Why We See Problems with Teeth Whitening:

The Science of Whitening, Part II* The Solutions

* Editor's note: Part 1 of this series appeared in the November 2012 edition of Dentaltown Magazine. To view Part 1 of this series and other articles by Dr. Rod Kurthy, visit http://tinyurl.com/axj2omx

by Rod Kurthy, DMD

Following the Science for Solutions to Whitening Frustrations

Maintaining Potency of Peroxide Whitening Gels

Constant refrigeration is the key to maintaining potency, effectiveness and the desired *instability* of whitening gels.[3,8,14-16,30,32] By refrigerating all whitening gels from the instant of manufacture until the dental office receives the product cold, use of chemical stabilizers such as an anhydrous base and "acidifiers" are unnecessary and can be avoided.[14]

When continuous refrigeration is used to stabilize peroxides during storage and shipping, instead of chemical stabilization of the gel itself:

1. Whitening gels are received cold by the dental practice and arrive at virtually 100 percent of their original potency and effectiveness.
2. Whitening gels may be formulated with a fully aqueous base and pH at or above pH 7.
3. Without the need for chemical stabilizers, whitening gels are much more *"unstable."* When placed in the warm mouth, the degradation of *unstable* peroxide is highly effective and thorough.[16,37]

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4. With a fully aqueous base, neutral or slightly basic pH and no chemical stabilizers, whitening gel osmolarity is not only much lower, but may be as little as one-eleventh the osmolarity of other whitening gels. With lower osmolarity, there is less "pull" on dentinal tubular fluid, and whitening sensitivity is significantly reduced.[16,17,33,34,63]

Chemically Influencing Production of Free Radicals

Fully aqueous gels with a neutral pH (allowed because of refrigeration) are very *unstable,* resulting in not only more thorough chemical breakdown in the mouth, but also the release of far more whitening radicals instead of ineffective oxygen and water.[16,37] This greatly enhances whitening results.[37]

Use of specific chemical accelerators that not only speed the breakdown of peroxide, but also produce ions and radicals (instead of just molecular oxygen and water) will greatly enhance the overall whitening results.[10, 13,26,27]

Extending Time of Bleaching Factor Release

A whitening tray design that prevents loss of whitening gel from whitening trays, and more importantly, at the same time prevents damaging peroxidase (found in saliva and sulcular fluid[13,14,39-43]) from entering the whitening tray, will result in a much longer duration of whitening activity. A longer duration of whitening activity provides more time for both oxygenation removal of organic debris from tooth microstructure and conversion of dark long-chain stain molecules to ultra-small white and colorless molecules (Fig. 1).[3,6,7,10,13]

Alteration of Whitening Gel Viscosity and Solubility

Because conventional whitening trays do not seal whitening gel in, and do not seal out damaging saliva and sulcular fluid,[16] conventional whitening gels are typically made with excessively high viscosity and more insoluble (anhydrous base). By making the gel viscous, it is more difficult for saliva and sulcular fluid to penetrate.

I'm sure you've heard the phrase "oil and water don't mix." Obviously if you make whitening gel with a more anhydrous base (we can think of as the "oil"), the saliva (we can think of as the "water") has a more difficult time penetrating the gels. The problem is that bleaching factors have a more difficult time getting out of highly viscous gel and into the microstructure of the teeth.

Also, following the logic of "oil and water don't mix," it is more difficult for bleaching factors to get out of the anhydrous base of the whitening gel, and into the aqueous ("water") environment of the tooth.

And of course, as discussed in part one of this article, even with the typical gels utilizing excessively high viscosity and anhydrous bases, studies have still shown that only very short times of whitening duration are found.[3,38]

When whitening trays are designed to seal out both saliva and sulcular fluid, whitening gels can be made without excessive viscosity and with 100 percent aqueous bases. This allows a rapid release of bleaching factors from the whitening gel into the microstructure of the teeth, yet still provides a much longer duration of active whitening.

Fig. 1: The most difficult area to achieve precision adaptation of bleaching trays is the facial of the lower anterior area. Yet note the high degree of adaptation and precision of KöR-Seal Whitening Trays. The precision is similar to the precision of fit normally expected for crown and bridge.

This fit and "seal" is responsible for preventing loss of whitening gel, and more importantly, prevention of seepage of damaging salivary and sulcular fluid peroxidase into the bleaching trays.

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Fig. 2: KöR Dual Activated, Tri-Barrel Hydremide Peroxide in-office whitening gel applied to teeth. Low surface tension results in enhanced absorption and penetration into tooth structure, yet does not run off teeth.

To prevent gels from running off teeth, in-office gels are also commonly higher viscosity. This viscosity results in a higher surface tension, causing less microscopic adaptation of the whitening gel to the tooth surface, slowing the absorption of bleaching factors from peroxide into the microstructure of the teeth. Formulation of whitening gels with lower surface tension/lower viscosity that will not run off the teeth will allow faster absorption of bleaching factors by tooth structure (Fig. 2).

pH Control

I previously discussed the benefits of guiding the peroxide reaction to produce ions and radicals instead of simply oxygen and water.[7,10,11,13,14,16,22-24,26-31,37,44] But remember, when ions and radicals are produced, hydrogen ions (acid) are also produced,[10,13,16,26,27-30] with all the accompanying problems previously discussed.[35,36] The addition of buffering agents to scavenge hydrogen ions released when free radicals are produced will maintain the desired non-acidic pH. The result is:

- Rapid breakdown of peroxide during the entire application period
- Continued production of free radicals (instead of a shift toward production of water and molecular oxygen) throughout the entire application
- Considerably lower osmolarity, resulting in much less whitening sensitivity[16,17,33-37,64]

How KöR Whitening Has Followed the Science of Teeth Whitening to Overcome Whitening Frustrations

1) KöR is the first whitening system in the world to maintain potency of an entire line of whitening gels by constant refrigeration from the instant of manufacture until received cold by the dental practice. Refrigeration enables formulation of whitening gels that are fully aqueous and a neutral pH. The result is an unusually *unstable* gel when placed in the warmth of the mouth,[29] resulting in a more thorough breakdown and production of large volumes of effective radicals, as well as an osmolarity as low as one-eleventh that of gels stabilized by anhydrous bases with acidifiers. Of course, this means significantly lower whitening sensitivity.[20,28]
2) The unique design of proprietary at-home KöR-Seal Whitening Trays effectively seals in the whitening gel and prevents rapid ingress of damaging saliva and sulcular fluid (Fig. 1). This physical seal enabled the formulation of KöR at-home whitening gels with lower viscosity and higher solubility – resulting in enhanced ability of bleaching factors to quickly exit the whitening gel and enter the tooth microstructure.
3) Inclusion of buffering systems into KöR Whitening gels, scavenging hydrogen ions (acid) as they are produced, maintaining a neutral pH.

The result of these features is unusually active, effective whitening gels within the trays for six or more hours, with some activity seen beyond 10 hours,[65] instead of the typical 25-35 minutes seen with conventional whitening trays.[38] Not only is there a greatly increased duration of action, but the neutral pH (maintained by buffering agents), 100 percent aqueous gel and exclusion of salivary and sulcular fluid peroxidase results in a high concentration of ions and radicals.

The extended activity time of bleaching factors provides the required daily intervals necessary to thoroughly disintegrate and remove color molecules via diffusion (oxygenation), rejuvenating the youthful ability to absorb bleaching factors

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into the microstructure of the teeth, resulting in thorough conversion of large, dark color molecules to ultra-small colorless and white molecules.[7]

When the higher concentration in-office peroxide gel is then placed on the teeth after at-home whitening, large quantities of radicals virtually flood any remaining resistant chromophores, providing a final burst of whiteness, even in resistant cases such as tetracycline staining.

KöR Dual-Activated, Tri-Barrel Hydremide Peroxide Technology

Use of dual-barrel delivery of in-office gels has prevented the formulation of products able to produce all of the desired properties previously discussed. Many of these desirable properties have been mutually exclusive – each time a desirable property is created, a negative property is automatically introduced.

There are many chemicals that cannot be mixed together until ready for use. Dual-barrel syringes afford only two barrels to separate chemicals into. This restricts the number of ingredients that can be used in a formula. In my research I found that by keeping the chemistry separated into three separate barrels (Fig. 3), I have freedom to add to the whitening gel formulation.

The combination of continuous refrigeration and Evolve's KöR Dual-Activated, Tri-Barrel Hydremide Peroxide technology has resulted in the following critical benefits:

1. Maintenance of potency and a long shelf life, yet still achieving:
   a. The desired chemical instability of the whitening gels in the mouth, resulting in aggressive, rapid, thorough release of bleaching factors.
   b. Osmolarity as little as one-eleventh that of anhydrous gels with acidifiers, resulting in significantly less sensitivity.
   c. Aggressive release of ions and radicals instead of simply water and molecular oxygen.
   d. Whitening gels received cold by dental offices at virtually 100 percent of the original effectiveness.
2. Chemically influenced production of free radicals:
   a. Dual methods of acceleration, both of which guide peroxide breakdown to aggressive ions and radicals.
   b. Use of neutral, fully aqueous gels that degrade to a higher percentage of ions and radicals.
3. Lowering whitening gel surface tension:
   a. Lower surface tension greatly speeds absorption of bleaching factors into tooth microstructure.
   b. Whitening gel that will not run off the teeth, even with the lower surface tension (Fig. 2).
   c. Permeability was increased so much that a new paint-on gingival barrier with a lower surface tension/increased ability to bond to teeth and gingiva was necessary.
4. Addition of a buffering agent to scavenge hydrogen ions:
   a. Allows aggressive release of ions and radicals, yet neutralizes hydrogen ions produced, keeping the pH stable. The result is not only aggressive bleaching factors released, but a reaction rate that continues rapidly throughout the entire application time.
   b. By maintaining a stable, neutral pH, the reaction continues to produce ions and radicals instead of shifting to production of only water and molecular oxygen.
   c. By maintaining a stable neutral pH, the rise in osmolarity is prevented and sensitivity is reduced greatly.

Fig. 3: KöR Dual Activated Hydremide Peroxide in-office whitening gel. Three sets of three syringes (A, B & C). Each set of three syringes is mixed and applied to the teeth for 20 minutes.

By designing a whitening system in full compliance with the dictates of whitening science and chemistry, even super-resistant stains like tetracycline, fluorosis and geriatric discoloration can be flooded with concentrations of bleaching factors necessary to break down even these stains. See figures 4, 5 and 6 for several before-and-after photos of tetracycline, fluorosis and geriatric discoloration cases. Virtually all patients may now obtain truly white teeth.

The practical benefits of a whitening system that predictably provides exciting whitening results include:

1. No more keeping your fingers crossed behind your back during in-office whitening, hoping the patient will be pleased with the result.
2. No more embarrassment by dental staff when patients complain about lack of success.
3. With occasional at-home maintenance, patients can be promised permanent whiteness of their teeth, yet still allowing their enjoyment of coffee, tea and red wine.
4. Enhanced confidence in the dentist, resulting in more acceptance of optional dental treatment.

Figs. 4a & 4b: Tetracycline case whitened with KöR Whitening. "After" photo was taken 2.5 months post-op. Case by Dr. Brian Weibling.
Figs. 5a & 5b: Fluorosis case whitened with KoR Whitening. "After" photo taken 12 months post-op. Case by Dr. John Cloud.
Figs. 6a & 6b: Geriatric discoloration case whitened with KöR Whitening. Case by Dr. Leonard Tau.
Figs. 7a & 7b: KöR Whitening of lower anterior teeth so that new upper porcelain crowns or veneers can also be made very light. Case by Dr. Clarence Keglar

5. Higher rates of patient referrals.
6. Ability to truly whiten lower anterior teeth (which are usually more difficult to whiten) to compliment white upper veneers (see figure 7). Most patients opt for only upper veneers, and want those veneers white.

Following the above scientific principles, KöR Whitening is available for any patient need, including daytime and nighttime at-home-only whitening, in-office-only whitening, as well as the full Deep Bleaching system, involving both at-home whitening and one in-office whitening visit.

To receive more information about the KöR Whitening system, call 866-763-7753. ■

Author's Bio

Dr. Rod Kurthy practices in Mission Viejo, California. He graduated with highest honors from Fairleigh Dickinson University School of Dentistry in 1978, and completed a GP residency at Newark Beth Israel Medical Center.

Dr. Kurthy's 35 years of research and development include laser and surgical periodontal bone regeneration; endodontic surgery, including bone regeneration and repair of resorptive lesions; teeth whitening; teeth sensitivity; and development of several cosmetic techniques and impression techniques, to name a few. His first participation in periodontal research was in 1976, and teeth whitening in 1977.

He is an international lecturer and author of five popular clinical and dental marketing books. He is the recipient of awards and accolades including the Mosby Scholarship Award; FDU Prosthodontics and Pediatric Dentistry Awards; the Omicron Kappa Upsilon Gold Key Award; a commendation from the Chief Attorney of the United States Department of Defense for his role in supporting patients' rights in disputes with insurance carriers; and in March, 2005, he was selected as the most respected member of Dentaltown.com by more than 60,000 of his peers.