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Review Article

DENTRIFRICES AND ITS RECENT ADVANCEMENTS: AN OVERVIEW

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Abstract

Designing and producing clinically effective, multifunctional toothpastes is an extremely complex undertaking. In formulating them a myriad of basic concerns must be satisfied, including safety, optimal rheology, pleasant flavor, packaging, shelf life and acceptable cost. Beyond that, the ultimate goal is to ensure that the toothpaste ingredients designed to accomplish each specialized function will remain compatible in a combined or final formulation. That requires for each active ingredient to retain its specific activity over time and under various storage conditions and to do so without compromising the other active ingredients to perform in a clinically effective manner. In short, the design, composition and manufacture of modern toothpastes has become enormously sophisticated. Present article will mainly focus on the recent advancements in dentrifrices.

KEYWORDS: Dentrifrices, tooth pastes, tooth powder, advancements

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INTRODUCTION

For centuries the main uses of dentifrices were related to cleaning the teeth, removal of unsightly enamel stains and promoting fresher breath. In modern era, toothpastes have replaced toothpowders. Today toothpastes represent by far the most

commonly manufactured preparation intended to be used, in conjunction with the tooth brush, for affecting the accumulation, removal and the metabolic activities of dental plaque.[1]Thus in the best interests of the public, dentists should be fully equipped with a body of knowledge about dentifrices so as to be able to advise their patients to make evidence based choices with regard to the most appropriate and effective toothpaste to use for improved oral health and a better quality of life.

DISCUSSION

The oxford English dictionary dates usage of the term dentifrice to 1558, defining it as a ***"powder or other preparation for rubbing or cleaning the teeth***"[2]. On august 1,1960 the ADA reported that CREST has been shown to be an effective anti cavity (decay preventive) dentifrice that can be of significant value when used in a conscientiously applied program of oral hygiene and regular professional care.

Thus it was not until the early twentieth century that the modern stable tooth paste or dental cream of very much complex constitution was produced.

COMPOSITION OF DENTRIFRICES

Active Ingredients[3]

Active ingredients help prevent caries, sensitivity, plaque/gingivitis, calculus formation and halitosis.The first active ingredient included was fluoride. Active ingredients and function

Anti-caries: Sodium fluoride, Sodium monofluorophosphate, Stannous fluoride, Amine fluoride and Xylitol

Anti-plaque/anti-gingivitis: Triclosan/copolymer, Stannous fluoride and Zinc citrate

Anti-calculus: Tetrapotassium pyrophosphate, Tetrasodium pyrophosphate, Sodium hexametaphosphate, Zinc compounds and Triclosan/copolymer.

Anti-halitosis: Essential oils, Chlorine dioxide, Triclosan/copolymer, Stannous fluoride/sodium and hexametaphosphate

Desensitizers: Potassium citrate, Potassium nitrate, Potassium chloride, Stannous fluoride and Strontium chloride

Anti-apthous agents: Aminoglucosidase and Glucose oxidase

Inactive Ingredients[3]

Inactive ingredients in dentifrices include binders, abrasives, surfactants, buffering agents, humectants, preservatives, sweeteners, flavorings and dyes.

RECENT ADVANCES IN DENTRIFRICES

Various advancements in dentrifrices are

- Pro – argin technology
- 'Liquid' dentifrice formulation
- Novamin technology
- Recaldent technology

PRO-ARGIN TECHNOLOGY[4]

Saliva plays a role in naturally reducing hypersensitivity by transporting calcium and phosphate into dentin tubules to induce tubule plugging and by forming a surface protective layer of salivary

glycoprotein with calcium and phosphate. Because alkaline pH favors these processes, salivary factors that maintain slightly alkaline ph in vivo have been suggested to favor occlusion of the tubules. Investigations of the science underpinning the mechanisms of natural occlusion have resulted in the development of a new 'saliva base composition' comprising arginine, an amino acid which is positively charged at physiological pH, bicarbonate which is a pH buffer and calcium carbonate which is a source of calcium.

A new dentifrice containing 8% arginine, calcium carbonate and 1450 ppm fluoride as monofluorophosphate has been clinically proven to provide lasting relief to sensitivity and superior relief than the previous leading desensitizing toothpastes available. It was demonstrated that the arginine containing toothpastes provides superior relief compared to toothpastes containing 2 % potassium ion as the active ingredient. More important to the patient suffering from sensitivity is the fact that the arginine containing toothpastes provide instant relief from dentin hypersensitivity when applied directly to the tooth and massaged for one mintute[5,6]. The relief is maintained with continued twice daily brushing. A study also showed that neither the desensitizing toothpaste containing 2 % potassium ion nor regular fluoride toothpaste provides instant relief when directly applied in the same manner. This is a real breakthrough for consumers suffering from hypersensitivity.

MECHANISM OF ACTION

Several imaging methods including CLSM, SEM, AFF have provided insight into the mechanism of action of the pro-argin technology, confirming that the technology effectively plugs and seal dentin tubules and that the occlusion achieved is resistant to acid challenge. CLSM studies have also shown that the arginine is delivered to the inner surfaces of dentin tubules within the occluded dentin plug. Clinical mapping using energy dispersive x-ray has shown that the material on the dentin surface and occluded within the dentin tubules primarily consists of calcium and phosphate. Hydraulic conductance has shown that the occlusion achieved with the arginine containing toothpastes result in reduced dentin fluid flow and inhibition of hydrodynamic system. They have also confirmed that the dentin occlusion is robust, as reduced permeability was maintained after 7 days of pulpal pressure and after treatment with strong acid[7]

Kleinberg suggested that the arginine physically adsorbs on the surface of calcium carbonate in vivo forming a positively charged agglomerate which readily binds with the negatively charged dentin on the exposed surfaces and within the tubules. In addition, pH of the agrinine-calcium carbonate agglomerate is sufficiently alkaline to facilitate deposition of calcium a phosphate from saliva and/or dentin fluid. The results of the mechanism of action studies are consistent with the kleinberg's hypothesis and support that interaction of arginine and calcium carbonate in vivo triggers deposition of phosphate, in addition to arginine, calcium and carbonate on the dentin surface and within the dentin tubules[8]. The pro-argin technology offers unique opportunities to both dental professionals and their patients alike. The in-office desensitizing product is clinically proven to provide instant sensitivity relief prior to and after dental procedures, such as scaling and root planning.

A NEW 'LIQUID' DENTRIFICE FORMULATION[9.10]

Since patients have shown a preference for new dentifrice forms with advanced physical properties, several manufacturers have now introduced liquid dentifrices into the market. Liquid dentifrice had been marketed in Europe since 1994 and is now increasingly gaining popularity in other parts of the world.

'Liquid dentifrice' formulations are not as runny as a true liquid such as water. They are less viscous and paste like than traditional dentifrices. Examination of teeth exposed to a lifetime of fluoride dentifrice has shown that the outer few micrometers of enamel can have fluoride levels as high as 1000 to 2000 parts per million but typically less interproximally. This may be because interproximal areas between teeth only rarely are affected by the mechanical action of tooth brushing owing to bristle size in relation to the tight contact area. In addition it may be because the foam of standard toothpaste is too viscous and therefore unable to penetrate completely between teeth that are in tight contact with one another. Hence, bacteria tend to accumulate on the interproximal surfaces and can demineralise them, further reducing effective fluoride concentration. Because of this tendency and the fact that most people rarely use floss, new dentifrice technologies with better foaming properties and finer, more abundant bubbles need to be developed to carry fluoride to interproximal and other hard to reach areas, enhancing the acid resistance of vulnerable enamel.

A study conducted to assess the efficacy of a new liquid dentifrice containing 1100 ppm fluoride , 0.3% triclosan and 2 % copolymer in a mildly foaming silica base demonstrated enhanced performance at interproximal tooth surfaces compared with standard, paste type positive control dentrifice that held the American dental association seal of acceptance.

NOVAMIN TECHNOLOGY

NovaMin is the brand name of a particulate bioactive glass that is used in dental care products for remineralisation of teeth. It was developed and patented by NovaMin Technology, Inc.. The active ingredient is the inorganic chemical calcium sodium phosphosilicate.[1.] It is made of synthetic mineral containing sodium,calcium, phosphorous and silica (sodium calciumphosphosilicate) which are all elements naturally found in the body[11].

Mechanism of action

When NovaMin particles come in contact with saliva or water, they rapidly release sodium, calcium and phosphorous ions into the saliva that are available for remineralization of the tooth surface. Unlike the other calcium phosphate technologies, the ions that NovaMin release form hydroxycarbonate apatite (HCA) directly, without the intermediate amorphous calcium phosphate phase.

The chemical reaction that leads to hydroxyapatite is:

$$5Ca^{2+} + 3PO_4^{3-} + OH^- \rightarrow Ca_5(PO_4)_3(OH)$$

NovaMin accelerates this process by increasing the saliva pH and supercharging the saliva with calcium and phosphorus ions. The NovaMin then releases calcium and phosphate ions to supplement the normal levels found in saliva. The increase in ionic concentration, combined with the increase in pH, causes the ions to precipitate onto the

tooth surface immediately to form hydroxy-carbonate apatite (HCA)[12]

NovaMin particles also attach to the tooth surface and continue to release ions and remineralize the tooth surface after the initial application. These particles have been shown, in in-vitro studies, to release ions and transform into HCA for up to two weeks [11]. Ultimately these particles will completely transform into HCA which is the mineral teeth and bones are made of.

NovaMin has been shown, in in-vitro and clinical studies, to be a significant tubule occluder and desensitizer. In a number of in-vitro studies NovaMin has been shown to occlude by over 80%. In a clinical on tooth hypersensitivity a NovaMin containing toothpaste (Oravive®) was shown to decrease sensitivity significantly greater that a strontium chloride toothpaste which is the favored tubule occlusion ingredient in Europe . In another clinical study on tooth hypersensitivity a NovaMin containing toothpaste (SootheRx®) was shown to decrease sensitivity by 90% which was highly significant versus placebo . In an open label study on a NovaMin product used to treat sensitivity post scaling and planning (NuCare® Root Conditioner), the product was shown to reduce sensitivity by up to 52 % 24 hours post procedure. Nearly 80% of the patients reported significant relief from sensitivity at the 24-hour post treatment time point. NovaMin has also been shown to have significant anti microbial properties and can kill up to 99.999% of oral pathogens associated with periodontal disease and caries. In a gingivitis study, A NovaMin containing toothpaste (Oravive®) was shown to reduce gingivitis by up to 58% used twice per day for 6-weeks which is equivalent to chlorhexadine used 3 times a day for 6-months[13]. Researchers have documented that NovaMin, when formulated with a fluoride dentifrice, exhibits a greater degree of remineralization than a fluoride dentifrice alone on early carious lesions[14,15].

In 2011, Consumer health care company GlaxoSmithKline (GSK) announced a dental formulation, which is the first for off-the-shelf markets to contain patented NovaMin technology designed to repair sensitive teeth. A new NovaMin-containing desensitizing paste and a take-home toothpaste under the GSK brand name called "NUPRO SENSODYNE-Powered by NOVAMIN was then launched. Although some NovaMin-containing products have been available in recent years, this was the first time that a major global toothpaste manufacturer added "NovaMin" to their product line.

RECALDENT TECHNOLOGY[16,17]

RECALDENT™ is the trademark applied to the CPP-ACP technology. When used as an ingredient in oral care products, RECALDENT™ (CPP-ACP) reduces the risk of **demineralization** and promotes **remineralization** of enamel subsurface lesions. .It is an ingredient derived from casein, part of the protein found in cow's milk. Its technical name is casein phosphopeptides-amorphous calcium phosphate, or CPP-ACP.

The School of Dental Science at the University of Melbourne in Australia has long been interested in the anticariogenic properties of milk .In 1981 they showed that milk, milk concentrates, powders and cheeses help prevent dental caries in animals and in situ caries models, though these properties of milk were known well before

this. Further investigation by the University showed that it was a particular part of the casein protein, the casein phosphopeptides, or CPP, that was responsible for the tooth-protective activity. They showed that peptides containing the cluster sequence of amino acids -Ser(P)-Ser(P)-Ser(P)-Glu-Glu have a remarkable ability to stabilize calcium and phosphate and keep them in a soluble, amorphous state. Normally, combining calcium and phosphate ions will result in the formation of insoluble calcium phosphate crystals. But in the presence of CPP this doesn't happen, and the calcium and phosphate remain in an ionic form that can diffuse into the tooth enamel and repair areas that have been damaged through the activity of plaque bacteria. This is the basis of preventing and reversing dental caries. The high concentration of calcium and phosphate ions at the tooth's surface can diffuse into uncavitated sub-surface lesions in the tooth enamel and re-crystallize, thereby adding minerals into the enamel and repairing the lesion.

The National Institutes of Health has discussed a need to move away from the "drill and fill" mentality to one of prevention of the disease processes. There now certainly is a focus on preventive dentistry that is preventing disease before it develops, and also minimum intervention trying to maintain as much of the tooth tissue as possible so if possible treating those early stages of disease so that it will arrest disease and actually even repair disease. Certainly fluorides are now known to arrest early stages of dental decay and can actually promote remineralization or repair of those early stages through salivary calcium phosphate. But one of the problems, certainly the rate limiting steps is that there's not enough calcium phosphate in saliva to actively promote that, and this is where the RECALDENT™(CPP-ACP) technology fits in very well because it provides this soluble bioavailable form of calcium phosphate, that will stop the caries process, repair early stages of decay, and act in an additive way with fluoride giving a synergistic effect with fluoride. Thus recaldent fits in very well with the preventive strategy.

Current and future applications of Recaldent

RECALDENT™ (CPP-ACP) would be suitable for use in any product that comes in contact with the tooth, so certainly consumer products such as toothpaste and mouthwash would be ideal, particularly because there is an additive effect between RECALDENT™ (CPP-ACP) and fluoride, so for toothpaste that normally contains fluoride, is a very suitable vehicle for delivering RECALDENT™ (CPP-ACP) with fluoride to get an additive effect. It has also been launched in the consumer oral health care market in sugarless chewing gum and more recently a sugar free, water-based creme containing RECALDENT™ (CPP-ACP) (GC Tooth Mousse/ Prospec MI Paste) has been made available to dental professionals. People with lactose intolerance don't have to be concerned with it because RECALDENT™(CPP-ACP) does not contain lactose so it's completely safe for people with lactose intolerance. It's also quite safe for people with a range of milk sensitivities. People who should be careful and cautious of using the product are those who have a true allergy to the milk protein casein. Other applications for RECALDENT™ (CPP-ACP), such as other oral care products (for both professional and consumer application) and

nutritional products, are currently being developed and are planned to be launched in the future

SUMMARY

Dental diseases are recognized as a major public health problem, in civilized society. The prevalence of tooth decay, various dental diseases, and tooth loss are so great that a permanent healthy oral system in the body is almost impossible. It is well known that dentifrices used in conjunction with toothbrushing act to reduce plaque and calculus deposits on teeth as well as assist in removing stains and discolorations.

Dentifrices thus play multiple roles and are the most common method used to maintain oral hygiene. The vast range of available products raises the issue of confusion in the eyes of consumers. This increases the need for the dentists to understand dentifrice ingredients and benefits to be able to give patients recommendations on dentifrice use. Recommendations should be based on an individual patient's specific needs and desires as well as the scientific support for a dentifrice Dental education through its various media and even at chairside is an important tool in raising awareness for this simple and relatively inexpensive method of controlling dental diseases.

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