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(54) Anticalculus oral composition

(57) Oral compositions such as mouthwashes and toothpastes, creams, gels, powders and gums containing as anticalculus agent phosphonoformic acid or salt thereof and optionally also an F-providing anticaries compound, and method of using such compositions.

SPECIFICATION

Anticalculus oral composition

The present invention relates to oral compositions containing an anticalculus agent.

Calculus is a hard, mineralized formation which forms on the teeth. Regular brushing aids in preventing a rapid build-up of these deposits, but even regular brushing is not sufficient to remove all of the calculus deposits which adhere to the teeth. Calculus is formed on the teeth when crystals of calcium phosphates begin to be deposited in the pellicle and extracellular matrix of the dental plaque and become sufficiently closely packed together for the aggregates to become resistant to deformation. There is no complete agreement on the route by which calcium and orthophosphate ultimately become the crystalline material called hydroxyapatite (HAP). It is generally agreed, however, that at higher saturations, that is, above the critical saturation limit, the precursor to crystalline HAP is an amorphous or microcrystalline calcium phosphate. "Amorphous calcium phosphate" although related to hydroxyapatite differs from it in atomic structure, particle morphology, and stoichiometry. The X-ray diffraction pattern of amorphous calcium phosphate shows broad peaks typical of amorphous material, which lack the long-range atomic order characteristic of all crystalline materials, including HAP. It is apparent therefore that agents which effectively interfere with crystalline growth of HAP will be effective as anticalculus agents. A suggested mechanism by which the anticalculus agents of the present invention inhibit calculus formation probably involves an increase of the activation energy barrier thus inhibiting the transformation of precursor amorphous calcium phosphate to HAP.

Studies have shown that there is a good correlation between the ability of a compound to prevent HAP crystalline growth *in vitro* and its ability to prevent calcification *in vivo*. See for example A. Gaffar et al. Calcified Tissue Research (1982):34:S8–S16.

A substantial number of different types of compounds and compositions have been developed for use as antibacterial, antiplaque, anticalculus agents in oral compositions, including for example such cationic materials as the bis-biguanide compounds and quaternary ammonium compounds, e.g. benzethonium chloride and cetyl pyridinium chloride, disclosed in U.S. 4,110,429. These cationic materials however tend to stain the teeth with continued use, and their antibacterial effect tends to disrupt or destroy the normal microflora of the mouth and/or digestive system.

A number of compounds containing one or more phosphono and/or carboxylic groups have been proposed as oral anticalculus agents, including for example 1-phosphon propane tricarboxylic acid (PPT) in Heins, U.S. 3,923,876, ethylenediamine tetramethylenephosphonicacid (Editempa) in Kim, U.S. 4,143,128, 2-phosphonobutane-1,2,4-tricarboxylic acid (PBTA) in Gaffar, U.S. 4,224,308, and phosphonoacetic acid (PAA) in Gaffar, U.S. 4,215,105. Such agents however have been regarded as subject to one or more objectionable problems and disadvantages, with respect to availability, cost, unsatisfactory solubility, stability, sensory properties such as taste and smell, dermal or internal toxicity, dissolution or other damage to tooth surfaces, and/or incompatibility or interference with other functionally active or conventional additives in the oral composition. Illustratively, as shown hereinafter, such compounds as PPT and Editempa when employed in an oral composition together with a fluorine-providing anticaries compound interfere unduly with the desired anticaries effect and it is thought that they may increase the rate of dissolution of tooth surfaces. On the other hand, PAA in an oral composition has been found to emit volatile osmophores providing an undesirable strong vinegary odour and a tart, sour taste generally objectionable and unacceptable to the prospective user.

The present invention aims to provide an improved anticalculus oral composition which will not be subject to one or more of the above problems and disadvantages.

The present invention also aims to provide an oral composition which inhibits the transformation of amorphous calcium phosphate to HAP crystal structure normally associated with calculus.

In accordance with certain of its aspects, the present invention relates to an oral composition comprising an oral (orally acceptable) vehicle containing in an effective amount, as an anticalculus agent, phosphonoformic acid (PFA) of the formula:

$H_2O_3P–COOH$,

or an orally acceptable salt thereof, preferably water soluble, such as with an alkali metal (e.g. sodium and potassium), ammonium, $C_1–C_{18}$ mono-, di- or tri-substituted ammonium (e.g. alkanol substituted such as mono-, di- and tri-ethanolammonium), or organic amine cation. A partially or completely neutralized salt may be employed, i.e. containing from 1 to 3 cations. The PFA compound may be anhydrous or hydrated. A preferred salt is the fully neutralized trisodium hexahydrate.

It is highly surprising that in contrast to the vinegary odour and tart sour taste of oral compositions containing the closely related PAA, those of the present invention containing PFA

are comparatively odour-free and have a neutral to sweet taste, being also dermally milder.

U.S. 4,215, 113 issued 29th July, 1980 to B. Eriksson et al discloses compositions containing PFA, but fails to disclose, contemplate or suggest oral compositions and treatment processes of the type disclosed and claimed herein, namely compositions such as mouthwashes and toothpaste, gels and creams, the latter containing essential abrasive or polishing material, which compositions are normally used briefly (but regularly or daily) for washing, gargling or brushing teeth in the oral cavity and then promptly removed or released from the oral cavity by the user, usually by rinsing with water. The patent does however contain ample disclosures of physiologically acceptable salts of PFA (and methods of making them and PFA per se) which are operative in the oral compositions of the present invention, and such disclosures are accordingly incorporated herein by reference thereto.

The concentration of the PFA compound (or salt) in the oral compositions of the present invention can range widely, typically upward from about 0.01% by weight, with no upper limit on the amount that can be utilized except as dictated by cost or incompatibility with the vehicle. Generally, weight concentrations of about 0.01% to about 10%, and preferably about 0.1% to about 4%, more preferably about 0.2% to about 3% are utilized. Oral compositions which in the ordinary course of usage could be accidentally ingested preferably contain concentrations of the PFA compound in the lower portions of the foregoing ranges. Thus, a mouthwash in accordance with the present invention preferably contains less than about 1.5% by weight of the PFA compound. Other dentifrice compositions, topical solutions and prophylactic pastes, the latter to be administered professionally, can preferably contain about 0.1% to 2% by weight of the PFA compound. The PFA compound should of course be compatible with the other components of the oral compositions of the present invention.

The PFA compounds of the present invention are anti-nucleating agents. Oral compositions of the present invention containing them are effective in reducing formation of dental calculus without unduly decalcifying or otherwise damaging or dissolving the dental enamel. In contrast to the above-mentioned cationic antibacterial, antiplaque, and anti-calculus agents, such PFA compounds and compositions have little or no tendency to stain the teeth.

In certain highly preferred forms of the present invention the oral composition may be substantially liquid in character, such as a mouthwash or rinse. In such a preparation the vehicle is typically a water-alcohol mixture desirably including a humectant as described below. Generally, the weight ratio of water to alcohol is in the range of from about 1.1 to about 20:1, preferably about 3.1 to 10:1 and more preferably about 4:1 to about 6:1. The total amount of water-alcohol mixture in this type of preparation is typically in the range of from about 70% to about 99.9% by weight of the preparation.

The pH of such liquid and other preparations of the present invention is generally in the range of from about 4.5 to about 9 and typically from about 5.5 to 8. The pH is preferably in the range of from about 6 to about 8.0. It is noteworthy that the compositions of the present invention may be applied orally at a pH below 5 without substantially decalcifying or otherwise damaging dental enamel. The pH can be controlled with acid (e.g. citric acid or benzoic acid) or base (e.g. sodium hydroxide) or buffered (as with sodium citrate, benzoate, carbonate, or bicarbonate, disodium hydrogen phosphate, sodium dihydrogen phosphate, etc.).

In certain other desirable forms of the present invention, the oral composition may be substantially solid or pasty in character, such as toothpowder, a dental tablet, a toothpaste, gel or dental cream. The vehicle of such solid or pasty oral preparations generally contains polishing material. Examples of polishing materials are water-insoluble sodium metaphosphate, potassium metaphosphate, tricalcium phosphate, dihydrated calcium phosphate, anhydrous dicalcium phosphate, calcium pyrophosphate, magnesium orthophosphate, trimagnesium phosphate, calcium carbonate, aluminium silicate, zirconium silicate, urea formaldehyde, silica, bentonite, and mixtures thereof. Preferred polishing materials include crystalline silica having particle sizes of up to about 5 microns, a mean particle size of up to about 1.1 microns, and a surface area of up to about 50,000 cm^2/gm, silica gel or colloidal silica, and complex amorphous alkali metal aluminosilicate.

When visually clear gels are employed, a polishing agent of colloidal silica, such as those sold under the trademark SYLOID as Syloid 72 and Syloid 74 or under the trademark SANTOCEL as Santocel 100 and alkali metal alumino-silicate complexes are particularly useful, since they have refractive indices close to the refractive indices of gelling agent-liquid (including water and/or humectant) systems commonly used in dentifrices.

Many of the so-called "water-insoluble" polishing materials are anionic in character and also include small amounts of soluble material. Thus, insoluble sodium metaphosphate may be formed in any suitable manner, as illustrated by Thorpe's *Dictionary of Applied Chemistry,* Volume 9, 4th Edition, pp. 510–511. The forms of insoluble sodium metaphosphate known as Madrell's salt and Kurrol's salt are further examples of suitable materials. These metaphosphate salts exhibit only a minute solubility in water, and therefore are commonly referred to as insoluble metaphosphates. There is present therein a minor amount of soluble phosphate material as impurities, usually a few percent such as up to 4% by weight. The amount of soluble phosphate

material, which is believed to include a soluble sodium trimetaphosphate in the case of insoluble metaphosphate, may be reduced or eliminated by washing with water if desired. The insoluble alkalimetal metaphosphate is typically employed in powder form of a particle size such that no more than about 1% of the material is larger than about 37 microns.

The polishing material is generally present in the solid or pasty compositions in weight concentrations of about 10% to about 99%. Preferably, it is present in amounts ranging from about 10% to about 75% in toothpaste, and from about 70% to about 99% in toothpowder.

In a toothpaste, the liquid vehicle may comprise water and humectant typically in an amount ranging from about 10% to about 90% by weight of the preparation. Glycerine, propylene glycol, sorbitol, polypropylene glycol and/or polyethylene glycol (e.g. 400,600) exemplify suitable humectant/carriers. Also advantageous are liquid mixtures of water, glycerine and sorbitol. In clear gels where the refractive index is an important consideration, about 3–30 wt.% of water, 0 to about 80 wt.% of glycerine, and about 20–80 wt.% of sorbitol is preferably employed.

Toothpastes, creams and gels typically contain a natural or synthetic thickener or gelling agent in proportions of about 0.1 to about 10, preferably about 0.5 to about 5 wt.%. A suitable thickener is synthetic hectorite, a synthetic colloidal magnesium alkali metal silicate complex clay available for example as Laponite (e.g. CP, SP 2002, D) marketed by Laporte Industries Limited. Laponite D analysis shows, approximately by weight, 58.00% SiO_2, 25.40% MgO, 3.05% Na_2O, 0.98% Li_2O, and some water and trace metals. Its true specific gravity is 2.53 and it has an apparent bulk density (g/ml at 8% moisture) of 1.0.

Other suitable thickeners include Irish moss, gum tragacanth, starch, polyvinylpyrrolidone, hydroxyethypropyl cellulose, hydroxybutyl methyl cellulose, hydroxypropyl methyl cellulose, hydroxyethyl cellulose (e.g. available as Natrosol), sodium carboxymethyl cellulose, poly(methyl vinyl ether/maleic anhydride) available for example as Gantrez AN 139 (GAF Corporation), colloidal silica such as finely ground Syloid (e.g. 244), and carboxyvinyl polymer for example available as Carbopol (e.g. 934, 940, 941). These Carbopol products of B.F. Goodrich Co. are described in U.S. 2,798,053, 2,923,692 and 2,980,655, being essentially colloidally water-insoluble acidic carboxylic polymers of acrylic acid cross-linked with about 0.75 to about 2.0% of a cross-linking agent of polyallyl sucrose or polyallyl pentaerythritol.

It will be understood that, as is conventional, the oral preparations are to be sold or otherwise distributed in suitable labelled packages. Thus, a jar of mouthrinse will have a label describing it, in substance, as a mouthrinse or mouthwash and having directions for its use; and a toothpaste, cream or gel will usually be in a collapsible tube, typically aluminium, lined lead or plastic, or other squeeze, pump or pressurised dispenser for metering out the contents, having a label describing it, in substance, as a toothpaste, gel or dental cream.

Organic surface-active agents may be used in the compositions of the present invention to achieve increased prophylactic action, assist in achieving thorough and complete dispersion of the anticalculus agent throughout the oral cavity, and render the compositions of the present invention more cosmetically acceptable. The organic surface-active agent may be present in an amount of 1.5 to 3.0% by weight of the composition. The organic surface-active material is preferably anionic, nonionic or ampholytic in nature, and it is preferred to employ as the surface-active agent a detersive material which imparts to the composition detersive and foaming properties. Suitable examples of anionic surfactants are water-soluble salts of higher fatty acid monoglyceride monosulphates, such as the sodium salt of the monosulphated monoglyceride of hydrogenated coconut oil fatty acids, higher alkyl sulphates such as sodium lauryl sulphate, alkyl aryl sulphonates such as sodium dodecyl benzene sulphonate, higher alkyl sulphoacetates, higher fatty acid esters of 1,2 dihydroxy propane sulphonate, and the substantially saturated higher aliphatic acyl amides of lower aliphatic amino carboxylic acid compounds, such as those having 12 to 16 carbons in the fatty acid, alkyl or acyl radicals, and the like. Example of the last mentioned amides are N-lauroyl sarcosine, and the sodium, potassium, and ethnolamine salts of N-lauroyl, N-myristoyl, or N-palmitoyl sarcosine which should be substantially free from soap or similar higher fatty acid material. The use of these sarcosinate compounds in the oral compositions of the present invention is particularly advantageous since these materials exhibit a prolonged and marked effect in the inhibition of acid formation in the oral cavity due to carbohydrate breakdown in addition to exerting some reduction in the solubility of tooth enamel in acid solutions.

Examples of water-soluble nonionic surfactants various reactive hydrogen-containing compounds reactive therewith having long hydrophobic chains (e.g. aliphatic chains of about 12 to 20 carbon atoms), which condensation products ("ethoxamers") contain hydrophilic polyoxyethylene moieties, such as condensation products of poly(ethylene oxide) with fatty acids, fatty alcohols, fatty amides, polyhydric alcohols (are condensation products of ethylene oxide with e.g. sorbitan monostearate) and polypropylene-oxide (e.g. Pluronic materials).

In certain preferred forms of the present invention a fluorine-providing anti-caries compound is present in the oral preparation. These compounds may be slightly soluble in water or may be fully water-soluble. They are characterised by their ability to release fluoride ions in water and by

substantial freedom from reaction with other compounds of the oral preparation. Among these materials are inorganic fluoride salts, such as soluble alkali metal, alkaline earth metal and heavy metal salts, for example, sodium fluoride, potassium fluoride, ammonium fluoride, calcium fluoride, a copper fluoride such as cuprous fluoride, zinc fluoride, a tin fluoride such as stannic fluoride or stannous chlorofluoride, barium fluoride, sodium fluorosilicate, ammonium fluorosilicate, sodium fluorozirconate, sodium monofluoro-phosphate, aluminium mono- and di-fluorophosphate, and fluorinated sodium calcium pyrophosphate. Alkali metal and tin fluorides, such as sodium and stannous fluorides, sodium monofluorophosphate (MFP) and mixtures thereof, are preferred.

The amount of the fluorine-providing compound is dependent to some extent upon the type of compound, its solubility, and the type of oral preparation, but it must be a non-toxic amount, generally about 0.01 to about 3.0% in the preparation. In a solid oral preparation, e.g. gel, toothpaste, or toothpowder, an amount of such compound which release up to about 1% fluoride ion by weight of the preparation is considered satisfactory. Any suitable minimum amount of such compound may be used, but it is preferable to employ sufficient compound to release about 0.005% to 1%, more preferably about 0.1% of fluoride ion. Typically, in the cases of alkali metal fluorides and stannous fluoride, this component is present in an amount up to about 2% by weight, based on the weight of the preparation, and preferably in the range of about 0.05 to 1%. In the case of sodium monofluorophosphate, the compound may be present in an amount of about 0.1–3.0%, more typically about 0.76%.

In a liquid oral preparation such as a mouthwash, the fluorine-providing compound is typically present in an amount sufficient to release up to about 1.0%, preferably about 0.001% to 0.5%, by weight of the fluoride ion. Generally about 0.01 to about 3.0 wt.% of such compound is present.

Whereas other materials may be incorporated in the oral preparations of the present invention such as whitening agents, preservatives, silicones, chlorophyll compounds, other anti-calculus agents, antibacterial antiplaque agents, and/or ammoniated material such as urea, diammonium phosphate, and mixtures thereof. These adjuvants, where present, are incorporated in the preparations in amounts which do not substantially adversely affect the properties and characteristics desired.

Any suitable flavouring or sweetening material may also be employed. Examples of suitable flavouring constituents are flavouring oils, e.g. oil of spearmint, peppermint, wintergreen, sassafras, clove, sage, eucalyptus, marjoram, cinnamon, lemon, and orange, and methyl salicylate. Suitable sweetening agents include sucrose, lactose, maltose, sorbitol, xylitol, sodium cyclamate, perillartine, APM (aspartyl phenyl alanine, methyl ester), saccharine and the like. Suitably, flavour and sweetening agents may together comprise from about 0.01% to 5% or more of the preparation.

In preparing the oral compositions of the present invention, it is preferred, but not essential, to add the PFA after the other ingredients (except perhaps some of the water) are mixed or contacted with each other to avoid a tendency for the PFA to be precipitated.

For instance, a mouthrinse or mouthwash may be prepared by mixing ethanol and water with surfactant, humectant, gum or thickener such as sodium carboxymethylcellulose or hydroxyethyl cellulose, and sweetener and adding thereto flavour, additional water and then the PFA compound. A toothpaste may be prepared by forming a gel with humectant, gum or thickener such as sodium carboxymethyl cellulose or hydroxyethyl cellulose, and sweetener and adding thereto polishing agent, flavour, additional water and then the PFA compound.

In the practice of the present invention an oral composition according to the present invention such as a mouthwash or toothpaste containing the PFA compound in an amount effective to inhibit calculus on dental surfaces is preferably applied regularly to dental enamel, such as every second or third day or preferably from about 1 to 3 times daily, at a pH of about 4.5 to about 9, generally about 5.5 to about 8, preferably about 6 to 8, for at least two weeks up to eight weeks or more up to a lifetime.

The PFA compound can be incorporated in chewing gum or other products, e.g. by stirring into a warm gum base or coating the outer surface of a gum base, illustrative of which may be mentioned jelutone, rubber latex, vinylite resins, etc., desirably with conventional plasticisers or softeners, sugar or other sweeteners or carbohydrates such as glucose, sorbitol and the like.

The invention may be put into practice in various ways, and a number of specific embodiments will be described to illustrate the invention with reference to the accompanying examples. All amounts and proportions referred to herein and in the appended claims are by weight and temperatures are in degrees C unless otherwise indicated.

Example 1

Inhibition of Crystal Growth of HAP

This is evaluated by a pH Stat method. 1.0 ml of an aqueous solution of $1X10^{-4}M$ to $1X10^{-5}M$ of the anti-calculus agent being tested and 0.1 M sodium dihydrogen phosphate is

placed in a reaction flask with 22 to 23 ml of distilled water with continuous stirring in an atmosphere of nitrogen. To this is added 1 ml of 0.1M $CaCl_2$ and the pH adjusted to 7.4±0.05 with NaOH (final concentration of Ca++ and $PO_4^{3-}=4X10^{-3}M$). Consumption of 0.1N NaOH is recorded automatically by a pH Stat (Radiometer). In this test, the formation of HAP occurs in two distinct phases. First rapid base consumption (1–4 min) takes place which then diminishes until 15–20 minutes when a second rapid uptake takes place. A delay in the time of the second rapid consumption indicates an interference with the crystal growth of HAP. Agents which interefere with HAP crystal growth are effective anticalculus agents. When PFA is tested by the foregoing procedure, the following results given in Table 1 are obtained.

Table 1

Anticalculus Agent (conc.)	Time for HAP Formation (Min.)	Delay in HAP Formation (Min.)
Water (control)	17.4	—
PFA (10 ppm)	18.0	—
PFA (20 ppm)	25.0	7.6
PFA (40 ppm)	>37	19.6

The above results shows that PFA effectively inhibits crystal growth of HAP *in vitro* and that the inhibition is not due to complexation or chelation of calcium since sub-stoichiometric ratios of PFA: calcium are employed.

Examples 2 to 5

The following examples set out in Table 2 are illustrative of mouthwash formulations according to the present invention, to be used in the normal manner, e.g. contacting the teeth in the oral cavity substantially regularly, e.g. several weeks or more up to a lifetime or until an anticalculus effect is no longer desired or necessary, in each case followed by removing the mouthwash from the oral cavity (without ingestion) as by rinsing with water.

Table 2

Example	2	3	4	5
Ingredient				
Flavour	0.22%	0.22%	0.22%	0.22%
Ethanol	15.0	15.0	15.0	15.0
Pluronic F108[1]	3.0	3.0	3.0	3.0
Glycerine	10.0	10.0	10.0	10.0
Na Saccharin	0.03	0.03	0.03	0.03
NaF	0.22	—	—	—
MFP[2]	—	—	0.76	—
PFA[3]	0.1	0.5	1.0	1.5
Water q.s. to	100	100	100	100
pH (with NaOH)	7.4	7.4	7.4	7.4
Appearance	Clear	Clear	Clear	Clear

Notes on Table 2

1 Approximately 20% polyoxypropylene, M.W.: 3250/80% polyoxyethylene block polymer nonionic surfactant—BASF-Wyandotte
2 Sodium monofluorophosphate
3 Trisodium hexahydrate salt.

Examples 6 and 7

The following examples set out in Table 3 are illustrative of anticalculus toothpastes according to the present invention, to be used in the normal manne, e.g. brushing the teeth with the toothpaste substantially regularly, e.g. 1 to 3 times daily or every 2nd or 3rd day for several weeks or more up to lifetime or until an anticalculus effect is no longer desired or necessary, in each case followed by removing the toothpaste from the oral cavity (without ingestion) as by rinsing with water.

Table 3

Example	6	7
Ingredients		
MFP	0.76%	—
Sodium lauryl sulphate	1.5	1.5%
Silica	30.0	30.0
Glycerine	25.0	25.0
Sodium benzoate	0.5	0.5
TiO_2	0.4	0.4
Sodiumcarboxymethyl cellulose	1.3	1.3
PFA[1]	1.0	1.0
Sodium saccharin	0.2	0.2
Flavour	1.0	1.0
Water q.s. to	100	100

Notes on Table 3

1 Trisodium hexahydrate salt

The dentifrice in Example 7 was extracted with water as follows: 10 grams of the dentifrice were mixed with 30 grams of deionised distilled water. After 5–10 minutes mixing, the slurry was centrifuged. The supernatants, water soluble fractions, were tested in the hydroxyapatite (HAP) formation test as described in example 1. A placebo dentifrice without PFA was also used as a control. The results are summarised in Table 4.

Table 4

Treatment	Conc. of HAP in Extracts	Time for Formation (Min.)	Delay in Formation (Min.)
Water	—	18.3	—
Placebo Toothpaste Extract	—	22.5	4.2
Active Toothpaste Extract	20[1] ppm	39.0	20.7

Notes on Table 4

1 Calculated from dilution factor of the extract.

The data in Table 4 indicates that PFA incorporated in a specific dentifrice maintained anticalculus effect since the extract containing PFA was effective in inhibiting HAP formation.

Example 8

In Vivo Test with Fluoride

The purpose of the present study was to test the effect in rats of topical application of 1-phosphonopropane tricarboxylic acid (PPT), phosphonoformic acid (PFA), sodium fluoride (NaF) and Editempa on plaque extent, fissure and smooth surface caries incidence, molar surface dissolution rate and fluoride content. The animals received ad libitum tap water and a cariogenic diet (2000a) containing 56% sucrose. In this study 12 litters of OM-rats, each litter consisting of 9 animals, were used.

On day 13 the animals with their dams were transferred to stainless-steel, screen-bottom cages and fed finely powdered Nafag stock diet and tap water ad libitum until day 20. Then they were distributed at random among the treatments and received the cariogenic diet and tap water ad libitum. On the days 21 and 22 they were inoculated twice daily with heavy suspensions of S. mutans OMZ–176 and A. Viscosus Ny-1. For 20 days from day 23 onwards, 100 microlitres of the test solutions 1–8 listed in table 5 below were applied with disposable syringes, twice daily. Plaque extent, caries of fissures and smooth surfaces, molar surface dissolution rate and fluoride content were assessed according to routine procedures. The results are shown in Tables 5A and 5B.

The meanings of the various columns in the Tables are as follows:

Table 5A

PE = Average per rat (N = 12) of smooth surface plaque extent
T = initial dentinal fissure carious lesions
B = advanced dentinal fissure carious lesions
E = smooth surface caries units

Table 5B

g = weight gains
upg = dissolution rate
I = fluoride concentration in first layer
II = fluoride concentration in second layer
I & II = fluoride concentration in first and second layer (I & II) commulated

Notes on Tables 5A and 5B

1 4 units at risk
2 12 fissures at risk
3 20 units at risk

Table 5A

Example	Test Solution	PE[1]	T[2]	B[2]	E[3]
8.1	Control, H_2O	2.3	8.1	2.7	10.8
8.2	300 ppm F^- (NaF)	2.3	5.8	1.0	4.0
8.3	0.82% PPT	2.5	8.3	2.5	10.2
8.4	0.82% PPT and 300 ppm F^-	2.2	6.3	1.3	5.3
8.5	0.82% FPA	2.4	7.7	1.9	12.4
8.6	0.82% PFA and 30 ppm F^-	2.1	6.0	1.1	3.9
8.7	0.82% Editempa	2.3	7.1	1.4	6.3
8.8	0.82% Editempa and 30 ppm F^-	2.1	6.5	1.0	3.7
$S_{\bar{x}}$	Standard error of the means	0.20	0.70	0.49	1.34
$S_{\bar{d}}$	Standard error of the difference between two means	0.29	1.00	0.70	1.89
$P_F <$		NS	0.001	0.01	0.001
LSD	0.05	0.57	1.98	1.38	3.76
LSD	0.01	0.75	2.62	1.83	4.98
LSD	0.001	0.97	3.39	2.37	6.44

Table 5B

Example	Test Solution	g	ugP	ppm F in layers I	II	I & II
8.1	Control, H_2O	78	158	46	19	32
8.2	300 ppm F^- (NaF)	80	130	263	75	169
8.3	0.82% PPT	77	151	46	22	34
8.4	0.82% PPT and 300 ppm F^-	79	139	188	69	128
8.5	0.82% FPA	76	152	60	28	44
8.6	0.82% PFA and 300 ppm F^-	77	129	207	71	139
8.7	0.82% Editempa	84	155	44	19	31
8.8	0.82% Editempa and 300 ppm F^-	77	142	159	55	107
$S_{\bar{x}}$	Standard error of the means	3.6	3.9	18.7	6.8	12.2
$S_{\bar{d}}$	Standard error of the difference between two means	5.2	5.5	26.4	9.6	17.2
$P_F <$		NS	0.001	0.001	0.001	0.001
LSD	0.05	10.2	11.0	52.4	19.0	34.2
LSD	0.01	13.6	14.6	69.5	25.2	45.3
LSD	0.001	17.5	18.8	89.8	32.6	58.6

The results in Table 5A and Table 5B establish the overall superiority of PFA relative to PPT and Editempa anticalculus agents when applied in combination with fluoride containing anticaries agent. The results show that although no significant differences were found among the test solutions with respect to smooth surface plaque extent (PE) and weight gains, the PFA/F solution exhibited significantly less interference to the anticaries, antidissolution, and F impregnation functions of the F-containing agent relative to the PPT/F and Editempa/F solutions. Thus, as to anticaries effects, initial lesions (T) were reduced from 8.1 (control) to 5.8 by the F (NaF) solution and to almost the same degree (6.0) by the PFA/F solution, but to only 6.3 by the PPT/F solution and 6.5 by the Editempa/F solution. The reductions in advanced lesions (B) from 2.7 (control) to 1.0 and in smooth surface caries (E) from 10.8 (control) to 4.0 by the F solution were substantially matched by the 1.1B and 3.9E of the PFA/F solution and the 1.0B and 3.7E of the Editempa/F solution, but not by the PPT/F solution (1.3B & 5.3E).

The superiority of PFA is even more pronounced with respect to minimising the rate of dissolution of dental surfaces (ugP). The control rate of 158 was reduced in almost identical amount by the F solution (130) and the PFA/F solution (129), in contrast to the effects of the PPT/F solution (139) and the Editempa/F solution (142).

The substantial superiority of PFA is also apparent with respect to maximising (i.e. minimising reduction of) the amount of anticaries F impregnation into layers I and II of the teeth produced by the F (NaF) solution. Whereas the F solution produced 169 ppm F in layers I and II compared to 32 ppm F produced by the control, the PFA/F solution produced 139 ppm F in these layers while the PPT/F solution produced only 128 ppm F and the Editempa/F solution was even more inferior, producing only 107 ppm F in these layers.

The present invention has been described with respect to preferred embodiments and it will be understood that modifications and variations thereof obvious to those skilled in the art are to be included within the spirit and purview of this application and the scope of the appended claims.

CLAIMS

1. An oral mouthwash, toothpaste, gel, cream, powder or gum composition comprising an orally acceptable vehicle containing in an effective amount as an anticalculus agent phosphonoformic acid or an orally acceptable salt thereof.

2. An oral mouthwash, toothpaste, gel, cream or powder composition comprising an orally acceptable vehicle containing an organic surface active agent and in an effective amount as an anticalculus agent phosphonoformic acid or an orally acceptable salt thereof.

3. An oral mouthwash, toothpaste, gel, cream or powder composition comprising an orally acceptable vehicle containing a carbohydrate as a humectant or sweetener and in an effective amount as an anticalculus agent phosphonoformic acid or an orally acceptable salt thereof.

4. An oral mouthwash, toothpaste, gel, cream or powder composition comprising an orally acceptable vehicle containing an effective anticaries amount of fluorine-providing anticaries compound and in an effective amount as an anticalculus agent phosphonoformic acid or an orally acceptable salt thereof.

5. An oral composition as claimed in any one of Claims 1 to 4 containing an alkali metal salt of phosphonoformic acid as anticalculus agent.

6. An oral composition as claimed in any one of Claims 1 to 5 containing the trisodium hexahydrate salt of phosphonformic acid as anticalculus agent.

7. An oral composition as claimed in any one of Claims 1 to 6 containing in an effective anticaries amount a fluorine-providing anticaries compound.

8. An oral composition as claimed in Claim 7 in which the said anticaries compound is sodium fluoride or sodium monofluorophosphate.

9. An oral composition as claimed in Claim 7 or Claim 8 containing about 0.01% to about 10% by weight of the said anticalculus agent.

10. An oral composition as claimed in Claim 9 containing about 0.1% to about 4% by weight of the said anticalculus agent.

11. An oral composition as claimed in any one of Claims 1 to 10 containing about 0.01% to about 5% by weight of combined flavour and sweetening agents.

12. An oral composition as claimed in any one of Claims 1 to 11 having a pH of about 4.5 to about 9.

13. An oral composition as claimed in Claim 12 having a pH of about 6 to about 8.

14. An oral composition as claimed in any one of Claims 1 to 13 in the form of a mouthwash in which the said vehicle comprises water and alcohol.

15. An oral composition as claimed in any one of Claims 1 to 13 in the form of a toothpaste, gel or cream, in which the said vehicle comprises a liquid vehicle and a dentally acceptable polishing material.

16. A mouthwash as claimed in Claim 14 substantially as specifically described herein with reference to any one of Examples 2 to 5.

17. A toothpaste, gel or cream as claimed in Claim 15 substantially as specifically described herein with reference to Example 6 or Example 7.

18. A method of inhibiting the formation of dental calculus comprising briefly contacting the teeth in the oral cavity with and then removing a calculus-inhibiting amount of a composition as claimed in any of Claims 1 to 17.

19. A method of inhibiting the formation of dental calculus and caries comprising briefly contacting the teeth in the oral cavity with and then removing a calculus-inhibiting and caries-inhibiting amount of a composition as claimed in claim 7 or Claim 8.

20. A method of inhibiting the formation of dental calculus comprising brushing the teeth in the oral cavity with and then removing a calculus-inhibiting amount of a composition as claimed in Claim 15.

21. In a method of preparing an oral mouthwash, toothpaste, gel, cream, powder or gum composition comprising an orally acceptable vehicle containing an effective amount of an anticalculus agent, the improvement comprising mixing in such composition as such agent phosphonoformic acid or an orally acceptable salt thereof.

22. The use of phosphonoformic acid or an orally acceptable salt thereof in the preparation of an oral composition for treatment of teeth to prevent or inhibit calculus formation.

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