, citrate, ascorbate, dicyanamide, L- or D-amino acids (e.g. arginate, glycinate, proline, etc.), glycolate, gluconate, maleate, sweetener anions (e.g. saccharinate, aspartamate, cyclamate), hydroxide, succinate, tartrate, docosate, linoleate, oleate and tosylate. Further embodiments of the invention will be apparent from the detailed description and the examples.

#### DESCRIPTION OF THE INVENTION

**[0074]** It should be understood that the detailed description, and specific examples, while indicating embodiments of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

**[0075]** As used throughout, ranges are used as shorthand for describing each and every value that is within the range. Any value within the range can be selected as the terminus of the range.

**[0076]** As used herein, the words “preferred” and “preferably” refer to embodiments of the invention that afford certain benefits, under certain circumstances. However, other embodiments may also be preferred, under the same or other circumstances. Furthermore, the recitation of one or more preferred embodiments does not imply that other embodiments are not useful, and is not intended to exclude other embodiments from the scope of the invention.

**[0077]** As used herein, the term “about,” when applied to the value for a parameter of a composition or method of this invention, indicates that the calculation or the measurement of the value allows some slight imprecision without having a substantial effect on the chemical or physical attributes of the composition or method. If, for some reason, the imprecision provided by “about” is not otherwise understood in the art

with this ordinary meaning, then “about” as used herein indicates a possible variation of up to 5% in the value.

**[0078]** As referred to herein, all compositional percentages are by weight of the total composition, unless otherwise specified.

**[0079]** In some embodiments, the present invention provides an oral care composition comprising an ionic liquid, wherein the ionic liquid comprises:

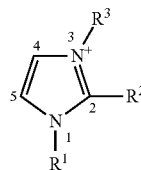
**[0080]** a) an imidazolium cation, and

**[0081]** b) an anion selected from the group consisting of salicylate, acetate, halide, phosphate, alkyl phosphate, sulfate, alkyl sulfate, and tosylate.

#### Imidazolium

**[0082]** An imidazolium cation in the context of this application may optionally have substituents including H, alkyl, alkenyl or aryl at positions 1 to 5.

**[0083]** In some embodiments, the imidazolium ion has the formula 1-R<sup>1</sup>-2-R<sup>2</sup>-3-R<sup>3</sup>-imidazolium, represented by the structure below, wherein R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected from H, alkyl and alkenyl.



**[0084]** As used herein, the term “alkyl” refers to a saturated aliphatic hydrocarbon, including straight-chain, branched-chain and cycloalkyl groups of 1 to 20 carbon atoms. Alkyl groups include methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl and decyl.

**[0085]** As used herein, the term “cycloalkyl” refers to a C<sub>3-8</sub> cyclic hydrocarbon.

**[0086]** As used herein, the term “alkenyl” refers to an unsaturated, open chain hydrocarbon with 2 to 20 carbon atoms and with one or more carbon-carbon double bonds. For example, alkenyl groups include allyl and vinyl.

**[0087]** R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> may be the same or different. The alkyl or alkenyl groups mentioned herein may be linear or branched. Typically, the alkyl or alkenyl groups are linear.

**[0088]** In some embodiments, R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently selected from H, C<sub>1-10</sub> alkyl and C<sub>2-10</sub> alkenyl. In a preferred embodiment, R<sup>1</sup> and R<sup>3</sup> are independently selected from C<sub>1-10</sub> alkyl and C<sub>2-10</sub> alkenyl, and R<sup>2</sup> is independently selected from, H, C<sub>1-10</sub> alkyl and C<sub>2-10</sub> alkenyl.

**[0089]** In some embodiments, the C<sub>1-10</sub> alkyl and C<sub>2-10</sub> alkenyl are linear. In other embodiments, the C<sub>1-10</sub> alkyl and C<sub>2-10</sub> alkenyl are branched.

**[0090]** In some embodiments, R<sup>1</sup> is C<sub>4-10</sub> alkyl or C<sub>4-10</sub> alkenyl. In other embodiments, R<sup>1</sup> is C<sub>6-10</sub> alkyl or C<sub>6-10</sub> alkenyl. In yet further embodiments, R<sup>1</sup> is C<sub>8-10</sub> alkyl or C<sub>8-10</sub> alkenyl.

**[0091]** In a preferred embodiment, R<sup>3</sup> is methyl.

**[0092]** Typically, R<sup>2</sup> is H. Optionally, R<sup>1</sup> is selected from C<sub>1-10</sub> alkyl, or from C<sub>4-10</sub> alkyl, or from C<sub>6-10</sub> alkyl, R<sup>2</sup> is H, and R<sup>3</sup> is methyl. Alternatively, R<sup>1</sup> is selected from C<sub>2-10</sub> alkenyl, or from C<sub>4-10</sub> alkenyl, or from C<sub>6-10</sub> alkenyl, R<sup>2</sup> is H, and R<sup>3</sup> is optionally methyl.

**[0093]** In some embodiments,  $R^1$ ,  $R^2$ , and  $R^3$  are independently selected from H,  $C_{4-10}$  alkyl and  $C_{4-10}$  alkenyl, or from H,  $C_{6-10}$  alkyl and  $C_{6-10}$  alkenyl, or from H,  $C_{8-10}$  alkyl and  $C_{8-10}$  alkenyl.

**[0094]** In a preferred embodiment,  $R^1$  is selected from  $C_{4-10}$  alkyl and  $C_{4-10}$  alkenyl, or from  $C_{6-10}$  alkyl and  $C_{6-10}$  alkenyl, or from  $C_{8-10}$  alkyl and  $C_{8-10}$  alkenyl,  $R^2$  is H, and  $R^3$  is optionally methyl.

**[0095]** In one embodiment,  $R^1$ ,  $R^2$  and  $R^3$  are methyl.

**[0096]** In a typical embodiment,  $R^1$  is a methyl, ethyl, propyl, butyl, or pentyl,  $R^2$  is H, and  $R^3$  is methyl.

**[0097]** In another embodiment,  $R^1$  is  $C_{6-10}$  alkyl (hexyl, heptyl, octyl, nonyl or decyl),  $R^2$  is H and  $R^3$  is methyl.

**[0098]** In yet another embodiment,  $R^1$  is allyl,  $R^2$  is H and  $R^3$  is methyl.

**[0099]** In a further embodiment,  $R^1$  is vinyl,  $R^2$  is H and  $R^3$  is methyl.

**[0100]** In some embodiments,  $R^1$  and  $R^2$  are independently selected from  $C_{1-5}$  alkyl (methyl, ethyl, propyl, butyl, or pentyl), and  $R^3$  is methyl.

**[0101]** In other embodiments,  $R^1$  and  $R^2$  are independently selected from  $C_{6-10}$  alkyl (hexyl, heptyl, octyl, nonyl or decyl), and  $R^3$  is methyl.

**[0102]** In yet further embodiments,  $R^1$  is vinyl or allyl,  $R^2$  is selected from methyl, ethyl, propyl, butyl, or pentyl, and  $R^3$  is methyl.

#### Anions

**[0103]** As used herein, the term “halide” refers to F, Cl, Br, I. In some embodiments, the anion is a halide selected from Br and Cl.

**[0104]** As used herein, the term “alkyl” is as defined above.

**[0105]** In some embodiments, the anion is an alkyl sulfate selected from methyl sulfate, ethyl sulfate, propyl sulfate, butyl sulfate, pentyl sulfate, hexyl sulfate, heptyl sulfate, and octyl sulfate. In a preferred embodiment, the anion is octyl sulfate.

**[0106]** In some embodiments, the alkyl sulfate and alkyl phosphate comprise from 1 to 22 carbon atoms. Optionally, the alkyl sulfate and alkyl phosphate comprise 1 to 4 carbon atoms, or 6 to 10 carbon atoms or 12 to 22 carbon atoms.

**[0107]** Typically, the anion is selected from the group consisting of acetate, bromide, chloride, methyl sulfate, ethyl sulfate, octyl sulfate, diethyl phosphate, and tosylate.

**[0108]** In preferred embodiments, the anion is selected from the group consisting of acetate, octylsulfate or tosylate.

**[0109]** In another embodiment, the anion is bromide.

**[0110]** In a further embodiment, anion is diethylphosphate.

**[0111]** In yet a further embodiment, the anion is tosylate.

**[0112]** In still yet a further embodiment, the anion is acetate.

#### Ionic Liquid

**[0113]** The term “ionic liquid” used in the context of the present invention means a salt comprising comprising a cation and an anion that is in liquid at a temperature of 100° C. or less and commonly have melting points below room temperature.

**[0114]** Any anion mentioned above may be used in combination with any of the imidazolium ions defined above to form the oral care composition of the present invention.

**[0115]** In some embodiments, the ionic liquid is selected from the group consisting of 1-ethyl-3-methylimidazolium

(EMIM) chloride, EMIM bromide, EMIM ethyl sulfate, EMIM diethyl phosphate, EMIM acetate, EMIM tosylate, 1-butyl-3-methylimidazolium (BMIM) chloride, BMIM bromide, BMIM methyl sulfate, BMIM octyl sulfate, BMIM acetate, 1-allyl-3-methylimidazolium (AMIM) chloride, 1-decyl-3-methylimidazolium (DMIM) chloride, and 1,2,3-trimethylimidazolium (TMIM) methyl sulfate.

**[0116]** Typically, the ionic liquid is present in the oral care composition in an amount of about 0.1 wt % to about 30 wt % based on the total weight of the composition.

**[0117]** In some embodiments, the ionic liquid is present in the oral care composition in an amount of about 0.5 wt % to about 20 wt %, or from about 1 wt % to about 15 wt %, based on the total weight of the composition.

**[0118]** Optionally, the ionic liquid is present in the oral care composition in an amount of about 5 wt % to about 15 wt %, or from about 7 wt % to about 12 wt %, based on the total weight of the composition.

**[0119]** Preferably, the ionic liquid is present in the oral care composition in an amount of about 8 wt % to about 10 wt % based on the total weight of the composition.

**[0120]** In some embodiments, the ionic liquid is present in the oral care composition in a concentration of about 1 mM to about 500 mM, or from about 4 mM to about 400 mM.

**[0121]** Optionally, the ionic liquid is present in the oral care composition in a concentration of about 5 mM to about 300 mM or from about 10mM to about 270 mM

**[0122]** Preferably, the ionic liquid is present in the oral care composition in a concentration of about 150 mM to about 250 mM, or from about 180 mM to about 220 mM or about 1 mM to about 50 mM.

**[0123]** In some embodiments, the oral care composition of the invention does not contain any other antibacterial or whitening agent.

#### Abrasives

**[0124]** Whilst, the compositions of the present invention may optionally further comprise an abrasive which may be useful, for example, as a polishing agent, it has been found that oral care compositions comprising ionic liquids as defined herein, are effective in removing biofilm or plaque, and whitening teeth, without the need for substantial amounts of abrasives. This is advantageous because abrasives can damage enamel and expose dentine tissues with repeated use, particularly, in subjects with soft enamel caused by disease or excessive exposure to food acids.

**[0125]** In one embodiment, the oral care composition comprises an abrasive in an amount of less than 0.1 wt % by total weight of the composition.

**[0126]** In another embodiment, the oral care composition comprises an abrasive in an amount of less than 0.01 wt % by total weight of the composition.

**[0127]** In yet another embodiment, the composition is substantially free, or free, of any abrasives.

**[0128]** Suitable optional abrasives include silica, for example in the form of precipitated silica or as admixed with alumina, insoluble phosphates, calcium carbonate, and mixtures thereof. Among insoluble phosphates useful as abrasives are orthophosphates, polymetaphosphates and pyrophosphates. Illustrative examples are dicalcium orthophosphate dihydrate, calcium pyrophosphate, calcium pyrophosphate, tricalcium phosphate, calcium polymetaphosphate and insoluble sodium polymetaphosphate.

### Carrier

**[0129]** Among useful carriers for optional inclusion in a composition of the invention are diluents, bicarbonate salts, pH modifying agents, surfactants, foam modulators, thickening agents, viscosity modifiers, humectants, sweeteners, flavorants, pigments, anticaries agents, and anticalculus or tartar control agents or abrasives. Carriers should be selected for compatibility with each other and with other ingredients of the composition.

**[0130]** Water is a preferred diluent and in some compositions such as mouthwashes, water is commonly accompanied by an alcohol, e.g., ethanol. The weight ratio of water to alcohol in a mouthwash composition is generally 1:1 to 20:1, for example 3:1 to 20:1 or 4:1 to 10:1. In a whitening liquid, the weight ratio of water to alcohol can be within or below the above ranges, for example, 1:10 to 2:1.

**[0131]** In a further embodiment, the composition of the invention comprises at least one bicarbonate salt, useful for example to impart a "clean feel" to teeth and gums due to effervescence and release of carbon dioxide. Any orally acceptable bicarbonate can be used, including without limitation, alkali metal bicarbonates such as sodium and potassium bicarbonates, ammonium bicarbonate and the like. One or more bicarbonate salts are optionally present in a total amount of about 0.1 wt % to about 50 wt %, for example about 1 wt % to 20 wt %, by total weight of the composition.

**[0132]** In a still further embodiment, the composition of the invention comprises at least one pH modifying agent. Such agents include acidifying agents to lower pH, basifying agents to raise pH, and buffering agents to control pH within a desired range. For example, one or more compounds selected from acidifying, basifying and buffering agents can be included to provide a pH of 2 to 10, or in various illustrative embodiments, 2 to 8, 3 to 9, 4 to 8, 5 to 7, 6 to 10, 7 to 9, etc. Any orally acceptable pH modifying agent can be used, including without limitation, carboxylic, phosphoric and sulfonic acids, acid salts (e.g., monosodium citrate, disodium citrate, monosodium malate, etc.), alkali metal hydroxides such as sodium hydroxide, carbonates such as sodium carbonate, bicarbonates, sesquicarbonates, borates, silicates, phosphates (e.g., monosodium phosphate, trisodium phosphate, pyrophosphate salts, etc.), imidazole and the like. One or more pH modifying agents are optionally present in a total amount effective to maintain the composition in an orally acceptable pH range.

**[0133]** In a still further embodiment, the composition of the invention comprises at least one surfactant. Any orally acceptable surfactant, most of which are anionic, nonionic or amphoteric, can be used. Suitable anionic surfactants include without limitation, water-soluble salts of C<sub>8-20</sub> alkyl sulfates, sulfonated monoglycerides of C<sub>8-20</sub> fatty acids, sarcosinates, taurates and the like. Illustrative examples of these and other classes include sodium lauryl sulfate, sodium coconut monoglyceride sulfonate, sodium lauryl sarcosinate, sodium lauryl isoehtionate, sodium laureth carboxylate and sodium dodecyl benzenesulfonate. Suitable nonionic surfactants include without limitation, poloxamers, polyoxyethylene sorbitan esters, fatty alcohol ethoxylates, alkylphenol ethoxylates, tertiary amine oxides, tertiary phosphine oxides, dialkyl sulfoxides and the like. Suitable amphoteric surfactants include without limitation, derivatives of C<sub>8-20</sub> aliphatic secondary and tertiary amines having an anionic group such as carboxylate, sulfate, sulfonate, phosphate or phosphonate. A suitable example is cocoamidopropyl betaine. One or more

surfactants are optionally present in a total amount of about 0.01 wt % to about 10 wt %, for example, from about 0.05 wt % to about 5 wt %, or from about 0.1 wt % to about 2 wt % by total weight of the composition.

**[0134]** In a still further embodiment, the composition of the invention comprises at least one foam modulator, useful for example to increase amount, thickness or stability of foam generated by the composition upon agitation. Any orally acceptable foam modulator can be used, including without limitation, polyethylene glycols (PEGs), also known as polyoxyethylenes. High molecular weight PEGs are suitable, including those having an average molecular weight of 200,000 to 7,000,000, for example 500,000 to 5,000,000, or 1,000,000 to 2,500,000. One or more PEGs are optionally present in a total amount of about 0.1 wt % to about 10 wt %, for example from about 0.2 wt % to about 5 wt %, or from about 0.25 wt % to about 2 wt %, by total weight of the composition.

**[0135]** In a still further embodiment, the composition of the invention comprises at least one thickening agent, useful for example to impart a desired consistency and/or mouth feel to the composition. Any orally acceptable thickening agent can be used, including without limitation, carbomers, also known as carboxyvinyl polymers, carrageenans, also known as Irish moss and more particularly t-carrageenan (iota-carrageenan), cellulosic polymers such as hydroxyethylcellulose, carboxymethylcellulose (CMC) and salts thereof, e.g., CMC sodium, natural gums such as karaya, xanthan, gum arabic and tragacanth, colloidal magnesium aluminum silicate, colloidal silica and the like. A preferred class of thickening or gelling agents includes a class of homopolymers of acrylic acid crosslinked with an alkyl ether of pentaerythritol or an alkyl ether of sucrose, or carbomers. Carbomers are commercially available from B. F. Goodrich as the Carbopol® series. Particularly preferred Carbopols include Carbopol 934, 940, 941, 956, 974P, and mixtures thereof. One or more thickening agents are optionally present in a total amount of from about 0.01 wt % to 15 wt %, for example from about 0.1 wt % to about 10 wt %, or from about 0.2 wt % to about 5 wt %, by total weight of the composition.

**[0136]** In a still further embodiment, the composition of the invention comprises at least one viscosity modifier, useful for example to inhibit settling or separation of ingredients or to promote re-dispersibility upon agitation of a liquid composition. Any orally acceptable viscosity modifier can be used, including without limitation, mineral oil, petrolatum, clays and organomodified clays, silica and the like. One or more viscosity modifiers are optionally present in a total amount of from about 0.01 wt % to about 10 wt %, for example, from about 0.1 wt % to about 5 wt %, by total weight of the composition.

**[0137]** In a still further embodiment, the composition of the invention comprises at least one humectant. Any orally acceptable humectant can be used, including without limitation, polyhydric alcohols such as glycerin, sorbitol, xylitol or low molecular weight PEGs. Most humectants also function as sweeteners. One or more humectants are optionally present in a total amount of from about 1 wt % to about 70 wt %, for example, from about 1 wt % to about 50 wt %, from about 2 wt % to about 25 wt %, or from about 5 wt % to about 15 wt %, by total weight of the composition.

**[0138]** In a still further embodiment, a composition of the invention comprises at least one sweetener, useful for example to enhance taste of the composition. Any orally

acceptable natural or artificial sweetener can be used, including without limitation dextrose, sucrose, maltose, dextrin, dried invert sugar, mannose, xylose, ribose, fructose, levulose, galactose, corn syrup (including high fructose corn syrup and corn syrup solids), partially hydrolyzed starch, hydrogenated starch hydrolysate, sorbitol, mannitol, xylitol, maltitol, isomalt, aspartame, neotame, saccharin and salts thereof, dipeptide-based intense sweeteners, cyclamates and the like. One or more sweeteners are optionally present in a total amount depending strongly on the particular sweetener (s) selected, but typically 0.005 wt % to 5 wt %, by total weight of the composition.

**[0139]** In a still further embodiment, a composition of the invention comprises at least one flavorant, useful for example to enhance taste of the composition. Any orally acceptable natural or synthetic flavorant can be used, including without limitation vanillin, sage, marjoram, parsley oil, spearmint oil, cinnamon oil, oil of wintergreen (methylsalicylate), peppermint oil, clove oil, bay oil, anise oil, eucalyptus oil, citrus oils, fruit oils and essences including those derived from lemon, orange, lime, grapefruit, apricot, banana, grape, apple, strawberry, cherry, pineapple, etc., bean- and nut-derived flavors such as coffee, cocoa, cola, peanut, almond, etc., adsorbed and encapsulated flavorants and the like. Also encompassed within flavorants herein are ingredients that provide fragrance and/or other sensory effect in the mouth, including cooling or warming effects. Such ingredients illustratively include menthol, menthyl acetate, menthyl lactate, camphor, eucalyptus oil, eucalyptol, anethole, eugenol, cassia, oxanone,  $\alpha$ -irisonone, propenyl guaiethol, thymol, linalool, benzaldehyde, cinnamaldehyde, N-ethyl-p-menthan-3-carboxamine, N,2,3-trimethyl-2-isopropylbutanamide, 3-(1-menthoxy)-propane-1,2-diol, cinnamaldehyde glycerol acetal (CGA), menthone glycerol acetal (MGA) and the like. One or more flavorants are optionally present in a total amount of from about 0.01 wt % to about 5 wt %, for example, from about 0.1 wt % to about 2.5 wt %, by total weight of the composition.

**[0140]** In a still further embodiment, a composition of the invention may comprise at least one colorant. Colorants herein include pigments, dyes, lakes and agents imparting a particular luster or reflectivity such as pearling agents. Any orally acceptable colorant can be used, including without limitation talc, mica, magnesium carbonate, calcium carbonate, magnesium silicate, magnesium aluminum silicate, silica, titanium dioxide, zinc oxide, red, yellow, brown and black iron oxides, ferric ammonium ferrocyanide, manganese violet, ultramarine, titanated mica, bismuth oxychloride and the like. One or more colorants are optionally present in a total amount of from about 0.001 wt % to about 20 wt %, for example, from about 0.01 wt % to about 10 wt %, or from about 0.1 wt % to about 5 wt %, by total weight of the composition.

**[0141]** In some embodiments, the composition comprises a fluoride ion source. Fluoride ion sources include, but are not limited to: stannous fluoride, sodium fluoride, potassium fluoride, potassium monofluorophosphate, sodium monofluorophosphate, ammonium monofluorophosphate, sodium fluorosilicate, ammonium fluorosilicate, amine fluoride such as olaffur (N'-octadecyltrimethylendiamine-N,N,N'-tris(2-ethanol)-dihydrofluoride), ammonium fluoride, and combinations thereof. In certain embodiments the fluoride ion source includes stannous fluoride, sodium fluoride, amine fluorides, sodium monofluorophosphate, as well as mixtures thereof. In certain embodiments, the oral care composition of

the invention may also contain a source of fluoride ions or fluorine-providing ingredient in amounts sufficient to supply about 50 to about 5000 ppm fluoride ion, e.g., from about 100 to about 1000, from about 200 to about 500, or about 250 ppm fluoride ion. Fluoride ion sources may be added to the compositions of the invention at a level of about 0.001 wt % to about 10 wt %, e.g., from about 0.003 wt % to about 5 wt %, 0.01 wt % to about 1 wt, or about 0.05 wt %. However, it is to be understood that the weights of fluoride salts to provide the appropriate level of fluoride ion will obviously vary based on the weight of the counter ion in the salt, and one of skill in the art may readily determine such amounts. A preferred fluoride salt may be sodium fluoride.

**[0142]** The composition of the present invention optionally comprises a saliva stimulating agent useful, for example, in amelioration of dry mouth. Any orally acceptable saliva stimulating agent can be used, including without limitation food acids such as citric, lactic, malic, succinic, ascorbic, adipic, fumaric and tartaric acids, and mixtures thereof. One or more saliva stimulating agents are optionally present in saliva stimulating effective total amount.

**[0143]** The composition of the present invention optionally incorporates one or more antisensitivity agents, e.g., potassium salts such as potassium nitrate, potassium bicarbonate, potassium chloride, potassium citrate, and potassium oxalate; capsaicin; eugenol; strontium salts; zinc salts; chloride salts and combinations thereof. Such agents may be added in effective amounts, e.g., from about 1 wt % to about 20 wt % by weight based on the total weight of the composition, depending on the agent chosen. The compositions of the present invention may also be used to treat hypersensitivity by blocking dentin tubules when applied to a tooth.

**[0144]** In some embodiments, the composition of the invention further comprises an antioxidant. Any orally acceptable antioxidant can be used, including butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), vitamin A, carotenoids, vitamin E, flavonoids, polyphenols, ascorbic acid, herbal antioxidants, chlorophyll, melatonin, and mixtures thereof.

**[0145]** In another embodiment, the composition comprises an orally acceptable zinc ion source useful, for example, as an antimicrobial, anticalculus or breath-freshening agent. One or more such sources can be present. Suitable zinc ion sources include without limitation zinc acetate, zinc citrate, zinc gluconate, zinc glycinate, zinc oxide, zinc sulfate, sodium zinc citrate and the like. One or more zinc ion sources are optionally and illustratively present in a total amount of from about 0.05 wt % to about 3 wt %, for example from about 0.1 wt % to about 1 wt %, by total weight of the composition.

**[0146]** The composition of the present invention may additionally optionally comprise a tartar control (anticalculus) agent as provided below. Tartar control agents among those useful herein include salts of the specified agents, including alkali metal and ammonium salts. The agents include: phosphates and polyphosphates (for example pyrophosphates), polyaminopropanesulfonic acid (AMPS), polyolefin sulfonates, polyolefin phosphates, diphosphonates such as azacycloalkane-2,2-diphosphonates (e.g., azacycloheptane-2,2-diphosphonic acid), N-methyl azacyclopentane-2,3-diphosphonic acid, ethane-1-hydroxy-1,1-diphosphonic acid (EHDP) and ethane-1-amino-1,1-diphosphonate, phosphonoalkane carboxylic acids and. Useful inorganic phosphate and polyphosphate salts include monobasic, dibasic and tribasic sodium phosphates, sodium tripolyphosphate, tet-



rapolyphosphate, mono-, di-, tri- and tetrasodium pyrophosphates, sodium trimetaphosphate, sodium hexametaphosphate and mixtures thereof. Other useful tartar control agents include polycarboxylate polymers and polyvinyl methyl ether/maleic anhydride (PVM/MA) copolymers, such as GANTREZ®.

**[0147]** In some embodiments, the composition of the present invention further comprises a nutrient. Suitable nutrients include vitamins, minerals, amino acids, and mixtures thereof. Vitamins include Vitamins C and D, thiamine, riboflavin, calcium pantothenate, niacin, folic acid, nicotinamide, pyridoxine, cyanocobalamin, para-aminobenzoic acid, bioflavonoids, and mixtures thereof. Nutritional supplements include amino acids (such as L-tryptophan, L-lysine, methionine, threonine, levocarnitine and L-carnitine), lipotropics (such as choline, inositol, betaine, and linoleic acid), and mixtures thereof.

#### Delivery

**[0148]** The oral care composition of the present invention preferably comprises an orally acceptable carrier for use in a product such as a mouth rinse (including dual phase mouthwash), toothpaste, actives in beads/strips, irrigation fluids, plaque removal fluids, bead formulas, formulations to be delivered through devices such as pens, back of a toothbrush and front of a toothbrush, formulations to be delivered through porous wicking materials, interdental brushes, fluid encased dental strips, floss impregnated or coated with the formulations or dried formulations, portables, oral trays, hard or soft candy, lozenge with a soft plaque dissolving liquid inside, lollipops with the plaque dissolving formulation imbedded into the lickable “candy” that can also help control tongue bacteria, peelable gels, patches, formulations for pop-rocks that upon popping, spread a fine mist of the formulation around oral cavity, tongue cleaners with plaque dissolving strips and dental strips. Accordingly, opportunities exist for professional use of the compositions of the present invention (e.g. during cleanings, irrigations, or aggressive periodontal procedures, such as root planning & scaling). The composition of the invention may be provided in any of the products defined herein.

**[0149]** In one embodiment, the composition of the invention can be dried into powder and utilized in a portable sachet. For example, upon mixing such a powder with a suitable solvent such as water, a rinse may be created to remove plaque, proteins and other debris in the mouth.

**[0150]** In another embodiment, the composition of the invention can be dried with abrasives such as silica, calcium carbonate or soft capsules that upon addition of small amount of water, creates a paste to brush away the plaque.

**[0151]** Formulations that increase the substantivity of ionic liquids onto a surface could be expected to increase the efficacy of biofilm, and hence plaque removal. For example, Tween 20 while also functioning as a surfactant, is also a wetting agent. Therefore, incorporation of such an agent could be expected to increase the wettability and spreading of a mouth rinse formulation according to the present invention, over the soft and hard tissue, increasing the formulation’s propensity for plaque dissolution and removal.

#### Methods of Use

**[0152]** The composition according to the present invention may be administered to or applied to a human or other animal

subject. The composition may be suitable for administration or application to the oral cavity of a human or animal subject. Typically, the composition is for reducing or removing dental plaque. The reduction or removal of plaque may occur through an inhibition of biofilm (a plaque precursor) formation and/or degradation of microbial biofilm.

**[0153]** The present invention further provides a composition as defined above for preventing or treating a disease condition of the oral cavity. Typically, the disease condition is caused by plaque. The disease condition may be selected from tooth decay, periodontal disease, gingivitis or xerostomia (dry mouth).

**[0154]** Accordingly, the present invention provides a composition as defined above for use as a medicament.

**[0155]** The present invention also provides a method of removing or reducing plaque from the oral cavity of a subject comprising administering a therapeutically effective amount of a composition comprising at least one ionic liquid to the subject. Preferably, the composition is an oral care composition as defined herein, and the composition is applied to the oral cavity. The composition may alternatively comprise a pyrazolium-based ionic liquid such as 1,2,4-trimethylpyrazolium methylsulfate or an ammonium-based ionic liquid such as choline salicylate, choline acetate, tris(2-hydroxyethyl)methylammonium sulfate (MTEOA methylsulfate).

**[0156]** In a preferred embodiment, the method is for treating or preventing a condition caused by plaque. Preferably, condition caused by plaque is selected from tooth decay, periodontal disease, gingivitis or xerostomia (dry mouth).

**[0157]** The present invention further provides a method of whitening teeth in a subject comprising administering a therapeutically effective amount of a composition comprising at least one ionic liquid to the subject. Preferably, the composition is an oral care composition as defined herein, and the composition is applied to the oral cavity. The composition may alternatively comprise a pyrazolium-based ionic liquid such as 1,2,4-trimethylpyrazolium methylsulfate or an ammonium-based ionic liquid such as choline salicylate, choline acetate, tris(2-hydroxyethyl)methylammonium sulfate (MTEOA methylsulfate).

**[0158]** The present invention still further provides a method of reducing the amount of bacteria in the oral cavity of a subject comprising administering a therapeutically effective amount of a composition comprising at least one ionic liquid to the subject, wherein the ionic liquid comprises:

**[0159]** a) an imidazolium cation, and

**[0160]** b) an anion selected from the group consisting of salicylate, acetate, halide, phosphate, alkyl phosphate, sulfate, alkyl sulfate, and tosylate. Preferably, the composition is an oral care composition as defined herein, and the composition is applied to the oral cavity.

**[0161]** The present invention additionally provides a use of an ionic liquid, in an oral care composition, for removing or reducing plaque in the oral cavity of a subject. The oral care composition is preferably as defined herein.

**[0162]** The present invention further provides a use of an ionic liquid, in an oral care composition, for whitening teeth in the oral cavity of a subject. The oral care composition is preferably as defined herein.

**[0163]** The present invention still further provides a use of an ionic liquid, in an oral care composition, for reducing the amount of bacteria in the oral cavity of a subject, wherein the ionic liquid comprises:

- [0164] a) an imidazolium cation  
 [0165] and  
 [0166] b) an anion selected from the group consisting of acetate, halide, phosphate, alkyl phosphate, sulfate, alkyl sulfate, and tosylate.

The oral care composition is preferably as defined herein.

[0167] Compositions comprising an ionic liquid, and in particular, wherein the ionic liquid comprises an imidazolium cation and an anion selected from the group consisting of salicylate, acetate, halide, phosphate, alkyl phosphate, sulfate, alkyl sulfate, and tosylate, are highly effective in inhibiting the growth of bacteria, degrading biofilms, and dissolving dental plaque. They possess the unique ability to offer a deep but gentle cleaning, and promote removal of biofilm and plaque without the need for harsh abrasives or rigorous brushing. The compositions are further able to remove stains and whiten teeth, again without the need for harsh abrasives or rigorous brushing.

[0168] The invention is further illustrated in the following non-limiting examples.

## EXAMPLES

### Example 1

#### Dissolution of Plaque

[0169] Dental plaque samples were obtained from subjects and treated with water to remove any water soluble actives. The samples were centrifuged at 13,000 g and the supernatant was collected and discarded. The remaining plaque that was insoluble in water was used to evaluate the plaque solubilizing potential of the ionic liquids.

[0170] Ionic liquids were added to the plaque sample, and the plaque sample was vortex mixed at room temperature. To ensure that the plaque was not simply suspended in the ionic liquid, the plaque containing vial with the ionic liquid was subsequently centrifuged at 13,000 g. Any undissolved plaque was visible as a pellet, and in this way, plaque dissolution could be visually monitored.

[0171] Plaque may form a suspension when mixed with water and that, on centrifugation, it is visible as an insoluble pellet. On addition of 1-ethyl-3-methylimidazolium bromide, the size of the plaque pellet is reduced, indicating that 1-ethyl-3-methylimidazolium bromide is effective in dissolving plaque. Similar results are obtained with choline acetate, choline salicylate and 1,2,4-trimethylpyrazolium methylsulfate.

### Example 2

#### Protocol for In Vitro Biofilm Removal

[0172] A 3-day old biofilm provided a sufficiently robust biofilm to help differentiate the efficacy of different prototype formulations in biofilm removal.

[0173] The 3-day old biofilm was grown on a 24 well plate using the artificial mouth consortium of bacteria (*A. naestlundii*, *S. oralis*, *V. parvula*, *L. casei*, *F. nucleatum*) and *S. mutans*. To generate the biofilm, plates were inoculated with saliva overnight to form a pellicle. The consortium of bacteria (1 mL) at an OD of ~0.2 was added to each well. The bacterial media (Tryptic Soy Broth with 6% sucrose) was changed after 48 hours. The 3-day old biofilm was treated with the prototype formulation (500  $\mu$ L) for 15 minutes on a plate shaker at 300 rpm. After incubation, the supernatant was

discarded. The optical density of each well was measured and the percentage reduction in optical density relative to the control (water) was calculated to determine the effect of the prototype formulation on biofilm removal.

[0174] As described herein, dental plaque is formed from a biofilm precursor. Therefore, the 3-day old biofilm serves as a good model to investigate the effects of test compounds on plaque removal.

### Example 3

#### Impact of Chain Length on Biofilm Removal

[0175] Using the protocol of Example 2, the effects of ionic liquids on biofilm reduction were tested. The percentage removal of a 3-day old biofilm using 0.28M concentration of different ionic liquids, formulated in the base prototype mouth rinse formation of Table 1. Water, untreated biofilm, and the commercially available mouthwash formulations with either CPC (cetyl pyridinium chloride) or sodium monofluorophosphate acted as negative controls for the experiment.

TABLE 1

Ingredient Name	Percentage
Deminerlized water	38.63
Propylene Glycol	10.00
Sorbitol non-browning/non-crys NF-sol	20.00
99.0%-101.0% Vegetable Glycerin	20.00
Surfactant - Tween 20	1.125
Flavor K91-6525	0.12
CPC	0.075
Sucralose	0.05
Ionic Liquids	10.00
Total	100.00

[0176] The ionic liquids tested were as follows: 1-ethyl-3-methylimidazolium (EMIM) chloride (Cl), EMIM bromide (Br), EMIM ethyl sulfate, EMIM diethyl phosphate, EMIM acetate (OAc), EMIM tosylate, 1-butyl-3-methylimidazolium (BMIM) chloride (Cl), BMIM bromide (Br), BMIM methyl sulfate, BMIM octyl sulfate, BMIM acetate (OAc), 1-allyl-3-methylimidazolium (AMIM) chloride, 1-decyl-3-methylimidazolium (DMIM) chloride, 1,2,3-trimethylimidazolium methyl sulfate, 1,2,3-trimethylpyrazolium (MMMPZ) methyl sulfate, and MTEOA methyl sulfate (tris (2-hydroxyethyl)methylammonium sulfate).

[0177] Table 2 indicates the percentage removal of a 3-day old biofilm using 0.28M concentration of different ionic liquids, formulated in the base prototype mouth rinse formation of Table 1, as compared to control compositions water, commercially available mouthwash (MW) formulations with either CPC (cetyl pyridinium chloride) or five enzymes to combat biofilm, and untreated biofilm.

TABLE 2

Sample Name	Percent Removal of a 3-day Oral Biofilm
Untreated	-1.3
DI water	-3.7
MW with CPC (0.075%)	13.4
MW with five enzymes	30.0
EMIM Cl	44.3

TABLE 2-continued

Sample Name	Percent Removal of a 3-day Oral Biofilm
BMIM Cl	43.8
AMIM Cl	44.8
DMIM Cl	57.3
EMIM Br	48.6
BMIM Br	48.0
BMIM MeSO <sub>4</sub>	53.9
TMIM MeSO <sub>4</sub>	51.8
MTEOA MeSO <sub>4</sub>	52.8
MMMPz MeSO <sub>4</sub>	57.8
EMIM Ethyl SO <sub>4</sub>	48.1
BMIM Octyl SO <sub>4</sub>	58.6
EMIM diethyl PO <sub>4</sub>	52.7
BMIM OAc	55.9
EMIM OAc	52.1
EMIM Tosylate	59.5

[0178] As seen in Table 2, each of the formulated ionic liquids were effective in removing oral biofilm by at least 40% or more. In particular, ionic compounds comprising an imidazolium cation, and an anion selected from salicylate, acetate, halide, alkyl phosphate, alkyl sulfate, and tosylate, are significantly more effective than the commercially available or control compositions in reducing biofilm formation. These compounds remove biofilm by an amount that is 2 to 6 times more than the amount removed by the commercially available mouth rinses.

[0179] Additionally, it can be seen from Table 2 that biofilm removal increases as the length of the side chain on the imidazolium cation (at the 1-position) is increased. In particular, DMIM chloride is significantly more effective in removing biofilm than EMIM chloride and BMIM chloride.

[0180] Furthermore, it can be seen from Table 2 that when the counterion is changed from chloride to bromide for EMIM and BMIM, there is an increase in biofilm removal by at least ~4%.

[0181] Thus, it may be concluded that ionic liquids having a longer chain in their core cation moiety and having a larger halide ion such as a bromide ion, enables greater biofilm removal.

[0182] Table 2 also reveal that in general, methyl sulfate anions perform better than the halide ions. Additionally, when the alkyl chain of the sulfate ion is increased, (for example, biofilm removal for BMIM methyl sulfate and BMIM octyl sulfate may be compared), biofilm removal is markedly enhanced.

[0183] Therefore, in conclusion, compositions comprising ionic liquids, in particular, wherein the ionic liquids comprise an imidazolium ion, are very effective in removing 3-day old biofilm, which serves as a model for removing plaque.

#### Example 4

[0184] Using the protocol of Example 2, the effects of varying the anion type in EMIM- and BMIM-based ionic liquids, on removal of a 3-day old biofilm, were investigated.

[0185] Table 3 illustrates the percentage removal of a 3-day old biofilm using 0.28M concentration of different EMIM-based ionic liquids having different anions, formulated in the base prototype mouth rinse formation of Table 1.

TABLE 3

EMIM Cationic Series	
Anion	Percent Biofilm Removed
Cl	44.3
Ethylsulfate	48.1
Br	48.6
Acetate	52.1
Diethyl phosphate	52.7
Tosylate	59.5

[0186] Table 4 illustrates the percentage removal of a 3-day old biofilm using 0.28M concentration of different BMIM-based ionic liquids having different anions, formulated in the base prototype mouth rinse formation of Table 1.

TABLE 4

BMIM Cationic Series	
Anion	Percent Biofilm Removal
Cl	43.8
Br	48.0
Methylsulfate	53.9
Acetate	55.8
Octylsulfate	58.6

[0187] Table 3 illustrates that the anions diethyl phosphate, acetate and tosylate are most effective in removing biofilm. Efficacy of biofilm removal appears to increase with negatively resonance stabilized species such as acetate and tosylate.

[0188] Table 4 illustrates that acetate and octylsulfate anions are more effective in removing biofilm than the halide ions.

[0189] Table 5 illustrates a direct comparison between EMIM and BMIM, with different anions, in removing biofilm.

TABLE 5

	Percent Biofilm Removed	
	EMIM	BMIM
Chloride	44.3	43.8
Bromide	48.6	48.0
Acetate	52.1	55.8

[0190] It can clearly be seen that acetate anions are most effective in removing biofilm, followed by bromide ions and chloride ions, respectively.

#### Example 5

##### Biofilm Removal by Other Imidazolium Compounds

[0191] Using the protocol of Example 2, the effects of 1-allyl-3-methylimidazolium (AMIM) chloride, 1,2,3-trimethylimidazolium (TMIM) methyl sulfate, and 1-decyl-3-methylimidazolium (DMIM) chloride on removal of a 3-day old biofilm, were compared. The results are illustrated in Table 6.

TABLE 6

Other Ionic Liquids	Percent Biofilm Removed
AMIM Chloride	44.8
TMIM Methylsulfate	51.8
MTEOA Methylsulfate	52.8
DMIM Chloride	57.3
MMMPz Methylsulfate	57.9

It can clearly be seen from Table 6 that DMIM chloride is most effective in removing biofilm. It can also be concluded that imidazolium cations with unsaturated side chains (e.g. AMIM chloride) are effective in removing biofilm.

Example 6

Teeth Whitening Effect of Imidazolium-Based Ionic Liquids

[0192] Mouthwash formulations of 1-ethyl-3-methylimidazolium (EMIM) with the anions tosylate, bromide, chloride and ethylsulfate, were evaluated for in-vitro removal of tooth stains.

[0193] The method of determining the effects of imidazolium-based ionic liquids on teeth whitening was carried out as follows:

[0194] The initial  $L^*a^*b^*$  measurements of dried artificially stained human teeth were captured. The teeth were then soaked in 1 ml of sample solution for one hour, and sample was replenished at 30 minutes. After treatment, teeth were soaked in DI water for approximately 10 minutes. The teeth were left to dry at least overnight, and final  $L^*a^*b^*$  measurements were then taken. ( $L^*a^*b^*$  refers to stain score in accordance with the Commission International de L'Eclairage Laboratory (CIELAB) color scale.  $L^*$  (lightness-darkness scale),  $a^*$  (red-green chroma) and  $b^*$  (yellow-blue chroma)).

[0195] The whitening efficacy was determined as follows:

$$\Delta W^* = W^*_{\text{final}} - W^*_{\text{initial}}$$

$$\text{where } W^* = (a^{*2} + b^{*2} + (L^* - 100)^2)^{1/2}$$

[0196] All the EMIM-based compounds were evaluated at 1M concentration in a prototype mouthwash formulation containing hydrogen peroxide, as illustrated in Table 7 (Prototype mouth wash formulation containing EMIM-based ionic liquids at 1M concentration.)

TABLE 7

Prototype Whitening MW Base	
Ingredient Name	Weight %
Glycerin	0.000
Propylene Glycol	2.500
Sorbitol	10.000
Surfactant-Tween 20	1.500
Ionic Liquid (1M)	30.000
Sodium Benzoate	0.110
CPC	0.075
Sucralose	0.050
Citrate Buffer	10.000
Flavor (K91-5916)	0.150
Water	45.615
Total	100.000

[0197] Table 8 illustrates the change in tooth whiteness effected by various EMIM-based liquids. A mouthwash

(MW) with 1.5% hydrogen peroxide ( $H_2O_2$ ) was used as a peroxide-containing control for the experiment. It can be seen that the tooth whitening capacities of the imidazolium-based ionic liquids decrease in the order: EMIM tosylate, EMIM Br, and EMIM Cl/EMIM ethyl sulfate. (EMIM Cl and EMIM ethyl sulfate produced similar whitening effects). Changes in teeth whiteness (W), lightness (L) and shade (E) were also assessed.

TABLE 8

Sample Name	$\Delta W$	$\Delta E$	$\Delta L$
EMIM EtSO4	-2.99	4.41	3.40
EMIM Br	-7.98	9.75	8.86
EMIM Cl	-3.40	4.88	3.86
EMIM Tos	-13.90	15.53	15.03
MW with 1.5% $H_2O_2$	-3.73	4.05	3.96

[0198] Again, EMIM-tosylate, a non-peroxide, provided the most significant tooth whitening benefit through dissolution and removal of surface tooth stains.

Example 7

Antibacterial Activity of Imidazolium-Based Ionic Liquids

[0199] The effects of 1-decyl-3-methylimidazolium (DMIM) chloride on bacterial growth were investigated in vitro. DMIM chloride was incorporated into a prototype mouth rinse as illustrated in Table 9. Growth inhibition of *A. viscosus* was assessed when using DMIM chloride in an amount of 0.01 wt %, 0.1 wt % and 1 wt % in the prototype mouth rinse. The growth inhibition was measured as a change in optical density over time. Table 9 depicts the formulation of 1-decyl-3-methylimidazolium chloride as a mouth rinse.

TABLE 9

Ingredient Name	Wt % Plaque dissolving formula
Propylene Glycol	4.00
Sorbitol non-browning/non-crys NF-sol	7.00
99.0%-101.0% Vegetable Glycerin	7.00
Flavor K91-6525	0.15
Polyoxyl 40 hydrated castor oil NF	1.00
Sucralose	0.001
1-decyl-3-methylimidazolium chloride	0.001-10%
Deminerlized water	q.s
Total	100.00

[0200] When formulated at 1 wt % concentration, 1-decyl-3-methylimidazolium chloride provides greater growth inhibition of *A. viscosus* than a mouthwash containing cetylpyridinium chloride. Growth inhibition of *A. viscosus* is maintained even when 1-decyl-3-methylimidazolium chloride is formulated at 0.312 wt % concentration.

Example 8

Short Interval Kill Test (SIKT)

[0201] SIKT determines the kill effect of a test article at a predetermined exposure time. Briefly, a culture of *A. viscosus* was incubated with 1-decyl-3-methylimidazolium, formulated in the prototype mouth rinse according to Table 9. The reaction was neutralized after 30 seconds by adding a neu-

tralizing broth. The reaction mixture was further diluted and plated on MCA (Microbial Count Agar) plates for viable bacterial count.

**[0202]** When 1-decyl-3-methylimidazolium chloride is formulated in the prototype mouth rinse according to Table 9 at 0.3, 0.6 and 1 wt % concentration, it is able to kill *A. viscosus* within 30 seconds.

#### Example 9

##### Minimum Inhibitory Concentration of 1-decyl-3-methylimidazolium Chloride

**[0203]** In order to determine the minimum concentration of 1-decyl-3-methylimidazolium chloride required to inhibit the growth of *A. viscosus*, an *A. viscosus* culture was incubated for 24 hours with varying concentrations of 1-decyl-3-methylimidazolium chloride, and bacterial growth inhibition was measured by taking optical density readings at 610 nm.

**[0204]** The minimum inhibitory concentration of 1-decyl-3-methylimidazolium chloride required to inhibit the growth of *A. viscosus* is 125 ppm.

#### Example 10

##### Formulations of 1-decyl-3-methylimidazolium Chloride in Oral Care Delivery Vehicles

**[0205]** Table 10 shows a typical formulation of 1-decyl-3-methylimidazolium chloride in a bead formulation.

TABLE 10

Ingredient Name	Wt % Plaque dissolving formula
Castor Oil	43.5
Flavor	15
WS-3 -Cooling sensate	1.5
10% Sucralose sln	5
Ionic Liquid	0.3-5
Propylene glycol	q.s
Total	100.00

**[0206]** Table 11 shows a typical formulation of 1-decyl-3-methylimidazolium chloride in a wick delivery device or in an interdental wicking brush

TABLE 11

Ingredient Name	Wt % Plaque dissolving formula
Glycerin	15
Propylene glycol	30
Flavor (89-186)	8
WS3-Cooling sensate	3
10% Sucralose soln	5
Ionic Liquid	0.3-10
Water pH adjusted if necessary	q.s
Total	100.00

#### Example 11

##### Formulation of Ionic Liquid in a Chewing Gum

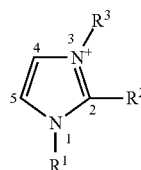
**[0207]** Xylitol, gum base, isomalt, gum arabic, flavors, maltitol syrup, titanium dioxide, coloring, shellac, carnauba wax, BHT (butylhydroxytoluene; to preserve freshness), and ionic liquid.

**[0208]** Whilst particular embodiments of the invention have been illustrated and described, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the scope of the invention as defined in the appended claims.

1. An oral care composition comprising an ionic liquid, wherein the ionic liquid comprises:

- a) an imidazolium cation and
- b) an anion selected from the group consisting of acetate, halide, phosphate, alkyl phosphate, phosphonate, pyrophosphate, hexametaphosphate, polymetaphosphate, orthophosphate, tripolyphosphate, sulfate, alkyl sulfate, lauryl sulfate, phenolsulfate, benzoate, acetylacetonate, carboxylate, citrate, ascorbate, dicyamide, L- or D-amino acids, glycolate, gluconate, maleate, sweetener anions, hydroxide, succinate, tartrate, docusate, linoleate, oleate, and tosylate.

2. The oral care composition of claim 1, wherein the cation is an imidazolium ion having the formula,



and wherein  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H, alkyl and alkenyl.

3. The oral care composition of claim 2, wherein  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H,  $C_{1-22}$  alkyl and  $C_{2-22}$  alkenyl.

4. The oral care composition of claim 3, wherein  $R^1$  and  $R^3$  are independently selected from  $C_{1-10}$  alkyl and  $C_{2-10}$  alkenyl, and wherein  $R^2$  is independently selected from, H,  $C_{1-10}$  alkyl and  $C_{2-10}$  alkenyl.

5. The oral care composition of claim 3 or 4, wherein  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H,  $C_{12-22}$  alkyl and  $C_{12-22}$  alkenyl.

6. The oral care composition of any of claims 3 to 5, wherein  $R_1$  is  $C_{6-10}$  alkyl or  $C_{6-10}$  alkenyl.

7. The oral care composition of any of claims 2 to 6, wherein  $R^2$  is H.

8. The oral care composition of any of claims 2 to 7, wherein  $R^3$  is methyl.

9. The oral care composition of any of claims 2 to 8, wherein  $R^1$  is selected from ethyl, butyl, hexyl, decyl, and allyl.

10. The oral care composition of any preceding claim, wherein the halide ion is a chloride ion or a bromide ion.

11. The oral care composition of any preceding claim, wherein the alkyl sulfate and alkyl phosphate comprises from 1 to 22 carbon atoms.

12. The oral care composition of claim 11, wherein the alkyl sulfate and alkyl phosphate comprises 1 to 4 carbon atoms, or 6 to 10 carbon atoms or 12 to 22 carbon atoms.

13. The oral care composition of any preceding claim, wherein the anion is selected from the group consisting of acetate, bromide, chloride, methyl sulfate, ethyl sulfate, octyl sulfate, diethyl phosphate, and tosylate.

14. The oral care composition of claim 13, wherein anion is selected from acetate, octylsulfate or tosylate.

15. The oral care composition of any of claims 1 to 13, wherein the ionic liquid is selected from the group consisting of 1-ethyl-3-methylimidazolium (EMIM) chloride, EMIM bromide, EMIM ethyl sulfate, EMIM diethyl phosphate, EMIM acetate, EMIM tosylate, 1-butyl-3-methylimidazolium (BMIM) chloride, BMIM bromide, BMIM methyl sulfate, BMIM octyl sulfate, BMIM acetate, 1-allyl-3-methylimidazolium (AMIM) chloride, 1-decyl-3-methylimidazolium (DMIM) chloride, and 1,2,3-trimethylimidazolium (TMIM) methyl sulfate

16. The oral care composition of any preceding claim, wherein the oral care composition comprises an abrasive in an amount of less than 0.1 wt % by total weight of the composition.

17. The oral care composition of claim 16, wherein the oral care composition comprises an abrasive in an amount of less than 0.01 wt % by total weight of the composition.

18. The oral care composition of any of claims 1 to 15, wherein the composition is substantially free of any abrasives.

19. The oral care composition of any preceding claim, wherein the ionic liquid is present in the oral care composition in an amount of 0.1 wt % to 30 wt % based on the total weight of the composition.

20. The oral care composition of claim 19, wherein the ionic liquid is present in the oral care composition in an amount of 0.5 wt % to 20 wt % based on the total weight of the composition.

21. The oral care composition of claim 20, wherein the ionic liquid is present in the oral care composition in an amount of 5 wt % to 15 wt % based on the total weight of the composition.

22. The oral care composition of claim 21, wherein the ionic liquid is present in the oral care composition in an amount of 8 wt % to 10 wt % based on the total weight of the composition.

23. The oral care composition of any preceding claim, wherein the ionic liquid is present in the oral care composition at a concentration of 1 mM to 500 mM.

24. The oral care composition of claim 23, wherein the ionic liquid is present in the oral care composition at a concentration of 5 mM to 300 mM.

25. The oral care composition of claim 24, wherein the ionic liquid is present in the oral care composition at a concentration of 15 mM to 250 mM.

26. The oral care composition of any preceding claim, comprising an orally acceptable carrier for a mouth rinse, toothpaste, oral beads or strips, irrigation fluid, plaque removal liquid, tongue spray, dental floss, candy, lozenge, chewing gum, patches and lollipop.

27. The oral care composition of any preceding claim, wherein the composition further comprises one or more agents selected from diluents, bicarbonate salts, pH modifying agents, surfactants, foam modulators, thickening agents, viscosity modifiers, humectants, sweeteners, flavorants, pigments, anticaries agents, anticalculus or tartar control agents, abrasives and mixtures thereof

28. The oral care composition of any preceding claim, wherein the composition is for removing or reducing plaque.

29. The oral care composition of any preceding claim, wherein the composition is for teeth whitening.

30. The oral care composition of any preceding claim, wherein the composition is for inhibiting the growth of bacteria.

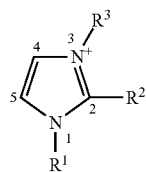
31. The oral care composition of any preceding claim, wherein the composition is for preventing or treating tooth decay, periodontal disease, gingivitis or xerostomia (dry mouth).

32. A method of removing or reducing plaque from the oral cavity of a subject comprising administering a therapeutically effective amount of a composition comprising at least one ionic liquid to the subject.

33. The method of claim 32, wherein the ionic liquid comprises:

- a) an imidazolium cation, and
- b) an anion selected from the group consisting of salicylate, acetate, halide, phosphate, alkyl phosphate, phosphonate, pyrophosphate, hexametaphosphate, polymetaphosphate, orthophosphate, tripolyphosphate, sulfate, alkyl sulfate, lauryl sulfate, phenolsulfate, benzoate, acetylacetonate, carboxylate, citrate, ascorbate, dicyamide, L- or D-amino acids, glycolate, gluconate, maleate, sweetener anions, hydroxide, succinate, tartrate, docusate, linoleate, oleate and tosylate.

34. The method of claim 33, wherein the cation is an imidazolium ion having the formula



and wherein  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H, alkyl and alkenyl.

35. The method of claim 34, wherein  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H,  $C_{1-22}$  alkyl and  $C_{2-22}$  alkenyl.

36. The method of claim 35, wherein  $R^1$  and  $R^3$  are independently selected from  $C_{1-10}$  alkyl and  $C_{2-10}$  alkenyl, and wherein  $R^2$  is independently selected from, H,  $C_{1-10}$  alkyl and  $C_{2-10}$  alkenyl.

37. The method of claim 35 or 36, wherein  $R_1$  is  $C_{12-22}$  alkyl or  $C_{12-22}$  alkenyl and are linear.

38. The method of any of claims 35 to 37, wherein  $R_1$  is  $C_{6-10}$  alkyl or  $C_{6-10}$  alkenyl.

39. The method of any of claims 34 to 38, wherein  $R^2$  is H.

40. The method of any of claims 34 to 39, wherein  $R^3$  is methyl.

41. The method of any of claims 34 to 40, wherein  $R^1$  is selected from ethyl, butyl, hexyl, decyl, and allyl.

42. The method of any of claims 33 to 41, wherein the halide ion is a chloride ion or a bromide ion.

43. The method of any of claims 33 to 42, wherein the alkyl sulfate and alkyl phosphate comprises from 1 to 22 carbon atoms.

44. The method of claim 43, wherein the alkyl sulfate and alkyl phosphate comprises 1 to 4 carbon atoms, or 6 to 10 carbon atoms or 12 to 22 carbon atoms

45. The method of any of claims 33 to 44, wherein the anion is selected from the group consisting of acetate, bromide, chloride, methyl sulfate, ethyl sulfate, octyl sulfate, diethyl phosphate, and tosylate.

46. The method of claim 45, wherein anion is selected from acetate, octylsulfate or tosylate.

47. The method of any of claims 32 to 45, wherein the ionic liquid is selected from the group consisting of 1-ethyl-3-methylimidazolium (EMIM) chloride, EMIM bromide, EMIM ethyl sulfate, EMIM diethyl phosphate, EMIM acetate, EMIM tosylate, 1-butyl-3-methylimidazolium (BMIM) chloride, BMIM bromide, BMIM methyl sulfate, BMIM octyl sulfate, BMIM acetate, 1-allyl-3-methylimidazolium (AMIM) chloride, 1-decyl-3-methylimidazolium (DMIM) chloride, and 1,2,3-trimethylimidazolium (TMIM) methyl sulfate.

48. The method of any of claims 32 to 47, wherein the composition comprises an abrasive in an amount of less than 0.1 wt % by total weight of the composition.

49. The method of claim 48, wherein the composition comprises an abrasive in an amount of less than 0.01 wt % by total weight of the composition.

50. The method of any of claims 32 to 47, wherein the composition is substantially free of any abrasives.

51. The method of any claims 32 to 50, wherein the ionic liquid is present in the composition in an amount of 0.1 wt % to 30 wt % based on the total weight of the composition.

52. The method of claim 51, wherein the ionic liquid is present in the composition in an amount of 0.5 wt % to 20 wt % based on the total weight of the composition.

53. The method of claim 52, wherein the ionic liquid is present in the composition in an amount of 5 wt % to 15 wt % based on the total weight of the composition.

54. The method of claim 53, wherein the ionic liquid is present in the composition in an amount of 8 wt % to 10 wt % based on the total weight of the composition.

55. The method of any of claims 32 to 54, wherein the ionic liquid is present in the composition at a concentration of 1 mM to 500 mM.

56. The method of claim 55, wherein the ionic liquid is present in the composition at a concentration of 5 mM to 300 mM.

57. The method of claim 56, wherein the ionic liquid is present in the composition at a concentration of 150 mM to 250 mM or 1 mM to 50 mM.

58. The method of any of claims 32 to 57, wherein the composition comprises an orally acceptable carrier for a mouth rinse, toothpaste, oral beads or strips, irrigation fluid, plaque removal liquid, tongue spray, dental floss, candy, lozenge, chewing gum, patches and lollipop.

59. The method of any of claims 32 to 58, wherein the composition further comprises one or more agents selected from selected from diluents, bicarbonate salts, pH modifying agents, surfactants, foam modulators, thickening agents, viscosity modifiers, humectants, sweeteners, flavorants, pigments, anticaries agents, anticalculus or tartar control agents, abrasives and mixtures thereof

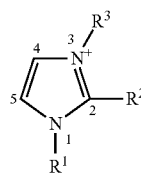
60. The method of any of claims 32 to 59, wherein the composition disrupts, detaches and/or dissolves plaque from the oral cavity.

61. The method of any of claims 32 to 60, wherein the method comprises preventing or treating tooth decay, periodontal disease, gingivitis or xerostomia (dry mouth).

62. A method of whitening teeth in a subject comprising administering a therapeutically effective amount of a composition comprising at least one ionic liquid to the subject.

63. The method of claim 62, wherein the ionic liquid comprises:

- a) an imidazolium cation, and  
 b) an anion selected from the group consisting of salicylate, acetate, halide, phosphate, alkyl phosphate, phosphonate, pyrophosphate, hexametaphosphate, polymetaphosphate, orthophosphate, tripolyphosphate, sulfate, alkyl sulfate, lauryl sulfate, phenolsulfate, benzoate, acetylacetonate, carboxylate, citrate, ascorbate, dicyanamide, L- or D-amino acids, glycolate, gluconate, maleate, sweetener anions, hydroxide, succinate, tartrate, docusate, linoleate, oleate and tosylate.
64. The method of claim 63, wherein the cation is an imidazolium ion having the formula



and wherein  $R^1$ ,  $R^2$ , and  $R^3$  are independently selected from H, alkyl and alkenyl.

65. The method of claim 64, wherein  $R^1$ ,  $R^2$ , and  $R^3$  are independently selected from H,  $C_{1-22}$  alkyl and  $C_{2-22}$  alkenyl

66. The method of claim 65, wherein  $R^1$  and  $R^3$  are independently selected from  $C_{1-10}$  alkyl and  $C_{2-10}$  alkenyl, and wherein  $R^2$  is independently selected from, H,  $C_{1-10}$  alkyl and  $C_{2-10}$  alkenyl.

67. The method of claim 65 or claim 66, wherein the  $C_{12-22}$  alkyl and  $C_{12-22}$  alkenyl are linear.

68. The method of claims 65 to 67, wherein  $R_1$  is  $C_{6-10}$  alkyl or  $C_{6-10}$  alkenyl.

69. The method of any of claims 64 to 68, wherein  $R^2$  is H.

70. The method of any of claims 64 to 69, wherein  $R^3$  is methyl.

71. The method of any of claims 64 to 70, wherein  $R^1$  is selected from ethyl, butyl, hexyl, decyl, and allyl.

72. The method of any of claims 63 to 71, wherein the halide ion is a chloride ion or a bromide ion.

73. The method of any of claims 63 to 72, wherein the alkyl sulfate and alkyl phosphate comprises from 1 to 22 carbon atoms.

74. The method of claim 73, wherein the alkyl sulfate and alkyl phosphate comprises 1 to 4 carbon atoms, or 6 to 10 carbon atoms or 12 to 22 carbon atoms 6 to 10 carbon atoms.

75. The method of any of claims 63 to 74, wherein the anion is selected from the group consisting of acetate, bromide, chloride, methyl sulfate, ethyl sulfate, octyl sulfate, diethyl phosphate, and tosylate.

76. The method of claim 75, wherein anion is selected from acetate, octylsulfate or tosylate.

77. The method of any of claims 62 to 75, wherein the ionic liquid is selected from the group consisting of 1-ethyl-3-methylimidazolium (EMIM) chloride, EMIM bromide, EMIM ethyl sulfate, EMIM diethyl phosphate, EMIM acetate, EMIM tosylate, 1-butyl-3-methylimidazolium (BMIM) chloride, BMIM bromide, BMIM methyl sulfate, BMIM octyl sulfate, BMIM acetate, 1-allyl-3-methylimidazolium (AMIM) chloride, 1-decyl-3-methylimidazolium (DMIM) chloride, and 1,2,3-trimethylimidazolium (TMIM) methyl sulfate.

**78.** The method of any of claims **62** to **77**, wherein the composition comprises an abrasive in an amount of less than 0.1 wt % by total weight of the composition.

**79.** The method of claim **78**, wherein the composition comprises an abrasive in an amount of less than 0.01 wt % by total weight of the composition.

**80.** The method of any of claims **62** to **77**, wherein the composition is substantially free of any abrasives.

**81.** The method of any of claims **62** to **80**, wherein the ionic liquid is present in the composition in an amount of 0.1 wt % to 30 wt % based on the total weight of the composition.

**82.** The method of claim **81**, wherein the ionic liquid is present in the composition in an amount of 0.5 wt % to 20 wt % based on the total weight of the composition.

**83.** The method of claim **82**, wherein the ionic liquid is present in the composition in an amount of 5 wt % to 15 wt % based on the total weight of the composition.

**84.** The method of claim **83**, wherein the ionic liquid is present in the composition in an amount of 8 wt % to 10 wt % based on the total weight of the composition.

**85.** The method of any of claims **62** to **84**, wherein the ionic liquid is present in the composition at a concentration of 1 mM to 500 mM.

**86.** The method of claim **85**, wherein the ionic liquid is present in the composition at a concentration of 5 mM to 300 mM.

**87.** The method of claim **86**, wherein the ionic liquid is present in the composition at a concentration of 15 mM to 250 mM or 1 mM to 50 mM.

**88.** The method of any of claims **62** to **87**, wherein the composition comprises an orally acceptable carrier for a mouth rinse, toothpaste, oral beads or strips, irrigation fluid, plaque removal liquid, tongue spray, dental floss, candy, lozenge, chewing gum, patches and lollipop.

**89.** The method of any of claims **62** to **88**, wherein the composition further comprises one or more agents selected from diluents, bicarbonate salts, pH modifying agents, surfactants, foam modulators, thickening agents, viscosity modifiers, humectants, sweeteners, flavorants, pigments, anticaries agents, anticalculus or tartar control agents, abrasives and mixtures thereof

**90.** The method of any of claims **64** to **89**, wherein  $R^1$  is ethyl,  $R^2$  is H and  $R^3$  is methyl.

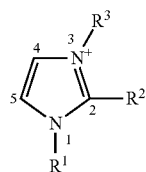
**91.** A method of reducing the amount of bacteria in the oral cavity of a subject comprising administering a therapeutically effective amount of a composition comprising at least one ionic liquid to the subject, wherein the ionic liquid comprises:

a) an imidazolium cation

and

b) an anion selected from the group consisting of salicylate, acetate, halide, phosphate, alkyl phosphate, phosphonate, pyrophosphate, hexametaphosphate, polymetaphosphate, orthophosphate, tripolyphosphate, sulfate, alkyl sulfate, lauryl sulfate, phenolsulfate, benzoate, acetylacetonate, carboxylate, citrate, ascorbate, dicyanamide, L- or D-amino acids, glycolate, gluconate, maleate, sweetener anions, hydroxide, succinate, tartrate, docusate, linoleate, oleate and tosylate.

**92.** The method of claim **91**, wherein the cation is an imidazolium ion having the formula



and wherein  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H, alkyl and alkenyl.

**93.** The method of claim **92**, wherein  $R^1$ ,  $R^2$  and  $R^3$  are independently selected from H,  $C_{1-22}$  alkyl and  $C_{2-22}$  alkenyl.

**94.** The method of claim **93**, wherein  $R^1$  and  $R^3$  are independently selected from  $C_{1-10}$  alkyl and  $C_{2-10}$  alkenyl, and wherein  $R^2$  is independently selected from H,  $C_{1-10}$  alkyl and  $C_{2-10}$  alkenyl.

**95.** The method of claim **93** or **94**, wherein the  $C_{12-22}$  alkyl and  $C_{12-22}$  alkenyl are linear.

**96.** The method of any of claims **93** to **95**, wherein  $R_1$  is  $C_{6-10}$  alkyl or  $C_{6-10}$  alkenyl.

**97.** The method of any of claims **93** to **96**, wherein  $R^2$  is H.

**98.** The method of any of claims **93** to **97** wherein  $R^2$  is methyl.

**99.** The method of any of claims **93** to **98**, wherein  $R^1$  is selected from ethyl, butyl, hexyl, decyl, and allyl.

**100.** The method of any of claims **91** to **99**, wherein the halide ion is a chloride ion or a bromide ion.

**101.** The method of any claims **91** to **100**, wherein the alkyl sulfate and alkyl phosphate comprises from 1 to 22 carbon atoms.

**102.** The method of claim **101**, wherein the alkyl sulfate and alkyl phosphate comprises 1 to 4 carbon atoms, or 6 to 10 carbon atoms or 12 to 22 carbon atoms.

**103.** The method of any of claims **91** to **102**, wherein the anion is selected from the group consisting of acetate, bromide, chloride, methyl sulfate, ethyl sulfate, octyl sulfate, diethyl phosphate, and tosylate.

**104.** The method of claim **103**, wherein anion is selected from acetate, octylsulfate or tosylate.

**105.** The method of any of claims **91** to **103**, wherein the ionic liquid is selected from the group consisting of 1-ethyl-3-methylimidazolium (EMIM) chloride, EMIM bromide, EMIM ethyl sulfate, EMIM diethyl phosphate, EMIM acetate, EMIM tosylate, 1-butyl-3-methylimidazolium (BMIM) chloride, BMIM bromide, BMIM methyl sulfate, BMIM octyl sulfate, BMIM acetate, 1-allyl-3-methylimidazolium (AMIM) chloride, 1-decyl-3-methylimidazolium (DMIM) chloride, and 1,2,3-trimethylimidazolium (TMIM) methyl sulfate.

**106.** The method of any of claims **91** to **105**, wherein the composition comprises an abrasive in an amount of less than 0.1 wt % by total weight of the composition.

**107.** The method of claim **106**, wherein the composition comprises an abrasive in an amount of less than 0.01 wt % by total weight of the composition.

**108.** The method of any of claims **91** to **105**, wherein the composition is substantially free of any abrasives.

**109.** The method of any of claims **91** to **108**, wherein the ionic liquid is present in the composition in an amount of 0.1 wt % to 30 wt % based on the total weight of the composition.

**110.** The method of claim **109**, wherein the ionic liquid is present in the composition in an amount of 0.5 wt % to 20 wt % based on the total weight of the composition.



**111.** The method of claim **110**, wherein the ionic liquid is present in the composition in an amount of 5 wt % to 15 wt % based on the total weight of the composition.

**112.** The method of claim **111**, wherein the ionic liquid is present in the composition in an amount of 8 wt % to 10 wt % based on the total weight of the composition.

**113.** The method of any of claims **91** to **112**, wherein the ionic liquid is present in the composition at a concentration of 1 mM to 500 mM.

**114.** The method of claim **113**, wherein the ionic liquid is present in the composition at a concentration of 5 mM to 300 mM.

**115.** The method of claim **114**, wherein the ionic liquid is present in the composition at a concentration of 15 mM to 250 mM or 1 mM to 50 mM.

**116.** The method of any of claims **91** to **115**, wherein the composition comprises an orally acceptable carrier for a mouth rinse, toothpaste, oral beads or strips, irrigation fluid, plaque removal liquid, tongue spray, dental floss, candy, lozenge, chewing gum, patches and lollipop.

**117.** The method of any of claims **91** to **116**, wherein the composition further comprises one or more agents selected from diluents, bicarbonate salts, pH modifying agents, surfactants, foam modulators, thickening agents, viscosity modifiers, humectants, sweeteners, flavorants, pigments, anticaries agents, anticalculus or tartar control agents, abrasives and mixtures thereof

**118.** The method of any of claims **92** to **117**, wherein  $R^1$  is decyl,  $R^2$  is H, and  $R^3$  is methyl.

**119.** The method of any of claims **91** to **118**, wherein the method further comprises preventing or treating tooth decay, periodontal disease, gingivitis or xerostomia (dry mouth).

**120.** Use of an ionic liquid, in an oral care composition, for removing or reducing plaque in the oral cavity of a subject.

**121.** Use of an ionic liquid, in an oral care composition, for whitening teeth in the oral cavity of a subject.

**122.** Use of an ionic liquid, in an oral care composition, for reducing the amount of bacteria the oral cavity of a subject,

wherein the ionic liquid comprises:

a) an imidazolium cation

and

b) an anion selected from the group consisting of salicylate, acetate, halide, phosphate, alkyl phosphate, phosphonate, pyrophosphate, hexametaphosphate, polymetaphosphate, orthophosphate, tripolyphosphate, sulfate, alkyl sulfate, lauryl sulfate, phenolsulfate, benzoate, acetylacetonate, carboxylate, citrate, ascorbate, dicyamide, L- or D-amino acids, glycolate, gluconate, maleate, sweetener anions, hydroxide, succinate, tartrate, docusate, linoleate, oleate and tosylate.

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