Antimicrobial and Diagnostic Feasibility of Inherently Therapeutic Nano-Hafnium for Periodontal Disease

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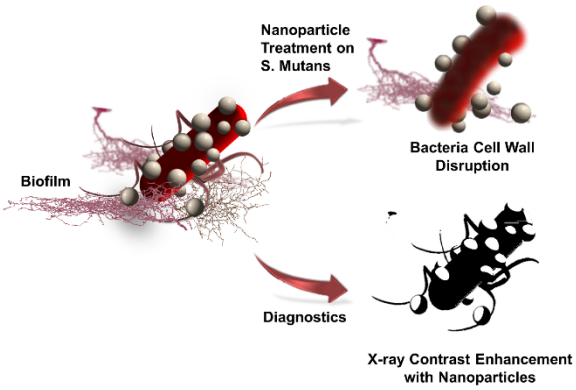
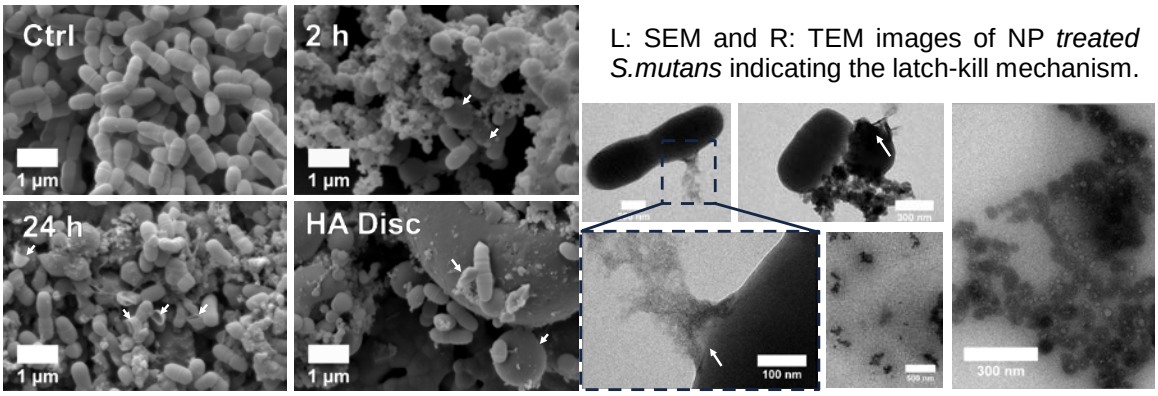
Although the eradication of tenacious oral biofilms is of paramount importance, their diagnosis can be a daunting task in dental clinics with current instrumental limitations especially in X-ray based techniques. This clinical need could be circumvented by the integration of antibacterial properties and X-ray contrast enhancement in a single nanoplatform specific to dental biofilms. Herein, scalable synthesis of nanoHafnium particles (Hf NPs) was carried out as confirmed by comprehensive physicochemical characterizations. TEM indicated the anhydrous diameter of the nanoparticles were 3.6±0.6 nm while X-ray diffraction spectroscopy (XRD) and electron diffraction patterns both indicated the amorphous structure of the as-synthesized nanoparticles. In addition, zeta potential measurements, solid and liquid state NMR spectroscopy, Xray Fluorescence spectroscopy (XRF) indicated the success of surface chemical modification. The particles could be utilized as X-ray contrast media for dental computed tomography (CT) with bactericidal properties towards cariogenic pathogens. *Ex vivo* studies on the extracted human tooth demonstrated striking CT attenuation from nanoparticles *vs.* tooth. Moreover, significant antibacterial properties of Hf NPs were concluded while electron microscopy (SEM and TEM) determined the antibacterial mechanism as 'latch and kill'. CT imaging of nanoparticle treated bacteria verified contrast enhancement in bacterial-rich regions. Importantly, Hf NPs could effectively inhibit the mature biofilm grown on an *ex vivo* model of human tooth. Furthermore, the nanoparticles were significantly more cytocompatible with NIH 3T3 fibroblast cells than commercial chlorhexidine antiseptic after exposure for 24 h. This is the first report on Hf NPs towards synchronous diagnostic and antibacterial treatment which can set the stage for the versatile theranostic probes in dental clinics.



The concept of the integration of diagnosis and antibacterial properties on a single platform for dental biofilm applications.



L: SEM and R: TEM images of NP *treated S.mutans* indicating the latch-kill mechanism.

Acknowledgement

We thank Frederick Seitz Materials Research Laboratory staffs, Roger Adams NMR Lab staffs, Beckman Institute of Technology microscopic suit staffs for their experimental and technical supports. TEM, AFM, zeta potential, XRF, XPS and XRD measurements were carried out at Frederick Seitz Materials Research Laboratory, UIUC. NMR studies were performed at Roger Adams Lab, UIUC. CT imaging was conducted at UIUC veterinary medicine school.