



# Effect of the saliva biomolecules on the interface zirconia/Ti6Al4V triboactivity

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## Effect of pH of H<sub>2</sub>O<sub>2</sub> solutions on the morphology and wear resistance of human dental enamel: an AFM study

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### ABSTRACT

**Introduction:** Teeth whitening is a highly demanded aesthetic dental procedure to remove teeth stains and get a whiter and perfect smile. This type of treatment is usually performed by the application on the teeth surface of hydrogen or carbamide peroxides which diffuse through the external layer of the teeth, enamel [1]. Although whitening treatments improve teeth appearance, they can impair teeth health, due to the eventual degradation of the teeth tissues. This may lead to abnormal wear and weaken the tooth structure. The aim of this work is to study the effect of the pH of 30% H<sub>2</sub>O<sub>2</sub> solutions on the surface of human enamel.

**Materials and methods:** Human molars were collected for the study with informed consents of the patients. Teeth were bleached in 30% H<sub>2</sub>O<sub>2</sub> solution with different pH values (2, 4 and 6). All samples were submitted to 11 bleaching sessions of 10 min each with alternate periods (2 min) of exposition to blue light. Microhardness, surface roughness and topography/morphology were characterised by microindentation tests, atomic force microscopy (AFM) and scanning electron microscopy (SEM), respectively, before and after the whitening treatments. AFM scratching tests (10 × 10 μm<sup>2</sup>) were performed, using a diamond probe. After the nanowear tests, topographical images of larger areas (20 × 20 μm<sup>2</sup>) which include the scratched squares were obtained with a silicon probe. The wear mechanisms were evaluated by SEM. Acceptance of the study protocol was obtained from a local ethics committee.

**Results:** The most significant changes on enamel surface were obtained for pH = 2: the microhardness decreases, and the surface roughness significantly increases as confirmed by the SEM image analysis. A higher wear rate was observed for pH = 2 in the AFM scratching tests. SEM observation of the wear zone showed differences in the wear mechanisms, which depend on the pH.

**Discussion and Conclusions:** Enamel microhardness, surface roughness and wear resistance are affected by the pH of the bleaching solution: pH = 2 led to the most adverse effects, which was attributed to hydroxyapatite demineralisation. The study of the effect of pH in the bleaching treatments is crucial to optimise this type of procedures and avoids enamel damage.

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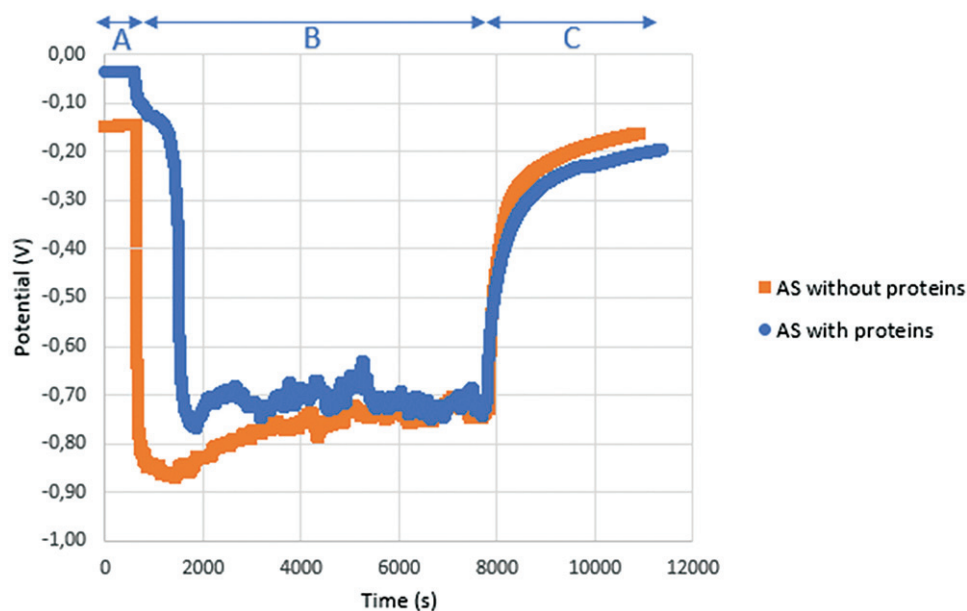
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**ABSTRACT**

**Introduction:** In some dental implants zirconia artificial dental crowns are fixed through a custom-built abutment made of a titanium alloy (Ti6Al4V) that, in turn, is tightly screwed to the implant. The rotational misfit at the implant-abutment hexagonal interface can lead to relative motion between the parts, resulting in interfacial wear. Usually, the wear tests are performed using artificial saliva (AS) without the addition of proteins. However, it is well documented that proteins can adsorb onto the biomaterials surface and may change the tribological response of the systems [1]. The objective of the present work was to evaluate the effect of the main proteins of natural saliva on the tribological behaviour of the pair zirconia/Ti6Al4V.

**Materials and methods:** Reciprocating pin on plate wear tests were performed using 6 mm balls of Ti6Al4V and plates of zirconia inside of a corrosion cell. The ball (working electrode) was connected to a potentiostat (GAMRY 600), through a wire and a calomel electrode was used as reference electrode. The wear tests were carried out in AS (composition described in [1]) without and with the addition of proteins (lysozyme 0.042 g/L + mucin 0.83 g/L + albumin 0.1 g/L) at 35 °C, during 2 h, with an applied load of 1 N, a sliding distance per cycle of 3 mm and a frequency of 1 Hz. The tests were performed after open circuit potential (OCP) stabilisation (Figure 1). OCP was recorded before, during and after wear testing.

**Results:** The results showed that the presence of proteins leads to a reduction of the total wear and of the corrosion activity at the interface zirconia/Ti6Al4V during sliding, at the initial stage of the wear test. In fact, the wear rate decreases from



**Figure 1.** Open circuit potential recording during a) stabilisation (before wear testing), b) sliding and (wear testing) and C) recovery (after wear testing) in AS with and without proteins.

$\sim 15 \times 10^{-5}$  to  $\sim 7 \times 10^{-5}$  mm<sup>3</sup>/Nm. In addition, the OCP obtained during sliding for AS + proteins is much higher than the one observed for AS during the first 15 min and it equals the AS OCP just after 113 min of wear testing.

**Discussion and conclusions:** The results suggest that the proteins adsorb at the sliding surfaces, forming a layer that acts as boundary lubricant. This layer prevents partially or totally the direct contact between the sliding surfaces and the total destruction of the passive film at the beginning of the tests (first 15 min). After the boundary film is disrupted, the passive film is totally destroyed, and the OCP drops to values near the ones observed for AS without proteins. In conclusion, the addition of proteins to saliva as an impact on the tribological response of the de sliding pair zirconia/Ti6Al4V.

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