Effects of Dose, Particle Size and Exposure Time on Tooth Mineralization from NovaMin-containing Dentifrices.

NovaMin Research Memo

Research Institution:
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Abstract: A series of experiments were performed to determine the relative impact of NovaMin concentration (dose), particle size and exposure time on deposition of new Calcium and Phosphorus onto tooth surfaces. NovaMin was Neutron Activated to allow scintillation counting of the Ca and P deposited onto the tooth surface, as distinguished from original Ca and P of the existing tooth structure.

Concentration of NovaMin had an exponential relationship to new mineral formation in a range from 0.01% to 10.0%, indicating that significant gains could be made from modest increases in concentration and that, for the particle size of NovaMin tested, the optimum concentrations were above 5%.

Exposure time has a generally linear effect on new mineral formation, up to 40 minutes of exposure time, indicating that users of NovaMin dentifrice would be best served to maximize dwell time by refraining from rinsing, drinking, etc. for some time after brushing.

Finally, it was shown that smaller particles, already known to release Ca and P ions more rapidly and in higher quantities, also formed higher amounts of new Ca and P deposition than did larger particles.

Objective:
A series of experiments were conducted to determine the relationship between amount of new calcium-phosphate mineral formation on tooth surfaces and the dose level and exposure time of teeth to NovaMin® (Bioglass) dentifrices, as well as effects on the size of the NovaMin particles themselves on surface mineral deposition.

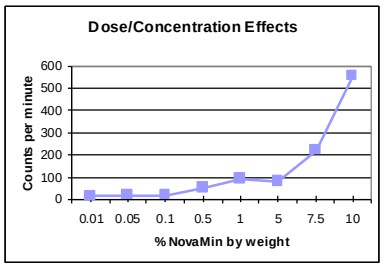
This work was conducted at Southwest Research Institute ("SwRI") and 50+ year old independent, non-profit research institute established for "the betterment of science and technology", located in San Antonio Texas. (www.swri.edu).

Methods:
In order to quantitatively distinguish and measure Ca and P that was being deposited onto the tooth surface from the pre-existing Hydroxyapatite of the natural tooth, SwRI developed a method whereby they exposed NovaMin particulates to neutrons, creating gamma ray emitting isotopes unique from those which would normally be found in teeth (a process called "Neutron Activation"). Further, while NovaMin contains Si, Na, Ca, and P, it was possible to infer that any measured radiation would be from the Ca and P, because the half-lives of the Si and Na isotopes were just a few hours, versus weeks for the Ca and P isotopes (approximately 25 and 2 weeks respectively). Since several days passed between Neutron Activation of the NovaMin and the experiments themselves, most or all gamma rays measured during the experiments would be from the Ca or P (although Si and Na may well be present).
In each of 3 experiments, extracted bovine teeth were used. In the experiment, the variable of dose (concentration), particle size and exposure time was isolated. Teeth were treated according to the experimental design and measurement was done via scintillation counting using a Beckman Instruments LS 6000 TA Scintillation Counter. Samples were each placed into a 10ml vial of Ready Gel liquid scintillation cocktail, with the treated surface facing the top of the standard scintillation vial.

The scintillation counts were used as a quantification of new Ca and P deposited on the surface – thus higher counts indicate higher levels of Ca and P deposition.

Experiment 1: Concentration
Commercially available aqueous dentifrices were used, with the addition of 0.01%, 0.05%, 0.1%, 0.5%, 1.0%, 5.0%, 7.5% and 10.0% NovaMin by weight (NovaMin "F5 Blend" of particulates used in all cases). Teeth were treated with a 1:1 mixture of the dentifrice and DI water for 1 minute, applied with a cotton tipped swab. Teeth were rinsed for 1 minute in DI water

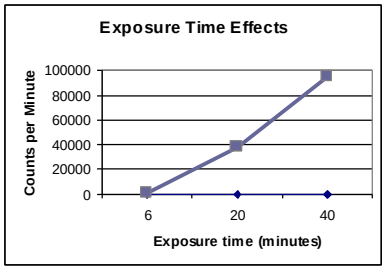
following treatment. Teeth were then measured via scintillation counting.



There was a strong relationship between dose/concentration and new Ca and P deposition, with a generally linear relationship between concentration and mineral deposition at lower concentrations and an exponential relationship at higher concentrations. For this particular particle size distribution the inflexion point was around a 5% concentration. As seen in following experiments, however, it would be expected that the inflexion point would be at lower concentrations for smaller particles and at higher concentrations for larger particles.

Experiment 2: Exposure Time

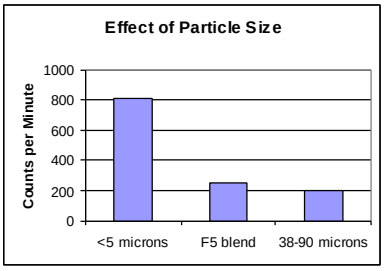
Dentifrices with a 7.5% concentration of NovaMin in a commercially available aqueous toothpaste base, using the "F5 Blend" of NovaMin particulates were used and exposure time was varied. Teeth were treated, with a 1:1 mixture of dentifrice and DI water, in two intervals of 3, 10, or 20 minutes each for total exposure times of 6, 20 or 40 minutes each. The teeth were rinsed between treatments and at the conclusion for 1 minute in DI water. Teeth were then measured via scintillation counting.



There was a generally linear relationship between exposure time and mineral deposition, indicating that increased exposure time yields increased mineralization, at least up to 40 minutes. While not surprising, this indicates that dentifrice users may maximize the mineralization effect by refraining from rinsing, drinking or eating for up to 40 minutes post treatment.

Experiment 3: Particle Size Effects

NovaMin of 3 different particle size distributions were tested in a slurry of deionized water and NovaMin at a 7.5% concentration. The particle size ranges tested included a small particle fraction, NovaMin "4505" (mean particle size of 5 microns); a broad range NovaMin "F5 Blend" (a blend of 5 particle size ranges, with a total range from about 5 microns up to about 150 microns) and a large particle fraction, with a range from 38-90 microns. As in the other experiments, the slurry was applied with a cotton tipped swab for 1 minute, and then rinsed for 1 minute in DI water. Teeth were then measured via scintillation counting.



Particles in a narrow, smaller range (4505) deposited much higher levels of mineral than did the broad range (F5 Blend) or the larger particles. This is consistent with other experimental work showing the release of Ca and P to be higher in smaller particles, due to the higher surface area-to-volume ratios in smaller particles.

Overall Conclusions:

Prior work has shown that NovaMin deposits Ca and P onto the tooth surface in the form of Hydroxycarbonate apatite. Additionally, prior work has shown that higher concentrations of NovaMin, as well as longer exposure and smaller particles release more Ca and P. This work confirmed that these higher releases resulted in higher deposition of Ca and P onto the tooth surface, suggesting that these variables will be important in determining the efficacy of NovaMin-containing dentifrices. In particular, varying concentration and particle size should allow for balances between the two to achieve good efficacy while also making consideration for formulation, texture, abrasiveness and cost-of-goods of dentifrice formulations.