Residual Platinum Plays a Substantial Role in Reducing Bacterial Attachment and Biofilm Development on the Surface of a Silorane-Based Bone Cement

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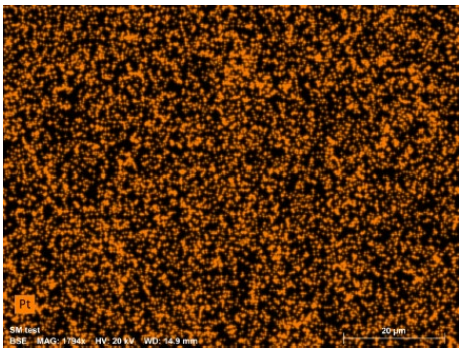
Statement of Purpose: Platinum catalysts are commonly used in the silicone industry for the preparation of monomers and for the cross-linking of polymers. A novel silorane-based epoxy, developed for orthopedic uses, relies on a dual curing system: part of which is light initiated and part of which is a platinum catalyst. This silorane-based biomaterial (SBB) is primarily a combination of two silorane comonomers, along with glass fillers, and the two initiation systems. Because the platinum catalyst is mixed in with the comonomers to initiate polymerization, platinum remains embedded in the material once polymerized, although it is not thought to be chemically bound to the matrix. Our previous research has shown the SBB cement to be significantly less conducive to bacterial colonization and biofilm development than PMMA cement. This characteristic makes the new material very promising for use as a bone cement. In this series of evaluations, we sought to explore the underlying causes of this innate antimicrobial property, hypothesizing that the presence of residual platinum is primarily responsible.

Materials and Methods:

SBB contains two silorane comonomers, CYGEP and PHEPSI, an yttria alumino-silicate glass filler (DY5), a light initiated catalyst (PIH + CPQ + EDMAB), and Lamoreaux's catalyst (LMC). SEM/EDS mapping of the material surface was performed for the primary elements of interest: O, C, Al, Si, Y, and Pt. Bioassays were run to compare the antibacterial properties of SBB components. Min Inhibitory Concentrations (MIC) for LMC, Octanol, PIH, CPQ, and EMDAB were computed for *S. aureus* (SA), *S. epidermidis* (SE), and *P. aeruginosa* (PA) using microdilution assays in MHB. Finally, a static assay was run to compare the bacterial burden on the surface of a silorane-based cement disk that incorporated a light initiation system only and on a disk of the dual-initiated SBB containing the platinum catalyst (LMC).

Results: EDS mapping showed the platinum in the SBB to be evenly dispersed within the matrix and available on the surface (Figure 1).

Only the PIH (*p*-(octyloxyphenyl)phenyliodonium hexafluoroantimonate) component of the light-initiation system showed any antibacterial potential (MIC = 6.67 µg/mL for SA and 4 for SE). DY5 glass filler showed no independent antimicrobial effect in PBS. Octanol alone had a 10-fold higher MIC than LMC (Platinum in Octanol) by vol% for both SA (0.0723 for LMC) and SE (0.0586 for LMC). Significantly lower amounts of bacteria were able to attach to the silorane-based material having platinum than to that without Pt ($p<0.01$, Figure 2).



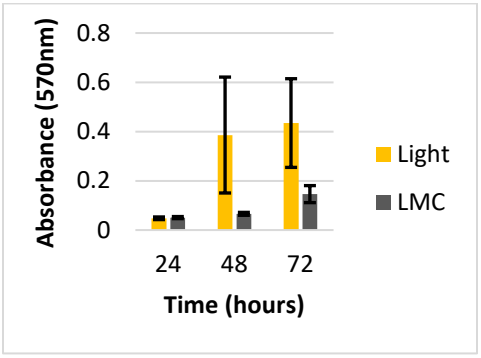


Figure 2. Bacterial density by Crystal Violet staining on a light-initiated silorane-based material w/o Pt (Light) and on our similarly composed material using the dual-initiation system including Pt (LMC), n=8.

Conclusions: As it is evenly dispersed and available near the surface of the SBB, platinum is a likely candidate for the material's antimicrobial properties. The literature suggests that platinum may be present as colloidal species after polymerization rather than as individual atoms. Residual platinum following catalysis is clearly implicated as the major antimicrobial component when comparing it against other SBB components and against a similar formulation containing no Pt. Further work to understand the mechanism of Pt's bacterial inhibition on the surface of the material is underway.