

ro Study of Tooth Enamel

Enamel Surface: Liquid Toothbrush Exposure 2 minutes

Earn

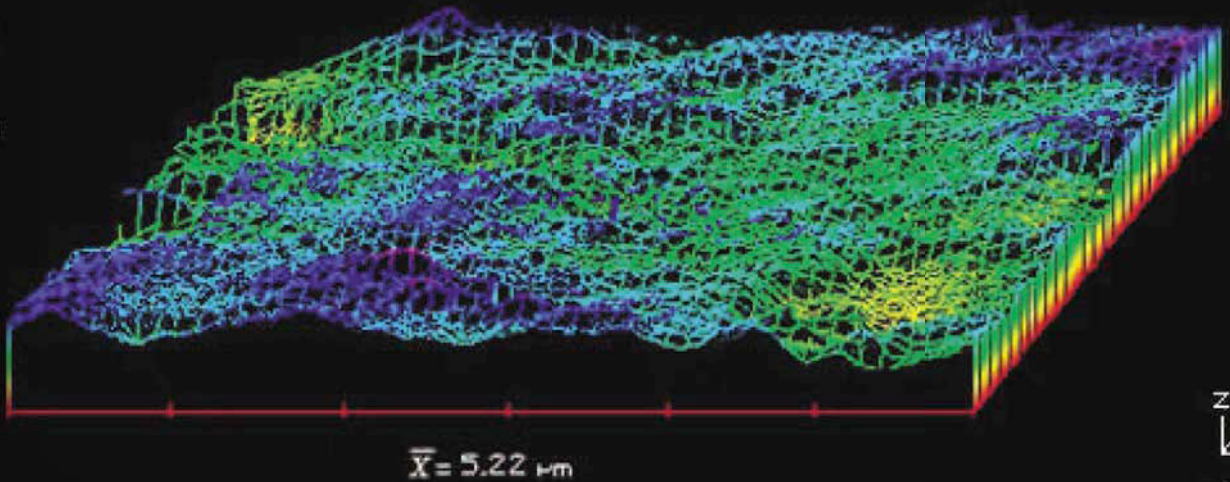
4 CEUs

This course was written for dentists, dental hygienists, and assistants.

New Advances in Tooth Whitening and Dental Cleaning Technology

A Peer-Reviewed Publication

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Educational Objectives

1. Understand the different types of tooth staining and their origins.
2. Know the different categories of tooth whiteners on the market and understand the mechanism of action of hydrogen peroxide.
3. Understand what side effects can occur with the use of whitening products and why these occur.
4. Understand aqueous cleaning technology, its mechanism of action, and results achieved using this technology.

I. Introduction

Throughout history, people have devised ways to clean and whiten teeth. The earliest method, used as early as 5,000 years ago, utilized a primitive toothbrush-like tool, a sarwak, made by chewing on one end of a twig and fashioning it into a brush-like structure. Two thousand years ago, various tooth-cleaning formulations were used that included eggshells, ground bone, and ground seashells as the primary cleaning ingredients. At the beginning of the early industrial age, there was a switch to a greater reliance on charcoal, sand, and salt. In fact, hydrated silica (a refined derivative of sand) and calcium carbonate (a refined chalk) are still commonly used today as the primary cleaning agents in dentifrices. The primary ingredients in modern tooth bleaching agents were reported to be effective, and were in use, more than a century ago.¹ These preparations included ingredients that were either analogs of hydrogen peroxide, other strong oxidizers, or acid.

Today, more adults are retaining their teeth, as dental caries has declined due partly to the inclusion of fluoride in toothpastes. Periodontal disease treatment is now being addressed by a variety of therapeutic ingredients added into an increasing number of preparations. Moreover, dental science has evolved during the same time period, with dental implants, veneers, and other sophisticated cosmetic restorative materials commonly available. All these have spurred on even greater interest and demand for oral health and beauty. At the same time, affluence and societal influences – including mass media coverage (and the use of Adobe® Photoshop® for glamour shots and television) and both professional and mass consumer advertising by oral care companies – have increasingly lead to interest and demand for esthetically-enhancing treatments such as tooth whitening. Moreover, as “baby boomers” are aging, they represent a new demographic of highly educated, health- and appearance-oriented older consumers, and they are willing to spend significant dollars to maintain or restore an esthetic, youthful appearance.

As a result of these trends and advances, dental professionals have diversified their practices by offering

new cosmetic and preventive treatments. New consumer oral care products have also come onto the market at a record pace. During 2005, tooth whitening represented a \$2 billion market.² To keep pace, oral health and dental whitening science have also become more sophisticated and intense.

II. Current Cleaning and Tooth Whitening Technology

Current cleaning and tooth whitening technology can be categorized into two types: 1) technology designed to remove only superficial extrinsic stains through mechanical abrasion; and 2) technology designed to remove both extrinsic and intrinsic stains through chemical mediation. To better understand how these technologies are designed to work, it is important to understand the nature and chemistry of the components that play roles in tooth staining.

Extrinsic Stains

Some individuals appear to be more susceptible than others to extrinsic (surface) tooth staining.³ The reasons are multi-factorial – it is likely that tooth surface morphology, salivary protein composition, diet, smoking history, and diligence of oral hygiene practices play roles in the nature and extent of extrinsic tooth discoloration.⁴ Recent studies have also shown that consumption of tea, coffee, red wine, and other foods rich in polyphenols⁵ causes a high level of extrinsic tooth staining. This primarily occurs as a result of charged surface interactions between the positively charged food molecules and the negatively charged tooth pellicle derived from salivary proteins.

Intrinsic Stains

Conversely, intrinsic tooth staining occurs when stains exist or penetrate below the enamel surface. This can happen when food molecules seep into enamel flaws and cracks, or, in some cases, between enamel rods. Intrinsic discoloration can also occur following a change to the structural composition or thickness of the dental hard tissues.⁶ Additionally, the normal color of teeth is determined by the natural off-white tints of the enamel and is reinforced by the yellow to brown shades of dentin beneath. A number of metabolic diseases and systemic factors are known to affect the developing dentition and cause discoloration as a consequence.⁷ Trauma to teeth is also a significant and common contributing factor for intrinsic tooth discoloration (Figure 1).⁸ It should be noted that intrinsic staining is particularly stubborn, and many studies report that it can take up to six months for tooth whitening to cause change.⁹ Tetracycline staining is particularly stubborn.^{10,11}

Figure 1. Traditional Methods of Stain Removal

	Extrinsic Stains	Intrinsic Stains
Site	External tooth surface	Internal and subsurface
Typical sources	Red wine, tobacco, coffee, tea; Foods rich in polyphenols; Highly positively charged molecules such as chlorhexidine gluconate	Natural enamel and dentin tint; Structural variation, metabolic diseases, systemic factors; Medications and trauma
Method of stain removal	Abrasives (physical removal); Surfactants (aids lifting of stain from surface, aids in removal)	Peroxides or peroxide analogs with or without chemical or heat activation (changes color of stains to clear; does not remove stains); Acids and methods of dehydration (opacification of enamel to obscure view of subsurface stains)

Modern Methods of Physical (mechanical) Cleaning

Today, physical cleaning in dentistry is achieved by using professional dental instruments or by using abrasives in toothpastes and in prophylaxis pastes. These all physically remove superficial tooth stain molecules. In recent years, there has been a trend towards the use of finer, gentler, and rounder abrasive ingredients in tooth cleaning preparations. There are two reasons for this. First, finer abrasives can serve the dual purpose of both cleaning and polishing, thereby imparting greater enamel surface luster and giving the impression of whiter teeth (the major point of difference in whitening toothpastes compared to more traditional varieties). Second, lower abrasivity lowers the likelihood of hard and soft tissue abrasion damage caused by over-zealous brushing. Nonetheless, Wulknitz among others has noted that the minimum amount of abrasive should be used.¹²

Dental researchers have raised the question as to whether a contemporary diet and lifestyle that often includes frequent consumption of highly acidic drinks (which contribute to increased hypocalcification and demineralization of teeth) should cause concern with respect to mechanical abrasion during brushing.¹³ Enamel and dentin are both more susceptible to abrasion following erosion.¹⁴

Abrasives currently used in tooth cleaning preparations include various forms of silicon dioxide and fused silicas (a constituent of sand and glass) (Figure 2), synthetic amorphous silicas, calcium carbonate (derived from seashells,

eggshells, or calcite (Figure 3) or from naturally mined chalk (Figure 4), mica (Figure 5), dicalcium phosphate dihydrate (derived from reacting aqueous phosphoric acid with aqueous suspensions of precipitated chalks), and aluminum oxide (a.k.a. alumina, derived from corundum (Figure 6) or from bauxite (Figure 7). Modern whitening toothpastes most often rely upon abrasives manufactured into extremely fine particles so that both mechanical cleaning and polishing can be achieved; the most common abrasive is aluminum oxide. Synthetic micro-fine rounded silicas and mica are also commonly used.

Figure 2. Silicon Dioxide



Figure 4. Chalk



Figure 6. Corundum



Figure 3. Calcite



Figure 5. Mica



Figure 7. Bauxite



Figure 8. Typical Toothpaste Ingredients

Binder	Provides body and prevents separation
Abrasive	Removes debris, imparts a polish
Surfactant	Loosens and suspends plaque
Buffering agents	Adjust pH
Humectant	Retains moisture, imparts sweetness
Fluoride	Caries preventive

Other ingredients typically contained in modern tooth cleaning preparations include binders (such as cellulose derivatives, gums, polymers of acrylic acid, or thickening silicas) that provide body and prevent separation of the ingredients; humectants (such as glycerin, sorbitol, or polyethylene glycols) that retain moisture, impart sweetness, and help to suspend or dissolve other ingredients; buffering agents that adjust pH; and surfactants (such as sodium lauryl sulfate) that are high-foaming and surface wetting agents for debris isolation and suspension (Figure 8). These surfactants are the only major “chemical clean-

ing” ingredient found in modern dentifrices. The mean pH of toothpastes is pH 8.

Chemical Tooth Bleaching

Chemical tooth bleaching can be performed by in-office professional treatment and/or by home-use products that are either dispensed by the patient’s dentist or purchased as over-the-counter (OTC) products. Professional and consumer “take-home” bleaching preparations are available as pastes or gels that are used in trays, paint-on liquids, strips; and rinses. Take-home products typically contain carbamide peroxide or hydrogen peroxide. These products have concentrations of up to 21% carbamide peroxide (equivalent to 7% hydrogen peroxide) or as much as 8% hydrogen peroxide. They also contain carbomers (for thickening and control) and acidifiers (for peroxide stabilization in aqueous solution), or alternatively have an anhydrous glycerin base. In-office treatments almost always use hydrogen peroxide as the oxidizer, at concentrations of 15% or more and typically in the 25 to 35% range (Figure 9). Rubber dams, or liquid dams with proper suction, must be used at these concentrations to prevent gingival irritation and ingestion.

Treatment may involve the use of a tray only, but more typically is supplied as a dual-component bleach/activator system that optionally uses another chemical or a light or heat source as a secondary or tertiary activator. Most often the chemical activator is either in the form of a transition metal-containing ingredient or is an alkaline pH adjuster that causes the second component to have a basic pH. Due to their high strengths, they require more thickener and more acidification to make them stable when compared to home-use products. Furthermore, professional chairside formulas have a secondary and often even a tertiary and quaternary method to cause a more rapid result. These activators take the form of pH modifiers, light sources, and heat sources.

Figure 9. Tooth Whitening Options

In-Office	<ul style="list-style-type: none"> • Hydrogen peroxide <ul style="list-style-type: none"> - Approximately 25-35% • Requires soft tissue protection • Activator <ul style="list-style-type: none"> - Chemical - Heat - Light • Most rapid results • Dentist applied
Take-Home	<ul style="list-style-type: none"> • Carbamide peroxide <ul style="list-style-type: none"> - Up to 21% • Used in trays <ul style="list-style-type: none"> - Twice a day - Overnight • Patient applied
OTC	<ul style="list-style-type: none"> • Hydrogen or Carbamide peroxide • Available as: <ul style="list-style-type: none"> - Tray systems - Strips - Paint-on liquids - Rinses • Consumer applied

In-office treatment offers patients more immediate results and gratification. For these reasons, as well as for practice-building reasons for the dental office, in-office whitening has become popular with patients. Both the in-office and take-home methods achieve varying degrees of whitening for a period of time – the amount depends upon the length of treatment, concentration of oxidizer, etiology of the stain, and the individual patient’s teeth and maintenance compliance and diet.

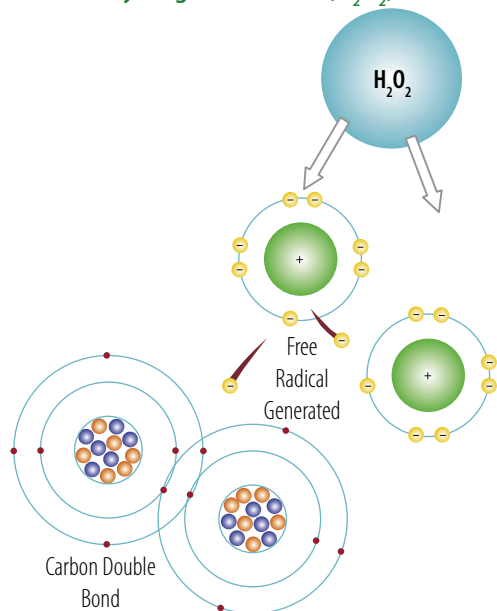
Formulation Strategies

The delivery vehicle – or base – can be anhydrous glycerin, a polyglycol mix, or a water-based mixture of acidified carbomers. Anhydrous glycerin has been used as a thickening agent for a tray-based 10% carbamide peroxide overnight whitening system. Carbamide peroxide is fairly stable in anhydrous formulations and is only broken down into hydrogen peroxide (3:1 ratio) by exposure to water and salivary enzymes. The pH of these preparations is either acidic or, most commonly, near neutral (pH = 7.0). Modern tooth bleaching preparations are more likely to contain carbomer (used commonly in oral care products as a thickener) or a close analog as a thickening agent to form a water-based gel, rather than using anhydrous glycerin. More modern formulations will also typically have a more acidic pH – this is primarily because peroxide analogs are unstable in aqueous solution and would otherwise have a very short shelf-life. The remaining ingredients in recently formulated tooth bleaching products have been designed to stabilize, control, deliver, and activate the peroxide. A new variety of tooth bleaching formulations contains amorphous calcium phosphate (ACP), which can fill in microscopic porosities, reducing sensitivity during whitening and imparting a luster.

III. Mechanism of Action: Peroxide Bleaching

Whether a tooth bleaching system contains carbamide peroxide or hydrogen peroxide, the mechanism of action of these systems involves hydrogen peroxide. Carbamide peroxide is broken down by salivary enzymes. It breaks down to release hydrogen peroxide and urea – for instance, 10% carbamide peroxide would break down to 3% hydrogen peroxide and 7% urea. Carbamide peroxide and hydrogen peroxide are generators of free radicals. Hydrogen peroxide converts colored materials into non-colored materials by oxidizing organic compounds within the enamel and dentin. Hydrogen peroxide breaks down into free radicals. These free radicals then work by breaking the carbon:carbon double bonds found in the double-bonded organic stains in the teeth (Figure 10). Breaking these bonds leads to lightening of the molecules until they lose their color, typically over hours or weeks depending on the manufacturer’s instructions.

**Figure 10. Mechanism of Action:
Hydrogen Peroxide (H₂O₂)**



Higher concentrations of the whitening agent may result in faster whitening of teeth, although no difference is found by the end of six weeks.^{15,16}

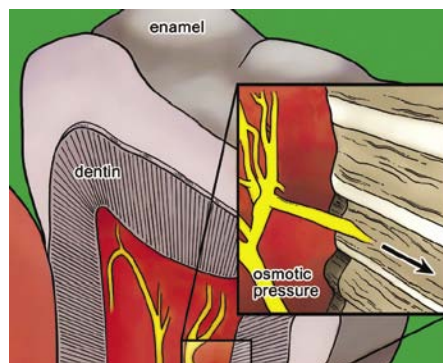
IV. Issues in Tooth Bleaching Treatment

While tooth whitening has become a mainstream treatment in the U.S. and is generally regarded as safe and effective, there are some issues related to treatment, with the most common reported side effect being tooth sensitivity¹⁷.

Sensitivity: A 1995 survey found that of more than 7,000 dentists using tooth whitening systems, only 20% reported no side effects in patients.¹⁸ Among those reporting side effects, the most common was sensitivity, followed by soft tissue irritation. Sensitivity is transient and has been reported variously as occurring 10% of the time¹⁹ and as occurring in more than 50% of patients.²⁰ Use of lower concentrations can result in less sensitivity.²¹ Although transient sensitivity has been reported, hydrogen peroxide and carbamide peroxide have not been found to induce pathological pulpal changes in testing. Use of 10% carbamide peroxide resulted in mild, reversible histological changes.²² The transient sensitivity experienced during tooth whitening treatments is believed to be due to an unfavorable osmotic gradient (Brannstrom's hypersensitivity theory). It is believed that the hypersensitivity associated with whitening is caused by dehydration²³ due to the acidified and thickened gels used that are held against the teeth. This results in a negative osmotic pressure and in odontoblastic processes being drawn into the dentinal tubules (Figure 11). Other factors that may con-

tribute to dehydration include bleaching lights used in in-office treatments and that heat the tooth. Anhydrous glycerin used as a thickening base in some formulations is also a dehydrating agent – this imparts greater levels of whiteness but is also responsible for higher levels of transient dentinal hypersensitivity. While sensitivity may be transient, it is an undesirable side effect.

Figure 11. Brannstrom's Hydrodynamic Theory



Rebound: Reversal following treatment occurs, and the stain reappears. The time that elapses post-treatment before this occurs varies from a few days or weeks, while other studies claim up to 47 months before any rebound effect occurs.²⁴ One study found a rebound in 40% of patients at six months with use of concentrations ranging from 16% – 18% carbamide peroxide.²⁵ Hydrogen peroxide works by changing the color of stain; it does not actually remove the stain molecules, and over time these revert to a stained condition. A further factor in rebound is the enamel surface changes that can occur during whitening – dehydration, and etching caused by acidic formulations, in themselves result in a whiter appearance, and as the tooth rehydrates and recalcifies this effect disappears.

Surface Changes: Use of hydrogen peroxide and carbamide peroxide has been found to result in surface changes in in vitro testing. Carbamide peroxide, with or without the addition of carbopol and glycerin, has been found to cause surface changes and roughness in in vitro testing, whether or not the samples were kept in artificial saliva between treatments.^{26,27} Other studies have found that the normal morphological variation in untreated enamel exceeds surface changes induced by up to 35% hydrogen peroxide.²⁸ One study testing varying concentrations of carbamide peroxide found no differences in the decreased surface microhardness between 10% and 22% concentrations.²⁹ Another study found changes in the absence of saliva, but not in the presence of saliva.³⁰

In contemporary bleaching preparations, the final formulation is usually acidic – the acids can also

decalcify and opacify teeth through etching, causing teeth to look chalky white and temporarily masking underlying discolorations.

Soft Tissue Irritation: Systems using higher concentrations of hydrogen peroxide or carbamide peroxide result in more gingival irritation. While some studies suggest that this may be due to tray design, one study conducted using a split-mouth design comparing 10% and 16% carbamide peroxides used as an overnight system still found gingival irritation to be greater using the 16% concentration.³¹ Peroxide is regarded as safe at low concentrations but has the potential to induce cell changes at high concentrations over an extended period of time.

Patient Compliance: Patient compliance is known to be an issue during tooth whitening treatments. Higher compliance has been found for systems with a shorter and less frequent wear period.³² Systems using overnight trays have been found to still have 10% of the active carbamide peroxide available at 10 hours, with 50% available after two hours of wear.³³

V. Ideal Properties for Tooth Whitening Products

Oral care products are used in an aqueous and complex biological environment. Both soft and hard tissues are exposed to the environment, and the oral cavity is a systemic portal. Oral care products should ideally have a rapid onset of action, clean thoroughly, offer convenient application without requiring expensive or cumbersome equipment, offer long-lasting results, and utilize rapid action to minimize the time they must remain in the mouth and to maximize their utility – patients are known to be non-compliant with trays³⁴ and this also avoids any active agent degradation issues.

Oral care products must have a high margin of safety systemically and intra-orally – they should induce no hard or soft tissue damage, nor should their use result in pain either with one-off or repeated use. Ideally, they should be low foaming, have low abrasivity, and offer true deep stain removal. Within this context, only a small number of chemicals are recognized as orally safe ingredients by the Food and Drug Administration (FDA), and many ingredients are food-grade additives.

VI. Aqueous Cleaning Technology

Aqueous cleaning technology is based upon the principles of mass action cleaning that provide the basis of cleaning formulations for surface and subsurface stain removal in laundry and detergent technology. Some researchers have recognized that physical abrasion could be substituted for more modern cleaning chemistry. In fact, cleaning through modern chemical principles produces results

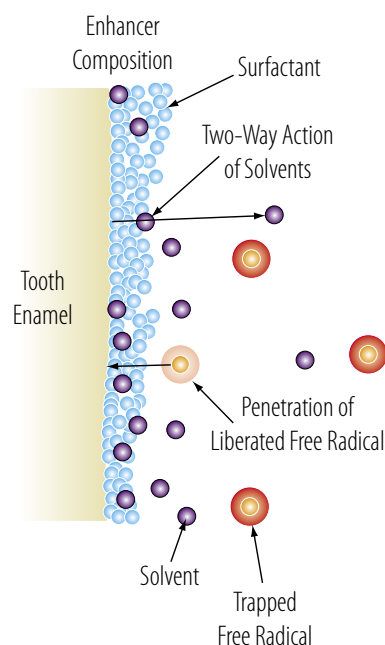
more rapidly and efficiently than those methods that rely on physical abrasion and, most importantly, chemical methods yield surfaces less damaged or altered. Furthermore, it has long been recognized that primary cleaning always supersedes bleaching, with the latter only used as a final booster for achieving maximal whiteness.

As directed by the principles of mass action cleaning, increasing the time a material is exposed to the cleaning agents increases stain removal, while elevating the temperature enables the bonds of the stain to be more easily broken apart and the remnants to be removed. The specific factors and ingredients that play a combined and balanced role in the ability of a specific product to effectively clean include time, temperature, solvents, surfactants, charged detergents, chelators, saponifiers, and enzymes and their action (Figure 12). Therefore, cleaning ability will vary depending upon the specific formulation.

Solvents

Aqueous cleaning technology employs solvents that are of low viscosity and easily penetrate the teeth to break the molecular bonds within the stain. They also help to break the molecular bond between the positively charged colored stain molecules and the negatively charged surfaces that they are physically bound to (Figure 12).

Figure 12. Action of Solvents



Surfactants

The surfactants (or wetting agents, which are contained in other oral care products) help lift stains from the surface via a bubbling action. The most common surfactant used in oral

care is sodium lauryl sulfate, but lower-foaming surfactants can be used efficiently and safely.

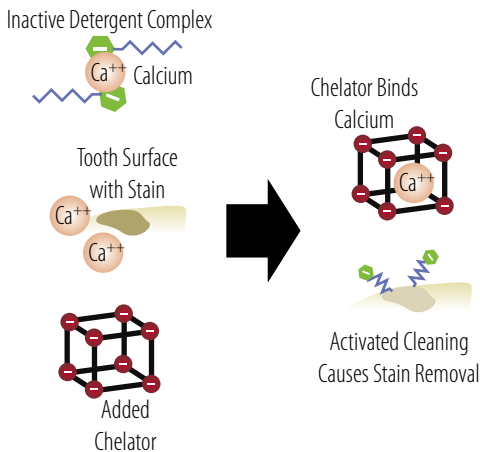
Anionic Detergents

Negatively-charged anionic detergents are included to attract and bind to positively-charged stain particles, helping to remove them from the tooth. Neutralization prevents rebinding to the substratum, and the bubbling nature helps to lift the stain off the surface. These detergents are the key ingredients that make the difference between laundry detergents and mere soap. Orally safe anionic detergents that can be added to oral care products to improve cleaning are available.

Chelators

All cleaning technologies work best in “soft” water. Saliva contains many minerals, and an orally safe, food-grade chelator is needed to bind excess calcium and other minerals that would otherwise interfere with the action of the detergent (Figure 13).

Figure 13. Action of Chelators



Saponifiers

Saponifiers contained in the formulation are designed to remove debris between the enamel microcracks and crevices, forming a foaming soapy emulsion that is removed.

Effervescent

Effervescent work to provide the needed action that is a substitute for physical scrubbing. By rapidly creating coarse “scrubbing bubbles” sufficient agitation of the cleaning solution is achieved to result in true stain removal without the need for physical hard abrasives.

Mechanism of Action and Benefits

It is believed that aqueous cleaning technology works by eliminating most enamel stains by a true chemical clean-

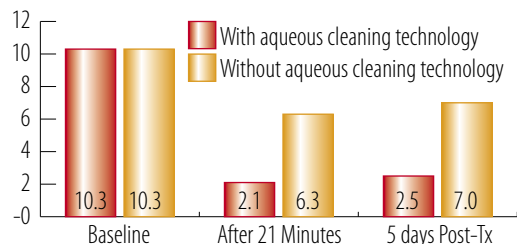
ing process, similar to that achieved in laundry detergent or carpet cleaners, with the exception that all ingredients used are all natural and classified as “Generally Regarded As Safe” (GRAS) by the FDA for both food and oral cleaning cosmetics.

The non-abrasive nature of these chemicals eliminates the possibility of frictional hard or soft tissue damage. The technology uses four different solvents, which, combined with surface tension, enable superior penetration, speeding up tooth cleaning and whitening. In contrast, current high-viscosity cleaning and bleaching formulae hold products in intimate contact with the tooth but may prevent some degree of penetration of the active ingredients, while carbomers used can retard the whitening process by scavenging free radicals.

Efficacy and Safety

Aqueous cleaning technology has been found to be safe in numerous clinical studies when used as a stand-alone, every-day cleaning agent for teeth and as a pre-treatment prior to use of a tooth bleaching system (Whitening Stain Remover Swabs™, GRINRX Corporation). Stains are removed rapidly and the formulation hydrates the teeth, due to its low surface tension and penetration ability. Sensitivity has not been reported with stand-alone use of this product. It contains no heavy thickeners such as carbomers that could affect the odontoblastic processes by changing the osmotic pressure. Sensitivity associated with tooth bleaching can be lowered if the aqueous cleaning technology is used pre-procedurally immediately before bleaching therapy. This allows any subsequently applied tooth bleaching preparation to work in cycles of three (3) to ten (10) minutes, which minimizes contact time. Figure 14 shows the results of a study using pre-treatment with aqueous cleaning technology or placebo (water). Water was swabbed onto patients’ teeth on one side of the arch, and whitening stain remover on the other side of the arch, as a pre-treatment prior to tooth whitening. Use of the whitening stain remover swabs resulted in significantly greater tooth whitening.

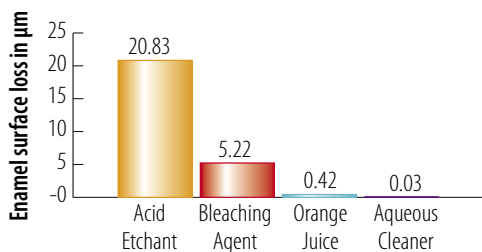
Figure 14. Enhancement of Whitening



In a recent laser profilometry study comparing a cleaning agent containing aqueous cleaning technology to a 7.5% hydrogen peroxide tooth bleaching product, orange juice, and acid etchant it was found that only the aqueous cleaning technology

did not induce enamel etching or enamel surface changes on standard 2 mm enamel blocks (Figure 15).³⁵

Figure 15. Enamel Surface Loss Induced by Various Agents



In this study, the enamel blocks were subjected to one of the four liquids for two minutes, and then thoroughly washed and dried prior to laser profilometry reading. The tooth whitening agent containing 7.5% hydrogen peroxide was found to result in significant changes to the enamel surface, while the aqueous cleaning technology did not (Figures 16 a and b).

Figure 16a. Enamel Surface Change With 7.5% Hydrogen Peroxide

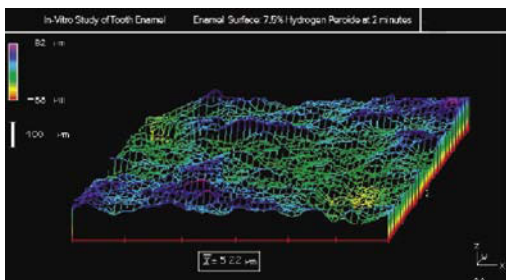
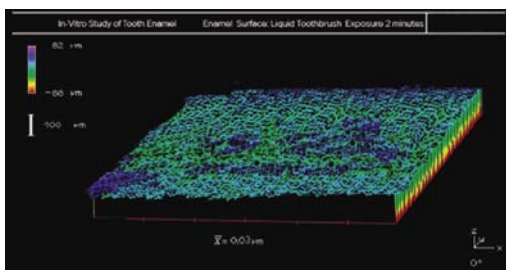


Figure 16b. Enamel Surface Change With Aqueous Cleaning Technology

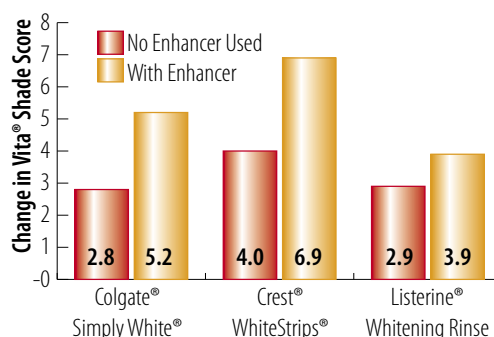


An in vitro study compared the same technology in the form of a universal tooth whitening enhanced liquid consisting of 2% hydrogen peroxide with surfactants and solvents versus placebo (water) as an adjunct to use of an in-office 20% hydrogen peroxide tooth whitening gel. Both groups were pre-treated with the test or placebo for three 10-minute cycles, followed by application of 20% hydrogen peroxide gel. Knoop tests revealed no differences in the subsurface enamel or dentin hardness. The

concentration of peroxide in the pulp chambers was statistically significantly higher (it resulted in a concentration twice as high) for the test substance, indicating that penetration into the tooth was greater. The study concluded that this high penetration ability influenced the efficacy and speed of tooth bleaching.³⁶ Nonetheless, the level of peroxide internally was 2,000 times less than would be required to result in pulpal enzyme damage.

A second study assessed pre-procedural use of the product prior to application of three different, commercially available take-home bleaching systems. Following five days of treatment, significant differences were found in the change in Vita shade when teeth were pre-cleaned prior to each application of bleaching gel (Figure 17). No dentinal sensitivity was reported in any of these cases.

Figure 17. Whitening Efficacy With and Without Enhancer



VII. Summary

Tooth cleaning and tooth whitening have been human goals for more than two thousand years. In the last two decades, tooth whitening has become a significant factor, with increasing interest and demand by patients. Physical cleaning is currently achieved in toothpastes through the use of abrasives. Chemical tooth whitening – bleaching – can be achieved using in-office, take-home, or OTC products. All use formulations of hydrogen peroxide, or carbamide peroxide, which breaks down into hydrogen peroxide and urea, at concentrations typically in the 10%–35% range. While effective at reducing the appearance of stain, these formulations are also associated with sensitivity as well as other side effects. Recently, aqueous cleaning technology has been introduced as a whitener and pre-treatment for whitening treatments. The development and initial application of aqueous cleaning technology in dental cleaning and tooth whitening and the results of testing utilizing the technology have been promising. It can be anticipated that as interest in tooth whitening and other cosmetic procedures continues to grow, new products utilizing this and other technologies will continue to be developed so that professional and

consumer demand can be met in a manner that is both highly safe and very efficacious.

Endnotes

- 1 Strassler HE. What's up with whitening? An update on professionally dispensed vital bleaching. ADTS. www.ineedce.com. Accessed November 2006.
- 2 Shephard, D. Tooth Whitening Choosing The Best Method. www.toothwhiteningvault.com/articles/tooth-whitening-choosing-the-best-method. Accessed November 2006.
- 3 Watts A, Addy M (2001). Tooth discoloration and staining: a review of the literature. *Br Dent J* 190:309–316.
- 4 Nathoo SA (1997). The chemistry and mechanisms of extrinsic and intrinsic discoloration. *J Am Dent Assoc* 128:68–108
- 5 G.B. Proctor, R. Pramanik, G.H. Carpenter, and G.D. Rees Salivary Proteins Interact with Dietary Constituents to Modulate Tooth Staining *J. Dent. Res.*, January 1, 2005; 84(1): 73–78.
- 6 Watts A, Addy M (2001). Tooth discoloration and staining: a review of the literature. *Br Dent J* 190:309–316.
- 7 Pindborg J J. Pathology of the dental hard tissues. Copenhagen: Munksgaard, 1970. p221.
- 8 Strassler HE. Update on toothwhitening systems. *J Esthet Dent* 1990;2:151–153.
- 9 Strassler HE. Update on toothwhitening systems. *J Esthet Dent* 1990;2:151–153.
- 10 Leonard RH, Haywood VB, et al. Nightguard vital bleaching of tetracycline-stained teeth: 54 months post treatment. *J Esthet Dent* 1999;11:265–277.
- 11 Matis BA, Wang Y, et al. Extended at-home bleaching of tetracycline-stained teeth with different concentrations of carbamide peroxide. *Quintessence Int* 2002;33:645–655.
- 12 Wulknitz, P. Cleaning power and abrasivity of European toothpastes. *Adv Dent Res* 1997;11:576–579.
- 13 Strassler HE. What's up with whitening? An update on professionally dispensed vital bleaching. ADTS. www.ineedce.com. Accessed November 2006.
- 14 Hooper S, West NX, Pickles MJ, et al. Investigation of erosion and abrasion on enamel and dentine: a model in situ using toothpastes of different abrasivity. *J Clin Periodontol.* 2003;30(9):802–808.
- 15 Leonard RH, Sharma A, Haywood VB. Use of different concentrations of carbamide peroxide for bleaching teeth: an in vitro study. *Quintessence Int* 1998;29:503–507.
- 16 Matis BA, Mousa HN, et al. Clinical evaluation of bleaching agents of different concentrations. *Quintessence Int* 2000;31:303–310.
- 17 Haywood VB. Treating sensitivity during tooth whitening. *Compend Contin Educ Dent.* 2005;26(9 Suppl 3):11–20.
- 18 Christensen GJ, Christensen RP. Home use bleaching study – 1995. *CRA Newsletter* 1995;19(10):1.
- 19 Ibid.
- 20 Nathoo S, Santana E 3rd, Zhang YP, et al. Comparative seven-day clinical evaluation of two tooth whitening products. *Compend Contin Educ Dent.* 2001;22(7):599–604, 606.
- 21 Ibid.
- 22 Fugaro JO, Nordahl I, Fugaro OJ, et al. Pulp reaction to vital bleaching. *Oper Dent.* 2004;29(4):363–368.
- 23 Papatthanasious A, et al. Clinical evaluation of a 35% hydrogen peroxide in-office whitening system. *Comp* 2002;23:335–346.
- 24 Leonard RH Jr, Bentley C, Eagle JC, et al. Nightguard vital bleaching: a long-term study on efficacy, shade retention, side effects, and patients' perceptions. *J Esthet Restor Dent.* 2001;13(6):357–369.
- 25 Brunton PA, Ellwood R, Davies R. A six-month study of two self-applied tooth whitening products containing carbamide peroxide. *Oper Dent.* 2004;29(6):623–626.
- 26 Basting RT, Rodrigues AL Jr, Serra MC. The effect of 10% carbamide peroxide, carbopol and/or glycerin on enamel and dentin microhardness. *Oper Dent.* 2005;30(5):608–616.
- 27 Cavalli V, Arrais CA, Giannini M, Ambrosano GM. High-

concentrated carbamide peroxide bleaching agents' effects on enamel surface. *J Oral Rehabil.* 2004;31(2):155–159.

- 28 Spalding M, Taveira LA, de Assis GF. Scanning electron microscopy study of dental enamel surface exposed to 35% hydrogen peroxide: alone, with saliva, and with 10% carbamide peroxide. *J Esthet Restor Dent.* 2003;15(3):154–164.
- 29 Basting RT, Rodrigues AL Jr, Serra MC. The effects of seven carbamide peroxide bleaching agents on enamel microhardness over time. *J Am Dent Assoc.* 2003;134(10):1335–1342.
- 30 Justino LM, Tames DR, Demarco FF. In situ and in vitro effects of bleaching with carbamide peroxide on human enamel. *Oper Dent.* 2004;29(2):219–225.
- 31 Leonard RH Jr, Garland GE, Eagle JC, Caplan DJ. Safety issues when using a 16% carbamide peroxide whitening solution. *J Esthet Restor Dent.* 2002;14(6):358–367.
- 32 Strassler HE. What's up with whitening? An update on professionally dispensed vital bleaching. ADTS. www.ineedce.com. Accessed November 2006.
- 33 Matis BA, Gaiao U, Blackman D, et al. In vivo degradation of bleaching gel used in whitening teeth. *J Am Dent Assoc.* 1999;130(2):227–235.
- 34 Strassler HE. What's up with whitening? An update on professionally dispensed vital bleaching. ADTS. www.ineedce.com. Accessed November 2006.
- 35 Giniger, M, Bastini, T, Olsen, B. Assessment of enamel surface effect caused by aqueous cleaning technology. *J Dent Res*, abstract 91293, accepted for publication
- 36 Spaid, M, Giniger, M. Effect of adjunctive universal whitening enhancer on enamel and dentin. *IADR 2006; Abstract 1665.*

Author Profile

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Dr. Robert Margeas currently serves as Adjunct Professor in the Department of Operative Dentistry at the University of Iowa College of Dentistry. He is also the Clinical Director and Instructor at the Center for Esthetic Excellence, Chicago, IL. Dr. Margeas has published numerous articles on esthetic dentistry and is a highly sought after international lecturer on the subject. His credentials include board certification by the American Board of Operative Dentistry and he is a Fellow of the Academy of General Dentistry (AGD). Dr. Margeas is on the Editorial Board for Contemporary Esthetics and is a consultant in Oral Health matters for the country of Canada. He maintains a very successful private practice, with a focus on comprehensive esthetic restorative dentistry, in Des Moines, IA.

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Questions

1. A toothbrush-like tool called a _____ was used as early as 5,000 years ago.
 - a. Sarwak
 - b. Warsak
 - c. Mantargo
 - d. None of the above
2. The primary ingredient in modern tooth-bleaching preparations was used _____.
 - a. Three thousand years ago
 - b. More than a century ago
 - c. Frequently by primitive man
 - d. None of the above
3. Tooth stains are _____.
 - a. Intrinsic
 - b. Extrinsic
 - c. Intra-osseous
 - d. a and b
4. Consumption of foods rich in _____ cause a high level of extrinsic staining.
 - a. Alkaline compounds
 - b. Acidic compounds
 - c. Polyphones
 - d. None of the above
5. Causes of intrinsic staining include _____.
 - a. Medications
 - b. Trauma
 - c. A change in the tooth's structural composition
 - d. All of the above
6. Physical (mechanical) cleaning is achieved by using _____ in toothpastes.
 - a. Fluoride
 - b. Abrasives
 - c. Coloring
 - d. None of the above
7. Common abrasives used in toothpastes include _____.
 - a. Silicon dioxide
 - b. Calcium carbonate
 - c. Alumina
 - d. All of the above
8. Abrasives used at present are finer, gentler and rounder than those used previously because _____.
 - a. There is less likelihood of soft- and hard-tissue damage
 - b. The fine abrasive imparts a greater enamel surface luster
 - c. Rougher abrasives are not available
 - d. a and b
9. In-office bleaching systems typically use hydrogen peroxide in the _____ range.
 - a. 5 to 10 percent
 - b. 10 to 20 percent
 - c. 25 to 35 percent
 - d. 40 to 60 percent
10. Carbamide peroxide breaks down into _____.
 - a. Hydrogen peroxide and urea
 - b. Hydrogen peroxide and oxygen
 - c. Calcium peroxide and urea
 - d. All of the above
11. Bleaching preparations can be manufactured with _____.
 - a. A water-based formulation
 - b. An anhydrous glycerin base
 - c. A pectin base
 - d. a and b
12. Hydrogen peroxide generates _____ that break(s) carbon-carbon double bonds.
 - a. Oxygen
 - b. Free radicals
 - c. Mallease
 - d. None of the above
13. Breaking the carbon:carbon double bonds in stain molecules _____.
 - a. Removes the stain
 - b. Lightens the stain
 - c. Forms hydrogenases
 - d. None of the above
14. The most common side effect associated with tooth bleaching is _____.
 - a. Tooth sensitivity
 - b. Changes in taste perception
 - c. Aphthous ulcers
 - d. All of the above
15. Effects associated with tooth bleaching include _____.
 - a. Soft tissue irritation
 - b. Sensitivity
 - c. Enamel surface changes
 - d. All of the above
16. The sensitivity associated with tooth whitening is believed to be due to _____.
 - a. A negative osmotic pressure
 - b. The outside temperature
 - c. How nervous the patient is
 - d. None of the above
17. Surface microhardness changes following the use of carbamide peroxide _____.
 - a. Are the same as with the use of water
 - b. Vary with the amount of sugar added as a sweetener
 - c. Have been found to be the same at both 10 percent and 22 percent concentrations
 - d. Have been shown to be less at lower concentrations
18. Aqueous cleaning technology is based upon _____.
 - a. Mass-action cleaning technology
 - b. Use of Chinese herbs
 - c. Nuclear medicine technologies
 - d. None of the above
19. Solvents contained in aqueous cleaning technology are _____.
 - a. Of low viscosity
 - b. Used to break the molecular bonds within the stain
 - c. a and b
 - d. None of the above
20. Surfactants work by _____.
 - a. Lifting stains from the surface via a bubbling action
 - b. Making the stain more visible for physical removal
 - c. Neutralizing acid
 - d. None of the above
21. Negatively-charged anionic detergents _____.
 - a. Bind to positively-charged stain particles
 - b. Bind to fluoride
 - c. Become neutrons when exposed to air
 - d. None of the above
22. Effervescent work by creating _____.
 - a. Coarse "scrubbing bubbles"
 - b. A white foamy emulsion
 - c. Space for an abrasive in the whitener to work
 - d. None of the above
23. Studies have found that use of aqueous cleaning technology results in _____.
 - a. Severe sensitivity
 - b. No sensitivity
 - c. An increase in salivary flow
 - d. None of the above
24. Pre-treatment with aqueous cleaning technology prior to use of a bleaching system _____.
 - a. Decreases the time required to bleach
 - b. Increases the time required to bleach
 - c. Makes no difference
 - d. None of the above
25. Laser profilometry study has shown that enamel etching is not induced by _____.
 - a. Orange juice
 - b. 7 percent hydrogen peroxide
 - c. Aqueous cleaning technology
 - d. Acid etchant
26. Aqueous cleaning technology contains abrasives.
 - a. True
 - b. False
27. High penetration ability has been found to _____.
 - a. Increase the efficacy of tooth bleaching
 - b. Decrease the efficacy of tooth bleaching
 - c. Remove less stain
 - d. Have no effect
28. The chemical activator contained in in-office whitening treatments is most often _____.
 - a. A transition metal-containing ingredient
 - b. An alkaline pH adjuster
 - c. Either a or b
 - d. None of the above
29. The sensitivity associated with toothbleaching is _____.
 - a. Permanent
 - b. Transient
 - c. An undesired side effect
 - d. b and c
30. Patients have been found to prefer tooth bleaching that _____.
 - a. Reduces how long a tray is worn
 - b. Reduces how frequently a tray is worn
 - c. a and b
 - d. None of the above

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