Protein film formation and its protective role on dental tissues under tribological and acidic conditions

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Introduction

Dental erosion (chemical degradation, corrosion) and tooth loss due to wear is an area of concern in modern dentistry, with growing interest in preventative and restorative measures. Acidic and high sugar diets are linked to being one of the leading causes of this. Pathological conditions, like Xerostomia (dry mouth syndrome), that reduce salary flow also have an effect on this [1]. A reduction of saliva in the oral cavity reduces its buffering capability and the amount of proteins suspended in the saliva which would adhere to dental and oral tissues to form a protective film known as the pellicle [2]. This film serves as a protective diffusion barrier against chemical attack and can reduce the dental and oral surface friction considerably [3-4]. If the film is not adequately formed, it can easily be removed due to the mechanical action of mastication. Once underlying enamel is exposed by this, chemical dissolution may take place in acidic conditions. This combination of mechanical and chemical interactions gradually wear teeth down over time.

While some studies have examined the components of this protein film formation and others have examined effects of tribology of surfaces in salivary mediums, it is not fully known how the pellicle's composition and structure influence its tribology under normal and acidic conditions. It is also not known what conditions can aid in maximizing the protective capabilities of this protein film, specifically looking at its composition and structure. This knowledge is essential for improved artificial saliva substitutes and other preventative therapies to reduce the effects of tooth erosion. This study therefore aims to examine the formation of these protein films on the surfaces of hard dental tissues and their protective roles under combined erosion and masticatory conditions.

Methodology

Tribological experiments were conducted by immersing bovine enamel and steatite (magnesium silicate) samples in solutions of different pH and ionic concentration, with and without the addition of porcine gastric mucin (PGM). A nanotribometer (Anton Parr, NTR^3) was used to simulate sliding of teeth after impact using a reciprocating ball on flat configuration against a Ø3 mm Yttria stabilized tetrahedral zirconia polycrystalline (Y-TZP). Friction was monitored by the tribometer and wear data was collected post-test using vertical scanning interferometry (Bruker, NPFlex) for wear scar analysis and Atomic Absorption Spectrophotometry (Agilent, 200 series AA with SIPS) for quantifying calcium dissolution into the immersing solutions.

The nanomechanical properties of the adhered mucin films was quantified using Atomic Force Microscopy, AFM, (Bruker, Multimode 8). Utilizing the Peakforce QNM imaging mode in liquid conditions, nano-indentations were performed over the enamel and steatite surfaces after immersion in a particular mucin solution for a given time period. Height data as well as elastic modulus, adhesion, dissipation and deformation would be determined for each pixel. A quartz crystal microbalance with dissipation monitoring, QCM-D, (Qsense, UK) was used to assess protein absorption kinetics. QCM experiments were conducted for these solutions to monitor the rate of growth, film thickness and viscoelasticity.

Results & Discussion

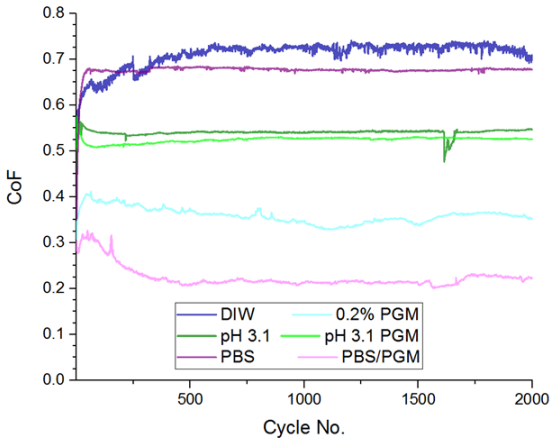

Figure 1 – Mean coefficient of friction for enamel samples. Deionised water (DIW), phosphate buffered saline (PBS), pH 3.1 citric acid (pH 3.1) and solution with mucin in (-PGM).

DIW and PBS mucin solutions give a much lower CoF compared to their non-mucin counterparts while the pH 3.1 mucin solution has had little influence on the friction, shown in Figure 1. The lower CoF in the PBS mucin solution was linked to the ionic content and the subsequent interactions with the mucins. This is supported in the QCM-D tests where the mucin's film thickness and elasticity of 26.4 nm and 22.2 kPa differ compared to the DIW mucin solution of 18.6 nm and 38.2 kPa. The presence of ions has been shown to influence the way in mucins modify friction as a result of the underlying film properties.

References

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