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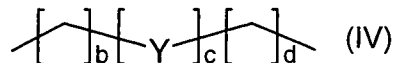
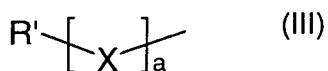
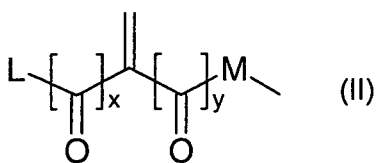
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(54) Title: DENTAL ADHESIVE COMPOSITION



(57) Abstract: A polymerizable dental adhesive composition, which comprises (i) 10 to 90 percent by weight based on the total weight of the composition of a mixture of hydrolysis-stable polymerizable monomers of formula (I): $\text{R}(\text{A})_m(\text{B})_n$ (I), wherein R is a single bond or a m+n valent organic group having 1 to 20 carbon atoms and optionally 1 to 5 atoms selected from the group of nitrogen, oxygen and sulfur atoms; independently represents a moiety of formula (II), wherein L is a hydrogen atom, a C_{1-6} alkyl group, a C_{3-8} cycloalkyl group, a C_{6-14} aryl group or a group of formula (III), wherein R' is a hydrogen atom, a C_{1-6} alkyl group, a C_{3-8} cycloalkyl group, or a C_{6-14} aryl group; X is O, S, NH or NR'' wherein R'' is a C_{1-6} alkyl group, a C_{3-8} cycloalkyl group, a C_{6-14} aryl group; a is O or 1; M is a group of formula (IV), wherein Y is O, S, NH or NR''' wherein R''' is a C_{1-6} alkyl group, a C_{3-8} cycloalkyl group, a C_{6-14} aryl group; b is an integer of from 0 to 3; c is O or 1; d is an integer of from 0 to 3; provided that when b is O, then Y cannot be O or S; x is O or i; y is O or i; provided that x and y cannot be both 1, and provided that x cannot be 1 when L or a group of formula (III) is a hydrogen atom, and provided that when x is O then a is also O, and provided that when y is 0 then b is greater than 0 or c is 0; B independently represents a group having antimicrobial activity or an acidic group; m is an integer of from 1 to 5; n is an integer of 0 to 3;

and m+n is at least 2; (ii) a water-soluble organic solvent and (iii) an initiator and a stabilizer; wherein the portion of antimicrobial monomers of formula (I) wherein n is greater than 0 and at least one B is a group having antimicrobial activity is at least 0.01 percent by weight based on the total weight of the mixture, and wherein the portion of acidic monomers of formula (I) wherein n is greater than 0 and at least one B is an acidic group is at least 0.1 percent by weight based on the total weight of the mixture.

Dental Adhesive Composition

Field of the Invention

The present invention relates to a dental adhesive composition having bactericidal activity and high storage stability prior to curing and having bacteriostatic activity when cured, while providing high mechanical resistance and high adhesion over the entire lifetime of the restoration after curing. The dental adhesive composition of the present invention may be a one-part composition having high storage stability prior to curing and high adhesive strength and long term bacteriostatic activities after curing without leaching of antimicrobial substances from the cured adhesive film. The present invention also relates to a process for the preparation of the dental adhesive composition.

Background of the Invention

Dental adhesives containing monomers having antimicrobially active groups are known. US-A 5,733,949 discloses an antimicrobial adhesive composition for dental use comprising an antimicrobial monomer, a monomer containing at least one acidic group, and a monomer containing at least one alcoholic hydroxy group, in combination with water and a polymerization catalyst. EP-A 1 285 947 discloses an antibacterial composition comprising an antibacterial salt compound, an acid group containing polymerizable monomer, a hydrophilic polymerizable monomer, and water.

The antimicrobial groups used in the prior art may show cytotoxic effects when leaching from the adhesive layer. Since the antimicrobial adhesive compositions known from the prior art contain hydrolyzable groups, the antimicrobial groups may be hydrolyzed from the adhesive layer and may leach from the adhesive layer. A leaching of cytotoxic groups may occur due to hydrolytic cleavage of a side chain containing the antimicrobial group. The leaching of cytotoxic groups may also occur due to hydrolytic cleavage of a polymer backbone containing the antimicrobial group. Due to the leaching of the antimicrobial groups by hydrolytic cleavage, the compositions known from the prior art cannot be formulated as strongly acidic compositions. Accordingly, EP-A 1 285 947 requires a basic compound selected from alkali metal hydroxides, strong basic acid salts not having an aromatic group, and aliphatic amines for improving the storage stability of the composition by adjusting the

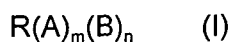
pH in a range of from 1.5 to 4.5. Moreover, hydrolysis of the polymerizable monomers and the leaching of antimicrobial substances leads to a deterioration of the adhesive bonding to the tooth structure and a weakening of the polymeric network. Moreover, the presence of monomers such as HEMA in large proportion leads to swellable cured products which tend to swell and hydrolyze in the oral cavity. Moreover, ethylene glycol as the ultimate hydrolysis product of HEMA further accelerates the deterioration of the properties of the adhesive composition before and after curing. Accordingly, a composition known from EP-A 1 285 947, which contains about 30 percent by weight of HEMA and an acidic polymerizable (meth)acrylate ester may show a satisfactory initial adhesion to dentin whereas the adhesion deteriorates over time due to the swelling and hydrolysis of the cured adhesive.

Accordingly, it is a problem of the present invention to provide a dental adhesive composition having high storage stability and bactericidal activity prior to curing and having bacteriostatic activity when cured, while providing high mechanical resistance and adhesion over the entire lifetime of the restoration after curing. Moreover, it is a problem of the present invention to provide a dental adhesive composition from which the leaching of antimicrobial molecules may be avoided.

Summary of the Invention

Accordingly, the present invention provides a polymerizable dental adhesive composition, which comprises

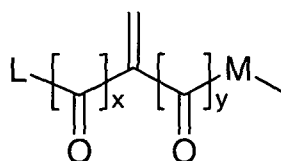
- (i) 10 to 90 percent by weight based on the total weight of the composition of a mixture of hydrolysis-stable polymerizable monomers of the following formula (I):



wherein

- R is a single bond or a $m+n$ valent organic group having 1 to 20 carbon atoms and optionally 1 to 5 atoms selected from the group of nitrogen, oxygen and sulfur atoms;
- A independently represents a moiety of the following formula (II):

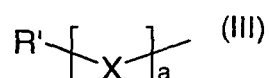
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(II)

wherein

L is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group or a group of the following formula (III)



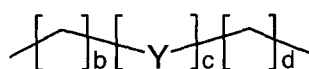
wherein

R' is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, or a C₆₋₁₄ aryl group;

X is O, S, NH or NR'' wherein R'' is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group;

a is 0 or 1;

M is a group of the following formula (IV)



(IV)

wherein

Y is O, S, NH or NR''' wherein R''' is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group;

b is an integer of from 0 to 3;

c is 0 or 1;

d is an integer of from 0 to 3;

provided that when b is 0, then Y cannot be O or S;

x is 0 or 1;

y is 0 or 1;

provided that x and y cannot be both 1, and

provided that x cannot be 1 when L or a group of formula (III) is a hydrogen atom, and

provided that when x is 0 then a is also 0, and

provided that when y is 0 then b is greater than 0 or c is 0;

B independently represents a group having antimicrobial activity or an acidic group;

m is an integer of from 1 to 5;

n is an integer of 0 to 3; and

m+n is at least 2;

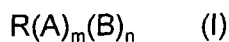
(ii) a water-soluble organic solvent and

(iii) an initiator and a stabilizer;

wherein the portion of antimicrobial monomers of formula (I) wherein n is greater than 0 and at least one B is a group having antimicrobial activity is at least 0.01 percent by weight based on the total weight of the mixture, and wherein the portion of acidic monomers of formula (I) wherein n is greater than 0 and at least one B is an acidic group is at least 0.1 percent by weight based on the total weight of the mixture.

Moreover, the present invention relates to a process for the preparation of a dental adhesive composition as defined by any one of claims 1 to 18, which comprises the step of mixing

- (i) 10 to 90 percent by weight based on the total weight of the composition of a mixture of hydrolysis-stable polymerizable monomers of the following formula (I):

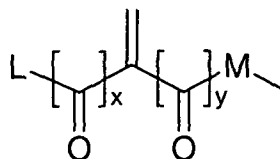


wherein

R is a single bond or a m+n valent organic group having 1 to 20 carbon atoms and optionally 1 to 5 atoms selected from the group of nitrogen, oxygen and sulfur atoms;

A independently represents a moiety of the following formula (II):

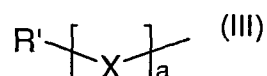
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(II)

wherein

L is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group or a group of the following formula (III)



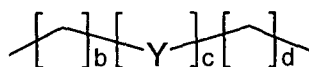
wherein

R' is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, or a C₆₋₁₄ aryl group;

X is O, S, NH or NR'' wherein R'' is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group;

a is 0 or 1;

M is a group of the following formula (IV)



(IV)

wherein

Y is O, S, NH or NR''' wherein R''' is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group;

b is an integer of from 0 to 3;

c is 0 or 1;

d is an integer of from 0 to 3;

provided that when b is 0, then Y cannot be O or S;

x is 0 or 1;

y is 0 or 1;

provided that x and y cannot be both 1, and

provided that x cannot be 1 when L or a group of formula (III) is a hydrogen atom, and

provided that when x is 0 then a is also 0, and

provided that when y is 0 then b is greater than 0 or c is 0;

B represents

-V-W

wherein

V represents a single bond or a hydrolyzable linker, and

W represents a group having antimicrobial activity;

m is an integer of from 1 to 5;

n is an integer of 0 to 3; and

m+n is at least 2;

(ii) a water-soluble organic solvent and

(iii) an initiator system;

wherein the portion of antimicrobial monomers of formula (I) wherein n is greater than 0 and at least one B is a group having antimicrobial activity is at least 0.01 percent by weight based on the total weight of the mixture, and wherein the portion of acidic monomers of formula (I) wherein n is greater than 0 and at least one B is an acidic group is at least 0.1 percent by weight based on the total weight of the mixture.

Detailed Description of the Preferred Embodiments

The dental adhesive composition according to the invention contains a mixture of hydrolysis-stable polymerizable monomers. A portion of the hydrolysis-stable polymerizable monomers contains an antimicrobial group. A portion of the hydrolysis-stable polymerizable monomers contains an acidic group. A portion of the hydrolysis-stable polymerizable monomers contains a crosslinking polymerizable monomer. The polymerizable monomers are hydrolysis-stable. Specifically, the polymerizable monomers do not contain groups such as ester groups, in the main chain which hydrolyze in aqueous media at pH 3 at room temperature within one month.

The polymerizable monomers are compounds of formula (I). The monomer of formula (I), comprises a moiety R, up to five polymerizable substituents A and optionally up to three groups B which are selected from acidic groups and/or antimicrobial groups. Accordingly, m is an integer of from 1 to 5 and n is an integer of from 0 to 3. The sum of m and n is at least 2. Accordingly, in case of a single polymerizable substituents A, the polymerizable monomer comprises an acidic group or an antimicrobial group.

Moiety A is an organic group having 1 to 20 carbon atoms and optionally 1 to 5 atoms selected from the group of nitrogen, oxygen and sulfur atoms. In a preferred embodiment, R is an organic group having 1 to 6 carbon atoms. The organic group has a valency of at least two and corresponds to the total number of substituents A and B. Accordingly, R may be divalent (n=2), trivalent (n=3), tetravalent (n=4), pentavalent (n=5), or hexavalent (n=6). Preferably, R is divalent or trivalent, most preferably divalent. A may be a hydrocarbon group which may be aliphatic and/or aromatic. The hydrocarbon group may be substituted by 1 to 6 C₁₋₄ alkyl groups provided that the total amount of carbon atoms of R does not exceed 20. Specific examples of the alkyl groups are methyl, ethyl, n-propyl, i-propyl, n-butyl, i-butyl or tert.-butyl. In a preferred embodiment, the hydrocarbon group may contain 1 to 5 oxygen atoms in the hydrocarbon group in the form of aliphatic or aromatic ether bonds, keto groups, carboxylic acid groups, or hydroxyl groups. Ester groups are not preferred in moiety R in view of hydrolysis stability of the polymerizable monomer. In case of an aliphatic group, R may be a straight chain or branched chain alkylene group or a cycloalkylene group. In case of an aromatic group, R may be an arylene group or a heteroarylene group. Specifically, R may be a divalent substituted or unsubstituted C₁ to C₂₀ alkylene group, substituted or unsubstituted C₆₋₁₄ arylene group, substituted or unsubstituted C₃ to C₂₀ cycloalkylene group, substituted or unsubstituted C₇ to C₂₀ arylenealkylenearylene group. Preferably, R represents a saturated aliphatic C₂₋₂₀ hydrocarbon chain which may contain 2 to 4 oxygen atoms, and which may be substituted by 1 to 6 C₁₋₄ alkyl groups, or R may be a substituted or unsubstituted C₇ to C₂₀ arylenealkylenearylene group which may be substituted by 1 to 6 C₁₋₄ alkyl groups.

The polymerizable monomer of formula (I) contains at least one and up to five polymerizable substituents A. In case more than one A is present, each A independently represents a moiety of the following formula (II). Accordingly, in one embodiment all A are identical. In a further embodiment, the polymerizable substituents A are different from each other.

In formula (II), A contains a polymerizable double bond. A carbonyl group may be adjacent to the double bond. Accordingly, x may be 0 or 1 and y may be 0 or 1. Two carbonyl groups adjacent to the same polymerizable double bond cannot be present in a substituent A. Accordingly, x and y cannot be both 1.

Substituent A further contains moieties L and M. L is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group or a group of formula (III). Specific examples of the C₁₋₆ alkyl groups are methyl, ethyl, n-propyl, i-propyl, n-butyl, i-butyl or tert.-butyl. Examples of the C₃₋₈ cycloalkyl are cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl. Specific examples of the C₆₋₁₄ aryl groups are phenyl or naphthyl. The C₁₋₆ alkyl group, the C₃₋₁₄ cycloalkyl group and the C₆₋₁₄ aryl group may optionally be substituted by one or more members of the group selected from a C₁₋₄ alkyl group, C₁₋₄ alkoxy group, and a phenyl. Examples for a C₁₋₄ alkyl group can include linear or branched alkyl groups having 1 to 4 carbon atoms, for example, methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl. Examples for an C₁₋₄ alkoxy group can include linear or branched alkoxy groups having 1 to 4 carbon atoms, for example, methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, isobutoxy, sec-butoxy, and tert-butoxy.

When L is a group of formula (III) then R' is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, or a C₆₋₁₄ aryl group. Specific examples of the C₁₋₆ alkyl groups are methyl, ethyl, n-propyl, i-propyl, n-butyl, i-butyl or tert.-butyl. Examples of the C₃₋₈ cycloalkyl are cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl. Specific examples of the C₆₋₁₄ aryl groups are phenyl or naphthyl. The C₁₋₆ alkyl group, the C₃₋₁₄ cycloalkyl group and the C₆₋₁₄ aryl group may optionally be substituted by one or more members of the group selected from a C₁₋₄ alkyl group, C₁₋₄ alkoxy group, and a phenyl. Examples for a C₁₋₄ alkyl group can include linear or branched alkyl groups having 1 to 4 carbon atoms, for example, methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl. Examples for an C₁₋₄ alkoxy group can include linear or branched alkoxy groups having 1 to 4 carbon atoms, for example, methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, isobutoxy, sec-butoxy, and tert-butoxy.

When L is a group of formula (III) then X is O, S, NH or NR'' wherein R'' is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group. Specific examples of the C₁₋₆ alkyl groups are methyl, ethyl, n-propyl, i-propyl, n-butyl, i-butyl or tert.-butyl. Examples of the C₃₋₈ cycloalkyl

are cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl. Specific examples of the C_{6-14} aryl groups are phenyl or naphthyl. The C_{1-6} alkyl group, the C_{3-14} cycloalkyl group and the C_{6-14} aryl group may optionally be substituted by one or more members of the group selected from a C_{1-4} alkyl group, C_{1-4} alkoxy group, and a phenyl. Examples for a C_{1-4} alkyl group can include linear or branched alkyl groups having 1 to 4 carbon atoms, for example, methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl. Examples for an C_{1-4} alkoxy group can include linear or branched alkoxy groups having 1 to 4 carbon atoms, for example, methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, isobutoxy, sec-butoxy, and tert-butoxy.

When L is a group of formula (III) then a is 0 or 1.

In a group of formula (II), M is a group of formula (IV). When b, c, and d in Formula (IV) is 0 then M represents a single bond.

When M is not a single bond, then Y in formula (IV) is O, S, NH or NR'' wherein R'' is a C_{1-6} alkyl group, a C_{3-8} cycloalkyl group, a C_{6-14} aryl group. Specific examples of the C_{1-6} alkyl groups are methyl, ethyl, n-propyl, i-propyl, n-butyl, i-butyl or tert.-butyl. Examples of the C_{3-8} cycloalkyl are cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl. Specific examples of the C_{6-14} aryl groups are phenyl or naphthyl. The C_{1-6} alkyl group, the C_{3-14} cycloalkyl group and the C_{6-14} aryl group may optionally be substituted by one or more members of the group selected from a C_{1-4} alkyl group, C_{1-4} alkoxy group, and a phenyl. Examples for a C_{1-4} alkyl group can include linear or branched alkyl groups having 1 to 4 carbon atoms, for example, methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl. Examples for an C_{1-4} alkoxy group can include linear or branched alkoxy groups having 1 to 4 carbon atoms, for example, methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, isobutoxy, sec-butoxy, and tert-butoxy.

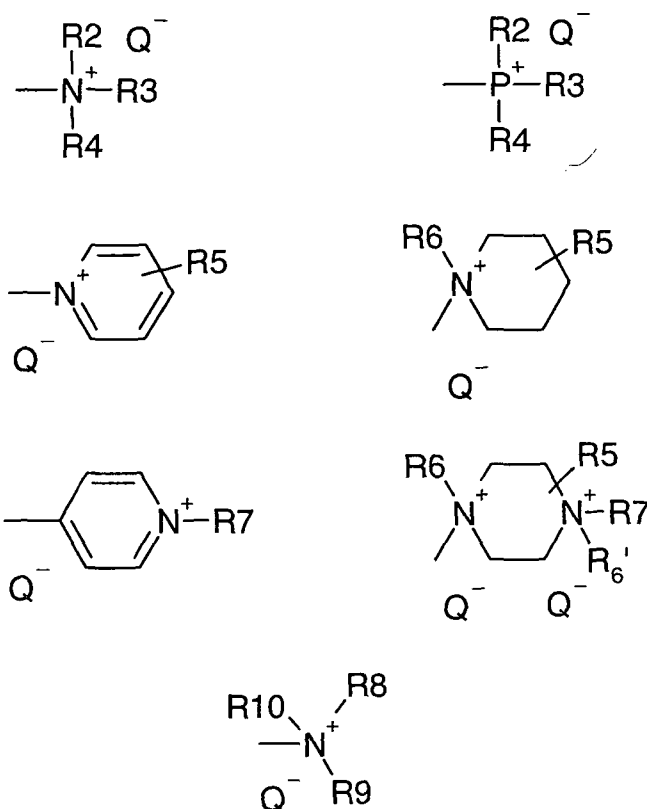
When M is not a single bond, then b is an integer of from 0 to 3; c is 0 or 1; d is an integer of from 0 to 3.

In formula (IV), when b is 0 and y is 1, then Y cannot be an oxygen atom. Otherwise, the polymerizable double bond of substituent A would be linked by a hydrolysable ester bond. Furthermore, an aldehyde group cannot be adjacent to the polymerizable double bond.

Accordingly, x cannot be 1 when L or a group of formula (III) is a hydrogen atom. Still further, an hetero atom such as oxygen, sulfur and nitrogen cannot be adjacent to the polymerizable double bond. Accordingly, when x is 0 then a is also 0; and when y is 0 then b is greater than 0 or c is 0.

A compound of formula (I) may contain up to 3 substituents B which may be the same or different and independently represent a group having antimicrobial activity or an acidic group.

Preferably, the groups B having antimicrobial activity are selected from



wherein R_2 , R_3 , R_4 and R_5 independently represent a C_{1-18} alkyl group, which may be substituted by one or more substituents selected from a hydroxyl group, a halogen atom or a phenyl group optionally substituted by a C_{1-6} alkyl group, a C_{1-6} alkoxy group, a halogen atom, a vinyl group or a cyano group, or two substituents selected from R_2 , R_3 , and R_4 together represent an C_{2-6} alkylene group forming with the nitrogen atom or phosphorous

atom to which they are bound a 3 to 7 membered ring; R6 and R6' is present or absent and when R6 or R6' are present, an anionic group Q⁻ is also present and R6 or R6' independently represent a hydrogen atom or a C₁₋₁₈ alkyl group, provided that at least one R6 and R6' is present, or R5 and R6 or R6' together represent an C₂₋₆ alkylene group, R7 represents a C₆₋₁₈ alkyl group, which may be substituted by one or more halogen atoms, or R6 or R6' and R7 together represent an C₂₋₆ alkylene group, R8 and R9 independently represent a C₆₋₁₈ alkyl group, which may be substituted by one or more substituents selected from a hydroxyl group, a halogen atom or a phenyl group optionally substituted by a C₁₋₆ alkyl group; and R10 represents a hydrogen atom or a C₁₋₁₈ alkyl group, or R10 and R8 or R9 together represent an C₂₋₆ alkylene group, Q⁻ represents an anionic group, which is attached by a single bond or a linker to the polymerizable group. The linker may be a hydrocarbon group having up to 12 carbon atoms and may contain up to 6 heteroatoms selected from O, N and S.

Preferably, the acidic groups are selected from a sulfonic acid group, a phosphoric acid ester group, a phosphonic acid group, and a carboxylic acid group.

The mixture of the hydrolysis-stable polymerizable monomers of formula (I) is contained in the dental adhesive composition in an amount of from 10 to 90, preferably 10 to 60 percent by weight based on the total weight of the composition. More preferably, 15 to 40 percent by weight are contained.

The portion of antimicrobial monomers of formula (I) wherein n is greater than 0 and at least one B is a group having antimicrobial activity is at least 0.01 percent by weight based on the total weight of the mixture. Preferably the portion is in a range of from 0.05 to 30 percent by weight, more preferably in a range of from 0.1 to 20 percent by weight.

The portion of acidic monomers of formula (I) wherein n is greater than 0 and at least one B is an acidic group is at least 0.1 percent by weight based on the total weight of the mixture. Preferably the portion is in a range of from 0.2 to 15 percent by weight.

A preferred group of monomers of formula (I) are those, wherein n is 0, and wherein A is a moiety of formula (II) wherein L is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, or a C₆₋₁₄ aryl group, and x is 0. More preferably, in this group A is a moiety of

formula (II) wherein y is 1, and wherein M is a moiety of formula (IV) wherein Y is NH or NR^{'''} wherein R^{'''} is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group, b is 0, c is 1, and d is an integer of from 0 to 3.

A further preferred group of monomers of formula (I) are those, wherein n is 0, and wherein A is a moiety of formula (II) wherein x is 1. More preferably, L is a group of formula (III) wherein R' is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, or a C₆₋₁₄ aryl group, X is O, S, NH or NR^{''} wherein R^{''} is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group, and a is 1.

A further preferred group of monomers of formula (I) are those, wherein n is greater than 0, and wherein A is a moiety of formula (II) wherein L is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, or a C₆₋₁₄ aryl group, and x is 0. More preferably, A is a moiety of formula (II) wherein y is 0, L is a hydrogen atom, and M is a group of formula (IV) wherein Y is O, b and c are 1, and d is an integer of from 0 to 3.

A further preferred group of monomers of formula (I) are those, wherein A is a moiety of formula (II) wherein y is 0, L is a hydrogen atom, and M is a group of formula (IV) wherein Y is NH or NR^{''} wherein R^{''} is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group, b is 0, c is 1, and d is an integer of from 0 to 3.

The dental adhesive composition according to the present invention may contain a filler. The filler may be an inorganic or organic filler or combinations thereof. In one embodiment, a suitable inorganic particulate filler may include colloidal or submicron silicas coated with a polymer. Small amounts of pigments to allow matching of the composition to various shades of teeth can be included. In one embodiment, the filler is contained in the dental adhesive material in an amount of less than 5 % by weight.

The dental adhesive composition according to the present invention contains a polymerization initiator and a stabilizer. The initiator is not particularly limited and may be preferably a photoinitiator. Specifically, camphor quinone may be mentioned.

The dental adhesive composition according to the invention may comprise an organic water soluble solvent and/or water. The organic water soluble solvent may be selected from alcohols, such as ethanol, propanol, butanol; and/or ketones such as acetone and methyl

ethyl ketone. Particularly preferred is acetone, ethanol and/or tert-butanol. Preferably, the total amount of solvent and, if present, water in the dental adhesive composition is in the range of from 10 to 90 percent by weight, preferably from 40 to 60 percent by weight.

Preferably, the molecular weight of the compound of formula (I) is in the range of from 100 to 1000, more preferably up to 500.

The dental adhesive composition according to the present invention may further contain a reactive diluent. Specific examples of a reactive diluent is selected from (meth) acrylic acid and itaconic acid.

The dental adhesive composition preferably has an adhesion to dentine of at least 10 MPa.

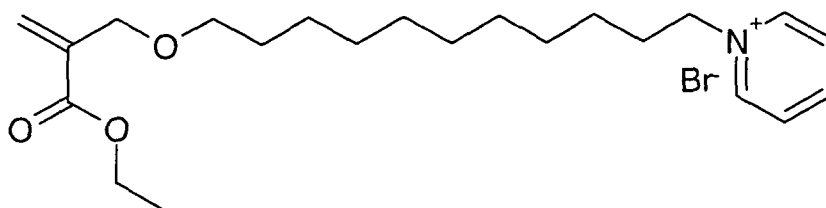
The dental adhesive composition according to the invention is preferably a one-part composition. A one-part composition means that the dental adhesive composition of the present invention is contained in only one container which may be stored and allows application of the dental adhesive composition without any mixing and without any special equipment before the application.

A hydrolysis-stable polymerizable monomers of formula (I) may be prepared according to the methods as disclosed in WO02/13768, WO03/013444, WO03/035013; WO2004/078100, WO2005/063778, EP 05 022 930.1, and EP 06 021 540.7.

The invention will now be illustrated in further detail with reference to the following Examples.

Example 1

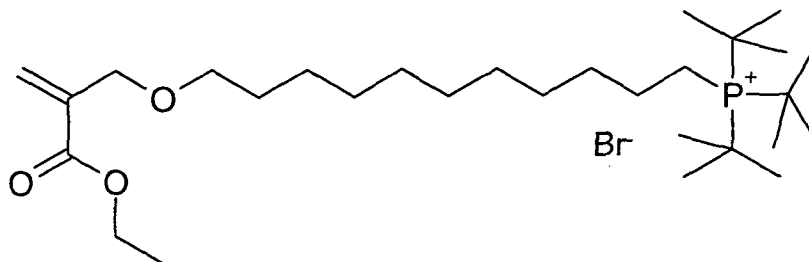
1-[3,7-Dioxa-4-oxo-5-methylene-octadecyl]pyridinium bromide



As solution of 20.0 g (0.055 mol) of ethyl 2-[11-bromo-2-oxatridecyl]acrylate and 4.78 g (0.0605 mol) pyridine dissolved in 200 ml toluene is stirred at 100 °C for 2 h. After cooling of the reaction mixture the product is isolated, washed with ether and dried in vacuum at rotation evaporator at 40 °C. Yield: 12.95 g (53 % of th.)

Example 2

1-[3.7-Dioxa-4-oxo-5-methylene-octadecyl]-tri-tert.-butyl phosphonium bromide



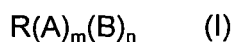
As solution of 14.67 g (0.040 mol) of ethyl 2-[11-bromo-2-oxatridecyl]acrylate and 8.986 g (0.044 mol) Tri-tert.-butyl phosphine dissolved 200 ml toluene is stirred at 100 °C for 2 h. After cooling of the reaction solution the product is isolated, washed with ether and dried in vacuum at rotation evaporator at 40 °C. Yield: 8.60 g (63.7 % of th.)

Application Example 1

0.4611 g N,N'-Bisacrylamido-N,N'-diethyl-1,3-propane, 0.3596 g Bisacrylamido-2,4,4-(2,2,4)-trimethylhexane, 0.1320 g ethyl 2-[4-dihydrogen phosphoryl-4,2-dioxapentyl]acrylate, 0.0240 g 1-[3.7-Dioxa-4-oxo-5-methylene-octadecyl]pyridinium bromide, 0.1076g 2-acrylamido-2-methyl-propane-sulfonic acid, 0.0085g camphor quinone, 0.0213 g bis(2,4,6-trimethylbenzoyl)-phenyl phosphine oxide and 0.0099 g dimethylamino benzoic acid ethyl ester are dissolved in a solvent mixture composed of 0.5850 g ethanol and 0.3150 g water. This formulation shows antimicrobial activity against *Streptococcus mutans*.

Claims

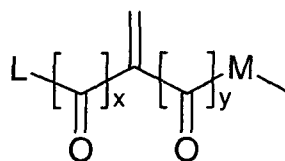
1. A polymerizable dental adhesive composition, which comprises
 - (i) 10 to 90 percent by weight based on the total weight of the composition of a mixture of hydrolysis-stable polymerizable monomers of the following formula (I):



wherein

R is a single bond or a m+n valent organic group having 1 to 20 carbon atoms and optionally 1 to 5 atoms selected from the group of nitrogen, oxygen and sulfur atoms;

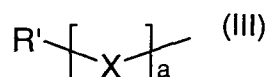
A independently represents a moiety of the following formula (II):



(II)

wherein

L is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group or a group of the following formula (III)



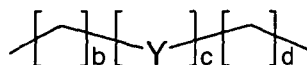
wherein

R' is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, or a C₆₋₁₄ aryl group;

X is O, S, NH or NR'' wherein R'' is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group;

a is 0 or 1;

M is a group of the following formula (IV)



(IV)

wherein

Y is O, S, NH or NR^{'''} wherein R^{'''} is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group;

b is an integer of from 0 to 3;

c is 0 or 1;

d is an integer of from 0 to 3;

provided that when b is 0, then Y cannot be O or S;

x is 0 or 1;

y is 0 or 1;

provided that x and y cannot be both 1, and

provided that x cannot be 1 when L or a group of formula (III) is a hydrogen atom, and

provided that when x is 0 then a is also 0, and

provided that when y is 0 then b is greater than 0 or c is 0;

B independently represents a group having antimicrobial activity or an acidic group;

m is an integer of from 1 to 5;

n is an integer of 0 to 3; and

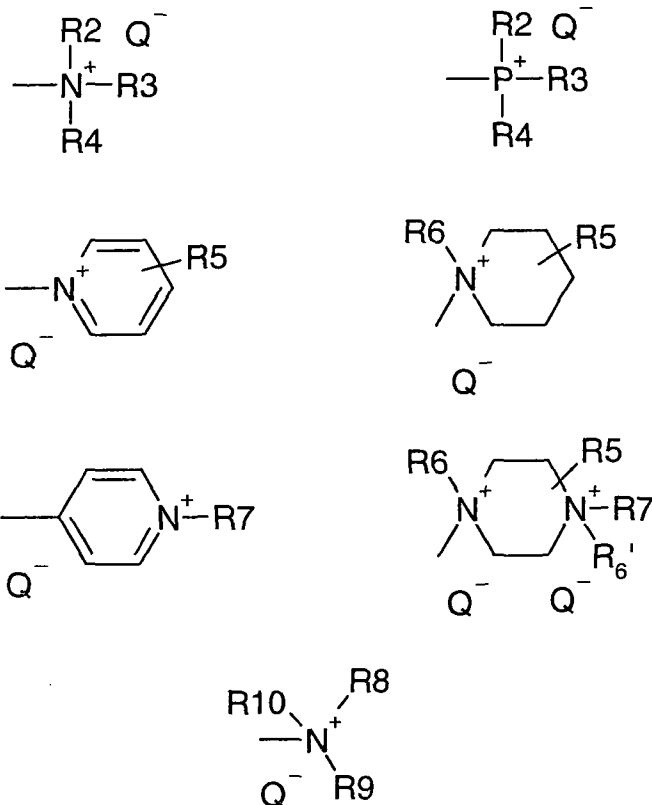
m+n is at least 2;

(ii) a water-soluble organic solvent and

(iii) an initiator and a stabilizer;

wherein the portion of antimicrobial monomers of formula (I) wherein n is greater than 0 and at least one B is a group having antimicrobial activity is at least 0.01 percent by weight based on the total weight of the mixture, and wherein the portion of acidic monomers of formula (I) wherein n is greater than 0 and at least one B is an acidic group is at least 0.1 percent by weight based on the total weight of the mixture.

2. The dental adhesive composition according to claim 1, wherein B contains a group selected from



wherein

R2, R3, R4 and R5

independently represent a C_{1-18} alkyl group, which may be substituted by one or more substituents selected from a hydroxyl group, a halogen atom or a phenyl group optionally substituted by a C_{1-6} alkyl group, a C_{1-6} alkoxy group, a halogen atom, a vinyl group or a cyano group, or two substituents selected from R2, R3, and R4 together represent an C_{2-6} alkylene group forming with the nitrogen atom or phosphorous atom to which they are bound a 3 to 7 membered ring;

R6 and R6'

is present or absent and when R6 or R6' are present, an anionic group Q^- is also present and R6 or R6' independently represent a hydrogen atom or a C_{1-18} alkyl group, provided that at least one R6 and R6' is present, or R5 and R6 or R6' together represent an C_{2-6} alkylene group,

R7 represents a C₆₋₁₈ alkyl group, which may be substituted by one or more halogen atoms, or R6 or R6' and R7 together represent an C₂₋₆ alkylene group,

R8 and R9

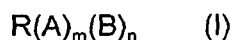
independently represent a C₆₋₁₈ alkyl group, which may be substituted by one or more substituents selected from a hydroxyl group, a halogen atom or a phenyl group optionally substituted by a C₁₋₆ alkyl group; and

R10 represents a hydrogen atom or a C₁₋₁₈ alkyl group,
or R10 and R8 or R9 together represent an C₂₋₆ alkylene group,

Q⁻ represents an anionic group, which is attached by a single bond or a linker to the polymerizable group.

3. The dental adhesive composition according to claim 1 or 2, wherein R is a m+n valent organic group having 1 to 18 carbon atoms.
4. The dental adhesive composition according to any one of the preceding claims containing monomers of formula (I), wherein V is an ester group.
5. The dental adhesive composition according to any one of claims 1 to 4 containing monomers of formula (I), wherein n is greater than 0, and wherein A is a moiety of formula (II) wherein L is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, or a C₆₋₁₄ aryl group, and x is 0.
6. The dental adhesive composition according to claim 5, wherein A is a moiety of formula (II) wherein y is 0, L is a hydrogen atom, and M is a group of formula (IV) wherein Y is O, b and c are 1, and d is an integer of from 0 to 3.
7. The dental adhesive composition according to claim 5, wherein A is a moiety of formula (II) wherein y is 0, L is a hydrogen atom, and M is a group of formula (IV) wherein Y is NH or NR" wherein R" is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group, b is 0, c is 1, and d is an integer of from 0 to 3.
8. The dental adhesive composition according to any one of the preceding claims, which further contains a filler.

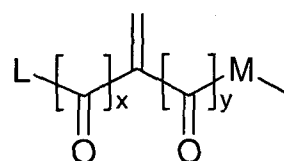
9. The dental adhesive composition according to any one of the preceding claims wherein the molecular weight of the compound of formula (I) is in the range of from 100 to 1000.
10. The dental adhesive composition according to any one of the preceding claims, which has an adhesion to dentine of at least 10 MPa.
11. The dental adhesive composition according to any one of the preceding claims, which is a one-part composition.
12. The dental adhesive composition according to any one of the preceding claims, which is an aqueous dental adhesive composition.
13. A process for the preparation of a dental adhesive composition as defined by any one of claims 1 to 12, which comprises the step of mixing
 - (i) 10 to 60 percent by weight based on the total weight of the composition of a mixture of hydrolysis-stable polymerizable monomers of the following formula (I):



wherein

R is a single bond or a m+n valent organic group having 1 to 20 carbon atoms and optionally 1 to 5 atoms selected from the group of nitrogen, oxygen and sulfur atoms;

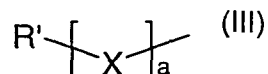
A independently represents a moiety of the following formula (II):



(II)

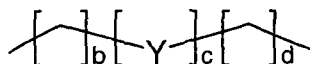
wherein

- L is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group or a group of the following formula (III)



wherein

- R' is a hydrogen atom, a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, or a C₆₋₁₄ aryl group;
 X is O, S, NH or NR'' wherein R'' is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group;
 a is 0 or 1;
 M is a group of the following formula (IV)



(IV)

wherein

- Y is O, S, NH or NR''' wherein R''' is a C₁₋₆ alkyl group, a C₃₋₈ cycloalkyl group, a C₆₋₁₄ aryl group;
 b is an integer of from 0 to 3;
 c is 0 or 1;
 d is an integer of from 0 to 3;
 provided that when b is 0, then Y cannot be O or S;
 x is 0 or 1;
 y is 0 or 1;
 provided that x and y cannot be both 1, and
 provided that x cannot be 1 when L or a group of formula (III) is a hydrogen atom, and
 provided that when x is 0 then a is also 0, and
 provided that when y is 0 then b is greater than 0 or c is 0;

B independently represents a group having antimicrobial activity or an acidic group;

m is an integer of from 1 to 5;

n is an integer of 0 to 3; and

m+n is at least 2;

(ii) a water-soluble organic solvent and

(iii) an initiator and a stabilizer;

wherein the portion of antimicrobial monomers of formula (I) wherein n is greater than 0 and at least one B is a group having antimicrobial activity is at least 0.01 percent by weight based on the total weight of the mixture, and wherein the portion of acidic monomers of formula (I) wherein n is greater than 0 and at least one B is an acidic group is at least 0.1 percent by weight based on the total weight of the mixture.