nanoXIM CarePaste

WHITE PAPER

ENAMEL REMINERALIZATION

Effectiveness of nanoXIM•CarePaste on enamel remineralization

Enamel remineralization

The **mineralized tissues in the human body are composed mostly of hydroxyapatite (HAp)**, a natural calcium phosphate ceramic that is abundant in bone and dentin (70%), and enamel (97%). **Tooth enamel**, the hardest tissue in the human body, is build **up** from **HAp nanocrystals** about 40 nm in size. Unlike bone, the enamel is acellular and **cannot be repaired naturally** [1]. As a result, effective enamel regeneration represents a significant clinical challenge.

Demineralization occurs when the mineral content of the teeth begins to wear away. This process can happen with the consumption of acidic foods and drinks, as well as by the acids produced through the bacterial metabolization of starches and sugars [2, 3]. Consequently, the nano-hydroxyapatite ions are removed from its structure, destroying the enamel crystals. If demineralization progresses over time, it can result in the formation of dental caries [4], a serious oral health concern affecting a significant portion of the global population. Particularly, in the United States, only 10% of adolescents and young adults are caries-free, and the incidence continues into adulthood, with more than 95% of adults suffering from caries on enamel and root surfaces [5].

These facts highlight the importance of remineralizing agents in dental hygiene. The chemical and structural similarity of nano-hydroxyapatite (nano-HAp) to enamel HAp makes it an excellent remineralizing agent. It deposits on the enamel surface and strongly binds to it, creating a new homogeneous surface layer (Figure 1) [6].

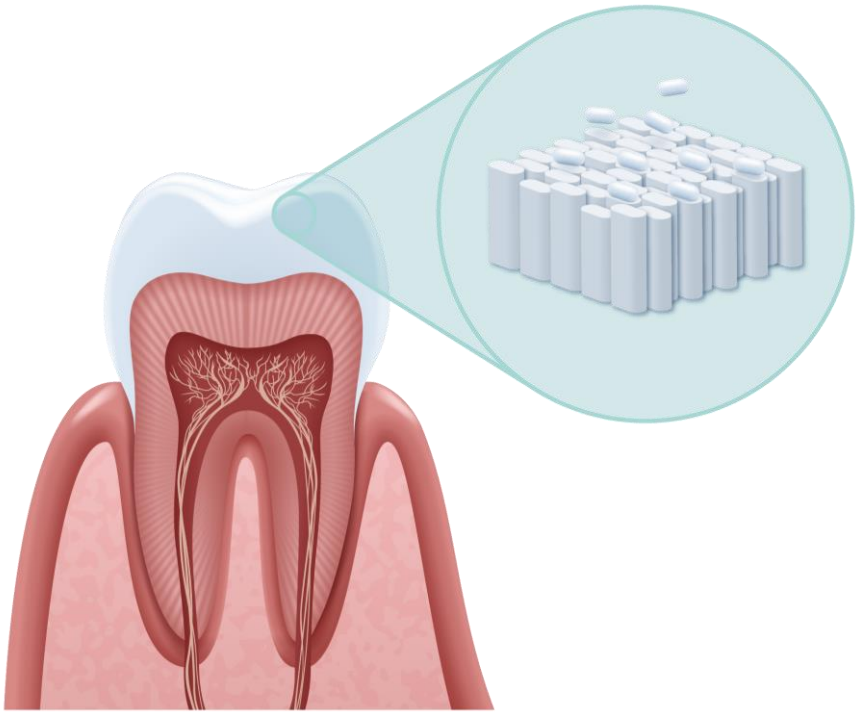

Figure 1: Nano-hydroxyapatite rod-shaped particles deposition on the enamel surface. A strong connection between the nanoparticles and the enamel is formed, resulting in a new remineralized layer.

nanoXIM•CarePaste

The nanoXIM•CarePaste is a nano-HAp ingredient produced and marketed by FLUIDINOVA. This synthetic water-based suspension ingredient has been **specifically developed for oral care applications**, such as toothpastes, gels, mouthwashes, dental floss, and other oral care products (personal and professional use). Nano-HAp is a calcium phosphate material widely accepted in dentistry and medicine, thanks to its exceptional biocompatibility and bioactivity. Its excellent performance comes from its nanometer size, which closely mimics natural teeth and bone. nanoXIM•CarePaste contains high-purity nanoparticles under 100 nm in size, being much smaller than the dentin tubules. Therefore, they can be easily integrated inside the tubules, blocking them and **reducing the pain associated with dental hypersensitivity**. Additionally, nanoXIM•CarePaste binds to the dentin apatite and tooth enamel, promoting the formation of a new apatite layer that, **remineralizes the enamel and protects the tooth surface**, while **restoring its natural whiteness**.

Mode of action

1.

Dental hypersensitivity, a short and sharp pain, prevents us from drinking hot coffee, ice cream, or even an orange juice without feeling pain. The action of certain food and drinks (hot, cold, acidic) are considered aggressions to our teeth, resulting in the exposure of dentin tubules and the underlying nerves to the external environment (the dentin loses its protective covering).

2.

HAp has a great potential in the treatment of dental hypersensitivity, as it can be incorporated inside the dentin tubules. Consequently, these become sealed and pain is reduced.

3.

As a result, a new layer is formed, remineralizing the tooth enamel and protecting the tooth surface, preventing the appearance of new cavities and making it resistant to acid attacks of our favourite meals.

4.

The deposition of HAp on the enamel surface improves its smoothness for better light reflection, and consequently brighter and whiter teeth.

The effectiveness of nanoXIM•CarePaste has been confirmed in numerous studies

Study 1

The goal of this *in vitro* study was to evaluate the potential of VITIS Whitening toothpaste (Dentaid S.L., Spain) containing 3% of nanoXIM•CarePaste in the remineralization of the enamel and dentin [7].

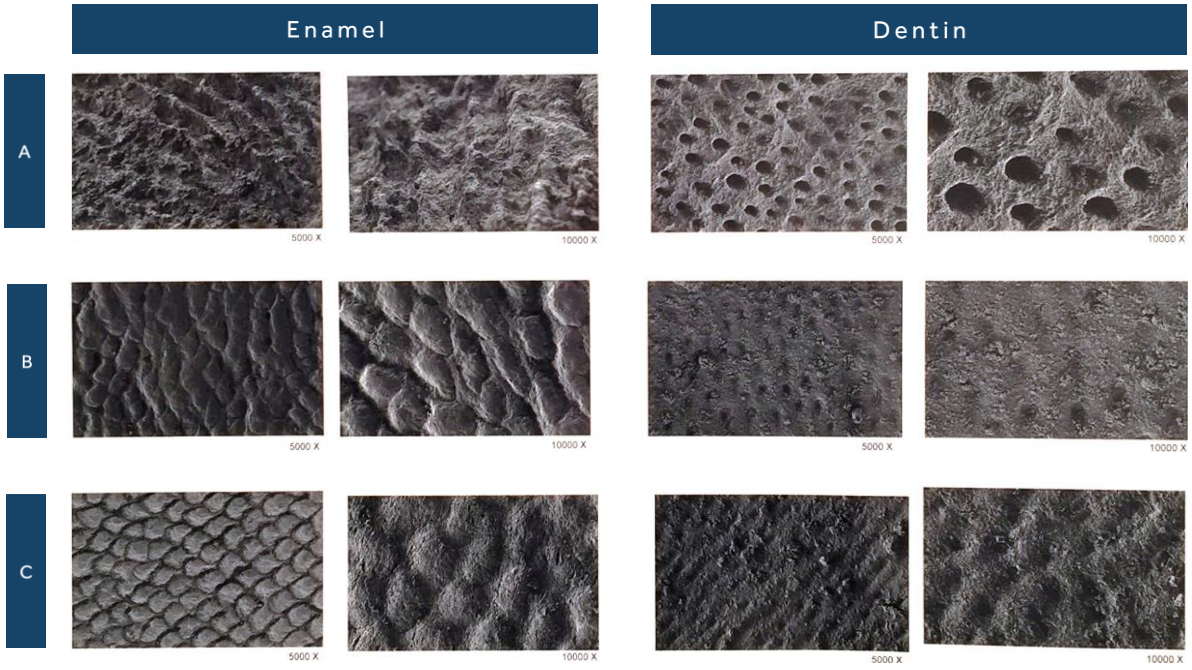

Figure 2: A: demineralized enamel and dentine with orthophosphoric acid at 37%;
B: remineralized enamel and dentine after four days of treatment with nHAp toothpaste, twice a day for 4 minutes;
C: after treatment, specimens were placed in contact with Coca-Cola® (pH = 2.52) for four minutes, twice a day for four days.

- ✓ A four-day treatment with VITIS Whitening toothpaste (containing 3% nanoXIM•CarePaste) effectively remineralized the enamel and dentin after their previously demineralization with orthophosphoric acid;
- ✓ The remineralized effect persisted even after a subsequent four-day exposure to Coca-Cola®.

Study 2

In the present study, the efficiency of four toothpastes in inhibiting demineralization adjacent to orthodontic brackets was evaluated *in vitro*. The tested toothpastes were Aclaim (6.5% nanoXIM•CarePaste, Group Pharmaceuticals, India), Apagard (nano-hydroxyapatite, Sangi, Japan), Clinpro Tooth Crème (Tricalcium phosphate and fluoride, 3M ESPE) and Colgate Total (Fluoride, Colgate-Palmolive Company, India). For that purpose, stainless steel brackets were applied on healthy maxillary first premolars and each toothpaste was applied daily during thirty-one days. After bracket removal, the teeth were observed under a polarized light microscope. The depths of demineralized enamel were measured in three different sites of gingival demineralized area: gingival margin, middle third and occlusal margin [8].

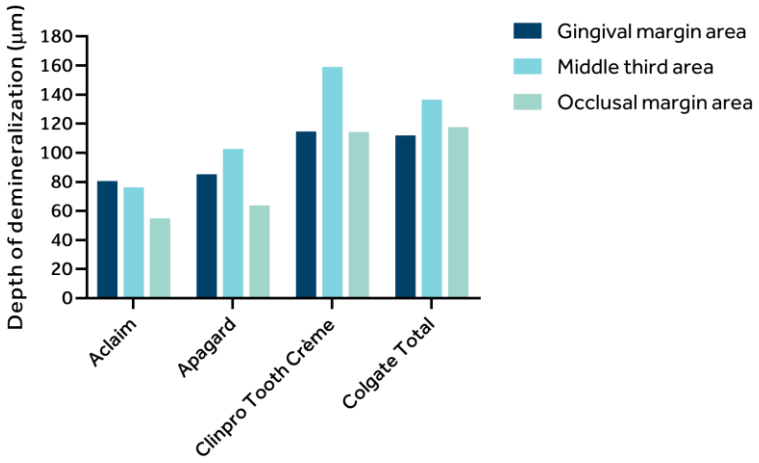

Figure 3: Site-specific comparison of depth of demineralization of each toothpaste tested. Lower values represent less demineralization.

- ✓ The Clinpro Tooth Crème and Colgate Total toothpastes were the least effective at inhibiting enamel demineralization, in opposition to toothpastes containing nano-hydroxyapatite;
- ✓ Between the two nano-hydroxyapatite toothpastes tested (Aclaim and Apagard), Aclaim containing nanoXIM•CarePaste offered superior reduction of the demineralized areas;
- ✓ The daily application of a toothpaste with nanoXIM•CarePaste provided higher protection against enamel demineralization in orthodontics.

Study 3

In this *in vitro* study, it was evaluated the capacity of nanoXIM•CarePaste nano-hydroxyapatite particles to adsorb and persist on teeth enamel surfaces. Bovine enamel samples were used as test substrate and different concentrations of nanoXIM•CarePaste test solutions (3, 6 and 12 %wt) were prepared by dilution in deionized water. Deionized water was also used as negative control. Enamel specimens were first etched in 0.1% citric acid and rinsed with water. The enamel specimens were then immersed in the test solutions for 15 minutes, removed and rinsed with water to remove non-adsorbed nano-hydroxyapatite. Adhesion of nano-hydroxyapatite particles to the enamel surface was subsequently analyzed using scanning electron microscopy (SEM) [9].

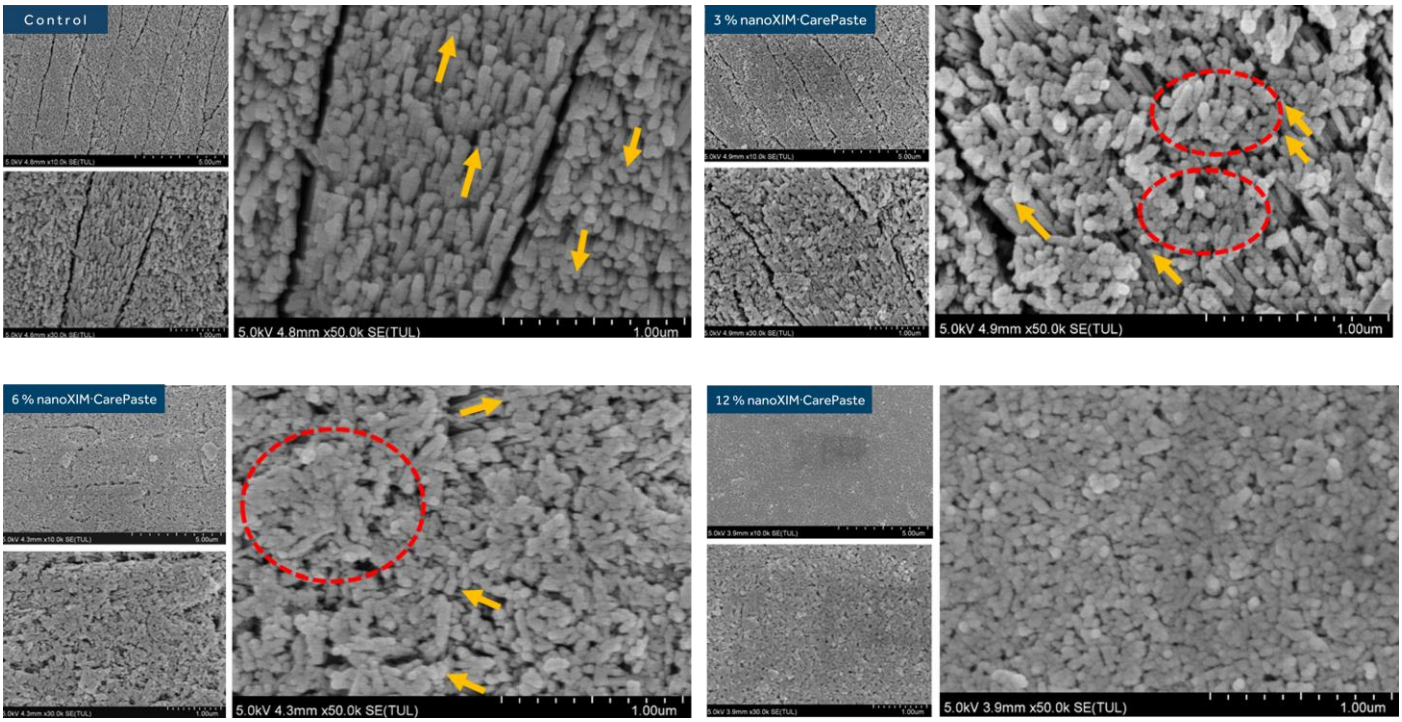

Figure 4: Scanning electron microscopy (SEM) images of enamel surfaces with different treatments. Orange arrows: natural orderly rod-like apatite crystallites. Red circles: nanoXIM•CarePaste nano-hydroxyapatite particles.

- ✓ The nano-hydroxyapatite contained in nanoXIM•CarePaste showed effective adsorption onto the enamel surface for all tested concentrations;
- ✓ The deposition was dose-dependent, with higher concentrations of nanoXIM•CarePaste resulting in greater deposition;
- ✓ Treatment with 12 %wt nanoXIM•CarePaste fully covered the enamel surface with nano-hydroxyapatite particles, effectively filling and repairing all damaged cracks on the enamel surface.

Conclusion

The studies stated in this document evidence the **success of nanoXIM•CarePaste as an oral care ingredient**, demonstrating its **excellent performance in enamel remineralization**.

nanoXIM•CarePaste achieves a higher rate of enamel remineralization than other commercial brands, remains on the teeth even after washing, and helps restore the enamel, creating a renewed tooth surface.

References:

1. Group Pharmaceuticals Ltd. Aclaim® Product Notes, 2012.
2. Kanzow, et al. Quintessence international, 2016.
3. Ahmadi-Motamayel, et al. Journal of Dental Sciences, 2013.
4. Hicks, et al. Journal of Clinic Pediatric Dentistry, 2005.
5. García-Godoy, et al. The Journal of the American Dental Association, 2008.
6. Anil, et al. International Journal of Environmental Research and Public Health, 2022.
7. Soler Ollé A, et al. 49ª Reunión Anual SEPA, Barcelona, Spain, 2015.
8. Singh, et al. The Journal of Indian Orthodontic Society, 2017.
9. FLUIDINOVA, Internal Report, 2024.

FLUIDINOVA

THE NANO-HYDROXYAPATITE SPECIALIST

FLUIDINOVA, S.A.

Rua de Rosa Jácome Felgueiras 57, 4475-188 Maia

Phone: +351 22 011 9746 | Email: nanoxim@fluidinova.com