BioArmor™ Technology in MultiMatch™ Flowable Chameleon Antimicrobial Dental Composite

Sustained Reduction in Bacterial Load and Demineralization via Mesoporous Silica–Octenidine Dihydrochloride Delivery

Premier® Dental Products Company

Executive Summary

Secondary (recurrent) caries remains the leading cause of restoration failure.[1] Traditional restorative composites are passive materials that do not actively address bacterial biofilm formation or acid-driven demineralization at the restoration interface.[2] BioArmor™ technology, incorporated into MultiMatch™ Flowable Composite, represents a new class of bioactive restorative materials designed to actively reduce bacterial load and demineralization as a function of the material's bioactive properties.

BioArmor™ is based on a cutting-edge antimicrobial nano technology that involves spherical mesoporous nano-silica particles infused with octenidine dihydrochloride (OCT), a broad-spectrum antimicrobial agent with a long history of safe clinical use.[3,4] Unlike other antimicrobial technologies, BioArmor™ provides controlled, ultra-long-term release of OCT, enabling penetration through biofilm and sustained antimicrobial efficacy.

The Clinical Problem: Biofilm and Recurrent Caries

Caries formation is a biofilm-mediated process driven by acid-producing microorganisms that demineralize enamel and dentin at restoration margins.[5,6] Once biofilm is established on a restorative surface, conventional materials offer no active defense, allowing bacterial proliferation, acidification, and eventual cavitation. [7]

Key challenges with existing antimicrobial materials include: short-term burst release, surface-only "contact kill" mechanisms, rapid loss of efficacy once biofilm accumulates, limited or no protection against demineralization, and potential for irritation or allergic reactions with some products. BioArmor™ was developed specifically to overcome these limitations.

MultiMatch™ Flow Indications for Use - Cleared by the FDA

- Direct restorations in all cavity classes (I-V)
- Base / liner under direct restoration
- Veneering of discolored anterior teeth
- Splinting of mobile teeth
- Extended pit and fissure sealing in molars and premolars
- Repair of composite/ceramic veneers
- Retention of thermoplastic aligners

What Is BioArmor™ Technology?

The addition of anti-microbial particles to MultiMatch™ Flow Chameleon Antimicrobial Composite reduces demineralization and the total amount of bacteria at the material surface, which is part of the caries-formation process.

BioArmor™ antimicrobial nano technology consists of spherical mesoporous nanosilica particles infused with octenidine dihydrochloride (OCT). The mesoporous silica functions as a molecular reservoir, holding OCT within nanoscale pores. The average particle size of silica is 450 nm, and the pore size is 1–2 nm, hence the mesoporous structure. This structure enables controlled diffusion rather than rapid depletion.

Fig. 1 Schematic illustration of a spherical mesoporous nano-silica used in BioArmor. Average particle size: 450 nm, the pore size is 1–2 nm.

BioArmor™ Technology exhibits remarkably prolonged antimicrobial activity. OCT penetrates and diffuses through biofilm at a controlled, slow rate, with only 0.02% of the compound released steadily over one month. This release is minimal relative to the total payload, with 99.98% of OCT retained, indicating that the antimicrobial reservoir would last for decades before depletion.

Despite the minimal relative release of OCT, BioArmor™ Technology demonstrates proven reduction in bacterial load and demineralization.

Why Octenidine Dihydrochloride (OCT)?

Octenidine dihydrochloride is a powerful, **broad-spectrum antiseptic agent** used globally for skin, mucosa, and wound disinfection. In Europe it is used in dental products, such as mouth washes and mouth rinses. Unlike chlorhexidine or quarternary ammonium, OCT is known to be non-irritating/gentle on oral tissues, which make it particularly suitable for long-term daily intraoral use. [3,4]

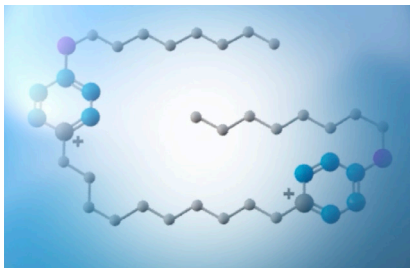


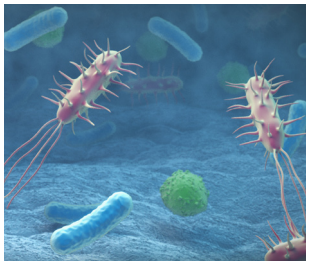
Fig. 2 Schematic representation of Octenidine Dihydrochloride molecule

OCT is **effective against gram-positive and gram-negative bacteria, fungi and enveloped viruses**, as well as multi-drug-resistant bacteria (ex. MRSA).[8] Importantly, **no acquired microbial resistance to OCT has been reported**, likely due to the broad nature of its antimicrobial action.

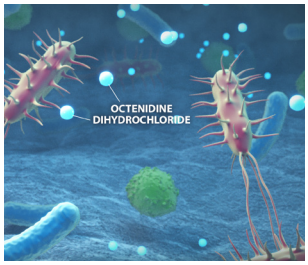
It is very stable and effective over a broad pH range 1.6 to 12.2 [9], encompassing the acidic conditions associated with cariogenic biofilms. Its broad-spectrum efficacy and long history of safe, effective use make it a trusted technology in dental applications.

BioArmor™ Mechanism of Action

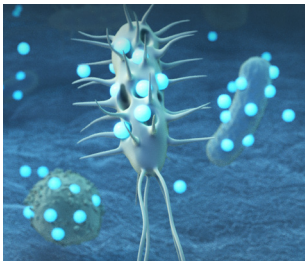
OCT is a multi-targeted bis-cationic surfactant that penetrates and destroys cell walls in a broad range of pathogens throughout the biofilm/marginal gap. OCT is using its positive charge to bind to negatively charged microbial cell walls, disrupting membrane integrity and causing leakage of vital intracellular contents, protein denaturation, and ultimately cell lysis and death.[10] In oral environment OCT is released from the nano-silica and diffuses away from the composite surface. It penetrates established biofilm, maintaining antimicrobial activity even after biofilm maturation. [11,12]



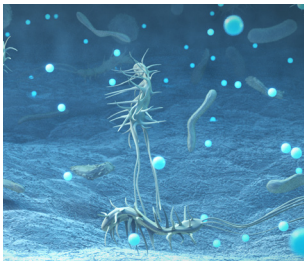
Intraoral biofilm: communities of microorganisms - primarily bacteria, along with fungi and viruses.



OCT diffuses away from the composite surface into biofilm.



OCT binds to negatively charged microbial cell walls of various pathogens.



OCT disrupts membrane integrity causing leakage of vital intracellular contents.

Fig. 3 Schematic Illustration of BioArmor's technology mechanism of action.

As OCT disperses through biofilm, it kills bacteria and critically disrupts fungi and viruses, stopping them from growing and multiplying. This leads to a significant reduction in acid-producing bacterial load on the restoration and restoration-adjacent areas, which in turn leads to reduction in demineralization. This protective process continues for the life of the restoration.

Evidence of Antibacterial Performance

In an *in vitro* model, MultiMatch™ Flow and a control material (a commercial composite without BioArmor™) were bonded to extracted human teeth. The samples were inoculated with *Streptococcus mutans* and incubated in a biofilm fermenter at 37 °C for 24 hours. Following incubation, samples were stained to differentiate live (green) and dead (red) bacteria and analyzed using confocal microscopy.

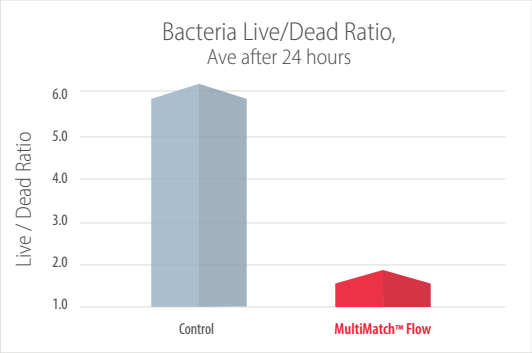


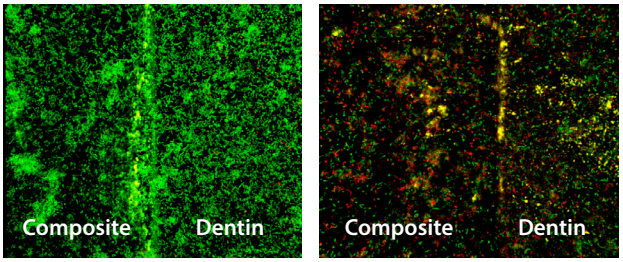
Fig 4. Average Live/Dead ratio of MultiMatch Flow and Control (commercial composite without BioArmor), N=4. One-way ANOVA and Tukey's multiple comparison tests were used for statistical analysis. The analysis shows a statistically significant difference between the two materials ($p<0.05$).

As shown in Figure 4, MultiMatch™ Flow demonstrated a markedly lower **live/dead bacterial ratio** (1.8 ± 0.5) compared to a control without BioArmor™ (6.1 ± 1.4) after 24 hours of incubation.[13] Such reduction indicates a substantial decrease in bacterial viability on the composite surface under biofilm fermentation conditions.

These findings show that BioArmor™ provides robust antibacterial protection by significantly suppressing biofilm viability, even under active biofilm growth conditions that are known to reduce bacterial susceptibility. By reducing the proportion of viable bacteria at the composite surface, BioArmor™ may help limit bacterial colonization at the restoration–tooth interface.

The **confocal microscopy images** also show clear evidence of antibacterial performance of MultiMatch™ Flow. In the images the composite is on the left, the dentin is on the right and the vertical line is the adhesive (3M Scotchbond® Universal).*

The MultiMatch™ Flow image is predominantly red, indicating a substantial proportion of dead bacteria. This effect is most pronounced at the composite surface, though dead bacteria are also observed on the adjacent dentin, highlighting the ability of OCT to diffuse into surrounding areas. In contrast, the Control composite, lacking antimicrobial technology, shows bacteria thriving. These images clearly demonstrate that MultiMatch™ Flow with BioArmor™ effectively reduces bacterial viability both at the composite surface and adjacent area.



Control composite with no antimicrobial properties

Premier® MultiMatch™ Flow with BioArmor™

Fig 5. Representative confocal images from MultiMatch Flow and Control (commercial composite without BioArmor). Live bacteria are stained in green and dead bacteria are stained in red.

BioArmor's ability to kill microorganisms helps significantly reduce demineralization, as illustrated by the next study.

Evidence Supporting Demineralization Reduction

An *in vitro* demineralization test was used to assess BioArmor's ability to reduce dentin demineralization at the restoration interface - a key step in secondary caries development. The study compared the performance of MultiMatch™ Flow to a control composite without BioArmor™. The evaluation employed the FDA-recognized Zurich Biofilm Model as a surrogate for *in situ* clinical evaluation. This model is well validated and widely used for studying caries-related biofilms and antimicrobial dental materials.[14, 15]

The study was conducted by using dentin blocks harvested from fully intact, unrestored extracted human 3rd molars. Standardized cavities were restored using 3M Scotchbond® Universal adhesive system followed by placement of either: MultiMatch™ Flow or Control. Specimens were incubated in biofilm fermenter for 7 days at 37˚C under highly cariogenic multi-species simulated oral environment, nutrients were added every 24 h. The bacterial biofilm formation included *Streptococcus mutans (GP), Streptococcus oralis (GP), Actinomyces naeslundii (GP),Veillonella dispar (GN), Fusobacterium nucleatum (GN) and Candida albicans (Fungus).* Demineralization at the dentin–restoration interface was quantified using micro-computed tomography (µCT), allowing three-dimensional volumetric analysis of mineral loss.[16]

*Scotchbond is not a registered trademark of Premier® Dental Product Company.

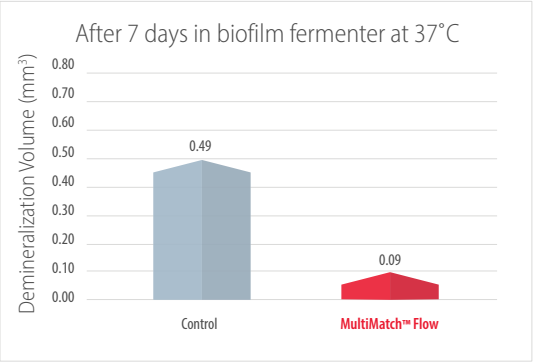


Fig 6. Average demineralized volume of MultiMatch Flow is nearly five times less than that of the Control

MultiMatch™ Flow showed a significant **reduction in dentin demineralization** versus the nonantimicrobial control, performing **nearly fivefold better**.

The marked reduction in demineralization observed with MultiMatch™ Flow suggests that the **BioArmor™ technology enhances protection of dentin at the restoration margin**, beyond that achieved by the non-antimicrobial Control composite. Because interfacial demineralization is a critical precursor to secondary caries, these findings support the evidence of bioactive and caries-modulating function of MultiMatch™ Flow. Importantly, the study design closely mimics clinical conditions—using human dentin, adhesive bonding, and a cariogenic biofilm challenge—strengthening its translational relevance despite its *in vitro* nature.

Conclusion

BioArmor™ antimicrobial technology leverages mesoporous nanosilica loaded with octenidine dihydrochloride to deliver a new standard in restorative dentistry. Through controlled release, deep biofilm penetration, broad-spectrum antimicrobial activity, exceptional efficiency and durability, BioArmor™ transforms MultiMatch™ Flow from a passive material into an active, longterm protective system. BioArmor™ disrupts cariogenic biofilms and helps reduce demineralization and bacterial load at the restoration surface. As a result, MultiMatch™ Flowable Chameleon Antimicrobial Dental Composite provides sustained protection aligned with modern caries biology and evidence-based biofilm science.

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