Antimicrobial Complex Coacervates as a Coating for Dental Implants

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Statement of Purpose: Dental implants are a popular solution to lost teeth. They are made from three components: implant, a screw-shaped section implanted into the jaw bone; abutment, a central bridging component; crown, a tooth-shaped prosthetic piece. The implant and abutment are commonly made from titanium, like many other biomedical implants, and are prone to infection. The abutment is exposed to the oral cavity, particularly during healing, making the adhesion of bacteria to its surface likely, especially when considering the amount of bacteria (over 700 species) present in the mouth.[1] Bacterial infection, if allowed to develop, can cause loss of the gum tissue and potentially of the supporting jaw bone thereby amplifying the risk of implant failure.[2]
Chlorhexidine (CHX) is a broad spectrum antimicrobial agent used extensively in dental products such as mouthrinse. By immobilizing it onto an abutment surface there is the potential to administer an antimicrobial effect at the site of bacterial colonization.[3]
Coacervates are formed from two oppositely charged polyelectrolytes which associate under aqueous conditions and, through hydrophobic phase separation, form a polymer-rich, viscous, liquid phase, surrounded by bulk water.[4] A benefit of coacervates is their propensity to sequester other particles/molecules from the surrounding solution.[5]
The aim of this work is to develop a CHX-based coacervate phase which could potentially be utilized as a new route for the development of anti-biofilm implant coatings.

Methods: Aqueous solutions of chlorhexidine digluconate and carboxymethyl-dextran (CMD) were mixed, at various concentrations, in order to form a stable coacervate phase. Resulting suspensions were investigated using UV-Visible Spectrophotometry (UV-Vis) and optical microscopy.
Known volumes of successful coacervate suspensions were drop-cast onto the surface of polished titanium substrates and allowed to dry. These surfaces were then investigated using Atomic Force Microscopy (AFM) and Scanning Electron Microscopy.
The antimicrobial efficacy of these surfaces against *Streptococcus gordonii* was investigated.

Results: The formation of a stable CHX-CMD coacervate was indicated through the employment of turbidity experiments (Vis-spectrophotometry). These coacervates settled and coalesced on the surfaces of the titanium substrates, reducing surface roughness (AFM, SEM, optical microscopy), Figure 1.

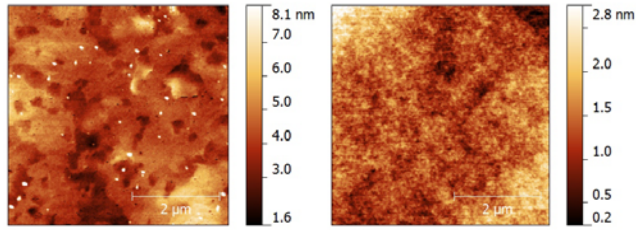

Figure 1. AFM images of uncoated titanium (left) compared to coacervate-coated titanium (right).

The coated surfaces exhibited a rapid CHX release upon immersion in water (UV-spectrophotometry) within 1 hour.
Adhesion and proliferation of *S. gordonii* were shown to be significantly reduced within 4 h by the presence of the CHX-coacervate film. This can be seen in Figure 2, where the bacteria have been fluorescently labeled to indicate live (green) and dead (red) bacteria.

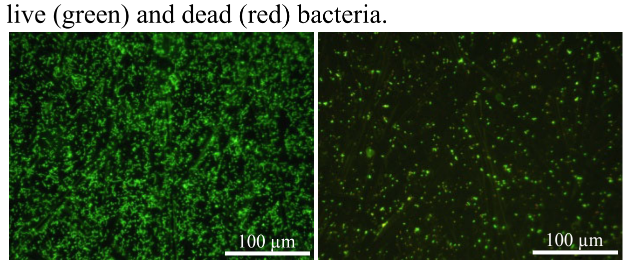

Figure 2. Optical micrographs of fluorescently labeled bacteria, live (green) and dead (red), on uncoated titanium (L) and CHX-CMD coacervate-coated titanium (R), after 4 hours exposure to a suspension of *S. gordonii*.

The reduction in the amount of bacteria present on the surface of the coated titanium can clearly be seen, in conjunction with an increase in the amount of dead/static (red/yellow) bacteria.

Conclusions: A stable coacervate phase has been formed from aq. CHX and CMD. These coacervates coalesced on clinically relevant titanium surfaces, resulting in the formation of a CHX-rich film. These coated surfaces exhibited a rapid CHX release within 1 hour and an antimicrobial effect against the oral bacterium *S. gordonii* within 4 hours. These results suggest the potential of this system as a coating for dental implant abutment surfaces.

References:

1- Aas JA. J Clin Microbiol. 2005:43:5721-5732.
2- Pye AD. J Hosp Infect. 2009:72:104-110.
3- Barbour ME. J Biomed Mater Res A. 2009:90:993-998.
4- Bohidar HB. J Surface Sci Technol. 2008:24:105-124.
5- Kizilay E. Adv Colloid Interface Sci. 2011:167:24-37.