

## Benefits of Functionalized Tricalcium Phosphate

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In the field of remineralization therapies for the tooth, much research has been devoted to creating systems of fluoride and calcium phosphate. But this hasn't been an easy task. For such systems to work, first it is critical the calcium component is isolated from the fluoride component, lest unfavorable reactions (i.e. calcium fluoride) occur; secondly, the topically applied fluoride and calcium interface constructively with the tooth. Traditionally, industry has solved these issues using conventional approaches, including, for example, preparing dental product with devoid of water, or at least nearly so; maintaining separate or hidden compartments in the dental product format to keep calcium and phosphate isolated; and, suggesting first a fluoride-only treatment, followed promptly by a fluoride-free calcium treatment. Alternately, there are strategies focusing on the formation of a partially insoluble calcium-phosphate-based mineral layer that forms on the tooth surface and functions as a sacrificial layer under acidic duress, with the aim of providing calcium and phosphate to the oral environment. While these above approaches may find utility, the purpose of this Editorial is to highlight a unique approach that solves the calcium-fluoride problem by exploiting defects manifested in the  $\beta$ -tricalcium phosphate structure, including under-bonded calcium oxide clusters as well as spatial voids in the lattice [1].

Using powerful mechanochemical methodologies, small amounts of organic molecules, such as sodium lauryl sulfate or fumaric acid, are fused with native  $\beta$ -tricalcium phosphate to yield functionalized tricalcium phosphate (fTCP) systems.\* These systems are tailored to the topical preparation's formulation and design as follows:

1. First, selection of an organic molecule is made based on the topical preparation and is evaluated in various testing models: for instance, fumaric acid is used in water-free systems such as fluoride varnishes, while sodium lauryl sulfate is used for fluoride dentifrice.
2. Then, backed with experimental data, the loading content of each functionalized system is matched with fluoride content to achieve the desired outcome of the topical preparation. For instance, the loading level of tricalcium phosphate system is lower for a dentifrice having 950 ppm fluoride compared to a dentifrice having 5,000 ppm fluoride.

The tailored design of these calcium phosphate systems 1) do not interfere with fluoride and 2) expand the remineralization effects on enamel and dentin relative to fluoride alone: thus, these systems facilitate fluoride compatibility and accommodate topical preparation versatility. Among the various fluoride and calcium phosphate systems currently available, the functionalized tricalcium phosphate system is a first-class calcium phosphate material providing the following benefits:

- Eliminates the need for special product designs/formulations aimed at minimizing unproductive calcium-fluoride interactions; and,
- Delivers controlled levels of bioactive calcium in order to maintain fluoride's efficacy, including mineralized integration into the tooth as well as acid-inhibition effects on microbial pathogens; and,
- Works via a secondary nucleation mechanism, utilizing the tooth structure as a model for subsequent mineral formation and growth; and,

- Improves the quality of fluoride's 'seeding' (i.e. mineralizing) effect to create strong, acid-resistant mineral relative to fluoride or calcium phosphate separately; and,
- Stimulates saliva-driven mineral growth, leading to improved remineralization at both the tooth surface and subsurface regions; and,
- Evaluated and optimized in multiple models commensurate with, for example, the United States' Food and Drug Administration and American Dental Association.

Presently, these functionalized systems are exclusively incorporated into several 3M Oral Care topical formats available globally, including Clinpro™ 5000, Clinpro™ Tooth Crème, Clinpro™ White Varnish with TCP, and Vanish™ White Varnish with TCP, and continue to demonstrate efficacy in various laboratory and clinical models, and importantly, in the clinical setting [1-5]. Available from the dental professional, these topically applied products are designed for those at moderate or high risk for tooth decay, including at-risk children and adults, those with dry-mouth conditions, a history of dental decay (including erosion), those experiencing hypersensitivity, and especially those fitted with orthodontic brackets and appliances.

### Disclosure

\*As a scientist who developed the functionalized tricalcium phosphate systems discussed here, I support their use; however, these systems may not be applicable in all situations.

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